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Hubble Space Telescope view of the Lagoon Nebula.
(Photo courtesy of NASA/ESA)

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Wood preservative testing

Most wood species used in commercial and residential construction have little natural biological durability and will suffer from biodeterioration when exposed to moisture. Historically, this problem has been overcome by treating wood for outdoor use with toxic wood preservatives. As societal acceptance of chemical use changes, there is continual pressure to develop and market new types of durable wood products. In the last few years, several new types of wood preservatives have become available, and other new formulations are expected to appear on the near horizon. There is also increasing interest in nontraditional wood products, including wood–plastic composites (WPCs), chemically modified wood, and thermally modified wood, which are believed to be as durable as traditional wood products, yet are nontoxic. The rapid evolution of durable wood products has further highlighted an old problem in wood protection—namely, how do we evaluate long-term durability with short-term tests? This challenge is complicated by the wide range of exposure environments, types of structures, and service-life expectations.

Over the last century, numerous laboratory and field test methods have been developed to evaluate durability. Many of these methods have gained broad acceptance in Europe, Australia, Asia, and the United States. In the United States, the American Wood Protection Association (AWPA) has more than 20 preservative evaluation standard methods; other organizations, such as ASTM International (formerly known as the American Society for Testing and Materials), have applicable methods as well. Appendix A of the AWPA Standards provides detailed guidelines on the types of tests that may be needed to evaluate new wood preservatives. In almost all of these tests, the performance of the test product is compared to that of untreated wood and a well-known and commercially accepted durable product.

This article briefly discusses some of the most important tests used in evaluating the durability of new wood products. The tests include accelerated laboratory decay tests, aboveground and ground-contact field exposures, and tests that evaluate properties, such as resistance to leaching and effects on fastener corrosion. The tests mentioned in this article should be considered as only a minimum; other tests are necessary as well.

Accelerated laboratory decay testing. Laboratory tests are more rapid than field tests and are often the first step in evaluating durable wood products. The most widely used laboratory test in the United States is the soil-block (also called soil-bottle) decay test. The procedure for this test is described in ASTM Standard D1413 or AWPA Standard E10. In brief, a cube of the wood product is placed in a bottle that contains moist soil and a feeder strip that has been preinoculated with a specific decay fungus. The intent of the method is to provide the fungus with ideal conditions for colonizing the test material and to evaluate the ability of the wood product to resist colonization. The extent of protection is measured as weight loss of the cube after exposure, with weight loss of the test product compared to weight loss of unprotected wood or wood treated with a reference preservative. Weight losses of less than 3–4% are generally indicative of good protection. AWPA guidelines require the soil-block test for durable wood products intended for use in either aboveground or ground-contact applications (Use Categories 2, 3, and 4). However, the relationship between the results of the soil-block test and in-service durability is poorly understood. One of the drawbacks of the method is that the fungi evaluated may not be relevant for in-service conditions. The standard fungi have been selected for their known resistance to some of the conventional preservatives and are not necessarily those found degrading wood products. The vigor of the fungi also varies greatly between laboratories, and the results appear to depend on factors such as the age of the fungal culture, soil properties, and moisture content. Thus, although the soil-block test does provide some insight into the ability of a wood product to resist colonization by certain fungi, it does not offer great promise for predicting the service life of a wood product used either in ground contact or above the ground.

Ground-contact stake tests. Stake tests continue to be the primary method of evaluating products intended for in-ground use. AWPA guidelines require field stake tests for durable wood products intended for use in ground contact (Use Category 4), and they also recommend these tests for wood products used above the ground (Use Categories 2 and 3). In these tests, stakes [usually with dimensions of 19 × 19 × 457 mm (0.75 × 0.75 × 18 in.), but other sizes are possible] are buried vertically to one-half their length in soil and then periodically removed and inspected. During inspection, the stakes are assigned a rating of 10 (unattacked), 9.5, 8, 7, 6, 4, or 0 (failure), depending on the extent of deterioration. AWPA Standard E7 details the test procedure. The durability of the test product is compared to that of untreated wood and a reference durable wood product.

Field stake evaluations are some of the most informative tests because they challenge the treated wood with a wide range of natural organisms under severe conditions. However, there are several factors that can interact to affect the results of these tests. Perhaps the most important of these factors are site conditions and duration of the test. Usually at least two different sites are used to account for differences in soil properties and types of organisms present, and at least one of the sites is in a region with a warm, moist climate. The AWPA Standards recognize that climate affects the rate of deterioration; for example, the minimum exposure time is 3 years in high-decay hazard areas such as southern Mississippi, whereas longer exposure times are required for low-decay hazard test sites such as Wisconsin. A test product intended for use in contact with the ground should be in nearly perfect condition after 3 years of exposure and should suffer only very minor attack after 5 years of exposure. However, results derived from northern climates can be misleading, even with longer exposures. For example, stakes that perform well for more than 5 years in Wisconsin can be virtually destroyed in fewer than 3 years in Mississippi. Products that perform well in ground-contact stake tests are generally very durable in aboveground applications, but the relationship between mediocre stake test performance and aboveground durability is not well understood.

Aboveground exposure tests. Aboveground field exposures are useful for treatments that will be used to protect wood above the ground. Although not as severe as field stake tests, aboveground tests do provide useful information on aboveground durability. There are many versions of aboveground tests, as described in AWPA Standards E9, E16, E18, E25, and E27. AWPA guidelines require one or more of these tests for wood products intended for use in aboveground applications (Use Categories 2 and 3), but they also are usually conducted for products intended for use in ground-contact application (Use Category 4). Specimens are exposed to the weather in an area with a warm, wet climate (usually either the southeastern United States or Hawaii). The specimens are designed to trap moisture and create ideal conditions for aboveground decay. The specimens are periodically inspected and given a rating for extent of deterioration using a scale (10, 9.5, 9, 8, 7, 6, 4, and 0) similar to that used in stake tests. Interpretation of the results of aboveground testing is challenging. The greatest source of difficulty is the wide variation in severity of exposure for wood used above the ground. The severity of aboveground exposure does vary with climate, but it also varies greatly with construction practices and localized site conditions (for example, moisture, temperature, and ultraviolet exposure). In areas where organic debris can collect in connections, the aboveground decay hazard may be higher than anticipated. Comparison to untreated wood specimens is especially important in these tests in order to assess the extent of the deterioration hazard.

Other common tests. Some types of tests do not involve biodeterioration. Instead, they evaluate properties that may indirectly affect biodeterioration or that provide information on other important properties. The laboratory leaching test helps to evaluate how rapidly the treatment will be depleted. A treatment needs leach resistance to provide long-term protection. In this test, small cubes of wood are immersed in water for 2 weeks. The methodology for this test is described in AWPA Standard E11. Laboratory corrosion testing is used to determine the compatibility of the treatment with metal fasteners, and the current procedures are described in AWPA Standards E12 and E17. Corrosion test methods continue to evolve to allow better correlation with in-service performance. Treatability testing is used to evaluate the ability of a treatment to penetrate deeply into the wood. Shallow surface treatments rarely provide long-term protection because degrading organisms can still attack the interior of the wood. Currently, there are no standard methods for evaluating treatability, but a recommended approach is provided in AWPA Appendix E. Strength testing compares the mechanical properties of treated wood with matched, untreated specimens. Treatment chemicals or processes have the potential to damage the wood, making it weak or brittle. ASTM Method 5664 is preferred for these strength-effect evaluations. AWPA guidelines require many of these tests for all intended applications, although the leaching test is not required for products intended for indoor use (Use Categories 1 and 2).

Adapting test methods to nontraditional wood products. With the commercial availability of nonconventional durable wood products such as WPCs and the emergence of chemically and thermally modified wood, there is an urgent need for modification of the current standards or development of entirely new standards. The current tests have been developed for more conventional wood protection systems and may not be appropriate for testing these newer materials. For example, WPCs (which, on average, consist of 50–65% wood fiber and 35–50% plastic) have slower moisture sorption compared to solid wood, and modified woods usually have a lower equilibrium moisture content compared to unmodified wood. As a result, these newer materials do not attain sufficiently high moisture content during the laboratory decay test period to facilitate fungal attack. Therefore, to increase the moisture content, WPCs can be preconditioned by soaking them in water at elevated or room temperature prior to insertion into the soil-block test. Simulating outdoor conditions by laboratory-accelerated weathering and then water-soaking the WPCs is another effective means of preconditioning prior to fungal durability testing. Many studies on these newer materials tend to modify the standards by using nonstandard protocols in order to understand the mechanism of decay resistance.

Field testing of wood-based materials, such as WPCs, provides additional valuable information on durability. In addition to moisture, fungi, and termite degradation, failure also can result from other environmental elements, including ultraviolet radiation, thermal cycling, and freeze-thaw cycling. These factors need to be considered in the testing of these materials, especially WPCs.

Review of test data and listing of new durable wood products. Once the appropriate tests of a wood product have been completed, the results are compiled and presented to one of two organizations for reviewing and listing of durable wood products. Traditionally, durable wood products have been reviewed by AWPA subcommittees, which are composed of representatives from industry, academia, and government agencies who have familiarity with conducting and interpreting durability evaluations. More recently, the International Code Council–Evaluation Service (ICC-ES) has evolved as an additional route for gaining building code acceptance of new types of pressure-treated wood. The ICC-ES does not standardize preservatives. Instead, it issues evaluation reports that provide evidence that a building product complies with the building codes. The tests required by ICC-ES are typically those developed by AWPA. It is important to note that separate toxicity evaluations by appropriate regulatory agencies (for example, the U.S. Environmental Protection Agency) are mandatory for any durable wood product that incorporates preservative pesticides.

For background information ***see*** CORROSION; ENVIRONMENTAL TOXICOLOGY; FUNGI; LEACHING; MOISTURE-CONTENT MEASUREMENT; WOOD ANATOMY; WOOD COMPOSITES; WOOD DEGRADATION; WOOD ENGINEERING DESIGN; WOOD PROCESSING; WOOD PRODUCTS; WOOD PROPERTIES in the McGraw-Hill Encyclopedia of Science & Technology.

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