

**METAL ALLOYS  
(ROUND 15)  
FERROUS ALLOYS**

**PROFICIENCY TESTING PROGRAM**

**January 2006**

**REPORT NO. 499**

**ACKNOWLEDGMENTS**

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## **1. FOREWORD**

This report summarises the results for the fifteenth round of a proficiency testing program on the chemical analysis of metal alloys. This round covered a series of chemical tests on ferrous alloys.

The program was conducted by Proficiency Testing Australia, the former Proficiency Testing Group of the National Association of Testing Authorities, Australia. The aim of the program was to assess laboratories' ability to competently perform the tests examined.

## **2. FEATURES OF THE PROGRAM**

- 2.1 A total of 22 laboratories participated in the program comprising 21 Australian laboratories and 1 from Pakistan.
- 2.2 Participating laboratories were supplied one low alloy steel disc sample 14mm thick x 38~44mm diameter.
- 2.3 The following tests were performed on the sample in duplicate:
  - Aluminium
  - Carbon
  - Copper
  - Chromium
  - Calcium
  - Manganese
  - Molybdenum
  - Nitrogen
  - Nickel
  - Phosphorus
  - Sulfur
  - Silicon
  - Tin
  - Niobium
- 2.4 Prior to distribution, the samples were analysed for homogeneity. Based on the results of this preliminary testing it was concluded that the samples were sufficiently homogeneous, therefore any results later identified as outliers could not be attributed to any significant sample variability. (Appendix B)
- 2.5 Laboratories were requested to perform the tests according to their copies of the "Instructions to Participants" and to record their results on the accompanying "Results Sheet", both of which were distributed to participants with the sample. (Appendix C)
- 2.6 Each laboratory was randomly allocated a code number for the program to allow for the confidential treatment of results. Reference to any laboratory in this report is made by its code number.

### 3. **FORMAT OF APPENDICES**

APPENDIX A contains:

- (a) The duplicate results reported by laboratories for each test and the calculated robust z-score
- (b) A table of robust statistics for each test – number of results, median, normalised IQR, robust CV, minimum, maximum and range.
- (c) A z-score chart calculated for the robust z-scores for each test.

APPENDIX B contains details of sample preparation and homogeneity testing data.

APPENDIX C contains a copy of the “Instructions to Participants” and the “Results Sheet”, as supplied to participants.

### 4. **OUTLIER RESULTS AND SUMMARY STATISTICS**

To achieve the program's aim of assessing laboratories' testing performance, a robust statistical approach has been utilised to generate the z-scores and summary statistics for the sample to assess participants' performance - number of results, median, normalised interquartile range, minimum, maximum and range,.

The z-score is a measure of how far the results are from the consensus value - a normalised value which gives a "score" to each result relative to the other results in the group.

$$\text{Robust Z-Score} = (\text{Laboratory Average} - \text{Median}) / \text{Normalised IQR}$$

Therefore a z-score close to zero means that the result agrees well with those from other laboratories.

The Median is the middle result, and it is a measure of the centre of the data. The Normalised IQR is a measure of the spread of the results, and it is calculated by multiplying the interquartile range (IQR) by a factor (0.7413) which relates it to the 'normal' distribution.

The summary of results was initially circulated to participants after the return of all results, to provide them with 'early information' about the results for the program.

Table A Summary Statistics provided the summary of results on page 3.

An outlier is any result with an absolute z-score value greater than three and is marked by the symbol §.

Table B Outlier Results summarises the outliers detected on page 4. Each determination was examined for outliers with all methods pooled.

**TABLE A: SUMMARY STATISTICS**

TEST (report to %)	Number of Results	Median	Normalised IQR
Aluminium (3 d.p.)	22	0.0280	0.0018
Carbon (3 d.p.)	22	0.2023	0.0062
Copper (3 d.p.)	21	0.1220	0.0033
Chromium (3 d.p.)	20	0.4895	0.0091
Calcium (4 d.p.)	6	0.00068	0.00025
Manganese (3 d.p.)	21	0.8080	0.0148
Molybdenum (3 d.p.)	20	0.1743	0.0070
Nitrogen (4 d.p.)	8	0.00740	0.00068
Nickel (3 d.p.)	20	0.4448	0.0077
Phosphorus (3 d.p.)	22	0.0133	0.0014
Sulfur (3 d.p.)	22	0.0268	0.0015
Silicon (3 d.p.)	21	0.2280	0.0089
Tin ( 3 d.p.)	12	0.0065	0.0015
Niobium (3 d.p.)	15	0.0015	0.0011

**TABLE B: OUTLIER RESULTS**

(by laboratory code number)

Test	Based on Robust Z-Score
Aluminium	4, 22
Carbon	-
Copper	5, 14, 19, 21, 22
Chromium	-
Calcium	-
Manganese	22
Molybdenum	-
Nitrogen	5
Nickel	1
Phosphorus	-
Sulfur	22
Silicon	-
Tin	-
Niobium	5

**5. PTA & TECHNICAL ADVISER'S COMMENTS**

The median results for all elements indicate close alignment to the certified values. Variation within laboratories is acceptable.

It is noted that the variation between laboratories is excessive for a number of elements. Overall however, the results achieved for this round were good. The coefficient of variation (CV) was low (<6%) for all elements except Aluminium, Calcium, Nitrogen, Tin, Phosphorus and Niobium.

Of the 22 laboratories who participated in this program, 7 laboratories reported outlier results. Of the 252 results returned, 12, i.e. 4.76% of the results, were identified as outliers. This is slightly better than the previous NATA program testing ferrous alloys (PTAC Report No. 323 – June 2000) where 7.79 % of results were identified as outliers.

There were no outliers reported for Carbon, Calcium, Chromium, Molybdenum, Phosphorus, Silicon and Tin.

One outlier was reported for each of Manganese (Lab code 22), Nitrogen (Lab code 5), Nickel (Lab code 1), Sulfur (Lab code 22) and Niobium (Lab code 5). Niobium in this standard is a residual element and at a concentration perhaps below the limit of detection of some instruments.

Two outliers were reported for Aluminium (Lab codes 4 & 22). Aluminium can sometimes be affected by the alumina grinding medium.

Five outliers were reported for Copper (Lab codes 5, 14, 19, 21 & 22). Without knowing which analytical line was used it is difficult to put forward a reason for the spread of results. However, four of the outlier results are very close which could relate to a different analytical line being used on these spectrometers.

In any case, laboratories reporting outlier results by the AES technique should review their selection of calibration standards for the concentration of the element concerned and investigate any potential interferences.

The sample disc used in this proficiency testing program could possibly be used as a reference sample for future analysis of this alloy type and/or to test any corrective action that may have to be undertaken.

## 6. **STATISTICAL FORMAT**

For each test, the following information is given:

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

### (a) **Table of Results and Z-Scores**

Each of these tables contains the results returned by each laboratory, including the code number for the method used, and the laboratory z-scores calculated for based on each laboratory's averaged results.

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

Outliers are identified in the table by a marker (§) next to the relevant z-score.

Please see reference [1] for details on how these z-scores are calculated.

### (b) **Summary Statistics**

The list of summary statistics appears at the bottom of the table of results and consists of:

- (i) the number of results for that test/sample (*No. of Results*);

- (ii) the median of laboratory's results - i.e. the middle value (*Median*);
- (iii) the normalised interquartile range of the results (*Normalised IQR*) - the interquartile range times 0.7413;
- (iv) the robust coefficient of variation, expressed as a percentage (*Robust CV*) - i.e.  $100 \times \text{Normalised IQR} / \text{Median}$ ;
- (v) the minimum and maximum laboratory results; and
- (vi) the range (*Maximum - Minimum*).

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

(c) Ordered Z-Score Charts

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

The y-axis of these charts has been limited to between +3 and -3. The outliers are clearly identifiable as the laboratories whose "bar" extends beyond these "cutoff" lines.

## 7. REFERENCE

[1] "Guide to NATA Proficiency Testing" – February 2004 (this document is located on the NATA website at [www.nata.asn.au](http://www.nata.asn.au) under "Publications – Proficiency Testing).



# **APPENDIX A**

## **All Results**

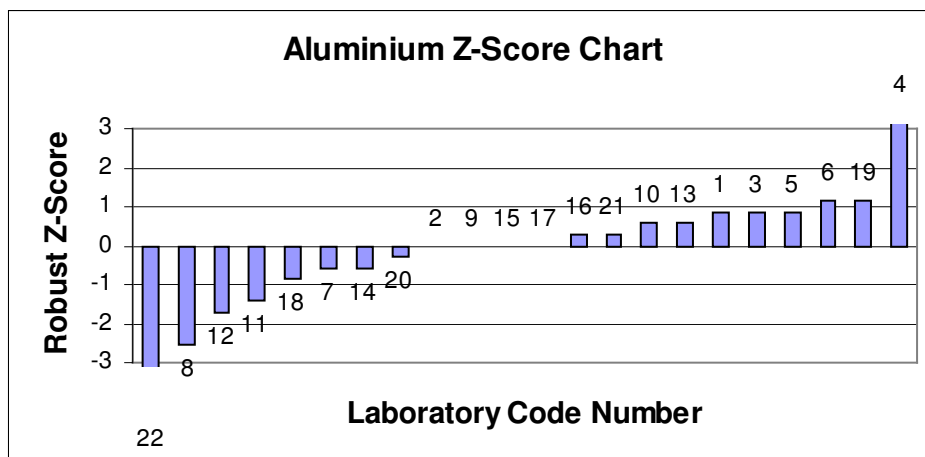
### **Summary Statistics**

### **Z-Score Charts**

**Aluminium (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.027	0.032	0.030	0.01	0.85	1
2	0.028	0.028	0.028	0.0005	0.00	1
3	0.030	0.029	0.030	0.001	0.85	1
4	0.035	0.033	0.034	0.009	3.40 §	1
5	0.027	0.032	0.030	0.007	0.85	1
6	0.030	0.030	0.030	0.009	1.14	1
7	0.027	0.027	0.027	0.001	-0.57	1
8	0.023	0.024	0.024	0.0015	-2.56	1
9	0.028	0.028	0.028	0.001	0.00	1
10	0.029	0.029	0.029	0.003	0.57	1
11	0.026	0.025	0.026	0.004	-1.42	1
12	0.025	0.025	0.025	0.0025	-1.70	1
13	0.029	0.029	0.029	0.004	0.57	1
14	0.027	0.027	0.027	0	-0.57	1
15	0.028	0.028	0.028	0.003	0.00	1
16	0.028	0.029	0.029	0.004	0.28	1
17	0.028	0.028	0.028	+0.011 -0.013	0.00	1
18	0.026	0.027	0.027	0.005	-0.85	1
19	0.031	0.029	0.030	0.003	1.14	1
20	0.028	0.027	0.028	0.002	-0.28	1
21	0.029	0.028	0.029	0.003	0.28	1
22	0.016	0.016	0.016	-	-6.81 §	1

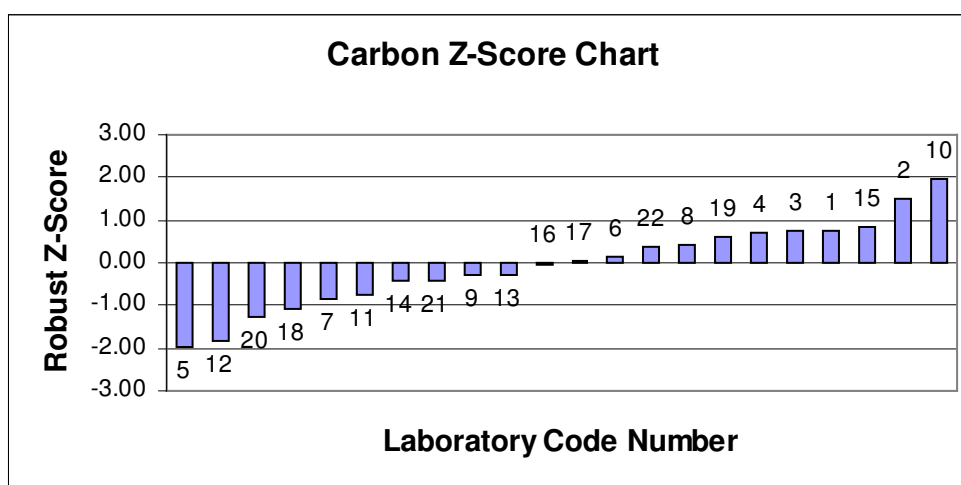
No. of Results	22
Median	0.0280
Norm IQR	0.0018
CV	6.29%
Min	0.016
Max	0.034
Range	0.018



**Carbon (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.203	0.211	0.207	0.05	0.77	1
2	0.213	0.210	0.212	0.0008	1.49	1
3	0.206	0.208	0.207	0.006	0.77	1
4	0.207	0.206	0.207	0.008	0.68	1
5	0.190	0.190	0.190	0.020	-1.97	1
6	0.204	0.202	0.203	0.021	0.12	1
7	0.196	0.198	0.197	0.008	-0.85	1
8	0.20	0.21	0.205	0.0157	0.44	1
9	0.201	0.200	0.201	0.006	-0.28	1
10	0.214	0.215	0.215	0.005	1.97	1
11	0.197	0.198	0.198	0.025	-0.77	1
12	0.189	0.193	0.191	0.0045	-1.81	1
13	0.197	0.204	0.201	0.009	-0.28	1
14	0.200	0.199	0.200	0.001	-0.44	1
15	0.209	0.206	0.208	0.0065	0.85	1
16	0.200	0.204	0.202	0.014	-0.04	1
17	0.203	0.202	0.203	+0.01 -0.03	0.04	1
18	0.196	0.195	0.196	0.01	-1.09	6
19	0.215	0.197	0.206	0.006	0.60	1
20	0.192	0.197	0.195	0.010	-1.25	1
21	0.200	0.199	0.200	0.013	-0.44	1
22	0.208	0.201	0.205	0.022	0.36	1

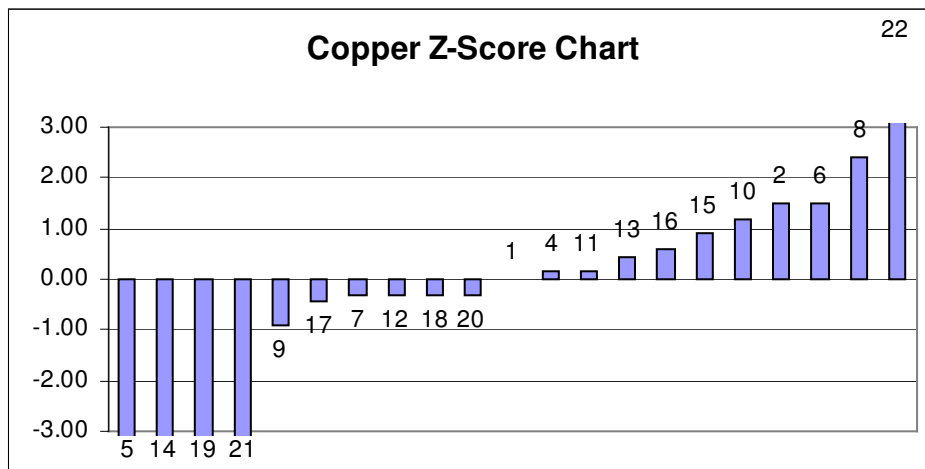
No. of Results	22
Median	0.2023
Norm IQR	0.0062
CV	3.07%
Min	0.190
Max	0.215
Range	0.025



**Copper (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.122	0.122	0.122	0.01	0.00	1
2	0.127	0.127	0.127	0.004	1.50	1
4	0.122	0.123	0.123	0.008	0.15	1
5	0.107	0.108	0.108	0.020	-4.35 §	1
6	0.128	0.126	0.127	0.010	1.50	1
7	0.121	0.121	0.121	0.004	-0.30	1
8	0.13	0.13	0.130	0.0000	2.40	1
9	0.119	0.119	0.119	0.003	-0.90	1
10	0.125	0.127	0.126	0.010	1.20	1
11	0.122	0.123	0.123	0.027	0.15	1
12	0.120	0.122	0.121	0.0028	-0.30	1
13	0.123	0.124	0.124	0.004	0.45	1
14	0.108	0.112	0.110	0.006	-3.59 §	1
15	0.125	0.125	0.125	0.004	0.90	1
16	0.124	0.124	0.124	0.009	0.60	1
17	0.121	0.120	0.121	+0.04 -0.04	-0.45	1
18	0.121	0.121	0.121	0.005	-0.30	3
19	0.104	0.116	0.110	0.009	-3.59 §	1
20	0.121	0.121	0.121	0.010	-0.30	1
21	0.107	0.115	0.111	0.017	-3.29 §	1
22	0.210	0.210	0.210	0.001	26.38 §	1

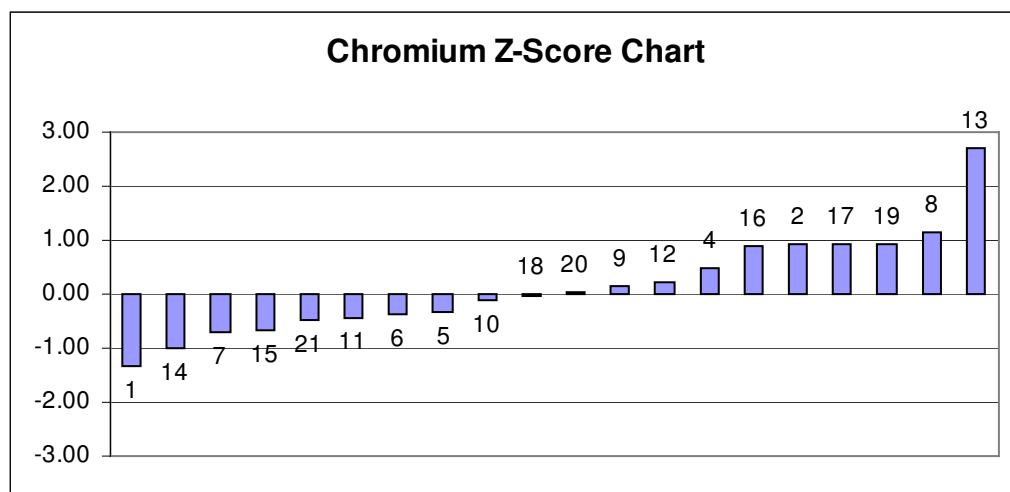
No. of Results	21
Median	0.1220
Norm IQR	0.0033
CV	2.73%
Min	0.108
Max	0.210
Range	0.103



**Chromium (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.477	0.478	0.478	0.05	-1.32	1
2	0.498	0.498	0.498	0.0008	0.94	1
4	0.493	0.495	0.494	0.002	0.50	1
5	0.485	0.488	0.487	0.020	-0.33	1
6	0.483	0.489	0.486	0.030	-0.39	1
7	0.483	0.483	0.483	0.012	-0.72	1
8	0.50	0.50	0.500	0.0076	1.16	1
9	0.491	0.491	0.491	0.006	0.17	1
10	0.488	0.489	0.489	0.026	-0.11	1
11	0.487	0.484	0.486	0.048	-0.44	1
12	0.492	0.491	0.492	0.0051	0.22	1
13	0.514	0.514	0.514	0.006	2.70	1
14	0.482	0.479	0.481	0.004	-0.99	1
15	0.485	0.482	0.484	0.014	-0.66	1
16	0.495	0.500	0.498	0.036	0.88	1
17	0.496	0.500	0.498	+0.12 -0.06	0.94	1
18	0.490	0.488	0.489	0.01	-0.06	3
19	0.501	0.495	0.498	0.004	0.94	1
20	0.489	0.491	0.490	0.010	0.06	1
21	0.489	0.481	0.485	0.014	-0.50	1

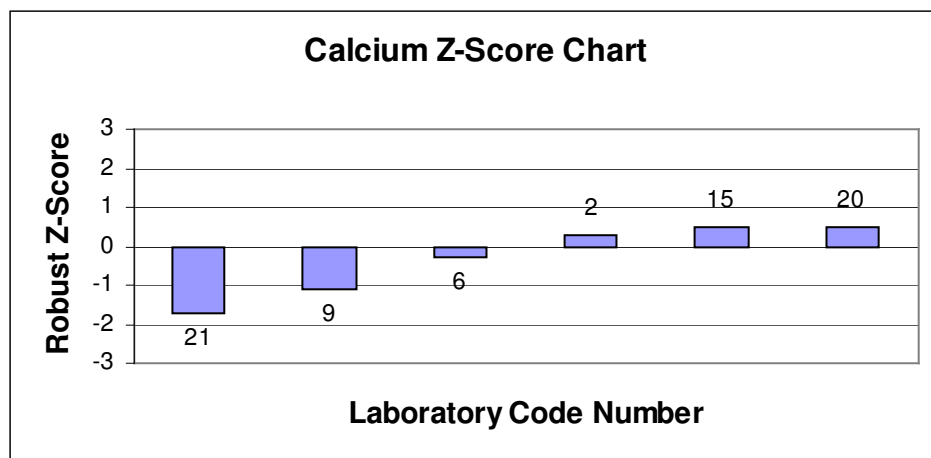
No. of Results	20
Median	0.4895
Norm IQR	0.0091
CV	1.86%
Min	0.478
Max	0.514
Range	0.037



**Calcium (0.0000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
2	0.0008	0.0007	0.0008	0.0001	0.30	1
6	0.0006	0.0006	0.0006	0.0004	-0.30	1
9	0.0004	0.0004	0.0004	0.0003	-1.10	1
15	0.0008	0.0008	0.0008		0.50	1
20	0.0010	0.0008	0.0009	0.0002	0.50	1
21	0.0003	0.0002	0.0003	0.0001	-1.70	1

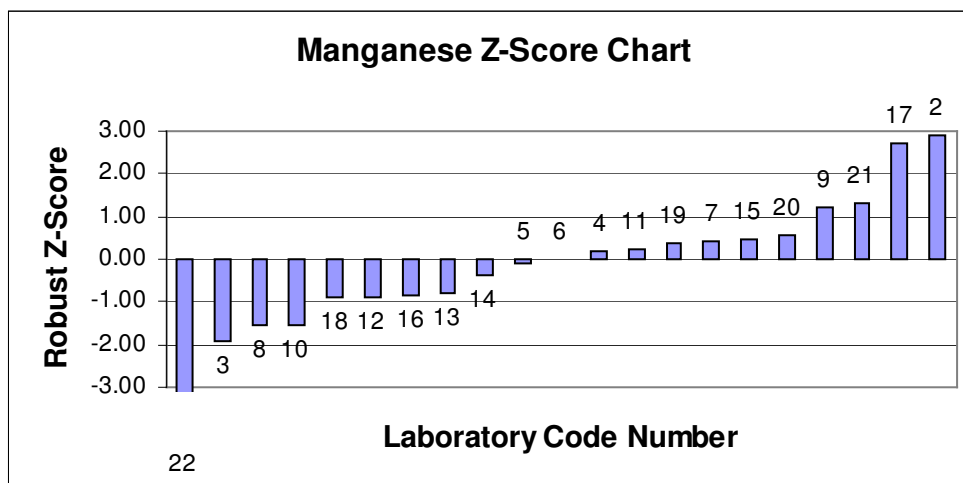
No. of Results	6
Median	0.00065
Norm IQR	0.00024
CV	37.07%
Min	0.0002
Max	0.0008
Range	0.0006



**Manganese (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
2	0.849	0.853	0.851	0.0014	2.90	1
3	0.781	0.778	0.780	0.010	-1.92	1
4	0.808	0.813	0.811	0.006	0.17	1
5	0.804	0.809	0.807	0.020	-0.10	1
6	0.810	0.806	0.808	0.036	0.00	1
7	0.813	0.815	0.814	0.021	0.40	1
8	0.78	0.79	0.785	0.0214	-1.55	1
9	0.830	0.822	0.826	0.008	1.21	1
10	0.785	0.785	0.785	0.020	-1.55	1
11	0.813	0.810	0.812	0.059	0.24	1
12	0.795	0.795	0.795	0.0105	-0.88	1
13	0.796	0.796	0.796	0.011	-0.81	1
14	0.803	0.802	0.803	0.001	-0.37	1
15	0.819	0.811	0.815	0.0137	0.47	1
16	0.788	0.803	0.796	0.057	-0.84	1
17	0.846	0.851	0.849	+0.06 -0.08	2.73	1
18	0.793	0.796	0.795	0.01	-0.91	3
19	0.826	0.801	0.814	0.028	0.37	1
20	0.815	0.817	0.816	0.015	0.54	1
21	0.826	0.829	0.828	0.016	1.32	1
22	0.729	0.709	0.719	0.02	-6.00 §	1

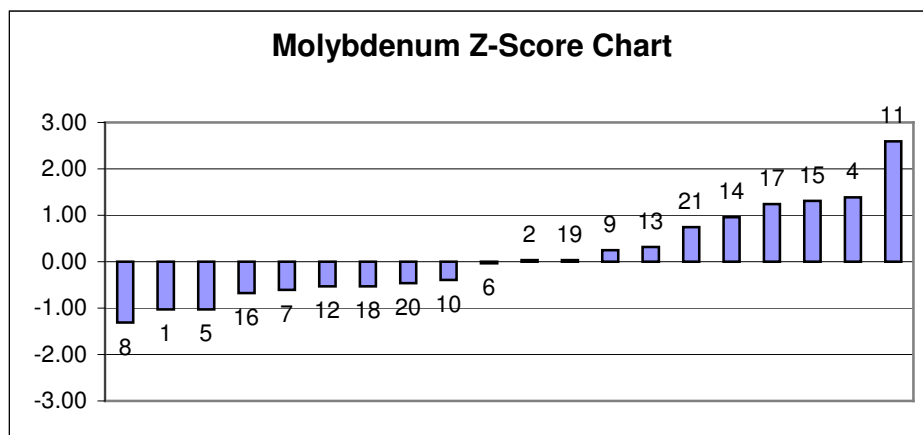
No. of Results	21
Median	0.8080
Norm IQR	0.0148
CV	1.83%
Min	0.719
Max	0.851
Range	0.132



**Molybdenum (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.167	0.167	0.167	0.01	-1.03	1
2	0.174	0.175	0.175	0.0004	0.04	1
4	0.184	0.184	0.184	0.014	1.38	1
5	0.167	0.167	0.167	0.020	-1.03	1
6	0.175	0.173	0.174	0.026	-0.04	1
7	0.170	0.170	0.170	0.004	-0.60	1
8	0.16	0.17	0.165	0.0000	-1.31	1
9	0.176	0.176	0.176	0.003	0.25	1
10	0.171	0.172	0.172	0.006	-0.39	1
11	0.193	0.192	0.193	0.034	2.59	1
12	0.170	0.171	0.171	0.0035	-0.53	1
13	0.176	0.177	0.177	0.005	0.32	1
14	0.182	0.180	0.181	0.003	0.96	1
15	0.188	0.179	0.184	0.005	1.31	1
16	0.169	0.170	0.170	0.012	-0.67	1
17	0.183	0.183	0.183	+0.07 -0.09	1.24	1
18	0.171	0.170	0.171	0.01	-0.53	3
19	0.179	0.170	0.175	0.003	0.04	1
20	0.171	0.171	0.171	0.010	-0.46	1
21	0.179	0.180	0.180	0.017	0.75	1

No. of Results	20
Median	0.1743
Norm IQR	0.0070
CV	4.04%
Min	0.165
Max	0.193
Range	0.028

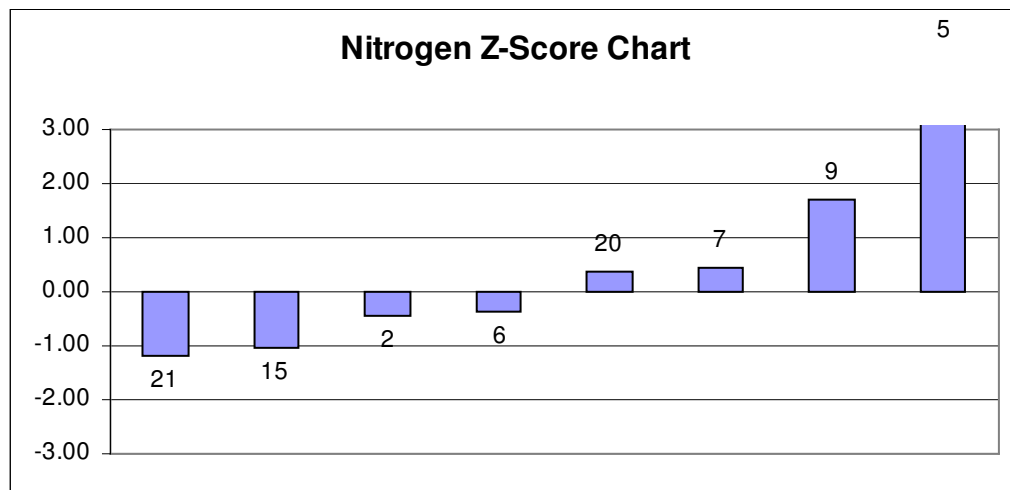




**Nitrogen (0.0000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
2	0.0074	0.0068	0.0071	0.0010	-0.44	1
5	0.0331	0.0333	0.0332	0.007	38.14 §	1
6	0.0070	0.0073	0.0072	0.003	-0.37	1
7	0.0076	0.0078	0.0077	0.0020	0.44	1
9	0.0077	0.0094	0.0086	0.003	1.70	1
15	0.0073	0.0061	0.0067	0.003	-1.03	1
20	0.0079	0.0074	0.0077	0.0006	0.37	1
21	0.0065	0.0067	0.0066	0.0009	-1.18	1

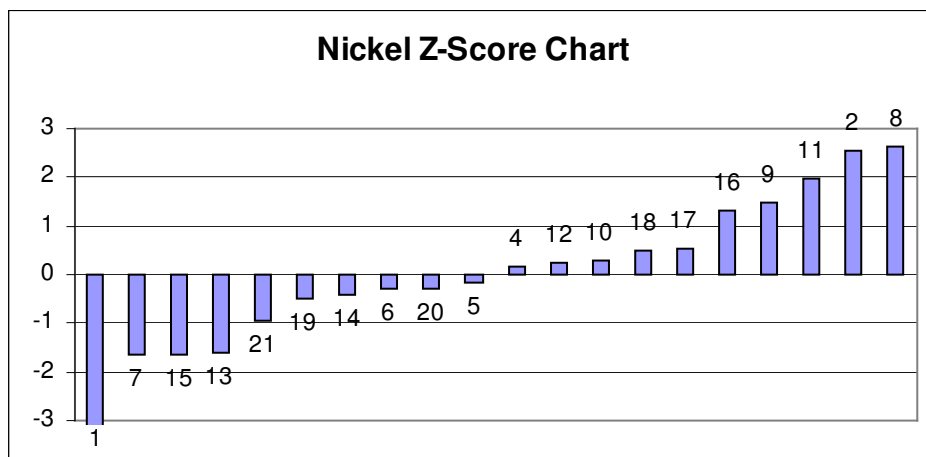
No. of Results	8
Median	0.00740
Norm IQR	0.00068
CV	9.14%
Min	0.0066
Max	0.0332
Range	0.0266



**Nickel (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.418	0.415	0.417	0.05	-3.67 §	1
2	0.464	0.465	0.465	0.0009	2.57	1
4	0.445	0.447	0.446	0.002	0.16	1
5	0.446	0.441	0.444	0.020	-0.16	1
6	0.442	0.443	0.443	0.046	-0.29	1
7	0.433	0.431	0.432	0.013	-1.66	1
8	0.46	0.47	0.465	0.0107	2.63	1
9	0.457	0.455	0.456	0.009	1.46	1
10	0.446	0.448	0.447	0.012	0.29	1
11	0.459	0.461	0.460	0.063	1.98	1
12	0.447	0.446	0.447	0.0034	0.23	1
13	0.432	0.433	0.433	0.007	-1.59	1
14	0.440	0.443	0.442	0.004	-0.42	1
15	0.430	0.434	0.432	0.007	-1.66	1
16	0.455	0.455	0.455	0.033	1.33	1
17	0.449	0.449	0.449	+0.015 -0.05	0.55	1
18	0.446	0.451	0.449	0.01	0.49	3
19	0.452	0.430	0.441	0.021	-0.49	1
20	0.443	0.442	0.443	0.010	-0.29	1
21	0.437	0.438	0.438	0.004	-0.94	1

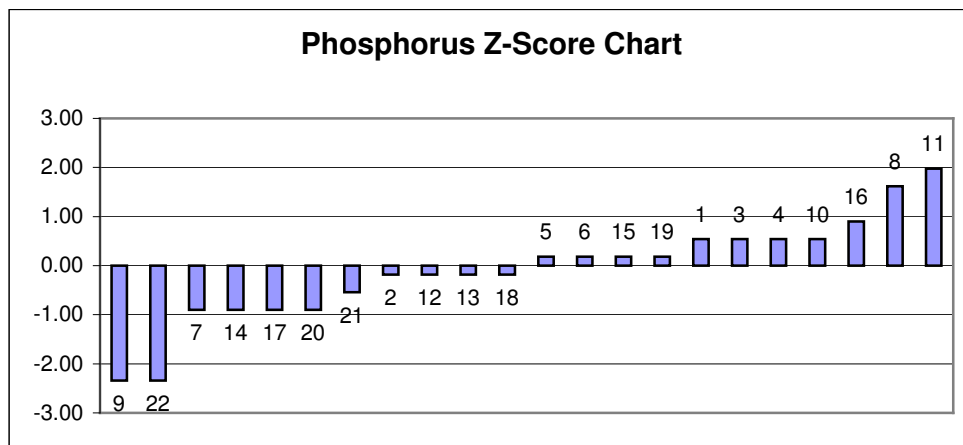
No. of Results	20
Median	0.4448
Norm IQR	0.0077
CV	1.73%
Min	0.417
Max	0.465
Range	0.049



**Phosphorus (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.014	0.014	0.014	0.01	0.54	1
2	0.013	0.013	0.013	0.0004	-0.18	1
3	0.014	0.014	0.014	0.001	0.54	1
4	0.014	0.014	0.014	0.002	0.54	1
5	0.014	0.013	0.014	0.007	0.18	1
6	0.013	0.014	0.014	0.003	0.18	1
7	0.012	0.012	0.012	0.002	-0.90	1
8	0.015	0.016	0.016	0.0010	1.62	1
9	0.010	0.010	0.010	0.001	-2.34	1
10	0.014	0.014	0.014	0.002	0.54	1
11	0.016	0.016	0.016	0.006	1.98	1
12	0.013	0.013	0.013	0.0015	-0.18	1
13	0.013	0.013	0.013	0.001	-0.18	1
14	0.012	0.012	0.012	0	-0.90	1
15	0.014	0.013	0.014	0.002	0.18	1
16	0.014	0.015	0.015	0.001	0.90	1
17	0.012	0.012	0.012	+0.0008 -0.008	-0.90	1
18	0.013	0.013	0.013	0.005	-0.18	5
19	0.015	0.012	0.014	0.002	0.18	1
20	0.012	0.012	0.012	0.001	-0.90	1
21	0.012	0.013	0.013	0.003	-0.54	1
22	0.010	0.010	0.010	0.01	-2.34	1

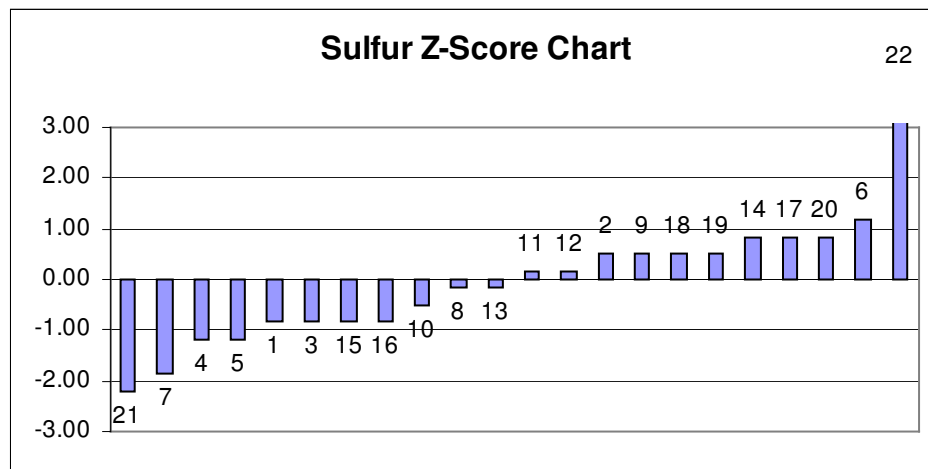
No. of Results	22
Median	0.0133
Norm IQR	0.0014
CV	10.49%
Min	0.010
Max	0.016
Range	0.006



**Sulfur (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.025	0.026	0.026	0.01	-0.84	1
2	0.027	0.028	0.028	0.0001	0.51	1
3	0.026	0.025	0.026	0.002	-0.84	1
4	0.025	0.025	0.025	0.002	-1.18	1
5	0.026	0.024	0.025	0.007	-1.18	1
6	0.029	0.028	0.029	0.005	1.18	1
7	0.024	0.024	0.024	0.003	-1.85	1
8	0.026	0.027	0.027	0.0022	-0.17	1
9	0.028	0.027	0.028	0.003	0.51	1
10	0.026	0.026	0.026	0.002	-0.51	1
11	0.026	0.028	0.027	0.008	0.17	1
12	0.027	0.027	0.027	0.0023	0.17	1
13	0.027	0.026	0.027	0.005	-0.17	1
14	0.029	0.027	0.028	0.003	0.84	1
15	0.027	0.024	0.026	0.0038	-0.84	1
16	0.026	0.025	0.026	0.002	-0.84	1
17	0.029	0.027	0.028	+0.012 -0.006	0.84	1
18	0.028	0.027	0.028	0.005	0.51	6
19	0.029	0.026	0.028	0.007	0.51	1
20	0.028	0.028	0.028	0.002	0.84	1
21	0.023	0.024	0.024	0.006	-2.19	1
22	0.033	0.032	0.033	0.01	3.87 §	1

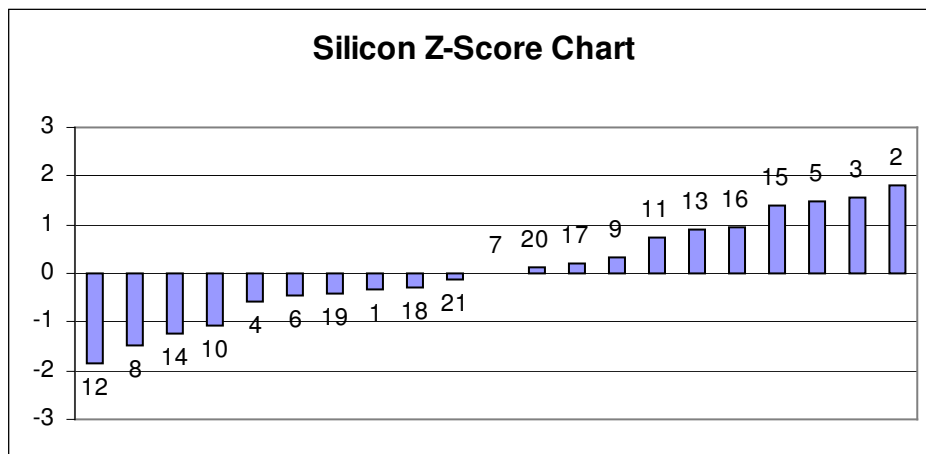
No. of Results	22
Median	0.0268
Norm IQR	0.0015
CV	5.54%
Min	0.024
Max	0.033
Range	0.009



**Silicon (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
1	0.226	0.224	0.225	0.05	-0.34	1
2	0.244	0.244	0.244	0.0015	1.80	1
3	0.243	0.241	0.242	0.004	1.57	1
4	0.225	0.221	0.223	0.005	-0.56	1
5	0.244	0.238	0.241	0.020	1.46	1
6	0.222	0.226	0.224	0.027	-0.45	1
7	0.229	0.227	0.228	0.007	0.00	1
8	0.21	0.22	0.215	0.0098	-1.46	1
9	0.231	0.231	0.231	0.006	0.34	1
10	0.218	0.219	0.219	0.008	-1.07	1
11	0.236	0.233	0.235	0.053	0.73	1
12	0.211	0.212	0.212	0.0041	-1.85	1
13	0.236	0.236	0.236	0.012	0.90	1
14	0.216	0.218	0.217	0.003	-1.24	1
15	0.239	0.242	0.241	0.004	1.41	1
16	0.233	0.240	0.237	0.017	0.96	1
17	0.230	0.230	0.230	+0.07 -0.05	0.22	1
18	0.224	0.227	0.226	0.01	-0.28	1
19	0.221	0.228	0.225	0.005	-0.39	1
20	0.229	0.229	0.229	0.020	0.11	1
21	0.227	0.227	0.227	0.007	-0.11	1

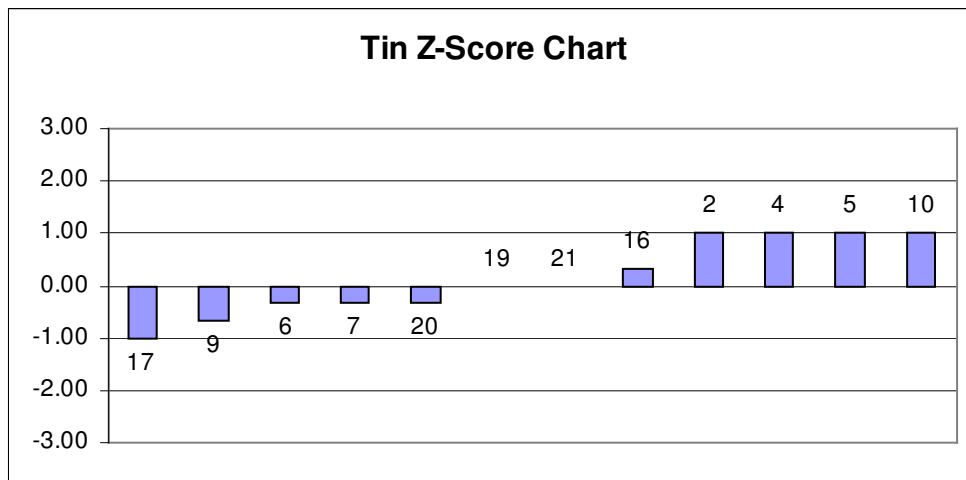
No. of Results	21
Median	0.2280
Norm IQR	0.0089
CV	3.90%
Min	0.212
Max	0.244
Range	0.033



**Tin (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
2	0.008	0.008	0.008	0.0000	1.01	1
4	0.008	0.008	0.008	0.002	1.01	1
5	0.009	0.007	0.008		1.01	1
6	0.006	0.006	0.006	0.007	-0.34	1
7	0.008	0.004	0.006	0.004	-0.34	1
9	0.005	0.006	0.006	0.002	-0.67	1
10	0.008	0.008	0.008	0.004	1.01	1
16	0.007	0.007	0.007	0.001	0.34	1
17	0.005	0.005	0.005	+0.01 -0.05	-1.01	1
19	0.006	0.007	0.007	0.002	0.00	1
20	0.006	0.006	0.006	0.001	-0.34	1
21	0.007	0.006	0.007	0.001	0.00	1

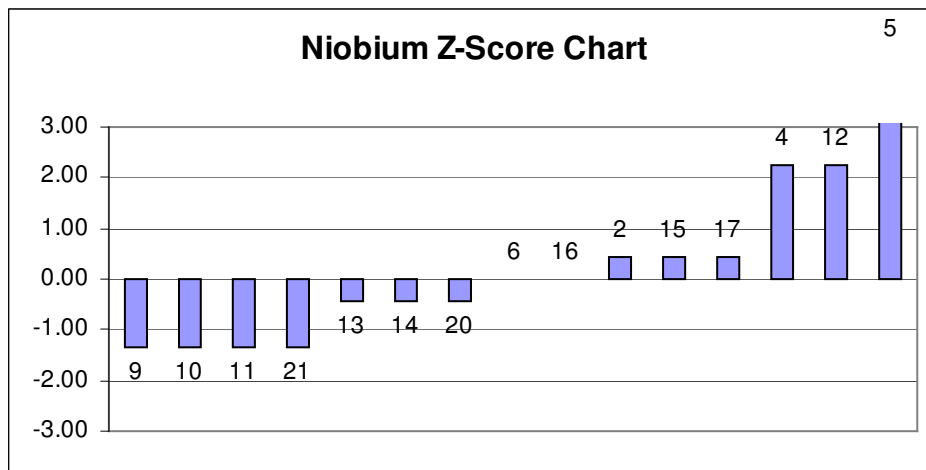
No. of Results	12
Median	0.0065
Norm IQR	0.0015
CV	22.81%
Min	0.005
Max	0.008
Range	0.003



**Niobium (0.000%)**

Lab Code	Result 1	Result 2	Average	MU	Robust Z-Score	Technique
2	0.002	0.002	0.002	0.0002	0.45	1
4	0.004	0.004	0.004	0.002	2.25	1
5	0.010	0.009	0.010	0.007	7.19 §	1
6	0.002	0.001	0.002	0.003	0.00	1
9	0.000	0.000	0.000	0.001	-1.35	1
10	0.000	0.000	0.000	0.000	-1.35	1
11	0.000	0.000	0.000	-	-1.35	1
12	0.004	0.004	0.004	0.0022	2.25	1
13	0.001	0.001	0.001	0.000	-0.45	1
14	0.001	0.001	0.001	0	-0.45	1
15	0.002	0.002	0.002	0.0002	0.45	1
16	0.001	0.002	0.002	0.0001	0.00	1
17	0.002	0.002	0.002	+0.008 -0.004	0.45	1
20	0.001	0.001	0.001	0.001	-0.45	1
21	0.000	0.000	0.000	0.001	-1.35	1

No. of Results	15
Median	0.0015
Norm IQR	0.0011
CV	74.13%
Min	0.000
Max	0.010
Range	0.010



# **APPENDIX B**

## **Homogeneity Testing**





HOMOGENEITY TESTING

15 samples were randomly selected and tested for 10 elements of interest under repeatability conditions (i.e. same operator, same method etc). The results are given below. Statistical Analysis indicate that there was no significant difference between the samples.

	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al
NATA 1	0.200	0.808	0.0143	0.0270	0.227	0.126	0.441	0.495	0.172	0.0276
NATA 3	0.199	0.807	0.0141	0.0268	0.226	0.125	0.443	0.494	0.173	0.0277
NATA 5	0.205	0.807	0.0139	0.0267	0.230	0.123	0.448	0.492	0.175	0.0279
NATA 6	0.199	0.805	0.0142	0.0263	0.227	0.121	0.443	0.497	0.173	0.0278
NATA 8	0.200	0.808	0.0140	0.0272	0.226	0.122	0.441	0.496	0.172	0.0274
NATA 9	0.203	0.808	0.0138	0.0261	0.228	0.122	0.444	0.495	0.173	0.0274
NATA 10	0.200	0.806	0.0141	0.0262	0.228	0.120	0.441	0.493	0.172	0.0276
NATA 15	0.201	0.808	0.0138	0.0266	0.229	0.123	0.444	0.494	0.173	0.0277
NATA 16	0.196	0.806	0.0143	0.0272	0.227	0.122	0.443	0.495	0.172	0.0276
NATA 17	0.202	0.806	0.0142	0.0265	0.228	0.122	0.446	0.495	0.172	0.0275
NATA 19	0.207	0.804	0.0141	0.0273	0.227	0.124	0.442	0.494	0.174	0.0281
NATA 20	0.203	0.813	0.0142	0.0274	0.231	0.124	0.449	0.494	0.172	0.0277
NATA 21	0.200	0.806	0.0138	0.0263	0.226	0.119	0.443	0.495	0.175	0.0280
NATA 22	0.199	0.808	0.0140	0.0265	0.228	0.124	0.444	0.496	0.174	0.0278
NATA 24	0.197	0.804	0.0140	0.0260	0.228	0.124	0.441	0.495	0.172	0.0274
mean	0.2007	0.8069	0.0141	0.0267	0.2277	0.1227	0.4435	0.4947	0.1720	0.0277
sd	0.0029	0.0022	0.0002	0.0005	0.0014	0.0019	0.0025	0.0012	0.0011	0.0002
cv	1.440%	0.271%	1.229%	1.721%	0.631%	1.523%	0.558%	0.250%	0.639%	0.775%

# **APPENDIX C**

## **Instructions to Participants**

**and**

## **Results Sheet**

**NATA PROFICIENCY TESTING PROGRAM**  
**METAL ALLOYS (ROUND 15) – FERROUS ALLOYS**  
**INSTRUCTIONS TO PARTICIPANTS**



To ensure that results from this program can be analysed properly, participants are asked to adhere carefully to the following instructions.

1. One ferrous alloy disc sample, marked “NATA”, has been supplied to each laboratory.
2. Test the percentage composition in duplicate on the sample for the following elements:

Aluminium, Carbon, Copper, Chromium, Calcium, Manganese, Molybdenum, Nitrogen, Nickel, Phosphorus, Sulfur, Silicon, Tin, and Niobium.

If the analysis of any element is not possible, please note this on the Results Sheet.

3. Participants are requested to perform all tests listed above for which NATA accreditation is held. Tests are to be performed by accredited test methods that would normally be used to test customer supplied samples. Participants are welcome to report results for any other tests for which NATA accreditation is not held.
4. Test for Nitrogen and Calcium are to be reported as % to four decimal places. The remaining elements are to be reported as a % to three decimal places. **Do not report any values as “<”.**
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  $k \approx 2$ ).
7. Testing may commence as soon as samples are received. All laboratories must return results and reports no later than **Friday 21 October 2005** to:

Dr Michael Li

National Association of Testing Authorities, Australia  
 7 Leeds St RHODES NSW 2138

Telephone: (02) 9736 8222  
 Fax: (02) 9743 5311 **or** (02) 9743 6664  
 Email: michael.li@nata.asn.au

**NATIONAL ASSOCIATION OF TESTING AUTHORITIES, AUSTRALIA**  
**METAL ALLOYS (ROUND 15) PROFICIENCY TESTING PROGRAM**



**- FERROUS ALLOYS -**

**Lab Code No**

**RESULTS SHEET**

TEST (report to %)	NATA Sample		MU ( $\pm$ )	Technique Code Number
	Result 1	Result 2		
Aluminium (3 d.p.)				
Carbon (3 d.p.)				
Copper (3 d.p.)				
Chromium (3 d.p.)				
Calcium (4 d.p.)				
Manganese (3 d.p.)				
Molybdenum (3 d.p.)				
Nitrogen (4 d.p.)				
Nickel (3 d.p.)				
Phosphorus (3 d.p.)				
Sulfur (3 d.p.)				
Silicon (3 d.p.)				
Tin ( 3 d.p.)				
Niobium (3 d.p.)				

Test Officer:

Signed:

Date: