Report No. 1145

Metal Alloys Proficiency Testing Program

Round 36

Low Alloy Steel

July 2019

Acknowledgments

PTA wishes to gratefully acknowledge the technical assistance provided for this program by Mr W Ting, Universal Scientific Laboratory Pty Ltd, along with the supply 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 chemical analysis of metal alloys. It constitutes the thirty sixth 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).

The program was conducted in May 2019 by Proficiency Testing Australia (PTA). The aim of the program was to assess laboratories’ abilities to competently perform the prescribed analyses.

The Program Coordinator was Mrs K Cividin and the Technical Adviser was Mr W Ting, Universal Scientific Laboratory. This report was authorised by Mr P Briggs, PTA General Manager.

2. FEATURES OF THE PROGRAM

(a) Participants were provided with one low alloy steel disc sample.

(b) A total of 10 laboratories received samples, comprising:

- 6 Australian participants; and
- 4 overseas participants, including:
    - Ethiopia, Qatar, Saudi Arabia and Singapore

All laboratories submitted their results for inclusion in this report.

(c) Laboratories were provided with the *Instructions to Participants* and *Results Sheet* (see Appendix C). Laboratories were requested to perform the tests according to their routine methods and to record their results on the *Results Sheet*.

(d) Prior to sample distribution, eight randomly selected samples were analysed for homogeneity. Based on the results of this testing (see Appendix B), the homogeneity of the samples was established.

(e) Each laboratory was randomly allocated a unique code number for the program to ensure confidentiality of results. Reference to each laboratory in this report is by code number only. Please note that one laboratory reported more than one set of results and, therefore, their code number (with letter) may appear several times in the same data set.

(f) Results (as reported by participants) with corresponding summary statistics (i.e. number of results, median, uncertainty of the median, normalised interquartile range, robust coefficient of variation, minimum, maximum and range) are presented in Appendix A. Measurement Uncertainty (MU) is also

presented where supplied by participants. Where this was not reported, “nr” will appear in that column. Please note that this information is presented for information purposes only and has not been used for the formal evaluation of results.

(g) A robust statistical approach, using z-scores, was utilised to assess laboratories’ testing performance (see Section 4). Robust z-scores and z-score charts relevant to each test are presented in Appendix A.

(h) The document entitled *Guide to Proficiency Testing Australia,* 2016 (reference [1]) defines the statistical terms and details the statistical procedures referred to in this report.

(i) A tabulated listing of laboratories (by code number) identified as having outlier results can be found on page 4.

3. FORMAT OF THE APPENDICES

(a) Appendix A contains the analysis of results reported by laboratories for the sample by all methods pooled. This section contains the following for each determinant, where appropriate:

- a table of results and calculated z-scores;
- a list of summary statistics; and
- ordered z-score charts.

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

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

4. STATISTICAL DESIGN OF THE PROGRAM

(a) Outlier Results and Z-scores

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 close to zero indicates that the result agrees well with those from other laboratories, 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 “**§**”.

The table on page 4 summarises the outlier results detected.

(b) Results Tables and Summary Statistics

Each of these tables contains the results returned by each laboratory, including the code number for the technique used, and the robust z-score calculated for each result, where applicable.

Results have been entered exactly as reported by participants. That is, laboratories which did not report results to the precision (i.e. number of decimal places) requested on the Results Sheet have not been rounded to the requested precision before being included in the statistical analysis.

Where a statistical analysis has been conducted, a list of summary statistics appears at the bottom of the table of results and consists of:

- the number of results for that test/sample (*No. of Results*);
- the median of these results, i.e. the middle value (*Median*);
- the uncertainty of the median; a robust estimate of the standard deviation of the *Median*;
- the normalised interquartile range of the results (*Normalised IQR*);
- the robust coefficient of variation, expressed as a percentage (*Robust CV*) - i.e. 100 x *Normalised IQR* / *Median*;
- the minimum and maximum laboratory results; and
- the range (*Maximum* - *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:

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

n = number of results

Please see reference [1] for further details on these robust summary statistics.

(c) Ordered Z-Score Charts

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

These charts contain solid lines at +3.0 and -3.0, so that outliers are clearly identifiable as those laboratories whose "bar" extends beyond these "cut-off" lines. The y-axis of these charts has been limited, so very large z-scores appear to extend beyond the chart boundary.

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

TABLE A: SUMMARY STATISTICS

Test	No. of Results	Median	Normalised IQR
Carbon	11	0.4540	0.0041
Manganese	11	0.7880	0.0143
Phosphorus	11	0.0110	0.0015
Sulfur	11	0.0160	0.0020
Silicon	11	0.2560	0.0119
Copper	11	0.1050	0.0048
Nickel	11	0.0515	0.0024
Chromium	11	0.1320	0.0020
Molybdenum	11	0.0195	0.0015
Cobalt	5	0.0035	0.0015
Vanadium	8	0.0020	0.0006

5. PTA AND TECHNICAL ADVISER'S COMMENTS

The sample used for this round was a medium carbon steel similar to AS/NZS 1045, which is in wide use globally, therefore accredited laboratories should be competent in the analysis of this material. For the AES arc/spark technique, which most participants used, there should be no inter-element effects arising from the analysis of this material and the accuracy of results will depend on the calibration status of the instrument and the cleanliness and homogeneity of the sample.

Increasingly, laboratories are using factory-calibrated atomic emission spectrometers. Therefore, all laboratories should be in possession of certified reference materials (CRMs) with which they can verify the calibration status of their instruments before generating and reporting results. Laboratories which have participated in previous PTA programs should be in possession of previously analysed samples which are effectively CRMs. Accurate results for non-salient elements (residuals or "tramps") are essential when specific heats (batches) of steel are being identified.

Carbon

Overall the results were satisfactory. The deletion of outliers gives good consistency between laboratories for this element. The outliers suggest that the calibration curve for laboratory codes 1 and 2 is awry, but the very low result for laboratory code 9 suggests that the calibration status of the instrument was either not established before analysis, or not calibrated for carbon at this level.

Manganese

In general, the results were satisfactory. The result for laboratory code 3 is questionable.

Nickel

Laboratory code 9 appears to have a calibration problem for this element. Like Copper, this is a "tramp" element and is normally present at low levels, however, accurate results are essential when establishing heat (batch) for identification or when a high figure can lead to undesirable metallurgical properties.

Chromium

The results were satisfactory. This is a "tramp" element and is normally present at low levels, however, accurate results are essential when establishing heat (batch) for identification or when a high figure can lead to undesirable metallurgical properties.

Molybdenum

Excluding the outliers, the results were satisfactory. Laboratory codes 7 and 9 appear to have questionable calibration at this level.

Phosphorus

With the exception of results for laboratory code 3a the results were satisfactory. It appears that their instrument read high at the low end of the range for this element.

A preliminary check with a certified reference material should have indicated this.

Sulfur
With the exception of results for laboratory code 1 the results were satisfactory. Their instrument appeared to have a negative bias at low levels of sulfur.

Silicon
The results were satisfactory.

Copper
This is a “tramp” element and is normally present at low levels, however, accurate results are essential when establishing heat (batch) for identification or when a high figure can lead to undesirable metallurgical properties. Laboratory code 3a’s calibration is questionable. Laboratory code 5’s result, rounded to 0.09% for normal reporting, is acceptable.

Cobalt
There are insufficient results to conclude anything other than that the figures are unremarkable.

Vanadium
With the exception of the outlier, the results were quite good. At this level, it is not unusual to encounter either negative or positive bias in the calibration curve. Cobalt and Vanadium will normally be present at very low levels giving no metallurgical effect and not being a factor in identifying batch (heat) of steel.

Variations within and between laboratories
Most results have been generated by AES arc/spark. Replicates within laboratories were very good and there was good correlation between laboratories when outliers were excluded.

Variation between methods
Most laboratories reported results generated by atomic emission spectroscopy. One laboratory used LECO/RFIR for carbon and silicon, photometry for phosphorus and silicon, and atomic absorption spectrometry for the remainder.

Possible sources of error
When using AES arc/spark it is vital that the calibration status of the instrument is checked before analysing unknowns, and adjusted if necessary. A certified reference material (CRM) should be run in parallel with all analyses, regardless of the technique employed. As previously mentioned, participating laboratories can use this samples and samples from previous rounds, for calibration and verification.

Measurement Uncertainties
Measurement Uncertainties (MU) were encouragingly low.

This is a common alloy and becomes a worthwhile addition to laboratories' "libraries" of CRMs. It can be used to confirm the calibration status of instruments and the accuracy of generated results.

The ability of a laboratory to accurately analyse this material is important for quality control (complies with specification), grade check (if problems using the material are encountered), or heat (batch) identification.

Analysis of this alloy should be within the scope of laboratories accredited in the field of Metals and Alloys - iron and steel. It is still important that results, particularly for the salient elements, but also for the residual ("tramp") elements, are as accurate as possible. This is necessary when a particular heat (batch) of steel has to be identified, therefore, confidence in the calibration status of instruments is vital, as is confidence in non-instrumental techniques (gravimetric and volumetric).

Analysis of Results by Method Groups

In order for methods to be grouped for analysis, PTA requires at least 11 sets of results from the same method group. As there were less than 11 results submitted for each method, reliable conclusions cannot be drawn from analysing grouped methods on this occasion. Therefore, results from all method groups have been pooled for analysis.

6. OUTLIER RESULTS

Laboratories reporting outlier results by pooled methods analysis are listed in the following table:

TABLE C: SUMMARY OF STATISTICAL OUTLIERS

Test	Laboratory Code No.
Carbon	1, 2, 9
Manganese	-
Phosphorus	3a
Sulfur	1, 9
Silicon	-
Copper	3a, 5
Nickel	3, 9
Chromium	1, 3, 3a
Molybdenum	7, 9
Cobalt	-
Vanadium	7

7. REFERENCES

[1] *Guide to Proficiency Testing Australia*, 2016 (This document can be found on the PTA website, www.pta.asn.au)

[2] AS1442-2007 *Carbon steels and carbon-manganese steels-Hot rolled bars and semifinished products.*

APPENDIX A

Results and Data Analysis

Carbon (0.000%)

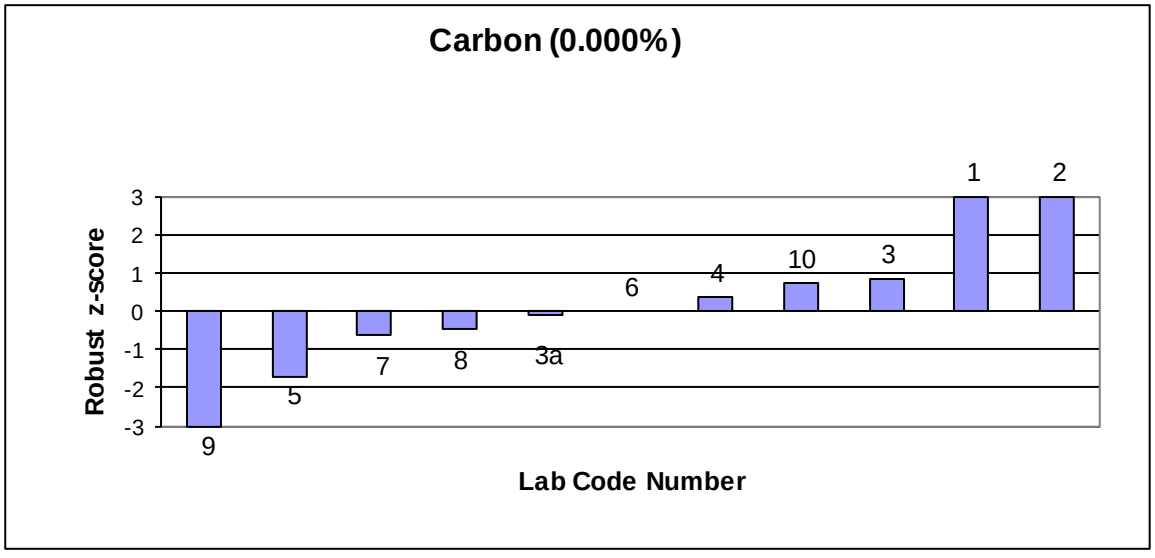
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.47	0.48	0.4750	0.005	5.15	§	1
2	0.476	0.480	0.4780	0.009	5.89	§	1
3	0.457	0.458	0.4575	nr	0.86		1
3a	0.449	0.458	0.4535	nr	-0.12		1
4	0.454	0.457	0.4555	0.01	0.37		6
5	0.445	0.449	0.4470	0.012	-1.72		1
6	0.452	0.456	0.4540	0.002	0.00		1
7	0.450	0.453	0.4515	0.020	-0.61		1
8	0.454	0.450	0.4520	0.0112	-0.49		1
9	0.31	0.301	0.3055	0.002	-36.42	§	1
10	0.459	0.455	0.4570	0.018	0.74		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
6 LECO/RFIR

No. of Results	11
Median	0.4540
Norm IQR	0.0041
Uncertainity of the Median	0.0015
Robust CV	0.9%
Min	0.306
Max	0.478
Range	0.173



Manganese (0.000%)

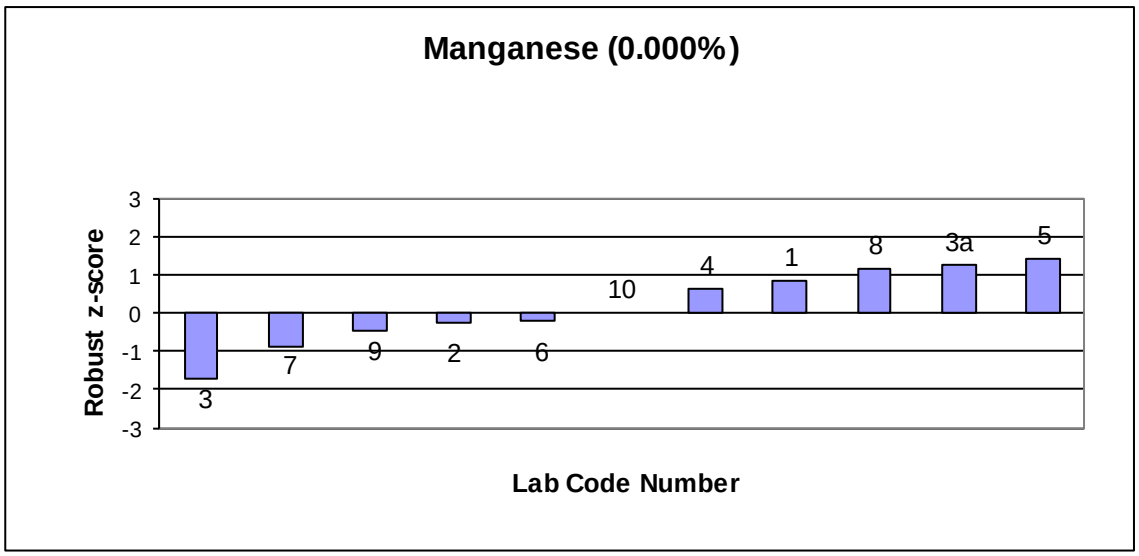
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score	Technique
1	0.80	0.80	0.8000	0.015	0.84	1
2	0.784	0.785	0.7845	0.009	-0.25	1
3	0.761	0.766	0.7635	nr	-1.72	1
3a	0.796	0.815	0.8055	nr	1.23	1
4	0.794	0.800	0.7970	0.01	0.63	3
5	0.805	0.811	0.8080	0.0243	1.40	1
6	0.784	0.786	0.7850	0.01	-0.21	1
7	0.774	0.777	0.7755	0.026	-0.88	1
8	0.805	0.804	0.8045	0.0170	1.16	1
9	0.781	0.782	0.7815	0.016	-0.46	1
10	0.787	0.789	0.7880	0.015	0.00	1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
3 AAS (Atomic Absorption Spectrometry)

No. of Results	11
Median	0.7880
Norm IQR	0.0143
Uncertainity of the Median	0.0054
Robust CV	1.8%
Min	0.764
Max	0.808
Range	0.045



Phosphorus (0.000%)

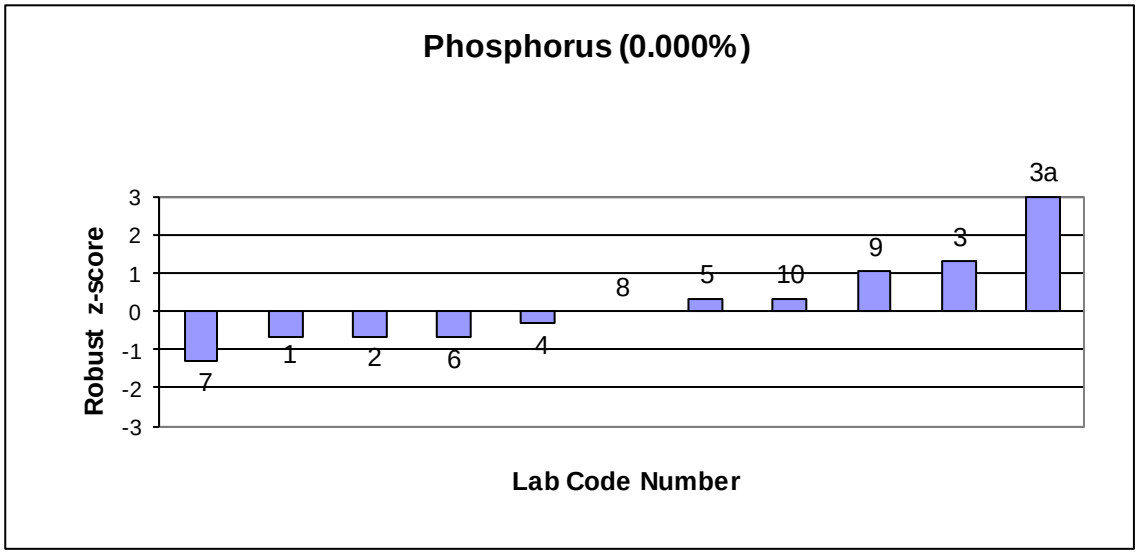
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.01	0.01	0.0100	0.0009	-0.66		1
2	0.010	0.010	0.0100	0.001	-0.66		1
3	0.013	0.013	0.0130	nr	1.32		1
3a	0.023	0.024	0.0235	nr	8.23	§	1
4	0.010	0.011	0.0105	0.005	-0.33		5
5	0.011	0.012	0.0115	0.0005	0.33		1
6	0.010	0.010	0.0100	0.002	-0.66		1
7	0.009	0.009	0.0090	0.003	-1.32		1
8	0.011	0.011	0.0110	0.0020	0.00		1
9	0.0126	0.0126	0.0126	0.0004	1.05		1
10	0.011	0.012	0.0115	0.002	0.33		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
5 Photometric

No. of Results	11
Median	0.0110
Norm IQR	0.0015
Uncertainity of the Median	0.0006
Robust CV	13.8%
Min	0.009
Max	0.024
Range	0.015



Sulfur (0.000%)

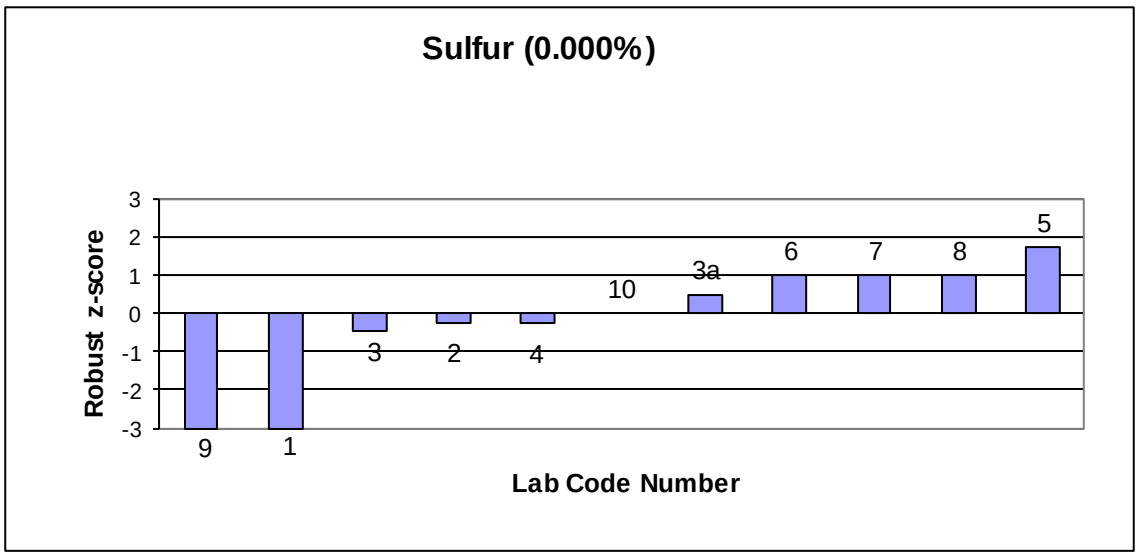
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.009	0.009	0.0090	0.0004	-3.43	§	1
2	0.016	0.015	0.0155	0.002	-0.25		1
3	0.015	0.015	0.0150	nr	-0.49		1
3a	0.017	0.017	0.0170	nr	0.49		1
4	0.015	0.016	0.0155	0.005	-0.25		6
5	0.020	0.019	0.0195	0.0011	1.72		1
6	0.018	0.018	0.0180	0.002	0.98		1
7	0.018	0.018	0.0180	0.004	0.98		1
8	0.018	0.018	0.0180	0.0056	0.98		1
9	0.0018	0.0018	0.0018	0.0001	-6.97	§	1
10	0.016	0.016	0.0160	0.003	0.00		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
6 LECO/RFIR

No. of Results	11
Median	0.0160
Norm IQR	0.0020
Uncertainity of the Median	0.0008
Robust CV	12.7%
Min	0.002
Max	0.020
Range	0.018



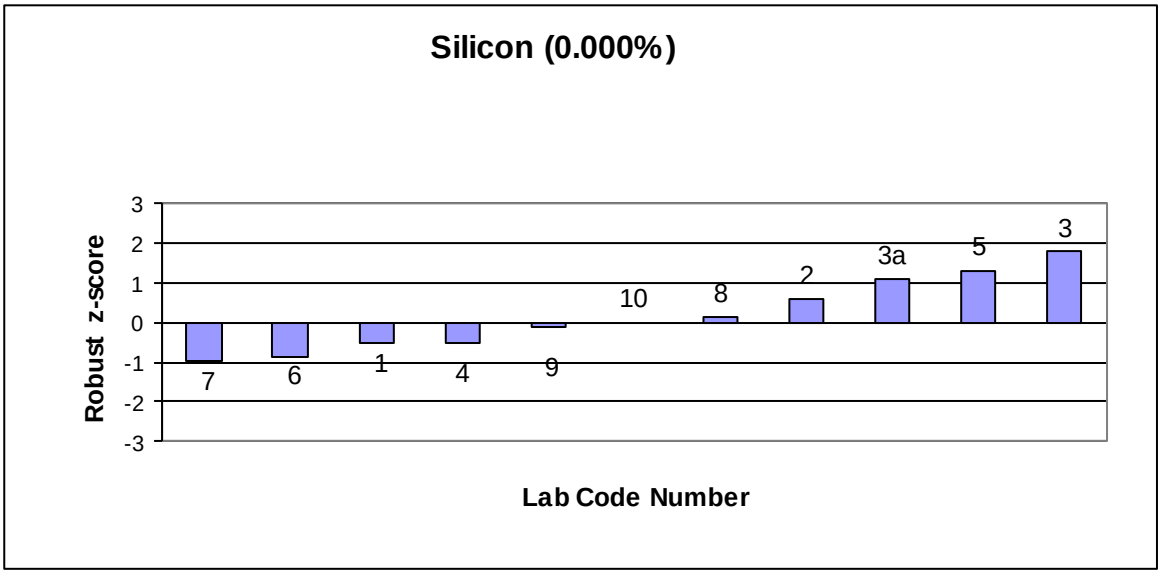
Silicon (0.000%)

Lab Code	Result 1	Result 2	Average	MU	Robust Z-score	Technique
1	0.25	0.25	0.2500	0.02	-0.51	1
2	0.263	0.263	0.2630	0.005	0.59	1
3	0.278	0.276	0.2770	nr	1.77	1
3a	0.269	0.269	0.2690	nr	1.10	1
4	0.249	0.251	0.2500	0.01	-0.51	5
5	0.271	0.272	0.2715	0.0205	1.31	1
6	0.244	0.247	0.2455	0.005	-0.89	1
7	0.244	0.245	0.2445	0.015	-0.97	1
8	0.258	0.257	0.2575	0.0156	0.13	1
9	0.258	0.251	0.2545	0.005	-0.13	1
10	0.255	0.257	0.2560	0.014	0.00	1

nr = not reported

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
5 Photometric

No. of Results	11
Median	0.2560
Norm IQR	0.0119
Uncertainity of the Median	0.0045
Robust CV	4.6%
Min	0.245
Max	0.277
Range	0.033



Copper (0.000%)

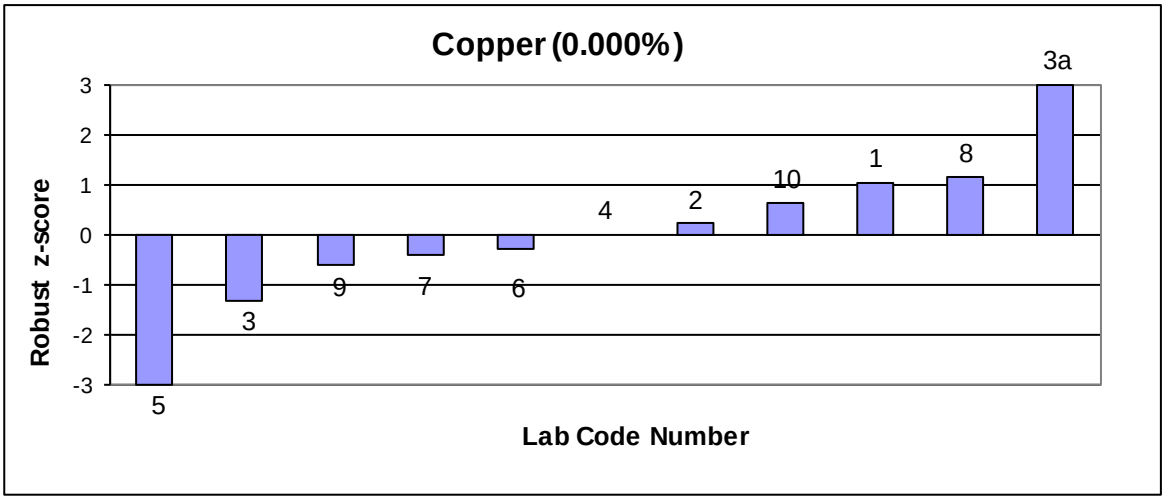
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.11	0.11	0.1100	0.002	1.04		1
2	0.105	0.107	0.1060	0.003	0.21		1
3	0.095	0.102	0.0985	nr	-1.35		1
3a	0.131	0.130	0.1305	nr	5.29	§	1
4	0.104	0.106	0.1050	0.005	0.00		3
5	0.086	0.088	0.0870	0.0096	-3.74	§	1
6	0.101	0.106	0.1035	0.005	-0.31		1
7	0.103	0.103	0.1030	0.010	-0.42		1
8	0.111	0.110	0.1105	0.0072	1.14		1
9	0.102	0.102	0.1020	0.0004	-0.62		1
10	0.108	0.108	0.1080	0.006	0.62		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
3 AAS (Atomic Absorption Spectrometry)

No. of Results	11
Median	0.1050
Norm IQR	0.0048
Uncertainity of the Median	0.0018
Robust CV	4.6%
Min	0.087
Max	0.131
Range	0.044



Nickel (0.000%)

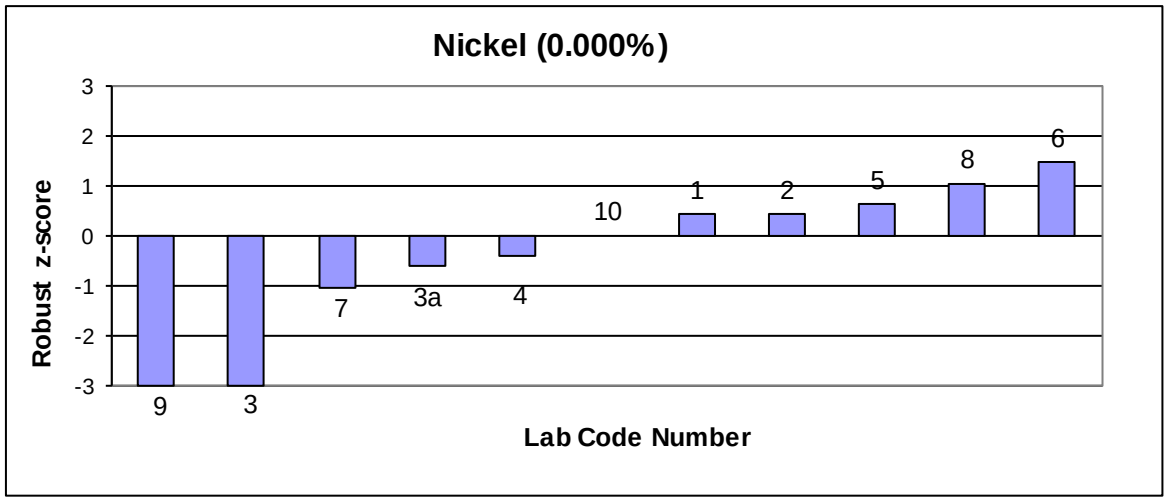
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.053	0.052	0.0525	0.011	0.42		1
2	0.053	0.052	0.0525	0.002	0.42		1
3	0.044	0.044	0.0440	nr	-3.11	§	1
3a	0.050	0.050	0.0500	nr	-0.62		1
4	0.050	0.051	0.0505	0.005	-0.42		3
5	0.053	0.053	0.0530	0.0026	0.62		1
6	0.057	0.053	0.0550	0.002	1.45		1
7	0.049	0.049	0.0490	0.007	-1.04		1
8	0.054	0.054	0.0540	0.0188	1.04		1
9	0.0287	0.0286	0.0287	0.0006	-9.48	§	1
10	0.051	0.052	0.0515	0.007	0.00		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
3 AAS (Atomic Absorption Spectrometry)

No. of Results	11
Median	0.0515
Norm IQR	0.0024
Uncertainity of the Median	0.0009
Robust CV	4.7%
Min	0.029
Max	0.055
Range	0.026



Chromium (0.000%)

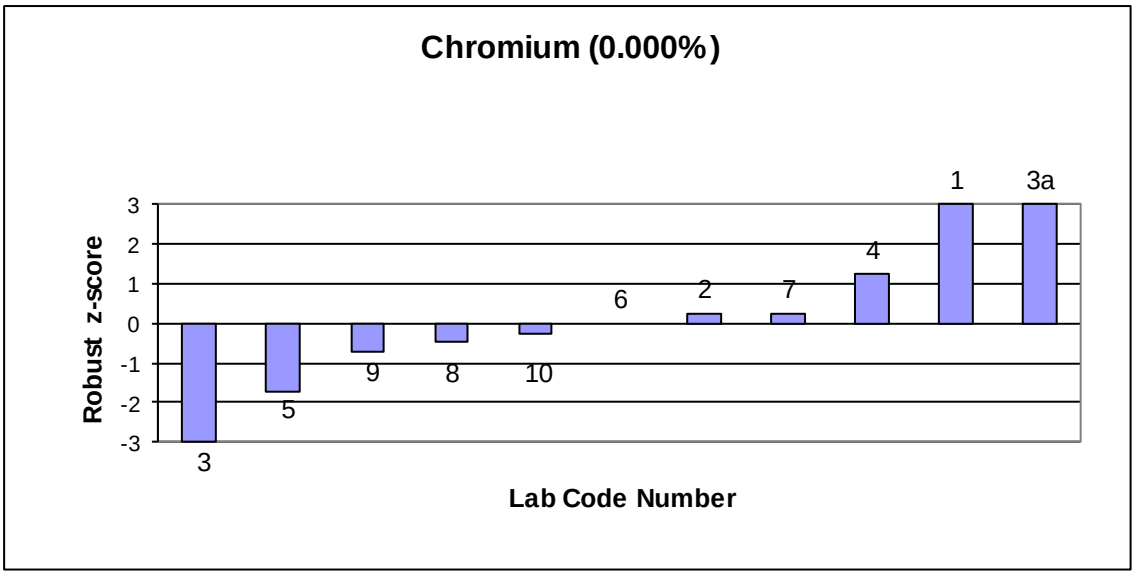
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.14	0.14	0.1400	0.004	3.92	§	1
2	0.132	0.133	0.1325	0.001	0.25		1
3	0.119	0.121	0.1200	nr	-5.89	§	1
3a	0.148	0.148	0.1480	nr	7.85	§	1
4	0.134	0.135	0.1345	0.005	1.23		3
5	0.128	0.129	0.1285	0.0107	-1.72		1
6	0.131	0.133	0.1320	0.002	0.00		1
7	0.132	0.133	0.1325	0.011	0.25		1
8	0.131	0.131	0.1310	0.0096	-0.49		1
9	0.131	0.13	0.1305	0.003	-0.74		1
10	0.132	0.131	0.1315	0.011	-0.25		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
3 AAS (Atomic Absorption Spectrometry)

No. of Results	11
Median	0.1320
Norm IQR	0.0020
Uncertainity of the Median	0.0008
Robust CV	1.5%
Min	0.120
Max	0.148
Range	0.028



Molybdenum (0.000%)

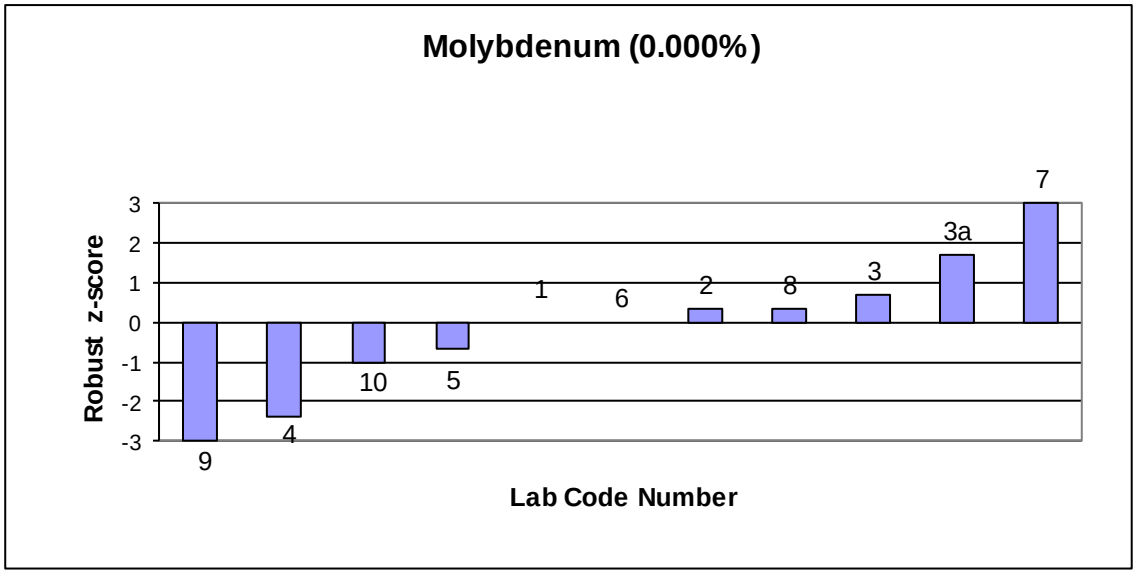
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.020	0.019	0.0195	0.005	0.00		1
2	0.020	0.020	0.0200	0.001	0.34		1
3	0.020	0.021	0.0205	nr	0.67		1
3a	0.022	0.022	0.0220	nr	1.69		1
4	0.016	0.016	0.0160	0.005	-2.36		3
5	0.018	0.019	0.0185	0.001	-0.67		1
6	0.018	0.021	0.0195	0.002	0.00		1
7	0.030	0.030	0.0300	0.005	7.08	§	1
8	0.020	0.020	0.0200	0.0060	0.34		1
9	0.0125	0.0123	0.0124	0.0004	-4.79	§	1
10	0.018	0.018	0.0180	0.007	-1.01		1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)
3 AAS (Atomic Absorption Spectrometry)

No. of Results	11
Median	0.0195
Norm IQR	0.0015
Uncertainity of the Median	0.0006
Robust CV	7.6%
Min	0.012
Max	0.030
Range	0.018



Cobalt (0.000%)

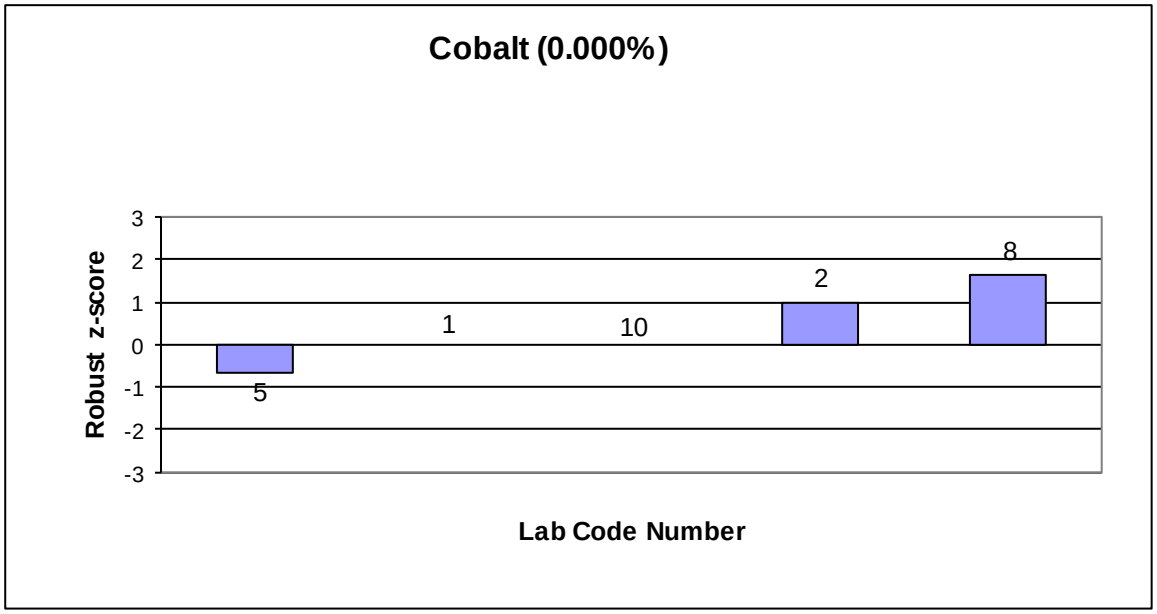
Lab Code	Result 1	Result 2	Average	MU	Robust Z-score	Technique
1	0.004	0.003	0.0035	nr	0.00	1
2	0.005	0.005	0.0050	0.001	0.99	1
5	0.003	0.002	0.0025	0.003	-0.66	1
8	0.006	0.006	0.0060	0.0068	1.65	1
10	0.004	0.003	0.0035	0.002	0.00	1

nr = not reported

§ = an outlier result i.e |z-score| ≥ 3.0

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)

No. of Results	5
Median	0.0035
Norm IQR	0.0015
Uncertainity of the Median	0.0008
Robust CV	43.3%
Min	0.003
Max	0.005
Range	0.003

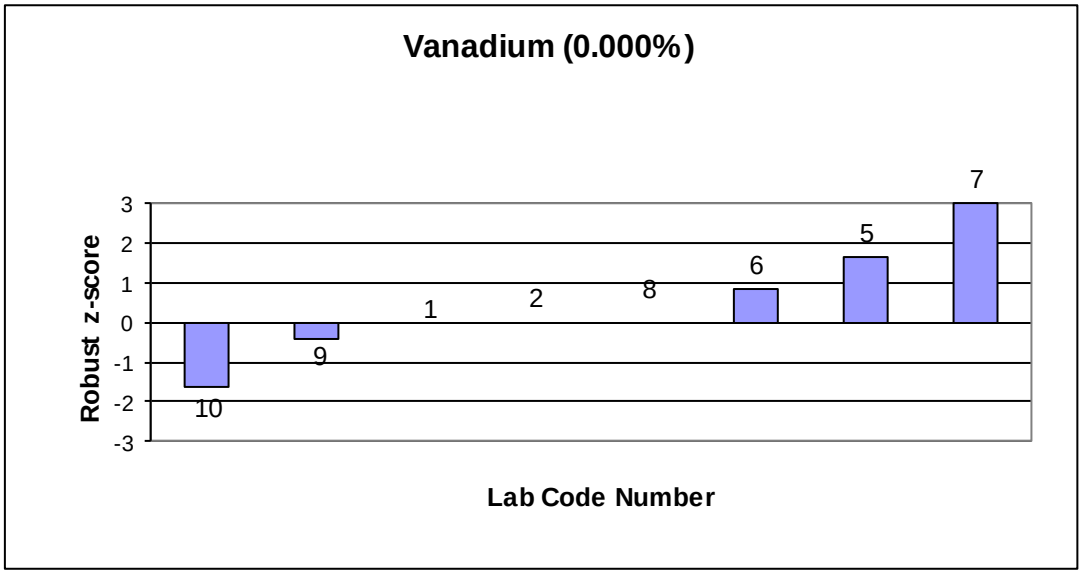


Vanadium (0.000%)

Lab Code	Result 1	Result 2	Average	MU	Robust Z-score		Technique
1	0.002	0.002	0.0020	0.0005	0.00		1
2	0.002	0.002	0.0020	0.001	0.00		1
5	0.003	0.003	0.0030	0.002	1.65		1
6	0.003	0.002	0.0025	0.002	0.83		1
7	0.004	0.004	0.0040	0.002	3.30	§	1
8	0.002	0.002	0.0020	0.0006	0.00		1
9	0.0017	0.0018	0.0018	0.0021	-0.41		1
10	0.001	0.001	0.0010	0.002	-1.65		1

Technique: 1 AES - Arc/spark (Atomic Emission Spectroscopy - Arc/Spark)

No. of Results	8
Median	0.0020
Norm IQR	0.0006
Uncertainity of the Median	0.0003
Robust CV	30.3%
Min	0.001
Max	0.004
Range	0.003



APPENDIX B

Homogeneity and Stability Testing

Sample Preparation and Homogeneity

The low alloy steel samples were supplied by Universal Scientific Laboratory Pty Ltd.

Eight discs were selected and tested for each element and the results are shown in the following tables:

Sample	Carbon	Sulphur	Phosphorus	Silicon	Manganese
1	0.4614	0.0158	0.0112	0.250	0.803
2	0.4532	0.0159	0.0121	0.253	0.810
3	0.4638	0.0162	0.0107	0.250	0.812
4	0.4573	0.0166	0.0111	0.250	0.804
5	0.4538	0.0160	0.0108	0.246	0.806
6	0.4548	0.0163	0.0118	0.254	0.816
7	0.4535	0.0162	0.0114	0.249	0.808
8	0.4587	0.0165	0.0109	0.249	0.791
Average	0.457	0.016	0.011	0.250	0.806
SD	0.004	0.000	0.000	0.002	0.01
CV	0.92%	1.72%	4.16%	0.52%	0.62%

Sample	Chromium	Nickel	Copper	Molybdenum
1	0.133	0.051	0.104	0.017
2	0.133	0.050	0.104	0.016
3	0.134	0.051	0.104	0.016
4	0.133	0.050	0.103	0.016
5	0.134	0.050	0.104	0.016
6	0.135	0.051	0.104	0.016
7	0.135	0.051	0.104	0.016
8	0.134	0.050	0.104	0.016
Average	0.134	0.050	0.104	0.016
SD	0.001	0.000	0.000	0.000
CV	0.69%	1.47%	0.00%	0.00%

Analysis of this data indicated that the samples were sufficiently homogeneous and, therefore, any results later identified as outliers could not be attributed to sample variability.

Stability Testing

Due to the nature of the samples it was not considered necessary to perform stability testing.

.

APPENDIX C

Documentation

Proficiency Testing Australia

Proficiency Testing Program

Metal Alloys (Round 36) – May 2019

INSTRUCTIONS TO PARTICIPANTS

Please read instructions carefully **BEFORE** commencing testing.

1. For this round each participant will be supplied with one metal disc.

2. Participants are asked to test the percentage composition (in duplicate) for each sample for the following elements:

   Carbon, Manganese, Phosphorus, Sulfur, Silicon, Copper, Nickel, Chromium, Molybdenum, Cobalt and Vanadium.

   If the analysis of any element is not possible, please note this on the results sheet.
   Please be advised that the initial measurement recorded is to be noted as "Result 1" and the following measurement is to be recorded as "Result 2" on the results sheet.

3. These tests are to be conducted by the methods used routinely in your laboratory. The sample should be treated as a routine sample.

4. Results are to be reported as a % to three decimal places. **Do <u>not</u> report any values as "<"**. The method used for each test should also be noted.

5. For each test note the appropriate technique code no. on the Results Sheet:

   1. AES – Arc/Spark (Atomic Emission Spectroscopy – Arc\Spark)
   2. AES – ICP (Atomic Emission spectroscopy – Inductively Coupled Plasma)
   3. AAS (Atomic Absorption Spectrometry)
   4. Gravimetric
   5. Photometric
   6. Other (please specify)

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

7. Testing may commence as soon as samples are received. All laboratories are asked to return their results by **Friday 31st May 2019** to:

   Karen Cividin
   Proficiency Testing Australia
   PO Box 7507
   Silverwater NSW 2128
   AUSTRALIA
   <u>Phone</u>: +61 2 9736 8295 <u>Fax:</u> +61 2 9743 6664

8. To allow for the confidential treatment of your results in the final report, you have been allocated a code number which appears on your results sheet.

C2

Proficiency Testing Australia

Proficiency Testing Program

Metal Alloys (Round 36) – May 2019

RESULTS SHEET

Date sample was received: _____ **Lab Code:**

TEST (report % to three decimal places)	**SAMPLE**		MU (±)	Technique Code No.
	Result 1	**Result 2**		
Carbon				
Sulfur				
Phosphorus				
Silicon				
Manganese				
Chromium				
Nickel				
Copper				
Molybdenum				
Vanadium				
Cobalt				

Signed: _____ **Date:** _____

*Please return no later than **Friday 31st May 2019**, to:*

Karen Cividin, Proficiency Testing Australia
PO Box 7507, Silverwater NSW 2128
phone: +61 2 9736 8295, fax: +61 9743 6664

- End of Report -