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Standard Practice for Selecting Wood Substrates for Weathering Evaluations of Architectural Coatings[1]

This standard is issued under the fixed designation D7787/D7787M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice offers guidelines for selecting wood or wood composite substrates for the evaluation of specific weathering performance characteristics of architectural coatings such as exterior paints, primers, and deck finishes.

1.2 Procedures include selecting wood species and choosing individual wood test panels through visual examination of the wood characteristics.

1.3 This practice is intended to cover the most commonly employed wood substrates used in weathering studies of architectural coatings. It is not intended to serve as a comprehensive guide for all wood species that may be employed for the purpose of evaluating weathering performance characteristics of architectural coatings.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4214 Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

3. Terminology

3.1 *Definitions:*

3.1.1 *weathering performance characteristic, n*—an attribute displayed by a coating after a period of exposure to natural sunlight, UV light, moisture, varying temperatures or other environmental elements.

3.1.1.1 *Discussion*—Weathering performance characteristics may include film integrity attributes such as checking, cracking, peeling, flaking, erosion, chalking; appearance attributes such as gloss or color retention; or resistance to dirt pickup, mildew, or algal defacement.

3.1.2 *wood condition factor, n*—an attribute of a wood panel that indicates its state prior to being used in a coatings performance evaluation.

3.1.2.1 *Discussion*—Wood condition factors may include duration of time since the panel was milled, chemical pretreatments, or exposure to environmental elements prior to being coated.

3.1.3 *wood panel, n*—a thin, flat substrate material composed of any species of wood or wood composite.

4. Summary of Practice

4.1 The experimenter first determines the critical weathering performance characteristics of the architectural coating being tested and determines the species and lumber grade of a wood or wood composite that is similar to the in-service application of the wood that is to be studied.

4.2 Wood species are selected based on the weathering performance characteristics of interest and the species that will likely be used for the studied application.

4.3 Individual test panels are selected based on visual observation of the following features: (*a*) growth patterns (rate of growth, % latewood, grain, etc.), (*b*) grain orientation, (*c*) characteristic feature (knots, checks, glue lines, etc.), and (*d*) color characteristics frequently associated with heartwood or sapwood of the wood and the type of wood extractives of the in service wood. Selection should be done using quantitative or qualitative criteria to ensure the best substrate representation for the test series. When evaluating multiple coating samples on the same board, in selecting the board, care must be taken to assure that the areas designated for each paint sample

[1] This practice is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.42 on Architectural Coatings.

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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.

contain similar characteristic features mentioned above to insure proper comparison of coating durability.

5. Significance and Use

5.1 Natural weathering tests can take several years and accelerated weathering evaluations often run for cycles requiring several weeks or months before obtaining useful data. Correlating wood panels selection with desired weathering performance characteristics assists a coatings experimenter in maximizing information in the desired time frame.

5.2 Because of the long time spans required for exposure testing, it is critical to plan a reliable experiment while controlling as many variables as possible. For this reason, selection of experimental panels made from representative wood species or composites, grades of lumber and surface types that are expected to be painted is very important.

5.3 This practice may be used for any types of exterior architectural coating intended for use on wood or wood composite substrate such as exterior house paints, primers, wood stains, or waterproofers.

6. Procedure

6.1 *Determine Critical Weathering Performance Characteristics:*

6.1.1 The determination of critical weathering performance characteristics is at the discretion of the experimenter depending on the performance indicators of interest for the coating system being evaluated.

6.1.2 Weathering characteristics typically of interest may include:

6.1.2.1 Film deterioration factors such as cracking, peeling, flaking, chalking, or blistering.

6.1.2.2 Ability of coating to adhere to wood or wood composite surface over extended periods as the substrate expands and contracts due to moisture, or thermal influences, or both.

6.1.2.3 Visual appearance factors such as color or gloss retention.

6.1.2.4 Extractive bleeding or other paint discoloration associated with the wood substrate.

6.1.2.5 Resistance to fungal or algal defacement.

6.1.2.6 Resistance to dirt pick-up.

6.2 Select wood characteristics for the experiment that will provide the most relevant results for the exposure experiment in the desired timeframe. Wood features and wood condition factors (as defined in 3.1.2) together with coating formulation and application method, including dry film thickness or coverage spread rate will determine the speed and extent of exhibited weathering performance characteristics.

6.2.1 Pre-weathering of wood substrates affects the weathering performance of coatings. Significant changes in the weathering results of coatings may be observed from periods of pre-weathering as short as one week. For this reason, adequate pre-weathering of panels is required if paint is to be applied sometime after wood installation on the structure.

6.2.2 Different types of wood chemical or thermal treatments, composite glue lines or type of binder used may impact a coatings performance or longevity.

6.3 *Select Wood Species (younger than 60 years old):*

6.3.1 *Southern Yellow Pine (Pinus spp.)*—This wood type is among the most commonly employed wood substrates for weathering tests due to its availability and low dimensional stability. It includes species such as shortleaf, slash, loblolly, and longleaf. Pine is often selected where film deterioration characteristics such as cracking, checking, and flaking are required. Pine boards tend to flex and expand more than other wood species in varying environmental conditions. Specific features of pine species are resin pockets and bleeding resin. For this reason, pine lumber used in a majority of architectural applications such as siding or trim boards must be kiln dried at a high temperature to set the resin.

6.3.2 *Cedar*—The term "Cedar" is a general term that can be applied for True Cedar (*Cedrus spp.*) but is also used for Western Redcedar (*Thuja plicata*) and Eastern Redcedar (*Juniperus virginiana*). Cedars generally will give a more dimensionally sound surface than Pine species. Film durability failures will normally take longer over cedar than pine. Cedar panels can be used to assess gloss and color retention, and it can be used to observe tannin stain-blocking resistance.

6.3.3 *Redwood (Sequoia sempervirens)*—Generally selected for its heavy tannin content to observe stainblocking effectiveness of architectural primers or topcoats.

6.3.4 *Pressure Treated Pine*—Includes various chemically treated wood. Pressure treated lumber is generally used for studying weathering effects of deck finishes, wood stains and waterproofing coatings. Pressure-treated pine is often selected to study erosion or film deterioration of waterproofing coatings, and long-term water repellent characteristics.

6.3.5 *Engineered Wood Trim (EWT) and Siding*—Includes manufactured wood products composed of wood segments, flakes, particles, or fiber-based composites, or combinations thereof. Use of EWT and siding now command a significant share of the wood cladding market. Thus, it is critical to evaluate these products in any general architectural finish performance evaluation.

6.4 *Selection of Wood Test Panels for Natural Weathering:*

NOTE 1—The techniques described for selection of wood test panels may be applied to any wood species and are not limited to the species listed previously.

NOTE 2—Supplementary information related to wood structure and features affecting paint performance can be found in relevant literature, including publications.[3]

6.4.1 *Panel Thickness*—Although the exact size of the wood test panel is not critical, natural weathering exposures are typically performed on boards 0.9 to 1.2 m [3 to 4 ft] in length, 13 to 20 cm [5 to 8 in.] wide, and 0.6 to 2.5 cm [¼ to 1 in.] in thickness. Boards with thickness greater than or smaller than these dimensions may affect the standard dimensional stability of a substrate, so it is recommended to use boards within 0.6 cm [¼ in.] variance within the same study for consistency. If the paint is designed for machine application, it is recommended to prepare the samples for testing using the same type

[3] Williams, R. S., *Wood Handbook, Wood as and Engineering Material 2010*, Chapter 16, "Finishing of Wood," (http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter_16.pdf).

of coaters and drying conditions as will be set up for production. In this case, panels should be of a size that they can be accommodated on the coater line. Coated samples could later be cut to the required size for testing.

6.4.2 *Moisture Content*—The panels selected should replicate the in-service applications of the wood. If the in-service application calls for dry wood, kiln dried pine boards processed under the appropriate conditions to set up resin should be used as is usually recommended for architectural applications. However, if the in-service wood is not likely to be kiln dried, then the panels should not be kiln dried. Panels that are selected should have the same moisture content that the coating manufacturer indicates is acceptable for the application. If the coating manufacturer requires dry wood, the wood should be dried to their specifications. If on the other hand the coating manufacturer's product is intended to be applied over green wood, the panel should not be dry (less than 20 % MC). Green lumber panels can be stored tightly wrapped in polyethylene film and frozen for a prolonged period of time. Before use, wrapped panels should be left on a bench for thawing and warming to room temperature as long as required. These green panels should be used as soon as possible.

6.4.3 *Wood Features*—Panels should be made from wood grades designated for a wide range of architectural applications. They should contain both heartwood and sapwood in adequate proportions and features such as knots, checks, segments of juvenile wood, bark, and pockets of resin and other features as accepted by grading.

6.4.4 *Wood Grains*—Panels of the same wood species should have a versatile grain density and ratio of latewood to earlywood as would be expected to be seen in wood architectural applications. Grain structure is related to wood density and its dimensional stability. Wood surfaces frequently contain annual ring patterns that can be classified as edge-grain, flat-grain or mixed. Paint performance is different on the edge-grain (vertical-grain or quarter-sawn) than on a flat-grain (slash-grain or plain-sawn) board surface due to different dimensional stability. Reduced adhesion of the paint to an exposed late wood surface is usually seen due to an exposed late wood surface. If a flat-grain wood surface is expected to be present in the targeted architectural application, as it frequently is, it must be adequately represented in the panels selected for paint testing.

6.4.5 *Wood Surface Finish*—Depending on the sawing and finishing equipment used, and the desired architectural appearance, the wood surface could be finished from very smooth to rough sawn. There is a known difference in paint durability on smooth versus rough wood with paint usually lasting longer on the rough sawn wood surface. For this reason, panels used for testing should have the surface milled as it is expected to be used in the targeted architectural application. If a variety of wood milling with different degrees of roughness are expected to be encountered, panels with extremely smooth and rough surfaces should be selected for testing.

6.4.6 *Wood Composites*—In the case of engineered wood products, attention has to be paid to the following: (*a*) for finger joint products, all types of glue lines must be represented for different wood segments with respect to grain density and orientation on both sides of the glue line, (*b*) for wood composite panels, the side designed by the manufacturer for exterior exposure must be identified, and (*c*) certain types of wood composites (for example, wood plastic composites) may require special surface treatment to achieve sufficient paint adhesion.

6.4.7 *Panel Grouping*—Wood panels for evaluation within a single test series should be grouped based on similar characteristics relative to the features of the selected wood species (this applies to the presence or absence of knots, or knots of certain size or type, resin pockets, heartwood or sapwood, fragments of bark or juvenile wood etc.), grain density, grain surface pattern (flat-grains and edge-grains or pitch and bark side), milling variations (smooth and rough) and moisture content. In many cases, groups of panels may contain several similar features or mixed grain patterns. If variations are present among the panels selected for testing, it is recommended that coating samples be repeated across the board variations.

6.4.8 Avoid panels that are weathered (unless this was designed in the experiment), moist (if dry wood is intended to be used), bowed, warped, have a raised grain (except when intentionally preweathered), have "encased knots," pine without properly set resin. Also, panels that are greater than 0.6 cm [¼ in.] difference in thickness than the rest of the same substrate should not be selected for the test.

NOTE 3—Long-term coating experiments have shown that any delay between initial surface preparation and application of coating negatively affects long-term paint adhesion.[4]

6.5 *Selection of Wood Panels for Accelerated Weathering:*

6.5.1 Panel size requirements vary for accelerated weathering. In some cases, a standard natural weathering test board can be configured to fit in the apparatus. In other cases, wood coupons with an exposed surface area of less than 25 cm^2 [4 $in.^2$] are required.

6.5.2 Trim panels from a single larger test board wherever possible. Use multiple test boards only if the boards have similar characteristics based on visual examination as described in 6.4.3.

6.5.3 Ensure the selected panels within the group (see 6.4.7) have the same characteristics relative to: (*1*) natural features of the wood such as the presence or absence of knots or knots of certain types and sizes, resin pockets, wood type (heartwood or sapwood) fragments of bark, pitch or juvenile wood, etc., (*2*) grain density, (*3*) grain orientation (for example, flat-grain or edge-grain, as well as orientation of the panel surface towards the pitch or bark of the log in flat grain sawn panels), (*4*) milling variations (smooth or rough sawn surface), and (*5*) chemical treatment, if any. The smaller the sample size, the more critical it is to scrutinize the similarities of the individual wood coupons and include all needed variability. Replicating samples in the experiment will also assist in obtaining complete information on accelerated weathering performance.

6.6 *Wood Test Panel Replication Strategies:*

[4] Williams, R. S, Jourdin, C., Daisey, G. I., and Springate, R. W., "Wood Properties Affecting Finish Service Life," *Journal of Coatings Technology*, Vol. 72, No. 902, March 2000.

6.6.1 Variability in weathering results is common even when wood test panels are selected carefully. As such, it is generally considered a best practice to expose replicates, at least triplicate where possible, of the same type of wood panels within an experiment.

6.6.2 Consider replication of panels with different grain patterns, milling variations, location/orientation of the board in a tree, and tree-to-tree variations within the same wood species.

6.6.3 For large studies where there are enough test coatings to require samples to be applied to multiple wood test panels before replication, a control coating should be specified and applied to each wood test panel in the study.

6.7 *Pre-treatment of Weathering Panels:*

6.7.1 All wood panels should be handled in a consistent manner during pre-treatment steps in accordance with Practice G147.

6.7.2 *Pre-weathering of Substrates*—Wood panels used in a single experiment should originate from the same weathering site and be exposed during the same period of time and to the same environmental conditions for pre-weathering. The duration, location, and parameters of pre-weathering should be agreed upon with the buyer and seller.

6.7.3 *Chalky Alkyd or Chalky Latex Panels*—Chalk panels should be prepared from the same batch of chalk-producing coating. Panels should be pre-weathered and evaluated regularly until the desired level of chalking has been achieved. Refer to Test Methods D4214 to determine the level of chalking observed in pre-treated panels. Typical studies employ panels with a chalk rating of 5; for studies requiring extreme chalking, a chalk rating of 3 may be used. The weathered surface should be cleaned following the paint manufacturer's recommendations prior to paint application.

6.7.4 *Gloss Alkyd Panels*—Gloss alkyd panels should be prepared from the same batch of alkyd coating. Gloss levels of panels in the same series should be evaluated to assure consistency in the surface being tested. Duration of aging the gloss alkyd coating before applying test paints may vary depending on experimenter preference; a typical guideline is to apply topcoat test paints after 30-90 days of curing time at ambient laboratory conditions for the gloss alkyd coating.

6.8 *Wood Panel Preparation:*

6.8.1 All wood panels should be handled in a consistent manner during specimen preparation steps in accordance with Practice G147.

6.8.2 Edges and the unexposed sides of the panels should be carefully sealed with a weather resistant coating. Particular attention should be paid with respect to the edges perpendicular to the wood fiber direction. Multiple coating applications may be required with proper coating spread rate and dry film thickness control. Consider designating one of the test coatings as a sealer for unexposed sides of the wood test panels.

6.8.3 Consideration should be taken to prepare the surface of carefully selected wood panels for consistency from board to board. The surface should be of similar quality to that is expected to be used in the architectural application.

6.8.4 Potential preparation techniques to consider include light sanding or chemical preparation treatments. Unless otherwise specified, wood panels should be clean and dry prior to coating.

6.8.5 Wood surface preparation techniques are not detailed in this practice but suggestions are often found in instructions provided on related consumer coatings products.

7. Keywords

7.1 exposure; weathering; wood substrate