EXPERT KNOWLEDGE
TEST PROCEDURES
OF ELASTOMER COMPONENTS

An offer of

O RING PRÜFLABOR RICHTER

TESTING CONSULTING DEVELOPING

Source: www.o-ring-prueflabor.de
Information as of 05/2014

Hardness Test

Test Standards Used:
ISO 48 (issue 9-2010), DIN ISO 48 (issue 10-2009), ISO 7619-1 (issue 10-2010), DIN ISO 7619-1 (issue 2-2012), DIN EN ISO 868 (issue 2003-10), ASTM D1415 (issue 2012), ASTM 2240 (issue 2010)

Hardness is defined as the resistance that a body sets against a harder penetrating body. The force of the indenter is usually determined in advance. In the case of metals, the hardness is assessed after removal of the indenter on the basis of the permanent plastic deformation. In the case of elastomers, most of which exhibit elastic behavior, the indentation depth of the indenter is measured during the test.[1]
The most common method for testing vulcanized elastomer compounds and articles is Shore A hardness (see Fig. 1). This test method was developed in 1915 by the American Albert L. Shore.[2] This test is carried out with a truncated cone as indenter and is actually only permitted for tests on test plates. If certain requirements are met - which will be discussed in the following article - ShA hardness tests can also be carried out on finished parts. The test force is generated by a spring and depends on the penetration depth of the truncated cone. The Shore hardness results from the penetration resistance. Due to this technical condition it was possible

[1] vgl. RÖTHEMEYER, Fritz und SOMMER, Franz: Kautschuktechnologie, Hanser-Verlag, München, Wien, 2001, S. 490
[2] vgl. http://de.wikipedia.org/wiki/H%C3%A4rte#F.C3.BCr_Elastomere (Zugriff auf Webseite am 10.12.2013)

O-Ring Prüflabor Richter GmbH
Kleinbottwarer Str. 1
71723 Großbottwar

Telefon 07148 / 16602-0
Fax 07148 / 16602-299
info@o-ring-prueflabor.de
www.o-ring-prueflabor.de

Geschäftsführer:
Dipl.-Ing. Bernhard Richter
Ust-ID-Nr. DE 277600966
Steuer-Nr. 71342/02407 FA LB

Sitz der Gesellschaft:
Großbottwar
Amtsgericht Stuttgart
HRB 737482

Volksbank Ludwigsburg
IBAN DE96 6049 0150 0820 5810 03
SWIFT GENODES1LBG

to build handy pocket measuring instruments, which were among other things a reason for the large acceptance of this test method in practice.

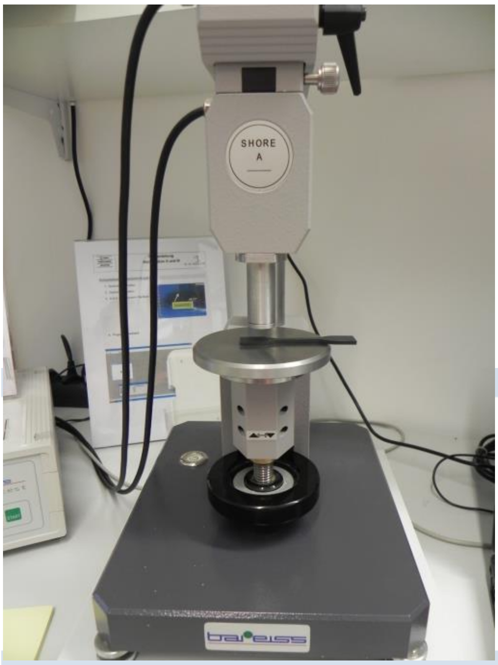

Fig. 1: One of two stationary ShoreA test devices as used in the O-ring test laboratory Richter. The module for the electronic acquisition of the measurement results is visible on the left side of the picture.

Better for finished products is usually a measurement of the micro-hardness in IRHD-M (see Fig.2), since a much smaller indenter (ball) is used. The indenter is loaded with a constant force (total force applied to the ball is 153.3±1 mN). The ratio between penetration depth and degree of hardness is not linear!

Fig. 2: One of two stationary IRHD, micro-testing devices in the O-ring testing laboratory Richter. They have a laser-guided bench, especially for the exact hardness measurement of O-rings.

The following figure (Fig. 3) compares the two test methods ShoreA and IRHD-micro:

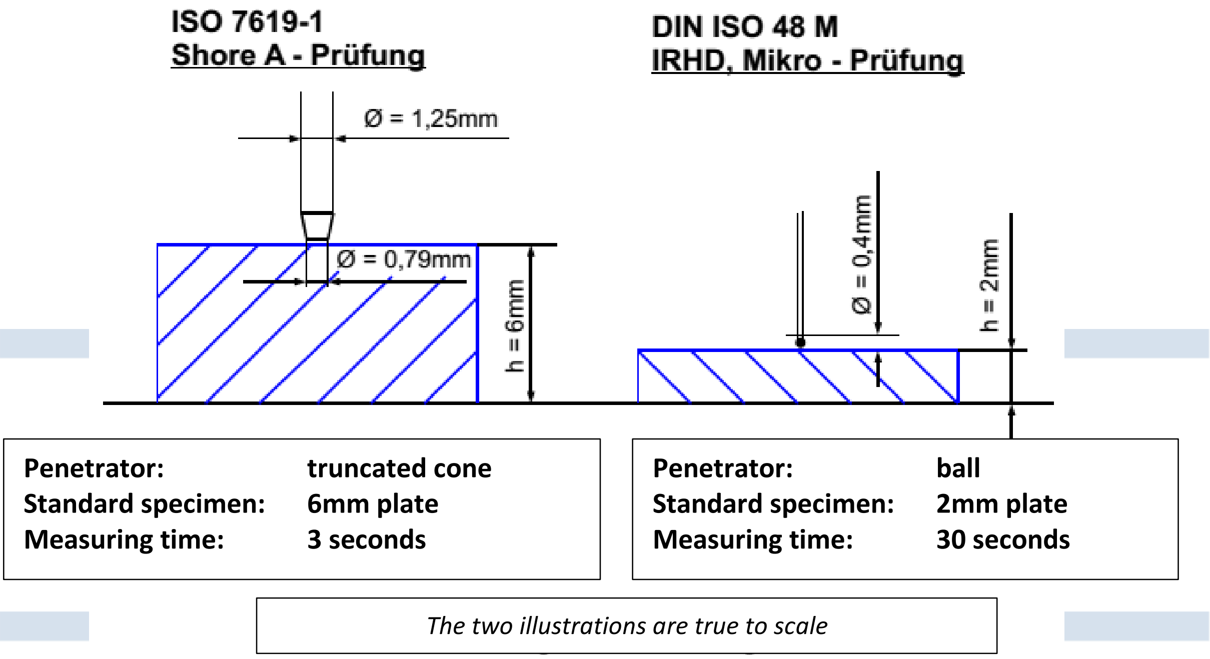

Fig.3: Comparison of the Shore A and Micro-IRHD test methods in the same ratio. This shows the sensitivity of the test device for Micro-IRHD testing. For instance, special care must be taken that the test ball does not break off, as this only leads to slightly altered test results and is therefore often detected too late.

Test results from the two different test methods mentioned above should not be compared and cannot be converted to each other by a formula, for example. Therefore, in practice, the desired degree of hardness with +/-5 hardness points is chosen very generously, so that the ShoreA hardness on the test plate[3] as well as the Micro IRHD measurement (=IRHD-M) on finished parts are still within this wide hardness range (+/-5). Due to this large tolerance, the hardness test method is only suitable to a limited extent for describing the consistency of a compound or the quality of an O-ring or seal.

For many users, hardness is the only material test at all that is carried out, which is why deviations from the target value are often evaluated too highly. For this reason, the following article will clarify why and when hardness testing is important and in which areas it does not help:

- The hardness gives a reference value for the deformation behavior of the material. A hard material (90 ShoreA / IRHD-M) has a higher resistance to gap extrusion at high pressures (> 70 bar), and also offers greater protection against assembly damage. A soft material (50 ShoreA / IRHD-M or less) deforms more easily and can better seal surface defects, e.g. a mold parting burr in a plastic molded part. Therefore, the choice of the nominal hardness determines to a certain extent the functionality of a gasket.

[3] Alternatively, the ShA hardness can also be measured on finished parts if these have plane-parallel surfaces with a thickness of 3 mm or more.

- Hardness is often mistakenly used as a measure of the stiffness of a material. Although both the hardness and the tensile-strength diagram (see tensile test) indicate something about the stiffness of an elastomer, these are essentially two different types of deformation. Tensile strain measurements involve large deformations of the whole mass, whereas hardness tests involve only small deformations. Even if hardness and stiffness (represented by a tensile strain diagram) would have a better correlation, the generally given fluctuation range of +/-5 hardness points would already correspond to a scatter range of approx. 15-20% in stiffness for ShoreA measurements, and even more for hard materials (>80 ShoreA). This shows that the determination of hardness alone is insufficient for the design of elastomer components for which a defined stiffness is important[4]. The hardness values on O-rings, for example, provide only a rough indication of the resistance to gap extrusion; further valuable indications of resistance can be derived from a tensile test using stress values and strength values.
- Hardness can only be regarded as a material parameter if tests are carried out in accordance with standards, which means on test plates.
- For finished part tests, geometric deviations from the standard hardness may occur. For molded parts, it must be decided at which point the measurement will be carried out. Technical literature also contains formulas for calculating the "true hardness"[5]. However, these can only be used in practice to a limited extent or with the respective specialized knowledge. In practice, it is particularly important to ensure that the test specimen has plane-parallel spots. If necessary, profile cuts can be made from finished parts. If the prerequisites for reproducible measurements are fulfilled on certain finished parts, the hardness testing method is a simple and effective method of material testing.
- As a finished part test, hardness offers a simple way of compound identification if it is evaluated together with other tests (e.g. density).
- Hardness measurements only give a very rough indication of possible under-cure. Therefore, hardness is not an effective measure to ensure a sufficient degree of vulcanization. This is often mistakenly assumed.
- The hardness test is clearly worse than other measuring methods with regard to the measuring equipment capability. Therefore, a deviation from the nominal value does not necessarily represent a significant reduction in quality. This can only be reliably assessed in combination with other tests (e.g. by the compression set or the tensile set).

Conclusion

[4] cf. SMITH, L.P:: The Language of Rubber, Oxford, 1993, S.12 f. Original English quotation paraphrased above: „Hardness cannot be assumed to be a close measure of stiffness. It is true that hardness and stiffness are both stress-strain relationships but the relationships are established for two entirely different kinds of deformation. Hardness measurements derive from small deformations at the surface. Stiffness measurements derive from gross deformations of the entire mass. Because of this difference, hardness is not a reliable measure of stiffness. Even if hardness and stiffness did have a better correlation, the irreducible five-point variation in durometer readings would be equivalent to a 15 to 20% variation in stiffness as measured by a compression-deflection test. Hardness measurements would not, therefore, be sufficiently accurate for design purposes. The misuse of hardness to measure stiffness is very common and causes much confusion."

[5] cf. PARKER HANNIFIN GmbH: Dichtungshandbuch, Bietigheim-Bissingen, 1999, P.61

Hardness is a valuable test feature but should always be combined with other tests during quality testing, for example with density and/or compression set. In practice, the significance of the hardness value is often significantly overestimated.