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An American National Standard

Standard Guide for Specifying and Evaluating Performance of Single Family Attached and Detached Dwellings—Durability[1]

This standard is issued under the fixed designation E2136; 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

This guide is part of a set which together presents a complete performance standard guide for specifying and evaluating single family attached and detached dwellings. The complete set in the series, when finished, is to include the attributes given in Fig. 1.

The series provides a framework for specifying and evaluating qualities of building products and systems to meet user needs without limiting ways and means. The format for this guide includes performance statements that consist of four components, Objectives-Criteria-Evaluation-Commentary (O-C-E-C), which together provide a systematic performance based approach for the intended purpose. These performance statements are presented in Section 8 against a Hierarchy of Building Elements as tabulated in Fig. 2.

The purpose of these standard guides is to provide a standardized methodology for describing performance parameters of single-family attached or detached dwellings. This methodology standardizes the descriptions of performance of a single-family dwelling, attached or detached, that can be expressed as performance statements (O-C-E-C) for a particular attribute, degradation factor, and user need.

These standard guides are intended for use by those who need to prescribe required levels of performance and those who need to rate a product which forms a single-family dwelling or part thereof. The standard guides include examples of performance statements that may be used for the specification and evaluation of design, materials, products, components, subsystems, and systems.

1. Scope

1.1 This guide gives examples of performance statements for durable in-place materials, products, components, subsystems, and systems for single family attached and detached dwellings, considering the effects of normal degradation factors to which they are anticipated to be subjected over their service lives. Table 1 provides a listing of the sections of this Guide that address durability including the performance statements.

1.2 Damage from extreme acts of nature, vandalism, or intentional destructive acts by dwelling inhabitants are not considered as normal degradation factors affecting durability in this guide.

NOTE 1—Performance statements regarding the performance of single family attached and detached dwellings under extreme acts of nature are addressed in the Guide on Structural Safety and Serviceability.

1.3 This guide also addresses site planning in so far as it affects the durability of single family attached and detached dwellings.

1.4 This guide is not intended to be used as a prescriptive regulatory document.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B117 Practice for Operating Salt Spray (Fog) Apparatus

[1] This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.25 on Whole Buildings and Facilities.

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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.

Attributes Addressed in the Series of Performance Standards for Single Family Attached and Detached Dwellings

A — Structural Safety and Serviceability
B — Fire Safety
C — Accident Safety
D — Health and Hygiene
E — Indoor Air Quality
F — Light
G — Acoustics
H — Durability
I — Accessibility
J — Security
K — Economics
L — Functionality
M — Aesthetics
N — Adaptability
O — Maintainability
P — Sustainability

FIG. 1 Attributes Addressed in the Series of Performance Standards

C1036 Specification for Flat Glass
C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass
C1172 Specification for Laminated Architectural Flat Glass
C1349 Specification for Architectural Flat Glass Clad Polycarbonate
D225 Specification for Asphalt Shingles (Organic Felt) Surfaced With Mineral Granules (Withdrawn 2012)[3]
D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D2444 Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
D2486 Test Methods for Scrub Resistance of Wall Paints
D3363 Test Method for Film Hardness by Pencil Test
D3462 Specification for Asphalt Shingles Made from Glass Felt and Surfaced with Mineral Granules
D3746 Test Method for Impact Resistance of Bituminous Roofing Systems
D4226 Test Methods for Impact Resistance of Rigid Poly-(Vinyl Chloride) (PVC) Building Products
D4449 Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance
D4812 Test Method for Unnotched Cantilever Beam Impact Resistance of Plastics
D5178 Test Method for Mar Resistance of Organic Coatings
D5420 Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)
D6110 Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics
E631 Terminology of Building Constructions
E632 Practice for Developing Accelerated Tests to Aid Prediction of the Service Life of Building Components and Materials
E695 Test Method of Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading
E773 Test Method for Accelerated Weathering of Sealed Insulating Glass Units (Withdrawn 2010)[3]
E774 Specification for the Classification of the Durability of Sealed Insulating Glass Units (Withdrawn 2006)[3]
E822 Practice for Determining Resistance of Solar Collector Covers to Hail by Impact With Propelled Ice Balls
E917 Practice for Measuring Life-Cycle Costs of Buildings and Building Systems
E997 Test Method for Structural Performance of Glass in Exterior Windows, Curtain Walls, and Doors Under the Influence of Uniform Static Loads by Destructive Methods
E998 Test Method for Structural Performance of Glass in Windows, Curtain Walls, and Doors Under the Influence of Uniform Static Loads by Nondestructive Method
E1017 Specification for Generic Performance Requirements for Exterior Residential Window Assemblies (Withdrawn 2003)[3]
E1233 Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential
E1825 Guide for Evaluation of Exterior Building Wall Materials, Products, and Systems
E2025 Test Method for Evaluating Fenestration Components and Assemblies for Resistance to Impact Energies

[3] The last approved version of this historical standard is referenced on www.astm.org.

Hierarchy of Building Elements Included in the Series of Performance Standards for Single Family Attached and Detached Dwellings

- **0. Whole Building System**
  - 0.1 All Building Subsystems
  - 0.2 Groups of Building Subsystems
- **1. Spaces**
  - 1.1 Entries
  - 1.2 Living Spaces
  - 1.3 Dining Spaces
  - 1.4 Kitchens
  - 1.5 Sleeping Spaces
  - 1.6 Bathrooms
  - 1.7 Water Closets
  - 1.8 Outdoor Living Spaces
  - 1.9 Storage Spaces
  - 1.10 Other
- **2. Structure**
  - 2.1 Foundation
  - 2.2 Superstructure
- **3. Exterior Enclosure**
  - 3.1 Grade Enclosure
    - 3.1.1 Floor on Grade
    - 3.1.2 Floor over Air Space
    - 3.1.3 Other
  - 3.2 Vertical and Sloped Enclosure
    - 3.2.1 Walls
    - 3.2.2 Windows
    - 3.2.3 Doors
    - 3.2.4 Other (e.g., railings, louvers, screens, etc.)
  - 3.3 Roofs
    - 3.3.1 Roof Coverings
    - 3.3.2 Skylights
    - 3.3.3 Other Roof Openings
  - 3.4 Joint Sealants
- **4. Interior Space Division**
  - 4.1 Vertical Space Dividers
    - 4.1.1 Partitions
    - 4.1.2 Doors
    - 4.1.3 Other
  - 4.2 Horizontal Space Dividers
    - 4.2.1 Floors
    - 4.2.2 Ceilings
    - 4.2.3 Floor/Ceiling Openings
    - 4.2.4 Other
  - 4.3 Stairs and Ramps
- **5. Plumbing**
  - 5.1 Plumbing Fixtures
  - 5.2 Domestic Water Distribution
  - 5.3 Sanitary Waste
  - 5.4 Rain Water Drainage
- **6. HVAC**
  - 6.1 Heating
    - 6.1.1 Heating Generation
    - 6.1.2 Heating Distribution
    - 6.1.3 Heating Terminal and Package Units
    - 6.1.4 Heating Controls and Instrumentation
  - 6.2 Cooling

FIG. 2 Hierarchy of Building Elements Included in the Series of Performance Standards

6.2.1 Cooling Generation
6.2.2 Cooling Distribution
6.2.3 Cooling Terminal and Package Units
6.2.4 Cooling Controls and Instrumentation
6.3 Ventilation
6.3.1 Ventilation Distribution
6.3.2 Ventilation Terminal and Package Units
6.3.4 Ventilation Controls and Instrumentation
7. Fire Protection Subsystems
7.1 Suppression
7.2 Detection
7.3 Notification
7.4 Fire Protection Specialties
8. Electrical Network
8.1 Electrical Service and Distribution
8.2 Lighting and Branch Wiring
9. Communication and Security Networks
9.1 Telephone
9.2 Intercom
9.3 Television
9.4 Security
9.5 Other
10. Fuel Networks
10.1 Gas
10.2 Oil
10.3 Other
11. Fittings, Furnishings and Equipment

FIG. 2 Hierarchy of Building Elements Included in the Series of Performance Standards *(continued)*

E2151 Terminology of Guides for Specifying and Evaluating Performance of Single Family Attached and Detached Dwellings
F925 Test Method for Resistance to Chemicals of Resilient Flooring
F1265 Test Method for Resistance to Impact for Resilient Floor Tile
G116 Practice for Conducting Wire-on-Bolt Test for Atmospheric Galvanic Corrosion
G149 Practice for Conducting the Washer Test for Atmospheric Galvanic Corrosion (Withdrawn 2004)[3]
G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
G152 Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
G153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

2.2 *American Architectural Manufacturers Association and Window and Door Manufacturers Association:*[4]
ANSI/AAMA/NWWDA 101/I.S. 2-97 Voluntary Specifications for Aluminum, Vinyl (PVC) And Wood Windows and Glass Doors
AAMA/WDMA 1600/I.S. 7-2000 Voluntary Specifications for Skylights
AAMA 910–93 Voluntary "Life Cycle" Specifications and Test Methods for Architectural Grade Windows and Sliding Glass Doors
AAMA 2603.8 Voluntary Performance Requirements and Test Procedures for Pigmented Organic Coatings. on Extruded Aluminum
AAMA 2604.2 Voluntary Specification for Residential Color Anodic Finishes
AAMA 2605.2 Voluntary Specification for High Performance Organic Coatings on Architectural Extrusion and Panels

[4] Available from Association for the Advancement of Medical Instrumentation (AAMI), 4301 N. Fairfax Dr., Suite 301, Arlington, VA 22203-1633, http://www.aami.org.

TABLE 1 Sections of this Practice Addressing Durability

Section Title	Section
Parameters Affecting Durability	5
Degradation Factors and Service Life	5.1
Site Considerations Affecting Durability	6
Site Design	6.1
Site Investigation Report	6.2
Special Evaluation Methods Used in Durability	7
Performance Statements (O-C-E-C)	8
Example of Minimum Service Lives for Typical Building Elements	X1
Examples of Special Evaluation Methods Used in Durability	X2
EM-1: General Evaluation Method for Durability of Materials and Elements	X2.1
EM-2: Evaluation Method for Determination of Resistance to Light Exposure	X2.2
EM-3: Determination of Resistance to Point Impact	X2.3
EM-4: Determination of Wash and Scrub Resistance	X2.4
EM-5: Determination of Scratch Resistance Rating with Pencil Hardness Test	X2.5
Examples of Durability Performance Statements	X3
Whole Building	X3.1
Spaces	X3.2
Structure	X3.3
Exterior Enclosure	X3.4
Interior Space Division	X3.5
Plumbing	X3.6
HVAC	X3.7
Fire Protection Subsystems	X3.8
Electrical Network	X3.9
Communication and Security Networks	X3.10
Fuel Networks	X3.11
Fittings, Furnishings, and Equipment	X3.12

AAMA 2606.1 Voluntary Guide Specifications and Inspection Methods for Integral Color Anodic Finishes for Architectural Aluminum

AAMA 2607.1 Voluntary Guide Specification and Inspection Methods for Clear Anodic Finishes for Architectural Aluminum

AAMA 2608.1 Voluntary Guide Specification and Inspection Methods for Electrolytically Deposited Color Anodic Finishes for Architectural Aluminum

AAMA 2611 Voluntary Standards for Anodized Architectural Aluminum

2.3 *American Concrete Institute:*[5]

ACI 318 Building Code Requirements for Reinforced Concrete, Part 3

ACI 530/ASCE 5/TMS 402 Building Code Requirements for Masonry Structures

2.4 *American Forest & Paper Association:*[6]

AF&PA Technical Report No. 7 The Permanent Wood Foundation System

2.5 *Asphalt Roofing Manufacturers Association (ARMA):*[7]

Residential Asphalt Roofing Manual

2.6 *Factory Mutual Research Corporation (FMRC):*[8]

FMRC 4450 Approval Standard for Class 1 Insulated Steel Deck Roofs

[5] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.

[6] Available from American Forest and Paper Association (AF&PA), 1111 19th St., NW, Suite 800, Washington, DC 20036, http://www.afandpa.org.

[7] Available from Asphalt Roofing Manufacturers Association (ARMA), Public Information Department, 750 National Press Building, 529 14th Street, NW, Washington, DC 20045, http://www.asphaltroofing.org.

[8] Available from Factory Mutual Research Corporation (FMRC), 1151 Boston-Providence Turnpike, PO Box 9102, Norwood, Massachusetts 02062.

FMRC 4470 Approval Standard for Class 1 Roof Covers

2.7 *International Council Code:*[9]

International Residential Code for One- and Two-Family Dwellings

2.8 *Underwriters Laboratories (UL):*[10]

UL 2218 Impact Resistance Testing of Prepared Roof Covering Material

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide refer to Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *commentary*—the fourth part of a performance statement, consisting of an informative narrative explaining aspects of the performance statement.

Discussion— A commentary may include one or more of the following: an explanation of how the objective relates to user needs in fields such as physiology, psychology, and culture or tradition; an explanation of how the criteria are established including guides for setting different levels of performance to meet various user needs; a discussion of the reliability of the evaluation method; and example solutions that are deemed to comply with the performance statement.

3.2.2 *criteria*—the second part of a performance statement, consisting of quantitative statements defining the level or range of performance necessary to meet an objective or, where such a level or range cannot be established, the units of measurement of the performance.

3.2.3 *detached dwelling*—a dwelling unit standing by itself.

3.2.4 *durability*—the capability of a building, assembly, component, product, or construction to maintain serviceability over at least a specified time.

3.2.5 *evaluation*—the third part of a performance statement, consisting of the method(s) of assessing conformance of the element being addressed to the criteria.

Discussion—The evaluation states the standards, inspection methods, review procedures, historical documentation, test methods, in-use performance, engineering analyses, models, or other means to be used in assessing whether or not a criterion has been satisfied.

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

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

3.2.8 *specifier*—the individual or organization using the standard guides to create specifications and ultimately accept dwelling designs, materials, products, components, subsystems, or buildings to be provided by providers.

3.2.9 *user need*—a statement of the activities and behavior to be carried out in relation to the dwelling by its residents, or other users, defined in terms of motor, kinetic, physiological, psychological, emotional, and other parameters of human behavior.

4. Significance and Use

4.1 This guide and the use of consensus performance standards for housing can significantly contribute to the removal of barriers to the acceptance of housing innovation in the global marketplace. This guide in conjunction with the balance of the set of standard guides, when complete, can also serve to improve communications between producers and consumers leading to enhanced quality and performance of housing.

4.2 This guide is not intended for use in specifying and evaluating residential construction other than single family attached and detached dwellings. Nevertheless, some performance statements may have application to assessing the durability of building materials, components, and systems used in other constructions.

4.3 Although this guide addresses site planning as it affects the durability of single family attached and detached dwellings, the site-planning issues considered are not to be construed as a comprehensive site specification.

4.4 This guide can be useful to managers of housing procurement projects, home builders, designers, product manufacturers, and evaluation services in addressing durability issues related to single family attached and detached dwellings. Such applications can require that the performance statement examples be written in mandatory language.

4.5 The performance statement examples given in this guide are intended to complement the durability requirements implied in prescriptive provisions of codes such as the International Residential Code for One- and Two-Family Dwellings (IRC).

4.6 *Limitations on Performance Prediction:*

4.6.1 The traditional approach to evaluating the durability in building materials, components, and systems has been related to specific materials, and their reaction over time to specific degradation factors. This is useful for establishing standards for the quality control and use of specific materials. However, it is not much help in making comparisons across a variety of traditional materials intended for the same use, in evaluating systems comprised of a number of specific materials (for example, walls), or in developing performance specifications and performance standards needed for innovative materials. Little research has considered the generic analysis of degradation factors acting upon building elements in residential application. Moreover, insufficient work has been done in the development of accelerated weathering tests in which the degradation processes simulate those occurring in practice. Also, much more material science studies of degradation mechanisms and rates are needed to form a strong foundation for performance prediction of building materials. For these reasons, the performance statements in this guide are examples

[9] Available from International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, http://www.iccsafe.org.

[10] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

and initial steps of an evolving process in developing performance standards for single family attached and detached dwellings. It is anticipated that, as this guide is applied to housing procurement projects and as more research into the subject of durability is carried out, the performance statement examples in this guide will change. Both providers and specifiers should consider the basis for modifications as performance statements are established.

4.6.2 General conformance to this guide is intended to provide reasonable assurance that the in-place materials, built elements, and service subsystems of attached and detached dwellings will be serviceable through their service lives. Conformance to the performance statement examples in Appendix X3 does not assure that the service-lives will be met. Many of the listed tests are empirical in nature, and often do not reflect the variety of exposure conditions to which a material may be subjected in different geographic locations. However, the tests can be useful in illustrating comparisons of the performance of competing materials and systems. Paragraph X2.1.2.3 suggests that Practice E632 be followed in developing service-life prediction data when little performance history is available for a material or system.

Table 2. Matrix of Typical Building Elements and Potential Degradation Factors

	User Factors												Weather Factors												Earth Factors			Other Factors					
		Operation/use	Point impact	Chemicals/Stains	Washing and Scrubbing	Abrasions	Thermal shock	Hot water exposure	Sunlight	Wind	Moisture including rain	Sand storms	Hail impact	Temperature maximum	Temperature minimum	Thermal shock	Water freeze-thaw	Moisture	Water	Chemicals	Vermin including termites	Bacteria and fungus	Frost (heaving)	Differential expansion	Corrosion	Chemical incompatibility	Physical incompatibility	Electrical current	Internal water/air pressure
1. SPACES																																	
	Entries																																
	Living spaces																																
	Dining spaces																																
	Kitchens																																
	Sleeping spaces																																
	Bathrooms																																
	Water closet																																
	Outdoor living spaces																																
	Storage spaces																																
	Other																																
2. STRUCTURE																																	
	Foundation								○	○	○	○	○	○	○	○	○		○	○	○	○											
	Superstructure								○	○	○	○	○	○	○	○	○		○	○	○												
3. EXTERIOR ENCLOSURE																																	
	Grade Enclosure	Floor on grade	○	●	●	○	○	○	●											○	○	○	○	○		○	○	○	●				
		Floor over air space	○	●	●	○	○	○	●											○	○	○	○	○		○	○	○	●				
		Other	○	●	●	○	○	○	●											○	○	○	○	○		○	○	○	●				
	Vertical and Sloped Enclosure	Walls	○	●	●	○	○	○	●	●	○	○	○	●	●	●	○	○		○	○	○	○	○	○	●	○	○	●				
		Windows	●	●	●	○	○	○	●	●	○	○	●	●	●	●	○	○		○	○	○	○	○	○	●	○	○	●				
		Doors	●	●	●	○	○	○	●	●	○	○	●	●	●	●	●	○		○	○	○	○	○	○	●	○	○	●				
		Other	○	●	●	○	○	○	●	●	○	○	●	●	●	●	○	○		○	○	○	○	○	○	●	○	○	●				
	Roofs	Roof coverings	○	●		○	○	○	●	●	○	○	●	●	●	○	○			○		○			○	●	○	○	●				
		Skylights	○	●		○	○	○	●	●	○	○	●	●	●	○	○			○		○			○	●	○	○	●				
		Other roof openings	○	●		○	○	○	●	●	○	○	●	●	●	○	○			○		○			○	●	○	○	●				
	Joint Sealants		○	○				○	○		○		○	○	○	○	○			○		○			○	●	○	○	●				
4. INTERIOR SPACE DIVISION																																	
	Vertical Space Dividers	Partitions	○	●	●	●	○	○	●													○	○			○	○	○	○				
		Doors	○	●	●	●	○	○	●													○	○			○	○	○	○				
		Other	○	○	●	○	○	○	●													○	○			○	○	○	○				
	Horizontal Space Dividers	Floors	○	●		●	○	○	●													○	○			○	○	○	○				
		Ceilings	○	○		○		○																		○		○	○				
		Floor/ceiling openings	○	○																		○	○										
		Other	○	○	●	○				●												○	○			○	○	○	○				
	Stairs and Ramps																																
5. PLUMBING																																	
	Plumbing Fixtures		○	●	●	●	○		●									○								●							
	Domestic Water Distribution		○	●	●	●	○		●								○									○	●	○					
	Sanitary Waste		○	●	●	●	○	○	●		○	○	○	○	○	●										○	●	○					
	Rain Water Drainage		○	○	○	○	○	○		●	○	○	○	○	○											○	○	○					
6. HVAC																																	
	Heating					●	●	●		●																			●				
	Cooling					●	●	●		●																			●				
	Ventilation					●	●	●		●																			●				
7. FIRE PROTECTION SUBSYSTEMS																		○															
				●	●	●	○	○		●																○	●	○					

8. ELECTRICAL NETWORK																																	
Electrical Service and Distribution				●	●	●					●																						
Lighting and Branch Wiring			●		●																								●				
9. COMMUNICATION AND SECURITY NETWORKS																																	
Telephone			●	●	●	●					●																		●				
Intercom			●	●	●	●					●																		●				
Television			●	●	●	●					●																		●				
Security			●	●	●	●					●																		●				
Other			●	●	●	●					●																		●				
10. FUEL NETWORKS																																	
																																	●
11. FITTINGS, FURNISHINGS, AND EQUIPMENT																																	
									●																				●				

○ indicates that the illustrative performance statement includes general criteria and evaluation methods.

● indicates that the illustrative performance statement includes specific criteria and evaluation methods.

5. Parameters Affecting Durability

5.1 *Degradation Factors and Service Life:*

5.1.1 *Interaction of Degradation Factors and Building Elements.* Table 1 is a matrix displaying the interaction of degradation factors affecting service life of building elements. The table is not all inclusive; the specifier can add other degradation factors (for example, specific pollutants) as warranted. Also, the specifier can delete degradation factors that are not applicable (for example, sandstorms, hail, and corrosion) in developing specific performance statements. In Table 1, every intercept with a "dot" has one or more examples of performance statements associated with it. An unfilled dot (designated by "o" in Table 1) indicates an example of a performance statement having general criteria and evaluation methods (EM-1 in Appendix X2) in terms of resistance to degradation factors over the service life. A filled dot (designated by "·" in Table 1) indicates a performance statement example having specific criteria and evaluation methods.

5.1.2 *Environmental Factors.* Durability requirements specify the resistance of building elements to the effects of a variety of user factors and environmental factors (that is, weather and earth factors) to which they may be subjected over their service-life. The environmental factors may vary as a function of geographic location and, in some cases, this variation may occur at the micro scale. For example, the effects of airborne salts and other chemicals on a dwelling depends on its location in relation to roads, airports, industrial sources of air pollution and local wind patterns. If such specific information on weather factors is available for a specific dwelling project, the specifier should make it available to providers.

5.2 *Anticipated Minimum Service Life:*

5.2.1 Specifiers of durability need, by definition, to consider the minimum acceptable, anticipated service lives of the products, components, assemblies, and subsystems for which performance specifications are developed. Information on the anticipated service life of the specific materials, products, components, assemblies, and subsystems proposed by providers in response to performance specifications is also needed. Table is provided to assist specifiers in the consideration of minimum acceptable, anticipated service lives necessary for the development of performance specifications of durability. Table includes a list of typical building elements that are organized by subsystems 2 through 11 of the Hierarchy of Building Elements presented in Figure 2. Specifiers should add to or select from this list of building elements depending on the scope of the performance specification they are developing, and then complete Table with the minimum anticipated service lives that they will accept. These minimum anticipated service lives may be based on the specifiers' knowledge and needs for the housing, user expectations, and life-cycle cost analysis, where the relationship between first cost and cost of renewal provides the basis for establishment of minimum service life. Practice E917 provides a protocol for measuring life-cycle costs of buildings and building systems.

5.2.2 Examples of anticipated minimum service lives for various building elements are given in Appendix X1. These examples are based on professional judgment of user expectations for minimal acceptable conventional construction in the U.S., which may be permanent or temporary, with normal maintenance activities. Note in Table X1.1 that a range of service lives is given for each building element. The ranges reflect experience that the service life of a given building element varies depending upon a number of factors including the type of material from which the product is manufactured, the manufacturing process, the service environment, and maintenance conducted over the service life.

6. Site Considerations Affecting Durability

6.1 *Site Design:*

6.1.1 There are many conditions specific to a building site that can have a significant effect on the durability of building materials, products, components, assemblies, and subsystems. This section addresses information that should be considered to protect a dwelling from surface and subsurface environmental degradation factors that can adversely affect the durability of the building materials, products, components, assemblies, and subsystems.

6.1.2 The specifier should provide information in the form of site design and site-building interface design of sufficient detail for providers to design the protection of the buildings against surface and subsurface environmental degradation factors such as water, chemicals and salts, and temperatures from the ground.

6.1.3 Alternatively the specifier may choose to make housing providers responsible for the design of site and building methods to protect buildings against water, chemicals and salts, and temperature from the ground. If so, each provider should determine, in the site design, the methods used on the site for protection. Additionally, each provider should determine, in the building design interfaces, the methods to be used in the buildings to protect them against surface and subsurface environmental degradation factors such as water, chemicals and salts, and temperature from the ground. In such cases, the specifier should provide site planning performance criteria.

6.2 *Site Investigation Report:*

6.2.1 A site investigation report for the protection of buildings against surface and subsurface environmental degradation factors such as water, chemicals and salts, and temperature from the ground should be prepared by the specifier or provider. The following information is generally included:

6.2.1.1 Maximum flood levels with a specified year recurrence interval.

6.2.1.2 Maximum precipitation with a specified year recurrence interval.

6.2.1.3 Maximum depth below grade of frost penetration with a specified year recurrence interval.

6.2.2 For the protection of buildings against water, chemicals and salts, and temperature the report generally correlates the site information of 6.2.1 in the following three areas of site and building design:

6.2.2.1 Site.

6.2.2.2 Site-building interface.

6.2.2.3 Building systems.

Table 3. Anticipated Minimum Service Life of Typical Building Elements

Building Element			Required Minimum Service Life years
STRUCTURE			
	Foundation	Single-family housing	
	Superstructure	Single-family housing	
EXTERIOR ENCLOSURE			
	Grade Enclosure	Floor on grade	
	Vertical and Sloped Enclosure	Walls	
		Wall finish — easily renewable	
		Wall finish — difficult to renew	
		Doors	
		Windows	
		Door and window finish — easily renewable	
	Roofs	Roof Covering	
		Skylights	
	Joint Sealants		
INTERIOR SPACE DIVISION			
	Vertical Space Dividers	Partitions	
		Partition surface finishes — easily renewable	
		Partition surface finishes — difficult to renew	
		Doors	
		Doors — easily renewable door paint	
	Horizontal Space Dividers	Floor surfaces — bath and w.c.	
		Floor surfaces — other	
		Ceiling surfaces — private spaces; easily renewable	
		Ceiling surfaces — private spaces; difficult to renew	
	Stairs and Ramps	Stair surfaces — private spaces	
PLUMBING			
	Piping	Accessible	
		Inaccessible	
	Fixtures		
	Fixture Trim		
	Hot Water Heater		
HVAC			
	Fuel pump		
	Pipes	Accessible	
		Inaccessible	
	Radiators		
	Fan Coil Units		
	Pumps		
	Boilers		
	Mechanical Refrigeration	Machines	
	Evaporative Coolers		
	Furnaces		
	Duct Work	Accessible	
		Inaccessible	
	Louvers		
	Thermostats		
	Exhaust Fans		
FIRE PROTECTION SUBSYSTEMS			
ELECTRICAL NETWOR			
	Conductors	Accessible	
		Inaccessible	
	Conduit		
	Exposed Raceways		
	Switches		
	Sockets		
	Overcurrent Protection	Circuit breaker	
	Panels		
	Switch Board		
	Light Fixtures		
COMMUNICATION AND SECURITY NETWORKS			
	Television Antenna		
FUEL NETWORKS			
	Fuel Storage	Above ground	
		Below ground	
	Fuel Supply Piping	Accessible	
		Inaccessible	
FITTINGS, FURNISHINGS AND EQUIPMENT			
	Furnishings	Built-in furnishings	
		Built-in furnishing surfaces — easily renewable	

6.2.3 The presentation of information in both graphic and written form should be based on the proposed site design topography and elevations (provided by the specifier or the provider) and the proposed design locations, positions, configurations, and elevations of buildings near, at and below ground.

6.2.4 Site designs for the protection of buildings against surface and subsurface environmental degradation factors can be used to determine the performance required at the site-building interface. The site investigation report should show the effect of specific site design considerations that can have a significant effect on the durability of building materials and systems. The site investigation report should address the anticipated flood level, precipitation level, water table and frost penetration level adjacent to buildings. The site design might include:

6.2.4.1 The reduction by diversion, ponding or other means of surface water runoff entering ground adjacent to buildings.

6.2.4.2 The reduction of subsurface water entering ground adjacent to buildings by the provision of subsurface drainage, either by pumping or by gravity, at site structures, at paved areas and at other site areas where the ground is or may be water-logged.

6.2.5 Site-building interface designs for the protection of buildings against surface and subsurface environmental degradation factors can be used to determine the performance required of the building and building systems. The designs may show the effect of anticipated flood level, precipitation level, water table level and frost penetration level at buildings. The site design might include:

6.2.5.1 The reduction by diversion or other means of surface water run-off entering ground at and around the envelope or the foundation of buildings.

6.2.5.2 The reduction of subsurface water entering ground around the envelope or the foundation of buildings by the provision of subsurface drainage, either by pumping or gravity, at the envelope or the foundation, or by other approved means.

6.2.5.3 The reduction of subsurface water entering ground under the floors or the foundation of buildings by the provision of subsurface drainage, either by pumping or gravity, or other approved means, at floors and foundations.

6.3 Building designs for the protection of buildings against surface and subsurface environmental degradation factors such as water, chemicals and salts, and temperatures should clearly show the methods used to provide adequate protection from environmental conditions that can have a significant effect on the durability of building materials, products, components, assemblies, and subsystems.

7. Special Evaluation Methods Used in Durability

7.1 Conformance of building materials, products, components, assemblies, and subsystems to many of the durability criteria examples provided in this guide may be determined by common evaluation methods. Examples of such evaluation methods (designated EM-1 through EM-5) that may be used to evaluate durability are given in Appendix X2. These evaluation methods are based on considerations of the most common types of user and environmental degradation factors to be encountered in practice. These five special evaluation methods are cited in some of the performance statement examples given in Appendix X3. In some cases, the examples of special evaluation methods are simplified versions of published standard test methods. A reason for not specifying the standard test methods is that they were generally developed for specific materials and, consequently, their direct application to the variety of materials and products covered by this guide is precluded. Additionally, the scope of these standard methods may limit their use to laboratory testing. In contrast, this guide allows several evaluation methods to be performed in both the laboratory and field, enabling the specifier, if warranted, to require field testing for durability in providers' test plans. The specifier is cautioned to check the appropriateness of evaluation methods before adding them to specifications.

8. Performance Statements (O-C-E-C)

8.1 Examples of performance statements for building materials, products, components, assemblies, and subsystems are given in Appendix X3 in O-C-E-C format. The objectives are based on considerations of normally encountered user, weather, earth, and other degradation factors (Table 1) which may reduce service life. In many evaluation methods, it is necessary to use test conditions more severe than those normally encountered by the product or system in practice to obtain useful results in a reasonable period of time. The performance statement examples in Appendix X3 provide examples to specifiers and providers in the development of performance specifications for the durability of building materials, products, components, assemblies, and subsystems for single-family attached and detached dwellings.

8.2 While the resistance of particular degradation factor for a specified service life is a valid performance criterion, it is often difficult to evaluate when the factors affecting performance are complex and interactive, or when accelerated test methods have not been developed. Where examples of criteria and test methods are given in Appendix X3, professional judgment has been used in determining that the particular criteria and test methods adequately simulate the anticipated degradation factors and their effects over the specified service life. Providers may suggest modifications to the criteria and test methods, especially if they can give adequate historic documentation that the anticipated degradation factors can be resisted for the service life, or that different criteria and test methods provide a better simulation of these degradation factors and their effects over the service life.

8.3 *The Hierarchy of Building Elements:*

8.3.1 The example performance statements given in Appendix X3 are presented against the Hierarchy of Building Elements tabulated in Figure 2. The order of presentation begins with "0. Whole Building System" followed in order by each of the 11 subsystems. Within each subsystem, the example performance statements follow in order down to the lowest levels of the hierarchy as needed. For example, the performance statements for subsystem "3. Exterior Enclosure" are followed by "3.1 Grade Enclosure", followed by "3.1.1 Floor on Grade" and lower if necessary, then followed by

"3.1.2 Floor over Air Space" and lower if necessary, "3.1.3 Other," "3.2 Vertical and Sloped Enclosure," and so forth.

8.3.2 To some extent the Hierarchy of Building Elements reflects the structure of the housing industry, and therefore, the organization of the provider teams. For example, a home-builder or developer is likely to be the systems integrator responsible for "0. Whole Building System." The provider teams may include separate subcontractors for "2.1 Foundation,"" 2.2 Superstructure," "5. Plumbing," "6. HVAC," and so forth, and separate suppliers for components such as "3.2.2 Windows,"" 4.1.2 Doors," "3.4 Joint Sealant," "5.1 Plumbing Fixtures," and so forth.

8.3.3 The Evaluation part of the performance statements includes the identification of information (for example, drawings, samples, test reports, and so forth) to be submitted by providers to document compliance with the criteria. The responsibility for making available this information rests with the provider. For performance statements at higher levels of the Hierarchy of Building Elements such as "0. Whole Building System," the technical information documenting compliance must be provided by the systems integrator. The systems integrator may assemble portions of this information from other members of the provider's team, such as subcontractors or suppliers. In some cases, the systems integrator may develop a performance specification for one or more products, components, or assemblies at lower levels of the Hierarchy of Building Elements in order to obtain this information.

8.3.4 For performance statements at lower levels of the Hierarchy of Building Elements, the information documenting compliance may be provided directly by a subcontractor or supplier member of the provider's team. For example, tests that are part of a performance statement for "3.2.2 Windows" will likely be carried out and reported by the window manufacturer or supplier.

9. Keywords

9.1 building materials and systems; durability; dwelling; performance criteria; single-family

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE OF MINIMUM SERVICE LIVES FOR TYPICAL BUILDING ELEMENTS

X1.1 This Appendix provides examples of anticipated minimum service lives for typical building elements. See Table X1.1. The example complements Table given in the main text of this guide.

X1.2 The examples are based on professional judgement of the members of ASTM Subcommittee E06.66 for minimal acceptable conventional construction in the U.S., which may be permanent or temporary, with normal maintenance activities.

Table X1-1. Examples of Minimum Anticipated Service Lives of Typical Building Elements

Building Element		Minimum Anticipated Service Life years
STRUCTURE		
Foundation	Single-family housing	20 — 60
Superstructure	Single-family housing	20 — 60
EXTERIOR ENCLOSURE		
Grade Enclosure	Floor on grade	20 — 40
Vertical and Sloped Enclosure	Walls	20 — 40
	Wall finish — easily renewable	4 — 10
	Wall finish — difficult to renew	20 — 60
	Doors	20 — 25
	Windows	20 — 25
	Door and window finish — easily renewable	3 — 10
Roofs	Roof Covering	12 — 25
	Skylights	15 — 25
Joint Sealants		3 — 10
INTERIOR SPACE DIVISION		
Vertical Space Dividers	Partitions	20 — 40
	Partition surface finishes — easily renewable	3 — 10
	Partition surface finishes — difficult to renew	15 — 25
	Doors	15 — 35
	Doors — easily renewable door paint	3 — 10
Horizontal Space Dividers	Floor surfaces — bath and w.c.	4 — 20
	Floor surfaces — other	3 — 20
	Ceiling surfaces — private spaces; easily renewable	3 — 10
	Ceiling surfaces — private spaces; difficult to renew	15 — 25
Stairs and Ramps	Stair surfaces — private spaces	3 — 15
PLUMBING		
Piping	Accessible	15 — 30
	Inaccessible	20 — 40
Fixtures		15 — 25
Fixture Trim		5 — 15
Hot Water Heater		5 — 15
HVAC		
Fuel pump		10 — 15
Pipes	Accessible	10 — 20
	Inaccessible	20 — 40
Radiators		15 — 40
Fan Coil Units		15 — 20
Pumps		10 — 15
Boilers		10 — 20
Mechanical Refrigeration	Machines	15 — 20
Evaporative Coolers		8 — 15
Furnaces		15 — 20
Duct Work	Accessible	20 — 40
	Inaccessible	20 — 25
Louvers		5 — 40
Thermostats		5 — 15
Exhaust Fans		5 — 15
FIRE PROTECTION SUBSYSTEMS		
		5 — 30
ELECTRICAL NETWOR		
Conductors	Accessible	20 — 25
	Inaccessible	20 — 40
Conduit		20 — 40
Exposed Raceways		15 — 40
Switches		5 — 15
Sockets		5 — 15
Overcurrent Protection	Circuit breaker	5 — 20
Panels		20 — 40
Switch Board		20 — 40
Light Fixtures		5 — 15
COMMUNICATION AND SECURITY NETWORKS		
Television Antenna		5 — 20
FUEL NETWORKS		
Fuel Storage	Above ground	10 — 20
	Below ground	20 — 30
Fuel Supply Piping	Accessible	20 — 30
	Inaccessible	20 — 40
FITTINGS, FURNISHINGS AND EQUIPMENT		
Furnishings	Built-in furnishings	5 — 20
	Built-in furnishing surfaces — easily renewable	5 — 10

X2. EXAMPLES OF SPECIAL EVALUATION METHODS USED IN DURABILITY

X2.1 *EM-1: General Evaluation Method for Durability of Materials and Elements.* In addition to specific durability criteria, this Guide includes objectives and criteria for materials and elements to resist a range of degradation factors (Table 1) to which they may be subjected over their service lives (Table). In the absence of detailed analysis of the interactions of each degradation factor and every material or element (in which case, a simulative physical test method may be specified), the following methods of evaluation are available:

X2.1.1 If the material, element, or method of installation proposed by the provider have a significant history of successful use in conditions with intensity of degradation factors equal to or greater than those anticipated in the project region, the providers may make available documentation of their use indicating probable success for the specified service lives.

X2.1.2 If the particular material, element, or method of installation proposed is innovative, or if it has no significant history of use in the presence of the specific intensities of degradation factors anticipated in the project region, the providers may make available one of the following:

X2.1.2.1 Documentation of favorable comparison of performance with the particular material, element, or method of installation with a history of adequate durability.

X2.1.2.2 Documentation of conformance to criteria and tests for durability of specific elements as established by applicable standards, if the provider can show that these tests indicate durability against anticipated degradation factors (see Table 1).

X2.1.2.3 Documentation of the results of simulation tests indicating the response of the product to the degradation factors in question; the proposed testing to document compliance of durability should be subject to approval of the specifier. This testing may be performed according to the provisions of Practice E632. The specifier should approve the extent of proposed testing under Practice E632 necessary to reach a decision on the durability of the building materials, products, components, assemblies, and subsystems.

X2.2 *EM-2: Evaluation Method for Determination of Resistance to Light Exposure.* Light exposure, both sunlight and internal light, may cause in color changes or fading which may be aesthetically unacceptable. Additionally, sunlight exposure may result in chemical deterioration. In assessing and comparing the effect of light exposure on materials, it is important that as many variables as possible be kept constant. Several types of apparatus, designed to remove the effects of seasonal and annual variation in sunlight, accelerate the deleterious effects of sunlight and, thus, reduce the required test period.

X2.2.1 Testing of materials for resistance to light may be done following the procedure described in Practice G151, using apparatus meeting the requirements of Practices G154 or G155. Other apparatus that may be considered, subject to the approval of the specifier, are described in Practices G152 and G153.

X2.3 *EM-3: Determination of Resistance to Point Impact.* Some elements in a dwelling will be subjected to accidental mistreatment upon their surfaces. Impacts which cover a significant area and are of a scale such that the integrity of all or part of a partition or other element may be damaged, are beyond the scope of this durability guide which deals only with cases where impacts on surfaces are on a limited area and the primary effect is damage to the surface itself.

X2.3.1 A prescribed impactor (for example, ball or weight), may be held at a selected distance and allowed to drop onto the test specimen. Subject each surface type to sufficient drops at randomly selected locations to adequately determine performance. Materials should be either rigidly mounted or mounted in the most rigid manner in which they are to be installed in the dwelling. A pendulum device can be used if surfaces are to be tested vertically.

X2.3.2 Surfaces may be inspected before and after testing in direct and reflected light to detect damage.

X2.3.3 Methods D256, D2444, D3746, D4226, D4812, D5420, D6110, E695, E822, E2025 and F1265 are examples of impact tests that may be considered by users of this set of standard guides.

X2.4 *EM-4: Determination of Wash and Scrub Resistance.* During occupancy, many exposed surfaces will need cleaning and these surfaces should not be harmed by normal cleaning practices. When comparing materials with regard to wash and scrub resistance, it is important that all of the variables present in the process be set constant. Although various countries have tests including apparatus which standardize these variables, these tests are themselves not comparable to one another, nor are their results necessarily related in any mathematically consistent way. For this reason, an acceptable test method which includes a specific apparatus is given as an example. Other test methods and apparatus which provide an adequate comparison between the performance of innovative materials with conventional materials may be selected by the specifier. In these cases, cleaning agents should be used according to manufacturers' instructions.

X2.4.1 The following is an example of an acceptable test procedure for wash and scrub resistance using an apparatus meeting the requirements of Method D2486. The test variables may be changed, subject to the approval of the specifier, based on anticipated user degradation factors.

X2.4.1.1 Immerse the brush bristles in water at 25 to 30° C (77 to 86 °F) for 30 minutes at a depth of 13 mm (0.5 in.). Shake the brush vigorously several times to remove "free" water and then soak an additional 4 minutes in a 5 per cent tri-sodium phosphate solution made with distilled water. Mount the test panel firmly on the washability apparatus; place the saturated brush on the specimen surface and start the motor. Allow the brush to travel at a rate of 37 ± 2 cycles (74 separate strokes ± 4 strokes) per minute.

X2.4.1.2 During the test permit additional tri-sodium phosphate solution to drop or run into the path of the brush at a rate

of about 12 drops per minute, or just sufficient to keep the panel wet. Remove the panel at the end of number of cycles specified; wash immediately in water at moderate temperature and inspect the surface within the middle 150 mm (6 in.) of brush travel by both reflected and transmitted light from the specified distances.

X2.5 *EM-5: Determination of Scratch Resistance Rating with Pencil Hardness Test.* Scratches in exposed surfaces may possibly contribute to accelerated degradation. Therefore, the scratch resistance of exposed surfaces of innovative materials may be tested and compared with the resistance of commonly used materials.

X2.5.1 The pencil test, based on Method D3363, is an example of an acceptable procedure for determining scratch resistance. Although developed for organic coatings, this pencil test is a straightforward and rapid method that might be adopted to evaluate the scratch resistance of building materials. The basis for this test lies in use of draftsman's pencils which are graduated carefully over a wide range of hardness of the lead. The lead of a pencil is a carefully compounded blend of graphite and clay with a resinous binder, an increased proportion of clay, increasing the hardness of the lead. Precautions are taken by pencil manufacturers to insure uniformity of hardness in each degree or grade. Draftsman's pencils are produced by most manufacturers in 17 grades, ranging from "9H" (hardest) to "6B" (softest). One manufacturer adds a "7B", making 18 grades. With such a range of graduated and controlled hardness standards available, and despite variation between pencil manufacturers, a hardness may be assigned to a surface in relation to these pencil hardness designations. If the pencil point is applied to the surface in a writing position and pushed forward to mark the surface, the pencil will scratch or mar the surface, or the surface will remain intact and crush the graphite of the pencil. When the hardness of the graphite and of the surface are at a parity—when the pencil does not mar the surface but the next harder grade does the hardness of the surface has been established.

X3. EXAMPLES OF DURABILITY PERFORMANCE STATEMENTS

X3.1 *Whole Building:*

X3.1.1 *Performance Statements Applicable to All Building Elements and Assemblies:*

X3.1.1.1 *General Durability of Materials*—See Fig. X3.1.

X3.1.1.2 *Deterioration Due to Differential Expansion*—See Fig. X3.2.

X3.1.1.3 *Deterioration Due to Galvanic Corrosion*—See Fig. X3.3.

X3.1.1.4 *Deterioration Due to Incompatibility with Chemicals*—See Fig. X3.4.

X3.1.1.5 *Deterioration Due to Physical Incompatibility*—See Fig. X3.5.

X3.1.2 *Criteria Applicable to Specific Groups of Building Elements:*

X3.1.2.1 *Durability of the Building Envelope and Foundation Against Ground Water*—See Fig. X3.6.

X3.1.2.2 *General Durability of Distribution Networks*—See Fig. X3.7.

NOTE X3.1—Numbers in parentheses in Fig. X3.6 and Fig. X3.7 refer to the Hierarchy of Building Elements given in Fig. 2.

X3.2 *Spaces:*

X3.2.1 *Durability of Elements in Building Spaces:*

X3.2.1.1 Elements in interior spaces should be designed and constructed to withstand the degradation factors that are likely to be encountered over their service lives in two ways. First, there are the degradation factors encountered by similar, identified elements and, second, there are degradation factors specific to the element itself. Users of this set of standard guides should refer to specific applicable performance statements for the respective similar elements. An example is the case of exposed overhead ducts in private spaces. Such ducts should meet all criteria for ceilings in private spaces as well as criteria for ductwork.

X3.3 *Structure:*

X3.3.1 *General Durability of Structural Elements (Foundations and Superstructures)*—See Fig. X3.8.

X3.3.2 *Durability of Foundations Against Ground Water*—See X3.1.2.1.

X3.4 *Exterior Enclosure:*

X3.4.1 *General Considerations:*

X3.4.1.1 *General Durability of the Exterior Enclosure*—See Fig. X3.9.

X3.4.1.2 *Durability of the Exterior Enclosure Against Specific Degradation Factors*—See Fig. X3.10.

X3.4.1.3 *Resistance of Exterior Enclosure to Effects of Temperature, and Freezing and Thawing Factors*— See Fig X3.11.

X3.4.1.4 *Durability of Exterior Enclosure Against Ground Water*—See X3.1.2.1.

X3.4.2 *Grade Enclosure.* See X3.1.2.1 and X3.5.1. This building element is not specifically addressed in this guide.

X3.4.3 *Exterior Walls, Windows and Doors:*

X3.4.3.1 *Durability of Windows and Resistance Doors—Mechanical Resistance*—See Fig. X 3.12.

X3.4.3.2 *Durability of Windows and Resistance Doors—Weather Resistance*—See Fig. X3.13.

X3.4.3.3 *Durability of Window and Door Glazing*—See Fig. X3.14.

X3.4.4 *Roofs:*

X3.4.4.1 *Durability of Roof Coverings*— See Fig. X3.15.

X3.4.4.2 *Durability of Skylights and Roof Windows*—See Fig. 3.16.

X3.4.5 *Durability of Joints and Joint Sealants*—See Fig. X3.17.

X3.5 *Interior Space Division:*

X3.5.1 *General Considerations:*

X3.5.1.1 *General Durability of Interior Space Dividers*—See Fig. X3.18.

X3.5.1.2 *Durability of Space Dividers Against Specific Degradation Factors*—See Fig. X3.19.

X3.5.2 *Partitions:*

X3.5.2.1 *Wall Base Resistance to Floor Washing*—See Fig. X3.20.

X3.6 *Plumbing:*

X3.6.1 *General Considerations for Plumbing Networks:*

X3.6.1.1 *Durability of Surfaces of Plumbing Network Elements*—See Fig. X3.21.

X3.6.1.2 *Durability of Plumbing Network Piping Against Normal Wear and Tear*—See Fig. X3.22.

X3.6.1.3 *Durability of Plumbing Network Against Freezing Exposure*—See Fig. X3.23.

X3.6.1.4 *Durability of Plumbing Network Piping Against Internal Pressure*—See Fig. X3.24.

X3.6.1.5 *Durability of Plumbing Network Piping and Fixtures Against Hot Water Exposure Pressure*—See Fig. X3.25.

X3.6.2 *Plumbing Fixtures.* Not addressed in this paragraph.

X3.6.3 *Domestic Water Distribution.* Not addressed in this paragraph.

X3.6.4 *Sanitary Waste:*

X3.6.4.1 *Durability of Drain, Waste, and Venting Piping Against Thermal Shock*—See Fig. X3.26.

X3.7 *HVAC:*

X3.7.1 *General Considerations:*

X3.7.1.1 *Durability of Surfaces of HVAC Network Elements Against Specific Degradation Factors*—See Fig. X 3.27.

X3.7.1.2 *Durability of HVAC Elements Against Internal Pressures*—See Fig. 3.28.

X3.7.2 *Heating:*

X3.7.2.1 *Durability of Heating Network Piping and Fittings Against Hot Water Exposure*—See Fig. X3.29.

X3.8 *Fire Protection Systems:*

X3.8.1 *General Considerations*— See Fig. X3.21 and Fig X3.23; the performance statements in those two figures may be applied to fire protection systems.

X3.8.1.1 *Durability of Fire Protection Systems Against Internal Pressure*—See Fig. X3.30.

X3.9 *Electrical:*

X3.9.1 *Electrical Service and Distribution:*

X3.9.1.1 *Durability of Surfaces of Electrical Network Elements Against Specific Degradation Factors*— See Fig. X3.31.

X3.9.2 *Lighting and Branch Wiring:*

X3.9.2.1 *Durability of Exterior Mounted Lighting Fixtures*—See Fig. X3.32.

X3.9.2.2 *Durability of Switches and Sockets Against Wear and Tear*—See Fig X3.33.

X3.10 *Communication and Security Systems.* Performance statements for communication and security systems are not directly addressed in this guide. Criteria and evaluation methods for such systems may be based on the performance statements given in Figs. X3.31–X3.33.

X3.11 *Fuel Networks:*

X3.11.1 *General Considerations:*

X3.11.1.1 *Durability of Fuel Network Against Internal Pressures*—See Fig. X3.34.

X3.12 *Fittings, Furnishings, and Equipment:*

X3.12.1 *Resistance of Kitchen and Bathroom Counters to Hot Water*—See Fig. X3.35.

X3.12.2 *Durability of Kitchen and Bathroom Surfaces Against Corrosion*—See Fig. X3.36.

Table X3-1. Matrix of Typical Distribution Networks and Potential Degradation Factors

	User Factors	Operation/use	Point impact	Chemicals/Stains	Washing and Scrubbing	Abrasions	Thermal shock	Hot water exposure	**Weather Factors**	Sunlight	Wind	Moisture including rain	Sand storms	Hail impact	Temperature maximum	Temperature minimum	Thermal shock	Water freeze-thaw	**Earth Factors**	Moisture	Water	Chemicals	Vermin including termites	Bacteria and fungus	Frost (heaving)	**Other Factors**	Differential expansion	Corrosion	Chemical incompatibility	Physical incompatibility	Electrical current	Internal water/air pressure
5. PLUMBING																																
Plumbing Fixtures		○	●	●	●	○		●										○										●				
Domestic Water Distribution		○	●	●	●	○		●		●								○									○	●	○	○		●
Sanitary Waste		○	●	●	●	○	○	●		●	○	○	○	○	○	○	●										○	●	○	○		●
Rain Water Drainage		○	○	○	○	○	○			●	○	○	○	○	○	○											○	○	○	○		○
6. HVAC																																
Heating			●	●	●			●		●																						●
Cooling			●	●	●					●																						●
Ventilation			●	●	●					●																						●
7. FIRE PROTECTION SUBSYSTEMS			●	●	●	○	○			●								○									○	●	○	○		●
8. ELECTRICAL NETWORK																																
Electrical Service and Distribution			●	●	●					●																						
Lighting and Branch Wiring		●		●																								●				
9. COMMUNICATION AND SECURITY NETWORKS																																
Telephone		●	●	●	●					●																		●				
Intercom		●	●	●	●					●																		●				
Television		●	●	●	●					●																		●				
Security		●	●	●	●					●																		●				
Other		●	●	●	●					●																		●				
10. FUEL NETWORKS																																●

○ indicates that the illustrative performance statement includes general criteria and evaluation methods.

● indicates that the illustrative performance statement includes specific criteria and evaluation methods.

Table X3-2. Matrix of Typical Structural Elements and Potential Degradation Factors

	User Factors	Operation/use	Point impact	Chemicals/Stains	Washing and Scrubbing	Abrasions	Thermal shock	Hot water exposure	**Weather Factors**	Sunlight	Wind	Moisture including rain	Sand storms	Hail impact	Temperature maximum	Temperature minimum	Thermal shock	Water freeze-thaw	**Earth Factors**	Moisture	Water	Chemicals	Vermin including termites	Bacteria and fungus	Frost (heaving)	**Other Factors**	Differential expansion	Corrosion	Chemical incompatibility	Physical incompatibility	Electrical current	Internal water/air pressure
2. STRUCTURE																																
Foundation										○	○	○	○	○	○	○	○	○		○	●	○	○	○								
Superstructure										○	○	○	○	○	○	○	○	○		○	●	○	○									

○ indicates that the illustrative performance statement includes general criteria and evaluation methods.

● indicates that the illustrative performance statement includes specific criteria and evaluation methods.

Table X3-3. Matrix of Typical Exterior Enclosure Elements and Potential Degradation Factors

		User Factors								Weather Factors												Earth Factors				Other Factors					
		Operation/use	Point impact	Chemicals/Stains	Washing and Scrubbing	Abrasions	Thermal shock	Hot water exposure	Sunlight	Wind	Moisture including rain	Sand storms	Hail impact	Temperature maximum	Temperature minimum	Thermal shock	Water freeze-thaw	Moisture	Water	Chemicals	Vermin including termites	Bacteria and fungus	Frost (heaving)	Differential expansion	Corrosion	Chemical incompatibility	Physical incompatibility	Electrical current	Internal water/air pressure
3. EXTERIOR ENCLOSURE																															
Grade Enclosure	Floor on grade		○	●	●	○	○	○										○	○	○	○	○	○	○	●	○	○		○
	Floor over air space		○	●	●	○	○	○	●									○		○	○	○		○	●	○	○		○
	Other		○	●	●	○	○	○	●										○	○	○	○	○	○	○	○	○		○
Vertical and Sloped Enclosure	Walls		○	●	●	○	○	○	●	●	○	○	●	●	●	○	●	○	○	○	○	○	○	○	○	●	○	○	○
	Windows		●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	○	○	○	○	○	○	○	○	●	○	○	○
	Doors		●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	○	○	○	○	○	○	○	○	●	○	○	○
	Other		○	●	●	○	○		●	●	○	○	●	●	●	○	○	○	○	○	○	○	○		○	●	○	○	○
Roofs	Roof coverings		○	●		○	○			●	○	○	●	●	●	○	○						○		○	●	○	○	○
	Skylights		○	●		○	○			●	○	○	●	●	●	○	○						○		○	●	○	○	○
	Other roof openings		○	●		○	○			●	○	○	●	●	●	○	○						○		○	●	○	○	○
Joint Sealants			○	○				○			○		○	○	○	○	○						○		○	○	○	○	○

○ indicates that the illustrative performance statement includes general criteria and evaluation methods.

● indicates that the illustrative performance statement includes specific criteria and evaluation methods.

Table X3-4. Matrix of Typical Interior Space Division and Potential Degradation Factors

		User Factors	Operation/use	Point impact	Chemicals/Stains	Washing and Scrubbing	Abrasions	Thermal shock	Hot water exposure	**Weather Factors**	Sunlight	Wind	Moisture including rain	Sand storms	Hail impact	Temperature maximum	Temperature minimum	Thermal shock	Water freeze-thaw	**Earth Factors**	Moisture	Water	Chemicals	Vermin including termites	Bacteria and fungus	Frost (heaving)	**Other Factors**	Differential expansion	Corrosion	Chemical incompatibility	Physical incompatibility	Electrical current	Internal water/air pressure
4. INTERIOR SPACE DIVISION																																	
Vertical Space Dividers	Partitions		○	●	●	●	○		○		●														○	○			○	○	○	○		
	Doors		○	●	●	●	○		○		●													○	○			○	○	○	○		
	Other		○	○	●	○	○		○		●													○	○			○	○	○	○		
Horizontal Space Dividers	Floors		○	●		●	○		○		●													○	○			○	○	○	○		
	Ceilings		○	○		○			○																			○		○	○		
	Floor/ceiling openings		○	○																					○								
	Other		○	○	●	○					●													○	○			○	○	○	○		
Stairs and Ramps																																	

○ indicates that the illustrative performance statement includes general criteria and evaluation methods.

● indicates that the illustrative performance statement includes specific criteria and evaluation methods.

TABLE X3.5 Substances for Determining Stain Resistance

	Floors, Walls, Doors, Counters		Floors and Doors
Substance	**Kitchens**	**Bathrooms**	**Other Spaces**
Cleaning Agents[1]	o	o	o[1,2]
Kerosene	o	o	
Isopropyl Alcohol		o	
Mineral Oil		o	o
Pencil			o
Cola Beverage	o		
Lipstick		o	
Ethyl Alcohol	o		o
Blood	o	o	o
Olive Oil	o		
Tea	o		o
Coffee	o		o
Lemon Juice	o		
Yogurt	o		
Mercurochrome	o	o	
5% Hydrogen Peroxide	o		

[1]Cleaning agents should be specified by the user of this set of standard guides as appropriate for the component and its anticipated use.
[2]Resistance to cleaning agents also required on walls of spaces other than kitchens and bathrooms.

TABLE X3.6 Chemical Solutions for Testing Durability of Surfaces of Plumbing Network Elements

Solution	% by Mass in Water
Alkyl-aryl sulfonate (for example, Oronite, Ultrawet, Nacconol)	5
Hydrochloric acid	5
Hydrogen peroxide	5
Sulfuric acid	3
Sodium carbonate	10
Sodium chloride	10
Sodium hydroxide	10
Sodium hypochlorite	5
Sodium perborate	5
Sodium acid sulfate	2

TABLE X3.7 Water Temperatures and Flow Rates for Testing Durability of Distribution Network Pipes and Fixtures

Pipe Diameter		Hot Water Flow Rate		Temperature	
mm	(in.)	L/min	(gal/min)	°C	(°F)
38	(1.5)	30	(8)	80	(176)
51	(2)	30	(8)	80	(176)
76	(3)	60	(16)	70	(158)
102	(4)	60	(16)	70	(158)
127	(5)	60	(16)	70	(158)
152	(6)	60	(16)	70	(158)

TABLE X3.8 Water Temperatures and Flow Rates for Testing Durability of Horizontally Supported Potable Hot Water Piping

Pipe Diameter		Hot Water Flow Rate		Temperature	
mm	(in.)	L/min	(gal/min)	°C	(°F)
19	(0.75)	15	(4)	80	(176)
25	(1)	20	(5)	80	(176)
32	(1.25)	25	(6.5)	80	(176)
38	(1.5)	30	(8)	80	(176)
51	(2)	35	(9)	80	(176)
64	(2.5)	40	(10)	70	(158)
76	(3)	45	(12)	70	(158)
102	(4)	50	(13)	70	(158)

TABLE X3.9 Water Temperatures and Flow Rates in Pipe Exposed to Low Ambient Air Temperature

Pipe Diameter		Hot Water Flow Rate		Temperature	
mm	(in.)	L/min	(gal/min)	°C	(°F)
38	(1.5)	30	(8)	80	(176)
51	(2)	30	(8)	80	(176)
76	(3)	60	(16)	70	(158)
102	(4)	60	(16)	70	(158)
127	(5)	60	(16)	70	(158)
152	(6)	60	(16)	70	(158)

TABLE X3.10 Water Temperatures and Flow Rates for Testing Durability of Heating Network Piping and Fittings

Pipe Diameter		Hot Water Flow Rate		Temperature	
mm	(in.)	L/min	(gal/min)	°C	(°F)
19	(0.75)	15	(4)	95	(203)
25	(1)	20	(5)	95	(203)
32	(1.25)	25	(6.5)	95	(203)
38	(1.5)	30	(8)	95	(203)
51	(2)	35	(9)	95	(203)
64	(2.5)	40	(10)	95	(203)
76	(3)	45	(12)	95	(203)
102	(4)	50	(13)	95	(203)

H — DURABILITY

0.1. WHOLE BUILDING SYSTEM—All Building Subsystems

A. General Durability of Materials

Objective		All materials of all building elements should be of a quality which performs satisfactorily for their service life.
Criteria	C-1:	Throughout their service life, all building elements and their materials, should perform as specified by the user of this set of standard guides, when subjected to the range of degradation factors given therein.
	C-2:	Throughout their service life, all materials which are exposed to view should age or weather in an aesthetically acceptable manner.
Evaluation Methods	E-1:	Observation/Physical test. EM-1
	E-2:	Observation/Physical test. EM-1
Commentary	•	The expected service life is set by the specifier for each of the building elements. Table X1-1 provides examples of ranges of minimum anticipated service lives of many common building elements.
	•	Several standard practices describe methods for evaluating color changes. For example, Method D1729 covers illumination, viewing conditions, and general procedures for evaluating color differences.

FIG. X3.1 General Durability of Materials for All Building Elements and Assemblies.

H — DURABILITY

0.1. WHOLE BUILDING SYSTEM—All Building Subsystems

B. Deterioration Due to Differential Expansion

Objective		Building elements and assemblies should not undergo appreciable deterioration throughout their service lives due to differential expansion.
Criterion	C-1:	Building elements and assemblies constructed of two or more materials which expand and contract at different rates due to thermal or other factors should be designed to resist or to allow for this difference in expansion and contraction such that the assemblies perform, as specified by the user of this set of standard guides, over their respective service-lives.
Evaluation Method	E-1:	Observation/Physical test. EM-1.
Commentary	•	The expected service life is set by the specifier for each of the building elements. Table X1-1 provides examples of minimum anticipated service lives of many typical building elements.

FIG. X3.2 Deterioration Due to Differential Expansion for All Building Elements and Assemblies

H — DURABILITY

0.1. WHOLE BUILDING SYSTEM—All Building Subsystems

C. Deterioration Due to Galvanic Corrosion

Objective		Metallic building elements and assemblies should not undergo appreciable deterioration throughout their service lives due to galvanic corrosion.
Criterion	C-1:	All metallic building elements and assemblies that are constructed of dissimilar metals that, when in contact, could cause galvanic corrosion during their service-lives should employ either a dielectric coupling or a suitable sacrifical anode between these metals.
Evaluation Method	E-1:	Observation/Computation/Physical test. EM-1. Providers may submit a schedule of all locations in the building where dissimilar metals are in contact or in close physical proximity. Where no use-history of the proposed dielectric coupling is available, the potential for galvanic corrosion may be analyzed by an appropriate test procedure such as Methods G116 or G149.
Commentary	•	"Appreciable deterioration" stated in the Objective denotes a level of deterioration that cannot be corrected during normal maintenance.

FIG. X3.3 Deterioration Due to Galvanic Corrosion for All Building Elements and Assemblies

H — DURABILITY

0.1. WHOLE BUILDING SYSTEM—All Building Subsystems

D. Deterioration Due to Incompatibility with Chemicals

Objective		Building elements and subsystems should not undergo appreciable deterioration throughout their service lives due to effects of chemicals including common salts.
Criterion	C-1:	All building elements and subsystems should be designed and constructed such that the effect of chemicals likely to act upon them during their service lives (including common salts contained in the earth and air), and the chemical effect of the building materials upon one another, should not, throughout the respective periods of their service-life, impair their performance.
Evaluation Method	E-1:	Observation/Computation/Physical Test. EM-1. Analysis and tests may simulate the chemical effects over the period of the design life, including the most severe, related environmental conditions of high chemical concentrations, and of high humidity and high temperature to which the building elements and subsystems are likely to be exposed.
Commentary	•	The expected service life is set by the specifier for each of the building elements. Table X1-1 provides examples of minimum anticipated service lives of many typical building elements.
	•	"Appreciable deterioration" stated in the Objective denotes a level of deterioration which cannot be corrected during normal maintenance.
	•	The test variables of the evaluation method should depend on the specific type and amounts of chemicals including common salts encountered. The chemical types and amounts need to be locally determined.
	•	Materials that contain salts are not a specific issue, unless such salts affect durability due to incompatibility, as demonstrated by EM-1.

FIG. X3.4 Deterioration Due to Incompatibility with Chemicals for All Building Elements and Assemblies

H — DURABILITY

0.1. WHOLE BUILDING SYSTEM—All Building Subsystems

E. Deterioration Due to Physical Incompatibility

Objective		Building elements and subsystems should not undergo appreciable deterioration throughout their service lives due to physical incompatibility.
Criterion	C-1:	All building elements and subsystems should be designed and constructed such that the physical effect of movement of the individual parts, subsystems, and systems due to general use, normal settlement, or other normal forces experienced by the building, should not, throughout the respective periods of their service lives, fatigue, abrade, crack or otherwise impair the performance of any element as specified by the user of this set of standard guides.
Evaluation Method	E-1:	Observation/Computation/Physical test. EM-1. Analysis and tests of elements and subsystems may simulate the effect on their connections over the period of their service lives. The most severe environmental and use conditions to which they are likely to be exposed are to be considered in the simulations.
Commentary		• "Appreciable deterioration" stated in the Objective denotes a level of deterioration which cannot be corrected during normal maintenance. • "Movement of the individual parts" refers to operability of moving parts.

FIG. X3.5 Deterioration Due to Physical Incompatibility for All Building Elements and Assemblies

H — DURABILITY

0.2. WHOLE BUILDING SYSTEM—Groups of Building Subsystems

A. Durability of the Exterior Enclosure (3.) and Foundation (2.1) Against Ground Water

Objective

All buildings should be sited and their foundations, walls and floors designed and constructed such that these building elements are protected from deterioration due to ground water.

Criterion

C-1: Foundations, walls, and floors should be protected against ground water deterioration by draining surface water from the house envelope, removing subsurface water from the vicinity of the envelope, installing water impervious membranes or water resistant construction, or a combination of these means.

Evaluation Methods

E-1a: Review of Plans. The specifier may review design plans for the construction to assure that adequate provisions against ground water deterioration are provided.

E-1b: Observation/Engineering Analysis. The provider may submit a site analysis report prepared by a geotechnical consultant (or equivalent professional). The report may include the following:

- Determination of the worst ground water table level for each building, as that level nearest the ground surface caused by any one or any combination of a specific recurrence level (e.g., 5 year) for floods, for precipitation and the water table level
- Determination, for the lowest floor of any space at or near ground, the distance below which the worst ground water table level must be if the water is not to exert a hydrostatic pressure in the envelope or floor
- Design recommendations from the geotechnical consultant.

Additionally, the provider may submit:

- Detailed site design and site-building interface design, if these are included in the provider's scope of work, to demonstrate compliance with the site investigation report and the geotechnical (or equivalent) consultant's design recommendations.
- Detailed drawings and specifications of exterior envelope and foundation elements, to demonstrate compliance with the site investigation report and the geotechnical consultant's design recommendations.

Commentary

- One method of compliance may be for the site surface at and adjacent to the building envelope to slope away and down from the envelope at not less than 1.5%, or at the value required by the specifier.
- Ground water may also be removed from the vicinity of, and from below, elements of the exterior enclosure (walls and floors) and foundations that are at, below, or near ground level for that ground water level caused by one or any combination of a specific recurrence level (e.g., 5 year) for floods, for precipitation and the water table level, as recommended by appropriate standards.
- Elements of the exterior enclosure (walls and floors) and foundation which are at, or below, the ground may be designed and constructed to prevent the entrance of ground water to the inner surface of the building by an impervious membrane, and/or by means of water resisting construction. The ground water level to be resisted should be that level covered by any one condition, or combination of conditions, described in the previous paragraph.
- Dampproofing of the exterior enclosure and floors at or near ground to prevent water rising through the capillaries of the materials, where the water table is below the bottom of the lowest floor of any space, may be provided as recommended by appropriate standards for the worst ground water table level. It is cautioned that dampproofing is not designed, or intended to be used, for resisting hydrostatic pressure.

FIG. X3.6 Durability of the Exterior Enclosure and Foundation Against Ground Water

H — DURABILITY		
0.2. WHOLE BUILDING SYSTEM—Groups of Building Subsystems		
B. General Durability of Distribution Networks (5., 6., 7., 8., 9., and 10.)		
Objective		Distribution networks should resist the degradation factors acting upon them for the duration of their service life.
Criterion	C-1:	All distribution network elements should be designed and constructed such that each is protected against the degradation factors that are likely to be encountered. The effect of these factors over the period of a distribution network's service-life should not reduce its ability to perform as specified by the user of this set of standard guides.
Evaluation Method	E-1:	Observation/Computation/Physical Test. EM-1.
Commentary	•	The distribution network elements need to be tested for resistance against only those degradation factors that are anticipated to be encountered at a specific site. Likely degradation factors are illustrated in Table X3-1.

FIG. X3.7 General Durability of Distribution Networks

H — DURABILITY		
2. STRUCTURE		
A. General Durability of Structural Elements (Foundations and Superstructures)		
Objective		Structural elements should resist the degradation factors acting upon them for the duration of their service life.
Criterion	C-1:	All structural elements should be designed and constructed such that each is protected against the degradation factors that are likely to be encountered. The effect of these degradation factors over the period of an element's service-life should not reduce its ability to perform as specified by the user of this set of standard guides.
Evaluation Method	E-1:	Observation/Computation/Physical test. EM-1.
Commentary	•	An example of an acceptable way to specify reinforced concrete and masonry products used for the construction of foundations is that they comply with the durability requirements of ACI 318, Part 3, (or an equivalent document), or ACI 530/ASCE 5/TMS 402, respectively. For a permanent wood foundation, an acceptable way would be to specify products according to AF&PA Technical Report No. 7.
	•	Likely degradation factors are illustrated in Table X3-2. Note that foundations above grade level can be subjected to weather factors.

FIG. X3.8 General Durability of Structural Elements (Foundations and Superstructures)

H — DURABILITY

3. EXTERIOR ENCLOSURE

A. General Durability of the Exterior Enclosure

Objective		Exterior elements of the building envelope should resist the degradation factors acting upon them for the duration of their service life.
Criterion	C-1:	All elements of the building envelope, above and below ground, should be designed and constructed such that each is protected against the degradation factors that are likely to be encountered. The effect of these degradation factors over the period of an element's service-life should not reduce its ability to perform as specified by the user of this set of standard guides.
Evaluation Method	E-1:	Observation/Computation/Physical test. EM-1. Guide E 1825 may aid users of this set of standard guides in developing performance statements for exterior wall materials, products, and systems.
Commentary		• Likely degradation factors are illustrated in Table X3-3. • Users of this standard guide are reminded that proper construction details are an acceptable method for providing protection against certain degradation factors, for example, termites. • Guide E 1825 was developed, in part, to provide guidance in the evaluation and qualification of wall materials, products, or systems for which the user does not have substantial long-term experience, or that are intended to be employed in a new or different manner.

FIG. X3.9 General Durability of the Exterior Enclosure

H — DURABILITY

3. EXTERIOR ENCLOSURE

B. Durability of the Exterior Enclosure Against Specific Degradation Factors

Objective

All outside elements of the exterior enclosure should resist the degradation factors associated with normal use without impairment of specified performance.

Criteria

All outside elements of the exterior enclosure should be designed and constructed such that each resists the effects of sunlight, point impact, scratching, and stains without impairment of specified performance over their expected service lives.

C-1: Sunlight - Appearance. When exposed to sunlight, all outside surfaces of the exterior enclosure (walls, roofs and floors) that are visible from any private space in the building, or from any public area outside the building, should not undergo change in color or texture greater than that specified by the user of this set of standard guides.

C-2: Sunlight - Physicochemical Changes. When exposed to sunlight, all outside surfaces of the exterior enclosure should not undergo any physical or chemical change that impairs their service-lives.

C-3: Point Impact - General. All outside surfaces of the exterior walls should resist the impact of a typical user activity (such as suddenly leaning against the surface, striking the surface with a small rubber ball, or accidentally striking the surface with a piece of construction material) with no cracking, flaking, indentation or other damage that would likely affect the specified performance over their service lives.

C-4: Point Impact -Hailstones. All outside surfaces of the exterior enclosure, including walls, roofing membranes, floors and windows and doors, which are not protected from direct hailstone impact by overhangs or by similar devices, should withstand the impact of a hailstone of the anticipated maximum size without breakage of the surface or impairment to its performance.

C-5: Scratch and Impingements. All outside surfaces of the exterior walls should withstand the pulling across them objects common to dwellings (such as shrubs and bushes, ladders with protective devices, and normal cleaning devices) with no visible deterioration to, or gouging of, the surface.

C-6: Stains. The exterior surface of exterior walls located within reaching distance by an adult from the ground or from any accessible floor surface such as balconies, roof terraces, etc., should resist the effects of staining and stain removal of such materials as follows with no deterioration:

- mud
- chalk
- carbonated cola
- coffee
- grease

C-7: Corrosion. All metallic elements and non-homogeneous assemblies of the exterior enclosure should not corrode, as evidenced by delamination, rust or other effects likely to impair performance over their service lives, beyond the extent considered allowable by the user of this set of standard guides.

Evaluation Methods

Evaluation methods may include, but are not limited to:

E-1: Physical Test (Specimen). EM-2. Specimens may be exposed to a fluorescent UV apparatus [e.g., Method G154 at 35°C ± 5°C (95°F ± 9°F) for 1920 hours (80 days]. Test specimens may be compared with identical but unexposed specimens under daylight conditions, at the specified distances. Physical or chemical change may be determined by close inspection of the sample for any deterioration, or by conducting tests of mechanical and chemical properties as approved by the specifier.

E-2: Same as E-1.

E-3: Physical Test. EM-3. Provider may propose method for conducting the impact test and the minimum impact energy that the test specimen would be expected to sustain.

FIG. X3.10 Durability of the Exterior Enclosure Against Specific Degradation Factors

	E-4: Physical Test - Hailstone. EM-3. Provider may propose method for applying the impact. The impact may be applied at 90° to horizontal surfaces and at 15° to vertical surfaces. E-5: Physical Test (Laboratory). The scratch resistance of surfaces may be evaluated according to a procedure adapted from Method D5178. After conducting this procedure, the surface may be visually examined from a distance of 3000 mm (120 in.) under daylight conditions for indication of scratches. The specifier may indicate the maximum acceptable load below which scratching would not occur. E-6: Physical Test (Laboratory or Field). Staining agents may be applied on surfaces in 300 mm (12 in.) streaks and allowed to dry at room temperature. After removal, the stained surfaces may be inspected at a viewing distance of 3000 mm (120 in.) in light conditions of 1000 to 2000 lux at the surface following the procedures of Method D4449. E-7: Physical Test (Specimen). Specimens may be exposed to a 5% salt spray at 25°C ± 5°C (77°F ± 9°F) for a period of one week (168 hours).
Commentary	• The criteria C-1 and C-2 above may be deemed met if there is evidence that the specified effects have not occurred on identical exterior enclosure assemblies exposed to solar conditions similar to those at the site for periods, which the specifier considers adequate to indicate that the specific service-life specified for exterior enclosure elements in Table 2, will likely be met. • Criterion C-4 may be invoked if there is a reasonable probability of exposure to hail storms. Factory Mutual Research Corporation (FMRC) 4450 and 4470, and Underwriters • Laboratories (UL) 2218 offer industry standard methods for conducting impact tests on roof cover assemblies. • An alternative scratch test (Evaluation E-5) may be EM-5, which is based on Method D3363. • Stain removal (Evaluation E-6) should be performed according to the instructions of the supplier of the stain remover. • Evaluation E-7 may be performed on envelope materials including proposed substrate, bonding, backing and finishes in final assembly form.

FIG. X3.10 Durability of the Exterior Enclosure Against Specific Degradation Factors *(continued)*

H — DURABILITY

3. EXTERIOR ENCLOSURE

C. Resistance of Exterior Enclosure to Effects of Temperature, and Freezing and Thawing Factors

Objective

All outside elements of the exterior enclosure should resist anticipated heat, cold thermal shock, and forces of freezing and thawing without impairment of specified performance.

Criteria

All outside elements of the exterior enclosure should be designed and constructed such that each resists the effects of anticipated maximum and minimum temperatures and freeze-thaw effects of the local climatic environment without impairment of specified performance over their expected service lives.

C-1: Opaque parts of the exterior enclosure should resist the effects of the anticipated maximum surface temperatures without cracking, swelling, flaking, blistering, discoloring, or other visible evidence of deterioration that will impair performance over their service lives.

C-2: Transparent and translucent parts of the exterior enclosure should resist the effects of the anticipated maximum temperature without cracking, swelling, blistering, discoloring or other visible evidence of deterioration that will impair performance over their service lives.

C-3: All parts of the exterior enclosure should resist the effects of the minimum temperature expected to be encountered in the geographic region of use without cracking, swelling, flaking, blistering or other visible evidence of deterioration that will impair performance over their service lives.

C-4: Opaque parts of the exterior enclosure should resist the effect of quick temperature changes from the lowest temperature encountered in a geographic region to the maximum encountered without cracking, swelling, flaking, blistering, discoloring, or other visible evidence of deterioration that will impair performance over their service lives.

C-5: Elements of exterior walls and their facing materials should be designed and constructed such that any freeze-thaw effect of the local climatic environment over their service-lives does not likely impair their appearance, strength or adhesion, and other properties as specified by the user of this set of standard guides.

Evaluation Methods

Evaluation methods may include, but are not limited to:

E-1: Physical test (Specimen). Specifier may propose exposing all parts in a mechanical convection oven at a temperature and for period of time selected in consideration of the maximum temperature expected in service. Alternatively, the specifier may propose that oven exposures be conducted such that rates of deterioration on heating are determined.

E-2: Physical test (Specimen). All transparent and translucent parts may be evaluated according to a procedure based on that given in Method E773, which includes testing for resistance to heat and humidity exposure and cyclic ultraviolet light exposure. The time period for the heat and humidity exposure may be specified by the user of this set of standard guides.

E-3: Physical test (Specimen). All parts may be placed in freezer for at least one week (168 h) at -20°C (-4°F).

E-4: Physical test (Specimen). Opaque specimens may be exposed to a continuous freeze-thaw cycle procedure that is specified by the user of this set of standard guides.

E-5: Physical test (Specimen). The number of cycles in a standard freeze-thaw test method may be specified by the user of this set of standard guides so as to simulate the local climate.

Commentary

- Tested exterior enclosure assemblies should include all typical joints. Parts of exterior enclosures may be constructed of materials (such as wood, concrete, metals, and plastics) that show physical change after exposure to the above tests. If the nature of the materials and the specific design is such that this change improves or does not reduce the aesthetic qualities of the buildings, the testing illustrated above may disallow materials when the physical change is evidence of potentially harmful physical deterioration (e.g., leaking, and

FIG. X3.11 Resistance of Exterior Enclosure to Effects of Temperature, and Freezing and Thawing Factors

	weakening). • Method E773 (cited in Evaluation E-2) was developed specifically for preassembled permanently sealed insulating glass units. However, the exposure tests given in Paragraph 8 of Method E773 may be adapted for all transparent and translucent parts of the exterior envelop. • Examples of temperatures that exterior enclosure components may reach are: • light colors 50°C (122°F) • medium colors 70°C (158°F) • dark colors 90°C (194°F)

FIG. X3.11 Resistance of Exterior Enclosure to Effects of Temperature, and Freezing and Thawing Factors *(continued)*

H — DURABILITY

3.2. EXTERIOR ENCLOSURE—Vertical and Sloped Enclosure

A. Durability of Windows and Doors—Mechanical Resistance

Objective	All doors and windows should be designed and installed so as to resist normal applied forces and the wear and tear of normal repeated use.
Criteria	All doors and windows should be designed and installed such that each resists the effects of repeated use, anticipated mechanical forces, and repeated wind loads without impairment of specified performance over their expected service lives.
C-1:	Repeated Use. All doors and windows should endure the number of repeated opening and closing cycles that are estimated to be experienced over their service lives with a force equivalent to that required to operate them, and at an estimated speed that would be attained in repeated opening and closing by an average user. During this cycling, no deterioration of operability and performance, and no impairment of the window's ability to perform at a performance level selected from the options provided in ANSI/AAMA/NWWDA 101/I.S 2-97 and AAMA 910-93, should occur. If recommended by the manufacturer, replacement of easily replaceable parts, and/or adjustment or lubrication of parts of the window and door mechanisms should be allowed during the testing by the specifier. The door and window hardware should be tested for the same amount of cycles by themselves (i.e., removed from doors and windows and tested).
C-2:	Parallel Forces: • Vertically projecting windows, both hinged or pivoted, when opened at an angle of 90° or to the furthest extent possible should resist the maximum vertical force anticipated in normal use with no breakage of glass, and with no deterioration of the window's operability and performance. • Horizontally or vertically sliding windows or doors, should resist the maximum force anticipated in normal use applied to the edges of the sash or door panel, in the direction of their movement. Tested windows should perform as follows: (1) no breakage of glass; (2) a slight displacement of the frame at point of application of the force in the plane of the glass; (3) no residual displacement of the frame; and (4) no deterioration of the window's operability and performance.
C-3:	Perpendicular Forces: Windows should resist the anticipated maximum force which will be

FIG. X3.12 Durability of Windows and Doors—Mechanical Resistance

	applied perpendicularly to their frames in normal use, with no breakage of glass and no deterioration of the window's operability and performance.
	C-4: Performance Under Repeated Wind Pressure Variations. Windows and doors should resist cyclic forces representing the long-term effects of repeated wind loads anticipated to be experienced throughout their service lives with no deterioration of performance.
	C-5: Hinge: All hinged windows (both vertical and horizontal) and doors, when blocked from total closing, should resist the maximum anticipated force to be applied in attempting to close the window with no failure of the hinges and no deterioration of the performance of the window or door.
	C-6: Scratch: All window and door frames and sash or panels should be tested for scratch resistance using the pencil test (D3363) on both interior and exterior surfaces. The acceptance criterion should be no chipping, scratching or residual indentation.
	C-7: General Construction: In addition to compliance with all other applicable requirements of the set of performance standards, an additional criterion should be that all windows and doors comply with ANSI/AAMA/NWWDA 101/I.S. 2-97.
Evaluation Methods	Evaluation Methods may consider ANSI/AAMA/NWWDA 101/I.S. 2-97; evaluation methods may include, but are not limited to:
	E-1: Physical test (Specimen/field). Providers may propose methods for executing this test. Windows may endure 4,000 cycles and doors 18,000 cycles of repeated opening and closing at an approximate speed of 15 m/min (49 ft/min)
	E-2: Physical test (Specimen/field). Providers may propose methods for executing this test. • Projected Windows: A force up to 70 N (16 lbf), applied parallel to the plane of the sash for 1 minute to the lower corner most distant from the window's axis of rotation, would not result in broken glazing or any damage to the window which would cause it to be inoperable. • Sliding Windows: When tested according to E987 using a load of 320 N (72 lbf), the operating sash members would not move from their original position, in relation to the glazing material, by more than 90% of the glazing bite.
	E-3: Physical test (Specimen/field). Providers may propose methods for executing this test. A force of 135 N (30 lbf), applied perpendicular to the latch rail of an opened window in accordance with section 2.2.4.5.4 of ANSI/AAMA/NWWDA 101/I.S. 2-97, would not result in deflection at the point of load application exceeding 2 mm (0.08 in.).
	E-4: Physical test (Specimen). Method E1233, Procedure A, may be performed. The specifier may select the number of cycles that the test would be conducted.
	E-5: Physical test (Specimen/field). Providers may propose methods for executing this test. A force of 270 N (60 lbf), applied perpendicular to the frame of an opened window in accordance with section 2.2.4.5.8 of ANSI/AAMA/NWWDA 101/I.S. 2-97 with the window operation blocked, would not result in glass breakage, or damage to the window which would cause it to be inoperable.
	E-6: Physical test (Specimen). EM-5. Method E 3363 may be performed using a 6H pencil. The pencil mark may be examined at a distance of 500 mm (20 in.) in light conditions of 1000 to 2000 lux.
	E-7: Observation. Providers may submit a schedule of all windows and doors and the specific standards to which they comply.
Commentary	• An ASTM Standard Specification for residential window assemblies is E1017.

FIG. X3.12 Durability of Windows and Doors—Mechanical Resistance *(continued)*

H — DURABILITY		
3.2. EXTERIOR ENCLOSURE—Vertical and Sloped Enclosure		
B. Durability of Windows and Doors—Weather Resistance		
Objective		All exterior doors and windows should not undergo appreciable deterioration throughout their service lives due to effects of weathering.
Criterion	C-1:	All exterior doors and windows should be designed and installed such that each resists the effects of weather factors including sunlight, moisture, and temperature without impairment of specified performance over their expected service lives.
Evaluation Method	E-1:	Physical Test (Specimen). Specifiers or providers may propose an evaluation method(s) based on procedures given in industry standards including AAMA 2603.8, AAMA 2604.2, AAMA 2605.2, AAMA 2606.1, AAMA 2607.1, AAMA 2608.1 and AAMA 2611.
Commentary	•	If the specifier or provider considers that the above (or other) industry standards do not address specific weathering factors anticipated for a given installation, then appropriate methods may be proposed based on test method EM-1.

FIG. X3.13 Durability of Windows and Doors—Weather Resistance

H — DURABILITY

3.2. EXTERIOR ENCLOSURE—Vertical and Sloped Enclosure

C. Durability of Window and Door Glazing

Objective

All window and door glazing materials should resist the degradation factors associated with normal use without impairment of specified performance.

Criteria

All window and door glazing materials should be designed and constructed such that each resists the effects of stains and sunlight stains without impairment of specified performance over their expected service lives.

C-1: Stain. All window and door glazing materials, whether glass, plastic or other material, should withstand the application on their surfaces (interior and exterior), and subsequent removal, of typically encountered staining materials without any residual staining, discoloration, scratching, change in gloss, change in light transmittance or other visible change or decay as specified by the user of this set of standard guides.

C-2: Sunlight. All window and door glazing materials in the exterior enclosure should undergo no color or texture change, as a result of exposure to sunlight, exceeding that specified as acceptable as specified by the user of this set of standard guides.

C-3: General. In addition to compliance with all other applicable requirements of the set of performance standards, all glass in windows and doors should comply with the requirements of applicable standards. Examples are Specifications C1036, C1048, C1172, C1349, and E774.

Evaluation Methods

Evaluation methods may include, but are not limited to:

E-1: E-1: Physical test (Specimen). Commonly available staining materials may be applied on a minimum of 100 mm^2 (0.16 in^2) of the center of samples of actual size and supported as would be in the building. After application, the stains may be allowed to dry for 24 hours at room temperature. Results may be observed in full sunlight from various angles to the plane of the surface and from various distances including 200 mm (8 in.) of the sample surfaces. Tests with the following materials may be required:

- lipstick
- grease pencil
- ink
- wet detergent
- kerosene
- ethyl and isopropyl alcohol
- tea and coffee
- lemon juice
- olive oil

E-2: Physical test (Specimen). EM-2. Specimens may be exposed to a fluorescent UV apparatus (for example, G154) for 1920 hours (80-days). The exposed specimens may be observed in light of 1000-2000 lux. Specimens may be compared with identical unexposed specimens placed adjacent to them in full sunlight. Alternatively, the color change may be quantified using instrumentation such as a spectrophotometer or a colorimeter.

E-3 Observation. Provider may submit glass schedules for all windows and doors, and the specific standards to which they comply. Documentation of compliance may be required.

Commentary

- Two standards on the structural performance of glass in windows and doors are Method E997 and Method E998.

FIG. X3.14 Durability of Window and Door Glazing

H — DURABILITY

3.3.1. EXTERIOR ENCLOSURE—Roofs—Roof Coverings

A. Durability of Roof Coverings

Objective		Roofs should be designed and constructed to resist the degradation factors likely to act upon them during their service lives.
Criterion	C-1:	In addition to meeting performance requirements recommended in other parts of this performance guide, roofs should be required to be designed and constructed in accordance with the requirements of applicable standards.
Evaluation Method	E-1:	Observation. Provider may indicate the specific set of standards to which the roofing materials comply. Plans, sections and details of the roof may be required to document compliance. Such documentation may be subjected to professional examination.
Commentary	•	Examples of applicable standards for roof coverings on single family dwellings are Specifications D225 and D3462 for asphalt shingles made from organic felt and glass felt, respectively. The Residential Asphalt Roofing Manual provides design and application methods for asphalt shingles.

FIG. X3.15 Durability of Roof Coverings

H — DURABILITY

3.3.2. EXTERIOR ENCLOSURE—Roofs—Skylights

A. Durability of Skylights and Roof Windows

Objective		All skylights and roof windows should be designed and installed so as to resist normal encountered degradation factors and the wear and tear of normal repeated use to which they are subjected over their service life.
Criterion	C-1:	All skylights and roof windows should comply with AAMA/WDMA 1600/I.S. 7.
Evaluation Method	E-1:	Observation. Provider may submit schedule of all skylights and roof windows and documentation of third party certification and test results.
Commentary	•	A schedule of all other applicable standards to which the products comply may also be submitted.

FIG. X3.16 Durability of Skylights and Roof Windows

H — DURABILITY

3.4 EXTERIOR ENCLOSURE—Joint Sealants

A. Durability of Joints and Joint Sealants

Objective		All joints and joint sealants of exterior enclosures should resist the degradation factors acting upon them for the duration of their service lives.
Criterion	C-1:	All joints and all joint sealants should be used and installed in accordance with applicable standards covering their use. They should not exhibit adhesion or cohesion failures as evidenced by cracking, loss of adhesion, or general degradation during their service lives.
Evaluation Method	E-1:	Observation. Provider may submit applicable standards and corresponding manufacturer's data on joint sealants.
Commentary	•	Standard test methods have been developed for the mechanical performance of joint sealants. Service life predictions are largely based on experiences with their use in specific exposures. A sounder basis for predicting the long-term performance of joint sealants is needed.

FIG. X3.17 Durability of Joints and Joint Sealants

H — DURABILITY

4. INTERIOR SPACE DIVISION

A. General Durability of Interior Space Dividers

Objective		Walls, doors, floors, ceilings and all other elements of interior spaces should resist the degradation factors associated with normal use without impairment of specified performance.
Criterion	C-1:	The effects of anticipated degradation factors on the respective service lives of walls, doors, floors, ceilings and all other elements of interior should not reduce their ability to perform as specified by users of this set of standard guides.
Evaluation Method	E-1:	Observation/Computation/Physical test. EM-1.
Commentary	•	Likely degradation factors are illustrated in Table X3-4.
	•	The specifier determines the specific degradation factors that are likely to be active for the particular application and environment. For example, if water freeze and thaw does not occur in a geographic region, then such testing should not be required.

FIG. X3.18 Durability of Interior Space Dividers

H — DURABILITY

4. INTERIOR SPACE DIVISION

B. Durability of Space Dividers Against Specific Degradation Factors

Objective

Surfaces of space dividers should resist the degradation factors associated with normal use without impairment of specified performance.

Criteria

Surfaces of space dividers should be designed and constructed such that each resists the effects of washing and scrubbing, scratch, chemicals, and stains without impairment of specified performance over their expected service lives.

C-1: Sunlight. When exposed to sunlight, all exposed surfaces of floors, walls, and doors in private spaces, and of kitchen and bathroom counters, should not undergo change in color or texture greater than that specified by the user of this set of standard guides.

C-2: Point Impact. All exposed surfaces of floors, walls and doors in private spaces, and of kitchen and bathroom counters, should resist the impact of an typical dropped object, such as cleaning equipment, cooking utensils, toys, and maintenance tools, with no visible surface defects (for example, cracks, chips, blisters, dents, and pinholes).

C-3: Washing and Scrubbing. All exposed surfaces of floors (other than carpet), walls, and doors in private spaces, and kitchen and bathroom counters, should withstand the cleaning applied by the use of cleaning brushes and agents during their service-life without softening or more than slight abrading, and change in color greater than that specified by the user of this set of standard guides.

C-4: Scratch. All exposed surfaces of floors (other than carpet), ceilings, walls and doors in private spaces, and of kitchen and bathroom counters, should have acceptable scratch resistance ratings.

C-5: Chemicals. Exposed surfaces of floors (except carpets), walls, doors and counters in kitchens and bathrooms should be resistant to exposure to chemicals including common salts typically encountered in residential dwellings without evidence of corrosion, cracking, swelling, or flaking.

C-6: Stains. Exposed surfaces of all floors, walls, doors, and kitchen and bathroom counters, should not discolor, flake, crack, swell, or corrode from the application of, and removal by a suitable method, of staining substances commonly found in residential dwellings.

Evaluation Methods

Evaluation methods may include, but are not limited to:

E-1: Physical test (Specimen). EM-2. Specimens may be exposed to a fluorescent UV apparatus (for example, G154) for the following periods:

- Floor surfaces exposed directly to the sun - 240 hours
- Floor surfaces not exposed directly to the sun - 96 hours
- Hard to renew surfaces of private walls and doors exposed directly to the sun - 240 hours
- All other walls and doors, with some indirect sun exposure - 96 hours
- Hard to renew surfaces of bathroom counters and kitchen counters exposed directly to the sun - 240 hours
- All other bathroom and kitchen counters, with some indirect light exposure - 96 hours

Exposed specimens may be compared with identical samples which have not been exposed. Exposed specimens may be observed in light of 1000-2000 lux at a distance of 1000 mm (40 in.).

E-2: Physical test (Specimen/field). EM-3. Testing may be conducted in which a 240 g ± 15 g (0.5 lbm ± 0.03 lbm) steel ball is dropped from the following distances:

- floors - 1500 mm
- walls - 400 mm
- doors - 500 mm
- bathroom counters and ½ area of kitchen counters - 1500 mm

Surfaces may be inspected from 1000 mm (40 in.) for wall and door surfaces, 2000 mm (80 in.) for floor and ceiling surfaces and 500 (20 in.) mm for counter surfaces. Light

FIG. X3.19 Durability of Space Dividers Against Specific Degradation Factors

		conditions may be 1000 to 2000 lux at the surfaces during inspection.
	E-3:	Physical test (Specimen). EM-4. Tests may be conducted using of an apparatus meeting the requirements of Method D2486, with a 5 % solution of tri-sodium phosphate, in which the following number of brush strokes are applied: • floors in kitchens, bathrooms and water closets - 100,000 brush strokes • all other floors - 50,000 brush strokes • walls and doors in kitchens, bathrooms and water closets - 100,000 brush strokes • all other doors - 20,000 brush strokes • bathroom counters and ½ area of kitchen counters - 200,000 brush strokes
	E-4:	Physical test (Specimen/field). EM-5. The scratch resistance ratings, using the pencil hardness test may be not less than the following: • floors - 3 H • ceilings - HB • walls - 2 H • doors - 3 H • bathroom counters and ½ area of kitchen counters - 9 H
	E-5:	Physical test (Specimen). Test may be performed according to a procedure adapted from Method F925. Test chemicals may be those suggested in Method F925, although other reagents including commercial products may be selected by users of this set of standard guides. Specimen surfaces may be inspected from 1000 mm (40 in.) in light conditions of 1000 to 2000 lux during and after exposure. Alternatively, changes in specimen properties such as thickness, indentation, or color may be measured as described in Method F925.
	E-6:	Physical test (Specimen/field). Each staining substance as marked in Table X3-5 may be applied in a 100 mm (4 in.) long streak on each surface type and left at between 20°C to 30°C (68°F to 86°F) for 24 hours. The acceptance criterion may be that, after removal of the staining substance by appropriate means, discoloration would not be apparent from 1000 mm (40 in.) away in light conditions of between 1000 and 2000 lux at the surface.
Commentary	•	Method F925 was developed for resilient flooring. The test procedure may be adopted for other types of flooring and building components such as walls, doors, and counters; in these cases, appropriate chemical reagents would need to be selected for testing.

FIG. X3.19 Durability of Space Dividers Against Specific Degradation Factors *(continued)*

H — DURABILITY

4.1.1. INTERIOR SPACE DIVISION—Vertical Space Dividers—Partitions

A. Wall Base Resistance to Floor Washing

Objective		The base of all walls located in rooms where floors are washable should be designed to resist deterioration due to water seepage.
Criteria	C-1:	The bottoms of walls located in all private rooms and spaces having washable floors should be provided with material designed to resist the physical and chemical effects of floor mopping on the lower surface of the wall.
	C-2:	Walls whose surfaces and/or internal assemblies are susceptible to deterioration by exposure to water through seepage, and which are located as described in Criterion C-1 above, may be provided with material designed to resist the penetration of water into the wall through leakage or capillary action.
Evaluation Methods	E-1:	Observation. Provider may submit details of all wall bases.
	E-2:	Observation. Provider may submit details of all wall bases.
Commentary	•	None

FIG. X3.20 Wall Base Resistance to Floor Washing

H — DURABILITY

5. PLUMBING

A. Durability of Surfaces of Plumbing Network Elements

Objective		Surfaces of all elements of the plumbing network exposed in private space, including fixtures, should resist the degradation factors associated with normal use without impairment of specified performance.
Criteria		Surfaces of all elements of the plumbing network exposed in private space, including fixtures, should be designed and constructed such that each resists the effects of sunlight, point impact, washing and scrubbing, scratch, chemicals, stains, and corrosion without impairment of specified performance over their expected service lives.
	C-1:	Sunlight. The criterion should be the same as C-1 of Section X3.5.1.2 for bathroom counters; exposure temperature should be 50°C ± 5°C (122°F ± 9°F).
	C-2:	Point Impact. The criterion should be the same as C-2 of Section X3.5.1.2; the impactor should be dropped from a height of 500 mm (20 in.) above the specimen.
	C-3:	Washing and Scrubbing. The criterion should be the same as C-3 of Section X3.5.1.2, for bathroom counters.
	C-4:	Scratch. The criterion should be the same as C-4 of Section X3.5.1.2 for bathroom counters.
	C-5:	Chemicals. Exposed surfaces of all plumbing fixtures should comply with Criterion C-6 of Section X3.5.1.2; specimens should be exposed using the chemical solutions in Table X3-6 at 60°C (140°F).
	C-6:	Stains. Exposed surfaces of all plumbing fixtures should comply with Criterion C-7 of Section X3.5.1.2 for bathroom surfaces.
	C-7:	Corrosion. All plumbing fixtures, including supply and drain trim should comply with Section X3.5.1.3.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	See X3.5.1.2, E-1
	E-2:	See X3.5.1.2, E-2
	E-3:	See X3.5.1.2, E-3
	E-4:	See X3.5.1.2, E-4
	E-5:	See X3.5.1.2, E-5
	E-6:	See X3.5.1.2, E-6
	E-7:	See X3.5.1.3
Commentary	•	None

FIG. X3.21 Durability of Surfaces of Plumbing Network Elements

H — DURABILITY

5. PLUMBING

B. Durability of Plumbing Network Piping Against Normal Wear and Tear

Objective		All exposed water supply, and drain, waste, vent and fire protection water piping and fittings should resist the degradation factors associated with normal wear and tear without impairment of specified performance.
Criterion	C-1:	All exposed water supply, and drain, waste, vent and fire protection water piping and fittings should be designed and installed so that each resists the effects of repeated use and anticipated mechanical degradation factors without impairment of specified performance over their expected service lives.
Evaluation Method	E-1:	Physical test (specimen). Specifier may provide test methods, test procedures, and minimum requirements for the evaluation of the piping components and systems. Tests for pressure piping systems would be specific to that application. Tests for non-pressure piping systems would be specific to that application.
Commentary	•	An example of a degradation factor associated with normal wear and tear of exposed piping may be impact; particularly for exposed piping located near a floor. In such a case, the specifier may require that no cracking and no permanent indentation beyond a specified limit result from an impact provided by a falling object of specified mass. Method D2444 has been used for plastic piping.

FIG. X3.22 Durability of Plumbing Network Piping Normal Wear and Tear

H — DURABILITY

5. PLUMBING

C. Durability of Plumbing Network Against Freezing Exposure

Objective		The plumbing network should be resistant to potential freezing conditions.
Criteria	C-1:	Water service piping and sewers below ground should be installed below the frost line.
	C-2:	If required by the specifying authority, piping adjacent to exterior building wall should be insulated or heated.
	C-3:	If vent terminals are exposed to freezing temperatures, actions such as increasing them one pipe size above sizes specified for above freezing conditions should be considered where warranted.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	Observation.
	E-2:	Observation.
	E-3:	Observation.
Commentary	•	This objective only needs to be considered if freezing conditions are anticipated to be encountered at site. Specifying authority should provide information on depth of frost line.

FIG. X3.23 Durability of Plumbing Network Against Freezing Exposure

H — DURABILITY

5. PLUMBING

D. Durability of Plumbing Network Piping Against Internal Pressure

Objective		All potable water supply, as well as drain, waste and vent, piping and fittings should be resistant to continued normal and occasional excess internal pressure.
Criteria	C-1:	Potable water piping and fittings should be water tight at expected maximum operating water pressures plus surge pressures.
	C-2:	Drain, waste and wet vent piping should withstand the internal pressure created by completely filling the system with water before it is put into service and there would be no leakage.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	Physical test (field). The potable water piping network may be filled with water and placed under the expected maximum operating pressure with all valves closed. It would maintain that pressure for not less than 24 hours. A surge pressure test equal to 150% of the maximum operating pressure may be applied for 10 minutes.
	E-2:	Physical test (field). All openings in DWV piping may be secured and the piping filled completely with water for 15 minutes during which period no leakage would occur. The joints would be continually observed for any evidence of leakage.
Commentary	•	If water were not available to conduct the DWV pressure test (i.e., E-2), then an air test may be conducted. In this case, caution is taken that the system is not over pressurized.

FIG. X3.24 Durability of Plumbing Network Piping Against Internal Pressure

H — DURABILITY

5. PLUMBING

E. Durability of Plumbing Network Piping and Fixtures Against Hot Water Exposure

Objective		Plumbing network piping and fixtures should be resistant to hot water exposure.
Criteria	C-1:	Drain, waste and vent piping of all diameters, when hung horizontally at the expected maximum slope and supported at the maximum span, should be capable of sustaining the expected maximum operating temperature and flow rate.
	C-2:	Potable hot water piping of all diameters, when supported horizontally at the maximum span, should be capable of sustaining the expected maximum operating hot water temperature and flow rate.
	C-3:	Surfaces of plumbing fixtures, after ultra violet, point impact, wash and scrub, scratch and chemical resistance tests should be capable of withstanding exposure, up to the top of their interior surfaces, to hot water for a reasonable period without permanent color change, softening, or significant residual deflection after drying.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	Physical test (Field). Drain, waste and vent piping may be hung with a slope of 10 mm/m (⅛ in./ft) and supported at the maximum span. Depending upon diameter, subject such piping may be subjected to hot water at temperatures and flow rates and temperatures as given in Table X3-7 for 2 min followed by a 4 min dwell time during which there is no flow. The drain, waste and vent piping may endure the following hot water exposure cycles: • 750 cycles for inaccessible piping • 325 cycles for accessible piping Deflections at mid-span may be measured throughout test; mid-span deflection may not exceed 1/4 of the difference in elevation between supports.
	E-2:	Physical test (Field). Potable hot water piping, when supported horizontally at the maximum span, may sustain, for 1 hour, the hot water exposure at the flow rates and temperatures given in Table X3-8. Maximum deflection of piping may be measured throughout test; the mid-span deflection would not exceed 2 times the pipe diameter.
	E-3:	Physical test (specimen/field). Tests on plumbing fixtures may be performed with fixtures mounted in the standard manner. Water standing in the fixture may be heated to expected maximum operating temperature using an immersion coil or other heating device. Surfaces may be capable of withstanding exposure, up to the top of their interior surfaces, to 60°C ± 5°C (140°F ± 9°F)) water for 120 hours without permanent color change, softening, or residual deflection of more than 10 mm (0.4 in.) one hour after drying.. Fixtures may be inspected in light conditions of 1000 - 2000 lux with hot water in them, one hour after drying, 24 hours after drying, and 120 hours after drying.
Commentary	•	None

FIG. X3.25 Durability of Plumbing Network Piping and Fixtures Against Hot Water Exposure

H — DURABILITY

5.3. PLUMBING—Sanitary Waste

A. Durability of Drain, Waste, and Venting Piping Against Thermal Shock

Objective		Drain, waste, and vent piping should be resistant to thermal shock.
Criterion	C-1:	Drain, waste, and vent piping of all diameters should be capable of sustaining the expected maximum operating hot water temperatures and flow rates with no visible cracking, when piping is continuously exposed to the lowest expected ambient air temperature that it will experience in service.
Evaluation Method	E-1:	Physical (specimen). Drain, waste, and vent piping may be exposed to an ambient temperature of -30°C (-22°F), or the lowest anticipated ambient air temperature, for at least 24 hours. The piping, while remaining exposed to this ambient temperature, may be subjected to hot water at flow rates and temperatures listed in Table X3-9 for 5 minutes while observed for cracking. After this exposure, the pipe may be capped and filled with cold tap water, 15°C to 25°C (59°F to 77°F) and placed under an internal pressure of 34 kPa (5 psi) for 15 minutes while observing for cracking.
Commentary	•	None

FIG. X3.26 Durability of Drain, Waste, and Venting Piping Against Thermal Shock

H — DURABILITY

6. HVAC

A. Durability of Surfaces of HVAC Network Elements Against Specific Degradation Factors

Objective		Surfaces of radiators, fan coil units, grilles and registers, exposed in private space, should resist the degradation factors associated with normal use without impairment of specified performance.
Criteria		Surfaces of radiators, fan coil units, grilles and registers, exposed in private space, should be designed and constructed such that each resists the effects of sunlight, point impact, washing and scrubbing, scratch, and stains without impairment of specified performance over their expected service lives.
	C-1:	Sunlight. The criterion may be the same as C-1 of Section X3.5.1.2 for wall surfaces.
	C-2:	Point Impact. The criterion may be the same as C-2 of Section X3.5.1.2; impact drop height may be 750 mm (30 in.).
	C-3:	Washing and Scrubbing. The criterion may be the same as C-3 of X3.5.1.2, for doors.
	C-4:	Scratch. EM-5. Scratch resistance may be specified as not less than 4H.
	C-5:	Stains. The criterion may be the same as C-7 of Section X3.5.1.2, for bathroom surfaces.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	See Section X3.5.1.2.
	E-2:	See Section X3.5.1.2.
	E-3:	See Section X3.5.1.2.
	E-4:	See Section X3.5.1.2.
	E-5:	See Section X3.5.1.2.
Commentary	•	None

FIG. X3.27 Durability of Surfaces of HVAC Network Elements Against Specific Degradation Factors

H — DURABILITY		
6. HVAC		
B. Durability of HVAC Elements Against Internal Pressures		
Objective		Piping, radiators, fan coil units, pumps, boilers, and chillers should be resistant to internal pressures.
Criterion	C-1:	Conformance should be no pressure reduction under test conditions.
Evaluation Method	E-1:	Physical test (Field). Piping and connected equipment may be filled with water and placed under 700 kPa (100 psi) for not less than 24 hours.
Commentary	•	None

FIG. X3.28 Durability of HVAC Elements Against Internal Pressures

H — DURABILITY		
6.1. HVAC—Heating		
A. Durability of Heating Network Piping and Fittings Against Hot Water Exposure		
Objective		Heating network piping and fittings should be resistant to hot water exposure.
Criterion	C-1:	Under conditions of the test, mid-span deflection should not exceed 2 times pipe diameter.
Evaluation Method	E-1:	Heating network water piping of all diameters, when supported horizontally at the maximum span, may be capable of sustaining the hot water exposure at flow rates and temperatures given in Table X3-10 for at least 1 hour. The mid-span deflection would be measured during the test.
Commentary	•	None

FIG. X3.29 Durability of Heating Network Piping and Fittings Against Hot Water Exposure

H — DURABILITY		
7.1. FIRE SUPPRESSION SUBSYSTEMS—Suppression Systems		
A. Durability of Fire Protection Systems Against Internal Pressure		
Objective		Fire protection supply piping and fittings should be resistant to internal pressure exposure.
Criterion	C-1:	Test pressure should be maintained for 2 hours with no pressure reduction.
Evaluation Method	E-1:	Physical test (Field). Fire protection water piping and fittings may be watertight at a pressure not less than 1400 kPa (200 psi), or 350 kPa (50 psi) in excess of the normal pressure when normal pressure is in excess of 1000 kPa (150 psi).
Commentary	•	None

FIG. X3.30 Durability of Fire Protection Systems Against Internal Pressure

H — DURABILITY

8.1. ELECTRICAL NETWORK—Electrical Service and Distribution

A. Durability of Surfaces of Electrical Network Elements Against Specific Degradation Factors

Objective		Surfaces of all switches, sockets, cover plates, and surface mounted raceways should resist the degradation factors associated with normal use without impairment of specified performance.
Criteria		Surfaces of space dividers should be designed and constructed such that each resists the effects of sunlight, point impact, washing and scrubbing, scratch, and stains without impairment of specified performance over their expected service lives.
	C-1:	Sunlight. The criterion should be the same Criterion C-1 of Section X3.5.1.2 for wall surfaces.
	C-2:	Point Impact. The criterion should be the same as C-2 of Section X3.5.1.2.
	C-3:	Washing and Scrubbing. The criterion should be the same as C-3 of Section X3.5.1.2 for doors.
	C-4:	Scratch. The criterion should be the same as C-4 of Section X3.5.1.2.
	C-5:	Stains. The criterion should be the same as C-7 of Section X3.5.1.2 for bathroom surfaces.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	See Section X3.5.1.2. The drop distance may be 750 mm (30 in.) for switches, sockets and cover plates, and 1500 mm (60 in.) for surface mounted raceways.
	E-2:	See Section X3.5.1.2.
	E-3:	See Section X3.5.1.2.
	E-4:	See Section X3.5.1.2. Pencil harness may be 6 H for all exposed surfaces.
	E-5:	See Section X3.5.1.2.
Commentary	•	None

FIG. X3.31 Durability of Surface of Electrical Network Elements Against Specific Degradation Factors

H — DURABILITY

8.2. ELECTRICAL NETWORK—Lighting and Branch Wiring

A. Durability of Exterior Mounted Lighting Fixtures

Objective		Exterior mounted lighting fixtures should resist the effects of stains and corrosion.
Criteria	C-1:	Stains. Exterior mounted lighting fixtures should comply with Criterion C-7 of Section X3.5.1.2 for the following substances: • cleaning agent • pencil • kerosene
	C-2:	Corrosion. Exterior mounted lighting fixtures should comply with Section X3.5.1.3.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	See Section X3.5.1.2.
	E-2:	See Section X3.5.1.3.
Commentary	•	Other staining agents may be added by the specifying authority.

FIG. X3.32 Durability of Exterior Mounted Lighting Fixtures

H — DURABILITY

8.2. ELECTRICAL NETWORK—Lighting and Branch Wiring

B. Durability of Switches and Sockets Against Wear and Tear

Objective		Switches and sockets should resist the degradation factors associated with normal use without impairment of specified performance.
Criteria	C-1:	Switches should withstand the maximum number of cycles expected over their service-life; conformance should be a minimum of 10,000 cycles of operation at rated load without failure.
	C-2:	Sockets should withstand the maximum cycles of insertion and removal of plugs expected over their service-life. Conformance in test (A) should be that sockets be removed and re-inserted 100 times without failure. Conformance in test (B) should be that the weight attached to the plug have a mass of 0.5 kg and the plug would remain in the socket for one minute.
Evaluation Methods		Evaluation methods may include, but are not limited to:
	E-1:	Physical test (Field). Switches may be connected to a power source and a matching load source (i.e., 30 amp switch to 20 amp load) and actuated for a specified number of cycles.
	E-2:	Physical test (Specimen). (A) Socket may be mounted horizontally, face down, and a plug inserted and removed for the specified number of cycles. (B) The same plug, with a weight of specified mass attached, may be inserted and would remain in the socket for a specified period without falling out, after performance of plug insertion test (A).
Commentary	•	None

FIG. X3.33 Durability of Switches and Sockets Against Wear and Tear

H — DURABILITY

10. FUEL NETWORKS

A. Durability of Fuel Networks Against Internal Pressures

Objective		Fuel storage tanks and fuel piping should be resistant to internal pressures.
Criteria	C-1:	Fuel storage tanks, above or below ground, should be resistant to their maximum internal operating pressures, with no reduction in pressure during testing.
	C-2:	Fuel piping should be resistant to their maximum internal operating pressure, with no reduction in pressure during testing.
Evaluation Methods	E-1:	Physical test (Field). Fuel storage tanks may be subjected to an air pressure of 15 kPa (2 psi) for not less than 1 hour.
	E-2:	Physical test (Field). Piping may be subjected to an air pressure at 525 kPa (75 psi) for not less than 24 hours.
Commentary		None

FIG. X3.34 Durability of Fuel Networks Against Internal Pressures

H — DURABILITY

11. FITTINGS, FURNISHINGS AND EQUIPMENT

A. Resistance of Kitchen and Bathroom Counters to Hot Water

Objective		Kitchen and bathroom counters should be designed and constructed such that they resist hot water at temperatures anticipated to be encountered over their service lives.
Criterion	C-1:	All kitchen and bathroom counters, after exposure to tests specified in para. 8.5.1.2, should withstand exposure to hot water without permanent color change, softening or residual deflection of more than 3 mm (0.1 in.) after drying for 1 hour.
Evaluation Method	E-1:	Physical test (field). Specimens may be subjected to 60°C ± 5°C (140°F ± 9°F) water for 240 hours and inspected after drying for 1 hour with a light source of 1000-2000 lux. Tested counters may be inspected in appropriate light conditions.
Commentary	•	This test may be performed by artificially flooding kitchen and bathroom counters, mounted in their usual position, with heated water. An immersion coil or similar device may be used to heat the water.

FIG. X3.35 Resistance of Kitchen and Bathroom Counters to Hot Water

H — DURABILITY

11. FITTINGS, FURNISHINGS AND EQUIPMENT

B. Durability of Kitchen and Bathroom Surfaces Against Corrosion

Objective		Bathroom and kitchen surfaces should resist the effects of corrosion to which they are likely to be subjected over their service-life.
Criterion	C-1:	All metallic and non-homogeneous materials and assemblies in bathrooms and kitchens should withstand a salt spray test without delamination and impairment of specified performance, and without rust appearing on surfaces to an extent greater than that specified by the user of this set of standard guides.
Evaluation Method	E-1:	Physical test (specimen). Tests may be performed in accordance with B117 (or equivalent method), on all metallic materials, and non-homogeneous assemblies, including proposed substrate, bonding, backing materials, and finishes. Specimens may be exposed to 5% salt spray at 25°C ± 5°C (77°F ± 9°F) for at least the following amount of time: • in bathrooms - 96 hours • in kitchens - 24 hours
Commentary	•	None

FIG. X3.36 Durability of Kitchen and Bathroom Surfaces Against Corrosion