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Standard Test Method of Accelerated Laboratory Test of Natural Decay Resistance of Woods[1]

This standard is issued under the fixed designation D 2017; 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 test method covers the evaluation of the natural decay resistance of wood. The test method may also be used to evaluate the resistance of wood products or of other organic materials subject to decay by wood-destroying fungi, such as those employed in the test.

1.2 *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]

D 1413 Test Method for Wood Preservatives by Laboratory Soil-Block Cultures

D 3507 Test Method for Preservative Penetration and Differentiating between Heartwood and Sapwood

3. Significance and Use

3.1 This test method is useful in determining the relative decay resistance between various species of wood. It is an initial means of estimating the ability of a wood species to resist severe microbial attack and, thereby, qualifying the performance level of a wood species.

3.2 This test method is not intended to provide quantifiably reproducible values. It is a qualitative test method designed to provide a reproducible means of establishing relative decay resistance between various species of wood.

4. Summary of Test Method

4.1 Wood samples in the form of small blocks that represent the timber species or product to be evaluated are exposed in decay chambers to pure cultures of decay fungi. The decay fungi are grown on a feeder strip of decay-susceptible wood or on filter paper placed on the substrate in the chamber. The test blocks are weighed before and after exposure, and any loss in weight is the measure of decay susceptibility or resistance of the wood. The test is terminated when nondurable, wood reference blocks indicate a weight loss of 50% or greater, or after 16 weeks. It is permitted to extend the test beyond the 16-week period for special investigations.

5. Apparatus

5.1 *Conditioning Chamber or Room*, maintained at a selected temperature between 20 and 30°C and a selected relative humidity between 25 and 75% The selected temperature shall not vary more than ±1°C and the selected humidity not more than ± 2%. It may be advantageous to have the same temperature and relative humidity as specified for the incubation room (5.2)[3].

5.2 *Incubation Room* (or cabinets), with temperature maintained at a selected temperature between 25 and 27°C and a relative humidity between 65 and 75%. The selected temperature shall not vary more than ±1°C and the relative humidity by ±2%.

5.3 *Balance*, direct-reading type preferred, sensitive to 0.01 g.

5.4 *Trays*, made from screening that permits free air movement around each block during initial drying and for convenient handling of the test blocks.

5.5 *Culture Bottles*, cylindrical or square 225 mL, or cylindrical 450 mL with a mouth diameter of at least 32 mm and fitted with metal screw caps free of cap liners (Fig. 1). An alternate lid using a 25 mm autoclavable filter with a pore size of 0.2 microns is acceptable to reduce or prevent mite infestation for the duration of the test. The lids are prepared by first drilling a centered 0.64 mm hole, then lightly sanding the interior of the lid with medium grit paper to ensure adhesion. The filter is glued on the inside using a small amount of high temperature silicon or slow curing epoxy. Allow the adhesive to cure overnight.

[1] This test method is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.06 on Treatments for Wood Products.

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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.

[3] For a simple apparatus for relative humidity control, see Scheffer, T. C., "Humidity Controls for Conditioning Rooms," *Forest Products Laboratory Report* No. 2048, USDA, Forest Service, January 1956. Small centrifugally actuated mist dispensers used for humidification in homes have been found satisfactory for this purpose.

5.6 *Steam Sterilizer*

5.7 Conventional equipment and glassware for culturing and aseptic handling of fungi and test material, such as drying oven, autoclave, refrigerator, nutrient medium, transfer needles, forceps, Petri dishes, and test tubes.

6. Test Fungi

6.1 Test fungi shall consist of cultures of the following wood-rotting fungi:[4]

6.1.1 *For Testing Softwoods: Gloeophyllum trabeum* Pers. ex. Fr. (ATCC No. 11539), and *Postia placenta* (Fr.) M. Lars. Et Lomb. (ATCC No. 11538).

6.1.2 *For Testing Hardwoods: P. placenta* (Fr.) M. Lars. Et Lomb. (ATCC No. 11538). *G. trabeum* Pers. ex. Fr. (ATCC No. 11539), and *Trametes versicolor* (L. ex. Fr.) Pilát. (ATCC No. 42462).

7. Culture Media

7.1 *Malt Agar Substrate*—The nutrient medium, which shall be used for the stock test tube cultures and for Petri dish cultures of the test fungi, shall be 2% malt extract and 1.5% agar by weight or an equivalent nutrient. It shall be sterilized at 103 kPa steam for 20 minutes.

7.2 *Soil Substrate*—A supply of loam soil to provide a substrate for the fungus. The soil shall have the following characteristics as described and evaluated in Test Method D 1413, section 8.2.

7.2.1

7.2.2 water holding capacity between 20 and 40%.

7.2.3 pH between 5.0 and 8.0.

7.2.4 oven dry weight of 120 cm^3 is 90 g or better.

8. Sampling

8.1 *Species of Wood* should be identified by standard procedures.

8.2 *Samples from Trees*—In sampling a timber species for standard evaluation of decay resistance, only the heartwood shall be used. No sapwood is durable where conditions are favorable for decay. For general appraisal of a timber species, select samples of wood from the lower most 4.5 m of the trunk, and insofar as possible, from the outer third of the heartwood radius, and from both sides of the trunk. The wood should be of representative quality for the species in respect to freedom from defects, rate of growth, and density. Enough trees and areas should be sampled to reveal any significant within-species variation in decay resistance. The more important the species and the wider its growing range, the greater the number of trees that usually will be needed to accomplish this; the minimum number for standard evaluation should in any case be 20. Tree diameters (D.B.H.), specific gravity and age of the sample trees, if determinable, should be included in the record.

8.2.1 Decay resistance of heartwood in some species varies markedly according to position in the trunk. It is important, therefore, that the approximate position of sampling be uniform. The outer heartwood of the lower trunk represents, better than any other place that might be sampled, the bulk of the heartwood in a tree, and the wood there is typically the most decay resistant.

8.2.2 In some instances, particularly in tropical hardwoods, there may be no visible heartwood and sapwood zones. With such woods, the sampling should extend across the outer one-third of the entire radius. The presence of any sapwood may be apparent in the results and can be grouped accordingly.

8.2.3 For all comparisons of decay resistance involving different trees, select the test samples of wood of different species from trees of comparable diameters and normal growth rates.

8.3 *Samples from Lumber*—If the decay resistance of wood from trees of strictly sawlog size is of primary interest, a species may be evaluated on heartwood obtained from lumber. The sample board should be randomly selected for normal quality from storage piles to make it probable that each board is from a different tree. Sampling procedures should ensure that the principal areas on which the species is grown are represented. The total number of boards and sampling areas needed per species depends on the importance of the species and the expanse of the growing region. The minimum number of boards for any species should be 40.

8.4 *Samples from Wood Products*—When it is necessary to sample a wood product as a means of evaluating a species, the objectives of sampling should be the same as noted in 8.3 for lumber. Unless wood product sampling accurately represents the wood species, this source of samples should be avoided unless the product itself is of chief interest.

9. Test Specimens

9.1 *Preparation of Specimens (Test Blocks)*—The samples shall be sawed into block specimens 25 by 25 by 9 mm in size, with the 9-mm dimension in the grain direction (see Fig. 1). The blocks shall be of normal growth rate and density, and be

NOTE—In practice, the test block is not inserted until the bottle has been inoculated and the test fungus has covered the feeder strip. This figure illustrates the use of one feeder strip and one block. The use of larger bottles allowing two feeder strips and two blocks for each block is permitted (see 5.5).

FIG. 1 Test Bottle Containing Soil, Feeder Strip, and Test Block

[4] These test fungi are available from the American Type Culture Collection, 1549 Manassas VA (www.atcc.com).

free of knots and abnormal amounts of resin or gums, and be without visible evidence of fungus infection. The blocks shall be labeled as to source promptly after sawing. A waterproof, ballpoint pen or a steel die are very satisfactory for this.

9.2 *Number of Blocks*—If the source of material for evaluation is from trees, then at least 20 samples shall be used. Each sample shall produce six blocks for each of the appropriate test fungi.

9.2.1 If the source materials are from boards or lumber, then samples shall be obtained from a minimum of 40 sample boards. Each sample board shall provide at least three (3) blocks for each of the appropriate test fungi.

10. Supplementary Blocks

10.1 *Reference Blocks*—If a softwood or softwood product is being tested, prepare 32 blocks (16 per fungus), of pine (*Pinus* sp.) sapwood, (Test Method D 3507),[5] or of some other coniferous wood of comparably low decay resistance; for example, either heartwood or sapwood of true fir (*Abies* sp.) or spruce (*Picea* sp.). If a broad-leaved species (hardwood) is being tested, prepare 48 sapwood blocks (16 per fungus) of sweetgum or of some other hardwood of comparably low decay resistance; for example, sapwood of beech (*Fagus*), birch (*Betula*), or maple (*Acer*). All reference blocks shall have the same dimensions as the test blocks (9.1). Obtain the oven-dry weights, R_1, of these blocks. The blocks will be subjected to decay in the manner and at the same time as the test blocks, and the progress of their decay will be used as a guide for terminating the incubation with the respective fungi (see 13.6). The terminal weight losses in these blocks also will serve as points of reference, establishing the fact that the test was of standard severity.

10.2 *Feeder Strips*:

10.2.1 *Wood Feeders*—Prepare a wood feeder strip for each culture bottle (one strip for 225 mL, and two strips for 450 mL bottles) to be inoculated with *P. placenta* or *G. trabeum.* Make the strips of any species having low decay resistance. Cut the strips from quartersawn or edge-grained stock 3 by 29 by 35 mm with the longest dimension parallel to the grain.

10.2.2 *Filter Paper Feeders*—Make a feeder strip of filter paper (qualitative coarse porosity) 29 by 35 mm for each culture bottle to be inoculated with *P. versicolor*. Alternatively, a non-durable hardwood feeder strip meeting the size and grain orientations provisions of 10.2.1 is acceptable for use.

11. Conditioning and Initial Weighing of Test Specimens

11.1 Place the labeled test blocks on screened trays and bring them to equilibrium weight in the conditioning room. Weigh them to the nearest 0.01 g. If the scale is outside the conditioning room, transfer the blocks to the scale in a closed container, so as to avoid weight changes due to differences in relative humidity between the conditioning and the scale room. This weight, W_1, will be the basis for determining the weight loss caused by decay during the test (Section 15).

[5] For differentiating heartwood and sapwood see "Color Tests for Differentiating Heartwood and Sapwood of Certain Oaks, Pines, and Douglas-fir," *Forest Products Laboratory Technical Note 253*, USDA, Forest Service, revised June 1954.

12. Preparation of Test Bottles

12.1 Shortly before the decay phase of testing is to begin (see Appendix), put into the culture bottles the water, loam soil, (see 7.2) and feeder strip, in order, as described in 12.2 and 12.3 and as illustrated in Fig. 1.

12.2 *Addition of Water*—The percentage of water in the bottled soil shall be 130 % of the water holding capacity of the soil (see Test Method D 1413, Section 9.2.2, Preparation of Culture Bottles, to determine the amount of water to add to a culture bottle. Measure the water into the bottles first. (The sequence of first water and then the soil leaves the glass surfaces clean above the soil level in the bottles. The water diffuses upward through the soil.)

12.3 *Addition of Soil and Feeder*—After the required water is added to the culture bottle, add the soil. This is conveniently done by volume measure, using a scoop of adjustable capacity and set to deliver the needed weight of soil. A funnel with a stem of large diameter that reaches nearly to the bottom of the culture bottles can be used to add the soil with a minimum dust settlement on the glass. Level the soil surface before it becomes wet, by gently shaking the bottle, Place the feeder on the soil (see 10.2).

12.4 *Sterilization of Bottles*—Stram sterilize the prepared bottles, with caps loosened, at 121°C for 30 min. When cool, the bottles will be ready for inoculation.

13. Decay Procedures

13.1 Make provision for coordinating the preparation of the test cultures, conditioning of the test blocks, inoculation of the bottles, and subsequent procedures. Scheduling of a typical test is outlined in the Appendix.

13.2 *Inoculation of Bottles*—After the sterilized culture bottles are thoroughly cooled, cut the fungus inoculum, approximately 10 mm square, from the growing edge of a Petri dish culture and place it on the soil next to and in contact with the edge of the feeder strip. Incubate the inoculated bottles, with lids released by a slight turn from a tightened position, at 26.7 ± 1°C and 70 ± 4 % relative humidity for approximately 3 weeks, or until the feeders are covered by mycelium. The bottles are then ready to receive the test blocks.

13.3 *Sterilization of Test Blocks*—Sterilization by ionizing radiation is the preferred method and avoids driving off volatiles that may be removed using other methods. The specimens shall be arranged parallel with each other and flat within a polyethylene envelope sealed with hot iron welding. The polyethylene sheeting shall be at least 90 microns in thickness (see Note 1). The envelopes are subjected to a radiation level of 2.0 to 2.5 Mrad when using radioisotopes or 2.0 to 5.0 Mrad if electron accelerators are used. After irradiation the envelopes may be stored for several weeks. When ready to insert the blocks into the bottles, open the envelope under aseptic conditions.

13.3.1 Other methods of sterilization are acceptable (steam, microwave, gases) but volatiles in the blocks may be driven off. If steam sterilization is used, put the conditioned and weighed test blocks into tightly closed containers and steam them at 100°C for 20 min.

NOTE 1—While the sheet can be welded on three sides, it is more

practical to use sheeting available as a roll. It is advisable to reduce the oxygen content of the envelope through the introduction of nitrogen gas. The sealed envelopes are sent to an irradiation center.

13.4 *Exposing of Test Blocks*—After sterilization, place the cooled blocks in the culture bottles, with cross-section face down on the feeder strips. If 225-mL bottles are used, add one block to each bottle; if 450-mL bottles are used, allow two blocks for each bottle. This should be done aseptically, using sterilized forceps, to avoid mold contamination. Allow for aeration of the jar by using the filtered lid or by unscrewing them one-quarter turn. Then place the bottles in a dark incubation room. To avoid losing the identity of any blocks that may become severely decayed, it is desirable to label the bottles as well as the blocks.

13.5 *Exposing the Reference Blocks*—Expose the reference blocks (see 10.1) at the same time and in the same manner as the test blocks.

13.6 *Timing the Exposure Period*—At the end of 8 weeks' incubation, remove two reference blocks, carefully brush off the mycelium, ovendry, and weigh them promptly, and record the weight as R_2. Withdraw, dry, and weigh additional pairs of blocks at weekly intervals and terminate that portion of the test to which a particular group of 12 reference blocks pertains when a curve of the weight losses versus time reaches the 50 % level. Calculate the percent weight loss as follows:

$$\text{Weight loss, \%} = [(R_1 - R_2)/R_1] \times 100 \quad (1)$$

13.7 The 16 replications of a given series of reference blocks will ordinarily permit weekly removals of block pairs after 8 through 15 weeks' exposure. If 50 % weight loss does not appear attainable in 16 weeks, the severity of the test or the selection of reference wood must be considered inadequate, since the test fungi and prescribed procedure will ordinarily cause a 50 % loss in a nondurable wood such as those listed in 10.1 within 12 weeks.

14. Handling Blocks After Exposure to Test Fungi

14.1 At the end of the exposure period (see 13.6), remove the test blocks from the bottles, and carefully brush any surface fungus growth from the test blocks. If any block is so badly deteriorated that the label cannot be read, place it in the inverted lid of the culture bottle, and label the lid according to the identifications carried on the bottle. Then place the blocks on screen-bottom trays to air dry for several days, and again condition them to constant weight in the conditioning room. Weigh to the nearest 0.01 g and record each weight as W_2.

15. Calculation of Weight Losses

15.1 Calculate the percent weight losses in the individual test blocks from the conditioned weights before and after exposure to the decay fungi as follows:

$$\text{Weight Loss, \%} = [(W_1 - W_2/W_1)] \times 100 \quad (2)$$

16. Evaluation of Results

16.1 The percent weight losses in the test blocks provide a measure of the relative decay susceptibility or, inversely, of decay resistance of the sampled wood or material. With the incubation period prescribed, losses may range from 0 to about 70 %. If a wood is highly decay resistant, slight gains in weight are often indicated, or there may be apparent slight losses without accompanying visible evidence of decay. Such results are a normal accompaniment of most tests and do not reflect any objectionable lack of prevision in the procedure. The percentage of residual wood in the test blocks (100 – percentage loss) furnishes a measure of relative decay resistance. Since decay resistance is positively correlated with the percentage of residual wood, residual weight is sometimes preferable to weight loss for indexing decay resistance.

16.2 Decay resistance may also be described in more general terms that meet most practical needs. Based on the reputations for durability of a sizable variety of woods and on test data, the following relations have been developed and are suggested for general use in interpreting either weight losses or residual weights: The relations suggested were established and confirmed through tests of a number of woods. The considerable background of underlying data indicate that there is comparatively good agreement between weight losses in the test as described and service experience with the tested woods.

Average Weight Loss (%)	Average Residual Weight (%)	Indicated Class of Resistance to a Specified Test Fungus
0 to 10	90 to 100	Highly resistant
11 to 24	76 to 89	Resistant
25 to 44	56 to 75	Moderately resistant
45 or above	55 or less	Slightly resistant or nonresistant

Examples of domestic heartwoods, indicated by both test and reputation to be prevalently in the foregoing classes of decay resistance when in ground contact are as follows (see Note 2):

16.2.1 *Highly Resistant or Resistant*—Redwood, western red cedar, black locust, and white oak.

16.2.2 *Moderately Resistant*—Douglas-fir, western larch.

16.2.3 *Slightly Resistant or Nonresistant*—Hemlocks, true firs, spruces, beech, and birches.

NOTE 2—Woods do not necessarily occupy the same relative position in order of decay resistance when subjected to ground contact as when exposed above ground. Results obtained with the test fungi *Postia placenta* and *Trametes versicolor* have indicated the class of decay resistance to be expected with ground contact. *Gloeophyllum trabeum*, although less able to attack resistant woods than the others, is believed to better index the class of resistance to be expected above ground.

17. Report

17.1 Reports of test results for a given wood or product shall contain concise information and data on essential features of the samples and testing including:

17.1.1 *For Tests of Wood*:

17.1.1.1 Species of wood and the test fungus.

17.1.1.2 Character of sample source (that is, trees, lumber, or product).

17.1.1.3 If tree sampling, tree diameters (D.B.H.; range and average). Also tree ages, if obtainable, and the average specific gravity of the sampled wood.

17.1.1.4 Geographical distribution of samples, and the number of trees or boards sampled in the respective localities.

17.1.2 *For Tests of Wood Products*:

17.1.2.1 Essential composition of the product, and the test fungus.

17.1.3 *For Either Wood or Wood Products*:

17.1.3.1 Duration of exposure and the average weight loss in the reference blocks removed at the time the exposure was terminated. The average weight loss would be indicated by the mean value derived according to Eq 1.

17.1.3.2 If there were any deviations from the standard procedure, they shall be fully described.

17.2 Results shall be reported in terms of the average percentage weight loss or percentage residual weight, or both, for each kind of wood or product, including a suitable statistical analysis to indicate the variability of the data. In the case of a wood species, report also the percentage of trees or boards that exhibited different levels of decay resistance; for example, as determined by the classification scheme shown in 16.2. In addition to an overall summary of results for a particular wood or product, summarize the data relative to any specific sampling variables (for example, diameter class of sampled trees, or the sampling locality) with which the decay resistance shows a practically significant amount of correlation.

18. Precision and Bias

18.1 This test method is dependent upon the physiological action of living organisms and care should be taken to avoid inferring that the results are quantitatively repeatable or reproducible. The relative efficacy on performance of the individual experimental levels should be obtainable, but repeatability and reproducibility as it relates to some absolute relationship between treatments should not be anticipated.

19. Keywords

19.1 decay; evaluation; laboratory; natural; resistance

APPENDIX

(Nonmandatory Information)

X1. TIMING OF STEPS IN PREPARING TEST BOTTLES AND IN EXPOSING TEST SPECIMENS TO DECAY

X1.1 The following sequence of procedures will serve as a guide in conducting the decay phase of the testing. The procedures will be initiated about the same time as, or shortly before, conditioning and initial weighing of the specimens described in Section 10.

X1.1.1 *First Day*—Inoculate Petri dishes (or equivalent) with the test fungi, to provide inoculum for the test bottles (see 13.2). A 100-mm dish will supply inoculum for at least 50 bottles.

X1.1.2 *3rd to 10th Day*—Prepare test bottles (Section 12).

X1.1.3 *10th to 14th Day*—Inoculate test bottles (see 13.2).

X1.1.4 *35th Day*—Expose blocks (see 13.4 and 13.5).

X1.1.5 *83rd to 140th Day*—Determine weight losses for reference blocks (see 13.6); stop the test when the prescribed 50 % weight loss is indicated.