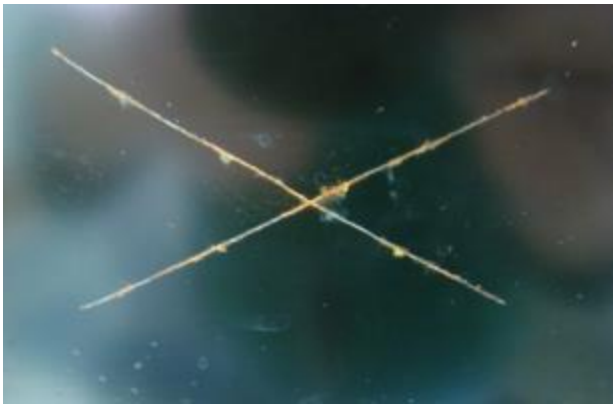
Kalcor University

Scratching the Surface of Pencil Hardness Testing

Since coatings are usually applied to a part's surface, it's natural to consider what kind of surface properties a coated part will exhibit.

Depending on the part, physical/functional properties of the surface are as important as cosmetic properties such as color or gloss. One of the more common physical properties customers are concerned about is how resistant the final coated surface will be toward scratching. Some industries have adopted their own standards for measuring scratch resistance such as the Hoffman scratch or pendulum hardness tests. Still, one of the more popular techniques is a simple (perhaps deceptively simple) pencil hardness test.



Pencil hardness is a measure of how resistant a coating film is to fracture due to friction from a sharp object. The underlying idea of the test is that an object made of a hard material will scratch an object made of a softer material. When testing coatings, measuring scratch hardness can be accomplished in two related ways.

The first approach is to measure the amount of force needed to cut through the coating film using a tool equipped with a tip made from a material of known hardness. This approach can be very precise, but requires some relatively complicated equipment since applying and measuring the exact amount of force can be complicated, not very portable or somewhat inexpensive.

This device uses varying pressure, and measures the force required to scratch the surface.

The second technique is to apply the same pressure, but instead vary the hardness of the tip that's used to scratch the surface. For example, given the same pressure, we would expect the surface of stainless steel to be easily scratched by a tip made of diamond, but not by a tip made of copper, since copper is softer than steel's surface. This is why cutting and engraving tools commonly use carbide bits and diamond points.

The pencil hardness test uses this same simple principle. While applying constant pressure, we attempt to scratch the coating surface using tips made of harder and softer materials. The point at which the hardness of the tip just matches the hardness of the coating indicates its hardness measure. In this case, the hardness of the tip is determined by the composition of the graphite among a set of pencils that range from very soft to very hard materials.

A set of calibrated test pencils intended for measuring Pencil Hardness

The Pencil Hardness Scale

The graphite grading scale is known as the HB scale and ranges from 6B at the softest end to 9H at the hardest end. Pencil manufacturers use the letter “B” to designate the blackness of the pencil’s mark, indicating a softer lead, and “H” to indicate a hard pencil. Historically, pencil makers also use combinations of letters to tell us about the graphite — a pencil marked “HB” is hard and black, a pencil marked “HH” is very hard, and a pencil marked “BBB” is really, really black and this very soft. Today, most pencils are designated by a number such as 2B, 4B or 2H to indicate the degree of hardness. For example, a 4B would be softer than a 2B and a 3H harder than an H. The modern HB scale ranges from 6B (softest) to 9H (hardest).

The modern HB Pencil Hardness Scale ranges from very soft to very hard tips

Summary of the Pencil Hardness test.

The detailed procedure of Pencil Hardness testing is described in several publications including ASTM Test Method D 3363 (Standard Test Method for Film Hardness by Pencil Test). Here we only provide a brief overview of the method for descriptive purposes.

First, you should purchase a set of high quality, calibrated pencils (sold for the purpose of testing hardness and available from a number of suppliers). The set should range from 6B to either 6H or 9H hardness.

A coated panel is placed on a firm horizontal surface. The pencil is held firmly against the film at a 45° angle (point away from the operator) and pushed away from the operator in a 6.5-mm (1⁄4-in.) stroke. The process is started with the hardest pencil and continued down the scale of hardness until the pencil that will not cut into or gouge the film. The pencil hardness is the pencil rating is this level of hardness which just doesn’t scratch the surface.

One of the criticisms of the test is that it is subject to a lot of variation from user to user. For example, it is important to use a consistent 45^{o} angle, and to apply a consistent amount of downward force. To improve the uniformity of this test, a number of suppliers have devised some tools to improve consistency. For example a metal “car” with hole drilled at the proper angle is used to assure consistent pressure is applied to the pencil tip.

This simple metal "car" produces more consistent test results by providing consistency in the angle and pressure during the Pencil Hardness test procedure

Interpretir

The point (ratch the surface is the reported surface harness level.

So what does this number really mean?

For one thing, it's a quick, inexpensive, portable and so very convenient method to quantify the resistance of a coated surface to resist scratching. But like any single measure of a coating, hardness measures must be taken in context of the overall properties of a coating.

Making a coating harder often has tradeoffs that may be equally important. For example, harder coatings are often less flexible as well. So, for example, if a coating for polymeric siding is made harder to resist scratching by tree limbs, or rocks, the coating may more prone to fracture if bent during shipping or installation or fracture on impact. Other tradeoffs could include compromises in adhesion or chemical resistance at the expense of improving surface properties.

Thus it is important to consider pencil harness as one data point in the overall measure of coatings properties. To understand the benefits and potential problems of pencil hardness, it's best to work with a coating formulator who can tailor the chemistry of your coating for the best overall performance for your coating application.