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Methodology of RMA-4 Rubber Hardness Testing using IRHD and Shore-A Methods

N. V. Raghavaiah
Mechanical Engineer, Mechanical Section, HWPM, Aswapuram, India

***Abstract*: RMA-4 quality rubber is one of the best barrier protections between metal and acids. Rubber hardness is one of the most widely measured properties used to characterize rubber. IRHD (International Rubber Hardness Degree) scale and the Shore-A scale are two testing methods widely accepted. The two test methods use totally different indentor geometries, applied forces, test times and procedures. This paper provides methodology studies of the differences between the tests and their relationship between scales where possible. This paper also highlights the merits of each test type. In conclusion, this paper aims to create a clear hardness testing methods of RMA-4 quality rubber and the results they provide**

***Keywords*: RMA-4, Rubber, IRHD, Shore, Hardness.**

1. Introduction to testing

RMA (Rubber Manufacturer's Association)-4 quality rubber is one of the best barrier protections between metal (mostly carbon steel) and acids (HCl or dilute acids). Besides Tensile strength, elongation, Hardness is one of the most widely measured properties used to characterize rubber. The IRHD (International Rubber Hardness Degree) Scale and the Shore-A Scale are widely used. A number of instrument types exist for both – the IRHD Micro/Dead Load and Shore-A scales are most commonly used for rubber

These test methods use totally different indentor geometries, applied forces, test times and procedures. The IRHD test is usually non-destructive, and as such has to be the preferred method for final product inspection; the test takes 35 seconds. In contrast, the Shore-A method is often destructive (leaving a permanent indentation), but the test only takes 1 or 3 seconds.

Instruments exist for most of the IRHD and Shore scales, both as tabletop and hand held versions. The IRHD Dead Load has a Micro counterpart, which has had an established standard.

In summary, this paper aims to create a clear understanding of common hardness testing methods and the results they provide.

2. History

The Shore instruments had historical priority over the IRHD instruments by more than 30 years. The accuracy of a range of hardness testers was investigated, concluding that the main limitations were associated with the operator. Instruments with a spherical indentor and foot gave the smallest errors; the largest errors were associated with the Shore durometer.

It is stated that the most widely used instrument was then the Shore A type even though the IRHD method produced more repeatable results between operators, with higher accuracy, reproducibility and precision. However, Shore A has a less critical dependence than IRHD on sample thickness.

RMA-4 Rubber quality as per table-1

Table 1
RMA-4 rubber quality

RMA-4 RUBBER QUALITY :	
a. Ash content	- 35%
b. Material of construction of rubber	- RMA 4
c. HAF carbon	- 15-25 Phr
d. Barytes	- 40-45 Phr
e. Bleed test (in 33%Hcl at 50^{O}C/72 h	- Change in weight 12%max
f. Tensile Kg/Sq. cm strength	- Minimum 110
g. Elongation at break	- Minimum 350%

3. Relationships between scales between IRHD and shore-A instruments

The Shore range of hardness testers incorporates eight scale types: A, B, C, D, DO, O, OO and M. These are used for testing a wider range of materials. The A scale is used for soft rubbers and elastomers and type C for medium hard rubbers and plastics; both types use a truncated cone shaped indentor. Type A is the most commonly used rubber scale. Type B is used to test moderately hard rubbers and type D is used to test hard rubbers and plastics. These three use a 3/32 inch spherically ended indentor. All types require samples more than 6mm thick.

The IRHD method is based on the use of dead loads (weights). A foot is used to hold the sample in place with a force of 8.3N (Dead Load) or 235mN in the case of the Micro hardness tester. A primary load of 0.3N (Dead Load) or 8.3mN (Micro hardness tester) is then applied for 5 seconds, providing a datum position. A secondary load of 5.4N (Dead Load) or 145mN (Micro) is then applied for 30 seconds. The incremental displacement from the datum is measured and converted to an IRHD value (a non-linear scale defined in the standard). The full-range displacement of (Normal) Dead Load is 1.8mm; the Micro uses0.3mm.

When analysed the durometer indentation, providing an approximate relationship between IRHD and Shore A of (IRH≈ HA + 4), although this is very dependent on the sample compound.

4. Experiment carried

From the above discussion that results obtained from hand-held durometers are not reliable due to operator dependence. Therefore, only bench mounted instruments were used to obtain the experimental results; however, the conclusions drawn will also be relevant to hand held instruments.

All instruments were calibrated before starting and the calibration was rechecked at the end. A standard temperature of 25 ^{O}C was used. The Shore instruments were set to both 1 and 3 second dwell time (since the results from these times differ). Test times are defined by the standard for the IRHD instruments (5 and 30 seconds). Each flat sample was tested in 5 different places and curved samples were tested as specified below.

This work to include the Dead Load and Shore-A instruments as well as incorporating results from curved surfaces.

Standard Wallace test blocks (varying compounds of natural rubber, supplied by IRMA) for both dead load and were used to provide comparative results for each instrument.

The Shore standard suggests that samples be plied to increase their effective thickness; this was done to determine the effect of varying sample thickness. This was extended to similar work on the IRHD dead load and Shore A instruments. The standard thickness is 2.5mm to 12.5mm. A selection of thinner samples were tested and plied to determine the effect of varying sample thickness.

This methodology included an investigation into the effect of increasing the ambient temperature. Therefore, tests were carried out on the Dead Load and Shore A instruments at a raised temperature to determine any effect.

5. Experiment Results

A. With test blocks

The standard test blocks gave repeatable results using Micro and Normal Dead Load instruments. The 1 and 3 second dwell times (Shore A) produced equivalent and repeatable results. The Dead Load readings were consistently a few units higher than the Shore A readings over the range tested (40 – 90 IRHD).

B. Thickness effect

The IRHD Dead Load and Shore A instruments were used to test the standard samples (2.5mm thick). As expected, the results differed from those obtained using the specified instrument for the sample thickness. The rubber and also the IRHD Dead Load plotted (see figure 1).

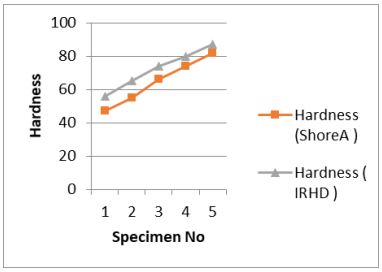

Fig. 1. Testing 2.5 mm thick samples

The Shore-A instrument read a few units lower as expected. Once the 2.5 mm thick samples were plied to 12.5mm thick (the standard thickness required for the IRHD Dead Load tester) the results came within the specified tolerances of the test pieces. Increasing the thickness further made little difference to the result. See fig. 2.

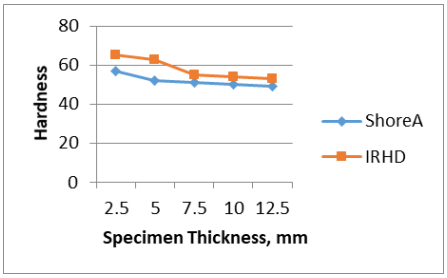

Fig. 2. Hardness reduction with increasing specimen thickness

C. Effect of temperature

Raising the temperature by 10OC appeared to make little difference to the results from the IRHD Dead Load on the standard test blocks (RMA-4 rubber). However, slightly lower values were observed on the harder samples tested on the Shore A instrument.

6. Conclusion

This paper has taken methodology of hardness testing using RMA-4 quality rubber at the IRHD and Shore-A Hardness measurement instruments as well as discussing and emphasizing the fundamental differences between the most common instruments used for rubber and elastomer hardness characterization. IRHD instruments are preferred for non-destructive testing with higher test cycle timings whereas the Shore A instrument is preferable for testing non-standard thickness samples and when shorter test cycle times are required. Accurate and repeatable timing is critical to allow Shore-A instruments to provide consistent and comparable results on RMA-4 quality rubber.

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