

BILATERAL COMPARISON IN HRC BETWEEN NMIJ AND NIMT

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Abstract – This bilateral comparison in HRC between National Metrology Institute of Japan, (NMIJ) and National Institute of Metrology (Thailand), (NIMT) was done in order to establish the hardness scales of NIMT and confirm their accuracy, which was designated by NIMT (± 0.45 HRC). The hardness blocks of 20 HRC, 30 HRC, 40 HRC and 60 HRC, which all have uniformity within ± 0.1 HRC according to EN ISO 6508-3, were used in this comparison. They were measured by NMIJ and NIMT with different conditions in order to indicate the performance of machines and hardness scales. Agreement of machine performance is within ± 0.13 HRC and agreement of hardness scales is within ± 0.24 HRC.

Keywords : Rockwell hardness, Testing cycle

1. INTRODUCTION

NIMT is the juristic person under the supervision of the Ministry of Science and Technology (Thailand). It is responsible for establishing, maintaining and developing the national measurement standards of Thailand. The hardness laboratory of NIMT has just been established for distributing hardness traceability to the industrial sector. NMIJ provides technical cooperation for setting up the Rockwell hardness standard to NIMT through the JICA/NIMT project. This cooperation is in the form of bilateral comparison of Rockwell hardness between NMIJ and NIMT. The bilateral comparison confirms the correspondence of hardness scales between NMIJ and NIMT.

2. COMPARISON METHOD

2.1 Measurement method

The aim of the bilateral comparison is to compare hardness measurement results between NMIJ and NIMT at different conditions as follows:

2.1.1 Same testing cycle

The measuring was made with a common indenter using the same testing cycles as NMIJ to compare the mean values of the standardizing machines without the influence of the

indenter normally used in the laboratory.

2.1.2 Common indenter

The measuring was made with a common indenter (NIMT used a testing cycle according to EN ISO 6508-3 compared with NMIJ results) to evaluate the influence of different testing cycles from EN ISO 6508-3.

2.1.3 Different indenter

The measuring was made with the reference indenter of the different laboratories using the same testing cycles as NMIJ. The mean values of NIMT and NMIJ including effects of the reference indenter were compared without the influence of testing cycle.

2.1.4 Different indenters, machines and testing cycles

The measuring was made with the reference indenter of the different laboratories (NIMT used a testing cycle according to EN ISO 6508-3 compared with NMIJ results). The measurement result includes every influence of standardizing machines, indenters and testing cycles.

2.2 Testing cycles

There were two different testing cycle conditions as follows:

2.2.1 Testing cycle of NMIJ

- Duration of preliminary test force: $T_1 = 3$ s
- The velocity of the indenter when increasing preliminary test force to total test force: $v = 10$ $\mu\text{m/s}$
- Duration of the application of total test force: $T_2 = 10$ s
- Waiting for 4 s before taking data

2.2.2 Testing cycle according to EN ISO 6508-3

- Duration of preliminary test force: $T_1 = 3$ s
- The velocity of the indenter when increasing preliminary test force to total test force: $v = 33$ $\mu\text{m/s}$
- Duration of the application of total test force $T_2 = 4$ s
- Waiting for 4 s before taking data

*Testing condition according to EN ISO 6508-3 is used as the standard condition of NIMT.

2.3 Description of artifact

There were two sets of artifacts in the bilateral comparison. Each set consisted of 3 blocks of steel, which have nominal hardness values of 20, 40 and 60 HRC. Asahi and Yamamoto are the manufacturers of these blocks. The

blocks were satisfied to the geometrical and hardness uniformity requirements according to the ISO6508 document.

2.4 Common indenter

The geometric shape of the indenter was measured by JBI (Japan Bearing Inspection Institute).

Mean radius of the curvature = 200.0 μm

Mean angle of the conical part = 119° 58'

2.5 Uncertainty of the measuring equipment

The measurement uncertainty of each laboratory is shown in Table I.

TABLE I. Measurement uncertainty of Laboratory

Metrology Institute	Expanded uncertainty (± HRC)		
	20 to 25 HRC	40 to 45 HRC	60 to 65 HRC
NMIJ	0.35	0.35	0.35
NIMT	0.45	0.45	0.45

3. MEASUREMENT RESULTS

3.1 Value measured with the common indenter and NMIJ testing cycle

The measurements were carried out using the same indenter and with NMIJ testing cycle. The results are given in Table 2 and are plotted in Fig.1. The mean values of standardizing machines have a difference within ± 0.13 HRC.

3.2 Value measured with the common indenter and testing cycle of the different laboratories

The measurements were carried out using the same indenter to compare the mean values of the standardizing machine including the influence of testing cycle used. The results are given in Table 2 and are plotted in Fig.2. The difference values are within ± 0.23 HRC.

3.3 Value measured with the different indenters using NMIJ testing condition

The measurements were carried out with each laboratory's indenter using NMIJ testing condition. The mean values were compared including the influence of the indenter used. The results are given in Table 3 and are plotted in Fig.3. The values are different within ± 0.12 HRC.

3.4 Value measured with the different indenter using the different testing cycle of each laboratory

The measurements were carried out with each laboratory's indenter using each laboratory's testing cycle. The mean values were compared including every influence of standardizing machines, indenters and testing cycles. The results are given in Table 3 and are plotted in Fig.4. The values are different within ± 0.24 HRC.

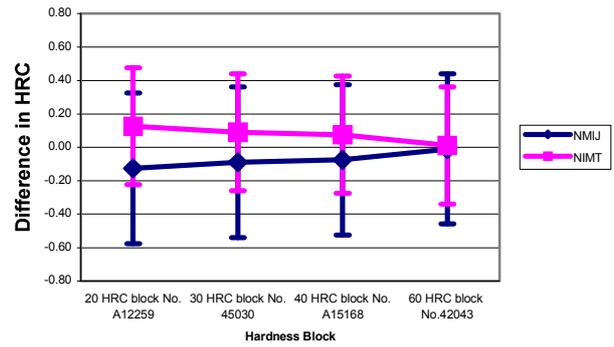


Fig. 1. Difference of the means value using common indenter and NMIJ testing cycle

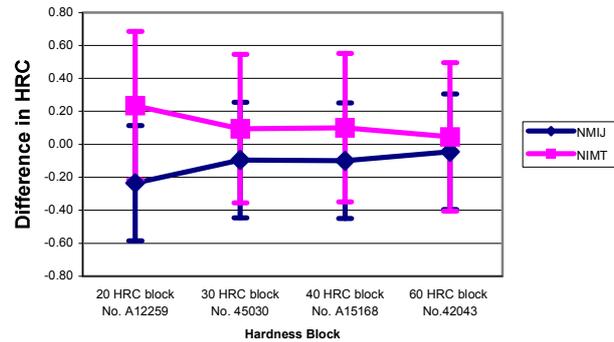


Fig. 2. Difference of the means value using common indenter and different testing cycle

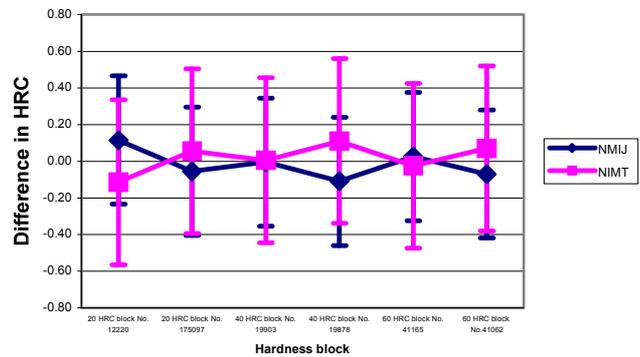


Fig. 3. Difference of the means value using each laboratory's indenter and NMIJ testing cycle

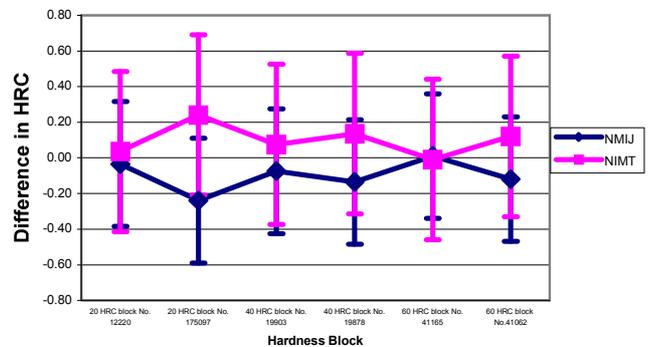


Fig. 4. Difference of the means value using each laboratory's indenter and different testing cycle

4. REPORTS

TABLE II. Measurement Result using common indenter

Lab.	Result in HRC unit				Testing cycle	Indenter
	20 HRC block No. A12259 *	30 HRC block No. 45030 **	40 HRC block No. A15168 **	60 HRC block No. 42043 **		
NMIJ	20.34	30.54	40.84	60.71	NMIJ testing cycle	Common indenter
NIMT	20.59	30.72	40.99	60.73	NMIJ testing cycle	
	20.81	30.73	41.04	60.80	EN ISO 6508-3	

TABLE III. Measurement Result using different indenters

Lab.	Result in HRC unit						Testing cycle	Indenter
	20HRC block No. 175097 *	20HRC block No. 12220 **	40HRC block No. 19878 *	40HRC block No. 19903 **	60HRC block No. 41062 *	60HRC block No. 41165 **		
NMIJ	20.95	20.17	40.71	40.71	60.28	60.41	NMIJ testing cycle	NMIJ
NIMT	21.06	19.94	40.93	40.72	60.42	60.36	NMIJ testing cycle	NIMT
	21.43	20.24	40.98	40.86	60.52	60.39	EN ISO 6508-3	

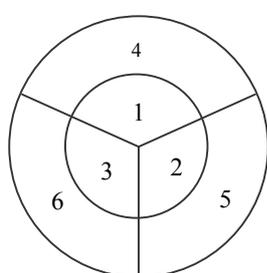
Remarks:

The measurement was consisted of 6 or 9 points of indentation.

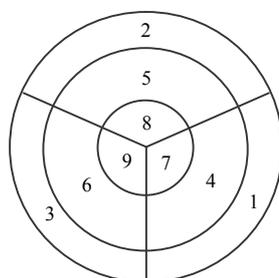
* referred to average value of 6 points of indentation

** referred to average value of 9 points of indentation

6 point-indentation was made on a block divided into 6 areas and 9 point-indentation was made on a block divided into 9 areas, as shown in the figure below.



6-areas block



9-areas block

5. CONCLUSION

This bilateral comparison represents a good comparison result between NMIJ and NIMT. It is satisfactory and confirms the accuracy of hardness scales, which were designated by NIMT (within ± 0.45 HRC). NIMT is confident in distributing the HRC traceability to the secondary laboratories and industrial sector in Thailand.

The result measured with different standard machines gives a difference within ± 0.13 HRC. The result measured with different testing cycles gives a difference within ± 0.23 HRC. The result measured with different indenters gives a difference within ± 0.12 HRC. The result measured with different hardness scales gives a difference within ± 0.24 HRC.

REFERENCES

- [1] EN ISO 6508-1/2/3: Metallic Materials- Rockwell hardness test