Physikalisch-technische Bundesanstalt Braunschweig

Kazakhstan Institute of Metrology

COOMET Rockwell PTB/KazInMetr comparison

Final report

Braunschweig, November 2008/ K. Herrmann
Karaganda, November 2008/ M. Zhamanbalin

1 Introduction

This bilateral comparison of Rockwell scales between Kazakhstan Institute of Metrology (abbreviated as KazInMetr) was agreed upon in the year 2006 in the COOMET theme 371/KZ/06, in which should participate the hardness laboratories of national metrology institutes of Germany (PTB) and Kazakhstan (KazInMetr). The Physikalisch-Technische Bundesanstalt Braunschweig (Germany) declared the readiness to act as pilot laboratory of the comparison.

2 Organization

Participants

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Time schedule of the comparison

The comparison started in August 2007 with the measurements at PTB. The following table shows the scheduled measuring time:

Institute/country	Time of measurements
PTB, Germany	08/2007
KazInMetr, Kazakhstan	05/2008

3 Standards

3.1 Description

In the bilateral comparison 8 sets for the Rockwell scales HRC, HRA, HRB, HR15N, HR30N, HR45N, HR15T, HR30T with each 3 different hardness levels are used, that is altogether 24 blocks. The blocks are triangular with an edge length of 70 mm x 70 mm x 70 mm and a thickness of 6 mm. The upper side of the blocks which is the measurement surface is finished. The blocks are manufactured as commercial products by Buderus Co., Germany.

3.2 Handling

It is recommended to clean the blocks after unpacking with alcohol and then sign the measurement locations with a fiber pen. After measurement all dots on the blocks must be removed before packing in order to avoid corrosion.

4 Measurand

The measurand is the hardness value in five locations on a hardness reference block. The procedure of the hardness measurement is defined in ISO 6508-1 and -3.

5 Methods of measurement

The measuring devices used by the participants are described in Appendix A1.

6 Measurement results

In the following table the results for the hardness reference blocks are summarized. The results are expressed by the mean values of each 5 indentations in Table 1.

Table 1: Mean values of the hardness measurement results (in HR)

Hardness scale	H_{PTB}	U_{PTB}	$H_{KazInMetr}$	$U_{KazInMetr}$	Δ(KazInMetr-PTB)	$\Delta_{acceptable}$
60 HRA	59.84	0.3	59.90	0.5	+0.06	0.58
70 HRA	71.33	0.3	71.10	0.5	-0.23	0.58
80 HRA	81.36	0.3	81.26	0.5	-0.10	0.58
60 HRB	59.03	0.5	58.36	0.8	-0.67	0.94
75 HRB	75.76	0.5	75.08	0.8	-0.68	0.94
100 HRB	97.64	0.5	97.04	0.8	-0.60	0.94
30 HRC	29.34	0.3	29.36	0.5	+0.02	0.58
50 HRC	49.84	0.3	49.71	0.5	-0.13	0.58
65 HRC	62.79	0.3	62.76	0.5	-0.03	0.58
70HR15N	71.00	0.4	70.85	0.7	-0.15	0.81
80HR15N	81.73	0.4	81.35	0.7	-0.38	0.81
90HR15N	89.87	0.4	89.83	0.7	-0.04	0.81
50HR30N	49.44	0.4	49.46	0.7	+0.02	0.81
60HR30N	60.93	0.4	60.47	0.7	-0.46	0.81
75HR30N	76.23	0.4	75.86	0.7	-0.37	0.81
30HR45N	31.17	0.4	31.03	0.7	-0.14	0.81
50HR45N	49.70	0.4	49.32	0.7	-0.38	0.81
65HR45N	65.13	0.4	65.15	0.7	+0.02	0.81
80HR15T	79.38	0.8	79.60	0.8	+0.22	1.13
85HR15T	83.80	0.8	84.02	0.8	+0.22	1.13
90HR15T	90.27	0.8	90.22	0.8	-0.05	1.13
55HR30T	54.62	0.8	55.50	1.2	+0.88	1.44
65HR30T	64.72	0.8	65.57	1.2	+0.85	1.44
80HR30T	78.34	0.8	78.88	1.2	+0.54	1.44

The acceptable difference between the measurement result of PTB and KazInMetr follows from:

$$\left|\Delta_{aceptable}\right| \le \sqrt{(U_{PTB}^2 + U_{KazInMetr}^2)}$$

The acceptable difference is confirmed by the stated uncertainties of the two participants of this bilateral comparison.

7 Results of calibrations

7.1 Results of KazInMetr

Measurements are carried out on the standard machine 8150 TK from Indentec Co. Indenters: standardizing diamond No.03592 for scales HRA, HRC, HRN and hardmetall ball, batch No.52891 for scales HRB, HRT. The following times are set: total force application time 4 s, reading time after application of the preliminary test force 3 s. The range of temperatures for hardness measurements: (18.0-24.0)^{o}C.

The results of the calibrations are contained in Table 2.

Table 2
Results of calibration of the hardness standard machine of KazInMetr

Quantity	Used calibration instrument	Result of calibration (uncertainty of the machine)
Preliminary test force, F_0	Force transducers 50kgf	0.2 N
Total test force, F	Force transducers 50kgf, 200kgf	1.5 N
Indentation depth h	Gauge blocks	0.2 μm
Preliminary test force duration time t_o	Stop watch	0.1 s
Indentation velocity	Stop watch	1 μm/s
Total test force duration time t	Stop watch	0.1 s
Indenter cone angle α	Measurement microscope	0.1°
Indenter radius r	Measurement microscope	2 μm
Diameter of ball indenter	Length measurement machine	2.5 μm
Deformation of frame	Hardened steel ball	0.3 μm

7.2 Results of PTB

Measurements are carried out on the hardness standard machine RNG10 for hardness scales HRA, HRB, HRC and on the hardness standard machine RNG 3 for hardness scales HRN and HRT. The indenters are No.836 for scales HRA, HRC and No 838 for scale HRN and hardmetal ball No. HRB1 for scales HRB, HRT. The following times are set: total force application time 4 s, total force application time: 7 s, reading time after application of the preliminary test force 3 s. The range of temperatures for hardness measurements: (20.0±0.5) ^{o}C.

The results of the calibrations are contained in Table 3.

Table 3
Results of calibration of the hardness standard machine of PTB

Quantity	Used calibration instrument	Result of calibration (uncertainty of the machine)
Preliminary test force, F_0	Force transducer 100 N	0.2 N
Total test force, F	Force transducer 2000 N	1.5 N
Indentation depth h	Laser interferometer	0.05 μm
Preliminary test force duration time t_o	Stop watch	0.1 s
Indentation velocity	Computer clock	0.5 μm/s
Total test force duration time	Stop watch	0.1 s

t		
Indenter cone angle α	Interference microscope	0.1°
Indenter radius r	Nano Measuring Machine	1 µm
Deformation of frame	Inductive measurement transducer	0.1 µm
Diameter of ball indenter	Length measurement machine	0.2 µm

8 Uncertainty budgets

The estimation of the uncertainty follows the guideline EURAMET/cg-16/v.01 [1].

8.1 Sensitivity coefficients of influence quantities

Sensitivity coefficients of influence quantities for the Rockwell hardness scales HRA and HRB are summarized in the Tables 4, 5 and 6.

Table 4: Sensitivity coefficients of influence quantities for Rockwell hardness scale HRA

Parameter	Symbol	Unit	Sensitivity coefficient symbol	Sensitivity coefficient	Source
Preliminary test force	F_0	N	$\frac{\Delta HRA}{\Delta F_0}$	-0.00372*Hardness(HRA) + 0.3574	NIST
Total test force	F	N	$\frac{\Delta HRA}{\Delta F}$	0.00137*Hardness(HRA) - 0.1396	NIST
Permanent depth of indentation	h	µm	$\frac{\Delta HRA}{\Delta h}$	1/2	Definition
Preliminary test force duration time	t_0	s	$\frac{\Delta HRA}{\Delta t_0}$	-0.0011*Hardness(HRA) + 0.0874	NPL
Indentation velocity	v	µm·s^{-1}	$\frac{\Delta HRA}{\Delta v}$	0.00035*Hardness(HRA) - 0.0224	NPL
Total test force duration time	t	s	$\frac{\Delta HRA}{\Delta t}$	0.00160*Hardness(HRA) - 0.162	NPL
Indenter angle	a	°	$\frac{\Delta HRA}{\Delta \alpha}$	0.18	NIM
Indenter radius	r	µm	$\frac{\Delta HRA}{\Delta r}$	0.058	NIM

Table 5: Sensitivity coefficients of influence quantities for Rockwell hardness scale HRB

Parameter	Symbol	Unit	Sensitivity coefficient symbol	Sensitivity coefficient	Source
Preliminary test force	F_0	N	$\frac{\Delta HRB}{\Delta F_0}$	-0.0022*Hardness(HRB) + 0.233	NIST
Total test force	F	N	$\frac{\Delta HRB}{\Delta F}$	0.00092*Hardness(HRB) - 0.139	NIST
Permanent depth of indentation	h	µm	$\frac{\Delta HRB}{\Delta h}$	1 / 2	Definition
Preliminary test force duration time	t_0	s	$\frac{\Delta HRB}{\Delta t_0}$	-0.00009*Hardness(HRB)^2 + 0.0128*Hardness(HRB) - 0.3254	NPL
Indentation velocity	v	µm·s^{-1}	$\frac{\Delta HRB}{\Delta v}$	-0.00014*Hardness(HRB) + 0.0102	NPL
Total test force duration time	t	s	$\frac{\Delta HRB}{\Delta t}$	-0.017	NIST
Indenter ball diameter	d	µm	$\frac{\Delta HRB}{\Delta d}$	-0.00049*Hardness(HRB) +0.022	NIM

Table 6: Sensitivity coefficients of influence quantities for Rockwell hardness scale HRC

Parameter	Symbol	Unit	Sensitivity coefficients at different hardness levels, HR		
			20 to 25	40 to 45	60 to 65
Preliminary test force	F_0	N	$1.2*10^{-1}$	$7.0*10^{-2}$	$5.0*10^{-2}$
Total test force	F	N	$-4.0*10^{-2}$	$-3.0*10^{-2}$	$-2.0*10^{-2}$
Indenter angle	α	°	$1.3*10^{0}$	$8.0*10^{-1}$	$4.0*10^{-1}$
Indenter radius	r	s	$1.5*10^{1}$	$3.0*10^{1}$	$5.0*10^{1}$
Permanent depth of indentation	h	µm	$-5.0*10^{-1}$	$-5.0*10^{-1}$	$-5.0*10^{-1}$
Indentation velocity	v	µm·s^{-1}	$-2.0*10^{-2}$	0.0*10°	$3.0*10^{-2}$
Preliminary test force duration time	t_0	s	$1.0*10^{-2}$	$5.0*10^{-3}$	$4.0*10^{-3}$
Total test force duration time	t	s	$-7.0*10^{-2}$	$-4.0*10^{-2}$	$-3.0*10^{-2}$

8.2 Uncertainty budgets of KazInMetr

Based on the sensitivity coefficients in par. 8.1 the following uncertainty budgets for the hardness scales HRA, HRB and HRC can be established for the case of rectangular distribution of the input quantities.

The expanded uncertainty follows from:

$$U_c = 2\sqrt{\sum_i (c_i u(x_i)^2}$$

Table 7A: Example of uncertainty budget for 35 HRA

Uncertainty budget for 35 HRA

Quantity X_i	Estimated value Δx_i		Standard uncertainty $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$	Sensitivity coefficient C_i	Uncertainty contribution $u_i(H)$
Preliminary test force, *Fo*	0.2	N	0.12	0.227	0.026
Total test force, *F*	1.5	N	0.87	-0.09165	-0.079
Permanent depth of indentation, *h*	0.2	µm	0.12	0.5	0.058
Preliminary test force dwell time, *to*	1.5	s	0.87	0.0489	0.042
Indentation velocity, *v*	10	µm·s^{-1}	5.77	-0.01015	-0.059
Total test force dwell time, *t*	2	s	1.15	-0.106	-0.122
Indenter angle, *α*	0.1	°	0.06	0.18	0.010
Indenter radius, *r*	5	µm	2.89	0.058	0.167
Deformation of frame, *DF*	0.3	µm	0.17	0.5	0.087
Combined uncertainty, u_c				k=2	0.257
Expanded uncertainty, Ue					0.51

Table 7B: Example of uncertainty budget for 55 HRA
Uncertainty budget for 55 HRA

Quantity X_i	Estimated value Δx_i		Standard uncertainty $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$	Sensitivity coefficient C_i	Uncertainty contribution $u_i(H)$
Preliminary test force, *Fo*	0.2	N	0.12	0.153	0.018
Total test force, *F*	1.5	N	0.87	-0.06425	-0.056
Permanent depth of indentation, *h*	0.2	µm	0.12	0.5	0.058
Preliminary test force dwell time, *to*	1.5	s	0.87	0.0269	0.023
Indentation velocity, *v*	10	µm·s^{-1}	5.77	-0.00315	-0.018
Total test force dwell time, *t*	2	s	1.15	-0.074	-0.085
Indenter angle, *α*	0.1	°	0.06	0.18	0.010
Indenter radius, *r*	5	µm	2.89	0.058	0.167
Deformation of frame, *DF*	0.3	µm	0.17	0.5	0.087
Combined uncertainty, u_c				k=2	0.225
Expanded uncertainty, Ue					0.45

Table 7C: Example of uncertainty budget for 85 HRA
Uncertainty budget for 85 HRA

Quantity X_i	Estimated value Δx_i		Standard uncertainty $u(x_i)=\frac{\Delta x_i}{\sqrt{3}}$	Sensitivity coefficient C_i	Uncertainty contribution $u_i(H)$
Preliminary test force, *Fo*	0.2	N	0.12	0.041	0.005
Total test force, *F*	1.5	N	0.87	-0.02315	-0.020
Permanent depth of indentation, *h*	0.2	µm	0.12	0.5	0.058
Preliminary test force duration, *to*	1.5	s	0.87	-0.0061	-0.005
Indentation velocity, *v*	10	µm·s^{-1}	5.77	0.00735	0.042
Total test force duration time, *t*	2	s	1.15	-0.026	-0.030
Indenter angle, *α*	0.1	°	0.06	0.18	0.010
Indenter radius, *r*	5	µm	2.89	0.058	0.167
Deformation of frame, *DF*	0.3	µm	0.17	0.5	0.087
Combined uncertainty, u_c				k=2	0.205
Expanded uncertainty, Ue					0.41

Table 7D: Example of uncertainty budget for 25 HRB
Uncertainty budget for 25 HRB

Quantity X_i	Estimated value Δx_i		Standard uncertainty $u(x_i)=\frac{\Delta x_i}{\sqrt{3}}$	Sensitivity coefficient C_i	Uncertainty contribution $u_i(H)$
Preliminary test force, *Fo*	0.2	N	0.12	0.178	0.021
Total test force, *F*	1.5	N	0.87	-0.116	-0.100
Permanent depth of indentation, *h*	0.2	µm	0.12	0.5	0.058
Preliminary test force dwell time, *to*	1.5	s	0.87	-0.06165	-0.053
Indentation velocity, *v*	10	µm·s^{-1}	5.77	0.0137	0.079
Total test force duration time, *t*	2	s	1.15	-0.017	-0.020
Indenter ball diameter, *d*	1	µm	0.58	0.00975	0.006
Deformation of frame, *DF*	0.3	µm	0.17	0.5	0.087
Combined uncertainty, u_c				k=2	0.176
Expanded uncertainty, Ue					0.35

Table 7E: Example of uncertainty budget for 60 HRB
Uncertainty budget for 60 HRB

Quantity X_i	Estimated value Δx_i		Standard uncertainty $u(x_i)=\frac{\Delta x_i}{\sqrt{3}}$	Sensitivity coefficient C_i	Uncertainty contribution $u_i(H)$
Preliminary test force, *Fo*	0.2	N	0.12	0.101	0.012
Total test force, *F*	1.5	N	0.87	-0.0838	-0.073
Permanent depth of indentation, *h*	0.2	µm	0.12	0.5	0.058
Preliminary test force duration time, *to*	1.5	s	0.87	0.1186	0.103
Indentation velocity, *v*	10	µm·s^{-1}	5.77	0.0186	0.107
Total test force dwell time, *t*	2	s	1.15	-0.017	-0.020
Indenter ball diameter, *d*	1	µm	0.06	-0.0074	0.004
Deformation of frame, *DF*	0.3	µm	0.17	0.5	0.087
Combined uncertainty, u_c				k=2	0.197
Expanded uncertainty, Ue					0.39

Table 7F: Example of uncertainty budget for 100 HRB
Uncertainty budget for 100 HRB

Quantity X_i	Estimated value Δx_i		Standard uncertainty $u(x_i)=\frac{\Delta x_i}{\sqrt{3}}$	Sensitivity coefficient C_i	Uncertainty contribution $u_i(H)$
Preliminary test force, *Fo*	0.2	N	0.12	0.013	0.002
Total test force, *F*	1.5	N	0.87	-0.047	-0.041
Permanent depth of indentation, *h*	0.2	µm	0.12	0.5	0.058
Preliminary test force dwell time, *to*	1.5	s	0.87	0.0546	0.047
Indentation velocity, *v*	10	µm·s^{-1}	5.77	-0.0242	0.140
Total test force dwell time, *t*	2	s	1.15	-0.017	-0.020
Indenter ball diameter, *d*	1	µm	0.58	-0.027	-0.016
Deformation of frame, *DF*	0.3	µm	0.17	0.5	0.087
Combined uncertainty, u_c				k=2	0.187
Expanded uncertainty, Ue					0.37

Table 7G: Example of uncertainty budget for HRC
Uncertainty budget for 3 levels HRC

x,	a,	$u^2(x_i)=\frac{a_i^2}{3}$	Sensitivity coefficients at different hardness levels ΔH			Contributions to $u^2(H)/HRC^2$ at different hardness levels		
			20 to 25	40 to 45	60 to 65	20 to 25	40 to 45	60 to 65
F_0/N	0.2	$1.3*10^{-2}$	$1.2-10^{-1}$	$7.0*10^{-2}$	$5.0*10^{-2}$	$1.9*10^{-2}$	$6,4*10^{-5}$	$3,3*10^{-5}$
F/N	1.5	$7.5*10^{-1}$	$-4.0*10^{-2}$	$-3.0*10^{-2}$	$-2.0*10^{-2}$	$1.2*10^{-3}$	$6,8*10^{-4}$	$3,0*10^{-4}$
α/°	0.1	$3.3*10^{-3}$	$1.3*10^{0}$	$8.0*10^{-1}$	$4.0*10^{-1}$	$5.6*10^{-3}$	$2.1*10^{-3}$	$5.3*10^{-4}$
r/mm	0.005	$8.3*10^{-6}$	$1.5*10^{1}$	$3.0*10^{1}$	$5.0*10^{1}$	$1.9*10^{-3}$	$7.5*10^{-3}$	$2.1*10^{-2}$
h/μm	0.2	$1.3*10^{-2}$	$-5.0*10^{-1}$	$-5.0*10^{-1}$	$-5.0*10^{-1}$	$3.3*10^{-3}$	$3.3*10^{-3}$	$3.3*10^{-3}$
v/(μm/s)	10	$3.3*10^{+1}$	$-2.0*10^{-2}$	0.0*10°	$3.0*10^{-2}$	$1.3*10^{-2}$	0.0*10°	$3.0*10^{-2}$
t_o/s	1.5	$7.5*10^{-1}$	$1.0*10^{-2}$	$5.0*10^{-3}$	$4.0*10^{-3}$	$7.5*10^{-5}$	$1.9*10^{-5}$	$1,2*10^{-5}$
t/s	2	$1.3*10^{0}$	$-7.0*10^{-2}$	$-4.0*10^{-2}$	$-3.0*10^{-2}$	$6,4*10^{-3}$	$2.1*10^{-3}$	$1.2*10^{-3}$
TOTAL u^2 /HRC^2 =Σu_i^2/HRC^2						0.03	0.02	0.06
Standard uncertainty *u/HRC*						0.18	0.13	0.24
Expanded uncertainty *U/HRC* = *ku*/HRC						0.36	0.26	0.47

9 Degree of equivalence

The degree of equivalence according to [2] is calculated as the pair of values ($d_{i,j}$, $U(d_{i,j})$ using

$$d_{i,j} = x_i - x_j$$

$$U(d_{i,j}) = 2u(d_{i,j}),$$

where $u(d_{i,j})$ is given by

$$u^2(d_{i,j}) = u^2(x_i) + u^2(x_j)$$

The degrees of equivalence are listed in Table 8.

Table 8
Degrees of equivalence of the comparison

Hardness scale	x_i	x_j	$u(x_i)$	$u(x_j)$	$\mathbf{d_{i,j}}$	$\mathbf{U(d_{i,j})}$
60 HRA	59.84	59.90	0.15	0.25	**-0.06**	**0.58**
70 HRA	71.33	71.10	0.15	0.25	**+0.23**	**0.58**
80 HRA	81.36	81.26	0.15	0.25	**+0.10**	**0.58**
60 HRB	59.03	58.36	0.25	0.40	**+0.67**	**0.94**
75 HRB	75.76	75.08	0.25	0.40	**+0.68**	**0.94**
100 HRB	97.64	97.04	0.25	0.40	**+0.60**	**0.94**
30 HRC	29.34	29.36	0.15	0.25	**-0.02**	**0.58**
50 HRC	49.84	49.71	0.15	0.25	**+0.13**	**0.58**
65 HRC	62.79	62.76	0.15	0.25	**+0.03**	**0.58**
70HR15N	71.00	70.85	0.20	0.35	**+0.15**	**0.81**
80HR15N	81.73	81.35	0.20	0.35	**+0.38**	**0.81**
90HR15N	89.87	89.83	0.20	0.35	**+0.04**	**0.81**
50HR30N	49.44	49.46	0.20	0.35	**-0.02**	**0.81**

60HR30N	60.93	60.47	0.20	0.35	**+0.46**	**0.81**
75HR30N	76.23	75.86	0.20	0.35	**+0.37**	**0.81**
30HR45N	31.17	31.03	0.20	0.35	**+0.14**	**0.81**
50HR45N	49.70	49.32	0.20	0.35	**+0.38**	**0.81**
65HR45N	65.13	65.15	0.20	0.35	**-0.02**	**0.81**
80HR15T	79.38	79.60	0.40	0.40	**-0.22**	**1.13**
85HR15T	83.80	84.02	0.40	0.40	**-0.22**	**1.13**
90HR15T	90.27	90.22	0.40	0.40	**+0.05**	**1.13**
55HR30T	54.62	55.50	0.40	0.60	**-0,88**	**1.44**
65HR30T	64.72	65.57	0.40	0.60	**-0.85**	**1.44**
80HR30T	78.34	78.88	0.40	0.60	**-0.54**	**1.44**

10 Discussions, conclusions and remarks

The COOMET Rockwell PTB/KazInMetr comparison can be considered as a successful metrological exercise. The stated uncertainties were confirmed by the found measurement result differences.
It is recommended to concentrate metrological investigations on the influence of ball indenter deviations at the HRT scale.

11 Reference

[1] Calibration guide EURAMET/cg-16/v.01 “Guidelines on the estimation of uncertainty in hardness measurements (originally EA-10/16)
[2] W. Bich, M.G. Cox, W.T. Estler, L. Nielsen, W. Woeger: Proposed guidelines for the evaluation of key comparison data, BIPM (2003)

Appendix

A1 Description of the instruments by the participants

A1.1 Hardness standard machines of PTB

1) Hardness standard machine RNG 10
The hardness standard machine RNG10 manufactured by PGH Kraftmessgeräte Halle (Germany) is intended for the Rockwell hardness scales HRA, HRB and HRC. It contains two suspensions, where the upper suspension with a mass of 10 kg generates the preliminary test force of 98,07 N and the lower suspension takes the corresponding deadweights which generate the additional test force. The measurement of the indentation depth is realized with a laser interferometer from SIOS Co. in Ilmenau with a resolution of 2 nm. The vertical movement of the indenter together with the suspensions is carried out with an electrical motor driving a ball screw spindle. As diamond Rockwell indenters one of a group standard consisting of four indenters is used. The Force-time-pattern according to ISO 6508 is realized with a control computer by Siemens Co. and a personal computer.

2) Hardness standard machine RNG 3
The hardness standard machine RNG3 manufactured by PGH Kraftmessgeräte Halle (Germany) is intended for the Superficial Rockwell hardness scales HRN and HRT. It contains two suspensions, where the upper suspension with a mass of 3 kg generates the preliminary test force of 29.42 N and the lower suspension takes the corresponding deadweights which generate the additional test force.

The vertical movement of the indenters together with the suspensions is carried out by a hydraulic piston driven by an oil pump with nozzles for the control of the force application velocity. The measurement of the indentation depth is realized with a laser interferometer from SIOS Co. in Ilmenau with a resolution of 2 nm. As diamond Rockwell indenters one of a group standard consisting of four indenters is used. The Force-time-pattern according to ISO 6508 is realized with an electro-hydraulic control system together with a software control on a personal computer.

A1.2 Hardness standard machine of KazInMetr

Measurements of hardness blocks are executed on the standard machine 8150 ТК, id.No032811. The standard machine are produced by Indentec Hardness Testing Machine Ltd, UK, in 2003. Indenters is manufactured by Star Industrial Tools Ltd, UK.
This machine is intended for the calibration of Rockwell hardness test blocks, and is designed to meet the requirements of ISO 6508.
It is fitted with a motorized leadscrew, which is used to raise the test block into the correct position. A test block is supported on a special tungsten carbide anvil. The machine has a lever system with automatic cycle applied forces. The resolution of the measuring device is 0,01 HR. The measuring device of standard machine has a linear transducer.