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Standard Guide for Design and Construction of Low-Rise Frame Building Wall Systems to Resist Water Intrusion[1]

This standard is issued under the fixed designation E2266; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes design, specification, selection, installation, and inspection of new building wall systems, exterior deck and stair components, doors, windows, penetrations and sealant joints of wood and metal frame buildings, typically four stories or less, to minimize water intrusion.

1.2 This guide does not address prevention of damage caused by water originating from the use of wet building materials or from indoor or outdoor humidity. Water from these sources can be important, and the potential for damage caused by water from these sources must not be overlooked in building design or construction.

1.3 This guide does not address roofing systems, except when the surface of a deck also serves as a roof and at locations where roof systems interface with building walls.

1.4 This guide does not address any type of barrier wall system.

1.5 This guide does not address any exterior insulation and finish system (EIFS).

1.6 This guide does not address foundation conditions where the bottom of a slab on grade or the grade of a crawl space is at or below the water table or subject to hydrostatic pressure.

1.7 This guide is intended to supplement and not duplicate building code requirements.

1.8 Maintenance, although important, is not covered in detail.

1.9 Application of finishes, such as paint and sealers, may be important in the performance of some types of cladding; however, this is not covered in detail.

1.10 This guide applies only to constructions with sheathing, which facilitates installation of the water-resistive barrier and associated flashings in a common plane.

[1] This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.55 on Performance of Building Enclosures.

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1.11 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.12 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory requirements prior to use.*

1.13 *Organization of Document:*

1.14 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
C11 Terminology Relating to Gypsum and Related Building Materials and Systems
C43 Terminology of Structural Clay Products (Withdrawn 2009)[3]
C55 Specification for Concrete Building Brick
C62 Specification for Building Brick (Solid Masonry Units Made From Clay or Shale)
C67/C67M Test Methods for Sampling and Testing Brick and Structural Clay Tile
C90 Specification for Loadbearing Concrete Masonry Units
C126 Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
C150/C150M Specification for Portland Cement
C168 Terminology Relating to Thermal Insulation
C216 Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
C270 Specification for Mortar for Unit Masonry
C652 Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale)
C717 Terminology of Building Seals and Sealants
C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
C836/C836M Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
C896 Terminology Relating to Clay Products
C898/C898M Guide for Use of High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Separate Wearing Course
C920 Specification for Elastomeric Joint Sealants
C926 Specification for Application of Portland Cement-Based Plaster
C957/C957M Specification for High-Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane With Integral Wearing Surface
C981 Guide for Design of Built-Up Bituminous Membrane Waterproofing Systems for Building Decks
C1063 Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
C1088 Specification for Thin Veneer Brick Units Made From Clay or Shale
C1127/C1127M Guide for Use of High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with an Integral Wearing Surface
C1180 Terminology of Mortar and Grout for Unit Masonry
C1186 Specification for Flat Fiber-Cement Sheets
C1193 Guide for Use of Joint Sealants
C1209 Terminology of Concrete Masonry Units and Related Units (Withdrawn 2009)[3]
C1232 Terminology for Masonry
C1299 Guide for Use in Selection of Liquid-Applied Sealants (Withdrawn 2012)[3]
C1400 Guide for Reduction of Efflorescence Potential in New Masonry Walls
C1405 Specification for Glazed Brick (Single Fired, Brick Units)
D226/D226M Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
D1079 Terminology Relating to Roofing and Waterproofing
D1970/D1970M Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
D3679 Specification for Rigid Poly(Vinyl Chloride) (PVC) Siding
D4477 Specification for Rigid (Unplasticized) Poly(Vinyl Chloride) (PVC) Soffit
D4756 Practice for Installation of Rigid Poly(Vinyl Chloride) (PVC) Siding and Soffit
D5843/D5843M Guide for Application of Fully Adhered Vulcanized Rubber Sheets Used in Waterproofing
D5898 Guide for Standard Details for Adhered Sheet Waterproofing
D5957 Guide for Flood Testing Horizontal Waterproofing Installations

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.
[3] The last approved version of this historical standard is referenced on www.astm.org.

D6134/D6134M Specification for Vulcanized Rubber Sheets Used in Waterproofing Systems
D6135 Practice for Application of Self-Adhering Modified Bituminous Waterproofing (Withdrawn 2014)[3]
D6622/D6622M Guide for Application of Fully Adhered Hot-Applied Reinforced Waterproofing Systems
D6864 Specification for Color and Appearance Retention of Solid Colored Plastic Siding Products (Withdrawn 2018)[3]
E241 Guide for Limiting Water-Induced Damage to Buildings
E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference
E631 Terminology of Building Constructions
E1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference
E1677 Specification for Air Barrier (AB) Material or Assemblies for Low-Rise Framed Building Walls
E1825 Guide for Evaluation of Building Exterior Enclosure Materials, Products, and Systems
E2112 Practice for Installation of Exterior Windows, Doors and Skylights
F1667 Specification for Driven Fasteners: Nails, Spikes, and Staples

2.2 *AAMA Standards:*[4]
AAMA 501 Methods of Test for Metal Curtain Walls
AAMA 501.2 Field Check of Metal Curtain Walls for Water Leakage
AAMA 502 Voluntary Specification for Field Testing of Windows and Sliding Doors
AAMA 850 Fenestration Sealants Guide Manual
AAMA IM-TM InstallationMasters Training Manual Window Selection Guide

2.3 *ACI Standard:*[5]
ACI 524 Guide to Portland Cement Plastering

2.4 *ANSI Standards:*[6]
ANSI/ASCE 7 Building Code Requirements for Minimum Design Loads in Buildings and Other Structures
ANSI/AHA A135.6 American National Standard for Hardboard Siding
ANSI/AAMA/NWWDA 101/I.S. 2-97 Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors
ANSI/AAMA/WDMA 101/I.S. 2/NAFS-02 Voluntary Performance Specification for Windows, Skylights, and Glass Doors

2.5 *APA Standards:*[7]
APA 303 Siding Manufacturing Specifications
Avoiding Moisture Accumulation in Walls
Buckling of Wood-Based Panel Siding
Installation of Stucco Exterior Finish Over Wood Structural Panel Wall Sheathing
Product Guide Performance Rated Sidings

2.6 *AWPA Standards:*[8]
AWPA C2 Lumber, Timbers, Bridge Ties and Mine Ties, Pressure Treatment
AWPA C28 Preservative Treatment by Pressure Processes of Structural Glue Laminated Members and Laminations Before Gluing
AWPA M4 Care of Pressure Treated Wood Products

2.7 *BIA Standard:*[9]
Technical Notes on Brick Construction

2.8 *CCMC Standard:*[10]
NRCC-45-673 Technical Guide for Sheathing, Membrane, Breather-Type

2.9 *CGSB Standard:*[11]
CAN/CGSB 51.32-M77 Sheathing, Membrane, Breather Type

[4] Available from Fenestration & Glazing Industry Alliance (FGIA), 1900 E Golf Rd, Suite 1250 Schaumburg, IL 60173, https://www.fgiaonline.org. On January 1, 2020, the American Architectural Manufacturers Association (AAMA) and Insulating Glass Manufacturers Alliance (IGMA) merged to become Fenestration & Glazing Industry Alliance (FGIA).
[5] Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, http://www.concrete.org.
[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[7] Available from APA – The Engineered Wood Association, 7011 S. 19th Street, Tacoma, WA 98466-5333, http://www.apawood.org.
[8] Available from American Wood Protection Association (AWPA), P.O. Box 361784, Birmingham, AL 35236-1784, http://www.awpa.com.
[9] Available from The Brick Industry Association (BIA), 12007 Sunrise Valley Drive, Suite 430, Reston, VA 20191, http://www.gobrick.com.
[10] Available from Canadian Construction Materials Centre (CCMC), Institute for Research in Construction, National Research Council Canada, 1200 Montreal Road, Building M-58, Ottawa, Ontario K1A 0R6, https://nrc-cnrc.canada.ca/.
[11] Available from Canadian General Standards Board (CGSB), 11 Laurier St., ~~Phase~~Portage III, Place du Portage, Gatineau, Quebec K1A 0S5, Canada, http://www.tpsgc-pwgsc.gc.ca/comm/cn-cu-eng.html.

2.10 *CMHC Standard:*[12]
Wood-Frame Envelopes in the Coastal Climate of British Columbia
2.11 *CPA Standards:*[13]
ANSI/AHA 135.6 Hardboard Siding
Recommended Basic Application Instructions for Hardboard Siding
Coatings Specification for Field-Applied Coatings on Hardboard Siding
Finishing Recommendations for New Construction Using Unprimed and Primed Hardboard Siding
Maintenance Tips for Hardboard Siding
2.12 *CSSB Standards:*[14]
Wall Construction Manual
Grading Rules for Certigrade Red Cedar Shingles
Grading Rules for Certi-Split Red Cedar Shakes
Grading Rules for Tapersawn Red Cedar Shakes
2.13 *Federal Specification:*[15]
UU B 790a Building Paper
2.14 *ICC-ES Standards:*[16]
AC38 Acceptance Criteria for Weather-Resistive Barriers
AC39 Acceptance Criteria for Walking Decks
2.15 *MLPB Standard:*[17]
Stucco in Residential Construction
2.16 *NCMA Standard:*[18]
NCMA TEK Bulletins
2.17 *NELMA Standard:*[19]
Standard Grading Rules for Northeastern Lumber
2.18 *NRCA Standard:*[20]
NRCA Roofing and Waterproofing Manual
2.19 *NWCB Standard:*[21]
Stucco Resource Guide
2.20 *PCA Standard:*[22]
Portland Cement (Stucco) Manual
2.21 *RIS Standard:*[23]
Standard Specifications for Grades of California Redwood Lumber
2.22 *SMACNA Standards:*[24]
Architectural Sheet Metal Manual
Residential Sheet Metal Guidelines
2.23 *SPC Standard:*[25]
Guide to Southern Pine Siding
2.24 *SPIB Standard:*[26]
Standard Grading Rules for Southern Pine Lumber
2.25 *SPRI Standard:*[27]
Flexible Membrane Roofing: A Professional's Guide to Specifications

[12] Available from Canadian Mortgage and Housing Corporation (CMHC), 700 Montreal Road, Ottawa, Ontario, K1A 0P7, Canada, http://www.cmhc-schl.gc.ca.
[13] Available from Composite Panel Association (CPA), 19465 Deerfield Avenue, Suite 306, Leesburg, VA 20176, https://www.compositepanel.org/.
[14] Available from Cedar Shake and Shingle Bureau (CSSB), ~~7101 Horne St #2, Mission, BC V2V 7A2,~~ 300 – 34334 Forrest Terrace, Abbotsford, B.C. V2S 1G7, Canada, http://www.cedarbureau.org.
[15] Available from U.S. General Services Administration (GSA), 1800 F Street, NW Washington, DC 20405, http://www.gsa.gov.
[16] The ICC Evaluation Service (ICC-ES) is reviewing Acceptance Criteria previously issued by the ICBO Evaluation Service. At the publication of this standard, AC38 and AC39 are considered Interim Criteria. ICC Evaluation Service, 3060 Saturn Street, Suite 100, Brea, California 92821, http://www.icc-es.org.
[17] Available from Minnesota Lath and Plaster Bureau (MLPB), 1270 Northland Dr, Ste 150, Mendota Hts, MN 55120, http://www.mnlath-plaster.com.
[18] Available from National Concrete Masonry Association (NCMA), 13750 Sunrise Valley Drive, Herndon, VA 20171, http://www.ncma.org.
[19] Available from Northeastern Lumber Manufacturers Association (NELMA), 272 Tuttle Road, Cumberland Center, ME 04021, http://www.nelma.org.
[20] Available from National Roofing Contractors Association (NRCA), 10255 W. Higgins Road, Suite 600, Rosemont, IL ~~60018560 7,~~60018-5607, http://www.nrca.net.
[21] Available from Northwest Wall ~~&~~and Ceiling Bureau (NWCB), ~~2825 Eastlake Ave E, Ste 350, Seattle, WA 98102,~~12437 NE 173rd PL, Suite 200, Woodinville, WA 98072, http://www.nwcb.org.
[22] Available from Portland Cement Association (PCA), 5420 Old Orchard Road, Skokie, Illinois 60077-1083, http://www.cement.org.
[23] Available from Western Wood Products Association, Redwood Inspection Service, 1500 SW First Ave., Ste 870, Portland, OR 97201, https://www.wwpa.org/.
[24] Available from Sheet Metal & Air Conditioning Contractors' National Association (SMACNA), 4201 Lafayette Center Dr., Chantilly, VA 20151-1219, http://www.smacna.org.
[25] Available from Southern Pine Council, 2900 Indiana Ave. Kenner, LA 70065, http://www.southernpine.com.
[26] Available from The Southern Pine Inspection Bureau (SPIB), P.O. Box 10915 Pensacola, FL 32524-0915, http://www.spib.org.
[27] Available from Single-Ply Roofing Industry (SPRI), 465 Waverley Oaks Road, Suite 421, Waltham, MA 02452, http://www.spri.org.

2.26 *SWRI Standard:*[28]
Sealants The Professional's Guide
2.27 *TCA Standard:*[29]
Ceramic Tile Handbook
2.28 *TLPC Standard:*[30]
Lath and Plaster Systems Manual
2.29 *USDC-FPL Standard:*[31]
Gen. Tech. Rep. FPL-GTR-113 Wood Handbook—Wood as an Engineering Material
2.30 *USDC-NIST Standard:*[32]
DOC PS 20 American Softwood Lumber Standard
2.31 *VSI Standard:*[33]
Installation: A How To Guide
2.32 ~~*WCLIB*~~ *West Coast Lumber Inspection Bureau (WCLIB) Standard:*[34]
Standard No. 17 Grading Rules for West Coast Lumber
2.33 *WDMA Standard:*[35]
WDMA I.S. 4 Water-Repellent Preservative Non-Pressure Treatment for Millwork
2.34 *WRCLA Standard:*[36]
Installing Siding
2.35 *WSCPA Standard:*[37]
Design Guide for Anchored Brick Veneer Over Steel Studs
2.36 *WWPA Standards:*[38]
Natural Wood Siding: Selection Installation and Finishing
Western Wood Grading Rules

3. Terminology

3.1 *Definitions*—For terms used in this guide, refer to Terminology E631. For an explanation of terms that may be used in referenced documents refer to Terminologies C43, C168, C717, C896, C1180, C1209, C1232, and D1079.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air retarder (AR)*—also commonly referred to as "air barrier" and "house wrap;" a material or system in building construction that is designed and installed to reduce air leakage either into or through an opaque wall. Refer to Specification E1677.

3.2.2 *barrier wall*—type of wall system that is intended to manage all precipitation at the exterior surface of the cladding and associated sealants and flashings. These walls are designed to prevent water intrusion by a combination of a water barrier on the exterior surface and temporary absorption of water.

3.2.2.1 *Discussion*—
These wall systems consist of the exterior surface of the wall and the exterior surface of fenestration products, usually connected by a sealant joint. Barrier wall systems may include fenestration systems that collect and drain water to the exterior.

3.2.3 *building wall components*—materials that function as or are designated as being essential to the effective weatherproofing of the building.

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[28] Available from Sealant Waterproofing & Restoration Institute (SWRI), 400 Admiral Blvd, Kansas City, MO 64106, http://www.swrionline.org.
[29] Available from The Tile Council of North America, Inc. (TCNA), 100 Clemson Research Blvd., Anderson, SC 29625, https://www.tcnatile.com.
[30] Available from Texas Lathing & Plastering Contractors Association (TLPCA), P.O. Box 152282 Arlington, TX 76015, http://www.tlpca.org.
[31] U.S. Department of Agriculture, Forest Service, Forest Products Laboratory (USDC-FPL) documents are available from the U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.
[32] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.
[33] Available from Vinyl Siding Institute (VSI), ~~National Housing Center, 1201 15th Street NW, Suite 220, Washington, DC 20005,~~1800 Diagonal Rd., Suite 545, Alexandria, VA 22314, http://www.vinylsiding.org.
[34] Available from ~~West Coast~~ Pacific Lumber Inspection Bureau ~~(WCLIB), P.O. Box 23145, Portland, OR 97281, http://www.wclib.org.~~(PLIB), 1010 South 336th Street #210, Federal Way, WA 98003-7394, http://www.plib.org.
[35] Available from Window & Door Manufacturers Association (WDMA), 330 N Wabash Avenue, Suite 2000, Chicago, IL 60611, https://www.wdma.com.
[36] Available from Western Red Cedar Lumber Association (WRCLA), ~~1220-595 Howe Street, Vancouver, BC Canada, V6C 2T5,~~Suite 415 4-32465 South Fraser Way, Abbotsford, BC Canada V2T 0C7, http://www.realcedar.com.
[37] Available from Western States Clay Products Association (WSCPA), 1315 Storm Parkway Torrance, CA 90501-5041, http://www.brick-wscpa.org.
[38] Available from Western Wood Products Association (WWPA), 1500 SW First Ave, Ste 870, Portland, OR 97201, http://www.wwpa.org.

3.2.4 *cladding*—the outermost component of the wall system that provides resistance to intrusion of water originating as precipitation into the wall. Examples of cladding are portland cement plaster (stucco), wood and wood-based siding, wood shingles, masonry veneer, and vinyl and aluminum siding.

3.2.5 *deck*—a horizontal surface intended for human occupancy or use that is exposed to the weather.

3.2.6 *drainage wall*—a wall system in which the cladding provides a substantial barrier to water intrusion, but which also incorporates means for dissipating water that may circumvent the cladding. For purposes of this standard, a drainage wall is assumed to incorporate a concealed water-resistive barrier over which drainage, away from water-sensitive components of the wall, may occur. In addition to drainage behind the cladding, evaporation may play an important role in dissipating moisture in some types of cladding.

3.2.7 *drainage wall, cavity*—a type of drainage wall characterized by a vertical air space, which is either wholly or substantially unobstructed, between the water-resistive barrier and the back surface of the cladding system. The space between the water-resistive barrier and the cladding may be bridged, depending on the type of cladding, by masonry ties, vertical furring, or open-mesh synthetic polymer media.

3.2.8 *exterior wall*—a wall or wall component that defines the exterior boundary of a building.

3.2.9 *flashing*—a component or system typically composed of sheet material that is employed at interfaces between building components for the purpose of diverting water directly to the exterior or onto the water-resistive barrier.

3.2.10 *frame building*—a building in which the walls and roofs are supported structurally by wood or light steel framing. Exterior surfaces typically are finished with cladding systems.

3.2.11 *hold points*—times in the course of construction where specific components are to be inspected prior to application or installation of covering components.

3.2.12 *low-rise*—a structure consisting of four or fewer stories of frame construction.

3.2.13 *maintenance interval*—the period of time a building component will function successfully without requiring action to achieve its service life.

3.2.14 *maintenance manual*—a document organized by building components or systems in the CSI[39] or other format agreeable to the owner, which includes, at a minimum, the following: original drawings and specification, as-built changes, warranties and guarantees, vendor-provided maintenance instructions, anticipated maintenance life, anticipated service life, maintenance recommendations and requirements, and names, addresses and phone numbers of subcontractors and installers.

3.2.15 *manufacturer's recommendations*—design, application, or construction recommendations provided by the manufacturer or vendor of a product or system by means of mass-distributed product literature, catalogs, internet web sites or manuals. Manufacturers may also authorize individuals to issue project-specific recommendations.

3.2.16 *pan flashing*—a type of flashing used at the base of large openings or penetrations, such as doors or windows. Pan flashings are designed to collect water and drain water directly to the exterior or onto the water-resistive barrier. Pan flashings have an upturned inner leg and upturned end legs, which form a three-sided pan.

3.2.17 *plaza deck*—a deck, the components of which are covered with materials or systems intended to protect the structure and/or enclosed areas below from precipitation or irrigation water.

[39] MasterFormat, 1995 Edition Master List of Numbers and Titles for the Construction Industry, is available from Construction Specifications Institute (CSI), 123 North Pitt St, Ste 450, Alexandria, VA 22314, http://www.csinet.org. This revised guide is used to classify construction resources, including project information, products, and human effort. The five-digit numbering system organizes construction specifications, project manuals, cost estimates, and data files.

3.2.18 *portland cement plaster (stucco) system*—systems include plaster, with portland cement and aggregate, and typically on frame buildings, metallic lath. Portland cement plaster (stucco) cladding may also include adhered veneer such as thin brick, ceramic and thin stone veneer.

3.2.18.1 *Discussion*—

For portland cement refer to Specification C150/C150M. For lathing and furring installation refer to Specification C1063. For portland cement plaster application refer to Specification C926.

3.2.19 *protected membrane plaza deck*—a plaza deck constructed with the waterproof membrane placed directly over the structural deck surface (usually concrete or wood panel sheathing) with a separate traffic-bearing surface, such as concrete, ceramic tile, or pedestal-supported pavers placed on top of the membrane.

3.2.20 *saddle flashing*—a type of flashing which covers the intersecting joint between a vertical surface and horizontal penetration or appendage, such as the right-angle intersection of a beam penetrating a wall, or the intersection of a parapet to a wall.

3.2.21 *self-adhering flashing*—some materials comply with Specification D1970/D1970M. This term applies to membrane systems of several types in which modified asphalt or butyl rubber adhesive is applied in the factory to sheets of polyethylene, polypropylene, or foil to a total thickness of ~~0.5~~0.5 mm to 1.5 mm ~~(0.020~~(0.020 in. to 0.060 in.).

3.2.21.1 *Discussion*—

This material, which is generally not intended for exposed use, can be used for areas requiring additional durability or resistance to wind-driven rain, such as flashing, reinforcement of corners, and as a lap sealant. When self-adhering flashings are used in conjunction with a water-resistive barrier, the materials should be compatible. These types of membranes have very low vapor permeance, and as such, should be used with caution when applied over large areas or entire wall surfaces.

3.2.22 *service life*—the period of time a building component or system will function successfully without replacement or excessive repair, assuming reasonable or expected periodic maintenance is performed.

3.2.23 *sheathing*—a rigid panel material fastened to the exterior surfaces of wall framing members, which provides a continuous plane interrupted only by intentional wall openings (such as those for fenestration units) and by small panel spacing gaps.

3.2.24 *soffit*—the underside of exposed horizontal surfaces, such as plaza decks, bay windows, roof overhangs, and heads of recessed window and door openings.

3.2.25 *water intrusion*—water originating as precipitation that penetrates beyond the water-resistive barrier of the wall.

3.2.25.1 *Discussion*—

Water that penetrates past the outermost surface of a drainage wall and beyond the water-resistive barrier that has the potential to cause deterioration of sheathing or framing. If the water penetrates in sufficient quantities or occurs chronically, the deterioration may be significant. Larger amounts of water intrusion may also result in obvious leakage to the interior and damage to the interior wall finishes, interior furnishings and equipment. Damage to framing and sheathing can occur without obvious visible leakage to the interior.

3.2.26 *water-resistive barrier*—the concealed barrier in a drainage wall system installed in exterior building walls before the installation of cladding.

3.2.26.1 *Discussion*—

The water-resistive barrier is not accessible and therefore is expected, along with associated flashings, to remain functional for the service life of the building wall system.

3.2.26.2 *Discussion*—

Specifications for water-resistive barriers include ICC-ES AC38 and CAN/CGSB 51.32-M77. Water-resistive barriers may also meet the requirements of Specification E1677 and function as air barriers.

3.2.27 *water-resistive barrier, felt-based*—asphalt-saturated felts meeting requirements of Specification D226/D226M, which defines Type I and II.

3.2.27.1 *Discussion*—

Type I felt is commonly called #15 felt and has a minimum weight of 560 g/m^2 (11.5 lb/100 ft^2) in accordance with Specification D226/D226M. Type II is commonly called #30 felt and has a minimum weight of 1270 g/m^2 (26 lb/100 ft^2) in accordance with

Specification D226/D226M. Note that some manufacturers market one "#15" felt that meets Specification D226/D226M and another "#15" felt that does not meet Specification D226/D226M.

3.2.27.2 *Discussion—*

The 2003 International Residential Code requires that felt have a minimum weight of 683 g/m^2 (14 lb/100 ft^2) and comply with Specification D226/D226M. The 2003 International Building Code and the 2003 NFPA5000 code require that felt comply with Specification D226/D226M, Type I. The ICC-ES AC38 requires that felts comply with "ASTM D226/D226M–97a."

3.2.28 *water-resistive barrier, paper-based (building paper)*—asphalt-treated kraft paper conforming to ICC-ES AC38 or CAN/CGSB 51.32-M77.

3.2.28.1 *Discussion—*

ICC-ES AC38 defines four grades that vary in water resistance from grade D (10 minutes) to grade A (24 hours). Grade D papers that exceed the minimum water resistance are available, for example, some manufacturers make a "60-minute" Grade D paper, which would have 1 hour of water resistance. The vapor permeance of the grades decreases from Grade D to Grade A. ICC-ES AC38 is based on Federal Specification UU B 790a.

3.2.29 *water-resistive barrier, polymer-based*—polymer-based barriers are proprietary polymeric sheet materials manufactured for use as water-resistive barriers. Commonly referred to as "house wraps," they typically provide air barrier functionality in addition to being a water-resistive barrier.

3.2.29.1 *Discussion—*

Standards include ICC Acceptance Criteria AC38 and CAN/CGSB 51.32-M77. Air barrier functionality is defined by Specification E1677.

4. Summary of Guide

4.1 This guide describes principles, materials and procedures for the design and construction of walls and decks of low-rise frame buildings to make them resistant to water intrusion from precipitation to minimize resulting damage.

4.2 This guide is based on the assumption that building wall systems are supposed to maintain their structural integrity for a period in excess of a traditional 30-year mortgage, and by extension, that water intrusion over that period is restricted to such a degree that water-induced structural damage is avoided. In essence the expectation is that a frame wall's water shedding functionality will remain viable over a period in excess of a traditional 30-year mortgage, given that the building is not subject to abuse, and receives a reasonable level of maintenance. This guide recognizes that not all components of a building's water-shedding system have the same life expectancies or maintenance requirements.

4.3 This guide includes both general and specific guidelines. Practical experience indicates that the guidelines, if properly implemented, will result in the assumption outlined in 4.2 being attained.

5. Significance and Use

5.1 This guide may be used by public agencies to set standards affecting the weather resistance, durability, and performance of new building wall systems, exterior deck and stair components, doors, windows, penetrations and sealant joints beyond those specifically defined in the building codes.

5.2 This guide may be used by building field inspectors as a resource for construction inspection during the construction phase of a project.

5.3 This guide may be used by private organizations or individuals to set standards affecting the weather resistance, durability, and performance of building walls.

5.4 This guide may be used by architects and engineers as a resource for making design decisions involving material selection, building wall detailing and specifications.

5.5 This guide may be used by architects and engineers as a resource for conducting submittal review and construction observation during the construction administration phase of a project.

5.6 This guide may be used by contractors as a resource and checklist for exercising field quality control.

6. General Design Principles

6.1 Guide E241 provides a comprehensive discussion of means to avoid moisture damage in buildings. It addresses water in liquid and vapor states and discusses water that enters a building either during construction or after completion.

6.2 Building wall systems must accommodate the precipitation to which they will be exposed with provision for a prudent factor of safety. Climate, building siting and building design determine the exposure to precipitation.

6.2.1 Building designs and details that have a history of successful use in dry climates may not perform adequately in wetter climates.

6.2.2 Limiting exposure of exterior walls to precipitation by using projecting elements, such as roof overhangs and flashing drip edges is effective.

6.2.3 Do not expose walls or decks to roof runoff.

6.3 Walls are most susceptible to water intrusion at joints in, and penetrations of, the exterior cladding system and at junctures of walls with roofs and decks.

6.4 Precipitation intrudes into exterior walls and plaza decks primarily by three means: gravity, wind, and capillary suction. Limitation of intrusion by these primary transport mechanisms is a basic design principle. Limitation of water intrusion past the cladding system can be brought about by a variety of means. These include:

6.4.1 Limiting the component's exposure to precipitation.

6.4.2 Limiting inclusion of features in the design that are difficult to successfully execute. For example, limit the size, complexity, or number of penetrations.

6.4.3 Designing and constructing the cladding system (in particular, the joints, interfaces, junctures and penetrations) so as to provide a reasonably effective barrier to water intrusion.

6.4.4 Design and construct the cladding system so as to limit water intrusion by gravity or wind. This usually involves the use of sealants and flashings and relies on proper integration of the sealants and flashings with each other and with the system components. The degree to which the cladding system must prevent water entry, given that precipitation exposure remains constant, is inversely related to the degree to which the wall system can dissipate water that may penetrate the cladding system.

6.4.4.1 ANSI/ASCE 7 can be used to calculate the design loads due to wind on exterior envelope components.

6.4.5 Flashing elements often need to be properly integrated not only with the cladding system and sometimes with sealants, but also with the water-resistive barrier. As implied in the definitions of drainage wall, flashing elements may be an integral part of the drainage system, and as such, must be properly integrated with both the water-resistive barrier and the cladding system to function properly.

6.4.6 Limiting water intrusion past wood-based cladding systems may also be accomplished by limiting capillary suction. This can, in turn, be accomplished by the use of cladding materials with limited capillary suction, by configuring elements of the cladding system to limit capillary suction at joints, and by use of water repellants or coatings on elements of the cladding system.

6.5 Some intrusion of precipitation past the exterior cladding system (generally at joints, penetrations and junctures) can be expected in most climates. This moisture must be dissipated, for if it accumulates, damage can be expected. Where the degree of intrusion past the exterior cladding system is limited, the required capacity for dissipation may be reduced. A construction's capacity for dissipation must be consistent with the level of intrusion. Over sufficiently short time spans, however, or within certain limits, a construction may be able to store moisture without incurring damage. Therefore, under certain circumstances, moisture storage capacity may allow a construction to tolerate a temporary imbalance between intrusion and dissipation. Some constructions may tolerate greater magnitudes of temporary imbalance between intrusion and dissipation, or more prolonged periods of temporary imbalance than others. Some constructions may tolerate imbalances of limited magnitude for appreciable time periods. No construction, however, can be expected to tolerate cumulative imbalances for long periods.

6.5.1 When some intrusion of precipitation past the exterior cladding system occurs, a water-resistive barrier, if properly manufactured and installed, has proven, within limits, to be effective at preventing further intrusion of precipitation into the wall. Prevention of such further intrusion aids in dissipation of the water from the system.

6.5.2 Moisture within exterior walls and plaza decks may be dissipated by drainage or evaporation. Dissipation by drainage is typically more rapid. Evaporation aided by air movement (ventilation) is typically much more rapid than evaporation that depends solely on vapor diffusion. For these reasons, cavity drainage walls are typically effective at dissipating moisture that intrudes through the cladding system. With or without a cavity, drainage walls can generally be considered as robust designs that can tolerate greater degrees of imperfection in construction and maintenance than can barrier walls.

6.5.3 Evaporation unaided by ventilation, although typically slower than evaporation aided by ventilation, may nonetheless be important in dissipating moisture from building wall systems, especially in wall systems with limited potential for drying by drainage or air movement. Therefore, actions or practices with the potential to inhibit drying from the wall assembly systems (for example, use of vapor retarders, see Practice C755) should not be undertaken without cognizance of this potential.

6.6 Maintenance can greatly influence durability of the exterior walls of frame buildings. Components directly exposed to exterior weather can be expected to require periodic maintenance on a schedule considerably shorter than the service life. This period is called the "maintenance interval." Access for maintenance of such components should be considered in the design. Most notable are sealant joints (which can be expected to require multiple replacements during the service life of the wall), and wood or wood-based components exposed to the weather, which can be expected to require refinishing with paint or stain or periodic application of water repellants. Seals integral with window units may likewise be expected to require maintenance or replacement within the duration of the service life.

7. Design Practices

7.1 Design practices for exterior cladding installation may be categorized as follows: *(1)* Design based on practical experience for the locality; or *(2)* Design based on understanding of principles such as those described in Section 6.

7.1.1 Design based on practical experience for the locality is the more traditional practice. In this approach, constructions are designed to emulate those that have, over the course of time, proven dependable in the locality. In practice, this approach usually involves cognizance of at least some of the principles outlined in Section 6. Designers using this approach may not, however, have reference to an organized list of principles such as described in Section 6. Because materials, products and installation methods, tools and personnel may change over time, this approach usually requires that design principles such as those described in Section 6 be recognized and addressed. This approach may also be aided by use of numerical modeling, most likely to predict how moisture conditions behind a secondary water-resistive barrier may be influenced by its vapor permeance.

7.1.2 Design based on understanding of design principles is practiced by evaluating whether a proposed construction takes the principles into account, and if necessary, altering the proposed construction so that they are followed. As implied in 7.1.1, the proposed construction may be a variant on a design that is common practice in a local area. Like designs based on practical experience, this approach may also be aided by use of numerical modeling.

7.2 Numerical modeling, using computer simulation models, can be used to predict moisture conditions within a proposed construction under a given set of conditions and assumptions. Most commonly, computer models are used to predict if a proposed construction, which may be resistant to precipitation leakage, can be expected to experience moisture accumulation as a result of vapor diffusion. Computer models may also be used to predict drying rates of walls fabricated with damp materials and enclosed before these materials dry thoroughly. Relatively simple one-dimensional hydrothermal models can be used for these purposes. Complex three-dimensional models may be used to predict moisture conditions in a given wall with assumed amounts and frequency of water intrusion into the wall. The utility of such models, however, relies on having realistic inputs for them. The more complex the model, the more inputs are required, all of which must be realistic.

7.2.1 Numerical modeling may be used to evaluate choice of a water-resistive barrier material. Modeling can estimate if a material has the appropriate vapor permeance and water resistance for a chosen wall design and climate.

8. General Guidelines

8.1 Design of installations should be by one or more of the approaches outlined in Section 7, but whichever approach is used as the primary approach, a review of the final design with regard to the principles in Section 6 should be made.

8.2 Components that are not accessible without unreasonable effort (or damage to other components that will be costly to replace) should have a service life equal to that of the cladding system.

8.3 Conform to manufacturer's most current recommendations for design and installation of proprietary products, except when such practice can be shown, with supporting rationale accepted by the designer or owner, to violate a design principle in Section 6. (**Warning—**Deviation from manufacturer's written installation instructions may void warranties. Consult manufacturer about proposed changes.)

8.3.1 Particular attention should be paid to manufacturer's recommendations that are published by building code related organizations. For example, the ICC Evaulation Service publishes Evaluation Reports that contain specific manufacturer's instructions that are to be met for approval by building officials in applicable jurisdictions.

8.4 Conform to referenced standards and industry association recommendations for design and installation of non-proprietary materials and generic products, except when such practice can be shown to violate a design principle in Section 6.

8.5 Be aware that selecting a product that conforms to a standard does not assure that the product will perform adequately in all applications. Procedures for evaluating products used in exterior walls are discussed in Guide E1825.

8.6 In the case of conflict among the requirements of this guide, manufacturer's recommendations, or referenced standards and industry association recommendations, the most stringent should be followed, unless the most stringent can be shown to violate a design principle in Section 6 or can be shown as unnecessary to meet the basic performance requirements of this guide.

8.7 Quality control during construction, specifically the use of checklists and hold points, is recommended.

8.8 Sealant joints should be designed and executed so as to permit anticipated maintenance or replacement without extraordinary or unusual effort.

8.9 Before building commissioning, the designer or builder should communicate to the building owner the anticipated maintenance life and requirements of the construction, if the requirements deviate appreciatively from conventional expectations. A maintenance manual is one way that these can be communicated to an owner.

8.10 Field testing of water penetration may be done using Test Method E1105. When testing cavity drainage walls, water penetration through the veneer of the masonry portion of a veneer wall would not necessarily indicate a failure of the wall system. Windows may be field tested by AAMA 501, AAMA 501.2, and AAMA 502.

9. Drainage Walls

9.1 *Drainage Walls—General:*

9.1.1 *Materials:*

9.1.1.1 *Water-Resistive Barrier*—Generally, a desirable water-resistive barrier membrane will have high resistance to water in a liquid form, moderate to low resistance to water in a vapor form, resistance to degradation by air, water, and ultraviolet radiation (prior to installation of cladding), resistance to tearing, and compatibility with adjacent materials, including sealants. There are several generic types of water-resistive barriers commercially available, and within those types, there is a variety of proprietary products. (Refer to 3.2, Definitions.) Currently, each of these generic types is regulated by different sets of standards. Additional physical property and performance data is published by manufacturers using a wide variety of standards. The result is that it is difficult, if not impossible, for a user to make technically useful comparative evaluations among the types and products available.

9.1.1.2 The selection of a water-resistive barrier, should take into account the nature of the cladding system. The potential for water to pass through cladding and the period of time that water may be held against the water-resistive barrier, varies from one cladding system to another. The long-term performance of a water-resistive barrier may be improved in most drainage wall systems by designing and constructing the cladding to avoid cracks or gaps, as well as providing sealed joints so that relatively little water may bypass the cladding and reach the water-resistive barrier.

9.1.1.3 Water-resistive barriers consisting of rigid board materials and liquid troweled-on materials are not addressed in this guide.

9.1.1.4 A complete installation may include a water-resistive barrier and one or more types of flashing material. Refer to 14.1.2 for a discussion of flashing materials.

9.1.2 *Design and Construction:*

9.1.2.1 Prior to installation of any cladding material or system, a water-resistive barrier should be installed over the exterior wall sheathing. The water-resistive barrier should be installed with appropriate flashing and penetration seals such that any wind-driven rain passing behind the cladding and reaching the water-resistive barrier will drain to the exterior of the wall or evaporate.

9.1.2.2 Wall water-resistive barrier will perform more effectively when installed over wall sheathing or other backing that will support the laps of the barrier permanently in tight contact. The mechanical support afforded to a water-resistive barrier membrane by rigid sheathing commonly results in significantly less damage to the membrane during construction, less cumulative wind-induced stress to the membrane in long-term service, and may reduce the likelihood of water passing through membrane laps.

9.1.2.3 Install water-resistive barrier materials horizontally with water-shedding (shingle) laps to provide a continuous barrier. Consult with manufacturers and building codes for minimum lap dimensions.[40] Exceeding minimum lap requirements is recommended as a simple method of improving reliability.

9.1.2.4 When using products that come pre-assembled with lath and water-resistive barrier (typically paper-based) in the same roll, install laps with lath on lath and paper on paper.

9.1.2.5 Procedures for fastening of the concealed water-resistive barrier depend on the type of sheathing used and upon whether the sheathing's mechanical properties permit secure fastening of the water-resistive barrier to the sheathing. Unless the sheathing has reliable mechanical properties that permit reliable fastening of the water-resistive barrier, fasteners must penetrate framing members. Workmanship in fastening the concealed water-resistive barrier is important, for the barrier may not function as intended if it is torn by careless installation of fasteners. The type of fastener used to install the concealed water-resistive barrier can affect the risk of tearing. It can be anticipated that fasteners used to install the cladding system may puncture the concealed water-resistive barrier.

9.1.2.6 Secure fastening of the cladding is of greater concern than is puncturing the concealed water-resistive barrier by cladding fasteners. Securing some cladding systems requires that fasteners engage the framing and not only the sheathing. In these systems, fasteners that do not engage the framing can result in excessive leakage through the fastener penetration of the water-resistive barrier and excessive warping, deflection or misalignment of the cladding, which can result in increased water penetration through the cladding. With a significant number of cladding systems, secure fastening requires that fasteners penetrate framing members, for example wood siding and lath for portland cement plaster (stucco) systems.

9.1.2.7 Except where adequate overhangs prevent water intrusion from wind-blown rain, roof membranes, underlayments or edge flashing should lap over the topmost portion of the wall water-resistive barrier in such a manner as to prevent water intrusion.

9.2 *Drainage Wall Cladding—Portland Cement Plaster (Stucco):*

9.2.1 *Materials:*

9.2.1.1 Conform to Specification C926 plaster materials and Specification C1063 for lath materials.

9.2.1.2 For adhered ceramic tile, thin brick, or thin stone veneer, conform to TCA Ceramic Tile Handbook.

9.2.2 *Design and Construction:*

[40] At this writing, minimum lap requirements include the following: The 2003 International Building Code states a performance criterion, "provide a continuous water-resistive barrier behind the exterior wall veneer." The 2003 International Residential Code and the 1997 Uniform Building Code require horizontal laps of, "2 in. (51 mm)" and vertical laps of, "6 in. (152 mm)." The 2003 NFPA 5000 code requires horizontal laps of, "3 in. (76 mm)," and vertical laps of, "6 in. (152 mm)." Manufacturers of polymeric water-resistive barriers have specific installation recommendations for their systems, which may be intended to have air barrier and water-resistive barrier functions. One example of a manufacturer's recommendations is horizontal laps of 150 mm (6 in.), vertical laps of 150 mm to 300 mm (6 in. to 12 in.), and use of joint sealing tape over laps.

9.2.2.1 Refer to Specification C926 for plaster application, Specification C1063 for lath installation, the PCA Portland Cement (Stucco) Manual, and ACI 524. Refer also to guides produced by regional associations, the TLPCA Lath and Plaster Systems Manual, the MLPB Stucco in Residential Construction, and the NWCB Stucco Resource Guide.

9.2.2.2 When wood panel sheathing is used in a wall that will be covered with portland cement plaster (stucco) cladding, refer to APA Installation of Stucco Exterior Finish Over Wood Structural Panel Wall Sheathing.

9.2.2.3 Soffit-type weeps and drip screeds should be installed at all intersections of vertical walls and soffits (including recessed window and door openings). Enclosed horizontal spaces should be vented between all joists.

9.2.2.4 For use with wood trim, refer to 9.3.2.1.

9.2.2.5 At wood-trimmed heads of windows, doors, and louvers and other penetrating features the joint between portland cement plaster (stucco) and wood should be protected with a sheet metal "Z" shaped flashing integrated with water-resistive barriers.

9.3 *Drainage Wall Cladding—Wood and Wood Derived Products:*

9.3.1 *Materials:*

9.3.1.1 *Wood Siding and Trim*—For horizontal siding, the siding must be pattern material[41] conforming to a siding grade by the rules of a recognized rules writing agency and graded under the supervision of an accredited inspection agency.[42] Recognition requirements for rules writing and inspection agencies are outlined in U.S. Department of Commerce DOC PS 20. Wood used for vertical board-and-batten or board-on-board siding may be of standard board configuration (that is, not pattern lumber) but should be of a grade recognized as suitable for use on building exteriors. Knot size and quality are generally recognized as determining suitability for use on the exterior surfaces of buildings. Sound tight knots will not adversely affect performance. Lumber with unsound or loose knots, which may fall out, is not acceptable. Refer to the ALSC[43] for accredited rules-writing and inspection agencies.

(1) Moisture Content—At installation, siding and trim should be at approximately the equilibrium moisture content. One guideline is to have wood moisture content within the annual range of equilibrium moisture content reported for several locations in the U.S. in "Drying and Control of Moisture Content and Dimensional Changes" in the USDA-FPL Gen. Tech. Rep. FPL-GTR-113, Wood Handbook. If the wall on which the trim or siding will be installed is exposed to appreciable amounts of direct sun, the acceptable maximum moisture content value at installation should be reduced by two percentage points from the maximum annual moisture content for a given location as reported in the Wood Handbook. Specifying kiln-dried material improves the likelihood that siding and trim will be at appropriate moisture content level at time of installation, although material that has not been adequately dried can, up to some limit,[44] be brought to an acceptable moisture content by acclimation on site. The way to assure that application occurs at an appropriate moisture level is by checking wood products with a moisture meter.[45] Storage practices by lumber wholesalers and retailers will influence moisture content level as delivered to the job site. Storage and acclimation practices by carpentry crews influence moisture content level at installation.

(2) Decay Resistance—All species commonly used for siding and trim in North America are softwood species, and are recognized as having a degree of decay resistance higher than that of the more decay-prone hardwoods (for example, aspen). Decay resistance however varies appreciably from species to species in the softwoods commonly used for siding and trim. Decay resistance also varies within species; heartwood content, and growth characteristics influence decay resistance. Redwood, western red cedar, and Alaska yellow-cedar are the most decay-resistant of the species commonly used in this application. The pines and spruces are the least decay-resistant of the species commonly used in this application. The degree of decay resistance required depends on climate, building siting and design, location on the building, siding pattern, and workmanship, and can also be affected by finish choice. Installation of siding on furring reduces the risk of siding decay, especially for flat-back sidings, (like shiplap,) that would otherwise have full back-surface contact with the water-resistive barrier. Siding exposed to appreciable amounts of direct sun, although more subject to weathering and warping, is usually less prone to decay.

(3) Dimensional Stability—Thicker and narrower boards or patterns have less tendency to cup or split. The same is true for material with vertical-grain faces, as opposed to flat-grain faces. Narrower boards and patterns will undergo the same proportional

[41] Examples of "pattern" siding are tongued and grooved, and bevel cut. The terminology and actual profile of pattern siding are determined by rules writing agencies.

[42] For lumber grading rules, refer to the publications of CSSB (Grading Rules for Certigrade Red Cedar Shingles, Grading Rules for Certi-Split Red Cedar Shakes, and Grading Rules for Tapersawn Red Cedar Shakes), NELMA (Standard Grading Rules for Northeastern Lumber), RIS (Standard Specifications for Grades of California Redwood Lumber), WCLIB (Standard No. 17), or WWPA (Western Wood Grading Rules); and SPIB (Standard Grading Rules for Southern Pine Lumber).

[43] Available from American Lumber Standard Committee (ALSC), Incorporated. 7470 New Technology Way, Suite F, Frederick, MD 21703, http://www.alsc.org.

[44] If the siding is to be installed on a wall with substantial sun exposure, adequate moisture content level is not likely to be achieved in unseasoned or minimally seasoned air-dried material by on-site acclimation.

[45] Correct use of a moisture meter includes making correction, where necessary for wood species and wood temperature at the time of reading.

amount of dimensional change as wider boards or patterns, but this translates into lesser total dimensional change. Splitting of siding is frequently the result of dimensional movement restrained by fasteners. Species of lower density, like redwood and cedar, are more dimensionally stable than higher density species.

(4) Finish Retention—Maintaining a finish (stain or paint) on lumber siding or trim will result in it staying flatter, will significantly reduce splitting and checking, and will inhibit surface erosion. Preventing surface checking also reduces the likelihood of decay establishment, which could otherwise be induced by liquid water absorption through surface checks. Penetrating stain finishes do not form surface films and will perform acceptably on virtually any wood surface. Latex stain finishes and paint finishes, on the other hand, are film-forming finishes and their performance can be greatly influenced by the nature of the wood surface. These finishes perform best on vertical-grain surfaces and on woods with gradual transitions in wood structure and density at earlywood-to-latewood interfaces (the cedars, redwood, and the white pines). Poorer performance of film-forming finishes can be expected on Douglas-fir and yellow pines (for example, Southern pine). Both film-forming and penetrating finishes perform better on rough-sawn than on smooth surfaces. Rough-sawn surfaces absorb more finish, and finish spread rates (area coverage per unit volume of finish) will thus be lower on rough-sawn surfaces.

9.3.1.2 *Hardboard,* primed panels conforming to ANSI/AHA A135.6.

9.3.1.3 *Plywood and Manufactured Wood Panels*—Exterior type, APA 303 series. Refer to APA Product Guide, Performance Rated Sidings.

9.3.1.4 *Wood Shakes and Shingles*—CSSB graded products.

9.3.1.5 *Fasteners*—Stainless steel, hot-dip galvanized steel, or non-corroding aluminum conforming to Specification F1667.

9.3.2 *Design and Construction:*

9.3.2.1 *Wood Trim* may be of standard board or pattern configuration and should be of a grade recognized as suitable for exterior use on building exteriors. Trim should be prime painted or treated with a penetrating water-resistant sealer on all sides and ends prior to installation. Note that some sealers are not compatible with paint finishes. Joints should be bedded in an elastomeric sealant that is compatible with the intended finish treatment. Embedment of joints in sealant can improve the long-term water resistance of joints.

9.3.2.2 *Wood Board Siding*—For cedar siding, refer to the WRCLA, Installing Siding. For southern pine siding refer to the SPC, Guide to Southern Pine Siding. For information on western species refer to the WWPA Natural Wood Siding: Selection Installation and Finishing.

9.3.2.3 *Plywood Siding*—For guidance on selection and finishing refer to APA Product Guide, Performance Rated Sidings. Also refer to APA publications, Avoiding Moisture Accumulation in Walls, and Buckling of Wood-Based Panel Siding.

9.3.2.4 *Hardboard Siding*—Consult the following publications of the Composite Panel Association: Recommended Basic Application Instructions for Hardboard Siding, Coatings Specification for Field-Applied Coatings on Hardboard Siding, Finishing Recommendations for New Construction Using Unprimed and Primed Hardboard Siding, Maintenance Tips for Hardboard Siding.

9.3.2.5 *Wood Shakes and Shingles*—For cedar shakes and shingles consult the CSSB Wall Construction Manual.

9.4 *Drainage Wall Cladding—Vinyl Siding:*

9.4.1 *Materials:*

9.4.1.1 Select siding materials meeting Specification D3679 and soffit materials meeting Specification D4477. For color fastness, select materials meeting Specification D6864.

9.4.2 *Design and Construction:*

9.4.2.1 Practice D4756 includes installation instructions and installation detail drawings. Refer also to guidelines contained in the VSI Installation: A How To Guide.

9.4.2.2 For use with wood trim, refer to 9.3.2.1.