REPORT NO. 823

Tensile Testing of Metals

Proficiency Testing Program

Round 5

September 2013

ACKNOWLEDGMENTS

PTA wishes to gratefully acknowledge the technical assistance provided for this program by Mr K Bazley, BlueScope Steel Limited, Port Kembla. PTA also wishes to thank OneSteel, Wetherill Park, for supplying the samples and to BlueScope Steel Limited, Port Kembla, for heat treating the steel samples for stability.

PO Box 7507 Silverwater NSW 2128 AUSTRALIA

CONTENTS

1. FOREWORD

This report summarises the results of a proficiency testing program on the tensile properties of metals. It constitutes the fifth round of an ongoing series of programs.

Proficiency Testing Australia (PTA) conducted the testing program in June / July 2013. 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 K Bazley, BlueScope Steel Limited, Port Kembla. This report was authorised by Mr P Briggs, PTA General Manager.

2. FEATURES OF THE PROGRAM

(a) A total of 29 laboratories participated in the program, two of which did not return results for inclusion in the final report. Laboratories from the following states and countries received samples:

5	NSW
4	VIC
4	WA
3	QLD
2	SA
1	TAS
2	SINGAPORE
1	BRAZIL
1	HONG KONG
1	IRAN
1	ITALY
1	MEXICO
1	NEW ZEALAND
1	QATAR
1	SOUTH KOREA

To ensure confidential treatment of results, each laboratory was allocated a unique code number. All reference to participants in this report is by allocated code numbers.

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) Laboratories were provided with two identical steel round bar samples. Both samples were 16 mm in diameter and 250 mm in length. Laboratories were asked to perform tests for:

- Tensile Strength (R_m);
- Percentage Elongation after Fracture (A%); and
- Percentage Reduction in Area after Fracture (Z%).

(d) All testing, recording and reporting was to be performed in accordance with the laboratory's routine test methods, but testing in accordance with AS 1391 or ISO 6892-1 were the preferred test methods.

(e) 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.

(f) Prior to distribution, the samples were tested for homogeneity. 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 Tensile Strength (R_m), Percentage Elongation after Fracture (A%) and Percentage Reduction in Area after Fracture (Z%). These sections contain, where appropriate:

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;
iii) ordered z-score charts; and
iv) a Youden diagram.

Section A4 contains information on the methods used by laboratories and the results reported by laboratories for Tensile Specimen Diameter, Tensile Specimen Gauge Length, Elastic Stress or Strain Rate and Plastic Strain Rate.

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

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

4. DESIGN OF THE PROGRAM

A uniform pair statistical design was chosen for this program. Samples 1 and 2 were identical samples for Tensile Strength (R_m), Percentage Elongation after Fracture (A%) and Percentage Reduction in Area after Fracture (Z%).

5. OUTLIER RESULTS

Robust z-scores have been used to assess each laboratory's testing performance. When calculated from single results, z-scores are used to detect excessively high or excessively low results in comparison to the consensus value (the median). Any result with an absolute z-score greater than or equal to three (*i.e.* ≤ -3.0 or ≥ 3.0) is classified as an outlier.

Youden two-sample diagrams are presented to highlight laboratory systematic differences. They are based on a plot of each laboratory's pair of results (i.e. sample 2 versus sample 1) and represented by a black spot.

These diagrams also feature an approximate 95% confidence ellipse for the bivariate analysis of the results, and dashed lines which mark the median value for each of the samples.

All points which lie outside the ellipse are labelled with the laboratory's code number. Note, however, that these points may not correspond with those identified as outliers. This is because the outlier criteria ($|z| \geq 3.0$) has a confidence level of approximately 99%, whereas the ellipse is an approximate 95% confidence region.

The points outside the ellipse on the Youden diagram roughly correspond to those with z-scores greater than 2.0 or less than -2.0. Laboratories which are outside the ellipse but have not been identified as outliers (i.e. have $2.0 < |z| < 3.0$) are encouraged to review their results.

As a guide to the interpretation of these diagrams:

(i) laboratories with significant systematic error components (i.e. between-laboratory variation) will usually have results outside the ellipse in either the upper right hand quadrant (as formed by the median lines) or the lower left hand quadrant (i.e. unusually high or low results for both samples); and

(ii) laboratories with significant random error components (i.e. within-laboratory variation) will have returned results that are substantially more variable than other participants, and these results will usually lie outside the ellipse in either the upper left or lower right hand quadrants (i.e. an unusually high result for one sample and low for the other).

For further details on the calculation and interpretation of robust z-scores and the construction and interpretation of Youden diagrams, please see the *Guide to Proficiency Testing Australia (2012)*.

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

Table A: Summary Statistics for All Tests

Test	Summary Statistics	Sample 1	Sample 2
Tensile Strength (R_m) (MPa)	Number of Results	28	28
	Median	524.5	522.0
	Normalised IQR	9.7	11.7
	Uncertainty (Median)	2.3	2.8
Percentage Elongation after Fracture (A%)	Number of Results	28	28
	Median	32.5	32.9
	Normalised IQR	2.7	3.8
	Uncertainty (Median)	0.6	0.9
Percentage Reduction in Area after Fracture (Z%)	Number of Results	28	28
	Median	72.0	72.0
	Normalised IQR	1.7	1.5
	Uncertainty (Median)	0.4	0.4

Notes:

1. For each test, the results for all test methods were pooled for analysis.
2. The uncertainty of the median was calculated as: $\sqrt{\frac{\pi}{2}} \times \frac{normIQR}{\sqrt{n}}$.

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

Test	Sample 1	Sample 2
Tensile Strength	1, 8, 15	1, 15, 25, 28
Percentage Elongation after Fracture	8, 25	-
Percentage Reduction in Area after Fracture	3, 14, 28	3, 14, 23, 28

Note:

Summary statistics and z-scores for Percentage Elongation after Fracture were calculated by converting the results to a proportional gauge length.

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

Twenty-seven of the 29 laboratories (93%) that participated in the program returned results. Of the 27 laboratories that submitted results for the program, the return rate for all tests is as follows:

Test	Sample 1	Sample 2
Tensile Strength	27 out of 27 (100%)	27 out of 27 (100%)
Percentage Elongation after Fracture	27 out of 27 (100%)	27 out of 27 (100%)
Percentage Reduction in Area after Fracture	27 out of 27 (100%)	27 out of 27 (100%)

6.2 Performance summary

One or more statistical outliers were reported by eight laboratories (28%) for this round of the Tensile Testing of Metals program. For comparison, 30% of the participants reported outlier results in Round 4 of the Tensile Testing of Metals program (see Report No. 770 for more details).

A total of 168 results were analysed in this round of the program. Of these results, sixteen (10%) were outliers. For comparison, 10% of the results analysed in Round 4 of the Tensile Testing of Metals program were outliers (see Report No. 770 for more details).

6.3 Tensile Strength

A total of 27 laboratories tested the samples for Tensile Strength, including one laboratory that submitted two sets of results. Of these 27 laboratories, 17 tested using the AS 1391 method, including one laboratory that submitted two sets of results. Three laboratories tested using the ISO 6892-1 method. One laboratory indicated that their method of testing was ISO 6895-1. It is likely that this laboratory tested using ISO 6892-1 and incorrectly recorded their method of testing. Four laboratories used other methods of testing. Two laboratories did not specify the method that they used for testing (see Appendix A4 for more details).

For the laboratories that used the AS 1391 method for sample 1, the median and standard error of the Tensile Strength results was 528.5 ± 2.0 MPa. For all methods pooled, the median and standard error of the Tensile Strength results was 524.5 ± 2.3 MPa.

For the laboratories that used the AS 1391 method for sample 2, the median and standard error of the Tensile Strength results was 530.5 ± 3.0 MPa. For all methods pooled, the median and standard error of the Tensile Strength results was 522.0 ± 2.8 MPa.

The methods were pooled when analysing the results for both samples.

Five laboratories reported outliers for Tensile Strength. Laboratories 1 and 15 reported outliers for both samples. Laboratory 8 reported an outlier for sample 1. Laboratories 25 and 28 reported outliers for sample 2.

All laboratories that have reported outliers should review their testing procedures and check their measurements, calculations and calibrations of their testing equipment.

The robust CVs for the Tensile Strength results were 1.85% and 2.24% for sample 1 and sample 2, respectively. These values are higher than the robust CV of 0.91% for the Tensile Strength results for the steel round bar sample used in Round 4 of this program (see Report No. 770).

Twenty laboratories reported measurement uncertainties associated with their Tensile Strength test results in this round.

6.4 Percentage Elongation after Fracture

A total of 27 laboratories tested the samples for Percentage Elongation after Fracture, including one laboratory that submitted two sets of results. Of these 27 laboratories, 16 tested using the AS 1391 method, including one laboratory that submitted two sets of results. Three laboratories tested using the ISO 6892-1 method. One laboratory indicated that their method of testing was ISO 6895-1. It is likely that this laboratory tested using ISO 6892-1 and incorrectly recorded their method of testing. Four laboratories used other methods of testing. Three laboratories did not specify the method that they used for testing (see Appendix A4 for more details).

Because the participants employed different diameter specimens and different gauge lengths for their tensile testing in this program, it was necessary to convert the Percentage Elongation after Fracture results submitted by the participants to a proportional gauge length. The results, converted to a proportional gauge length, are displayed in Appendix A2, while the formula used to convert the results is given on page A2.3 of Appendix A2.

For the laboratories that used the AS 1391 method for sample 1, the median and standard error of the Percentage Elongation after Fracture results (converted to a proportional gauge length) was 32.9 ± 0.9%. For all methods pooled, the median and standard error of the Percentage Elongation after Fracture results (converted to a proportional gauge length) was 32.5 ± 0.6%.

For the laboratories that used the AS 1391 method for sample 2, the median and standard error of the Percentage Elongation after Fracture results (converted to a proportional gauge length) was 32.9 ± 1.3%. For all methods pooled, the median and standard error of the Percentage Elongation after Fracture results (converted to a proportional gauge length) was 32.9 ± 0.9%.

The methods were pooled when analysing the results for both samples.

Two laboratories reported outliers for Percentage Elongation after Fracture. Laboratories 8 and 25 reported outliers for sample 1. There were no outliers reported for sample 2.

The robust CVs for the Percentage Elongation after Fracture results were 8.40% and 11.64% for sample 1 and sample 2, respectively. These values compare well with the robust CV of 11.22% for the Percentage Elongation after Fracture results for the steel round bar used in Round 4 of this program (see Report No. 770).

Nineteen laboratories reported measurement uncertainties associated with their Percentage Elongation after Fracture test results in this round.

6.5 Percentage Reduction in Area after Fracture

A total of 27 laboratories tested the samples for Percentage Reduction in Area after Fracture. Of these 27 laboratories, 16 tested using the AS 1391 method, including one laboratory that submitted two sets of results. Three laboratories tested using the ISO 6892-1 method. One laboratory indicated that their method of testing was ISO 6895-1. It is likely that this laboratory tested using ISO 6892-1 and incorrectly recorded their method of testing. Four laboratories used other methods of testing. Three laboratories did not specify the method that they used for testing (see Appendix A4 for more details).

For the laboratories that used the AS 1391 method for sample 1, the median and standard error of the Percentage Reduction in Area after Fracture results was 73.0 ± 0.7%. For all methods pooled, the median and standard error of the Percentage Reduction in Area after Fracture results was 72.0 ± 0.4%.

For the laboratories that used the AS 1391 method for sample 2, the median and standard error of the Percentage Reduction in Area after Fracture results was 72.0 ± 0.5%. For all methods pooled, the median and standard error of the Percentage Reduction in Area after Fracture results was 72.0 ± 0.4%.

The methods were pooled when analysing the results for both samples.

Four laboratories reported outliers for Percentage Reduction in Area after Fracture. Laboratories 3, 14 and 28 reported outliers for both samples. Laboratory 23 reported an outlier for sample 2.

It is likely that laboratories 3 and 28 have calculated the percentage reduction in diameter after fracture instead of the percentage reduction in area after fracture.

Following the issuing of the summary sheets for this round, laboratory 14 advised that they had made calculation errors for Percentage Reduction in Area after Fracture. Their result for sample 1 should have been 75%, while their result for sample 2 should have been 57%. It should be noted that their sample 2 result of 57% still would have obtained an outlier.

The Percentage Reduction in Area after Fracture results are of concern. This calculation should be relatively simple. The number of laboratories incorrectly calculating the result probably indicates that these testing laboratories do not usually make this calculation, however, the formula is specified in the testing standards.

The robust CVs for the Percentage Reduction in Area after Fracture results were 2.32% and 2.06% for sample 1 and sample 2, respectively. These values compare well with the robust CV of 2.83% for the Percentage Reduction in Area after Fracture results for the steel round bar used in Round 4 of this program (see Report No. 770).

Seventeen laboratories reported measurement uncertainties associated with their Percentage Reduction in Area after Fracture test results in this round.

6.6 Measurement Uncertainty

There appears to be some confusion regarding measurement uncertainty (MU) by the participants in this round of the program. A number of laboratories have not reported their MU, other laboratories have not reported their MU units and one laboratory has reported results of “95%.” An approach, such as that described in AS 1391 Appendix H, “An Error Budget”, to the estimation of the MU in tensile testing should be followed.

6.7 Other Reported Results

In addition to reporting results for Tensile Strength, Percentage Elongation after Fracture and Percentage Reduction in Area after Fracture, participants were also asked to report the Tensile Specimen Diameter, Tensile Specimen Gauge Length, Elastic Stress or Strain Rate and Plastic Strain Rate. The details reported by each of the participants are displayed in Appendix A4.

The information reported is limited, but it was requested in the hope that it would assist in the analysis of the results, especially in converting the Percentage Elongation after Fracture results to a proportional gauge length. Laboratories 13, 20 and 25 reported using some unusual gauge lengths this round.

The stress or strain rate units used by laboratories should be specified. There was a large range in the stress and strain rates reported by the participants in this round of the program and many of these results were reported in unusual units. The range of test conditions and test pieces (allowed by the standards), along with test setups, will always allow for variation in the test results obtained.

7. REFERENCES

1. *Guide to Proficiency Testing Australia (2012)*. (This document is located on the PTA website at www.pta.asn.au under Programs / Documents).

2. AS 1391 (2007) – *Metallic materials – Tensile testing at ambient temperature.*

3. ISO 6892-1 (2009) – *Metallic materials – Tensile testing – Part 1: Method of test at room temperature.*

APPENDIX A

Summary of Results

Section A1

Tensile Strength

A1.1

Tensile Strength (R_m) (MPa) – Results and Z-Scores

Lab Code	Sample 1			Sample 2		
	Result	MU (±)	Z-Score	Result	MU (±)	Z-Score
1	577	-	5.42 **§**	589	-	5.74 **§**
3	533	2.56	0.88	525	2.52	0.26
4A	535	-	1.08	535	-	1.11
4B	525	-	0.05	520	-	-0.17
5	523	1.7	-0.15	521	1.6	-0.09
6	531	0.14	0.67	532	0.14	0.86
7	526	2	0.15	529	2	0.60
8	469	-	-5.73 **§**	535	-	1.11
9	521	4.2	-0.36	526	4.2	0.34
11	532	0.25	0.77	534	0.25	1.03
12	520	2	-0.46	511	2	-0.94
13	534	13	0.98	518	6	-0.34
14	512	1.76%	-1.29	506	1.25%	-1.37
15	590	-	6.76 **§**	665	-	12.25 **§**
16	524	5	-0.05	518	5	-0.34
17	516	1.82%	-0.88	519	1.82%	-0.26
18	528	-	0.36	512	-	-0.86
19	527	-	0.26	522	-	0.00
20	519	4	-0.57	523	4	0.09
21	534	2	0.98	534	2	1.03
22	514	95%	-1.08	516	95%	-0.51
23	509	0.55	-1.60	506	0.55	-1.37
24	532	0.1	0.77	535	0.1	1.11
25	518.73	0.06	-0.60	475.55	0.06	-3.98 **§**
26	521	9.9	-0.36	522	9.9	0.00
27	529	-	0.46	533	-	0.94
28	510	6.6	-1.50	487	6.3	-3.00 **§**
30	520	1.77	-0.46	521	1.77	-0.09

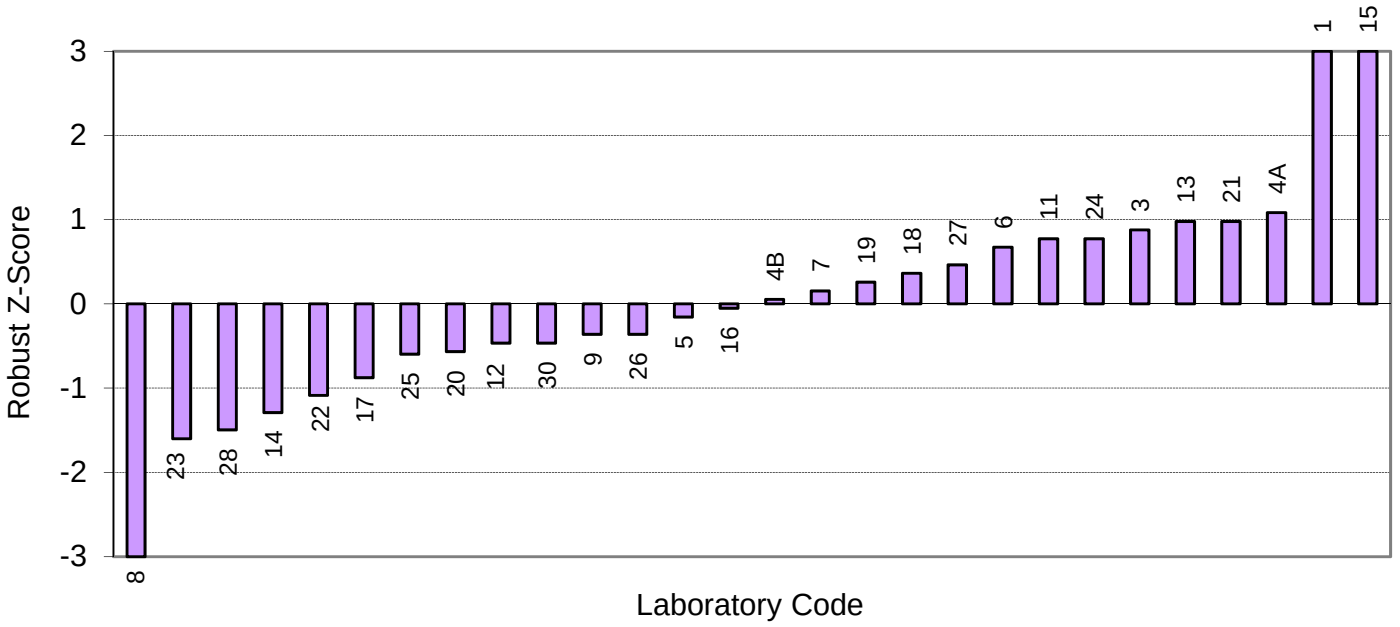
Summary Statistics

Statistic	Sample 1	Sample 2
Number of Results	28	28
Median	524.5	522.0
Normalised IQR	9.7	11.7
Uncertainty (Median)	2.3	2.8
Robust CV	1.85%	2.24%
Minimum	469	476
Maximum	590	665
Range	121	189

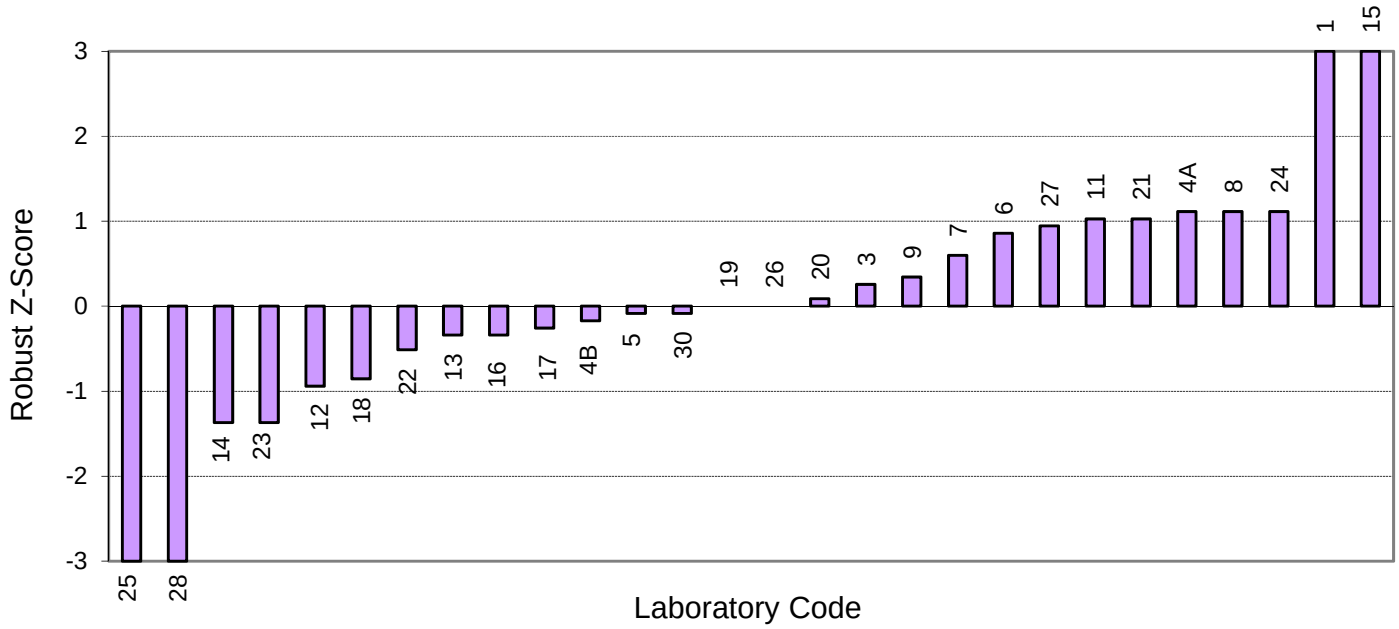
Notes:

1. § denotes an outlier (i.e. |z-score| ≥ 3.0).
2. The Youden diagram on the following page is provided for information only.

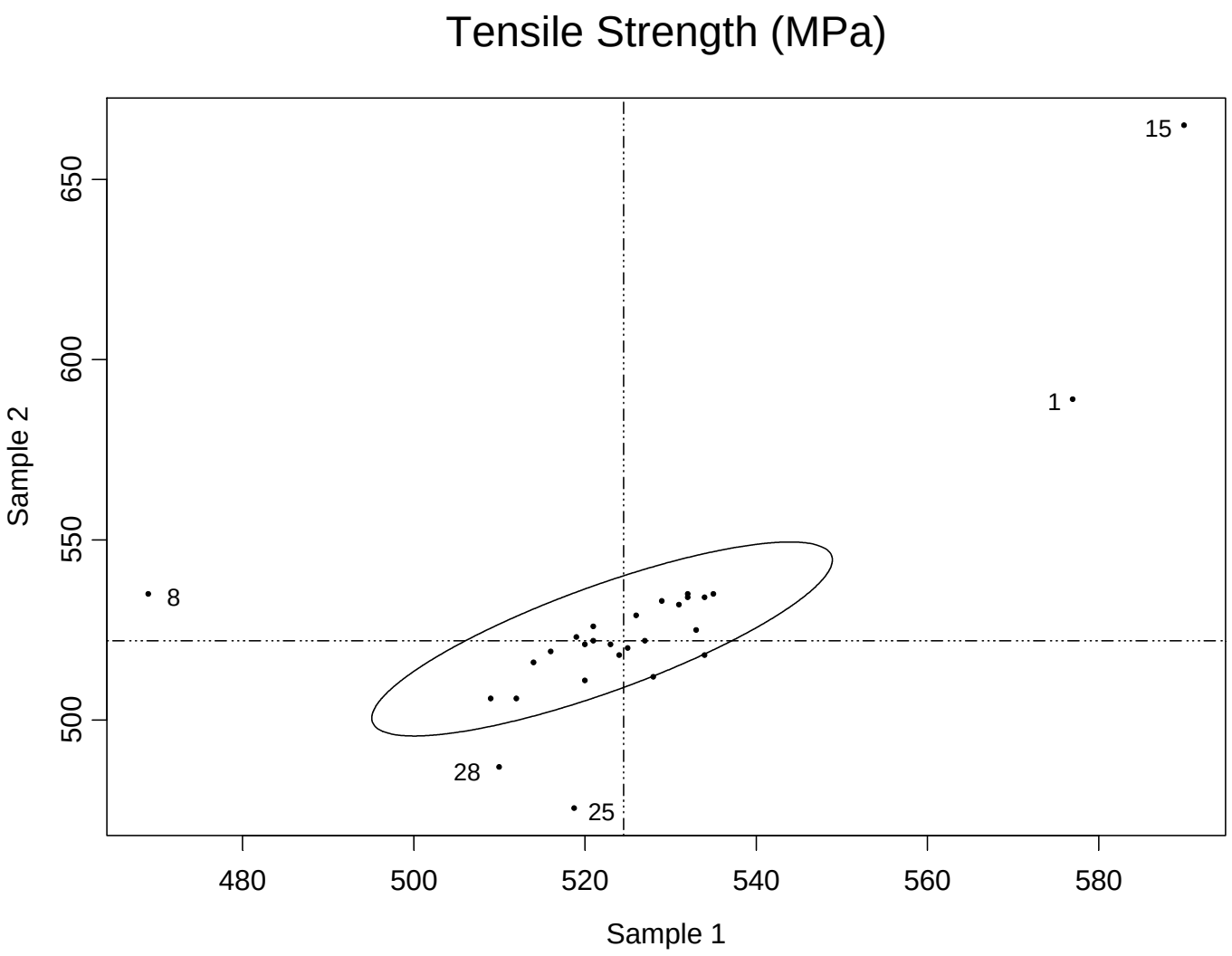
Tensile Strength (R_m) - Sample 1



Tensile Strength (R_m) - Sample 2



A1.3


Tensile Strength (MPa)
Sample 2
650
600
550
500
480
500
520
540
560
580
Sample 1
15
1
8
28
25

Section A2

Percentage Elongation after Fracture

A2.1

Percentage Elongation after Fracture (A%) – Results and Proportional Gauge Length (PGL) Results

Lab Code	Sample 1			Sample 2		
	Result	MU (±)	PGL Result	Result	MU (±)	PGL Result
1	35	-	35	33	-	33
3	34	0.82	34	34	0.82	34
4A	29	-	29	28	-	28
4B	29	-	29	30	-	30
5	36	0.1	36	37	0.1	37
6	31	0.08	31	30	0.08	30
7	36	2	36	36	2	36
8	22	-	22	28	-	28
9	31	0.7	31	31	0.7	31
11	31	0.025	31	32	0.025	32
12	34	0.064	34	36	0.065	36
13	29	0.1	29	30	0.1	30
14	31	1.13%	31	36	1.11%	36
15	41	-	35	42.5	-	36
16	33.0	1.6	33	35.0	1.7	35
17	33	1.82%	33	31	1.82%	31
18	36	-	36	38	-	38
19	29	-	29	30	-	30
20	31	3	31	33	3	33
21	32	1	32	34	1	34
22	33	95%	33	33	95%	33
23	40	0.026	40	38	0.026	38
24	32	0.02	32	32	0.02	32
25	27.11	0.5	24	40.26	0.5	38
26	33	0.7	33	34	0.7	34
27	35	-	35	32	-	32
28	33	0.1	30	30	0.1	27
30	33	-	33	31	-	31

A2.2

Percentage Elongation after Fracture (A%) – Proportional Gauge Length (PGL) Results and Z-Scores

Lab Code	Sample 1		Sample 2	
	PGL Result	Z-Score	PGL Result	Z-Score
1	35	0.95	33	0.03
3	34	0.54	34	0.31
4A	29	-1.26	28	-1.28
4B	29	-1.28	30	-0.78
5	36	1.27	37	1.05
6	31	-0.53	30	-0.76
7	36	1.27	36	0.79
8	22	-3.89 **§**	28	-1.30
9	31	-0.55	31	-0.51
11	31	-0.57	32	-0.26
12	34	0.66	36	0.88
13	29	-1.23	30	-0.73
14	31	-0.56	36	0.78
15	35	0.86	36	0.83
16	33	0.18	35	0.53
17	33	0.19	31	-0.51
18	36	1.32	38	1.29
19	29	-1.27	30	-0.77
20	31	-0.55	33	0.00
21	32	-0.21	34	0.25
22	33	0.17	33	0.00
23	40	2.71	38	1.29
24	32	-0.16	32	-0.23
25	24	-3.11 **§**	38	1.23
26	33	0.16	34	0.27
27	35	0.88	32	-0.23
28	30	-0.86	27	-1.44
30	33	0.19	31	-0.51

Summary Statistics

Statistic	Sample 1	Sample 2
Number of Results	28	28
Median	32.5	32.9
Normalised IQR	2.7	3.8
Uncertainty (Median)	0.6	0.9
Robust CV	8.40%	11.64%
Minimum	22	27
Maximum	40	38
Range	18	10

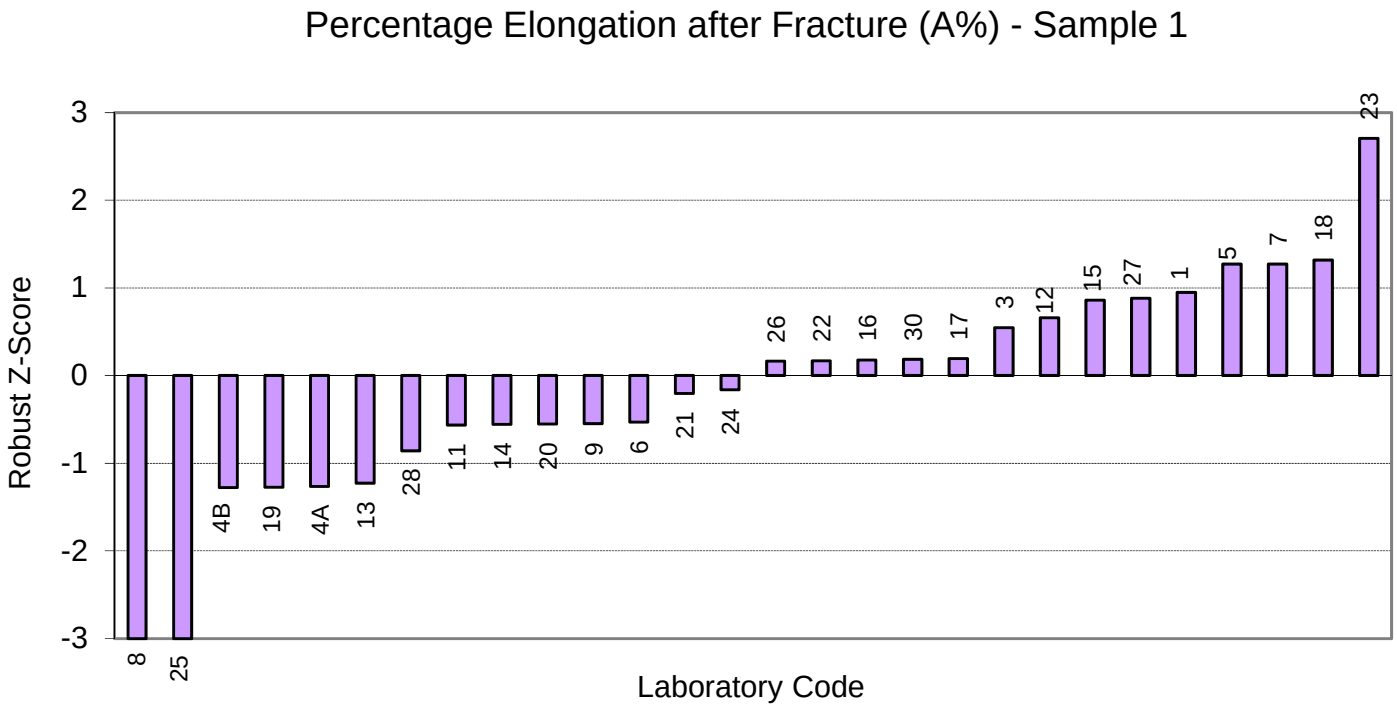
Notes:

1. § denotes an outlier (i.e. |z-score| ≥ 3.0).

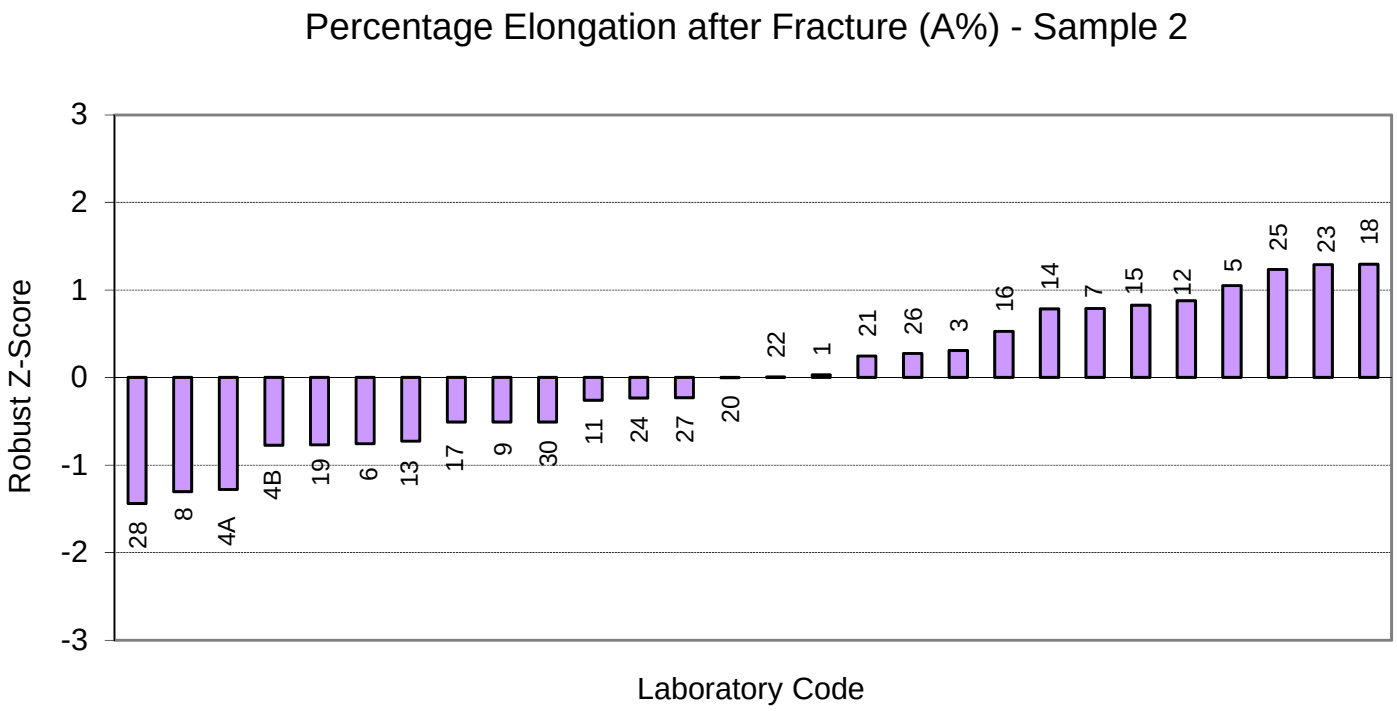
2. The Youden diagram on the following page is provided for information only.

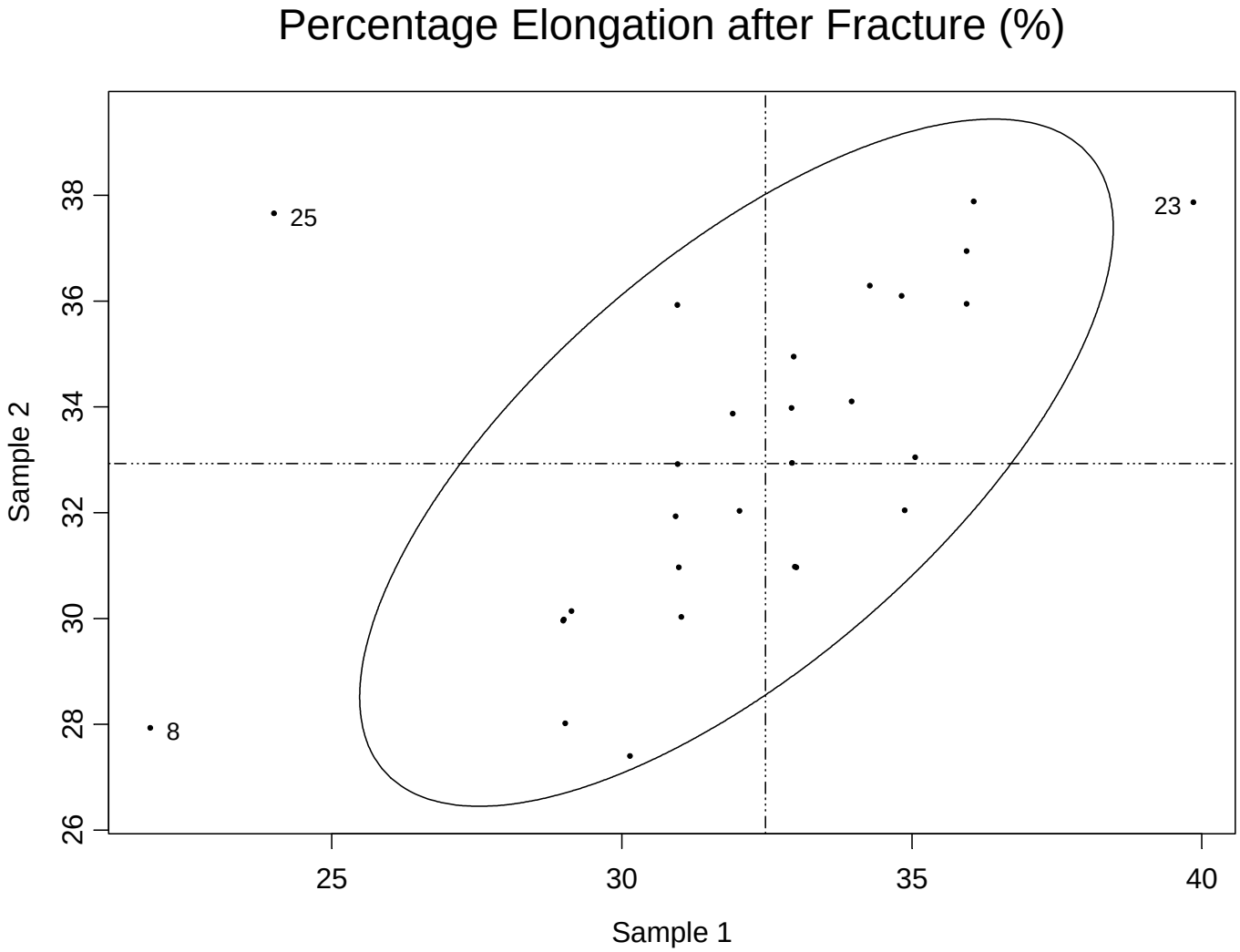
3. To analyse the Percentage Elongation after Fracture results, the results submitted by participants were converted to a proportional gauge length using the formula:

$$\text{PGL Result} = \frac{\text{Result}}{2} \times \left(\frac{\text{Tensile Specimen Gauge Length}}{\sqrt{\pi \times \left(\frac{\text{Tensile Specimen Diameter}}{2} \right)^2}} \right)^{0.4}.$$



A2.4


Percentage Elongation after Fracture (A%) - Sample 2
Robust Z-Score
3
2
1
0
-1
-2
-3
28
8
4A
4B
19
6
13
17
9
30
11
24
27
20
22
1
21
26
3
16
14
7
15
12
5
25
23
18
Laboratory Code


Percentage Elongation after Fracture (%)
Sample 2
38
36
34
32
30
28
26
25
8
23
25
30
35
40
Sample 1

Section A3

Percentage Reduction in Area after Fracture

A3.1

Percentage Reduction in Area after Fracture (Z%) – Results and Z-Scores

Lab Code	Sample 1			Sample 2		
	Result	MU (±)	Z-Score	Result	MU (±)	Z-Score
1	73	-	0.60	73	-	0.67
3	48	0.11	-14.39 **§**	48	0.11	-16.19 **§**
4A	71	-	-0.60	71	-	-0.67
4B	70	-	-1.20	71	-	-0.67
5	73	0.7	0.60	73	0.8	0.67
6	73	0.08	0.60	72	0.08	0.00
7	73	2	0.60	72	2	0.00
8	76	-	2.40	73	-	0.67
9	72	0.1	0.00	71	0.1	-0.67
11	72	-	0.00	72	-	0.00
12	72	0.3	0.00	73	0.294	0.67
13	72	0.8	0.00	72	1.7	0.00
14	25	-	-28.18 **§**	43	-	-19.56 **§**
15	70	-	-1.20	71	-	-0.67
16	73.0	3.0	0.60	73.0	3.0	0.67
17	72	2.58%	0.00	73	2.58%	0.67
18	73	-	0.60	74	-	1.35
19	68	-	-2.40	68	-	-2.70
20	73	3	0.60	73	3	0.67
21	74	2	1.20	74	2	1.35
22	73	95%	0.60	73	95%	0.67
23	68	0.026	-2.40	67	0.026	-3.37 **§**
24	73	0.02	0.60	74	0.02	1.35
25	71.6	0.7	-0.24	73.2	0.7	0.81
26	73	1.4	0.60	73	1.4	0.67
27	72	-	0.00	69	-	-2.02
28	47	0.5	-14.99 **§**	45	0.5	-18.21 **§**
30	73	-	0.60	72	-	0.00

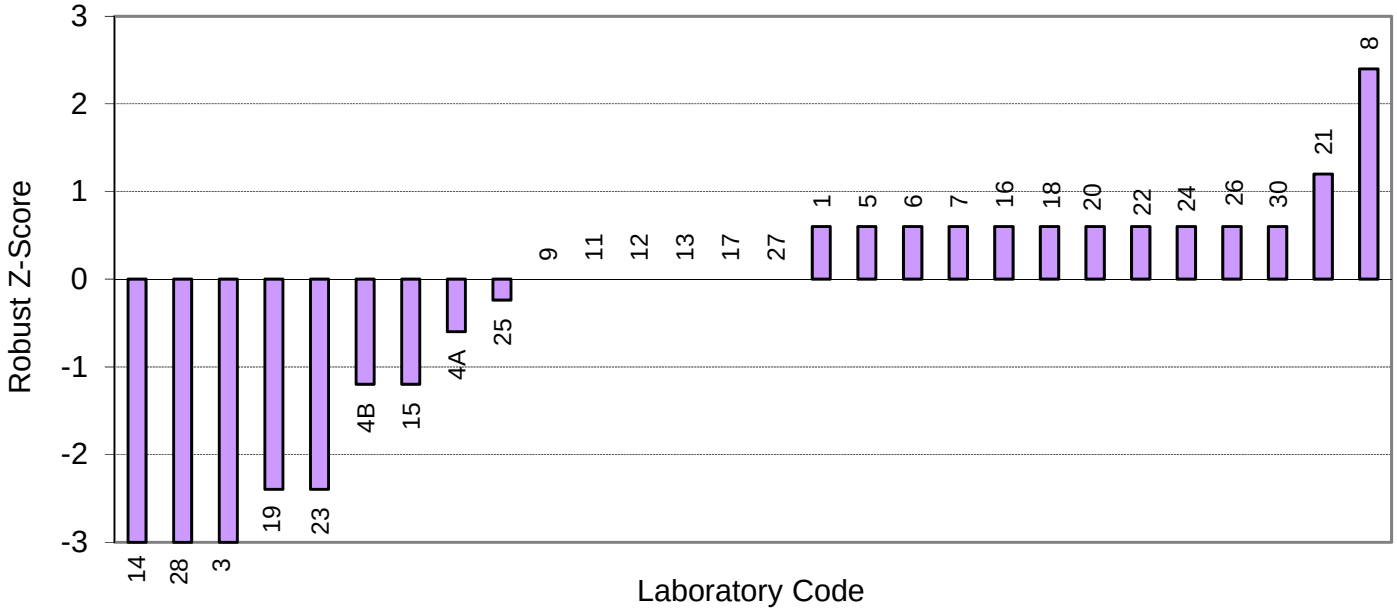
Summary Statistics

Statistic	Sample 1	Sample 2
Number of Results	28	28
Median	72.0	72.0
Normalised IQR	1.7	1.5
Uncertainty (Median)	0.4	0.4
Robust CV	2.32%	2.06%
Minimum	25	43
Maximum	76	74
Range	51	31

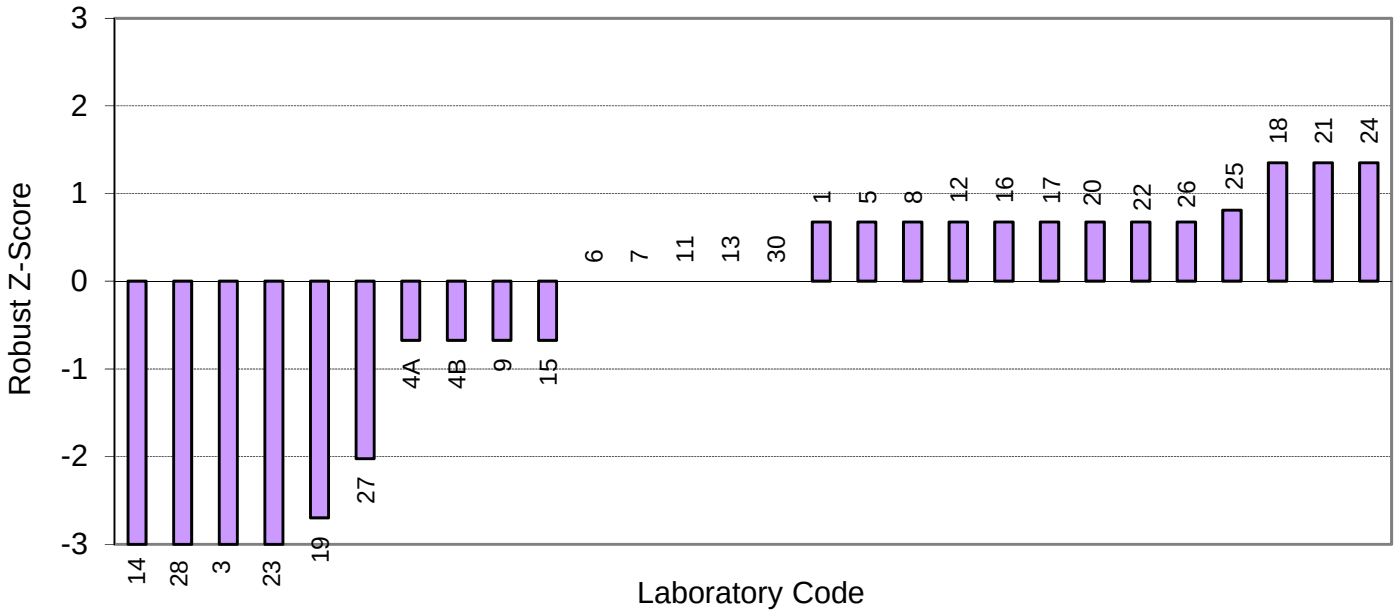
Notes:

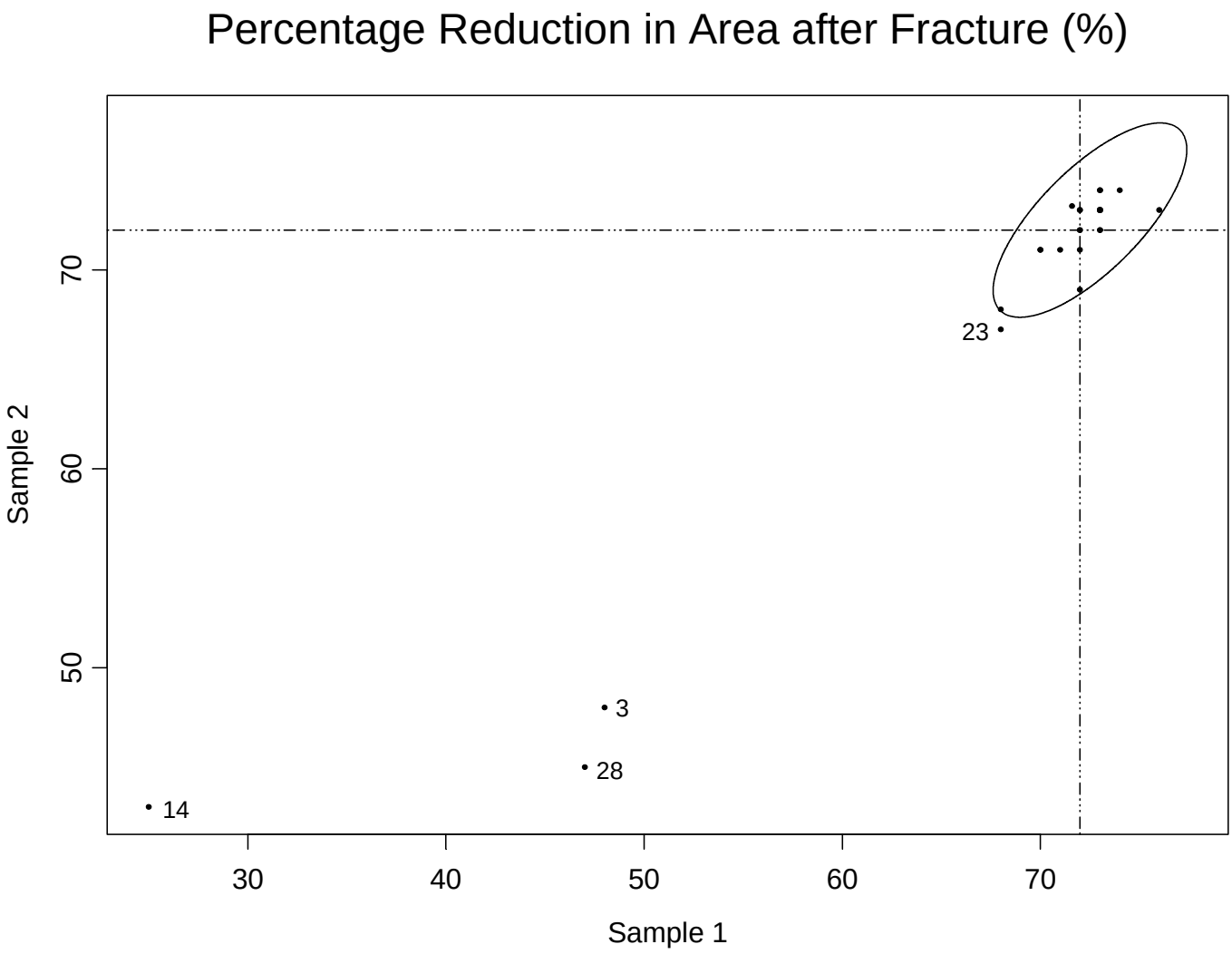
1. § denotes an outlier (i.e. |z-score| ≥ 3.0).
2. The Youden diagram on the following page is provided for information only.

Percentage Reduction in Area after Fracture (Z%) - Sample 1



Percentage Reduction in Area after Fracture (Z%) - Sample 2




Percentage Reduction in Area after Fracture (%)
Sample 2
Sample 1
50
60
70
30
40
50
60
70
23
3
28
14

Section A4

Method Information and Other Reported Results

A4.1

Method Information

Lab Code	Tensile Strength	Percentage Elongation after Fracture	Percentage Reduction in Area after Fracture
1	AS 1391	AS 1391	AS 1391
3	AS 1391	AS 1391	AS 1391
4A	AS 1391	AS 1391	AS 1391
4B	AS 1391	AS 1391	AS 1391
5	AS 1391 - 2007	AS 1391 - 2007	AS 1391 - 2007
6	AS 1391	AS 1391	AS 1391
7	AS 1391	AS 1391	AS 1391
8	AS 1391	AS 1391	AS 1391
9	ISO 6895-1	ISO 6895-1	ISO 6895-1
11	AS 1391 - 2007	AS 1391 - 2007	AS 1391 - 2007
12	KS B 0802	KS B 0802	KS B 0802
13	ISO 6892-1	ISO 6892-1	ISO 6892-1
14	BS EN 10002-1 2001	BS EN 10002-1 2001	BS EN 10002-1 2001
15	AS 1391 - 2007	AS 1391 - 2007	AS 1391 - 2007
16	ISO 6892-1	ISO 6892-1	ISO 6892-1
17	STD	STD	STD
18	AS 1391	AS 1391	AS 1391
19	AS 1391 - 2007	AS 1391 - 2007	AS 1391 - 2007
20	DIN EN ISO 6892-1 (2009)	DIN EN ISO 6892-1 (2009)	DIN EN ISO 6892-1 (2009)
21	AS 1391	-	-
22	AS 1391	AS 1391	AS 1391
23	AS 1391	AS 1391	AS 1391
24	AS 1391 - 2007	AS 1391 - 2007	AS 1391 - 2007
25	-	-	-
26	AS 1391 - 2007	AS 1391 - 2007	AS 1391 - 2007
27	AS 1391	AS 1391	AS 1391
28	ASTM A-370	ASTM A-370	ASTM A-370
30	-	-	-

A4.2

Tensile Specimen Diameter and Tensile Specimen Gauge Length

Lab Code	Tensile Specimen Diameter (mm)				Tensile Specimen Gauge Length (mm)			
	Sample 1		Sample 2		Sample 1		Sample 2	
	Result	MU (±)	Result	MU (±)	Result	MU (±)	Result	MU (±)
1	9.93	-	9.94	-	50	-	50	-
3	10.00	0.005	9.90	0.005	50	0.29	50	0.29
4A	9.95	-	9.96	-	50	-	50	-
4B	9.98	-	10.01	-	50	-	50	-
5	10.01	0.007	10.01	0.005	50	0.03	50	0.05
6	9.95	0.08	9.95	0.08	50	0.08	50	0.08
7	10.01	0.02	10.01	0.02	50	0.02	50	0.02
8	5.87	-	5.82	-	29	-	29	-
9	13.98	0.01	14.00	0.01	70	0.5	70	0.5
11	10.03	0.021	10.03	0.021	50	0.021	50	0.021
12	9.97	0.009	9.97	0.01	51	0.01	51	0.01
13	9.95	0.09	9.87	0.05	50.45	0.02	50.06	0.02
14	16.01	1.33%	16.04	0.47%	80	0.25	80	0.25
15	15.00	-	15.00	-	50	-	50	-
16	10.00	0.01	10.01	0.01	50.0	0.05	50.0	0.05
17	12.36	0.21%	12.40	-	62.00	0.27%	62.00	-
18	15.88	-	16.08	-	80	-	80	-
19	9.97	-	9.99	-	50	-	50	-
20	9.99	-	9.97	-	49.94	-	49.67	-
21	10.04	0.01	10.07	0.01	50	0.01	50	0.01
22	10.02	95%	10.02	95%	50	95%	50	95%
23	16.10	0.004	16.10	0.004	80	0.013	80	0.013
24	9.95	0.021	9.95	0.021	50	0.02	50	0.02
25	16.10	0.1	16.80	0.1	59.54	0.2	71.25	0.2
26	10.03	0.07	9.99	0.07	50	0.5	50	0.5
27	10.06	-	9.94	-	50	-	50	-
28	12.51	0.02	12.51	0.02	50	0.02	50	0.02
30	13.98	0.011	13.99	-	70	0.032	70	-

A4.3

Elastic Stress or Strain Rate (number / sec)

Lab Code	Sample 1		Sample 2	
	Result	MU (±)	Result	MU (±)
1	-	-	-	-
3	-	-	-	-
4A	-	-	-	-
4B	-	-	-	-
5	-	-	-	-
6	0.00025	-	0.00025	-
7	0.000015	-	0.000017	-
8	0.0025	-	0.0025	-
9	20 MPa/s	-	20	-
11	-	-	-	-
12	12 MPa	-	12 MPa	-
13	-	-	-	-
14	7.5 MPa/s	-	7.6 MPa/s	-
15	5 mm/min	-	5 mm/min	-
16	15 MPa / sec	2 MPa / sec	15 MPa / sec	2 MPa / sec
17	0.004	-	-	-
18	35	-	35	-
19	0.1 mm/sec	-	0.1 mm/sec	-
20	0.0063	-	0.0064	-
21	-	-	-	-
22	-	-	-	-
23	10.1 $MPas^{-1}$	-	10.3 $MPas^{-1}$	-
24	20 $MPas^{-1}$	-	20 $MPas^{-1}$	-
25	31.36 min	0.2	31.36 min	0.2
26	0.0008	0.000011	0.0008	0.000011
27	0.00025 mm/mm/s	-	0.00025 mm/mm/s	-
28	-	-	-	-
30	-	-	-	-

A4.4

Plastic Strain Rate (number / sec)

Lab Code	Sample 1		Sample 2	
	Result	MU (±)	Result	MU (±)
1	-	-	-	-
3	0.0012	-	0.0012	-
4A	-	-	-	-
4B	-	-	-	-
5	-	-	-	-
6	0.005	-	0.005	-
7	-	-	-	-
8	-	-	-	-
9	0.0007	-	0.0007	-
11	-	-	-	-
12	0.67%	-	0.67%	-
13	-	-	-	-
14	0.5 mm/s	-	0.5 mm/s	-
15	5 mm/min	-	5 mm/min	-
16	0.005	0.001	0.005	0.001
17	0.005	-	-	-
18	0.008	-	0.008	-
19	0.4 mm/sec	-	0.4 mm/sec	-
20	0.0066	-	0.0066	-
21	-	-	-	-
22	-	-	-	-
23	-	-	-	-
24	-	-	-	-
25	30.30	0.2	30.32	0.2
26	0.0022	0.000042	0.00222	0.000042
27	0.333 mm/s	-	0.333 mm/s	-
28	-	-	-	-
30	-	-	-	-

APPENDIX B

Homogeneity Testing

HOMOGENEITY TESTING

Before the test pieces were distributed to participants, ten samples were selected at random and tested to assess the variability of the samples to be used in the program. Analysis of this 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

Tensile Testing Of Metals Proficiency Testing Program Round 5, June 2013

Instructions To Participants

To ensure that the results of this program can be analysed correctly, participants are asked to note carefully:

1) The samples for this tensile testing program comprise of two steel round bar samples, labelled 1-x and 2-x.

2) The tests to be performed in this program are:

   - Tensile Strength (R_m);
   - Percentage Elongation after Fracture (A%); and
   - Percentage Reduction in Area after Fracture (Z%).

3) The samples have been heat treated and the tests may commence as soon as samples are received. The samples are to be treated in the same manner as routinely tested samples.

4) All testing, recording and reporting is to be performed in accordance with your routine test methods, but testing in accordance with AS 1391 – *Metallic materials – Tensile testing at ambient temperature* (2007) or ISO 6892-1 – *Metallic materials – Tensile testing – Part 1: Method of test at room temperature* (2009) are the preferred test methods.

5) Report only one result per sample, based on the determination for each property. For each determination, results are to be reported to the accuracy and in the units indicated on the Results Sheet.

6) The method of testing used should also be reported on the Results Sheet (*e.g.* AS 1391, ISO 6892-1, etc.)

7) The Percentage Elongation after Fracture (A%) results will be converted to a proportional gauge length before analysis. Participants should therefore report the Tensile Specimen Diameter and Tensile Specimen Gauge Length.

8) Participants 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) 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, ensuring the confidentiality of your results.

10) 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 17 July 2013**. Results reported later than this date may not be analysed in the final report.

C2.1

PROFICIENCY TESTING AUSTRALIA

Tensile Testing Of Metals Proficiency Testing Program

Round 5, June 2013

RESULTS SHEET

Laboratory Code:

Test	Report results to nearest	Sample 1		Sample 2		Method
		Result	MU (±)	Result	MU (±)	
Tensile Strength (R_m)	1 MPa					
Percentage Elongation after Fracture (A%)	1 %					
Percentage Reduction in Area (Z%)	1%					

Where possible, please also report the values for the following:

Test	Report results to nearest	Sample 1		Sample 2	
		Result	MU (±)	Result	MU (±)
Tensile Specimen Diameter	0.01 mm				
Tensile Specimen Gauge Length	1 mm				
Elastic Stress or Strain Rate	number / sec				
Plastic Strain Rate	number / sec				

All estimates of measurement uncertainty (MU) must be given as a 95% confidence interval (coverage factor $k \approx 2$).

Print Name: _____ Signature & Date: _____

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