

REPORT NO. 1183

**Hardness Testing of Metals
Proficiency Testing Program
Round 17**

February 2020

ACKNOWLEDGMENTS

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1. FOREWORD

This report summarises the results of a proficiency testing program on the hardness properties of metals. It constitutes the seventeenth 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 November / December 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 13 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	HONG KONG
1	SAUDI ARABIA
1	TANZANIA

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.

- (b) The results reported by participants are presented in Appendix A.
- (c) Each laboratory was provided with a steel sample, approximately 60 mm in diameter and approximately 30 mm thick. The sample was to be tested for Brinell, Vickers, Rockwell B and Rockwell C hardness.
- (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 five sections (A1-A5).

Sections A1-A4 contain the analysis of results reported by laboratories for Brinell, Vickers, Rockwell B and Rockwell C 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 A5 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.* $100 \times \text{Normalised IQR} / \text{Median}$;
- *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:

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

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.* $2.0 < |z\text{-score}| < 3.0$). 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	10
	Median	293.0
	Normalised IQR	9.0
	Uncertainty (Median)	3.6
Vickers Hardness (HV)	Number of Results	11
	Median	306.0
	Normalised IQR	7.6
	Uncertainty (Median)	2.9
Rockwell B Hardness (HRB)	Number of Results	6
	Median	105.80
	Normalised IQR	1.22
	Uncertainty (Median)	0.63
Rockwell C Hardness (HRC)	Number of Results	7
	Median	30.40
	Normalised IQR	1.98
	Uncertainty (Median)	0.94

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

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

Twelve of the 13 laboratories (92%) that received samples submitted results for inclusion in the final report. Of these 12 laboratories, five (42%) submitted results for all four tests.

The return rate for all tests is as follows:

- Brinell Hardness 10 out of 12 83%
- Vickers Hardness 11 out of 12 92%
- Rockwell B Hardness 6 out of 12 50%
- Rockwell C Hardness 7 out of 12 58%

6.2 Performance summary

Statistical outliers were reported by one of the 12 laboratories (8%) that returned results in this round of the program. For comparison, 15% of the participants reported outlier results in Round 16 of this program (see Report No. 1153 for more details).

A total of 34 results were analysed in this program. Of these results, one (3%) was an outlier result. For comparison, 6% of the results analysed in Round 16 of this program were outlier results (see Report No. 1153 for more details).

6.3 Brinell Hardness

A total of ten laboratories tested the sample for Brinell hardness. Of these laboratories, six tested using the AS 1816 method. Two laboratories tested using the ISO 6506 method. Two laboratories tested using ASTM methods (see Appendix A5 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 293.0 ± 3.6 HB.

The CV for the Brinell hardness results for this round was 3.1%. This is lower than the CV of 7.2%, obtained for the Brinell hardness results in Round 16 of this program (see Report No. 1153).

There were no outliers reported for Brinell hardness.

Six 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, eight tested using the AS 1817 method. Two laboratories tested using the ISO 6507 method. One laboratory tested using the ASTM E92 method (see Appendix A5 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 306.0 ± 2.9 HV.

The CV for the Vickers hardness results for this round was 2.5%. This compares well with the CV of 2.1%, obtained for the Vickers hardness results in Round 16 of this program (see Report No. 1153).

There were no outliers reported for Vickers hardness. Three laboratories (codes 4, 9 and 12) obtained absolute z-scores between 2.0 and 3.0.

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

6.5 Rockwell B Hardness

A total of six laboratories tested the sample for Rockwell B hardness. Of these laboratories, two tested using the AS 1815 method. One laboratory tested using the ISO 6508 method. One laboratory reported using ISO 6505. It is assumed that this was a mistake and that the laboratory meant to report ISO 6508 as their method of testing. One laboratory tested using both AS 1815 and ISO 6508. One laboratory did not report the method that they used for testing, instead stating that their results were “out of range of standard” (see Appendix A5 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 105.80 ± 0.63 HRB.

The CV for the Rockwell B hardness results for this round was 1.2%. This is lower than the CV of 4.9%, obtained for the Rockwell B hardness results in Round 16 of this program (see Report No. 1153).

One laboratory (code 8) obtained an outlier for Rockwell B hardness. This laboratory's average of 71.5 HRB, against the overall median of 105.80 HRB, may be due to inappropriate load applied or correct test procedures not being followed. It may also be that their machine was out of calibration or was due for a maintenance check. This laboratory is recommended to evaluate Rockwell hardness readings against their Brinell or Vickers results, using standardised hardness conversion charts to ensure they report correct test results.

Another reason for the low Rockwell B results reported by laboratory code 8 may be that their 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 variations in the material across the surface (e.g. Rockwell readings close to the grooves and in the centre). This can also mean that participants may need to carry out more than three tests and report results that include better range.

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

6.6 Rockwell C Hardness

Of the seven laboratories that tested the sample for Rockwell C hardness, four tested using the AS 1815 method. One laboratory tested using the ISO 6508 method. One laboratory reported using ISO 6505. It is assumed that this was a mistake and that the laboratory meant to report ISO 6508 as their method of testing. One laboratory tested using the ASTM E18 method (see Appendix A5 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 C hardness results was 30.40 ± 0.94 HRC.

The last round of the Hardness Testing of Metals program in which the participants tested a sample for Rockwell C hardness was Round 7. The CV for the Rockwell C hardness results for this round was 6.5%. This is higher than the CV of 4.4%, obtained for the Rockwell C hardness results in Round 7 of this program (see Report No. 891).

There were no outliers reported for Rockwell C hardness. One laboratory (code 8) obtained an absolute z-score between 2.0 and 3.0.

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

6.7 Measurement Uncertainty

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

- | | | |
|-----------------------|-------------|-----|
| • Brinell Hardness | 6 out of 10 | 60% |
| • Vickers Hardness | 7 out of 11 | 64% |
| • Rockwell B Hardness | 5 out of 6 | 83% |
| • Rockwell C Hardness | 5 out of 7 | 71% |

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.

6.8 General Comments

Considering that the hardness values of the tested samples for this round of the program fell outside of the range of the Rockwell B standardised scales, the overall performance of the participating laboratories is very good, with only one outlier.

Participating in proficiency testing programs is very important for testing laboratories, as it can assist in identifying any weaknesses in a laboratory's system that may be present and allow laboratories to address such weaknesses and help to improve their overall technical competency and proficiency.

All the participants are encouraged to report on all the necessary information, in order to better analyse the test results.

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 E10-18 Standard Test Method for Brinell Hardness of Metallic Materials*.
10. *ASTM E18-19 Standard Test Methods for Rockwell Hardness of Metallic Materials*.
11. *ASTM E92-17 Standard Test Method for Vickers Hardness and Knoop Hardness of Metallic Materials*.
12. *ASTM E110-14 Standard Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers*.

APPENDIX A

Summary of Results

Section A1

Brinell Hardness

A1.1

Brinell Hardness (HBW) – Results and Z-Scores

Lab Code	Scale	Temp. (°C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	10/3000/15	26	274	280	282	279	2.8	-1.56
2	10/3000	21.0	299	299	300	299	5	0.67
3	10/3000/10	26	285	293	292	290	9.0	-0.33
4	10/3000	20	293	285	293	290	-	-0.33
8	10/30/10	24.9	290	288	283	288	3	-0.56
9	10/3000	27	285	285	285	285	-	-0.89
10	2.5/187.5	22	307	307	307	307	9.1	1.56
11	10/3000/12	21	303	298	296	299	-	0.67
12	10/3000/25	23	298	302	302	300.6	2.4	0.85
13	10/3000	26.7	293	293	302	296	-	0.33

Summary Statistics

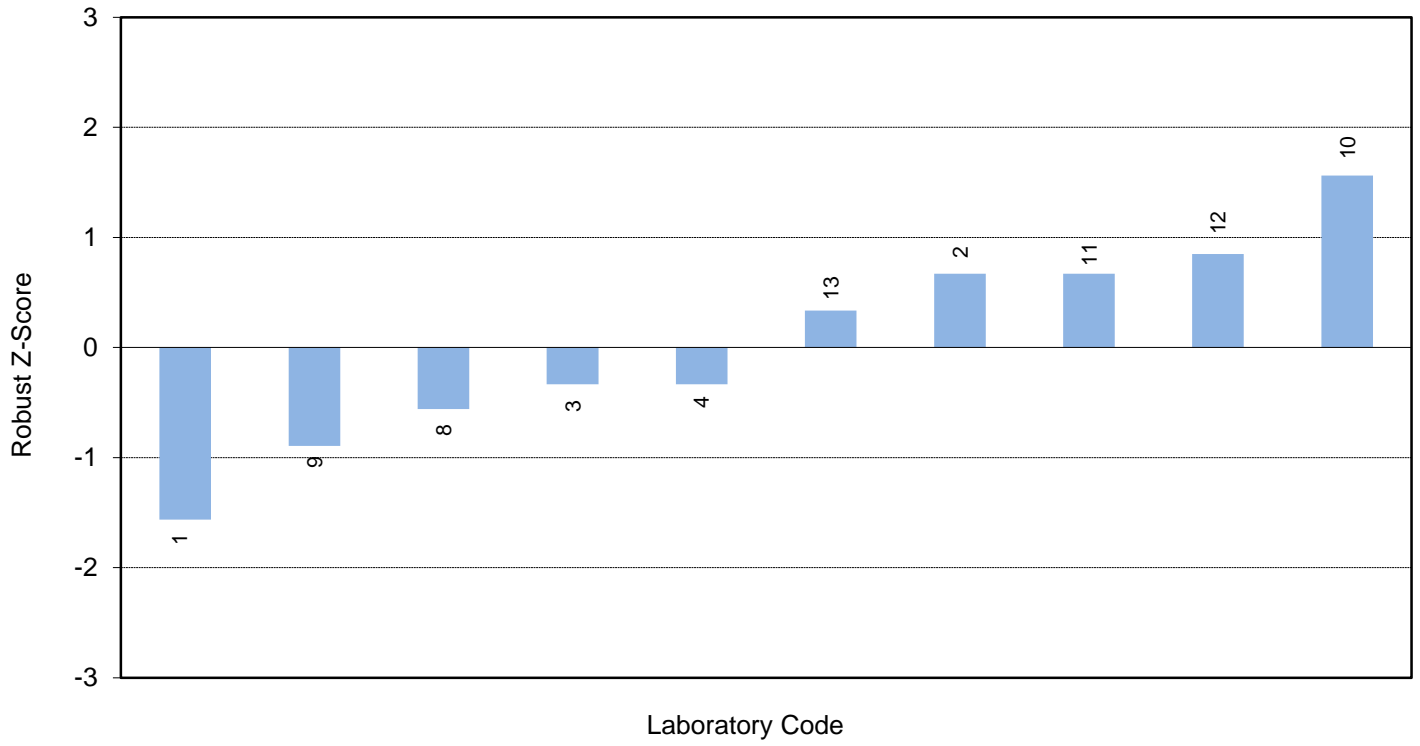
Statistic	Average Result
Number of Results	10
Median	293.0
Normalised IQR	9.0
Uncertainty (Median)	3.6
Robust CV	3.1%
Minimum	279
Maximum	307
Range	28

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.

A1.2

Brinell Hardness (HBW)



Section A2

Vickers Hardness

A2.1

Vickers Hardness (HV) – Results and Z-Scores

Lab Code	Load	Temp. (°C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	10	26	289	296	299	295	3.2	-1.44
2	50	21.0	316	316	313	315	5	1.18
3	30	26	305	298	298	300	7.7	-0.79
4	10	20	283	286	289	286	-	-2.62
5	30	21	303	303	301	302	3.3	-0.52
8	30	25	305.4	302.2	309.4	306	4.4	0.00
9	10	27	329	327	327	327.6	-	2.83
10	10	22	312	308	305	308	9.7	0.26
11	10	21	307	304	312	307.6	-	0.21
12	30	23	290	283	282	285	1.2	-2.75
13	30	22.5	316	295	310	307	-	0.13

Summary Statistics

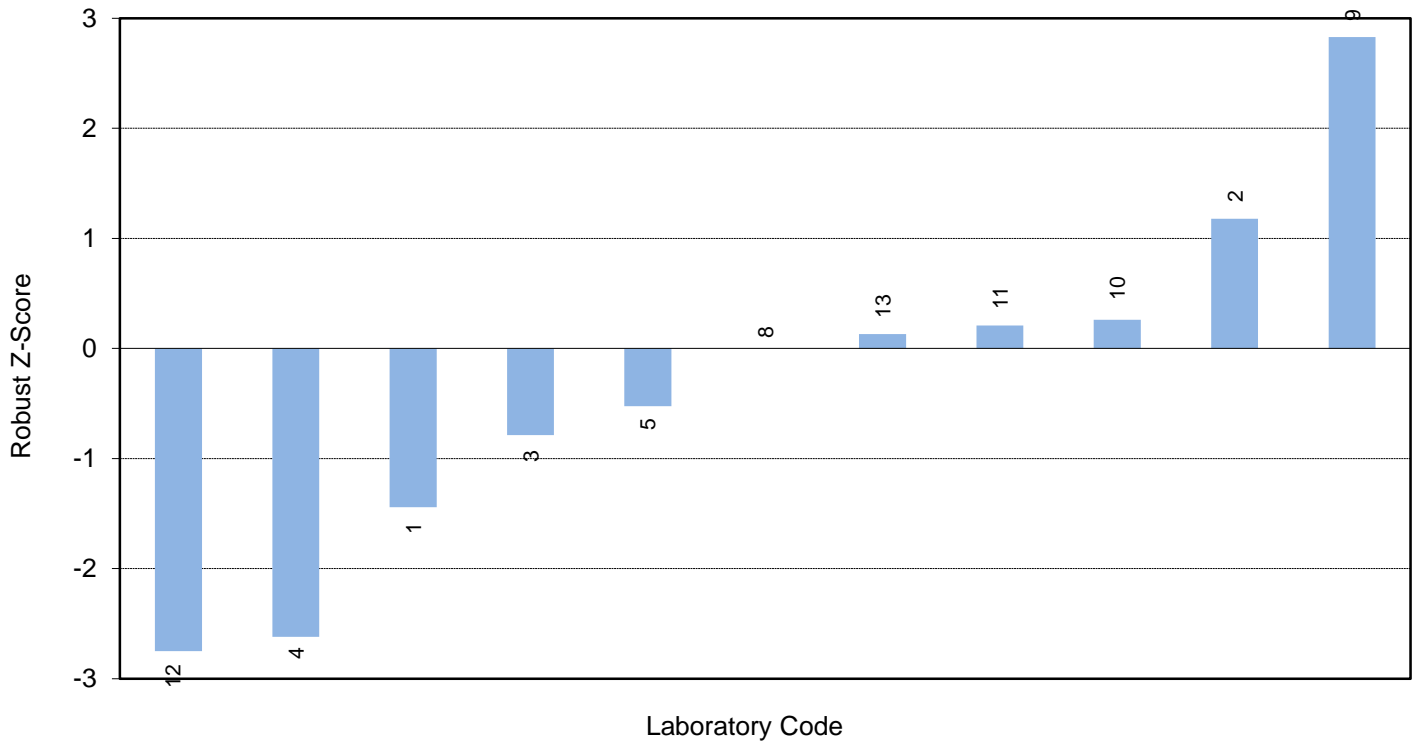
Statistic	Average Result
Number of Results	11
Median	306.0
Normalised IQR	7.6
Uncertainty (Median)	2.9
Robust CV	2.5%
Minimum	285
Maximum	328
Range	43

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.

A2.2

Vickers Hardness (HV)



Section A3

Rockwell B Hardness

A3.1

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

Lab Code	Temp. (°C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	26	105.3	106.2	106.5	106.0	0.4	0.16
2	21.0	107.5	107.5	107.3	107.4	-	1.31
6	21	105.4	105.5	105.8	105.6	0.42	-0.16
8	24.8	72.2	71.8	70.4	71.5	0.83	-28.07 §
10	22	105.7	105.2	104.8	105.2	1.1	-0.49
12	23	106.6	106.6	107.3	106.8	0.49	0.82

Summary Statistics

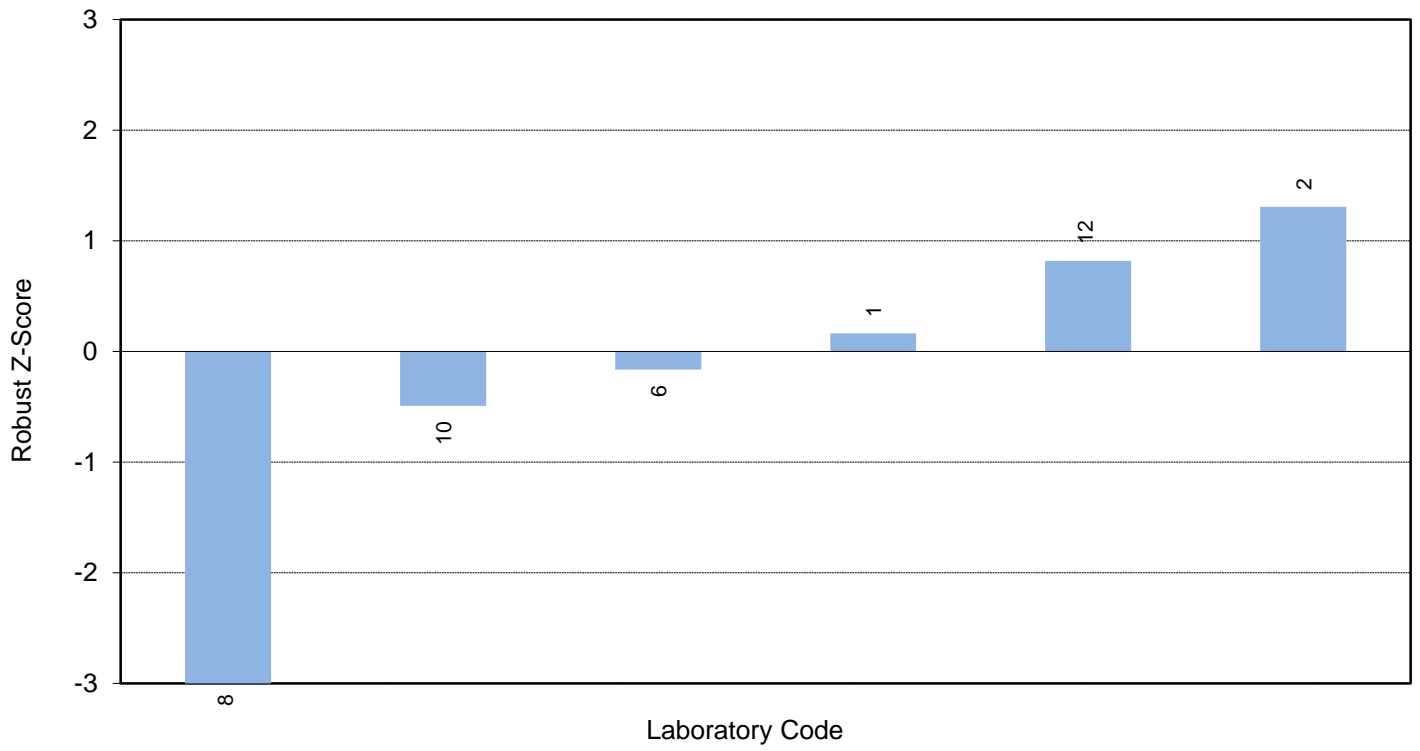
Statistic	Average Result
Number of Results	6
Median	105.80
Normalised IQR	1.22
Uncertainty (Median)	0.63
Robust CV	1.2%
Minimum	71.5
Maximum	107.4
Range	35.9

Notes:

1. § denotes an outlier (i.e. $|z\text{-score}| \geq 3.0$).
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.

A3.2

Rockwell B Hardness (HRB)



Section A4

Rockwell C Hardness

A4.1

Rockwell C Hardness (HRC) – Results and Z-Scores

Lab Code	Temp. (°C)	Test 1	Test 2	Test 3	Average	MU (±)	Z-Score
1	26	29.0	29.2	29.3	29.2	0.3	-0.61
2	21.0	31.3	31.6	30.4	31.1	1.5	0.35
8	24.8	23.8	25.3	27.1	25.4	0.83	-2.52
10	22	31.3	31.9	32.1	31.8	0.5	0.71
11	21	30.8	31.5	29.0	30.4	-	0.00
12	23	28.5	29.5	29.0	29.0	0.38	-0.71
13	22.5	32.0	30.9	31.6	31.5	-	0.56

Summary Statistics

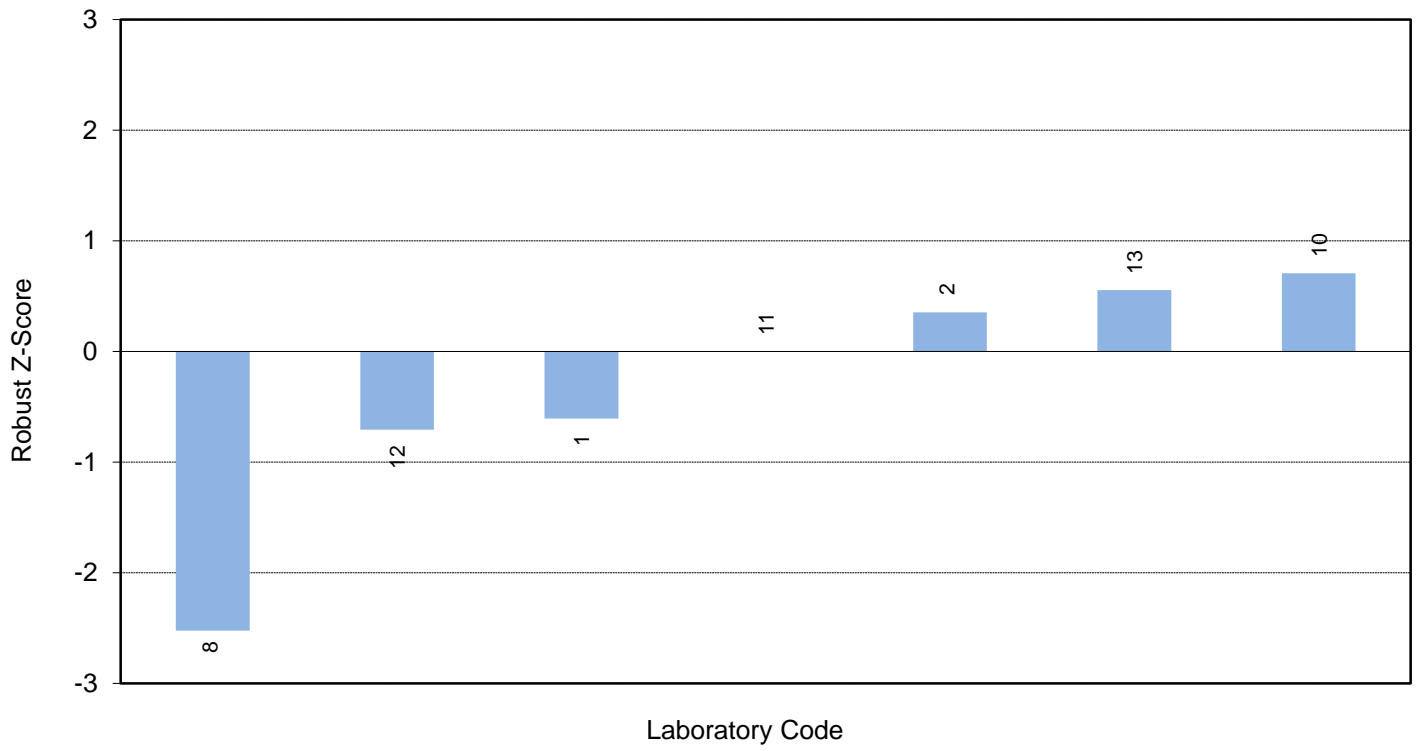
Statistic	Average Result
Number of Results	7
Median	30.40
Normalised IQR	1.98
Uncertainty (Median)	0.94
Robust CV	6.5%
Minimum	25.4
Maximum	31.8
Range	6.4

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.

A4.2

Rockwell C Hardness (HRC)



Section A5

Methods Used and Surface Preparation

A5.1

Methods Used

Lab Code	Brinell Hardness	Vickers Hardness
1	AS 1816.1 - 2007	AS 1817.1 - 2007
2	AS 1816.1	AS 1817.1
3	AS 1816.1 - 2007	AS 1817.1 - 2003
4	AS 1816.1	AS 1817.1
5	-	AS 1817.1
6	-	-
8	ISO 6506-1	ISO 6507-1
9	AS 1816.1 - 2007	AS 1817.1 - 2003
10	BS EN ISO 6506-1: 1999 & 2014	BS EN ISO 6507-1: 1998 & 2018
11	ASTM E10	ASTM E92
12	AS 1816	AS 1817
13	ASTM E110	AS 1817.1

Methods Used (continued)

Lab Code	Rockwell B Hardness	Rockwell C Hardness
1	AS 1815.1 - 2007	AS 1815.1 - 2007
2	Out of range of standard	AS 1815.1
3	-	-
4	-	-
5	-	-
6	AS 1815.1, ISO 6508-1	-
8	ISO 6505-1	ISO 6505-1
9	-	-
10	BS EN ISO 6508-1: 1999 & 2016	BS EN ISO 6508-1: 1999 & 2016
11	-	ASTM E18
12	AS 1815	AS 1815
13	-	AS 1815.1

A5.2

Surface Preparation

Lab Code	Preparation Details
1	The surface was polished using SiC abrasive paper (2000 grit).
2	No surface preparation performed.
3	<ol style="list-style-type: none">1. The lower face was ground parallel to the test face.2. The test face was hand prepared using progressively finer 240, 800 and 1000 grit Wet & Dry paper to produce a witness mark over the full surface. Preparation with each finer grade continued until the previous witness was removed.
4	Polish to 1 μm finish.
5	Wet ground to a #1200 grit surface finish using silicon carbide papers.
6	No surface preparation performed.
8	No surface preparation performed.
9	No surface preparation performed.
10	No surface preparation performed.
11	Light finish grinding.
12	Sample was hand ground and diamond polished to 3 μm .
13	No surface preparation performed.

APPENDIX B

Homogeneity Testing

B1.1

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 Brinell, Vickers and Rockwell C hardness. The results of the homogeneity testing are displayed below:

Homogeneity Testing Results

Brinell HBW 10/3000

Sample No.	Result 1	Result 2	Result 3	Result 4	Result 5	Average
1	272	292	295	298	302	291.8
9	271	269	280	293	298	282.2
17	272	280	295	293	285	285.0
18	269	277	278	283	293	280.0
26	268	278	283	290	288	281.4
27	272	269	271	288	283	276.6
36	274	286	283	298	295	287.2
39	278	277	283	288	292	283.6

Vickers HV 10

Sample No.	Result 1	Result 2	Result 3	Result 4	Result 5	Average
1	289	299	267	298	293	289.2
9	289	311	275	281	309	293.0
17	279	286	312	311	309	299.4
18	279	305	279	289	308	292.0
26	270	294	299	292	289	288.8
27	289	298	300	312	309	301.6
36	296	278	294	295	292	291.0
39	269	272	285	288	309	284.6

B1.2

Rockwell C HRC

Sample No.	Result 1	Result 2	Result 3	Result 4	Result 5	Average
1	28.5	31.9	28.6	30.8	31.7	30.30
9	29.2	32.1	29.0	32.3	28.9	30.30
17	27.5	28.7	31.5	31.4	30.8	29.98
18	30.6	28.7	28.8	30.2	31.8	30.02
26	26.9	26.8	30.4	29.1	29.9	28.62
27	27.6	27.5	30.5	29.7	30.4	29.14
36	30.4	29.1	30.3	31.0	30.4	30.24
39	29.5	28.1	28.7	28.8	32.2	29.46

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

Hardness Testing Of Metals Proficiency Testing Program Round 17, November 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 a steel sample, approximately 60 mm in diameter and 30 mm thick. The sample has a number labelled on the circumference.
- 2) The sample is to be tested for Brinell, Vickers, Rockwell 'B' and Rockwell 'C' 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) 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.
- 4) 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 **Wednesday 18 December 2019**. Results reported later than this date may not be analysed in the final report.

Hardness Testing Of Metals Proficiency Testing Program

Round 17, November 2019

RESULTS SHEET

Laboratory Code:

Sample I.D.	Scale	Report to nearest	Test Temp °C	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							
	Rockwell Scale B	0.1 HRB							
	Rockwell Scale C	0.1 HRC							

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

If Yes, please give details of preparation.

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Print Name: _____

Signature: _____

Date: _____

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