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NPL NUCLEAR INDUSTRY PROFICIENCY TEST EXERCISE 2016

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NPL Nuclear Industry Proficiency Test Exercise 2016

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ABSTRACT

A sixth Nuclear Industry Proficiency Test Exercise has been run by NPL. One sample was prepared, consisting of a nominal 200 L drum loaded with plastic bottles (500 ml each), some containing ion exchange resin and some vermiculite. The 'resin bottles' were spiked with known weights of a standard solution of ^{241}Am, ^{60}Co and ^{137}Cs. The activity concentrations (averaged across the drum's contents) were approximately 8.3 Bq g^{-1}, 0.83 Bq g^{-1} and 1.0 Bq g^{-1} respectively. No activity was added to the 'vermiculite bottles'.

The participants were required to report the activity concentrations of the individual radionuclides. Information disclosed to the participants initially included the radionuclides present, activity concentration ranges, details of the empty drum (e.g. its mass and dimensions) and the percentage of each material type present. The drum was measured by 9 UK and 7 overseas laboratories. Approximately 37 % of the initial results were statistically 'in agreement' with the NPL value. The participants were then given the location of the activity within the drum and a subset of the participants submitted additional results, 65 % of which agreed with the NPL value. Results from the second round of reporting were mostly higher than those reported initially. This PTE points to possible issues with the assay of ^{241}Am and the use of Segmented Gamma Scanners for drummed waste.

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1 INTRODUCTION

The accurate measurement of radioactivity in potentially active waste materials generated in nuclear site decommissioning is essential for correct waste categorisation. This is important for public safety, to reduce the industry's costs and to minimise volumes of material being sent to the UK's LLW repository. The National Physical Laboratory (NPL) runs Nuclear Industry Proficiency Test Exercises ('drum comparisons') [Dean, 2007, 2010, 2012, 2013, 2015] to enable laboratories involved in the clearance and sentencing of bulk γ-emitting waste to test their measurement procedures. The exercises provide a check on the modelling techniques used for calculating detection efficiencies and enable participants to demonstrate measurement capability to third parties.

This report describes the sixth PTE in this series, covering:

- the preparation of the 'standard drum';
- the circulation of the drum and reporting of data;
- the reported results and data analysis.

2 PREPARATION OF STANDARD DRUM

The following materials were procured / prepared:

- Standardised radionuclide solutions of ^{241}Am, ^{60}Co and ^{137}Cs;
- 60 kg of ion-exchange resin;
- 5 kg of vermiculite
- 240 x 500 ml HDPE bottles;
- 1 x 200 L steel drum.

The activity concentrations of the individual radionuclide solutions had been previously determined by assay in a re-entrant secondary standard ionisation chamber. Each ampoule had also been measured using a γ-spectrometer to check for the presence of any γ-emitting impurities; none were detected. The solutions were combined and the concentrations in the mixed solution were determined gravimetrically and confirmed by γ-spectrometry. An additional solution of ^{241}Am was also prepared.

Ion-exchange resin (310 g nominal) was dispensed to each of 192 empty 500 ml bottles. The mixed radionuclide solution was dispensed to the bottles from a plastic pycnometer; the pycnometer was weighed throughout the dispensing sequence in such a way that the total mass of solution dispensed to each subset of 48 bottles was known. The separate ^{241}Am solution was then also dispensed to the resin bottles (the reason for this was that the mixed radionuclide solution had been used in a previous PTE and it was necessary to change the radionuclide ratios).

Vermiculite (50 g nominal) was dispensed to each of the remaining empty 500 ml bottles. No activity was added to these bottles.

The 'resin bottles' were loaded into the base of the empty drum (in 3 layers of 48). The 'vermiculite bottles' (2 layers of 48) were placed on top of the resin bottles and the drum lid was clamped on. The drum was certificated for the activity concentrations of each radionuclide present (see Table 1) and was designated as source X160216.

3 CIRCULATION OF DRUM AND REPORTING OF DATA

An initial mailshot was prepared (see Appendix A) and circulated to potential participants. The reporting deadlines in this mailshot were later revised to 2 December and 16 December (the reason for there being two deadlines is given below).

A Reporting Form (Appendix B) was sent to the participants along with the following details:

- The activity concentration range (1 - 10 Bq/g);
- Details of the empty drum from the manufacturer;
- The mass of the drum empty (18.1 kg nominal) and full (80.1 kg nominal);
- The percentage by mass of the drum's contents:
    - HDPE (20 % nominal)
    - Ion-exchange resin (74 % nominal)
    - Vermiculite (6 % nominal).

The participants were required to report their measurement results by the 'first deadline', after which NPL disclosed the location of the activity within the drum and invited the participants to submit additional data by a 'second deadline'. The two datasets were analysed separately as described below.

A listing of the participants is given in Appendix C.

4 RESULTS AND DATA ANALYSIS

To preserve anonymity, each participant was assigned a number, and their results were coded accordingly. Some of the laboratories had also participated in previous exercises and their numbers were changed for the current exercise.

On receipt of the results, NPL carried out data analyses using the method described below [Harms, 2009].

Firstly, the deviation from the assigned (NPL) value of each laboratory value was calculated, given by:

$$D = 100\frac{L-N}{N} = 100\left(\frac{L}{N}-1\right) \qquad [1]$$

where:

D = deviation from the NPL value (%)
L = the participant's value (Bq g^{-1})
N = the NPL value (Bq g^{-1})

The error bars in the graphs represent the standard uncertainty (k=1) of the deviation:

$$u_{\mathrm{D}} = 100\frac{L}{N}\sqrt{\left(\frac{u_{\mathrm{L}}}{L}\right)^2+\left(\frac{u_{\mathrm{N}}}{N}\right)^2} \qquad [2]$$

where:

u_{D} = standard uncertainty of the deviation (%)

u_L = standard uncertainty of the participant's value (Bq g^{-1})
u_N = standard uncertainty of the assigned value (Bq g^{-1})

The results were evaluated using three tests:

$$\zeta = \frac{L - N}{\sqrt{u_L^2 + u_N^2}} \quad [3]$$

$$R_L = \frac{u_L}{L} \quad [4]$$

$$z = \frac{L - N}{\sigma_p} = \frac{L - N}{0.05823\,N} \quad [5]$$

where:

ζ = zeta score
R_L = relative uncertainty of the participant's value
Z = z-score
σ_p = standard deviation for proficiency assessment

The standard deviation for proficiency assessment represents the level of performance that NPL would wish laboratories to be able to achieve. It corresponds to a deviation 'D' of 15% at the 99% confidence level.

The zeta and *z*-scores were used to determine whether the difference between the participant's value and the NPL value was significantly different from zero. An IQR (Inter-Quartile Range) outlier test was used to determine whether a particular R_L value was significantly larger than the other values in a data set; the IQR was used to calculate a limiting value of R_L, 'R_{lim}'.

Results for which the absolute values of the zeta score and the z-score were both ≤ 2.576 (corresponding to a significance levels of $\alpha = 0.01$) and for which the relative uncertainty R_L was not significantly larger than the other values in the data set were regarded as being 'in agreement' with NPL. These are marked in dark blue in the deviation plots. If either (i) the relative uncertainty R_L was significantly larger than the other values in the data set, (ii) the result passes the zeta test but not the z-test (i.e. large deviation from the NPL value combined with a large uncertainty), or (iii) the result passes the z-test but not the zeta test (small deviation from the NPL value combined with a small uncertainty), the participant's value is classified as 'questionable' (these are given in yellow in the deviation plots). If the absolute values of both the zeta score and the z-score are > 2.576, then the participant's value is classified as 'discrepant' from the NPL value (red points), regardless of the value of the relative uncertainty R_L.

The results of the participants' original measurements, along with the zeta scores, z-scores and outlier results, are given in Tables 2 - 4. The deviations and the outlier data are plotted in Figures 1 – 6 (the value 'R_{lim}' is denoted by a dotted line in Figures 2, 4 and 6).

The results of participants' additional measurements (i.e. after the first deadline and after the location of the activity had been disclosed) are given in Tables 5 – 7 and the deviations are plotted in Figures 7 – 9. Insufficient data were submitted to calculate 'R_{lim}' values for this dataset, so all results were deemed to have passed the outlier test.

5 DISCUSSION

Sixteen laboratories participated in the exercise. Fourteen reported results by the first deadline (of whom four submitted additional results after the first deadline). One laboratory submitted results only after the first deadline and one laboratory was unable to submit any results due to an equipment problem.

Of the participants who submitted results, fourteen used hyperpure Ge γ-spectrometers of various types and one used two NaI-based instruments, each consisting of three crystals (participant 12, results 12A and 12B). Participants 5, 10 and 14 used detectors with three Ge crystals and participants 5, 6 (results 6B, 6C and 6D), 9 (result 9B) and 11 used a Segmented Gamma Scanner (SGS) or carried out measurements of drum segments.

A range of efficiency modelling methods and software were used, including ISOCS/MCNP, ISOTOPIC, SNAP, NDA2000 and in-house methods. A range of detector calibration sources were cited, including the use of in-house 'drum standards' containing a variety of matrices.

Of the initial results (i.e. submitted by the first deadline), 37 % were 'in agreement' with the assigned value. The percentages in agreement by nuclide were ^{241}Am 43 %, ^{60}Co 52 % and ^{137}Cs 16 %. The results as a whole for ^{137}Cs showed a significant bias (relative to the assigned value) of -17 %.

For the second round of reporting, participants adjusted their efficiency models to take account of the true distribution of the activity within the drum. Of these results, 65 % were in agreement with NPL – however, perhaps more significantly, nineteen of the results were higher than in the first dataset and only one was lower (one being unchanged). This time, the ^{241}Am data had a significant positive bias (approximately + 35 %, if one outlying result is excluded) whereas the ^{60}Co and ^{137}Cs data exhibited biases of only + 2 % and - 1 % (with one outlying result excluded) respectively.

Although the radionuclide datasets (from the second round) were small and had large spreads, it is interesting to compare the biases with those observed for the same radionuclide datasets in the 2014 PTE (^{241}Am + 30 %, ^{60}Co + 7 % and ^{137}Cs + 4 %). In 2014, the activity had been uniformly distributed throughout the drum and measurement protocols took account of this. The similar bias for ^{241}Am compared with the 2016 PTE suggests a possible issue with the over-estimation of ^{241}Am activities in drummed wastes even when the model apparently takes account of the distribution of the activity within the sample volume. This may in turn have implications for the correct sentencing of plutonium wastes based on ^{241}Am measurements.

In previous exercises in this series [Dean, 2007, 2010, 2012, 2013, 2015], SGS measurements often produced low results. Although in the current exercise the SGS results were both low and high, only two such results out of the 18 submitted were in agreement with NPL, suggesting possible issues with this type of measurement protocol for waste in 200 L drums.

6 ACKNOWLEDGEMENTS

The author wishes to thank the participating organisations for the time and effort they have put into analysing the drum, and for the information provided. Also, thanks go to Daniel Ainsworth for organising the transport of the drum and to Peter Ivanov and Steven Judge for reviewing this report.

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8 TABLES

Table 1 - Principal radionuclides in X160216

Radionuclide	Decay mode	Activity concentration (averaged across contents of drum) @ 2016-06-01 1200 UTC• (Bq g^{-1})	Standard uncertainty (k=1) (Bq g^{-1})	Standard uncertainty (k=1) (%)
^{241}Am	α/γ	8.257	0.033	0.40
^{60}Co	β^-/γ	0.8272	0.0034	0.41
^{137}Cs	β^-, β^-/γ	1.0391	0.0075	0.72

• Universal Time, Co-ordinated. This replaced Greenwich Mean Time in 1972. Format of date isYYYY-MM-DD.

Table 2 - Reported results for ^{241}Am (first deadline)

NPL activity concentration = (8.257 ± 0.033) Bq g^{-1} (k=1) Reference time: 2016-06-01 1200 UTC

Participant code	Reported activity concentration (Bq/g)	Reported uncertainty (%)	Zeta score	Z score	D (%)	Outlier test result	Classification
1A	7.75	156	-0.04	-1.05	-6.14	Outlier	Questionable
1B	7.34	10.08	-1.24	-1.91	-11.11	Not outlier	In agreement
2	9.17	33	0.30	1.90	11.06	Not outlier	In agreement
3	7.6	14.4	-0.60	-1.37	-7.96	Not outlier	In agreement
4	7.50	22.4	-0.45	-1.57	-9.17	Not outlier	In agreement
5	5.826	27	-1.55	-5.06	-29.44	Not outlier	Questionable
6A	5.12	40.3	-1.52	-6.52	-37.99	Not outlier	Questionable
6B	5.63	40.3	-1.16	-5.46	-31.82	Not outlier	Questionable
6C	2.40	25.8	-9.45	-12.18	-70.93	Not outlier	Discrepant
6D	10.43	30.3	0.69	4.52	26.32	Not outlier	Questionable
7	8.2	21.0	-0.03	-0.12	-0.69	Not outlier	In agreement
8A	10.410	34.094	0.61	4.48	26.07	Not outlier	Questionable
8B	10.815	34.082	0.69	5.32	30.98	Not outlier	Questionable
8C	10.172	34.076	0.55	3.98	23.19	Not outlier	Questionable
9A	18.5	14	3.95	21.30	124.05	Not outlier	Discrepant
9B	15.7	15	3.16	15.48	90.14	Not outlier	Discrepant
10	6.15	50	-0.69	-4.38	-25.52	Not outlier	Questionable
11	58.34	9.2	9.33	104.16	606.55	Not outlier	Discrepant
13A	8.29	20.08	0.02	0.07	0.40	Not outlier	In agreement
13B	8.91	20.09	0.36	1.36	7.91	Not outlier	In agreement
13C	8.55	20.08	0.17	0.61	3.55	Not outlier	In agreement
13D	8.61	20.08	0.20	0.73	4.28	Not outlier	In agreement
14	7.20	27.62	-0.53	-2.20	-12.80	Not outlier	In agreement

Table 3 - Reported results for ^{60}Co (first deadline)

NPL activity concentration = (0.8272 ± 0.0034) Bq g^{-1} (k=1) Reference time: 2016-06-01 1200 UTC

Participant code	Reported activity concentration (Bq/g)	Reported uncertainty (%)	Zeta score	Z score	D (%)	Outlier test result	Classification
1A	0.710	36.6	-0.45	-2.43	-14.17	Not outlier	In agreement
1B	0.80	6.25	-0.54	-0.56	-3.29	Not outlier	In agreement
2	0.87	15	0.33	0.89	5.17	Not outlier	In agreement
3	0.57	5.9	-7.61	-5.34	-31.09	Not outlier	Discrepant
4	0.712	20.51	-0.79	-2.39	-13.93	Not outlier	In agreement
5	0.617	11	-3.09	-4.36	-25.41	Not outlier	Discrepant
6A	0.80	10.4	-0.33	-0.56	-3.29	Not outlier	In agreement
6B	0.64	20.0	-1.46	-3.89	-22.63	Not outlier	Questionable
6C	1.00	20.1	0.86	3.59	20.89	Not outlier	Questionable
6D	1.02	20.1	0.94	4.00	23.31	Not outlier	Questionable
7	0.79	11.5	-0.41	-0.77	-4.50	Not outlier	In agreement
8A	0.750	23.083	-0.45	-1.60	-9.33	Not outlier	In agreement
8B	0.827	22.958	0.00	0.00	-0.02	Not outlier	In agreement
8C	0.771	22.898	-0.32	-1.17	-6.79	Not outlier	In agreement
9A	0.728	6	-2.26	-2.06	-11.99	Not outlier	In agreement
9B	0.615	7	-4.91	-4.41	-25.65	Not outlier	Discrepant
10	0.94	7	1.71	2.34	13.64	Not outlier	In agreement
11	0.75	9.6	-1.07	-1.60	-9.33	Not outlier	In agreement
12A	1.10	10	2.48	5.66	32.98	Not outlier	Questionable
12B	0.717	26.88	-0.57	-2.29	-13.32	Not outlier	In agreement
13A	0.67	14.45	-1.62	-3.26	-19.00	Not outlier	Questionable
13B	0.68	14.34	-1.51	-3.06	-17.79	Not outlier	Questionable
13C	0.64	14.39	-2.03	-3.89	-22.63	Not outlier	Questionable
13D	0.63	14.41	-2.17	-4.09	-23.84	Not outlier	Questionable
14	1.03	27.24	0.72	4.21	24.52	Not outlier	Questionable

Table 4 - Reported results for ^{137}Cs (first deadline)

NPL activity concentration = (1.0391 ± 0.0075) Bq g^{-1} (k=1) Reference time: 2016-06-01 1200 UTC

Participant code	Reported activity concentration (Bq/g)	Reported uncertainty (%)	Zeta score	Z score	D (%)	Outlier test result	Classification
1A	0.795	47.5	-0.65	-4.03	-23.49	Not outlier	Questionable
1B	0.65	7.69	-7.70	-6.43	-37.45	Not outlier	Discrepant
2	1.12	26	0.28	1.34	7.79	Not outlier	In agreement
3	0.70	8.0	-6.00	-5.60	-32.63	Not outlier	Discrepant
4	0.805	20.97	-1.39	-3.87	-22.53	Not outlier	Questionable
5	0.779	19	-1.76	-4.30	-25.03	Not outlier	Questionable
6A	0.91	16.2	-0.87	-2.13	-12.42	Not outlier	In agreement
6B	0.83	20.1	-1.25	-3.46	-20.12	Not outlier	Questionable
6C	1.31	15.5	1.33	4.48	26.07	Not outlier	Questionable
6D	1.25	10.2	1.65	3.49	20.30	Not outlier	Questionable
7	0.85	11.7	-1.90	-3.13	-18.20	Not outlier	Questionable
8A	0.867	25.036	-0.79	-2.84	-16.56	Not outlier	Questionable
8B	0.875	22.985	-0.82	-2.71	-15.79	Not outlier	Questionable
8C	0.867	24.946	-0.80	-2.84	-16.56	Not outlier	Questionable
9A	0.816	8	-3.40	-3.69	-21.47	Not outlier	Discrepant
9B	0.736	7	-5.82	-5.01	-29.17	Not outlier	Discrepant
10	1.06	7	0.28	0.35	2.011	Not outlier	In agreement
11	1.01	13.2	-0.22	-0.48	-2.80	Not outlier	In agreement
12A	5.59×10^{-7}	55.08	-139.10	-17.17	-99.99	Not outlier	Discrepant
12B	0.838	24.32	-0.99	-3.32	-19.35	Not outlier	Questionable
13A	0.78	20.24	-1.64	-4.28	-24.94	Not outlier	Questionable
13B	0.75	20.20	-1.91	-4.78	-27.82	Not outlier	Questionable
13C	0.79	20.21	-1.56	-4.12	-23.97	Not outlier	Questionable
13D	0.79	20.23	-1.56	-4.12	-23.97	Not outlier	Questionable
14	1.30	27.25	0.74	4.31	25.11	Not outlier	Questionable

Table 5 - Reported results for ^{241}Am (second deadline)

NPL activity concentration = (8.257 ± 0.033) Bq g^{-1} (k=1) Reference time: 2016-06-01 1200 UTC

Participant code	Reported activity concentration (Bq/g)	Reported uncertainty (%)	Zeta score	Z score	D (%)	Classification
1Ai	7.45	144	-0.08	-1.68	-9.77	In agreement
1Aii	10.3	325	0.06	4.25	24.74	Questionable
4	9.91	22.40	0.74	3.44	20.02	Questionable
8A	13.039	15.718	2.33	9.95	57.91	Questionable
8B	13.549	15.692	2.49	11.01	64.09	Questionable
8C	12.743	15.718	2.24	9.33	54.33	Questionable
9	31.1	15	4.90	47.51	276.65	Discrepant

Table 6 - Reported results for ^{60}Co (second deadline)

NPL activity concentration = (0.8272 ± 0.0034) Bq g^{-1} (k=1) Reference time: 2016-06-01 1200 UTC

Participant code	Reported activity concentration (Bq/g)	Reported uncertainty (%)	Zeta score	Z score	D (%)	Classification
1Ai	0.710	36.7	-0.45	-2.43	-14.17	In agreement
1Aii	0.870	56.0	0.09	0.89	5.17	In agreement
4	0.792	20.51	-0.22	-0.73	-4.26	In agreement
8A	0.856	4.190	0.80	0.60	3.48	In agreement
8B	0.943	3.781	3.23	2.40	14.00	Questionable
8C	0.883	3.652	1.72	1.16	6.746	In agreement
9	0.871	14	0.36	0.91	5.29	In agreement
15	0.84	12	0.13	0.27	1.55	In agreement

Table 7 - Reported results for ^{137}Cs (second deadline)

NPL activity concentration = (1.0391 ± 0.0075) Bq g^{-1} (k=1) Reference time: 2016-06-01 1200 UTC

Participant code	Reported activity concentration (Bq/g)	Reported uncertainty (%)	Zeta score	Z score	D (%)	Classification
1Ai	0.797	47.7	-0.64	-4.00	-23.30	Questionable
1Aii	1.01	78.8	-0.04	-0.48	-2.80	In agreement
4	0.995	20.97	-0.21	-0.73	-4.24	In agreement
8A	1.035	6.828	-0.06	-0.07	-0.39	In agreement
8B	1.045	6.638	0.08	0.10	0.57	In agreement
8C	1.035	6.490	-0.06	-0.07	-0.39	In agreement
9	1.06	14	0.14	0.35	2.01	In agreement
15	1.01	9	-0.32	-0.48	-2.80	In agreement

9 FIGURES

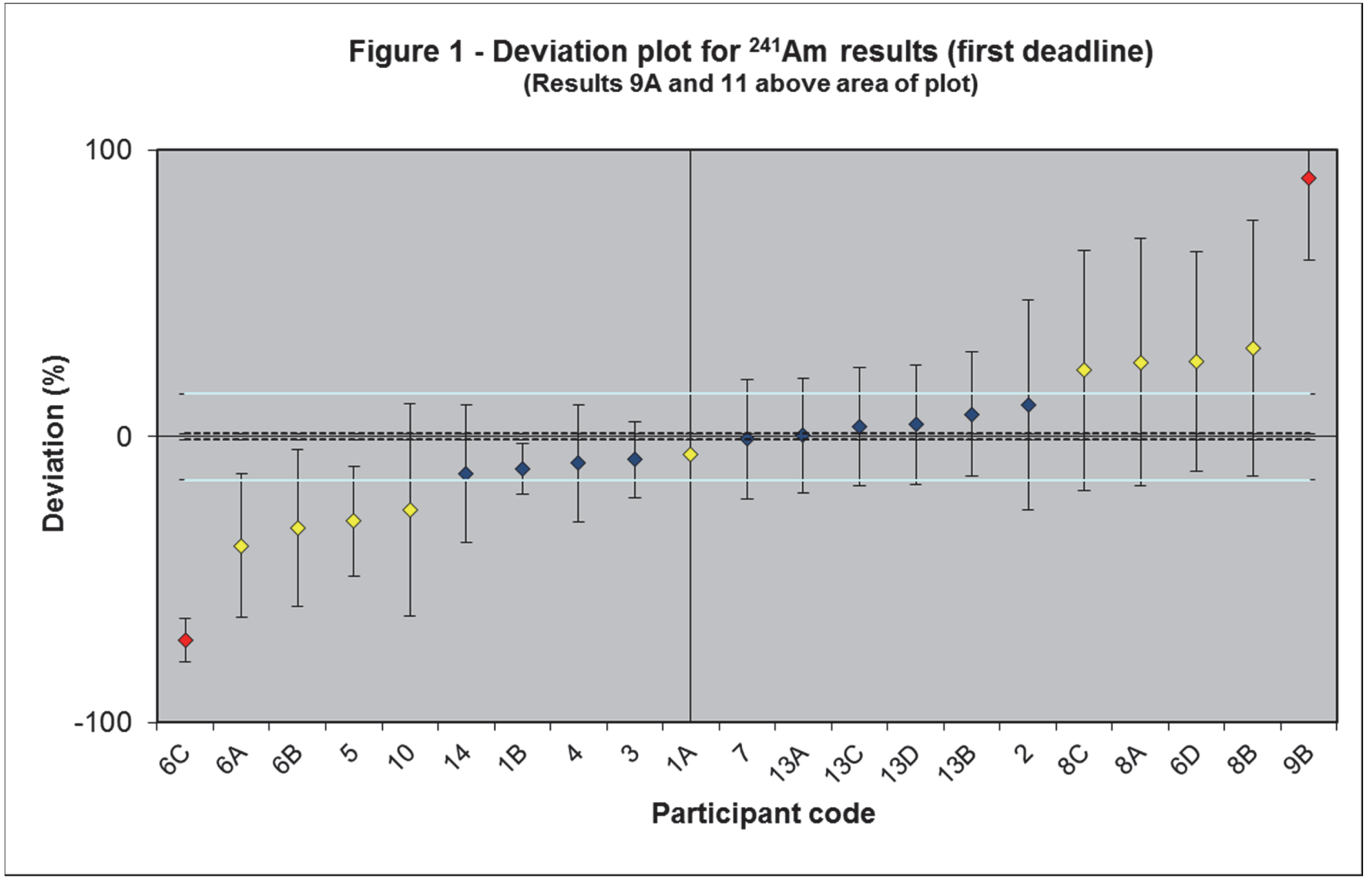
Figure 1 - Deviation plot for 241Am results (first deadline)
(Results 9A and 11 above area of plot)
100
0
-100
Deviation (%)
6C
6A
6B
5
10
14
1B
4
3
1A
7
13A
13C
13D
13B
2
8C
8A
6D
8B
9B
Participant code

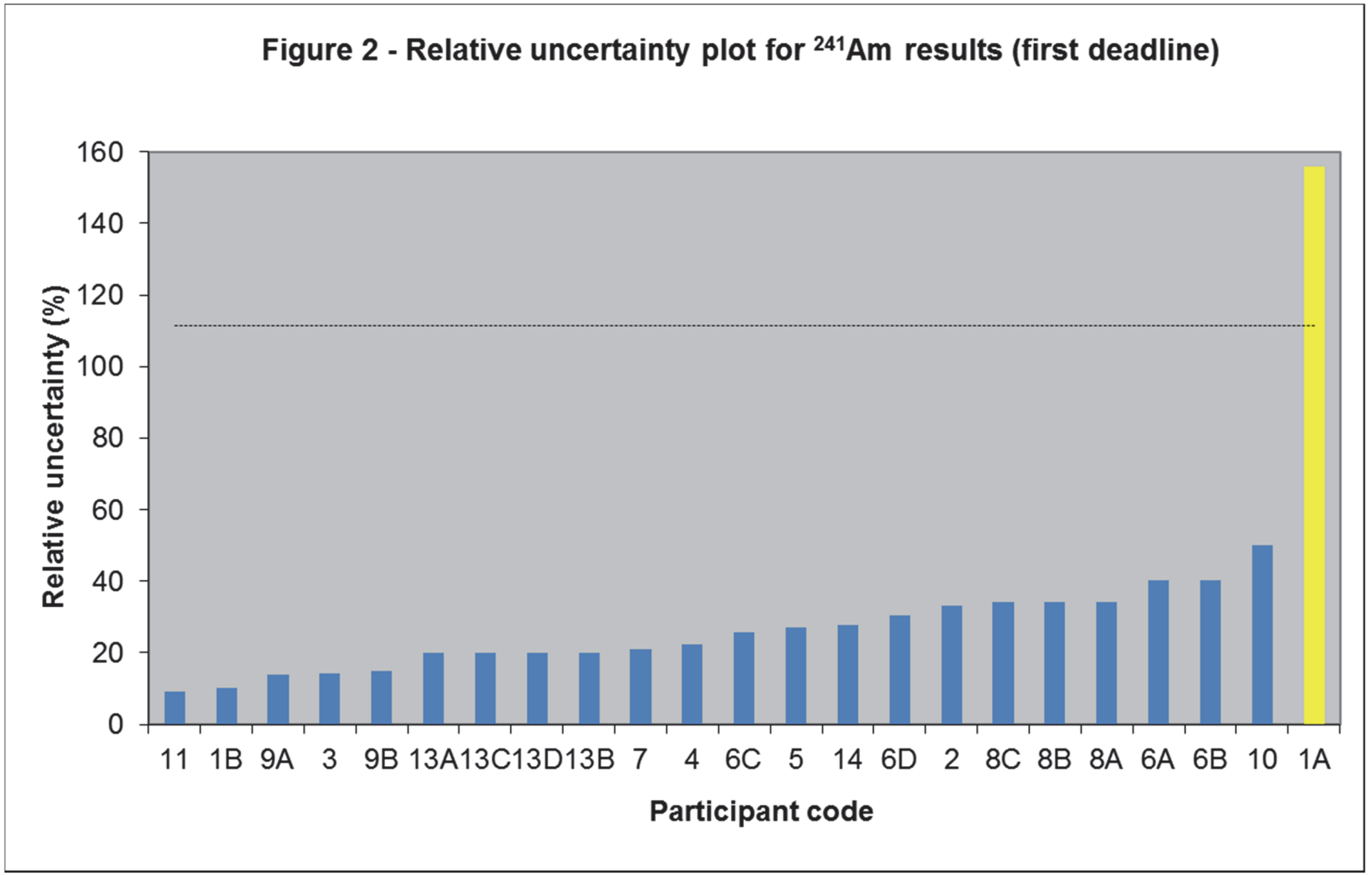
Figure 2 - Relative uncertainty plot for 241Am results (first deadline)
Relative uncertainty (%)
160
140
120
100
80
60
40
20
0
11 1B 9A 3 9B 13A 13C 13D 13B 7 4 6C 5 14 6D 2 8C 8B 8A 6A 6B 10 1A
Participant code

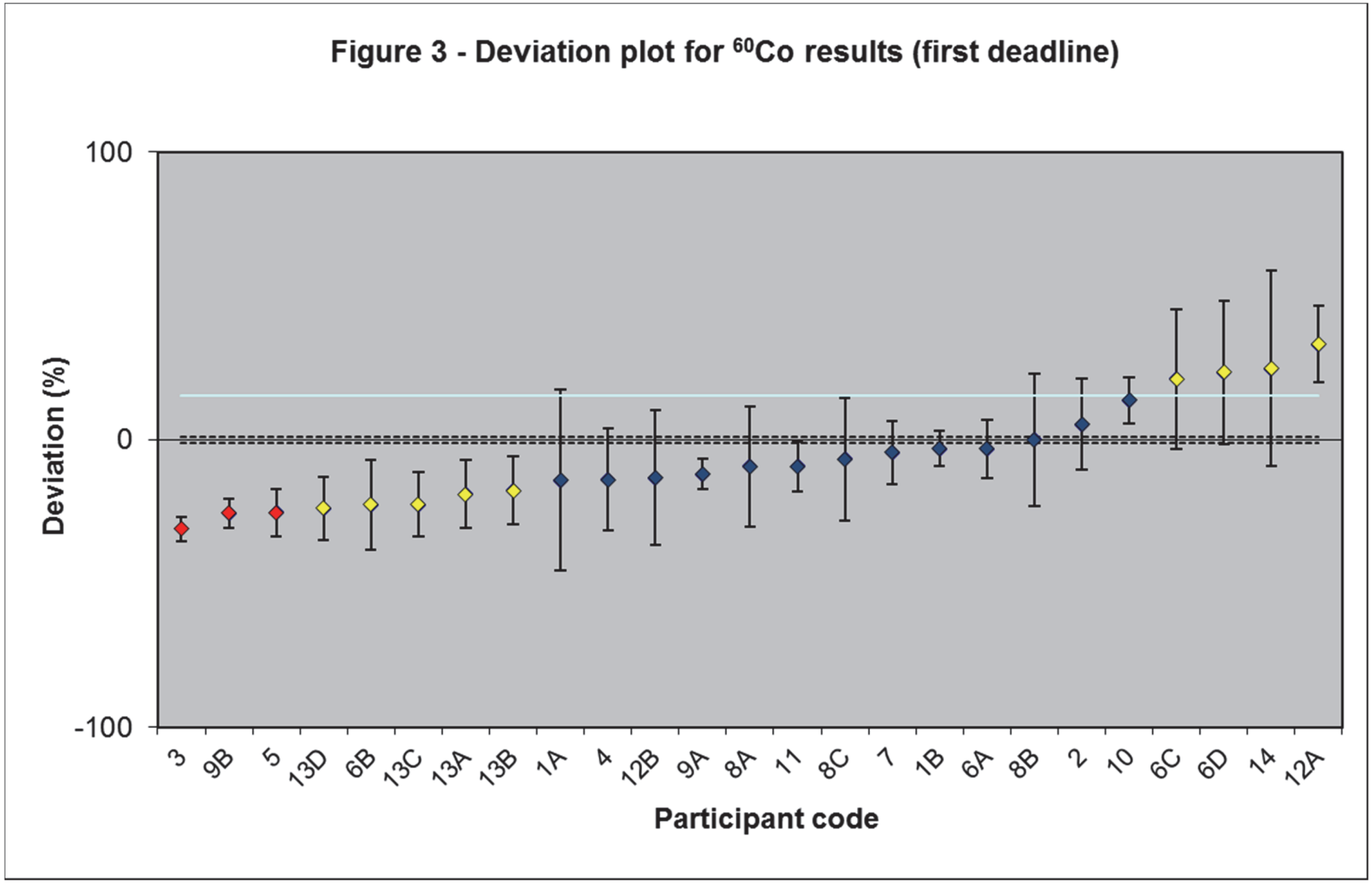
Figure 3 - Deviation plot for 60Co results (first deadline)
100
0
-100
Deviation (%)
3
9B
5
13D
6B
13C
13A
13B
1A
4
12B
9A
8A
11
8C
7
1B
6A
8B
2
10
6C
6D
14
12A
Participant code

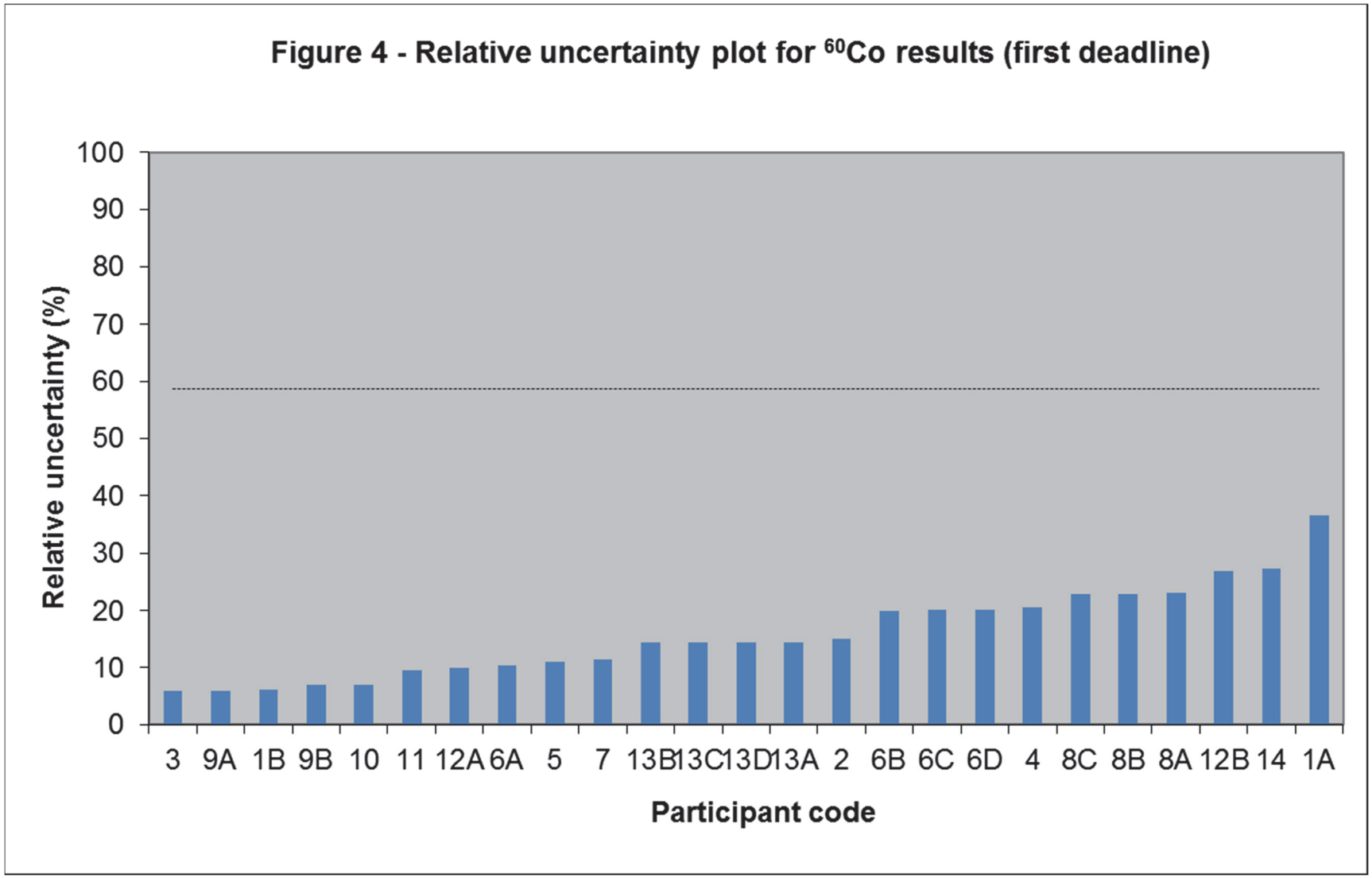
Figure 4 - Relative uncertainty plot for 60Co results (first deadline)
Relative uncertainty (%)
100
90
80
70
60
50
40
30
20
10
0
3 9A 1B 9B 10 11 12A 6A 5 7 13B 13C 13D 13A 2 6B 6C 6D 4 8C 8B 8A 12B 14 1A
Participant code

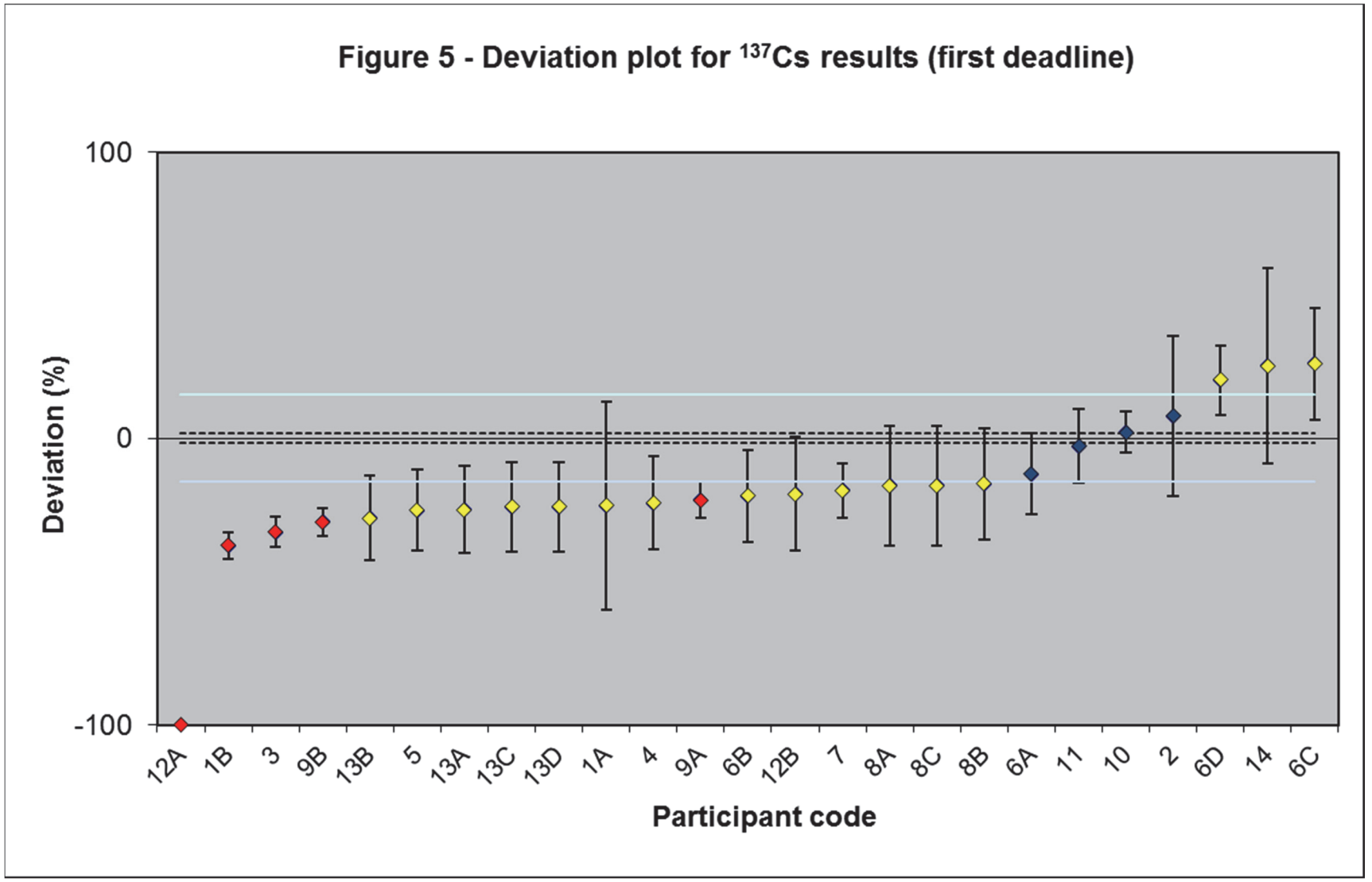
Figure 5 - Deviation plot for 137Cs results (first deadline)
100
0
-100
Deviation (%)
12A
1B
3
9B
13B
5
13A
13C
13D
1A
4
9A
6B
12B
7
8A
8C
8B
6A
11
10
2
6D
14
6C
Participant code

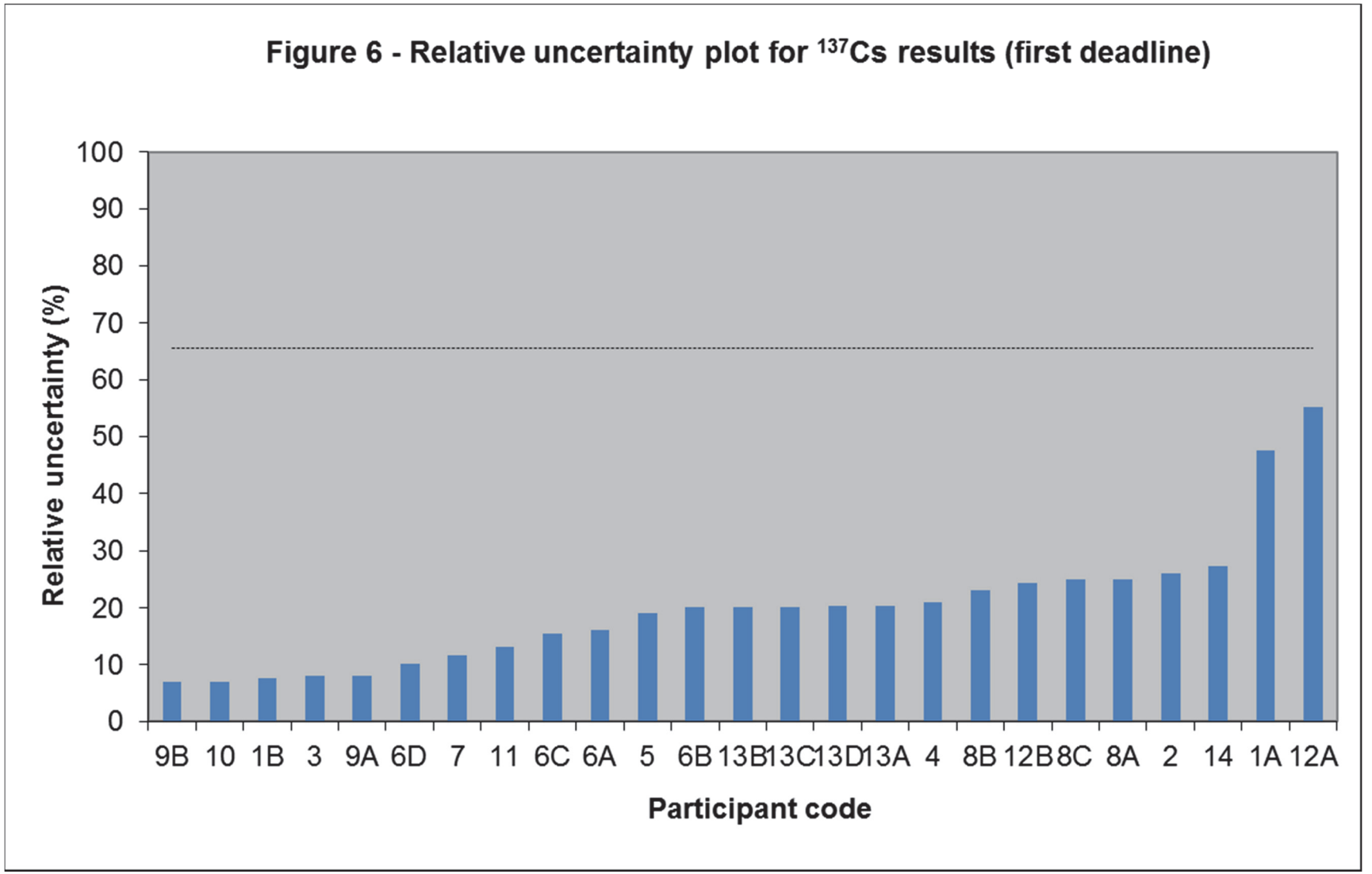
Figure 6 - Relative uncertainty plot for 137Cs results (first deadline)
Relative uncertainty (%)
100
90
80
70
60
50
40
30
20
10
0
9B 10 1B 3 9A 6D 7 11 6C 6A 5 6B 13B 13C 13D 13A 4 8B 12B 8C 8A 2 14 1A 12A
Participant code

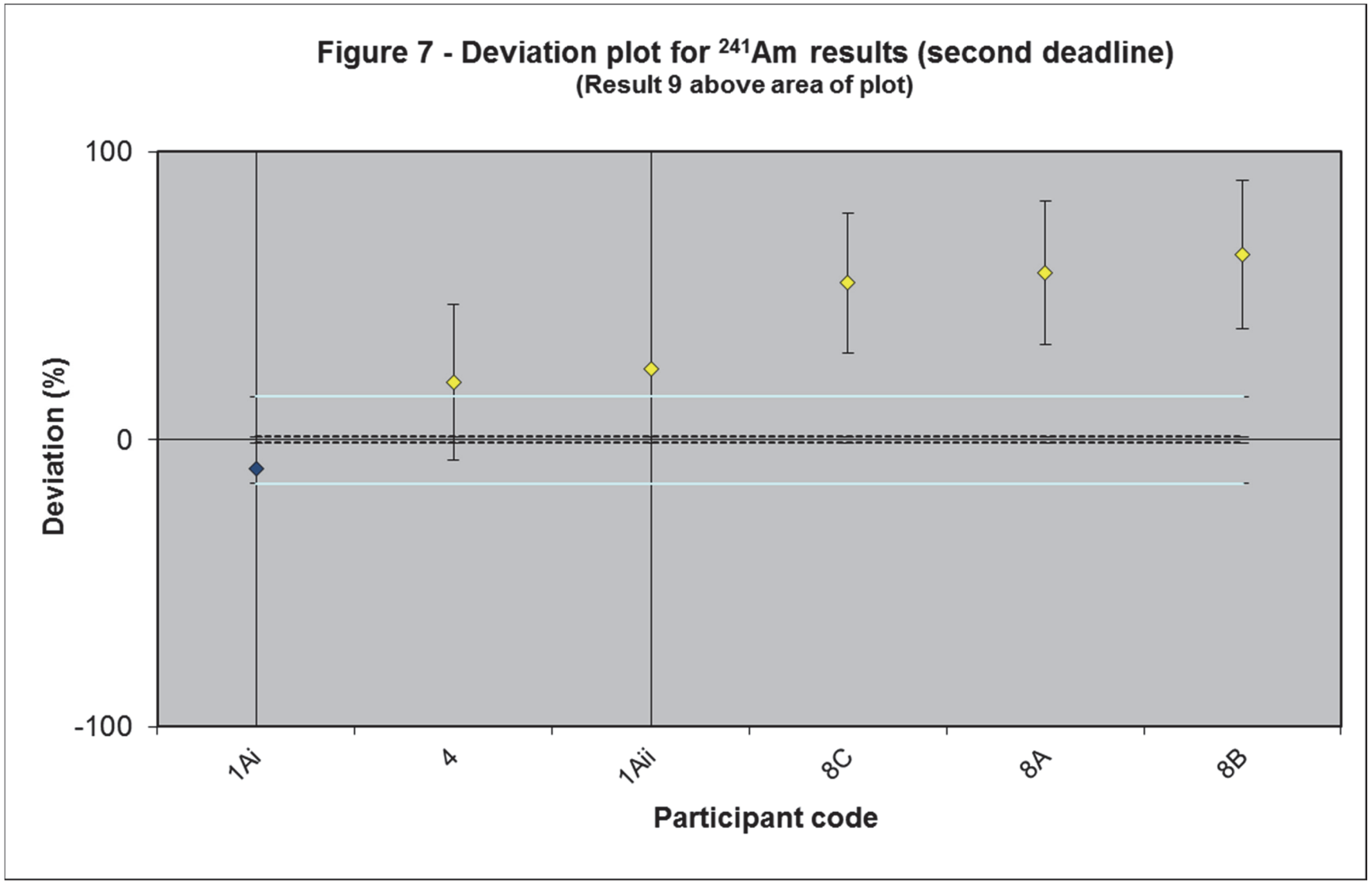
Figure 7 - Deviation plot for 241Am results (second deadline)
(Result 9 above area of plot)
100
0
-100
Deviation (%)
1Ai
4
1Aii
8C
8A
8B
Participant code

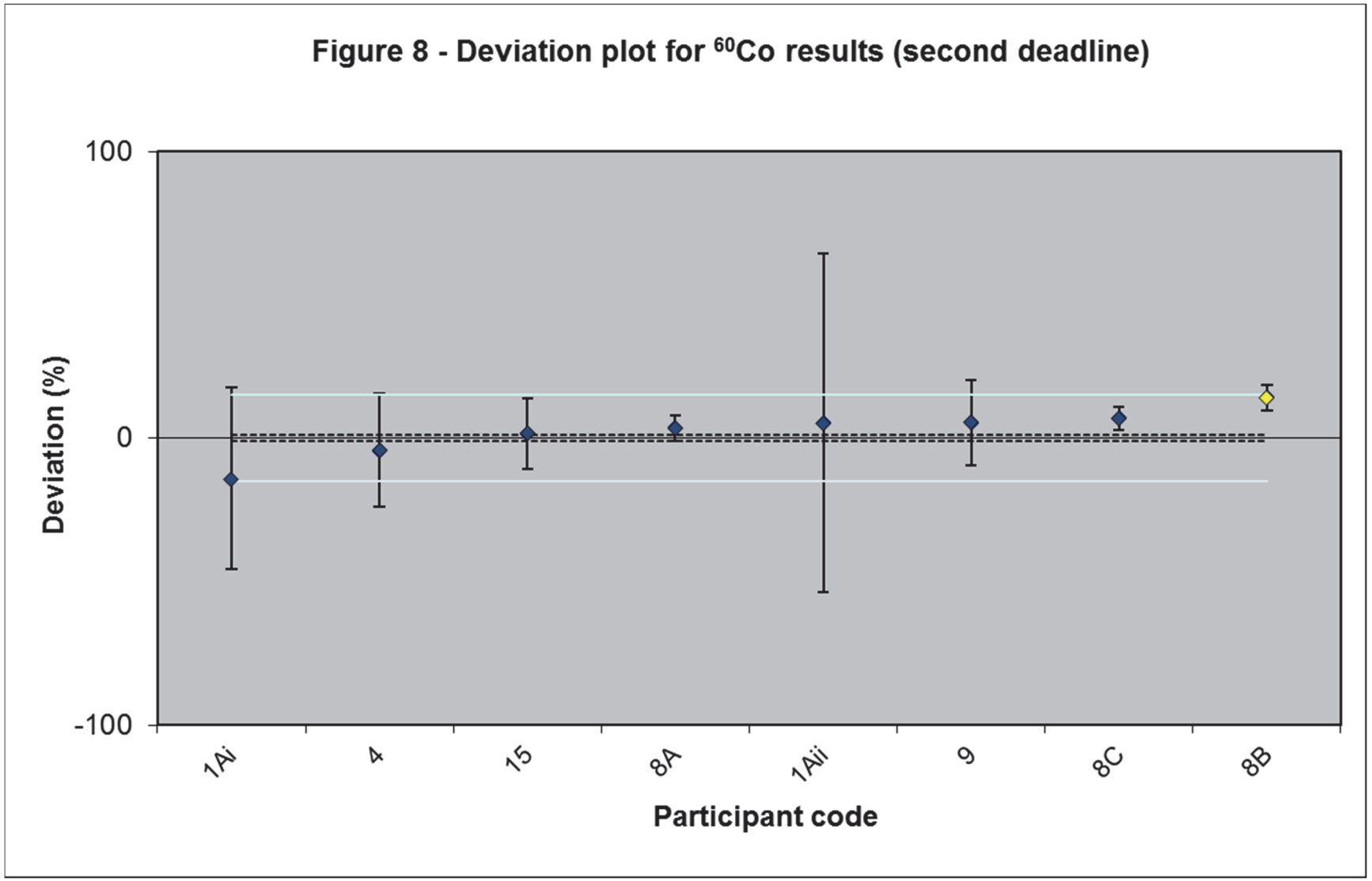
Figure 8 - Deviation plot for 60Co results (second deadline)
100
0
-100
Deviation (%)
1Ai
4
15
8A
1Aii
9
8C
8B
Participant code

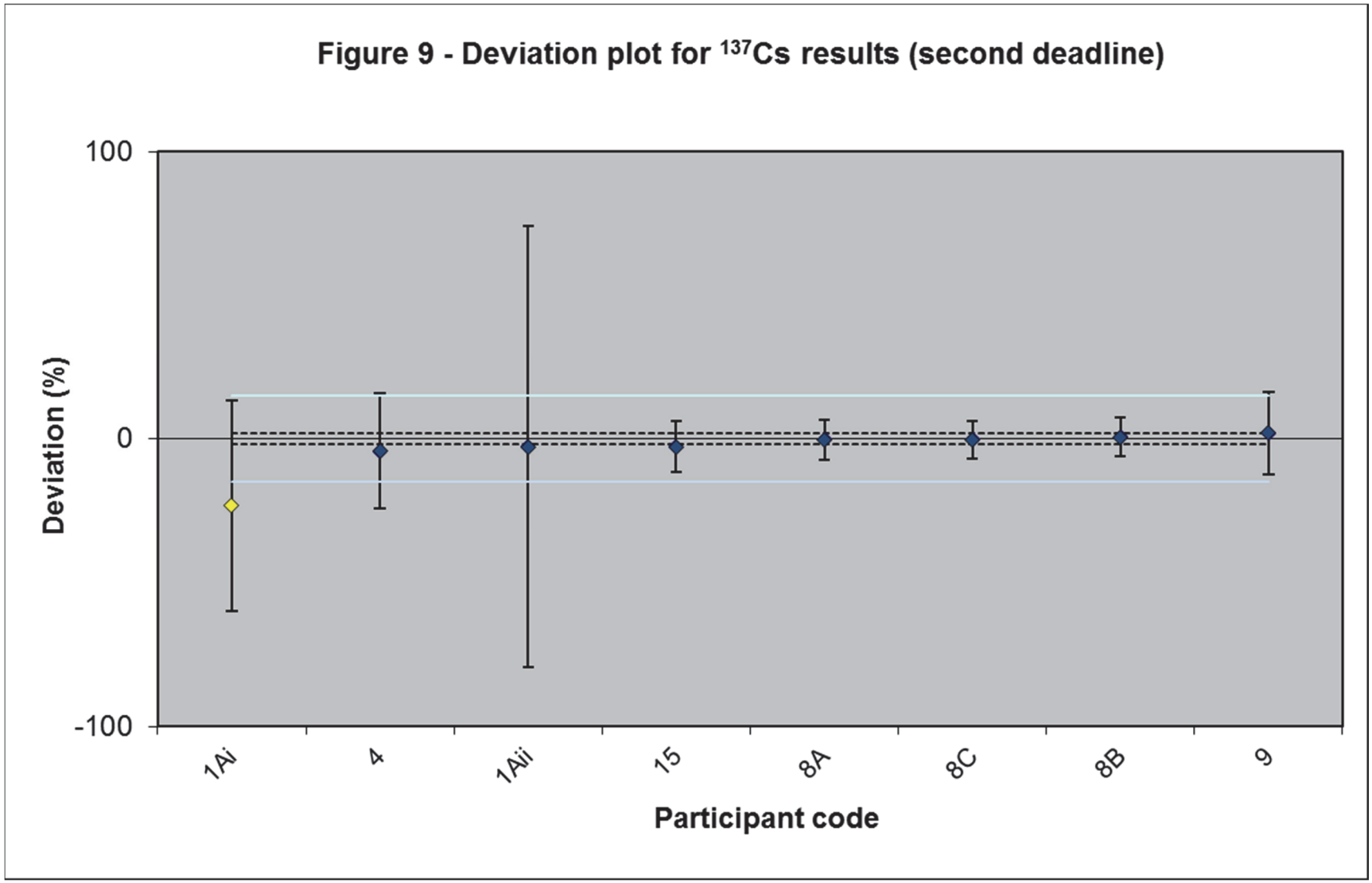
Figure 9 - Deviation plot for 137Cs results (second deadline)
100
0
-100
Deviation (%)
1Ai
4
1Aii
15
8A
8C
8B
9
Participant code

10 APPENDIX A – Initial Mailshot

Dear Colleague,

NPL DRUM NUCLEAR INDUSTRY PROFICIENCY TEST EXERCISE 2016

NPL is about to run its sixth drum-based bulk-waste proficiency test exercise to enable laboratories worldwide involved in decommissioning and site clearance to test their bulk-waste gamma measurement procedures. As in previous exercises, the purpose is to provide the user community with a voluntary, independent and confidential test of their bulk waste measurement procedures.

In brief: NPL will prepare a single 'mock waste' sample in a 200-litre steel drum. The drum will contain plastic bottles, some filled with ion-exchange resin (containing activity) and others with vermiculite with no activity added. The radionuclides ^{241}Am, ^{60}Co and ^{137}Cs will be present in each 'resin bottle' and the overall activity concentration in the drum will be in the range 1 – 10 Bg g^{-1}.

The drum will be available for measurement between 6 June and 30 September 2016 and participants will be asked to report the activity concentrations of the individual radionuclides. A short exercise report will be published in December 2016. All results will be coded and treated as confidential.

If you are interested in participating, please read the full details given on pages 2 to 3 below and then complete and return the PTE Enquiry Form. Please note that requests to participate must be received by close of business on 1 April 2016.

We hope you are interested and that you will be able to participate.

Yours faithfully

Julian Dean March 2016

A) Plan for NPL Drum Nuclear Industry PTE 2016

NPL will prepare a single 'mock waste' sample in a 200-litre steel drum. The drum will contain 240 plastic bottles (in 5 'layers' of 48), some filled with ion-exchange resin and others with vermiculite. The radionuclides ^{241}Am, ^{60}Co and ^{137}Cs will be present in each 'resin bottle'. The activity will be added to each resin bottle as a few weighed drops of standardised solution, so the distribution of activity in a bottle will approximate to a point source. The 'vermiculite bottles' will have no activity added. The overall activity concentration of the drum (i.e. activity / total mass of material in drum) will be in the range 1 – 10 Bg g^{-1}.

The drum will be delivered to (and collected from) the participants on agreed dates. Participants will be given 3 working days to measure the drum (excluding arrival and dispatch days). The drum will be an Excepted Package.

NPL will initially disclose the percentage by mass of plastic, resin and vermiculite present, the dimensions of the drum and the mass of the drum (empty and full). Participants will be asked to report their measurements of the individual radionuclide activity concentrations, along with details of calibration procedures and instrumentation used, before an initial deadline.

NPL will then disclose the location of the resin bottles in the drum and invite participants to submit additional results (by a second deadline) should they wish. Note that revisions to results submitted

earlier will not be accepted at this time. NPL will then prepare a short draft report (including all results, coded for anonymity) and issue to all participants.

Note that the filled drum will have a mass of approximately 100 kg and will be loaded on a pallet. Participants must have arrangements in place for moving the drum from and to the courier's van; they must also ensure that the drum is secured to the pallet and bears the address label provided by NPL before it is returned to the courier.

B) Timetable

11 Action	Dates
Interested laboratories to reply to this mailshot	By 1 April 2016
NPL to contact each laboratory, advise if they can be accommodated, and, if so, agree receipt and dispatch dates	By 27 May 2016
Participants to submit Purchase Orders	Within two weeks of notification of receipt and dispatch dates
Participants to measure drum	Within agreed dates in the period 6 June and 30 September 2016
Participants to submit results (not knowing location of resin bottles)	By 14 October 2016 ('first deadline')
NPL to disclose location of resin bottles	17 October 2016
Participants, if they wish, to submit additional results	By 28 October 2016 ('second deadline')
NPL to disclose activity concentrations	31 October 2016
NPL to issue report	December 2016

C) How to participate

Please complete the enclosed Enquiry Form and return it by close of business on **1 April 2016** to radioactivity@npl.co.uk . Please indicate on the form which weeks in the period 6 June to 30 September 2016 you would prefer for delivery of the sample drum to your site. Note that you will be allocated three full working days to measure the drum (excluding the arrival and dispatch days).

IMPORTANT: If the exercise is oversubscribed we shall deal with requests for inclusion on a first-come-first-served basis, so please **PLEASE DO NOT SUBMIT A PURCHASE ORDER AT THIS STAGE**. We shall contact you by 27 May to confirm whether or not we can accommodate you, and if so we will agree receipt and dispatch dates with you and ask you to submit your order at that time. Participants must ensure Purchase Orders are submitted within two weeks to ensure that they receive the drum on the allocated date.

D) Fees

The fees will be as follows:

- Participation: **£1150**
- Delivery: **To be advised**

NPL will arrange for a courier to deliver and pick-up on the agreed dates.

12 APPENDIX B – Reporting form

NUCLEAR INDUSTRY PTE 2016 REPORTING FORM	
Participating laboratory	
Contact person	
Address	
Submission date	

Radionuclide	Activity concentration (Bq g^{-1}) RT 1200 UTC, 01/06/16	Type A uncertainty (%, k=1)	Type B uncertainty (%, k=1)	Combined standard uncertainty (%, k=1)
^{241}Am				
^{60}Co				
^{137}Cs				

Please provide brief details of the following:

Detector type	
Scanning method used (including, e.g., detector collimation, segmented scanning and rotation of drum)	
Matrix density correction applied	
Calibration standards used	
Efficiency modelling and software	
Other	

13 APPENDIX C – List of Participants

Dr H Beddow
Nuvia Ltd
The Library
Eighth Street
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Mr W De Boeck
SCK-CEN
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Belgium

Mr T Dieudonne
IRE
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B-6220 Fleurus
Belgium

Mr G Faulkner
Devonport Royal Dockyard Ltd
Babcock Marine – Devonport
Plymouth
Devon PL1 4SG
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Mr A Frith
AMEC Foster Wheeler Nuclear UK Ltd
Analytical Services
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Birchwood
Warrington WA3 6GN
UK

Mr M Giacomelli
ZVD Zavod za varstvo pri delu d.o.o.
Centre for Physical Measurements
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SI-1260 Ljubljana-Polje
Slovenia

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Winfrith
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Mr T Homer
Magnox Ltd
Hinkley ‘A’ site
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Somerset TA5 1YA
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Mr L Jones
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Mr E Mauro
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00123
Rome
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Mr M Roveri
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Joint Research Centre
ND Unit - Laboratory for Radioactivity Measurements (LMR)
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Mr B Wellens
Nuclear Engineering Seibersdorf GmbH
Forschungszentrum Seibersdorf
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Austria