Designation: D3456 – 18

Standard Practice for Determining by Exterior Exposure Tests the Susceptibility of Paint Films to Microbiological Attack[1]

This standard is issued under the fixed designation D3456; 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 provides guidelines for determining the susceptibility of paint films to microbiological attack on exterior exposure. While it is recognized that various organisms may occur on an exposed coating, the specific types of organisms are mainly of academic interest. The degree to which microbiological discoloration occurs is the primary concern.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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]

D1006 Practice for Conducting Exterior Exposure Tests of Paints on Wood

D1849 Test Method for Package Stability of Paint

D3274 Test Method for Evaluating Degree of Surface Disfigurement of Paint Films by Fungal or Algal Growth, or Soil and Dirt Accumulation

D6132 Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Coating Thickness Gage

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

3. Summary of Practice

3.1 Simple observation of a coated object subjected to exterior exposure is considered a practical and reliable method for determining the degree that microorganisms discolor the coating. However, this applies to a specific coated object exposed under a given set of conditions. It should be recognized that there are critical factors that influence the amount of fungal growth that may occur on the same coated object when exposed to other conditions. These factors include the geographic location, local atmospheric conditions such as the dust and pollen content of the air, angle of exposure, degree to which the coating is subjected to weathering, effects of moisture and sunlight, the substrates on which the coating is applied, and the coatings in the paint system under test. The latter factor includes the stability of the coating while packaged in the container, as well as the composition of the coatings included in the total system and the thickness of each coating applied. Thus, while microorganisms occur on the surface of the last film applied, the degree of microbiological growth that will occur is also influenced by the composition of the undercoats. All the above factors should be considered in the selection of a coating resistant to discoloration by microorganisms.

4. Significance and Use

4.1 The growth of fungi and algae in and on the surface of paint films represents a major cause of discoloration or disfigurement of painted surfaces. This practice covers the preparation of coatings for testing, their application on substrates, and the arrangement of the coated panels on exterior test fences to determine the degree of microbiological attack that may occur on the surface of the coatings over a period of time. This practice is intended to provide guidelines for, and a discussion of, the various factors critical in selection of exterior coatings resistant to discoloration or disfigurement by algae and fungi.

[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 D01.28 on Biodeterioration.

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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.

5. Preparation and Application of Coatings

5.1 *Conditioning of Coatings Prior to Application*—Individual coatings to be used in the paint system should be properly aged under suitable conditions prior to testing. Hydrolysis, amalgamation, absorption, and other physical and chemical changes that may have a profound influence on the resistance of a coating to microorganisms usually increase with increasing temperature. It is recognized that actual storage periods of paints prior to use may vary from one to several years, and the peak temperature encountered may be as warm as 70°C (160°F). However, a recommended conditioning period consists of 1 year at room temperatures or 1 month at 50°C (125°F) as in Test Method D1849. The conditioning of coatings prior to testing shall be agreeable to the producer and the user in the case of a referee test.

5.2 *Preparation of Coatings for Application*—Prior to application of the various coatings to be included in the total paint system, thoroughly reconstitute each coating by appropriate mixing or shaking. At the time of application, there must be no settling, incompatibility, or other stability problem observable in the coating in the container.

5.3 *Application of Paint System*—Apply each coating in the total paint system in an appropriate manner to provide a specified and reasonably uniform film thickness. The presence and thickness of different coatings in the complete system can have a pronounced effect on the degree of microbiological discoloration that will occur. Thus, each paint in the system must be applied as recommended by the manufacturer. It is important that the producer and the user agree on the type of coatings and the spreading rate of each coating in the final test film (Note 1). The drying time between coats and the curing time of the total system prior to exposure should also be specified. Recommended practice for house paint is 2 days between coats and no less than 7 days and not longer than 1 month prior to the exterior exposure. Industrial and industrial maintenance coatings may require a different practice that should be acceptable to the producer and the user.

NOTE 1—Coating thickness can be confirmed with Test Method D6132 and/or Practice D7091 and may be reported in the final report if performed. Alternatively, coating thickness can be recorded by spread rate (for example, grams/square cm).

5.4 *Test Surface Area*—On each substrate use a test area not less than 310 cm^2 (48 $in.^2$) in size. When only one type of substrate is being used, expose at least duplicate panels. When more than one substrate is employed for each exposure condition, duplicate panels of each substrate are not usually required. In case of a referee test, it is recommended that replication and size of test area be agreed on between the producer and the user. Common practice in the industry is to use 152 by 915-mm (6 in. (nominal) by 36-in.) panels for house paint exposures and to use 305-mm (12-in.) metal panels of various widths for exposures of industrial and industrial maintenance coatings.

6. Substrates for Testing

6.1 *General Considerations*—The substrate on which a paint system is exposed can have a significant effect on the degree of microbiological discoloration that may occur. Coated wood surfaces generally support more mold and algae than do coatings on metals or masonry surfaces. This is perhaps due to some nutrients and greater porosity for retention of available moisture in wood surfaces. The type of metal substrate can have either an adverse or beneficial influence on the growth of fungi and algae. Some metals can inactivate certain microbiocides, thereby allowing greater microbiological discoloration. It should also be recognized that metals may also reduce the growth of microorganisms because of toxic compounds resulting from weathering of the metal. Masonry surfaces generally inhibit microbiological growth because of their alkaline nature. However, this same characteristic can contribute to microbiological discoloration by hydrolyzing alkali-sensitive microbiocides that may have been used in the coating. The recommended substrates for testing coatings for resistance to discoloration by microorganisms vary according to the intended use of the coatings. In referee cases, the substrate for testing shall be mutually agreeable to the producer and the user. Industrial coatings should be evaluated on the surface for which they are designed. Trade sales and industrial maintenance coatings are general-purpose coatings and should perform on a variety of substrates. For such coatings, test exposures on the following substrates are recommended for the indicated reasons.

6.2 *Wood Substrates*—Sapwood of pine and fir generally is considered conducive to growth of microorganisms. This may be due to nutrients in the wood and to the low dimensional stability, resulting in microcracking of coatings applied on the wood with subsequent mold growth in these cracks. Plywood, hardboard, and other wood-derived products support varying degrees of fungal growth depending on the nutrient value, degree of moisture absorption, and dimensional stability of the base material. Redwood tends to have better dimensional stability and otherwise has insignificant effect on the microbiological growth on coatings applied over it. Cedar lumber generally contains compounds that aid in resisting microbiological growth. Both cedar and redwood contain colored extractives that can bleed through coatings to discolor the surface. Some of these extractives can also be nutrients that contribute to microbiological growth, resulting in added discoloration.

6.3 *Metal Substrates*—Iron, galvanized steel, and aluminum are common substrates for paints. Iron and zinc compounds generally inhibit microbiological growth. On the other hand, these metals may react with certain microbiocides to reduce the microbiological inhibition. Certain microbiocides can also cause discolored corrosion products or loss of adhesion by the coating on these surfaces. Aluminum is rather chemically inert and does not itself promote microbiological growth. It may, however, cause loss of microbiological resistance of coatings containing certain mercury compounds because of the amalgamation reaction by aluminum and mercury. This can result in loss of adhesion.

6.4 *Masonry Substrates*—The extremes of masonry surfaces generally consist of two conditions: fresh surfaces, which are relatively alkaline and free of fungi and algae, and weathered surfaces that are less alkaline and may be discolored because of microbiological growth. Weathered masonry surfaces represent useful test surfaces since microbiological contamination can grow through inadequately preserved coatings from the underside. Weathered masonry surfaces also offer a relatively uniform surface from panel to panel. Such uniformity is useful in statistically determining the relative effectiveness of various coatings or of various wash solutions for cleaning or "sterilizing" a surface before repainting. Exposures of coatings on both clean masonry panels and weathered panels can provide useful results and both are recommended as test substrates.

6.5 *Moldy "Mildewed" Repaint Surfaces*—Weathered paint films that are discolored by microbiological growth are also useful in determining the efficacy of wash solutions to clean or "sterilize" an old paint film prior to repainting. Such moldy repaint surfaces also are useful in determining the resistance of a coating system to discoloration due to microorganisms growing through the paint system from the underside.

7. Arrangement of Coated Panels on Exterior Test Fences

7.1 Paint systems should offer long-term resistance to microbiological growth both in completely exposed areas and in shady, protected areas. Where sunlight and moisture are in abundance, chalking will occur. However, chalking is slow to occur in shady areas. Thus, an effective microbiocide for a coating must have long-term light stability, heat resistance, and be sufficiently soluble and toxic to cause microbiological inhibition, and it must have limited solubility or leachability from the coating system such that it remains in the system for sufficiently long periods of time. Ideally, it should not induce chalking for cleaning of the surface, since such chalking will cause fading or tinted paints.

7.2 The most realistic conditions of exposure can best be realized on the exterior of houses. Unfortunately, buildings with the various substrates and located in desirable localities and geographic locations are seldom available. However, comparisons of various coating systems can be made by exposing coated panels on exterior test fences. Positions of exposure should vary to include completely exposed weathering conditions and also protection from weathering. The exposed conditions are useful in determining the influence of temperature, sunlight, moisture, various substrates, and subsequent chalking on a coating. The protected, shady exposures are useful in determining the relative microbiological inhibition of coatings in the absence of chalking.

7.3 Construction of test fences for *protected or shady conditions* can be similar to that given in Practice D1006 but modified to provide for a larger test area in the protection of an eave. A protected area under an eave facing north best represents the desired conditions. This eave should have a minimum of 455 mm (18 in.) overhang. The panels should be exposed in a lapped position as would be encountered with wood siding on a house. The test area for each system should begin immediately under the eave and continue down the test fence to a point at least 610 mm (2 ft) below an imaginary horizontal line, which is derived by projecting at a 45° angle from the outer edge of the eave, downward and inward to the test panels. Thus, an 18-in. eave would require a minimum of 1.06 m (3.5 ft) of test panels, beginning immediately under the eave down to the bottom edge of the exposure area. The inverted horizontal surface of the soffit under the northerly eave is an ideal test environment as well. Also, this area does not usually collect excessive dirt. Thus, any microbiological discoloration is readily apparent.

7.4 Construction of test fences for *exposed conditions* can be similar to that in Practice D1006 but modified to provide for offset panels held at an angle of 5° (±5°) off vertical facing south. Construction should allow exposures such that moisture falling on the test area of one panel will not drip on the next panels below.

8. Geographic Location of Test Fences

8.1 The climatic and environmental conditions of the test fences should be similar to those of the areas in which the paint system is intended for use. For coatings to be used nationally, it is desirable to expose in warm and humid environments. Exposures should be made in both shady conditions and in direct sunlight. It should be recognized that the microflora occurring in different parts of a country will vary so that mold and algae encountered in one test location may not necessarily be those of another.

9. Periods of Exposure

9.1 The time of the year when the initial exposure is first made can be critical. Because of differences in weather from year to year, results of exposures from one year to another may also vary. In order to compare the tendency for two or more paint systems to become discolored through microbiological growth, it is advisable that the paint systems be exposed at the same time. It is frequently desirable to include both a positive and a negative control. The negative (fail) control is a paint system known to discolor quite severely under standard exposure conditions and may be used on each panel. A positive (pass) control is a paint system that will perform reasonably well in the same known exposure conditions.

10. Ratings for Microbiological Discoloration

10.1 Ratings must be made in accordance with Test Method D3274 (See Note 2.).

NOTE 2—If ratings are performed using any other evaluation system, that system must be agreed upon by all parties involved and be clearly defined and described in the report.

10.2 It is desirable to obtain mold ratings prior to initiation of chalking and erosion, since it is prior to this occurrence that a paint film is most prone to discoloration by spore-cluster type (dirt-like) mold growth. Chalking can occur within several months, or it may never occur, depending on the paint formulation and its exposure to weathering conditions. Therefore, mold ratings are suggested after 3, 6, 9, 12, 18, and 24 months and yearly thereafter. Make yearly inspections immediately following seasonal growing conditions. Most extensive microbiological growth usually develops during periods of warm and humid weather. Thus, make any ratings of microbiological discoloration immediately following the warm, humid period of the year.

10.3 The following reporting criteria must be include in the report:

Exposure Period:

Location:

Test conditions—weather report (average and/or unusual) during exposure period:

Sample pre-treatment:

Sample coating descriptions (color, coating composition):

Sample preparation details (substrate, film thickness, number of coats, application tools):

Spatial orientation (angle and compass direction):

11. Keywords

11.1 exposure; exterior; microbiological paint films