Issue No. 26 – February 2011 **Updated from Original August 2001 Publication**

Don't be hardheaded on hardness! – An overview of the appropriate use of hardness testing techniques.

- **Sources of Inaccuracy**
- **Common Mistakes**
- **Conversion Errors**

The next issue of Technical Tidbits will discuss tensile testing.

Hardness Testing Pitfalls

Last month's edition of Technical Tidbits introduced the concept of hardness testing and gave a brief description of the various scales used. This edition focuses on sources of inaccuracy and common mistakes made during hardness testing. Any of these pitfalls could cause rejection of good incoming material or outgoing parts, which wastes time, effort, and money. Even worse, there the small chance of accepting out of specification incoming material, or having faulty parts pass final inspection.

To insure that no erroneous readings are taken, it is crucial to follow all procedures outlined in the appropriate ASTM specifications. Consult ASTM E10 for Brinell testing, E18 for Rockwell testing, E92 for Vickers testing, and E384 for general microindentation hardness testing.

The hardness testing device must be in good working condition. The calibration should be adjusted and certified yearly by an accredited service. Each day of use, the calibration should be tested by taking sample readings on a test block of known hardness.

When taking a hardness measurement, it is important that the sample be properly fixtured. Parts should not be free to move on the anvil. For microindentation hardness testing, the samples should be metallographically mounted in resin. The mount should then be ground down to the section of interest and polished for best results.

When possible, testing on curved surfaces should be avoided. Cylindrical parts should either be tested on end or in cross-section. If it is absolutely necessary to test a curved surface, use an anvil that is designed to hold a round object, and be certain that the specimen is not free to move during the test. Note that the hardness reading will be low on a convex surface and high on a concave surface. ASTM E18 has conversion charts for curved surfaces.

Hardness readings are most accurate when the result is near the center of the scale. If a reading comes up near the upper or lower bound of a scale, it may be best to retest using another scale to ensure accuracy. Any readings that fall completely outside the recommended range are suspect, and another hardness scale must be used.

The figures below show some common mistakes made in hardness testing. During a hardness test, a work-hardened zone will form around each indentation. Therefore, any nearby subsequent indentation will be affected by that zone. As a general rule, indentations should be spaced a minimum of two indentation diameters apart (Figure 1). Also, the surface of a piece of metal will be slightly harder than the interior due to cold work from rolling, drawing, machining, stamping, etc. Therefore, any readings taken in cross section should be kept a minimum of two indentation diameters away from the surface in order to get the true hardness of the part, unless the surface hardness is of more importance.

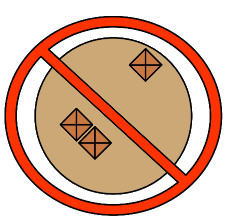

Figure 1.

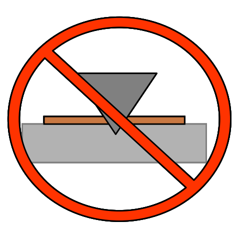

Figure 2.

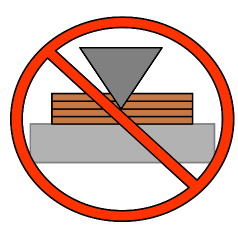

Figure 3.

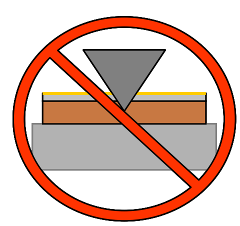

Figure 4.

Hardness Testing Pitfalls (continued)

One of the most common mistakes is the use of a load/indenter combination that is too large for the thickness of the material. Generally, the thickness of the strip must be at least 10 times greater than the expected indentation depth. Occasionally, Rockwell C tests on thin strip material will result in the indentation of the anvil underneath the strip (Figure 2). These readings will bear no resemblance whatsoever to the true hardness of the sample piece, since the indentation will be affected by the anvil hardness and the interface between the sample and the anvil. Sometimes, the tester will attempt to cheat the rules of hardness testing by stacking several pieces of strip together in order to use a standard Rockwell test (Figure 3). This is also wrong, since the interfaces between the pieces of strip will have a significant effect on the reading.

Plated samples should always be tested in cross-section, so that the indentation can be made entirely in the base metal. The alternative is to chemically or physically remove the plating, although this can effect the hardness of the base metal. Most plating materials are significantly harder or softer than the base metal on which they reside. A hardness measurement taken through the plating will show results that vary wildly from that of the base metal (Figure 4).

Conversions between different hardness scales should be avoided. There are conversion charts available, which cover specific materials and hardness scales. These charts are covered under the ASTM E140 specification. Because of the error involved, conversion charts should only be used when it is impossible to test under the conditions specified. For example, if incoming material is certified to a given Vickers hardness, the final part should be tested on a Vickers scale, not tested on a Knoop scale and converted to Vickers. Furthermore, it is vital to use the correct conversion chart. For example, at a Vickers hardness of 160, cartridge brass has a Rockwell B hardness of 83.5, while wrought aluminum shows a Rockwell B hardness of 91, according to ASTM E140. If the chart for the material of interest cannot be found in the specification, contact the material's manufacturer for the appropriate conversion.

Hardness testing can be a very effective means of verifying the properties of base metal or finished parts. However, there are many potential sources of error in these tests. For this reason, material hardness specifications show a much larger range than any other material property specification. Great care must be taken to ensure that the test is properly administered. Anything that can affect the value of the measurement must be taken into account. The cost of a false reading can be much greater than that of the additional time and effort spent in verifying the accuracy of the measurement.

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MATERION

References:

Fee, Segabache & Tobolski "Hardness Testing" ASM Handbook V. 8 pp 69-113 ©1985 ASM International

ASTM E10
ASTM E18
ASTM E92
ASTME E384
ASTM E140

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