Hardness Traceability System
(Rockwell Hardness and Global Standards)
Hiroshi Yamamoto, Takashi Yamamoto, Hiroyuki Kawashima, and Shushi Sudoh
Yamamoto Scientific Tool Laboratory Co., Ltd.

1. Introduction

As a matter of fact, global standards for hardness testing are set by International Organization for Standardization. The ISO standard for hardness testing consists of three parts: Part 1 is for test methods, Part 2 is for testing machines, and Part 3 is for hardness standard blocks. JIS provides three independent standards, but they have perfect consistency with the three parts of the ISO hardness-testing standard. These standards prescribe that hardness testing machines first be subject to direct verification of their test force, indenter, testing cycle, and hardness indicator, and then that hardness must actually be measured using standardized blocks for indirect verification. This is a globally agreed fact. In this connection, the traceability or the uncertainty of Rockwell hardness has been a topic of international debate. This paper discusses our position on this issue as a manufacturer of hardness standardized blocks.

2. ISO Hardness Standards

A hardness standard is primarily established by the above-mentioned direct verification using metrological standards. There is also a growing consensus that the testing cycle for determinating the standard values of hardness blocks, which are used for indirect verification, should be unified globally by referring to ISO. Despite the existence of an international standard virtually established by ISO, outdated testing cycles are still used. Now, the world must choose either of the two testing cycles: the flexible ISO-based one advocated by ASTM, or the outdated and rigid special test cycle for standardizing machines (≠ISO). This is because the slight difference in hardness standard values resulting from using different test cycles cannot be ignored any more.

There is an emerging move toward international certification of hardness, but there are still many problems to be solved. The value of uncertainty still differs from nation to nation, or organization to organization, even when they test the same hardness block with almost the same level of standardizing machines [1]. To resolve the situation, the world needs a common evaluation method established upon international standards.

3. The Standard Value of a Hardness Block and Testing Cycle: Loading Speed Experiments

Due to the nature of hardness tests for material testing, any difference in loading conditions could bring a difference in their test results. Therefore, it is essential to internationally unify the testing cycle for determining the standard value of a hardness block. To address this issue, the following experiments were carried out on the effects of differences in the testing cycle, or loading conditions for determinating the standard value of hardness blocks.

3.1 Test Method and Specimen

Various high-accuracy hardness standard blocks, mostly made of steel, were used for the specimen. For the testing machine, a Wilson 2000 Rockwell hardness tester equipped with a high-accuracy displacement meter and a load cell was used. A Vickers diamond indenter was used for the indenter. The standard blocks were tested by applying six levels of test force from 15 to 45 kgf (the Rockwell Superficial range) or from 60 to 150 kgf (the Rockwell range) at five different Load Rise Times (LRTs) between 1 to 100 seconds to measure their Vickers hardness values. The load dwell time was fixed at one second.

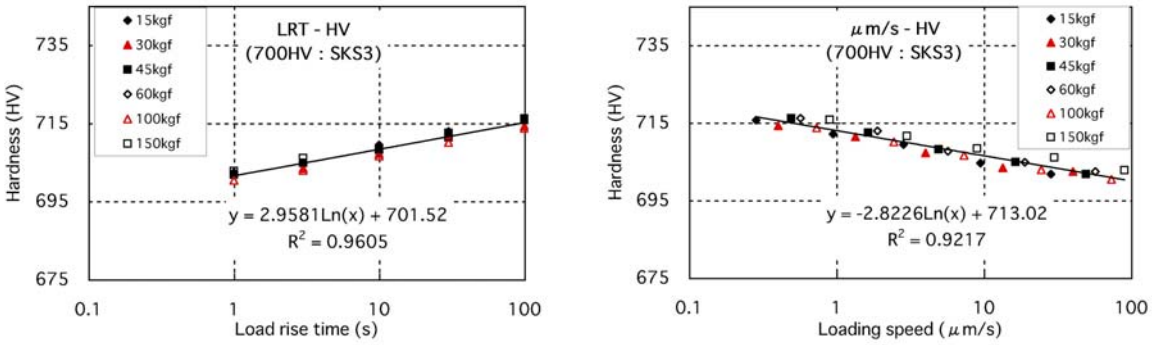

Fig. 1 Vickers Hardness at Different Loading Speeds (700HV: SKS3 steel hardness block)

3.2 Test Results

The test results are shown in Figure 1. The loading speed for hardness testing can be expressed in the form of indenter penetration speed, in μm/s, besides Load Rise Time (LRT) as used in ISO. Therefore, the test results are shown in both units of measure for comparison. For steel hardness blocks, as loading speed increased, the value of hardness decreased by a few percent in a higher hardness range, while the reverse phenomenon was seen in a lower hardness range. This phenomenon almost agrees with the results using a Vickers testing machine (with a load dwell time of zero) [2]. This indicates that the flexible testing cycle as stated in ASTM can be employed for general hardness testing without a problem. It also implies that the use of any loading conditions that differ from the testing cycle for general hardness testing should be avoided when determinating the standard value of hardness standards, which requires greater accuracy.

The test results also suggest that the unit of LRT is more practical and reasonable as the unit of loading speed for hardness testing. Figure 2 shows the results of HRC hardness tests using the same blocks and testing equipment as above. The load dwell time was fixed at one second, as it was in the Fig. 1.

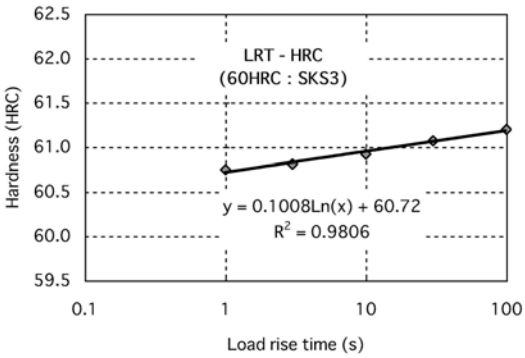

Fig. 2 Rockwell Hardness at Different Loading Speeds (60 HRC: SKS3 steel hardness block)

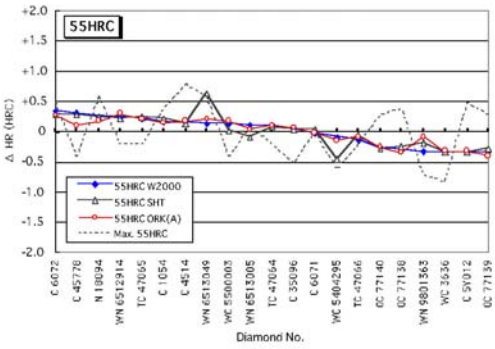

Fig. 3 Comparison of Rockwell Diamond Indenters (55 HRC)

3.3 Other Issues

Another issue to be addressed is the method for applying the initial load, especially for dead-weight testing machines. In addition, the issue of the embedded structure of Rockwell diamond indenters has also been discussed [3], as suggested in Fig. 3, as well as the geometrical accuracy of Rockwell diamond indenters. These problems should first be addressed when discussing the issue of the Rockwell hardness standard.

4. Summary

(1) Rockwell hardness standard is basically established by metrological standards, such as force and length, and the ISO international standards for hardness test.
(2) The issue of the standard value of hardness blocks still has many problems to be solved concerning indenters and others. Some people may therefore think they can choose any loading conditions that are not compliant to ISO, because the accuracy of the standard hardness value cannot be precisely established anyway at the moment. However, irrespective of the standardization of indenter and testing machine, if we do not rely on standardized testing cycles, variations will be caused in the standard hardness value.
(3) Load Rise Time (LRT) may be a more practical and reasonable unit of measure for specifying the speed of loading in hardness tests.

References

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2) *Takashi Yamamoto and Hiroshi Yamamoto*: “On the Standard Block for Hardness,” Proceeding of HARDMEKO 1998, p.23
3) *Hiroshi Yamamoto and Takashi Yamamoto*: “Effects of the Hardness Test Conditions,” Proceeding of XIV IMEKO World Congress 1997, p.252