REPORT NO. 1153

Hardness Testing of Metals

Proficiency Testing Program

Round 16

August 2019

ACKNOWLEDGMENTS

PTA wishes to gratefully acknowledge the technical assistance provided for this program by Mr S Sameem, ARL Laboratory Services Pty Ltd. Also our thanks go to ARL Laboratory Services Pty Ltd, for the supply and homogeneity testing of the samples.

PO Box 7507 Silverwater NSW 2128 AUSTRALIA

CONTENTS

1. FOREWORD

This report summarises the results of a proficiency testing program on the hardness properties of metals. It constitutes the sixteenth round of an ongoing series of programs. This program is accredited to ISO/IEC 17043: 2010 "*Conformity assessment - General requirements for proficiency testing"* by International Accreditation New Zealand (IANZ).

Proficiency Testing Australia (PTA) conducted the testing program in June 2019. The aim of the program was to assess laboratories' ability to competently perform the nominated tests.

The Program Coordinator was Dr M Bunt. The Technical Adviser was Mr S Sameem, ARL Laboratory Services Pty Ltd. This report was authorised by Mrs K Cividin, PTA Quality Manager.

2. FEATURES OF THE PROGRAM

(a) A total of 14 laboratories received samples, one of which did not return results for inclusion in the final report. Laboratories from the following countries received samples:

10	AUSTRALIA
1	SAUDI ARABIA
1	SOUTH KOREA
1	TANZANIA
1	THAILAND

To ensure confidential treatment of results, each laboratory was allocated a unique random code number. Reference to each laboratory in this report is by its code number. Please note that one laboratory reported more than one set of results and, therefore, this laboratory's code number (with letter) could appear several times in the same data set.

(b) The results reported by participants are presented in Appendix A.

(c) Each laboratory was provided with an aluminium sample, approximately 65 mm in diameter and approximately 35 mm thick. The sample was to be tested for Brinell, Vickers and Rockwell B hardness testing.

(d) Laboratories were requested to perform the tests according to the *Instructions to Participants* provided and to record the results, along with an estimate of their measurement uncertainty (MU) for each result, on the accompanying *Results Sheet*, which was distributed with the samples. Copies of these documents appear in Appendix C.

(e) Prior to distribution, the samples were tested for homogeneity by ARL Laboratory Services Pty Ltd. Based on the results of this testing, the homogeneity of the samples was established (see Appendix B).

3. FORMAT OF THE APPENDICES

(a) Appendix A is divided into four sections (A1-A4).

Sections A1-A3 contain the analysis of results reported by laboratories for Brinell, Vickers and Rockwell B hardness. These sections contain:

i) a table of results reported by laboratories for each test, with estimates of their MUs and calculated z-scores;
ii) a listing of the summary statistics; and
iii) ordered z-score charts.

Section A4 contains information on the methods used by the participants and the surface preparations they performed.

(b) Appendix B contains details of the homogeneity testing.

(c) Appendix C contains copies of the *Instructions to Participants* and *Results Sheet*.

4. STATISTICAL DESIGN OF THE PROGRAM

The summary statistics calculated for each test / sample consists of:

- *No. of Results*: the total number of results for that test / sample;
- *Median*: the middle value of the results;
- *Normalised IQR*: the normalised interquartile range of the results;
- *Uncertainty of the Median*: a robust estimate of the standard deviation of the *Median*;
- *Robust CV*: the robust coefficient of variation expressed as a percentage, *i.e.* 100 x *Normalised IQR* / *Median*;
- *Minimum*: the lowest laboratory result;
- *Maximum*: the highest laboratory result; and
- *Range*: the difference between the *Maximum* and *Minimum*.

The median is a measure of the centre of the data.

The normalised IQR is a measure of the spread of the results. It is calculated by multiplying the interquartile range (IQR) by a correction factor, which converts the IQR to an estimate of the standard deviation. The IQR is the difference between the upper and lower quartiles (*i.e.* the values above and below which a quarter of the results lie, respectively).

For normally distributed data, the uncertainty of the median is approximated by:

$$\sqrt{\frac{\pi}{2}} \times \frac{normIQR}{\sqrt{n}}$$

where *normIQR* is the normalised IQR and *n* is the number of results.

In order to assess laboratories' testing performance, a robust statistical approach, using z-scores, was utilised. Z-scores give a measure of how far a result is from the consensus value (*i.e.* the median), and gives a "score" to each result relative to the other results in the group.

A z-score with an absolute value less than or equal to 2.0 is considered to be satisfactory, whereas, a z-score with an absolute value greater than or equal to 3.0 is considered to be an outlier and is marked by the symbol "§". Laboratories are also encouraged to review results which have an absolute z-score value between 2.0 and 3.0 (*i.e.* $2.0 < |\text{z-score}| < 3.0$). These results are considered to be questionable results.

Ordered z-score charts indicate each laboratory's robust z-score, in order of magnitude, marked with its laboratory code number. From these charts, each laboratory can readily compare its performance relative to the other laboratories.

The ordered z-score charts in Appendix A are limited on the vertical axis to +3.0 and -3.0, so that outliers are clearly identifiable as those laboratories whose "bar" extends beyond the chart boundary.

For further details on the calculation and interpretation of robust z-scores and ordered z-score charts, please see the *Guide to Proficiency Testing Australia (2019)*.

5. OUTLIER RESULTS

The following table summarises the results submitted by participants for the program.

Table A: Summary Statistics for All Tests

Test	Summary Statistics	Average Result
Brinell Hardness (HBW)	Number of Results	8
	Median	98.0
	Normalised IQR	7.0
	Uncertainty (Median)	3.1
Vickers Hardness (HV)	Number of Results	12
	Median	105.0
	Normalised IQR	2.2
	Uncertainty (Median)	0.8
Rockwell B Hardness (HRB)	Number of Results	11
	Median	52.40
	Normalised IQR	2.56
	Uncertainty (Median)	0.97

Table B: Summary of Statistical Outliers
(By laboratory code number)

Test	Outliers (Laboratory Code No.)
Brinell Hardness	14
Vickers Hardness	8
Rockwell B Hardness	-

Notes:

1. For each test, the results for all test methods were pooled for analysis.
2. Summary statistics and z-scores were calculated for the average hardness value reported for each test.

6. PTA AND TECHNICAL ADVISER'S COMMENTS

Consensus values (medians), derived from participants' results, are used as the assigned values in this program. These values are not metrologically traceable to an external reference.

The summary statistics, uncertainties of the assigned values and outliers, for each of the tests, are reported in Tables A and B above. Complete details of the statistical analyses appear in Appendix A.

6.1 Return rate

Thirteen of the 14 laboratories (93%) that received samples submitted results for inclusion in the final report. Of these 13 laboratories, seven (54%) submitted results for all three tests.

The return rate for all tests is as follows:

- Brinell Hardness 8 out of 13 62%
- Vickers Hardness 11 out of 13 85%
- Rockwell B Hardness 11 out of 13 85%

6.2 Performance summary

Statistical outliers were reported by two of the 13 laboratories (15%) that returned results in this round of the program. For comparison, 8% of the participants reported outlier results in Round 15 of this program (see Report No. 1128 for more details).

A total of 31 results were analysed in this program. Of these results, two (6%) were outlier results. For comparison, 3% of the results analysed in Round 15 of this program were outlier results (see Report No. 1128 for more details)

6.3 Brinell Hardness

A total of eight laboratories tested the sample for Brinell hardness. Of these laboratories, six tested using the AS 1816 method. One laboratory tested using the ISO 6506 method. One laboratory tested using the ASTM E110 method (see Appendix A4 for more details).

There were not enough results submitted for any specific method to draw reliable conclusions from analysing grouped methods on this occasion. The methods were pooled when analysing the results.

For all methods pooled, the median and its standard uncertainty for the Brinell hardness results was 98.0 ± 3.1 HB.

The CV for the Brinell hardness results for this round was 7.2%. This is higher than the CV of 2.6%, obtained for the Brinell hardness results in Round 15 of this program (see Report No. 1128).

Laboratory code 14 reported an outlier for Brinell hardness. This laboratory's average result of 50.0 HB, against the median of 89.0 HB, may suggest deficiencies in their Brinell testing procedure. This may include, but not be limited to, their test machine being out of calibration or due for maintenance, their test methodology not being aligned with the standardised testing methods or, perhaps, testing personnel requiring further training and evaluation on the Brinell testing procedure.

Laboratory code 12 could only perform Brinell hardness testing with a 10/3000 loading set up and have not had any prior experience with aluminium testing. Following AS 1816.1: 2007, for testing of light metals such as aluminium, a recommended Force to Diameter ratio of 15 is recommended, but not limited. Using a 10/3000 set up, laboratory code 12 was requested to report the mean diameter of their indentation results, which were above 6.00 mm, and outside of Table 2 ISO 6506-4: 2014. However, using the last two values of the table (5.99 and 6.00) in interpolation, the mean diameters of the indentations were converted to hardness values, by ARL Laboratory Services Pty Ltd. The average of the Brinell results for laboratory code 12 was 88.2 HB, against the median of 98.0 HB, deeming the results of laboratory code 12 to be satisfactory.

Five laboratories reported measurement uncertainties associated with their Brinell hardness test results in this round.

6.4 Vickers Hardness

Of the eleven laboratories that tested the sample for Vickers hardness, nine tested using the AS 1817 method. One laboratory tested using the ISO 6507 method. One laboratory submitted two sets of results using the ASTM E92 method (see Appendix A4 for more details).

There were not enough results submitted for any specific method to draw reliable conclusions from analysing grouped methods on this occasion. The methods were pooled when analysing the results.

For all methods pooled, the median and its standard uncertainty for the Vickers hardness results was 105.0 ± 0.8 HV.

The CV for the Vickers hardness results for this round was 2.1%. This is lower than the CV of 3.0%, obtained for the Vickers hardness results in Round 15 of this program (see Report No. 1128).

Laboratory code 8 reported an outlier for Vickers hardness. This laboratory's low Vickers result may be due to an inappropriate load being applied or correct test procedures not followed. It may also be that their machine was out of calibration or was due for a maintenance check. It is recommended that laboratory code 8 evaluate Vickers hardness readings against their Brinell or Rockwell results, using standardised hardness conversion charts, to ensure that they report correct test results.

Another reason that the results for laboratory code 8 are lower than other participants could be that this laboratory's Vickers results are not representative of the whole test surface area. All the participants are highly encouraged to report the hardness of the samples that may represent the whole surface, as there may exist some variation of the material across the surface (*e.g.* Vickers readings close to the grooves and in centre). This also means that participants may carry out more than three tests and report results that include a wider range.

Six laboratories reported measurement uncertainties associated with their Vickers hardness test results in this round.

6.5 Rockwell B Hardness

A total of eleven laboratories tested the sample for Rockwell B hardness. Of these laboratories, eight tested using the AS 1815 method. One laboratory tested using the ISO 6508 method. One laboratory tested using the KS B 0806 method. One laboratory tested using the JIS Z 2245 method (see Appendix A4 for more details).

There were not enough results submitted for any specific method to draw reliable conclusions from analysing grouped methods on this occasion. The methods were pooled when analysing the results.

For all methods pooled, the median and its standard uncertainty for the Rockwell B hardness results was 52.40 ± 0.97 HRB.

The CV for the Rockwell B hardness results for this round was 4.9%. This compares well with the CV of 4.9%, obtained for the Rockwell B hardness results in Round 15 of this program (see Report No. 1128).

There were no outliers reported for Rockwell B hardness. Laboratory code 9 obtained an absolute z-score between 2.0 and 3.0.

Seven laboratories reported measurement uncertainties associated with their Rockwell B hardness test results in this round.

6.6 Measurement Uncertainty

The number and percentage of laboratories that reported estimates of their measurement uncertainty for each test is as follows:

• Brinell Hardness	5 out of 8	63%
• Vickers Hardness	6 out of 11	55%
• Rockwell B Hardness	7 out of 11	64%

The variation between the estimates of measurement uncertainty ranged from not reporting at all, to some reporting numerical values, while others reported percentages.

Any laboratory that reported a measurement uncertainty less than two times the uncertainty of the median may have underestimated their measurement uncertainty.

Any laboratory that reported a measurement uncertainty greater than three times the normalised IQR may have overestimated their measurement uncertainty.

All participants are highly encouraged to report and use measurement uncertainty, so that the program analysis can provide a better outlook of the overall performance for this program.

6.7 General Comments

Although there were two reported outliers for this round of the program, the overall performance of the participating laboratories in this round was very good. The testing of aluminium is not as easy as it may seem. This is primarily due to hardness tests on aluminium not being sought-after often and, therefore, not all the participants were expected to report their results within the statistically acceptable limits without some guidance.

The participating laboratories are expected to follow their routine testing procedures, for any material type, for hardness testing and report the test results that can be considered reliable, repeatable and valid, using the loading conditions they deem fit. The statistical analysis and review of this program looks into all the results and thoroughly considers whether the results should be regarded as acceptable or outliers.

7. REFERENCES

1. *Guide to Proficiency Testing Australia (2019)*. (This document is located on the PTA website at www.pta.asn.au under Programs / Documents).
2. *ISO/IEC 17043: 2010 Conformity assessment - General requirements for proficiency testing*.
3. *AS 1815.1: 2007 Metallic materials – Rockwell hardness test – Test method (scales A, B, C, D, E, F, G, H, K, N, T)*.
4. *AS 1816.1: 2007 Metallic materials – Brinell hardness test – Test method (ISO 6506-1: 2005, MOD).*
5. *AS 1817.1: 2003 Metallic materials – Vickers hardness test – Test method (ISO 6507-1: 1997, MOD)*.
6. *ISO 6506-1: 2014 Metallic materials – Brinell hardness test – Part 1: Test method.*
7. *ISO 6507-1: 2018 Metallic materials – Vickers hardness test – Part 1: Test method*.
8. *ISO 6508-1: 2016 Metallic materials – Rockwell hardness test – Part 1*: *Test method*.
9. *ASTM E92-17 – Standard Test Method for Vickers Hardness and Knoop Hardness of Metallic Materials.*
10. *ASTM E110-14 – Standard Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers.*
11. *KS B 0806: 2000 – Metallic materials - Test method of Rockwell hardness*.
12. *JIS Z 2245: 2011 – Rockwell hardness test – Test method*.

APPENDIX A

Summary of Results

Section A1

Brinell Hardness

A1.1

Brinell Hardness (HBW) – Results and Z-Scores

Lab Code	Scale	Temp. (^{o}C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	10/3000/12	22	92.6	95.8	96.5	95	-	-0.43
6	10/500/10	21	100	99	100	100	1.8%	0.29
7	5/250/15	20.4	98	99	99	99	3	0.14
8	-	22.5	105.6	106.9	108.2	106.9	6.09	1.27
11	5/250	21	105	104	106	105	-	1.00
12	10/3000	21.9	89.5	87.5	87.5	88.2	-	-1.40
13	5/250/15	20	96	97	98	97	2.0	-0.14
14	5/250/10	25	50	50	50	50	2	-6.85 **§**

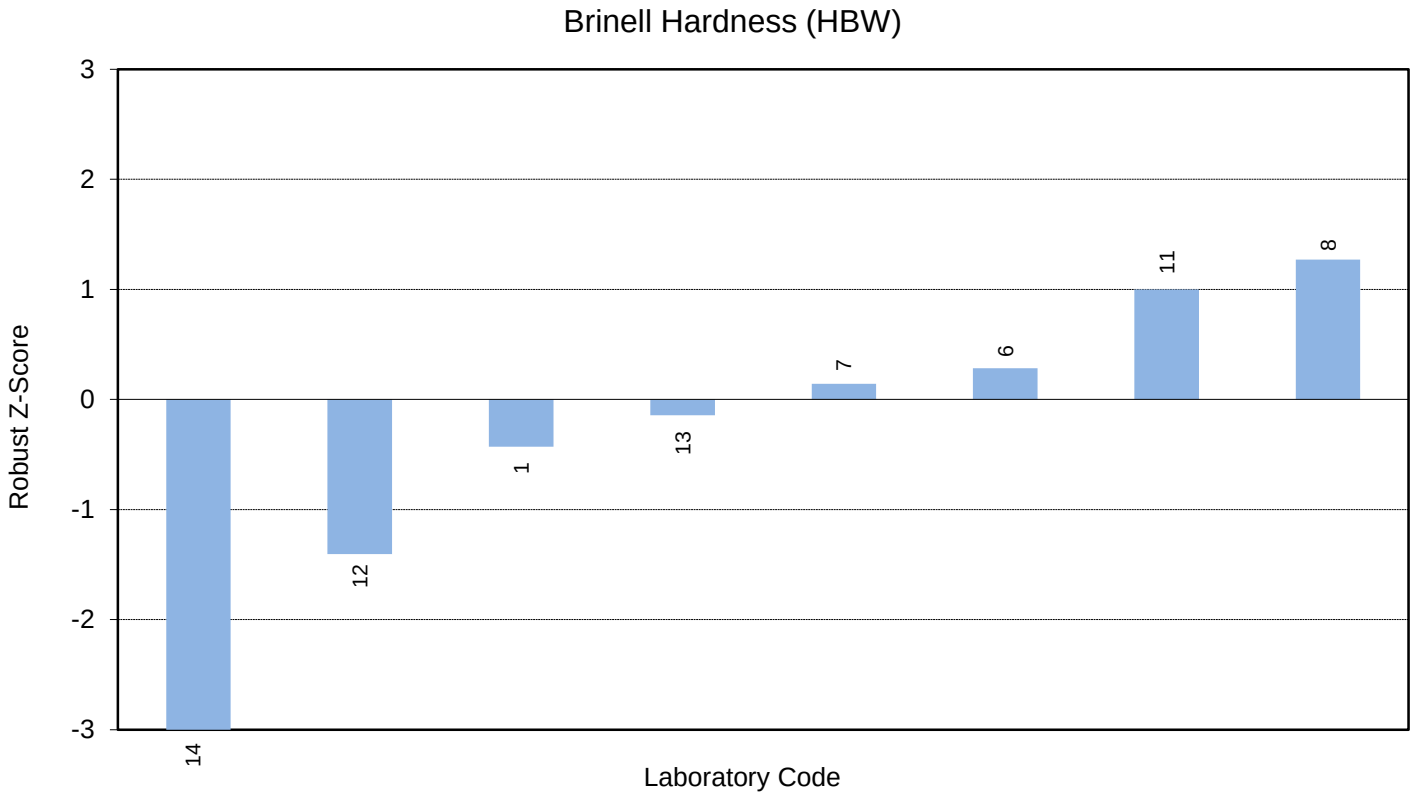
Summary Statistics

Statistic	Average Result
Number of Results	8
Median	98.0
Normalised IQR	7.0
Uncertainty (Median)	3.1
Robust CV	7.2%
Minimum	50
Maximum	107
Range	57

Notes:

1. **§** denotes an outlier (i.e. |z-score| ≥ 3.0).
2. The results for all test methods were pooled for analysis.
3. Summary statistics and z-scores have been calculated for the average results reported.
4. Laboratory code 7 reported that the testing of an aluminium sample was outside their normal scope of testing and that they had no reference block of this material.
5. The Brinell Hardness results for laboratory code 12 were calculated by ARL Laboratory Services Pty Ltd.

A1.2


Brinell Hardness (HBW)
Robust Z-Score
3
2
1
0
-1
-2
-3
14
12
1
13
7
6
11
8
Laboratory Code

Section A2

Vickers Hardness

A2.1

Vickers Hardness (HV) – Results and Z-Scores

Lab Code	Load	Temp. (^{o}C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	1	22	105	106	106	106	-	0.45
4	10	20	105	107	106	106	4	0.45
6	5	21	104	102	103	103	1.4%	-0.90
7	2	20.4	104	104	108	105	3	0.00
8	-	22.5	94.6	94.4	94.7	94.6	4.4	-4.68 **§**
9	2	21	99	103	101	101	-	-1.80
10A	5	24	104	105	106	105	1.9%	0.00
10B	5	24	107	105	105	106	3.8	0.45
11	2	21	107.0	109.7	109.9	108.9	-	1.75
12	2.5	21.9	107	109	109	108.33	-	1.50
13	3	20	103	102	104	103	1.8	-0.90
14	2.5	25	103	100	105	103	-	-0.90

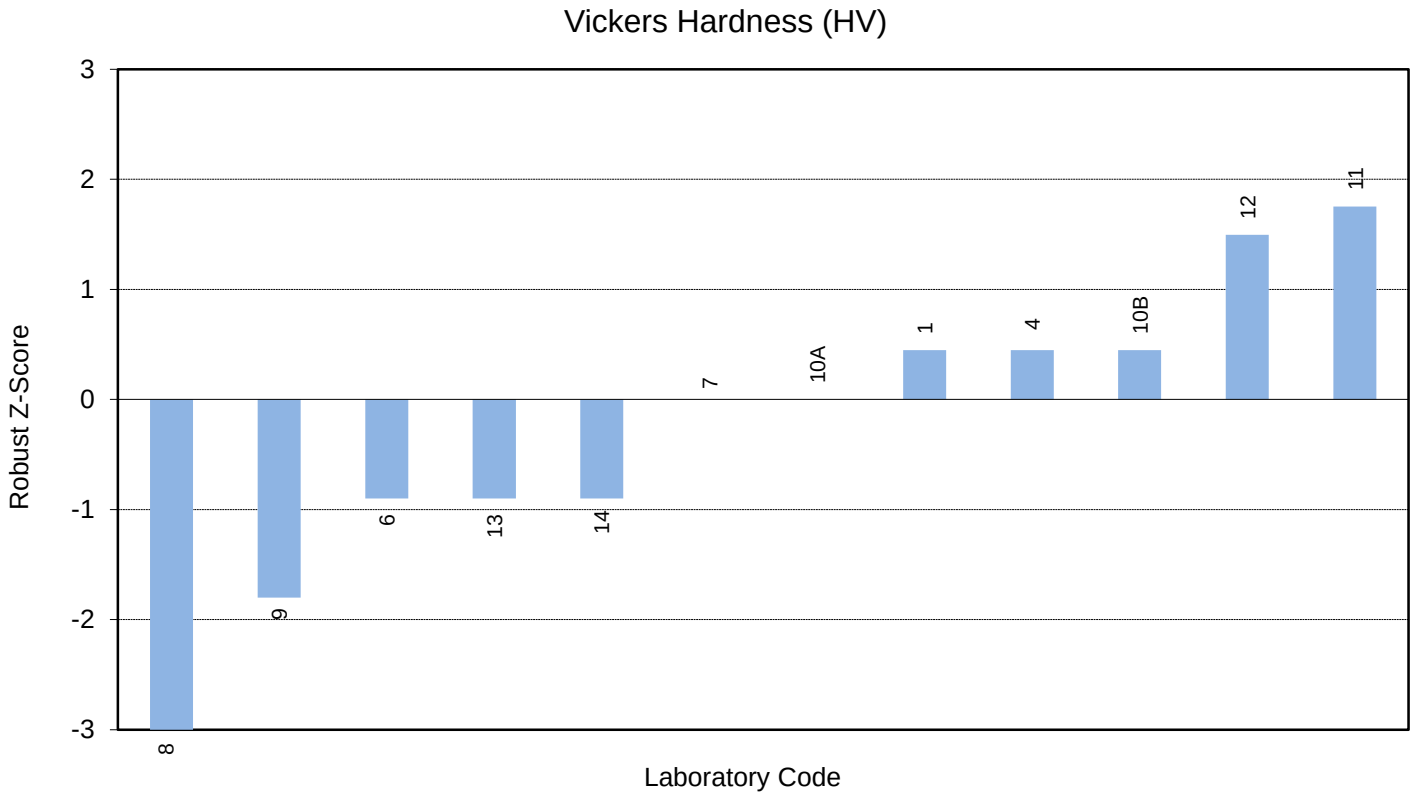
Summary Statistics

Statistic	Average Result
Number of Results	12
Median	105.0
Normalised IQR	2.2
Uncertainty (Median)	0.8
Robust CV	2.1%
Minimum	95
Maximum	109
Range	14

Notes:

1. **§** denotes an outlier (i.e. |z-score| ≥ 3.0).
2. The results for all test methods were pooled for analysis.
3. Summary statistics and z-scores have been calculated for the average results reported.
4. Laboratory code 7 reported that the testing of an aluminium sample was outside their normal scope of testing and that they had no reference block of this material.
5. Laboratory code 14 did not provide an estimate of their measurement uncertainty for Vickers testing, as their testing machine was not calibrated at the load used.

A2.2


Vickers Hardness (HV)
Robust Z-Score
3
2
1
0
-1
-2
-3
8
9
6
13
14
7
10A
1
4
10B
12
11
Laboratory Code

Section A3

Rockwell B Hardness

A3.1

Rockwell B Hardness (HRB) – Results and Z-Scores

Lab Code	Temp. (^{o}C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	22	49.8	49.4	49.7	49.6	-	-1.09
2	23.8	50.3	49.8	49.6	49.9	1.2	-0.98
4	20	53.0	53.8	54.0	53.6	2	0.47
5	25.0	51.7	51.1	50.7	51.2	5.03	-0.47
6	21	53.5	54.0	53.8	53.8	-	0.55
7	20.4	55	54.8	55.5	55.1	1.5	1.06
8	22.5	50.6	50.4	50.7	50.6	0.37	-0.70
9	21	47.0	46.5	46.8	46.8	-	-2.19
11	21	54.2	53.9	53.9	54.0	-	0.63
13	20	53.1	52.5	51.7	52.4	0.6	0.00
14	25	53.5	53.5	53.5	53.5	0.3	0.43

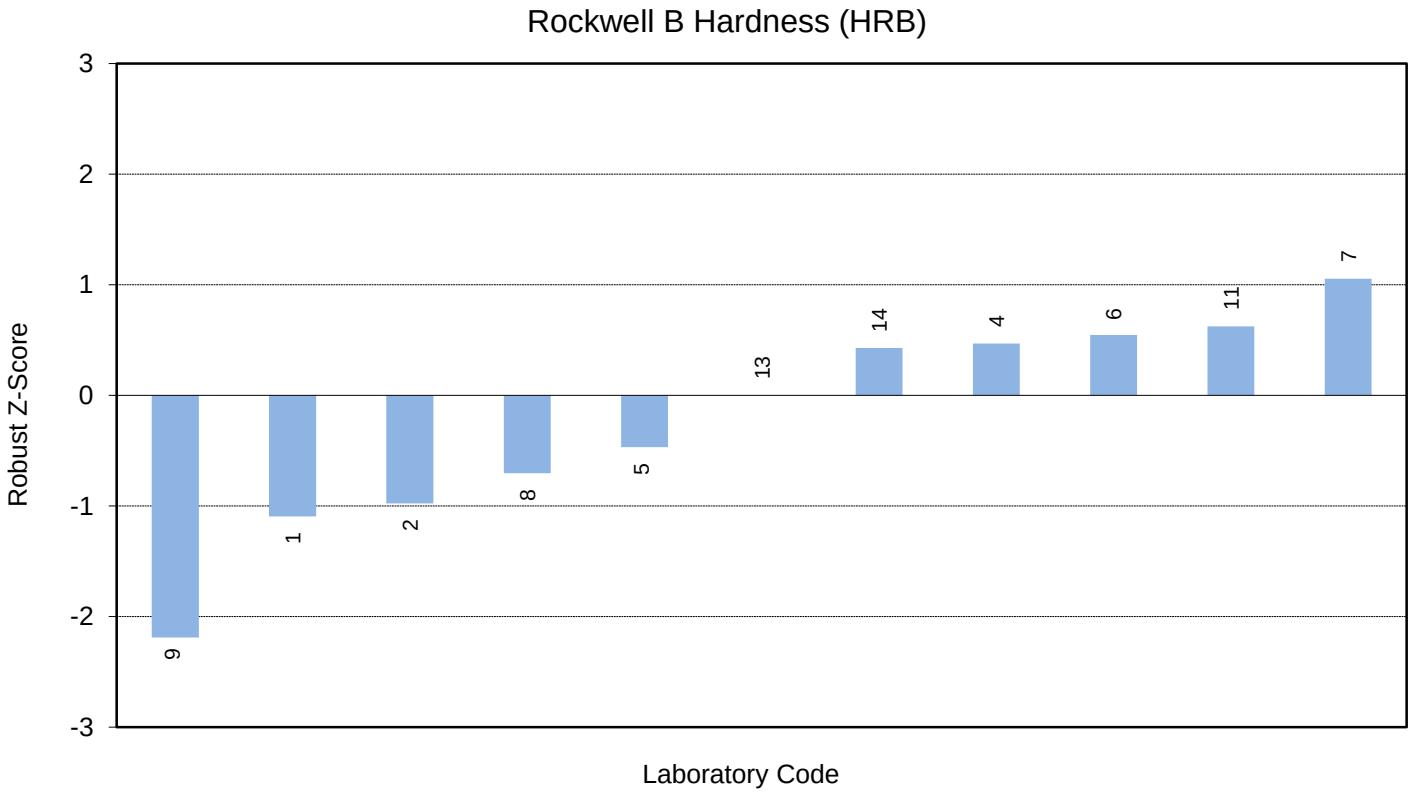
Summary Statistics

Statistic	Average Result
Number of Results	11
Median	52.40
Normalised IQR	2.56
Uncertainty (Median)	0.97
Robust CV	4.9%
Minimum	46.8
Maximum	55.1
Range	8.3

Notes:

1. The results for all test methods were pooled for analysis.
2. Summary statistics and z-scores have been calculated for the average results reported.
3. Laboratory code 7 reported that the testing of an aluminium sample was outside their normal scope of testing and that they had no reference block of this material.

A3.2


Rockwell B Hardness (HRB)
Robust Z-Score
3
2
1
0
-1
-2
-3
9
1
2
8
5
13
14
4
6
11
7
Laboratory Code

Section A4

Methods Used and Surface Preparation

A4.1

Methods Used

Lab Code	Brinell Hardness	Vickers Hardness	Rockwell B Hardness
1	ASTM E110	AS 1817.1	AS 1815.1
2	-	-	KS B 0806
4	-	AS 1817.1	AS 1815.1
5	-	-	JIS Z 2245: 2011
6	AS 1816.1 - 2007	AS 1817.1 - 2003	AS 1815.1 - 2007
7	AS 1816.1	AS 1817.1	AS 1815.1
8	ISO 6506-4	ISO 6507-1	ISO 6508-1
9	-	AS 1817	AS 1815
10A	-	ASTM E92:17	-
10B	-	ASTM E92:17	-
11	AS 1816.1	AS 1817.1	AS 1815.1
12	AS 1816	AS 1817	-
13	AS 1816.1 - 2007	AS 1817.1 - 2007	AS 1815.1 - 2007
14	AS 1816.1 - 2007	AS 1817.1 - 2003	AS 1815.1 - 2007

A4.2

Surface Preparation

Lab Code	Preparation Details
1	No surface preparation performed.
2	No surface preparation performed.
4	No surface preparation performed.
5	No surface preparation performed.
6	Polished to 6 micron finish.
7	Polished to 1 micron finish.
8	No surface preparation performed.
9	1200 grit paper with water.
10A	No surface preparation performed.
10B	No surface preparation performed.
11	No surface preparation performed.
12	No surface preparation performed.
13	The surface was polished using SiC abrasive paper (2000 grit).
14	No surface preparation performed.

APPENDIX B

Homogeneity Testing

HOMOGENEITY TESTING

Before the samples were distributed to participants, eight randomly selected samples were tested for homogeneity by ARL Laboratory Services Pty Ltd. Five hardness measurements were made around the testing area, for each of the eight samples, for each hardness test. The results of the homogeneity testing are displayed below:

Homogeneity Testing Results

Brinell HBW 5/250

Sample No.	Result 1	Result 2	Result 3	Result 4	Result 5	Average
7	97.2	95	98.3	98.3	99.5	97.7
12	101	102	102	102	103	102.0
14	98.3	99.5	98.3	98.3	97.2	98.3
20	99.5	98.3	98.3	98.3	97.2	98.3
27	99.5	97.2	97.2	98.3	98.3	98.1
32	97.2	97.2	97.2	98.3	97.2	97.4
37	98.3	97.3	98.3	97.2	101	98.4
39	98.3	99.5	98.3	97.2	97.2	98.1

Vickers HV 3

Sample No.	Result 1	Result 2	Result 3	Result 4	Result 5	Average
7	98	106	104	103	104	103.0
12	106	105	109	112	112	108.8
14	104	105	104	103	103	103.8
20	111	109	106	105	107	107.6
27	111	109	110	107	111	109.6
32	108	110	107	113	106	108.8
37	115	113	111	118	110	113.4
39	109	105	110	107	105	107.2

B1.2

Rockwell B HRB

Sample No.	Result 1	Result 2	Result 3	Result 4	Result 5	Average
7	48.7	51.0	49.1	50.7	48.8	49.66
12	51.5	50.4	50.6	50.5	48.8	50.36
14	51.3	49.4	51.0	50.1	52.0	50.76
20	50.8	51.0	51.1	52.5	53.0	51.68
27	49.8	50.1	52.6	49.2	51.3	50.60
32	49.1	50.1	51.1	50.5	49.9	50.14
37	49.8	50.1	52.6	49.2	51.3	50.60
39	48.9	50.2	50.4	51.1	51.6	50.44

Analysis of the homogeneity testing data indicated that the samples were sufficiently homogeneous for the program and, therefore, any participant results identified as outliers cannot be attributed to sample variability.

APPENDIX C

Instructions to Participants
and
Results Sheet

PROFICIENCY TESTING AUSTRALIA

Hardness Testing Of Metals Proficiency Testing Program Round 16, June 2019

Instructions to Participants

To ensure that the results of this program can be analysed correctly, participants are asked to adhere carefully to these instructions.

1) The sample for this hardness testing program consists of an aluminium sample, approximately 65 mm in diameter and 35 mm thick. The sample has a number labelled on the circumference.

2) The sample is to be tested for Brinell, Vickers and Rockwell 'B' hardness. The samples contain a groove. The testing area is to be within the groove. Participants may wish to improve the surface to provide a better testing surface.

3) Although the hardness loading scales and conditions are at the discretion of the participating laboratories, the following loading conditions have proven to provide consistent results: HV2, HRB, and HBW 5/250.

4) The sample should be treated as a routine laboratory sample. All testing, recording and reporting is to be performed in accordance with your routine test methods.

5) Please use the attached Result Sheet to record and report your results to Proficiency Testing Australia. Please also report the method used for testing (*e.g.* AS 1816.1, ISO 6506.1, etc. for Brinell hardness testing, AS 1817.1, ISO 6507.1, etc. for Vickers hardness testing, AS 1815.1, ISO 6508.1, etc. for Rockwell HRB hardness testing).

6) Do not discard the hardness test sample until you have received the final report. You may be asked to carry out a retest or to return the sample to Proficiency Testing Australia for retesting at the laboratory that performed the homogeneity tests.

7) For this program, your laboratory has been allocated the code number on the attached Results Sheet. All reference to your laboratory in reports associated with this program will be via this code number, thus ensuring the confidentiality of your results.

8) Laboratories are also requested to calculate and report an estimate of uncertainty of measurement for each reported measurement result. All estimates of uncertainty of measurement must be given as a 95% confidence interval (coverage factor $k \approx 2$).

9) Return the Results Sheet, either by mail, email or facsimile, to:

Mark Bunt
Proficiency Testing Australia
PO Box 7507
Silverwater NSW 2128
AUSTRALIA

Telephone: + 61 2 9736 8397 (1300 782 867)
Fax: +61 2 9743 6664
Email: mbunt@pta.asn.au

All results should arrive at the above address by no later than **Friday 28 June 2019**. Results reported later than this date may not be analysed in the final report.

C2.1

PROFICIENCY TESTING AUSTRALIA

Hardness Testing Of Metals Proficiency Testing Program

Round 16, June 2019

RESULTS SHEET

Laboratory Code: ☐

Sample I.D.	Scale	Report to nearest	Test Temp ºC	Results					Standard (AS, ISO, etc.)
				Test 1	Test 2	Test 3	Average	MU (±)	
	Brinell (/ /) (mm/kg/s)	1 BHN							
	HV ( ) Insert load used	1 HV							
	HRB	0.1 HRB							

Did you carry out surface preparation on the obverse surfaces of the samples for the hardness tests? Yes / No

If Yes, please give details of preparation.

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Print Name: _____

Signature: _____

Date: _____

-----End of Report-----