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Standard Guide for Low Slope Insulated Roof Membrane Assembly Performance[1]

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1. Scope

1.1 This guide lists test methods intended to establish a minimum level of performance for insulated roof membrane assemblies, and lists pertinent design guidelines and installation methods in a unified manner. Material tests and evaluations are included with and without roof insulation.

1.2 It is not possible to establish a precise correlation between laboratory tests on roof assemblies and natural weathering due to variations in geographical climate, design, material and installation.

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

2. Referenced Documents

2.1 *ASTM Standards:*

D 95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation[2]

D 2523 Practice for Testing Load-Strain Properties of Roofing Membranes[3]

D 4434 Specification for Poly(Vinyl Chloride) Sheet Roofing[3]

D 4637 Specification for Vulcanized Rubber Sheet Used in Single-Ply Roof Membrane[3]

D 4798 Test Method for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials (Xenon-Arc Method)[3]

D 4799 Test Method for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials (Fluorescent UV and Condensation Method)[3]

D 5019 Specification for Reinforced Non-Vulcanized Polymeric Sheet Used in Roofing Membrane[3]

D 5147 Test Methods for Sampling and Testing Modified Bituminous Sheet Material[3]

D 5601 Test Method for Tearing Resistance of Roofing and Waterproofing Materials and Membranes[3]

D 5602 Test Method for Static Puncture Resistance of Roofing Membrane Specimens[3]

D 5635 Test Method for Dynamic Puncture Resistance of Roofing Membrane Specimens[3]

D 5849 Test Method for Evaluating Resistance of Modified, Bituminous Roofing Membranes to Cyclic Joint Displacement[3]

E 96 Test Methods for Water Vapor Transmission of Materials[4]

2.2 *ASCE Standard:*

ASCE-7 Minimum Design Loads for Buildings and Other Structures[5]

2.3 *ANSI/SPRI Standard:*

ANSI/SPRI RP-4 Wind Design Guide for Ballasted Single Ply Roof Systems[6]

3. Terminology

3.1 *roof assemblies*—the weathering or waterproofing material, whether film, flexible membrane, semi-flexible membrane, factory or field manufactured; the underlying substrate including insulation (if used) above or below the membrane, or both; supporting deck structure and method of attachment of the entire assembly. Low slope roof assemblies may be up to 25 % slope. Some roof assemblies may accommodate higher slopes.

3.2 *performance*—the ability of the roof system as designed, manufactured, and installed to provide adequate levels of expected service life in terms of watertightness, thermal protection, and condensation control, while being maintainable. Live loading of the roof system may also occur.

4. Significance and Use

4.1 A roof assembly must work as a system. Any component of the roof assembly demonstrating an inherent weakness or inability to perform will diminish the roof system performance

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 04.04.

[4] *Annual Book of ASTM Standards*, Vol 04.06.

[5] Available from American Society of Civil Engineering, 1801 Alexander Bell Drive, Reston, VA 20191–4400.

[6] Available from American National Standards Institute and Single Ply Roofing Institute, 200 Reservoir St., Suite 309A, Needham, MA 02194.

and service life expected. This guide lists minimum performance attributes required of low slope roof assemblies. Products not previously used as roof membrane materials require additional tests beyond the scope of this document. This guide is not intended for use on in-service roofing materials. Roof membranes and other components should conform to ASTM product standards, if available.

5. Roof Design Classifications

5.1 *Type of Construction*:

Class	Construction
I New	New
II Replace	Remove existing roof membrane (and existing insulation, if necessary) and replace
III Re-cover	Re-cover existing roof membrane

5.2 *Methods of Attachment*:

Roof Membrane Configuration	Method of Attachment
Method A Adhered	Uses a variety of adhesives including hot and cold applied.
Method B Loose laid ballasted	Uses aggregate ballast or pavers. Structure needs capacity to carry ballast dead load.
Method LD Loose laid air pressure equalization valves	Uses air pressure equalization valve with loose laid membrane tightly sealed at edge. Needs airtight deck.
Method M Partially attached/ mechanically fastened	Uses a variety of fasteners and attachment schemes that anchor membrane to roof deck for uplift resistance.
Method P Protected membrane	Uses aggregate ballast, pavers, or other dead load devices for wind uplift resistance of extruded polystyrene.

6. Roof Material Attributes

6.1 The roof membrane and insulated roof system shall be tested according to the procedures in Table 1. In addition, the

TABLE 1 Roof Material Attributes

Property	Criteria
A. Static indentation resistance Use Test Method D 5602. Tested at –18°C, 23°C, 70°C (0°F, 73°F, 158°F). Test membrane with specified insulation system over rigid concrete support. Concrete to have 50 mm (2 in.) minimum thickness with minimum compressive strength of 17.2 MPa (2 500 psi). If no insulation is used, report none.	Report static puncture resistance per Section 11 of Test Method D 5602 for each test temperature.
B. Dynamic indentation resistance Use Test Method D 5635. Tested at –18°C, 23°C, 70°C (0°F, 73°F, 158°F). Test membrane with specified insulation system over rigid concrete support. Concrete to have compressive strength of 17.2 MPa (2 500 psi). If no insulation is used, report none.	Report dynamic puncture resistance per Section 12 of Test Method D 5635 for each test temperature.
C. Cyclical fatigue—membrane only Use Test Condition 3 of Test Method D 5849 at 0°C (32°F).	Run 500 cycles. Report results per Section 11 of Test Method D 5849. If less than 500 cycles, report cycles achieved and failure mode.
D. Heat conditioning Use this sequence of tests on new roof membranes intended for exposure (smooth or granule surfaced, plain or reinforced). Membrane materials without existing ASTM material standards should follow the test conditions cited below based on color. Membrane materials with existing ASTM material standards should use the heat conditioning test called for.	
1. For black membrane materials—28 days at 80°C (176°F)	Report change in tensile strength and elongation. Report changes in sample dimension and thickness.
2. For gray membrane materials—28 days at 70°C (158°F)	Report change in tensile strength and elongation. Report changes in sample dimension and thickness.
3. For white membrane materials—28 days at 60°C (140°F)	Report change in tensile strength and elongation. Report changes in sample dimension and thickness.
E. UV radiation—membrane only 1. For unsurfaced membranes, use Test Method D 4798 or D 4799. Follow test criteria and exposure for each material standard listed; minimum 4 000 h with condensation cycle, or minimum irradiance called for in ASTM material standards.	1. <5.5°C (10°F) change in low temperature flex. 2. Report change in tensile strength and elongation. 3. No cracks. 4. Report visual appearance and note color change, if any.
F. Water exposure—membrane only 1. Run 45 cycles of immersion in water at 23°C and 50°C (±2°C) (73°F and 122°F ±4°F) for 24 h followed by dark oven heat aging at 70°C (158°F) for 24 h. Determine moisture content according to Test Method D 95 for membrane at start of test and after 45th cycle.	1. <1 % change in weight. 2. Report visual appearance and note color change, if any.
G. Moisture permeance—membrane only 1. Determine according to Test Methods E 96. Use Procedure B or BW at 23°C (73°F)	1. <0.10 perms. 2. Report conditioning, procedure and test temperature used and results.
H. Tear resistance—membrane only 1. Conduct tear resistance test at –18°C, 23°C and 70°C (±2°C) (0°F, 73°F and 158°F ±4°F) per Test Method D 5601.	1. Report tear resistance per Section 7 of Test Method D 5601 for each temperature tested.
I. Tensile strength, elongation, strain energy Membrane only per Practice D 2523; Specifications D 4434, D 4637, or D 5019; or Test Method D 5147. Include testing of lap seams where called for in the standards.	Report values of tensile strength, elongation and/or strain energy per standard used.

roof membrane shall meet specific test requirements where identified.

7. Design of Roofing Assembly

7.1 The roofing system may consist of the following functional layers from the bottom to the top.

7.1.1 structural deck

7.1.2 air retarder

7.1.3 vapor retarder

7.1.4 thermal insulation

7.1.5 roofing membrane

7.2 The following paragraphs list the minimum design requirements for each functional layer of the roof assembly. These may exceed the requirements of the local building code.

7.2.1 *Structural Deck*—The structural deck shall have the capacity to support the full design load, including dead load, live loads, and environmental loads anticipated or mandated by code. The dead load of the roof system shall be included as part of the design load. Deck deflection should be limited to L/240 under full design load. Ponding due to deck deflection should not occur. Provide overflow drains or scuppers when interior drains are used. The live load capacity shall not be less than 98 Kg/m^2 (20 psf) and should have adequate capacity to resist construction loads.

7.2.2 *Air Retarder*—Air retarders are used to retard the flow of air from the interior into the roof system. When air retarders are used properly, they reduce the effects from wind on some roofing systems. With care, the vapor retarder and air retarder functions may be provided by the same materials.

7.2.3 *Vapor Retarder*—The vapor retarder retards the transfer of the moist-warm interior vapor into the roofing system. A vapor retarder should be used on the warm side of the system over moist occupancies, and at locations where the quantity of moisture accumulated in the winter exceeds the moisture capacity of the materials in the system.

7.2.4 *Thermal Insulation*—Thermal insulation must be used wherever a building is heated or cooled except industrial facilities where excess process heat needs to be dissipated. Where used, it should be installed in two or more layers with offset joints. Tapered insulation can be used where necessary to provide a positive slope to the drains. Provide sump areas at all roof drains to assist drainage. The insulation selected must be compatible with the membrane system selected and have the heat, moisture stability and compressive resistance needed for the application selected.

7.2.5 *Roofing Membrane*—The roofing membrane may be single ply or multi-ply, depending on the materials involved. Where applicable, the properties of the roof membrane shall meet or exceed the minimum values shown in Table 1 before and after artificial weathering, heat conditioning, water immersion, and fatigue cycling.

7.3 *Roof System Design*:

7.3.1 The membrane material selected for use shall pass the tests outlined in Section 6, modified to reflect the weather extremes anticipated for the locality of use, including wind.

7.3.2 All classes of roof construction should have a positive slope to drain (2 % minimum for new construction, other than coal tar roof assemblies and l % minimum for new construction for coal tar roof assemblies).

7.3.3 Consideration for use of a vapor retarder should be given for all new roof construction and roof replacement constructions. Roof re-cover constructions shall be evaluated as a roof system with the existing roof serving as a vapor retarder, unless the existing roof membrane is cut open before re-cover.

7.3.4 Roof re-cover constructions should have no entrapped moisture greater than the equilibrium moisture content (for insulation material) at 21°C (70°F) and 90 % relative humidity, or make provisions to handle entrapped moisture in a timely fashion without degradation to the roofing assembly.

7.3.5 Mechanical fasteners that hold the membrane down, either directly or indirectly, shall be considered active fasteners. All other fasteners shall be considered passive. All fasteners shall be evaluated for corrosive resistance per Section 4.1 of the SPRI Guide.[7] Report amount of surface corrosion observed.

7.3.6 Method M roofs using mechanical fasteners should have a factor of safety of 2.0 against fastener pullout.

7.3.7 Wind uplift forces should be determined according to ASCE-7. Roof system wind uplift resistance shall have a minimum 2.0 factor of safety. For ballasted single ply roofs use ANSI/SPRI RP-4 for determining their wind uplift resistance.

7.3.8 Deck and wall movements should be accounted for in the design, including differential movements of discrete elements.

7.3.9 Design elevation of adjoining deck elements shall not differ by more than 6 mm (0.25 in.) in elevation change.

NOTE 1—Interior drains are recommended in climates where ice forms; they should be installed in the heated areas of buildings, where possible; reduce or omit insulation around drains. Gutters are only recommended in warmer climates, or where interior drains are not practical. Scuppers are generally used as emergency overflow for roofs with parapets; size scuppers large enough to allow for prompt drainage based on local rain intensity records. No part of the roofing system should be permitted to block the prompt drainage of water.

NOTE 2—*Mechanical Protection*—The mechanical protection layer helps resist impact, external fire, and in some assemblies, also protects the membrane from destructive solar radiation. Metallic skins, aggregate, stone ballast, granules, and concrete pavers are frequently used.

8. Keywords

8.1 cyclical fatigue; dynamic puncture; felts; heat conditioning; moisture content; multiple ply; roofing membrane; single ply; static puncture; structural deck; temperature; thermal insulation; wind tear resistance

[7] *Flexible Membrane Roofing: A Professional's Guide to Specifications*, published by Single Ply Roofing Institute, Needham, MA.