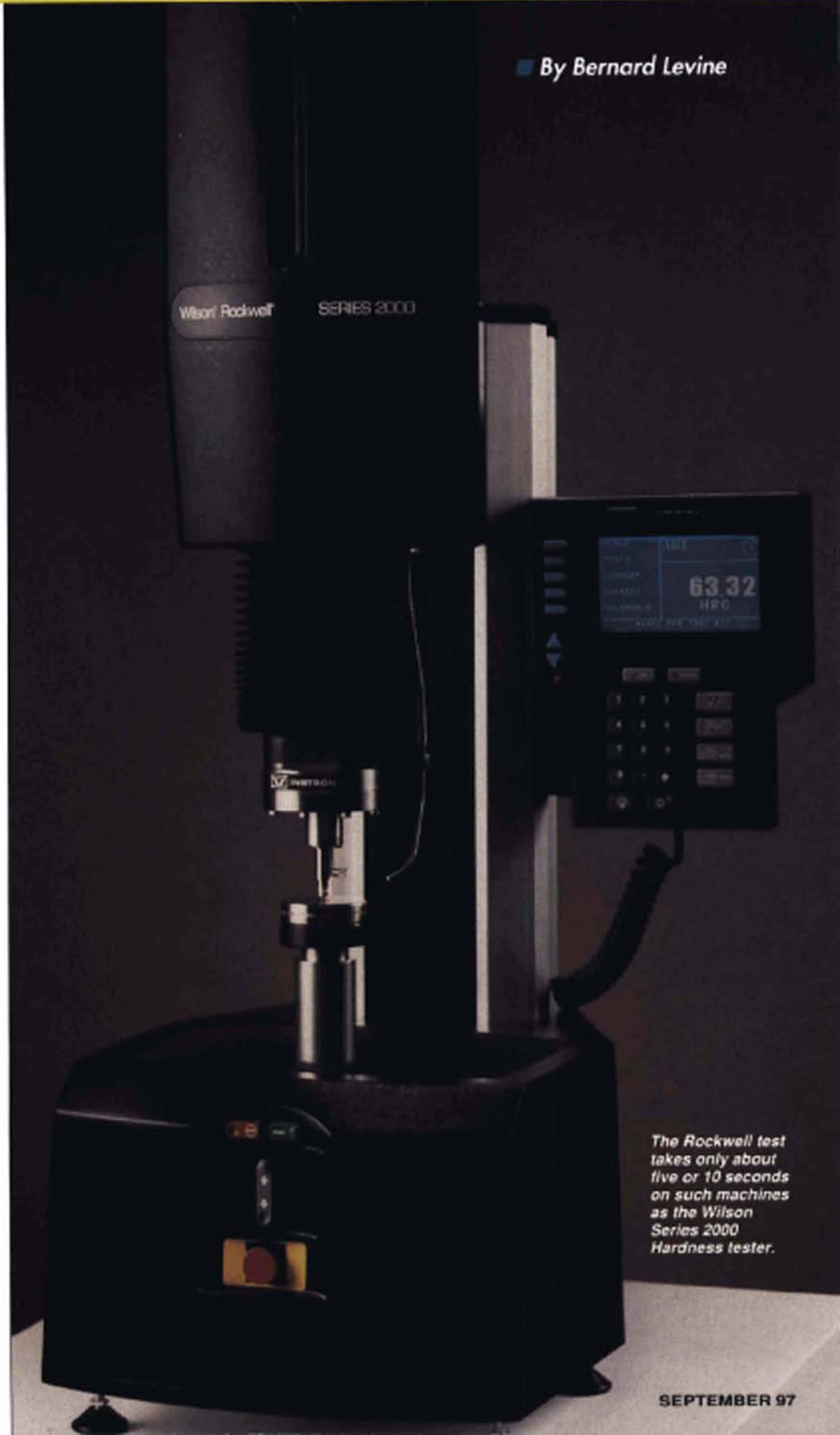
ROCKWELL HARDNESS

What It Is And What It Means To Your Blades

By Bernard Levine



The Rockwell test takes only about five or 10 seconds on such machines as the Wilson Series 2000 Hardness tester.

"Any blade should be Rockwell tested at several different points."

Author's note: The technical information in the following is based on **Fundamentals of Rockwell Hardness Testing** *published by Wilson Instruments, a division of Instron Corp., and from the* **Metals Handbook** *published by the American Society for Metals.*

Knife manufacturers and merchants often advertise that their blades test to certain hardness values on the "Rockwell C scale." One German company even features an indentation left by its Rockwell testing apparatus on every blade it sells. But what, exactly, does Rockwell hardness mean? What does it tell you about a blade? And what's a good or useful Rockwell value?

Knifemakers seek two abilities in their blades: to take a sharp edge and to hold the edge under all sorts of use and abuse. The main factors that influence these two abilities are hardness, toughness and flexibility.

Material that isn't hard can still be very sharp. If you've ever gotten a paper cut or a splinter from a pine board, you know. Of course, a sharp piece of soft material will quickly be blunted by any material harder than itself (recall the children's game, "Scissors, Paper, Stone"). To make a blade edge that will stay sharp, one must use a material that's either already hard, such as glass, or a material that can be hardened, such as steel.

You can see the importance of toughness and flexibility when you compare a glass knife to a steel one. Glass easily can be made as sharp as the finest steel, perhaps even sharper—all you have to do is break it. However, as sharp as it is, glass is also brittle and inflexible. When Native Americans made knives of volcanic glass (obsidian), they made them in large numbers and treated them as casually as modern society treats disposable razor and utility knife blades. They knew that the sharp but brittle blades would not last long in daily use.

And those Native American knifemakers didn't need to worry about hardness testing. Once they'd learned to recognize obsidian or flint, they knew that any such stone would be hard enough to make a good blade.

Steel is different. While divergent steel alloys do vary slightly in color and texture, there's no way to tell by eye if a given piece of steel has been hardened or not. Even if you're sure that a piece has been hardened, there's no way to tell by looking just how hard it is or if it's been hardened uniformly across its length, width or thickness.

Testing Hardness

Curiously, hardness is not an inherent property of any material, particularly not the indentation hardness measured by modern testing instruments. The ***Metals Handbook*** defines hardness as the "resistance of metal to plastic deformation, usually by indentation. However, the term may also refer to stiffness or temper, or to resistance to scratching, abrasion, or cutting."

The traditional way to gauge the hardness of a steel blade was to touch its edge with a file or a sharpening stone. In past times sets of files of varying temper were made for testing hardness. Yet, this sort of test gives only a subjective impression. Moreover, if the blade is highly finished, a file test will leave unsightly scratches.

This uncertainty about the hardness of steel was equally a problem in other areas besides cutlery, such as machine tools, rock drills, watch springs and railroad car wheels. To resolve this uncertainty in a practical manner, manufacturers needed a quick, precise and repeatable way to measure hardness without damaging the piece being tested.

An effective solution to the problem was invented in 1919 by Stanley P. Rockwell. He was employed as a metallurgist in a New England plant that manufactured ball bearings. It was not the hardness of the steel balls that concerned Rockwell, it was the hardness and uniformity of the races in which they rolled. He built an apparatus that would quickly, accurately and repeatably measure the hardness of a bearing race at any number of points. This Rockwell testing instrument proved equally useful for testing the hardness of all sorts of other steel parts, indeed, for testing other metals as well, and even for testing nonmetallic materials such as plastics.

The wide range of material and hardness that a Rockwell tester can accommodate is the reason why there are a variety of Rockwell scales, and a variety of penetrators and anvils made for use in the testing machines. Just as one doesn't use a truck scale to weigh a parakeet or a micrometer to measure the height of a building, one doesn't use the incorrect Rockwell scale if one expects useful and repeatable results.

Rockwell Testing

The process of Rockwell testing is simplicity itself. On a manual tester,

Which Hardness For Which Knife?

According to Ed Severson, metallurgist for Crucible Service Centers, the answer to which hardness is best for which steel depends on how the blade will be deployed. If the blade is going to be used to "whack with," such as a machete on vines, bushes, etc., a medium carbon steel with a medium hardness in the low-to-mid 50s should suffice. Blades with such hardnesses dull easily but should be easy to sharpen. For blades requiring very sharp edges the reverse is true. The steel should be high carbon and extremely hard—as high as the low 60s. The resulting blades should hold their edges well but may be difficult to sharpen.

As for the steels themselves, Severson said most are modern versions of the same thing. For instance, ATS-34 and 154-CM are 440-C "with a little molybdenum added" for high-temperature heat treating. The molybdenum gives a "hardness kick" of about 58 RC at around 1,000° F, whereas 440-C at the same temperature Rockwells out at about 50.

—*By* Blade *staff*

Damascus blades, such as the Katz special-edition AK 8008, may test differently in selected areas due to differential tempering (soft back, hard edge, etc.).

the test takes five to 10 seconds. An automatic tester, built into an assembly line, can test parts and sort them by hardness in about one second per part.

After the piece is placed in the Rockwell tester, the hardness test itself involves four steps. First, the penetrator (either a diamond Brale® or a hardened steel ball, depending on the scale) is applied to the spot being tested under a minor load of 10 kilograms of force (kgf). This load can be applied with springs or with compressed air. [Brale is Wilson Instrument's designation for a diamond penetrator with a conical shape, an included angle of 120°, and a spherical tip with a radius of 0.200 mm.]

Second, the major load is applied to the penetrator. This major load is either 60, 100 or 150 kgf, again depending on the scale. Third, the major load is removed, leaving the minor load in place.

Fourth, the penetration under the major load is measured, and this measurement is converted reciprocally and automatically into a Rockwell hardness number. The smaller the penetration, the greater the hardness and the higher the Rockwell number. One Rockwell number represents a penetration of 0.002 millimeter (0.000080 inch, i.e., eight one-hundred-thousandths of an inch). Thus, the penetrator would make an indentation 0.006 mm larger in a blade with a hardness of RC 58 than it would in a blade with a hardness of RC 61. The actual indentation in a hardened steel blade is only a small fraction of a millimeter.

The reason for applying the minor load before the actual measurement is to improve precision. The minor load flattens any surface imperfections or distortions at the point of testing, allowing for accuracy and repeatability of measurements.

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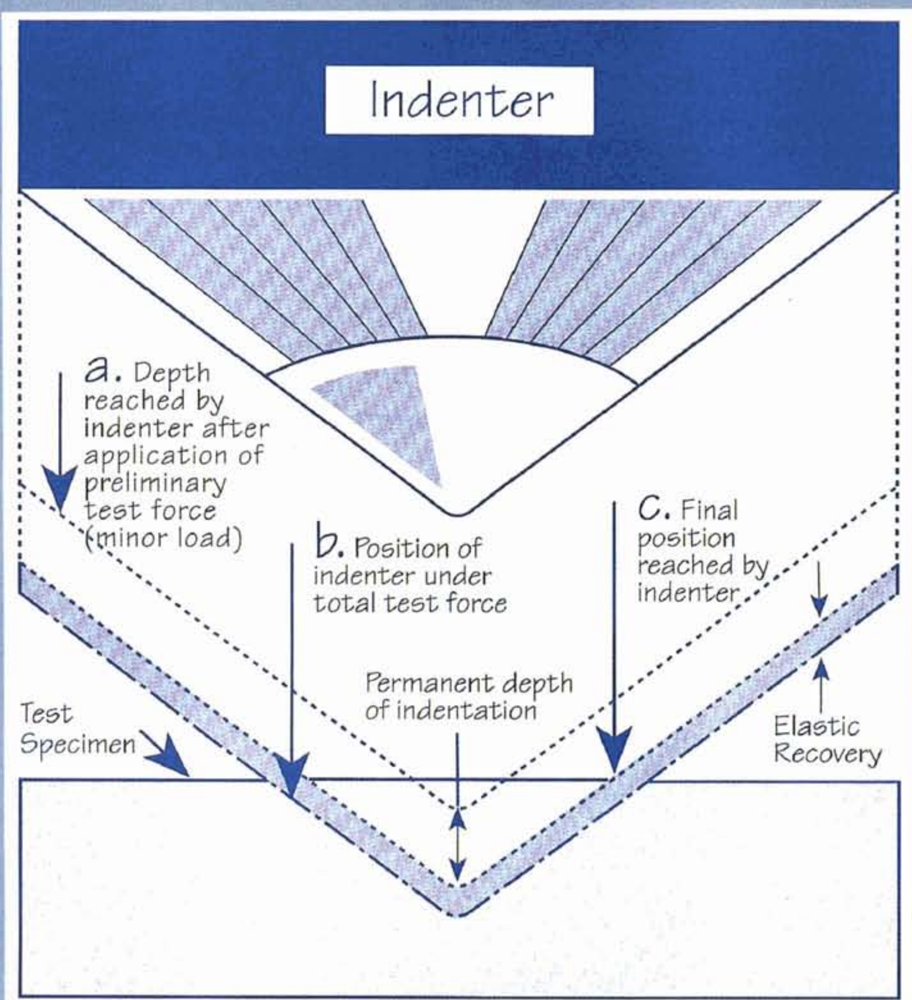

First, the preliminary test force, or pre-load, is applied (a). Then, an additional test force is applied to reach the total required test force (b). This force is held for a predetermined amount of time and then released. With the preliminary test force still applied, the indenter reaches the final position (c). The distance traveled from the reference position is measured and then converted to a hardness number. (The preceding information and accompanying illustration are courtesy of NewAge Industries, Willow Grove, Pennsylvania.)

The C Scale

The scale used for testing the hardness of knife blades and other hardened steel items is the Rockwell C scale. Tests employing the C scale use the diamond Brale and the full 150 kgf major load. The theoretical maximum hardness is infinity, which would be 100 on the Rockwell C scale. Infinite hardness is of course impossible, and few substances test very much over RC 70. The range of hardness for functional knife blades is mainly between about RC 50 and RC 63. Most good sport knives test around RC 58 to RC 62. Blades toward the high end of this range tend to be good at edge holding, but very difficult to resharpen. Blades toward the lower end are easier to sharpen but may not stay sharp as long, especially under demanding use.

Because Rockwell hardness testing yields a number, it seems absolute and precise. However, the test has important limitations often overlooked by both the marketer and the consumer. First, a single test is only valid at the point of testing. Any blade, especially one that has been hardened by hand and eye, should be tested at several points.

Second, the Rockwell test is a surface hardness test. It cannot reveal anything about the hardness of the interior of a steel item.

Third, to quote from Wilson Instruments, maker of Rockwell hardness testers, "the Rockwell test is a measure of the resistance of a material to permanent indentation. Indentation hardness is not a fundamental property of a material. However, reliable relationships have been established between the various tests and important properties of materials—for example, tensile strength and machinability. Furthermore, indentation hardness has become one of the more reliable controls of the heat treatment and quality of manufactured parts."

For more information about Rockwell hardness testing contact: John Foley, Marketing Manager, Dept. BL, Wilson Instruments, Inc., Instron Corp., 100 Royall, Canton, MA 02021 or the American Society for Testing & Materials (ASTM), Dept. BL, 1916 Race, Philadelphia, PA 19103. BLADE