



**EURAMET Supplementary Comparison between
INRIM and UME in Rockwell Hardness Scales
(HRA - HRB - HRC)**

Technical Protocol

EURAMET.M.H-S1.a.b.c

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1. Introduction

A bilateral supplementary comparison between INRIM (National Metrology Institute of Italy) and TUBITAK UME (National Metrology Institute of Turkey) had been decided to be organized in the field of Hardness Metrology to determine the consistency of the national hardness standards in both countries realizing Rockwell Hardness measurements in accordance with ISO 6508-1:2016 and ISO 6508-3:2015 standards, including the new definition of HRC scale accepted by CIPM/CCM WGH. Most widely used Rockwell Hardness scales such as HRA, HRB and HRC will be the scope of the comparison which will be piloted by INRIM.

The blocks to be used in the comparison will be provided by UME. It is required that each NMI will measure five hardness levels for HRC and four hardness levels for HRA and HRB scales on the same transfer standards, using both their own indenters and common indenters which also will be provided by UME. Measurements will be realized first by UME as the provider of the blocks, then the pilot laboratory INRIM, then again by UME for checking the stability of transfer standards.

The NMIs are requested to realize traceability of each component constituting the hardness scales on their national standards to the base SI units and constitute their uncertainty budgets before the comparison measurements.

2. Participating Institutes

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3. Transfer Standards to be Used in the Comparison

In the bilateral comparison a total of three sets of hardness reference blocks will be used, one set for each hardness scale of HRA, HRB and HRC, separately. Five blocks for HRC scale and four blocks for each of HRA and HRB scales, a total of 13 hardness reference blocks will be provided by TUBITAK UME. Some information related to the hardness reference blocks to be used in the comparison is given below.

HRA Scale

No	Hardness Value	Serial Number	Producer
1	27 HRA	668-385	YAMAMOTO
2	46 HRA	666-752	YAMAMOTO
3	66 HRA	293-733	YAMAMOTO
4	87 HRA	284-385	YAMAMOTO

HRB Scale

No	Hardness Value	Serial Number	Producer
1	32 HRB	668-326	YAMAMOTO
2	53 HRB	661-029	YAMAMOTO
3	73 HRB	666-251	YAMAMOTO
4	95 HRB	666-850	YAMAMOTO

HRC Scale

No	Hardness Value	Serial Number	Producer
1	25 HRC	492-096	YAMAMOTO
2	36 HRC	489-678	YAMAMOTO
3	45 HRC	369-719	YAMAMOTO
4	57 HRC	454-774	YAMAMOTO
5	67 HRC	486-336	YAMAMOTO

The first measurements will be performed by UME as the provider of the blocks and common indenters, then the transfer standards and common indenters will be sent to the pilot laboratory INRIM and INRIM will realize its measurements with INRIM – own - indenters and common indenters and the hardness blocks and common indenters will be sent back to UME. Then UME will realize its second measurements with UME indenters (own indenters which is also supposed to be the common indenter) for checking the stability of the transfer standards.

UME is responsible for providing blocks and common indenters to be used in the comparison. The costs for transportation, customs and related administrative fees will be covered by UME. Below are some pictures of the transfer standards to be used in the comparison.

Transfer Standards for HRA Scale



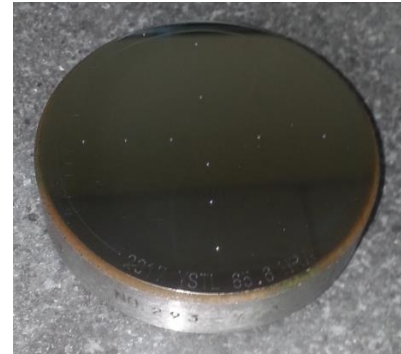
S/N: 668-385, 27 HRA



S/N: 666-752, 46 HRA



S/N: 293-733, 66 HRA

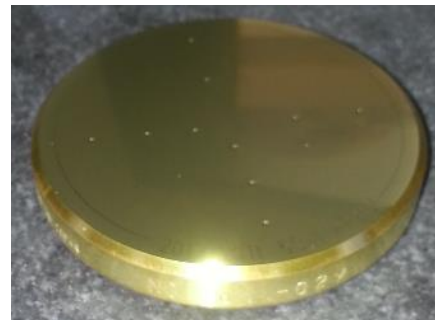


S/N: 284-385, 87 HRA

Transfer Standards for HRB Scale



S/N: 668-326, 32 HRB



S/N: 661-029, 53 HRB

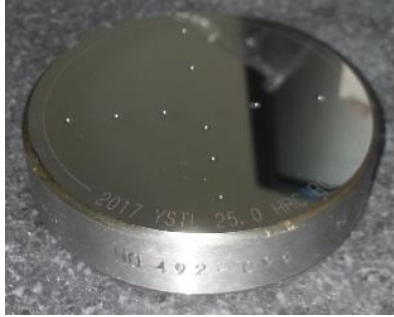


S/N: 666-251, 73 HRB



S/N: 666-850, 95 HRB

Transfer Standards for HRC Scale



S/N: 492-096, 25 HRC



S/N: 489-678, 36 HRC



S/N: 369-719, 45 HRC



S/N: 454-774, 57 HRC



S/N: 486-336, 67 HRC

4. Procedure

Each participant shall first assure that the national standards to be used in the comparison at least be in accordance with ISO 6508-1:2016 [1] and ISO 6508-3:2015 [2] standards. Under these circumstances the components to be calibrated/verified are as follows;

- Force (preliminary load, total load, preliminary load after removal of the total load)
- Testing cycle (In accordance with the new definition of HRC scale accepted by CCM WGH or at least in accordance with ISO 6508-1:2016 and ISO 6508-3:2015 standards)
- Indenter geometrical parameters (in accordance with ISO 6508-3:2015 standard)
- Depth measurement system (in accordance with ISO 6508-3:2015 standard)

After management of calibration of the components given above, the blocks shall be placed in the laboratory one day before the measurements for temperature equilibrium. The measurement steps can be as follows;

- Before starting the measurements, make sure the standardizing machines are working properly in accordance with their design parameters and relevant ISO standards requirements
- Make sure that the anvil where the blocks are seated on and both surfaces of the reference blocks are clean. For this purpose **Isopropyl alcohol** and a suitable soft material can be used
- Make sure that the relevant scale and related indenter and other requirements are mounted/selected etc.
- Record the ambient temperature
- Make two sets of 7 measurements (with the two indenters, one common and one own) uniformly distributed on the surface of the block and record them on the data form
- Record the ambient temperature

Seven measurements are planned to be taken and discard the first two to eliminate the effects coming from adaptation of the machine and the blocks. In the calculations the last five indentations will be taken into consideration. The first two indentations will be recorded but will not be used in the calculations.

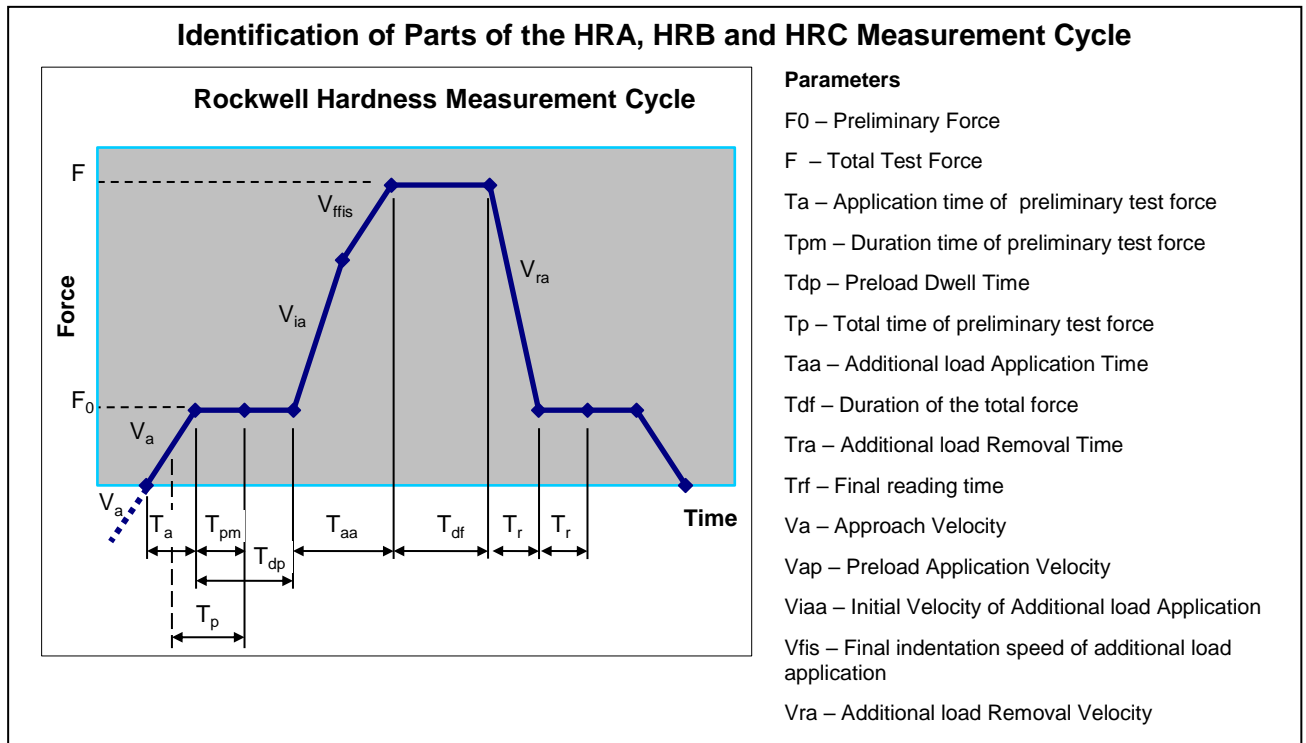
5. Reference Values of Influence Parameters

To perform measurements under the same or very similar conditions by the participants it will be significant to agree on reference values of the influence parameters and testing cycles and realize them as much as possible. In this comparison the following reference values shall be used in the measurements. Deviations from these values shall be taken into the uncertainty calculations. Below are the reference values and measurement cycle to be used in the HRA, HRB and HRC measurements.

Reference Values and Measurement Cycle for Rockwell Hardness Scales

<i>Reference values for HRA, HRB and HRC Scales</i>					
Symbol	Test parameters		Reference value	Start measurement	Stop measurement
F_0	Preliminary force		98,0665 N	-	-
F	Total test force for HRA		588,399 N		
	Total test force for HRB		980,665 N		
	Total test force for HRC		1470,998 N	-	-
α	Angle of the indenter (HRA, HRC)		120°	Blend point of the sphere and cone	±400 µm
D	Diameter of ball indenter (HRB)		1,5875 mm	-	-
R_a	Spherical tip radius of the indenter (HRA, HRC)		200 µm	-30° (from the axis)	+30° (from the axis)
V_{fis}	Final indentation speed of additional load application		30 µm·s ⁻¹	~80% F	~99% F
T_p	Total time of preliminary test force	$T_p = \frac{T_a}{2} + T_{pm}$	3 s	-	-

T_a	Application time of preliminary test force			~1% F_0	~99% F_0
T_{pm}	Duration time of preliminary test force		-	~99% F_0	Reading
T_{df}	Duration of the total force	5 s		~99% F	~99% F
T_{rf}	Final reading time	4 s		~101% F_0	Reading
T	Temperature of test	23°C		Beginning of the test	End of the test



6. Uncertainty Evaluation

Before the measurements, each participant laboratory shall carry out the calibration of the hardness standardizing machine and calculate their uncertainties. The following parameters which will constitute the uncertainty budgets are requested to be calibrated.

- test forces (preloads and total load)
- depth measuring system
- cone angle of the indenter, (HRA, HRC)
- spherical tip of the indenter, (HRA, HRC)
- diameter of the ball indenter, (HRB)
- final indentation speed of additional force application
- total time of preliminary test force
- duration of the total force

- final reading time
- reproducibility of the primary hardness machine

EURAMET/cg-16/v.02 [3] and JCGM 100 [4] documents may be used for the uncertainty budget calculations. Each laboratory has the responsibility for determining their own uncertainty budget and uncertainty value for each measurement or a common budget can be used. The uncertainty budget is requested to be presented to the pilot laboratory together with the measurement results.

7. Time Table of the Measurements

The measurements will be made first by UME as the provider of the reference hardness blocks and then the pilot laboratory INRIM and then UME again for checking the stability of the transfer standards. The measurements are planned to be realized in accordance with the following time table.

Institute/Country	Lab	Date of measurements
UME, Turkey	Participant	May, 2018
INRIM, Italy	Pilot	June, 2018
UME, Turkey	Participant	July, 2018

8. Transportation

The travelling standards (hardness reference blocks) and the common indenters are transported in a protective case or wooden box which will be prepared by UME. When the blocks are sent/transported the receiving institute must inspect them and notify the sending laboratory by e_mail. Before packing the blocks for transportation to the next participant (after measurements are finished) they shall be cleaned with Isopropyl alcohol and shall be wrapped in their anti-rusting paper, put in their original case and placed in the transportation box so that no damage can happen during transportation.

Travelling standards should be accompanied by custom documents, ei. with ATA carnet if an ATA carnet is used.

9. Data Compilation

Each laboratory will enter the measurement results and uncertainty values in the data sheet provided in the annex for each hardness reference block.

The participants are requested to give a short description of their national standards used for the comparison measurements.

The pilot laboratory is responsible for collecting and compiling the measurement data from the participants and prepare the reports.

The first draft, draft A, will be prepared as soon as all the results have been received from the participants.

After comments, remarks and discussion, a second draft, draft B, will be subsequently prepared for the EURAMET and will include an Appendix containing proposals for a reference value and degrees of equivalence. If it is approved by the EURAMET, a Final Report will be prepared and sent to the EURAMET.

The results will be used to support the CMCs of the participating laboratories declared in Appendix C of the MRA.

10. References

- [1] EN ISO 6508-1: 2016, Metallic Materials – Rockwell Hardness Test - Part1: Test Method (scales A, B, C, D, E, F, G, H, K, N, T).
- [2] EN ISO 6508-3: 2015, Metallic Materials - Rockwell Hardness Test - Part3: Calibration of Reference Blocks (scales A, B, C, D, E, F, G, H, K, N, T).
- [3] EURAMET/cg-16/v.02: 2011, Guidelines on the Estimation of Uncertainty in Hardness Measurements
- [4] JCGM 100: 2008, Evaluation of measurement data - Guide to the expression of uncertainty in measurement.
- [5] EN ISO/IEC 17043: 2010, Conformity Assessment-General requirements for proficiency testing.

Annex: Measurement Data Form.

HRA Scale

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRA				
1		Mean / HRA	Uniformity / HRA	Uncertainty / HRA	
2					
3					
4					
5					
6					
7					

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRA				
1		Mean / HRA	Uniformity / HRA	Uncertainty / HRA	
2					
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4					
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6					
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	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRA				
1		Mean / HRA	Uniformity / HRA	Uncertainty / HRA	
2					
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4					
5					
6					
7					

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRA				
1		Mean / HRA	Uniformity / HRA	Uncertainty / HRA	
2					
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HRB Scale

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
	No	Measurements / HRB			
1		Mean / HRB	Uniformity / HRB	Uncertainty / HRB	
2					
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4					
5					
6					
7					

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
	No	Measurements / HRB			
1		Mean / HRB	Uniformity / HRB	Uncertainty / HRB	
2					
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4					
5					
6					
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	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
	No	Measurements / HRB			
1		Mean / HRB	Uniformity / HRB	Uncertainty / HRB	
2					
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	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
	No	Measurements / HRB			
1		Mean / HRB	Uniformity / HRB	Uncertainty / HRB	
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HRC Scale

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRC				
1		Mean / HRC	Uniformity / HRC	Uncertainty / HRC	
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4					
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7					

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRC				
1		Mean / HRC	Uniformity / HRC	Uncertainty / HRC	
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	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRC				
1		Mean / HRC	Uniformity / HRC	Uncertainty / HRC	
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	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRC				
1		Mean / HRC	Uniformity / HRC	Uncertainty / HRC	
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3					
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6					
7					

HRC Scale

	Indenter	Producer			
		Serial N.			
	Block	Producer			
		Serial N.			
		Nom. H.			
No	Measurements / HRC				
1		Mean / HRC	Uniformity / HRC	Uncertainty / HRC	
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