Technology Profile

Value to Wood

TP–04–01W
August 2004

Finish Hardness Testing Techniques

Many manufacturers who apply a finish to their products are concerned that the finish will provide adequate lasting protection, and that the quality and value of the product is not compromised, so that the customer remains satisfied.

Flooring, furniture, case goods, and millwork producers conduct a number of hardness and wear-resistance test procedures. The main function of any finished surface is to withstand external wear, which relates in most cases, to the resistance to abrasion. In general abrasion is directly related to important finishing parameters such as the hardness of the substrate and the top-coat, impact resistance, adhesion capabilities, and scratch resistance of finished surfaces.

For this Profile, the term hardness is defined as the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

To ensure the overall quality of a finished surface, companies must not only measure hardness as a property, but also carefully monitor key factors that influence surface properties and parameters.

Common Finish Types and Suitability for Application

Table 1 summarizes the most common finish types in relation to their performance. Additionally, Table 1 provides information on the relative durability of each type of finish. For manufacturers of finished goods, this information can be used to help select the most appropriate finish for their product(s). For more detailed information on the durability of a finish, wood product producers should consult with their finish supplier. Most suppliers have information on durability, including hardness, which can help when choosing the best finish for the application system and product(s).

Surface Parameters and Testing Methods

The most common surface parameters and testing methods are shown in Table 2. Depending on the usage, uniformity and consistency of finishes are ensured through industry standards and government regulations. Existing standards not only regulate important factors such as strength, durability and stability of components, but also regulate performance attributes related to different products. For example, the regulations pertaining to finishes applied to children's bedroom furniture are different than those for finishes applied to dining room furniture.

Testing Standards for Surfaces

Throughout the world, different testing standards are used, depending on the country where the product is manufactured and the intended final use. In some cases, companies develop their own in-house standards. In-house standards

Forintek Canada Corp.

Natural Resources Canada | Ressources naturelles Canada

Table 1. Quick Comparison Guide to Factory Finish Systems

Finish System	Standard Production Finishes (commonly available)					Specialty Finishes (specify after consultation)				
	Nitro-cellulose Lacquer	Pre-catalyzed Lacquer	Post-catalyzed Lacquer	CAB & Water Acrylic Lacquer	Conversion Varnish	Synthetic Penetrating & Simulated Oil	Catalyzed Vinyl	Catalyzed Poly-urethane	Polyester	UV-cured Epoxy, Polyester, Urethane
General durability	2	2	3	2	4	1	4	5	5	5
Repairability	5	4	4	3	3	5	4	2	1	1
Abrasion resistance	2	4	4	3	4	1	4	5	5	5
Finish clarity	5	4	5	4	3	5	3	3	4	5
Yellowing in time	1	2	3	4	4	2	3	4	4	3
Finish flexibility	1	2	3	3	4	5	4	4	1	3
Moisture resistance	3	3	4	3	4	1	5	5	5	5
Solvent resistance	1	2	4	1	5	1	5	5	5	5
Stain resistance	4	4	5	4	5	1	5	5	5	5
Heat resistance	1	2	5	1	5	1	5	5	5	5
Household chemical resistance	3	4	5	3	5	2	5	5	5	5
Build/Solids	2	3	3	4	4	1	4	4	4	5
Drying time	5	5	5	3	4	2	5	3	2	5
Affects wood flame spread	Yes	Yes	Yes	No	No	No	No	No	Yes	No

5 = Excellent to 1 = Poor. The numerical ratings are subjective judgements based on the general performance of generic products. Special formulations and facilities will influence some of the performance characteristics.

Source: 2003 AWI/AWMAC – 8th Edition Quality Standards

often classify finished surfaces into different categories depending on where that surface will be installed. For example, it may be desirable to have a writing desk with a harder finish than for that of bedroom furniture.

Testing the Hardness of the Finish

Hardness is not an intrinsic material property defined in terms of fundamental units of mass, length and time. Rather, a hardness property value is the result of a defined measurement procedure.

The four most commonly used hardness and wear-resistance testing methods used by the furniture industry are described below.

Impact Test Method

A common method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape with a specific force applied for a specific length of time.

The impact test is often used to determine the elasticity of a finish, which in turn correlates to the hardness of the finish. The test procedure measures the resistance of a finish to surface damage caused by a relatively small impact. The available testing devices vary, but they normally consist of a vertical steel cylinder and an impact tool such as a metallic or diamond sphere.

Table 2. Surface Parameters and Test Methods

Surface Parameters	Test Method
Hardness	Scratch Test, Impact Test
Elasticity	Impact Test
Adhesion of the Finish	Cross Cut Test, Pull Off Test
Thermal Properties	Dry and Wet Heat Test, Cigarette Test
Light and Colour Fastness	Weathering Test
Wear-resistance	Abrasion Test

After applying a set force and measuring the diameter or cross-sectional area of the circular impact dent, impact resistance can be determined. In this way, the brittleness and hardness of a lacquer or a paint/stain can be evaluated. If a surface failure occurs, shatter marks will be become visible.

Figure 1. Handheld Impact Indenter

Sward Hardness Rocker Test Method

The Sward hardness rocker method is often used for testing surface hardness of coating materials such as paints, lacquers and plastic surfaces.

Figure 2. Hardness Rocker

The measured hardness is proportional to the time required to dampen out the rocking motion of the instrument. The hardness measured is proportional to the time in seconds for the oscillating rocker to decrease in amplitude in response to hardness changes.

The principle of the machine is that the oscillations of a gyro wheel-shaped rocker will be dampened more by softer finishes than by harder finishes.

Abrasion Test Method (Taber Abrasers)

Abrasers are precision test instruments commonly used by furniture, case goods, and flooring industries to measure accelerated wear-resistance of a variety of test specimens. Examples of these include solid wood surfaces, painted or lacquered surfaces, and plastic-coated substrates.

Figure 3. Taber Abraser

Materials to be tested are subjected to the wear action of two abrasive wheels at a known pressure (in grams). A wear pattern on the test specimen results when a pair of abrasive wheels is rotated in opposite directions by a turntable on which the test specimen is mounted. A sliding action occurs when the abrading wheels travel on the material along a horizontal axis. Abrasive wheels are available in different levels of abrasiveness to suit a wide range of material.

Test results are measured as a wear factor or as a numerical abrasion index of the test specimen. There are four test methods for calculating this index.

1. **Weight Loss Testing Method**

   When comparing finishes that have reasonably similar qualities, the weight loss testing method is normally used. The wear index rate indicates the weight loss in milligrams per thousand cycles of abrasion. The lower the wear index, the better the abrasive resistance of the surface tested.

2. **Visual Testing Method**

   This testing method is often used for polished, printed or glazed surfaces that withstand less than 300 abrasion cycles before reaching the visible end point of the test.

3. **Volume Loss Testing Method**

   When comparing finishes that are considerably different in structure, a correction factor must be applied to the weight loss testing method to achieve a comparative wear-resistance factor. The use of a correction factor provides a wear index related to the loss in volume of the material.

4. **Depth Testing Method**

   Occasionally, the depth of the wear using a specific pressure and type of wheel is measured after a given number of cycles have been completed. After the predetermined number of cycles have been completed, the depth of the abrasion is measured using an optical micrometer.

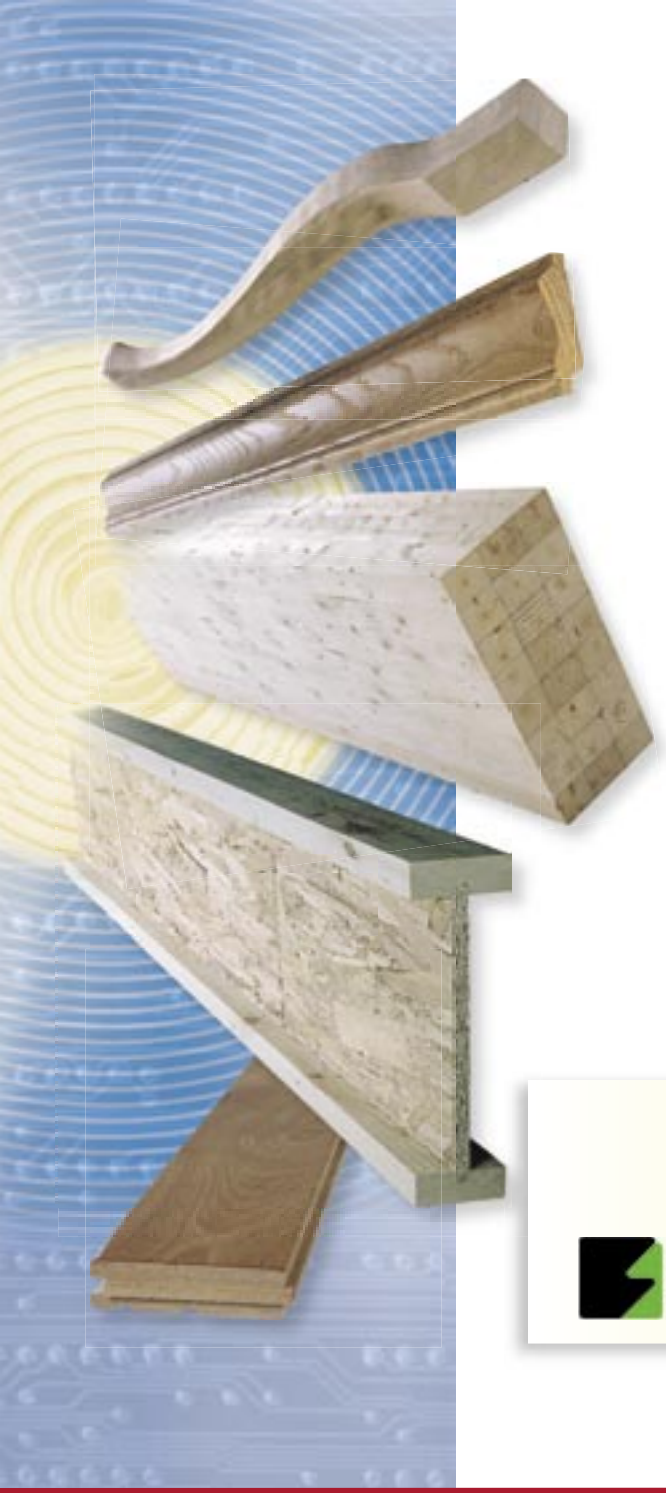
Figures 4 and 5 below are examples of abrasive tests conducted with a varying number of cycles. Examining the images shows that as the number of cycles increases, more of the finish is removed.

Figure 4. Sample at 120 cycles

Figure 5. Sample at 220 cycles

Scratch Hardness Test Method

The scratch hardness tester is a low-cost, simple method to determine the resistance of coating materials to surface scratching. This method is often used to test paints and lacquers applied to furniture components.



The scratch test uses pencil leads with different degrees of hardness. The lead is moved with a constant pressure over the finished surface of the test specimen at a fixed angle to the substrate. The degree to which the appropriate pencil lead damages the surface is taken as a measurement of scratch resistance.

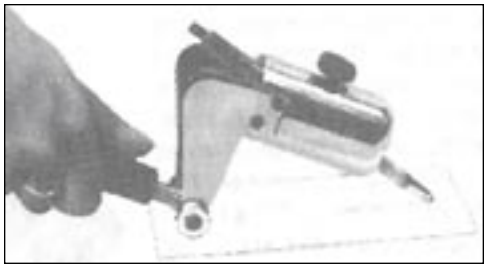


Figure 6. Scratch Hardness Tester

Summary

Product performance and ease of application are some of the key elements in a successful finishing system. As wood product manufacturers develop new products, it is important to match the coating with the end product's desired performance characteristics. Ensuring that the coating is performing as planned is done through regular testing. While some tests are more involved than others and are better suited to particular finishes, simple tests are available that can be conducted by manufacturers.

For information on the 2004-2005 ***Value to Wood*** research program,
visit www.valuetowood.ca

Forintek Canada Corp. | Université Laval | UNB | University of Toronto | UBC

*Ce **Profil technologique** est également disponible en français.*

Value to Wood

As part of the ***Value to Wood*** program, funded by Natural Resources Canada, Forintek's Industry Advisors are providing technical services to value-added wood product manufacturers in all regions of Canada. If you need information on any technical issue related to wood product manufacturing, you can:

- Send a request via *valuetowood.ca* (Help Desk).
- Contact a *Value to Wood* co-ordinator at one of the following locations:

Forintek Canada Corp.
Value to Wood Co-ordinator (West)
2665 East Mall, Vancouver, BC
Canada V6T 1W5

Tel: (604) 224-3221
Fax: (604) 222-5690

Forintek Canada Corp.
Value to Wood Co-ordinator (East)
319, rue Franquet, Quebec, QC
Canada G1P 4R4

Tel: (418) 659-2647
Fax: (418) 659-2922