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IAEA-RML-2016-01 Proficiency Test for Determination of Radionuclides in Sea Water

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International Atomic Energy Agency

IAEA-RML-2016-01 PROFICIENCY TEST FOR DETERMINATION OF RADIONUCLIDES IN SEA WATER

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IAEA-RML-2016-01 PROFICIENCY TEST FOR DETERMINATION OF RADIONUCLIDES IN SEA WATER

INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

The Radiometrics Laboratory of the IAEA Environment Laboratories has been providing quality support products and services for the past 50 years. These include the organization of proficiency tests and interlaboratory comparisons, and the production of certified reference materials, including a wide range of marine sample matrices and radionuclide levels.

As part of these activities, a third proficiency test exercise was organized, at the request of the Nuclear Regulation Authority of Japan, to test the performance of participating laboratories in an analysis of radionuclides in a seawater sample. This exercise was initiated to support laboratories in seawater analyses of ^{3}H, ^{134}Cs, ^{137}Cs and ^{90}Sr in relation to the accident at the Fukushima Daiichi nuclear power plant in March 2011 and subsequent contamination of the marine environment. Earlier exercises are described in IAEA Analytical Quality in Nuclear Applications Series Nos 40–43 and 51.

The IAEA is grateful to the Government of Monaco for its support and wishes to thank all the participants and laboratories who took part in this proficiency test exercise. The IAEA officers responsible for this publication were A.V. Harms, I. Osvath and D. Osborn of the IAEA Environment Laboratories.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The IAEA Environment Laboratories (IAEA-EL) in Monaco and Seibersdorf regularly organize proficiency tests (PT) for radionuclides in environmental samples to support laboratories in IAEA Member States.

1.2. OBJECTIVES

This proficiency test was initiated to support laboratories in sea water analyses of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs. The results of this exercise allowed the participating laboratories to evaluate their performance in the analysis of these radionuclides for this sample type.

1.3. SCOPE

This publication describes the organization and the results of a third proficiency test organized in cooperation with the Nuclear Regulation Authority (NRA) in Japan. A total of 55 laboratories from 30 countries participated in this exercise during the period September – December 2016. This included 17 laboratories from Japan and 38 laboratories from other IAEA Member States. The results of the Japanese laboratories were considered as a separate group (participants 1–17). The full list of participants is given on pages 59–65. Results of similar earlier exercises are described in IAEA Analytical Quality in Nuclear Applications Series Nos 40–43 and 51 [1–5] and in Ref. [6].

1.4. STRUCTURE

This publication contains a description of material offered and the reporting requirements (Section 2), the performance criteria (Section 3), the results of the exercise and discussion (Section 4), an appendix presenting the performance evaluation sorted by radionuclide (Appendix I), an appendix presenting the performance evaluation sorted by participant (Appendix II) and a list of participants (Appendix III).

2. MATERIAL AND METHODS

2.1. MATERIAL DISTRIBUTION AND REPORTING REQUIREMENTS

A sample containing 5 L of filtered Mediterranean sea water spiked by the IAEA with the radionuclides ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs was distributed to the participants, with the massic activities only known to the IAEA. The massic activities were traceable to a standard provided by Czech Metrology Institute ČMI. The combined massic activities in the exercise samples were lower than the natural activity level of ^{40}K in sea water (which is approximately 12 Bq kg^{-1}). The ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs massic activities for the samples were approximately 1.4, 0.22, 0.22 and 0.18 Bq kg^{-1}, respectively. The sample also contained a non-active Cs-carrier at 10 mg kg^{-1} in order to stabilize the solution and to avoid adsorption of Cs to the container walls. No Sr was added to the sample as non-active Sr present naturally in sea water will act as a carrier for ^{90}Sr.

The participants were required to report to the IAEA the ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs massic activities (in Bq kg^{-1}) of the proficiency test sample combined with the associated uncertainties (also in Bq kg^{-1}). Additionally, the participants were asked to submit the following:

- A short description of the analytical method used for the sample analysis. The Information Sheet sent to the participants suggested for ^{3}H distillation followed by liquid scintillation counting. For ^{90}Sr, precipitation from sea water as mixed Ca/Sr oxalate or carbonate followed by a standard ^{90}Sr procedure (e.g. a radiochemical procedure such as precipitation with fuming nitric acid, liquid-liquid extraction or extraction chromatography followed by a measurement technique such as gas-flow proportional counting or liquid scintillation counting) were suggested. For ^{134}Cs and ^{137}Cs, three methods were suggested: (i) direct gamma spectrometry, (ii) adsorption on AMP (ammonium molybdophosphate, $(NH_4)_3PO_4Mo_{12}O_{36}$) and subsequent gamma spectrometry or (iii) adsorption on copper hexacyanoferrate ($Cu_2[Fe(CN)_6]$) and subsequent gamma spectrometry;

– Type of calibration and software used for gamma ray spectrometry;
– Nuclear data used;
– An uncertainty budget for the measurement results.

The reference date for reporting massic activities was set at 1 September 2016. At this date, the ranges for the traceable massic activities in the proficiency test exercise samples sent to the participants were 1.40–1.42 Bq kg^{-1} ^{3}H, 0.2201–0.2226 Bq kg^{-1} ^{90}Sr, 0.2238–0.2264 Bq kg^{-1} ^{134}Cs and 0.1756–0.1776 Bq kg^{-1} ^{137}Cs, respectively (see Table 1).

TABLE 1. IAEA ASSIGNED VALUES

Participant	^{3}H massic activity (Bq kg^{-1})	^{90}Sr massic activity (Bq kg^{-1})	^{134}Cs massic activity (Bq kg^{-1})	^{137}Cs massic activity (Bq kg^{-1})
1*	1.40 ± 0.05	0.2203 ± 0.0016	0.2240 ± 0.0009	0.1757 ± 0.0014
2*	1.41 ± 0.05	0.2214 ± 0.0016	0.2251 ± 0.0009	0.1766 ± 0.0015
3*	1.41 ± 0.05	0.2204 ± 0.0016	0.2242 ± 0.0009	0.1759 ± 0.0014
4*	1.41 ± 0.05	0.2218 ± 0.0016	0.2256 ± 0.0009	0.1770 ± 0.0015
5*	1.41 ± 0.05	0.2211 ± 0.0016	0.2249 ± 0.0009	0.1764 ± 0.0015
6*	1.42 ± 0.05	0.2222 ± 0.0016	0.2260 ± 0.0009	0.1773 ± 0.0015
7*	1.41 ± 0.05	0.2215 ± 0.0016	0.2253 ± 0.0009	0.1767 ± 0.0015
8*	1.41 ± 0.05	0.2208 ± 0.0016	0.2245 ± 0.0009	0.1761 ± 0.0015
9*	1.41 ± 0.05	0.2217 ± 0.0016	0.2254 ± 0.0009	0.1769 ± 0.0015
10*	1.41 ± 0.05	0.2215 ± 0.0016	0.2252 ± 0.0009	0.1767 ± 0.0015
11*	1.41 ± 0.05	0.2206 ± 0.0016	0.2244 ± 0.0009	0.1760 ± 0.0015
12*	1.41 ± 0.05	0.2207 ± 0.0016	0.2244 ± 0.0009	0.1761 ± 0.0015
13*	1.41 ± 0.05	0.2219 ± 0.0016	0.2257 ± 0.0009	0.1770 ± 0.0015
14*	1.41 ± 0.05	0.2217 ± 0.0016	0.2255 ± 0.0009	0.1769 ± 0.0015
15*	1.41 ± 0.05	0.2215 ± 0.0016	0.2253 ± 0.0009	0.1767 ± 0.0015
16*	1.41 ± 0.05	0.2215 ± 0.0016	0.2252 ± 0.0009	0.1767 ± 0.0015
17*	1.41 ± 0.05	0.2209 ± 0.0016	0.2246 ± 0.0009	0.1762 ± 0.0015
18	1.40 ± 0.05	0.2203 ± 0.0016	0.2240 ± 0.0009	0.1757 ± 0.0014
19	1.41 ± 0.05	0.2205 ± 0.0016	0.2243 ± 0.0009	0.1760 ± 0.0014
20	1.41 ± 0.05	0.2214 ± 0.0016	0.2252 ± 0.0009	0.1766 ± 0.0015
21	1.41 ± 0.05	0.2209 ± 0.0016	0.2246 ± 0.0009	0.1762 ± 0.0015
22	1.41 ± 0.05	0.2213 ± 0.0016	0.2251 ± 0.0009	0.1766 ± 0.0015
23	1.41 ± 0.05	0.2206 ± 0.0016	0.2244 ± 0.0009	0.1760 ± 0.0015
24	1.41 ± 0.05	0.2214 ± 0.0016	0.2252 ± 0.0009	0.1767 ± 0.0015
25	1.41 ± 0.05	0.2217 ± 0.0016	0.2254 ± 0.0009	0.1769 ± 0.0015
26	1.41 ± 0.05	0.2213 ± 0.0016	0.2251 ± 0.0009	0.1766 ± 0.0015
27	1.41 ± 0.05	0.2208 ± 0.0016	0.2246 ± 0.0009	0.1762 ± 0.0015
28	1.41 ± 0.05	0.2209 ± 0.0016	0.2246 ± 0.0009	0.1762 ± 0.0015
29	1.41 ± 0.05	0.2211 ± 0.0016	0.2249 ± 0.0009	0.1764 ± 0.0015
30	1.41 ± 0.05	0.2216 ± 0.0016	0.2254 ± 0.0009	0.1768 ± 0.0015
31	1.42 ± 0.05	0.2223 ± 0.0016	0.2261 ± 0.0009	0.1773 ± 0.0015
32	1.41 ± 0.05	0.2210 ± 0.0016	0.2247 ± 0.0009	0.1763 ± 0.0015

TABLE 1. IAEA ASSIGNED VALUES (cont.)

Participant	^{3}H massic activity (Bq kg^{-1})	^{90}Sr massic activity (Bq kg^{-1})	^{134}Cs massic activity (Bq kg^{-1})	^{137}Cs massic activity (Bq kg^{-1})
33	1.42 ± 0.05	0.2223 ± 0.0016	0.2261 ± 0.0009	0.1773 ± 0.0015
34	1.41 ± 0.05	0.2210 ± 0.0016	0.2248 ± 0.0009	0.1763 ± 0.0015
35	1.41 ± 0.05	0.2219 ± 0.0016	0.2257 ± 0.0009	0.1770 ± 0.0015
36	1.41 ± 0.05	0.2208 ± 0.0016	0.2246 ± 0.0009	0.1762 ± 0.0015
37	1.41 ± 0.05	0.2215 ± 0.0016	0.2252 ± 0.0009	0.1767 ± 0.0015
38	1.41 ± 0.05	0.2216 ± 0.0016	0.2253 ± 0.0009	0.1768 ± 0.0015
40	1.41 ± 0.05	0.2216 ± 0.0016	0.2253 ± 0.0009	0.1768 ± 0.0015
41	1.41 ± 0.05	0.2219 ± 0.0016	0.2257 ± 0.0009	0.1770 ± 0.0015
42	1.41 ± 0.05	0.2211 ± 0.0016	0.2248 ± 0.0009	0.1764 ± 0.0015
43	1.41 ± 0.05	0.2217 ± 0.0016	0.2255 ± 0.0009	0.1769 ± 0.0015
44	1.41 ± 0.05	0.2204 ± 0.0016	0.2241 ± 0.0009	0.1759 ± 0.0014
45	1.41 ± 0.05	0.2210 ± 0.0016	0.2247 ± 0.0009	0.1763 ± 0.0015
46	1.41 ± 0.05	0.2212 ± 0.0016	0.2249 ± 0.0009	0.1764 ± 0.0015
47	1.41 ± 0.05	0.2210 ± 0.0016	0.2248 ± 0.0009	0.1763 ± 0.0015
48	1.41 ± 0.05	0.2211 ± 0.0016	0.2249 ± 0.0009	0.1764 ± 0.0015
49	1.41 ± 0.05	0.2212 ± 0.0016	0.2249 ± 0.0009	0.1765 ± 0.0015
50	1.41 ± 0.05	0.2211 ± 0.0016	0.2249 ± 0.0009	0.1764 ± 0.0015
51	1.41 ± 0.05	0.2208 ± 0.0016	0.2245 ± 0.0009	0.1761 ± 0.0015
52	1.41 ± 0.05	0.2210 ± 0.0016	0.2248 ± 0.0009	0.1764 ± 0.0015
53	1.41 ± 0.05	0.2222 ± 0.0016	0.2260 ± 0.0009	0.1773 ± 0.0015
54	1.41 ± 0.05	0.2212 ± 0.0016	0.2249 ± 0.0009	0.1765 ± 0.0015
55	1.42 ± 0.05	0.2226 ± 0.0016	0.2264 ± 0.0009	0.1776 ± 0.0015

* Participant from Japan

3. PERFORMANCE CRITERIA

The methodology adopted for this exercise is described in Ref. [6] and was slightly updated from the existing IAEA methodology [7] (i.e., in this exercise a k value of 2.58 instead of 2.56 was used and a normalisation factor was introduced to the trueness equation; see Equation 5 below). The scoring system took into account the accuracy, precision and trueness of the reported data and included in the evaluation both the combined standard uncertainty of the IAEA value and the combined standard uncertainty reported by the participating laboratories. The IAEA values, which were used for the data evaluation, were the certified values of radionuclides at the reference date. A result must pass three tests described in 3.1 and 3.2 below (see Table 2) to be assigned the status 'Accepted', otherwise it was assigned the status 'Warning' or 'Not accepted'.

3.1. ACCURACY

The first step in producing a score for a result $Value_{\text{Analyst}}$ was the estimation of the bias. The relative bias between the Analyst's value and the IAEA target value was calculated as follows and expressed as a percentage:

$$Bias_{\text{relative}} = \frac{Value_{\text{Analyst}} - Value_{\text{IAEA}}}{Value_{\text{IAEA}}} \times 100\% \quad (1)$$

The absolute value of the relative bias was compared to the Maximal Accepted Relative Bias (MARB). Participants' results were scored as 'Pass' for accuracy when:

$$|Bias_{\text{relative}}| \leq \text{MARB} \quad (2)$$

The MARB values used in this evaluation were 20% for both ^{134}Cs and ^{137}Cs and 25% for both ^{3}H and ^{90}Sr.

3.2. PRECISION AND TRUENESS

The precision *P* for each result was calculated according to the following equation:

$$P = \sqrt{\left(\frac{unc_{\text{IAEA}}}{Value_{\text{IAEA}}}\right)^2 + \left(\frac{unc_{\text{Analyst}}}{Value_{\text{Analyst}}}\right)^2} \times 100\% \quad (3)$$

The precision *P* was compared to the Limit of Accepted Precision (LAP). The participants' results were scored as 'Pass' for precision when:

$$P \leq \text{LAP} \quad (4)$$

The LAP values used in this evaluation were 20% for both ^{134}Cs and ^{137}Cs and 25% for both ^{3}H and ^{90}Sr.

The participants' results for trueness were scored as 'Pass' when:

$$|Bias_{\text{relative}}| \leq \frac{Value_{\text{Analyst}}}{Value_{\text{IAEA}}} 2.58\, P \quad (5)$$

3.3. FINAL EVALUATION

For the final evaluation, all three scores were combined (see Table 2). The result was considered as 'Accepted' if it passed all three tests. If the accuracy test was failed, the result was considered as 'Not accepted'. If the accuracy test was passed but one of the other two tests was failed, the result was assigned the 'Warning' status. The 'Warning' status will reflect cases in which the reported result was close enough to the assigned property value, but its associated uncertainty was deemed to be either too small or too large.

TABLE 2. PERFORMANCE EVALUATION CRITERIA

Accuracy	Precision	Trueness	Final evaluation
Pass	Pass	Pass	Accepted
Pass	Fail	Pass	Warning
Pass	Pass	Fail	Warning
Fail	Pass/Fail	Pass/Fail	Not accepted

These evaluation criteria can also be illustrated by plotting the relative bias against the relative uncertainty of the participants' result (see Figure 1). In the illustrated case, a relative uncertainty of 1% for the IAEA value is assumed with MARB and LAP limits of 20%.

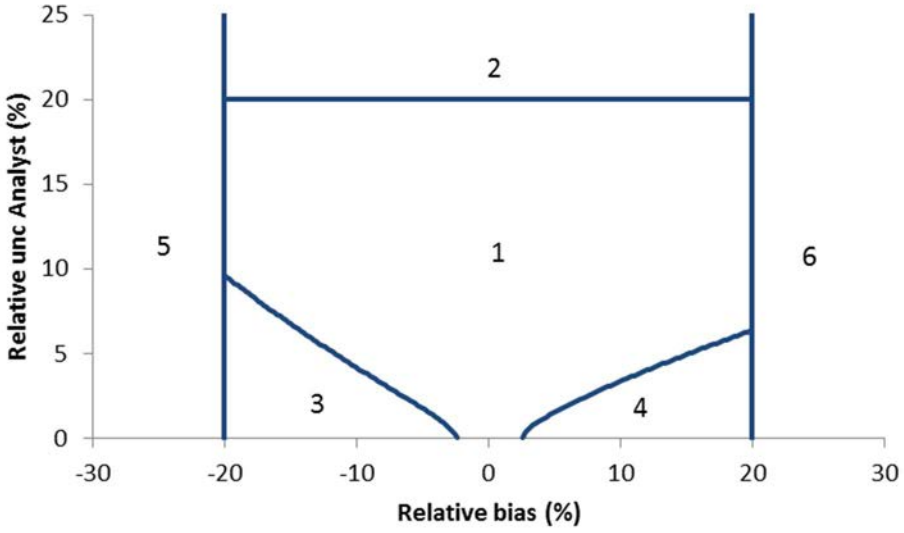

FIG. 1. Visualization of performance evaluation criteria.

The plot consists of six zones (Zone 1 'Accepted'; Zones 2, 3 and 4 'Warning'; Zones 5 and 6 'Not accepted'), whose areas are defined by the three tests used above to evaluate the data. The areas of Zones 1, 3 and 4 are finite, while the areas of Zones 2, 5 and 6 are infinite. A result located in Zone 1 passes all three tests (evaluation 'Accepted'). A result located in Zone 2 fails only the precision test as its associated uncertainty is deemed to be too large (evaluation: 'Warning'). A result located in Zones 3 and 4 fails only the trueness test as its associated uncertainty is deemed to be too small (evaluation: 'Warning'). A result located in Zones 5 and 6 fails (at least) the accuracy test as its relative bias is larger than the MARB (evaluation: 'Not accepted').

3.4. COMPARISON OF PARTICIPANTS' VALUES WITH THE IAEA VALUES

The means and the uncertainties for the combined participants' results were calculated according to a method developed by Cox (i.e. the weighted mean of the largest consistent subset containing p results) [8] and subsequently compared with the IAEA values. The mean of the combined participants' results, $Value_{\text{Combined}}$, was tested against the IAEA value, $Value_{\text{IAEA}}$, using this equation:

$$t = \frac{Value_{\text{Combined}} - Valu_{\text{IAEA}}}{\sqrt{(unc_{\text{Combined}})^2 + (unc_{\text{IAEA}})^2}} \quad (6)$$

The effective degrees of freedom v_{eff} were determined with the Welch-Satterthwaite equation. The effective degrees of freedom v_{eff} were rounded and the critical value t_{crit} for this value was identified.

The criterion for passing the t test was:

$$|t| < t_{\text{crit}} \quad (7)$$

If the absolute value of t was greater than the critical value t_{crit}, this indicates there was a significant difference between the combined participants' results and the IAEA value.

4. RESULTS AND DISCUSSION

In total 159 measurement results were reported by 55 laboratories from 30 countries for ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs. The evaluation of these results showed that 72% of all reported results were 'Accepted', while 17% of the individual measurement results were 'Not accepted' with the remaining 11% having the 'Warning' status. The performance evaluation for ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs is summarized in Table 3. The subset of the 50 Japanese participants' results showed that 84% of all reported results were 'Accepted', while 6% of the results were 'Not accepted', with the remaining 10% having the 'Warning' status.

TABLE 3. SUMMARY EVALUATION OF THE RADIONUCLIDES REPORTED

Radionuclide	Number of submitted results	Accepted	Warning	Not accepted
^{3}H	24 (10)	14 (7)	3 (1)	7 (2)
^{90}Sr	27 (8)	19 (5)	4 (3)	4 (0)
^{134}Cs	54 (16)	43 (15)	5 (1)	6 (0)
^{137}Cs	54 (16)	38 (15)	5 (0)	11 (1)

NOTE: The numbers in brackets represent the subset of Japanese results

For ^{134}Cs there was a significant negative bias of the combined participants' results (–2.8%), while there was no significant bias for ^{3}H (–1.0%), ^{90}Sr (–2.3%) and ^{137}Cs (2.2%) (see Table 4).

TABLE 4. COMPARISON OF THE COMBINED PARTICIPANTS' RESULTS WITH THE IAEA VALUE

Nuclide	Combined participants' result (Bq kg^{-1})	IAEA value (Bq kg^{-1})	Size of the LCS* (%)	*t*-value	Critical *t*-value	Bias (%)
^{3}H	1.395 ± 0.021	1.41 ± 0.05	18 (75%)	–0.30	2.07	–1.0
^{90}Sr	0.216 ± 0.004	0.2214 ± 0.0016	20 (74%)	–1.20	2.06	–2.3
^{134}Cs	0.2187 ± 0.0022	0.2250 ± 0.0009	49 (91%)	–2.67	2.00	–2.8
^{137}Cs	0.1804 ± 0.0021	0.1765 ± 0.0015	47 (87%)	1.50	1.99	2.2

*Size of the LCS (largest consistent subset) denotes the percentage of the returned results contributing to combined participants' results

For ^{3}H, ^{90}Sr and ^{137}Cs about half of the participants' results showed a negative bias (58%, 44% and 39% of the results, respectively), while for ^{134}Cs the 42 out of 54 participants' results (78% of the results) showed a negative bias. Coincidence summing is a problem for ^{134}Cs as it leads to signal loss and hence underestimation of the activity levels for this radionuclide. It is clear from the results that some participants did not make a sufficient correction for coincidence summing. For the combined Japanese results, there were no significant relative differences with the IAEA values for all four radionuclides. Table 5 summarizes the data evaluation sorted by laboratory code.

TABLE 5. SUMMARY EVALUATION

Lab code	^{3}H	^{90}Sr	^{134}Cs	^{137}Cs
1*	A	A	A	A
2*	W	W	A	A
3*	A	W	A	A
4*			A	A
5*			A	A
6*	A	W	A	A
7*	NA	A	A	A
8*			A	A
9*	A	A	A	A
10*			A	A
11*			A	A
12*	A			
13*	A		A	A
14*			A	NA
15*			A	A
16*	NA	A	W	A
17*	A	A	A	A
18			A	A
19	A		A	A
20		A	A	A
21			W	NA
22			A	A
23		A	NA	A
24	A	A	A	A
25		A	A	NA
26		A	A	A
27			A	A
28			A	A
29	A	A	A	A
30	A		A	A
31		A	A	A
32	W	A	A	NA
33		A	A	A
34	NA		A and W	A and A
35	NA	A	A	A
36	A		W	A
37		NA	A	A
38	W	A	A	A

TABLE 5. SUMMARY EVALUATION (cont.)

Lab code	^{3}H	^{90}Sr	^{134}Cs	^{137}Cs
39		A	NA	NA
40	NA	W	A	NA
41			A	W
42		NA	A	NA
43			NA	W
44	NA	NA	A	NA
45		A	A and A	A and A
46			W	W
47	A		A	A
48	A	A		
49			NA	W
50				
51	NA		NA	NA
52			NA	NA
53		NA	A	A
54			A	W
55			A	NA

A indicates 'Accepted', W indicates 'Warning' and NA indicates 'Not accepted'
* Participant from Japan

The performance evaluation sorted by radionuclide and the bias plots are presented in Appendix I (see Tables 6–9 and Figures 2–9). In the bias plots, the 'Accepted' results are represented by dark blue points. 'Warning' and 'Not accepted' results are represented by the yellow and red points, respectively. The error bars represent the standard uncertainties of the bias (with a coverage factor of $k = 1$). The dotted lines represent a relative bias of ± 25% or ± 20% (Maximum Accepted Bias for ^{3}H/^{90}Sr and ^{134}Cs/^{137}Cs, respectively). The performance evaluation sorted by laboratory code is presented in Appendix II. All laboratories reported their values with standard uncertainties ($k = 1$). However, a large spread in the submitted uncertainties was observed with relative uncertainties (at $k = 1$) ranging from 2.1% to 30% for ^{3}H, from 1.5% to 20% for ^{90}Sr, from 2.0% to 47% for ^{134}Cs and from 1.6% to 43% for ^{137}Cs. However, most reported relative uncertainties were in the range of 5% – 12% (^{3}H and ^{90}Sr), 6% – 10% (^{60}Co) and 3% – 10% (^{134}Cs and ^{137}Cs).

For ^{3}H, all participants performed a distillation of the sea water samples, followed by liquid scintillation counting (LSC). Six participants (9*, 12*, 17*, 19, 30 and 48) performed electrolytic enrichment after distillation (and obtained excellent results with, in general, small uncertainties of less than 8% at $k = 1$). The direct measurements after distillation yielded slightly larger uncertainties generally between 8% and 15%.
For ^{90}Sr, the large majority of participants used gas-flow proportional counting (GPC) of chemically separated ^{90}Y as the analysis technique, except Participants 20, 35, 39 and 45 who used LSC/Cherenkov counting. Chemical separation techniques used included precipitations of Sr-oxalate or Sr-carbonate, barium chromate precipitations, iron hydroxide precipitation, nitric acid precipitations, cation-exchange chromatography, Sr-extraction chromatography and direct liquid-liquid extraction of ^{90}Y with HDEHP (di-(2-ethylhexyl)phosphoric acid). No significant difference between the performances of the chemical separation techniques is apparent.

For ^{134}Cs and ^{137}Cs, a small majority of the participants measured the sea water samples directly with gamma spectrometry, while the remaining laboratories either used a pre-concentration technique (i.e. adsorption on ammonium molybdophosphate or Ni/Cu cyanoferrate) to separate the caesium radionuclides from the sea water matrix followed by gamma spectrometry (Participants 1*, 3*, 9*, 13* 15*, 16*, 17*, 22, 27, 33, 35, 38, 40, and 44), evaporation of the sample followed by gamma spectrometry (Participants 19 and 52) or they used a combination of techniques (Participants 23, 34, 45 and 51). No significant difference in the performance between the two techniques is apparent.

APPENDIX I. PERFORMANCE EVALUATION TABLES SORTED BY RADIONUCLIDE

TABLE 6. EVALUATION RESULTS FOR ^{3}H

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
1*	1.57	0.13	1.40	0.04	12	8.9	25	Pass	Pass	Pass	Accepted
2*	1.06	0.05	1.41	0.04	–25	5.7	12	Pass	Pass	Fail	Warning
3*	1.40	0.12	1.41	0.04	0	9.1	23	Pass	Pass	Pass	Accepted
4*	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
5*	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
6*	1.64	0.17	1.42	0.05	16	11	32	Pass	Pass	Pass	Accepted
7*	0.93	0.13	1.41	0.04	–34	14	25	Fail	Pass	Fail	Not accepted
8*	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
9*	1.39	0.04	1.41	0.04	–1	4.2	11	Pass	Pass	Pass	Accepted
10*	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
11*	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
12*	1.36	0.07	1.41	0.04	–3	6.1	15	Pass	Pass	Pass	Accepted
13*	1.56	0.18	1.41	0.05	10	12	33	Pass	Pass	Pass	Accepted
14*	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
15*	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
16*	2.40	0.13	1.41	0.04	70	6.4	26	Fail	Pass	Fail	Not accepted
17*	1.30	0.06	1.41	0.04	–8	5.6	14	Pass	Pass	Pass	Accepted
18	–	–	1.40	0.04	–	–	–	–	–	–	Not reported

TABLE 6. EVALUATION RESULTS FOR ^{3}H (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
19	1.22	0.16	1.41	0.04	–13	13	30	Pass	Pass	Pass	Accepted
20	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
21	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
22	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
23	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
24	1.56	0.23	1.41	0.04	11	15	43	Pass	Pass	Pass	Accepted
25	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
26	< 5.2	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
27	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
28	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
29	1.38	0.11	1.41	0.04	–2	8.6	22	Pass	Pass	Pass	Accepted
30	1.43	0.03	1.41	0.04	1	3.8	10	Pass	Pass	Pass	Accepted
31	–	–	1.42	0.05	–	–	–	–	–	–	Not reported
32	1.1	0.3	1.41	0.04	–22	27	55	Pass	Fail	Pass	Warning
33	< 2.0	–	1.42	0.05	–	–	–	–	–	–	Not evaluated
34	0.90	0.24	1.41	0.04	–36	27	45	Fail	Fail	Pass	Not accepted
35	2.9	0.9	1.41	0.05	106	30	159	Fail	Fail	Pass	Not accepted
36	1.5	0.3	1.41	0.04	9	20	57	Pass	Pass	Pass	Accepted
37	–	–	1.41	0.04	–	–	–	–	–	–	Not reported

TABLE 6. EVALUATION RESULTS FOR ^{3}H (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
38	1.3	0.4	1.41	0.04	–6	27	66	Pass	Fail	Pass	Warning
39	< 0.7	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
40	19.6	1.6	1.41	0.04	1286	8.8	292	Fail	Pass	Fail	Not accepted
41	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
42	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
43	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
44	7.0	0.7	1.41	0.04	399	11	134	Fail	Pass	Fail	Not accepted
45	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
46	< 4.5	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
47	1.34	0.12	1.41	0.04	–5	10	23	Pass	Pass	Pass	Accepted
48	1.27	0.10	1.41	0.04	–10	8.5	20	Pass	Pass	Pass	Accepted
49	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
50	< 3.3	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
51	0.85	0.08	1.41	0.04	–40	10	16	Fail	Pass	Fail	Not accepted
52	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
53	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
54	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
55	–	–	1.42	0.05	–	–	–	–	–	–	Not reported

TABLE 7. EVALUATION RESULTS FOR ^{90}Sr

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
1*	0.231	0.017	0.2203	0.0016	5	7.4	20	Pass	Pass	Pass	Accepted
2*	0.254	0.009	0.2214	0.0016	15	3.6	11	Pass	Pass	Fail	Warning
3*	0.190	0.006	0.2204	0.0016	–14	3.2	7.2	Pass	Pass	Fail	Warning
4*	–	–	0.2218	0.0016	–	–	–	–	–	–	Not reported
5*	–	–	0.2211	0.0016	–	–	–	–	–	–	Not reported
6*	0.242	0.004	0.2222	0.0016	8.8	1.6	4.5	Pass	Pass	Fail	Warning
7*	0.217	0.013	0.2215	0.0016	–2	6.0	15	Pass	Pass	Pass	Accepted
8*	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
9*	0.24	0.03	0.2217	0.0016	10	11	31	Pass	Pass	Pass	Accepted
10*	–	–	0.2215	0.0016	–	–	–	–	–	–	Not reported
11*	–	–	0.2206	0.0016	–	–	–	–	–	–	Not reported
12*	–	–	0.2207	0.0016	–	–	–	–	–	–	Not reported
13*	–	–	0.2219	0.0016	–	–	–	–	–	–	Not reported
14*	–	–	0.2217	0.0016	–	–	–	–	–	–	Not reported
15*	–	–	0.2215	0.0016	–	–	–	–	–	–	Not reported
16*	0.222	0.010	0.2215	0.0016	0	4.6	12	Pass	Pass	Pass	Accepted
17*	0.203	0.017	0.2209	0.0016	–8	8.4	20	Pass	Pass	Pass	Accepted
18	–	–	0.2203	0.0016	–	–	–	–	–	–	Not reported
19	–	–	0.2205	0.0016	–	–	–	–	–	–	Not reported

TABLE 7. EVALUATION RESULTS FOR ^{90}Sr (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
20	0.203	0.010	0.2214	0.0016	–8	5.0	12	Pass	Pass	Pass	Accepted
21	–	–	0.2209	0.0016	–	–	–	–	–	–	Not reported
22	–	–	0.2213	0.0016	–	–	–	–	–	–	Not reported
23	0.22	0.04	0.2206	0.0016	1.1	17	44	Pass	Pass	Pass	Accepted
24	0.200	0.013	0.2214	0.0016	–10	6.3	15	Pass	Pass	Pass	Accepted
25	0.27	0.05	0.2217	0.0016	22	19	58	Pass	Pass	Pass	Accepted
26	0.252	0.019	0.2213	0.0016	14	7.7	22	Pass	Pass	Pass	Accepted
27	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
28	–	–	0.2209	0.0016	–	–	–	–	–	–	Not reported
29	0.204	0.013	0.2211	0.0016	–8	6.4	15	Pass	Pass	Pass	Accepted
30	–	–	0.2216	0.0016	–	–	–	–	–	–	Not reported
31	0.246	0.013	0.2223	0.0016	10	5.3	15	Pass	Pass	Pass	Accepted
32	0.234	0.016	0.2210	0.0016	6	6.9	19	Pass	Pass	Pass	Accepted
33	0.225	0.023	0.2223	0.0016	1	10	27	Pass	Pass	Pass	Accepted
34	–	–	0.2210	0.0016	–	–	–	–	–	–	Not reported
35	0.25	0.05	0.2219	0.0016	13	20	58	Pass	Pass	Pass	Accepted
36	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
37	0.163	0.019	0.2215	0.0016	–26	12	22	Fail	Pass	Fail	Not accepted
38	0.225	0.014	0.2216	0.0016	2	6.3	16	Pass	Pass	Pass	Accepted

TABLE 7. EVALUATION RESULTS FOR ^{90}Sr (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
39	0.22	0.03	0.2213	0.0016	1	14	36	Pass	Pass	Pass	Accepted
40	0.190	0.010	0.2216	0.0016	–14	5.3	12	Pass	Pass	Fail	Warning
41	–	–	0.2219	0.0016	–	–	–	–	–	–	Not reported
42	0.055	0.007	0.2211	0.0016	–75	12	8.1	Fail	Pass	Fail	Not accepted
43	–	–	0.2217	0.0016	–	–	–	–	–	–	Not reported
44	0.107	0.012	0.2204	0.0016	–51	11	14	Fail	Pass	Fail	Not accepted
45	0.225	0.022	0.2210	0.0016	2	10	26	Pass	Pass	Pass	Accepted
46	–	–	0.2212	0.0016	–	–	–	–	–	–	Not reported
47	–	–	0.2210	0.0016	–	–	–	–	–	–	Not reported
48	0.216	0.013	0.2211	0.0016	–2	6.1	15	Pass	Pass	Pass	Accepted
49	–	–	0.2212	0.0016	–	–	–	–	–	–	Not reported
50	–	–	0.2211	0.0016	–	–	–	–	–	–	Not reported
51	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
52	–	–	0.2210	0.0016	–	–	–	–	–	–	Not reported
53	0.066	0.003	0.2222	0.0016	–70	4.4	3.8	Fail	Pass	Fail	Not accepted
54	–	–	0.2212	0.0016	–	–	–	–	–	–	Not reported
55	–	–	0.2226	0.0016	–	–	–	–	–	–	Not reported

TABLE 8. EVALUATION RESULTS FOR ^{134}Cs

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
1*	0.219	0.015	0.2240	0.0009	–2	6.9	17	Pass	Pass	Pass	Accepted
2*	0.236	0.009	0.2251	0.0009	5	3.8	10	Pass	Pass	Pass	Accepted
3*	0.230	0.005	0.2242	0.0009	2.6	2.1	5.5	Pass	Pass	Pass	Accepted
4*	0.241	0.009	0.2256	0.0009	7	3.9	11	Pass	Pass	Pass	Accepted
5*	0.220	0.009	0.2249	0.0009	–2	4.2	11	Pass	Pass	Pass	Accepted
6*	0.206	0.022	0.2260	0.0009	–9	11	25	Pass	Pass	Pass	Accepted
7*	0.191	0.018	0.2253	0.0009	–15	9.4	21	Pass	Pass	Pass	Accepted
8*	0.205	0.022	0.2245	0.0009	–9	11	25	Pass	Pass	Pass	Accepted
9*	0.210	0.012	0.2254	0.0009	–7	5.6	13	Pass	Pass	Pass	Accepted
10*	0.218	0.023	0.2252	0.0009	–3	11	26	Pass	Pass	Pass	Accepted
11*	0.191	0.015	0.2244	0.0009	–15	7.9	17	Pass	Pass	Pass	Accepted
12*	–	–	0.2244	0.0009	–	–	–	–	–	–	Not reported
13*	0.225	0.011	0.2257	0.0009	0	4.8	12	Pass	Pass	Pass	Accepted
14*	0.228	0.016	0.2255	0.0009	1	7.0	18	Pass	Pass	Pass	Accepted
15*	0.239	0.013	0.2253	0.0009	6	5.3	15	Pass	Pass	Pass	Accepted
16*	0.198	0.010	0.2252	0.0009	–12	5.0	11	Pass	Pass	Fail	Warning
17*	0.218	0.010	0.2246	0.0009	–3	4.6	12	Pass	Pass	Pass	Accepted
18	0.225	0.016	0.2240	0.0009	0	7.1	18	Pass	Pass	Pass	Accepted
19	0.219	0.013	0.2243	0.0009	–2	5.9	15	Pass	Pass	Pass	Accepted

TABLE 8. EVALUATION RESULTS FOR ^{134}Cs (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
20	0.199	0.013	0.2252	0.0009	–12	6.5	15	Pass	Pass	Pass	Accepted
21	0.20	0.04	0.2246	0.0009	–11	20	46	Pass	Fail	Pass	Warning
22	0.210	0.008	0.2251	0.0009	–7	3.8	9.2	Pass	Pass	Pass	Accepted
23	0.176	0.010	0.2244	0.0009	–22	5.7	12	Fail	Pass	Fail	Not accepted
24	0.254	0.019	0.2252	0.0009	13	7.5	22	Pass	Pass	Pass	Accepted
25	0.240	0.020	0.2254	0.0009	6	8.3	23	Pass	Pass	Pass	Accepted
26	0.220	0.020	0.2251	0.0009	–2	9.1	23	Pass	Pass	Pass	Accepted
27	0.23	0.03	0.2246	0.0009	3	11	30	Pass	Pass	Pass	Accepted
28	0.210	0.010	0.2246	0.0009	–7	4.8	12	Pass	Pass	Pass	Accepted
29	0.220	0.013	0.2249	0.0009	–2	5.8	15	Pass	Pass	Pass	Accepted
30	0.218	0.010	0.2254	0.0009	–3	4.6	11	Pass	Pass	Pass	Accepted
31	0.226	0.017	0.2261	0.0009	0	7.6	20	Pass	Pass	Pass	Accepted
32	0.222	0.022	0.2247	0.0009	–1	9.9	25	Pass	Pass	Pass	Accepted
33	0.235	0.016	0.2261	0.0009	4	6.8	18	Pass	Pass	Pass	Accepted
34A	0.191	0.014	0.2248	0.0009	–15	7.3	16	Pass	Pass	Pass	Accepted
34B	0.191	0.008	0.2248	0.0009	–15	4.2	9.2	Pass	Pass	Fail	Warning
35	0.20	0.03	0.2257	0.0009	–14	14	31	Pass	Pass	Pass	Accepted
36	0.186	0.011	0.2246	0.0009	–17	5.8	12	Pass	Pass	Fail	Warning
37	0.203	0.019	0.2252	0.0009	–10	9.4	22	Pass	Pass	Pass	Accepted

TABLE 8. EVALUATION RESULTS FOR ^{134}Cs (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
38	0.220	0.020	0.2253	0.0009	–2	9.1	23	Pass	Pass	Pass	Accepted
39	0.151	0.018	0.2250	0.0009	–33	12	21	Fail	Pass	Fail	Not accepted
40	0.190	0.020	0.2253	0.0009	–16	11	23	Pass	Pass	Pass	Accepted
41	0.18	0.03	0.2257	0.0009	–18	15	31	Pass	Pass	Pass	Accepted
42	0.21	0.04	0.2248	0.0009	–8	18	42	Pass	Pass	Pass	Accepted
43	0.15	0.07	0.2255	0.0009	–33	47	82	Fail	Fail	Pass	Not accepted
44	0.208	0.014	0.2241	0.0009	–7	6.5	16	Pass	Pass	Pass	Accepted
45A	0.209	0.013	0.2247	0.0009	–7	6.2	15	Pass	Pass	Pass	Accepted
45B	0.217	0.019	0.2247	0.0009	–3	8.6	21	Pass	Pass	Pass	Accepted
46	0.19	0.04	0.2249	0.0009	–16	20	44	Pass	Fail	Pass	Warning
47	0.210	0.020	0.2248	0.0009	–7	9.5	23	Pass	Pass	Pass	Accepted
48	–	–	0.2249	0.0009	–	–	–	–	–	–	Not reported
49	0.28	0.04	0.2249	0.0009	26	13	44	Fail	Pass	Pass	Not accepted
50	–	–	0.2249	0.0009	–	–	–	–	–	–	Not reported
51	0.137	0.016	0.2245	0.0009	–39	12	18	Fail	Pass	Fail	Not accepted
52	0.161	0.025	0.2248	0.0009	–28	16	29	Fail	Pass	Pass	Not accepted
53	0.211	0.011	0.2260	0.0009	–7	5.1	12	Pass	Pass	Pass	Accepted
54	0.200	0.020	0.2249	0.0009	–11	10	23	Pass	Pass	Pass	Accepted
55	0.246	0.021	0.2264	0.0009	9	8.4	23	Pass	Pass	Pass	Accepted

TABLE 9. EVALUATION RESULTS FOR ^{137}Cs

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
1*	0.187	0.012	0.1757	0.0014	6	6.5	18	Pass	Pass	Pass	Accepted
2*	0.163	0.011	0.1766	0.0015	–8	6.8	16	Pass	Pass	Pass	Accepted
3*	0.170	0.003	0.1759	0.0014	–3.3	1.8	4.6	Pass	Pass	Pass	Accepted
4*	0.212	0.017	0.1770	0.0015	20	8.0	25	Pass	Pass	Pass	Accepted
5*	0.180	0.008	0.1764	0.0015	2	4.7	12	Pass	Pass	Pass	Accepted
6*	0.182	0.016	0.1773	0.0015	3	8.8	23	Pass	Pass	Pass	Accepted
7*	0.173	0.020	0.1767	0.0015	–2	12	29	Pass	Pass	Pass	Accepted
8*	0.207	0.021	0.1761	0.0015	18	10	31	Pass	Pass	Pass	Accepted
9*	0.171	0.009	0.1769	0.0015	–3	5.1	13	Pass	Pass	Pass	Accepted
10*	0.162	0.025	0.1767	0.0015	–8	15	37	Pass	Pass	Pass	Accepted
11*	0.185	0.016	0.1760	0.0015	5	8.7	24	Pass	Pass	Pass	Accepted
12*	–	–	0.1761	0.0015	–	–	–	–	–	–	Not reported
13*	0.169	0.009	0.1770	0.0015	–5	5.4	13	Pass	Pass	Pass	Accepted
14*	0.121	0.014	0.1769	0.0015	–32	12	20	Fail	Pass	Fail	Not accepted
15*	0.196	0.012	0.1767	0.0015	11	6.1	17	Pass	Pass	Pass	Accepted
16*	0.158	0.008	0.1767	0.0015	–11	4.9	11	Pass	Pass	Pass	Accepted
17*	0.171	0.008	0.1762	0.0015	–3	4.8	12	Pass	Pass	Pass	Accepted
18	0.176	0.017	0.1757	0.0014	0	9.7	25	Pass	Pass	Pass	Accepted
19	0.165	0.012	0.1760	0.0014	–6	7.3	18	Pass	Pass	Pass	Accepted

TABLE 9. EVALUATION RESULTS FOR ^{137}Cs (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
20	0.162	0.013	0.1766	0.0015	–8	8.1	19	Pass	Pass	Pass	Accepted
21	0.31	0.04	0.1762	0.0015	76	14	63	Fail	Pass	Fail	Not accepted
22	0.177	0.004	0.1766	0.0015	0.2	2.4	6.2	Pass	Pass	Pass	Accepted
23	0.165	0.008	0.1760	0.0015	–6	4.9	12	Pass	Pass	Pass	Accepted
24	0.179	0.014	0.1767	0.0015	1	7.9	21	Pass	Pass	Pass	Accepted
25	0.220	0.020	0.1769	0.0015	24	9.1	29	Fail	Pass	Pass	Not accepted
26	0.19	0.03	0.1766	0.0015	8	16	44	Pass	Pass	Pass	Accepted
27	0.174	0.013	0.1762	0.0015	–1	7.5	19	Pass	Pass	Pass	Accepted
28	0.200	0.010	0.1762	0.0015	13	5.1	15	Pass	Pass	Pass	Accepted
29	0.210	0.017	0.1764	0.0015	19	7.9	24	Pass	Pass	Pass	Accepted
30	0.195	0.020	0.1768	0.0015	10	10	29	Pass	Pass	Pass	Accepted
31	0.182	0.019	0.1773	0.0015	2	11	28	Pass	Pass	Pass	Accepted
32	0.215	0.017	0.1763	0.0015	22	7.9	25	Fail	Pass	Pass	Not accepted
33	0.178	0.012	0.1773	0.0015	0	6.8	18	Pass	Pass	Pass	Accepted
34A	0.196	0.023	0.1763	0.0015	11	12	34	Pass	Pass	Pass	Accepted
34B	0.189	0.009	0.1763	0.0015	7	4.8	13	Pass	Pass	Pass	Accepted
35	0.20	0.03	0.1770	0.0015	15	13	39	Pass	Pass	Pass	Accepted
36	0.154	0.009	0.1762	0.0015	–12	6.0	13	Pass	Pass	Pass	Accepted
37	0.197	0.019	0.1767	0.0015	11	9.7	28	Pass	Pass	Pass	Accepted

TABLE 9. EVALUATION RESULTS FOR ^{137}Cs (cont.)

Lab code	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
38	0.196	0.018	0.1768	0.0015	11	9.2	26	Pass	Pass	Pass	Accepted
39	0.139	0.020	0.1765	0.0015	–21	14	29	Fail	Pass	Pass	Not accepted
40	0.214	0.020	0.1768	0.0015	21	9.4	29	Fail	Pass	Pass	Not accepted
41	0.18	0.07	0.1770	0.0015	–1	40	102	Pass	Fail	Pass	Warning
42	0.21	0.04	0.1764	0.0015	21	17	53	Fail	Pass	Pass	Not accepted
43	0.15	0.07	0.1769	0.0015	–15	43	95	Pass	Fail	Pass	Warning
44	0.237	0.016	0.1759	0.0014	35	6.6	23	Fail	Pass	Fail	Not accepted
45A	0.185	0.009	0.1763	0.0015	5	5.0	13	Pass	Pass	Pass	Accepted
45B	0.19	0.03	0.1763	0.0015	8	15	43	Pass	Pass	Pass	Accepted
46	0.18	0.05	0.1764	0.0015	2	26	67	Pass	Fail	Pass	Warning
47	0.200	0.020	0.1763	0.0015	13	10	29	Pass	Pass	Pass	Accepted
48	–	–	0.1764	0.0015	–	–	–	–	–	–	Not reported
49	0.17	0.04	0.1765	0.0015	–2	21	53	Pass	Fail	Pass	Warning
50	–	–	0.1764	0.0015	–	–	–	–	–	–	Not reported
51	0.132	0.013	0.1761	0.0015	–25	10	19	Fail	Pass	Fail	Not accepted
52	0.141	0.024	0.1764	0.0015	–20	17	35	Fail	Pass	Pass	Not accepted
53	0.179	0.012	0.1773	0.0015	1	6.5	17	Pass	Pass	Pass	Accepted
54	0.17	0.04	0.1765	0.0015	–4	24	58	Pass	Fail	Pass	Warning
55	0.224	0.017	0.1776	0.0015	26	7.5	24	Fail	Pass	Fail	Not accepted

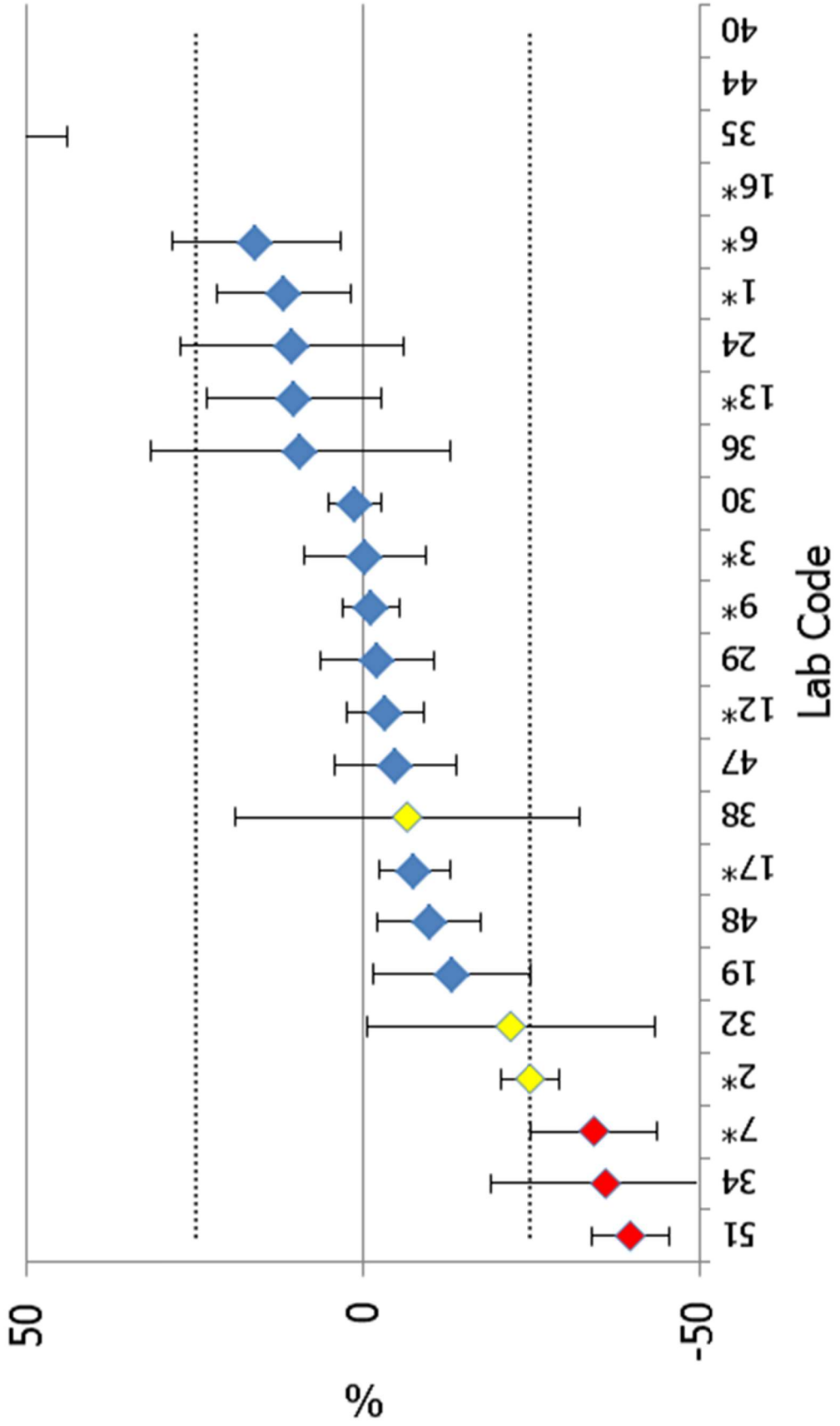
50
0
-50
%
Lab Code
51
34
7*
2*
32
19
48
17*
38
47
12*
29
9*
3*
30
36
13*
24
1*
6*
16*
35
44
40

FIG. 2. H-3 bias.

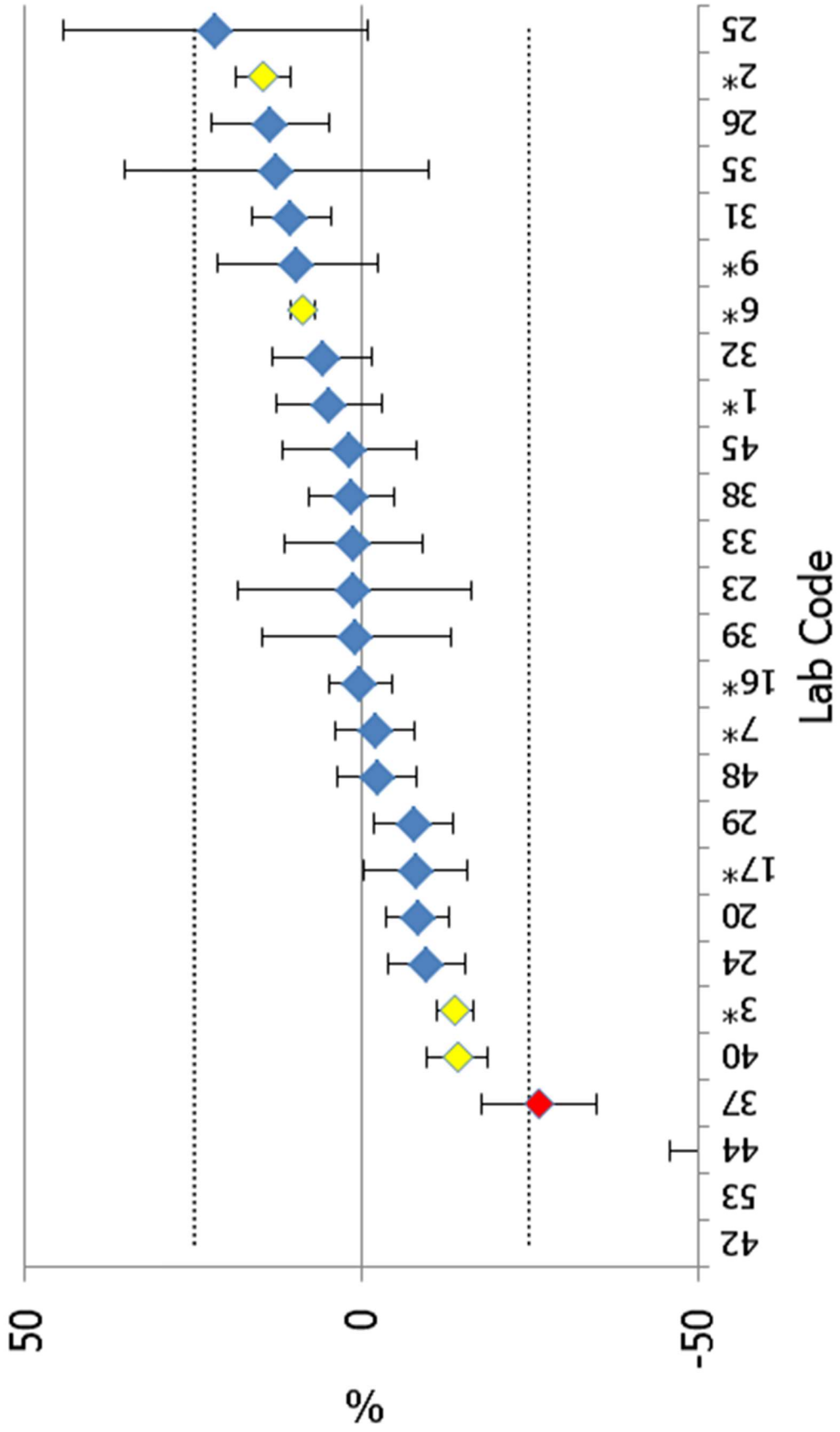

FIG. 3. Sr-90 bias.

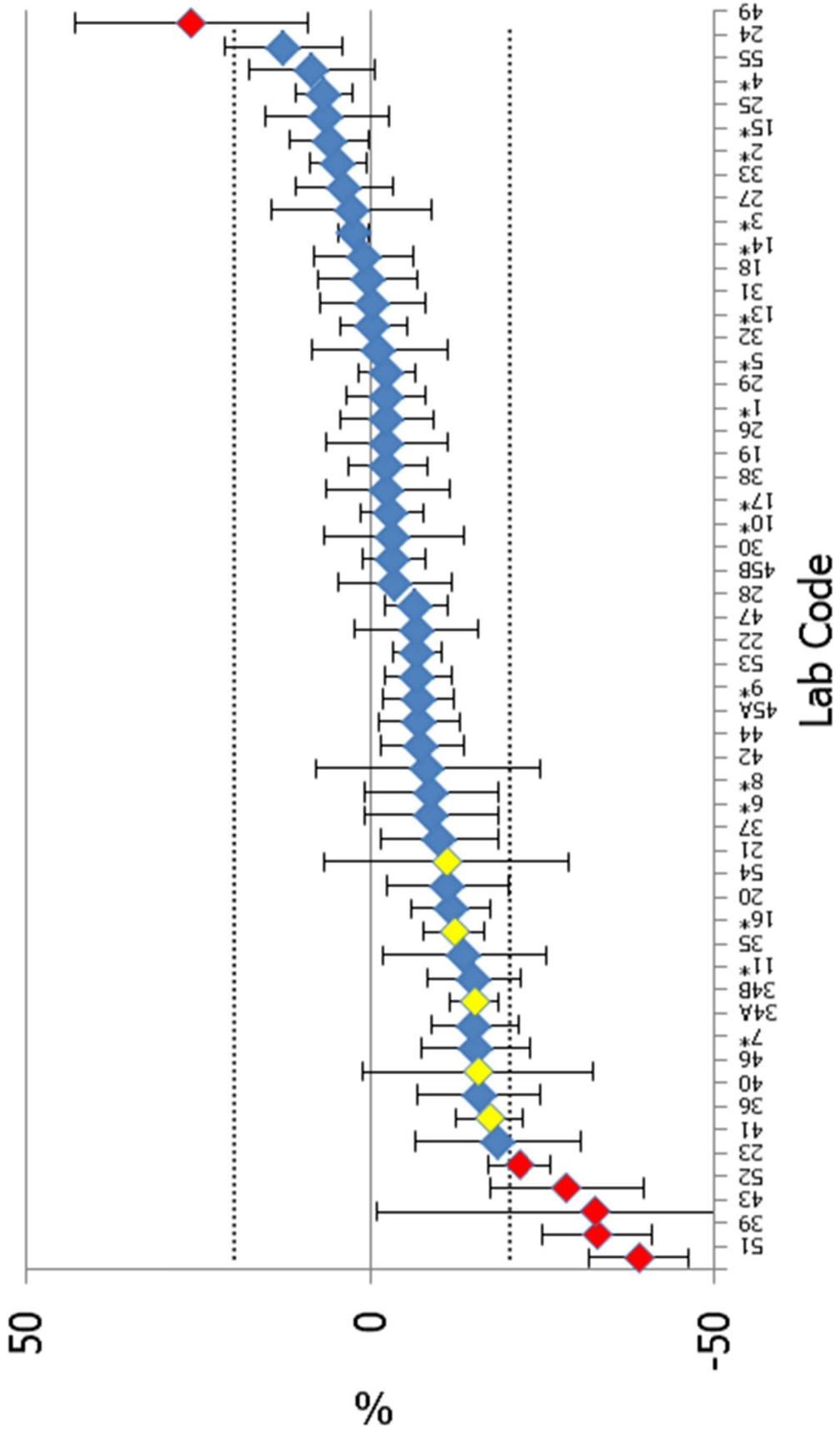

FIG. 4. Cs-134 bias.

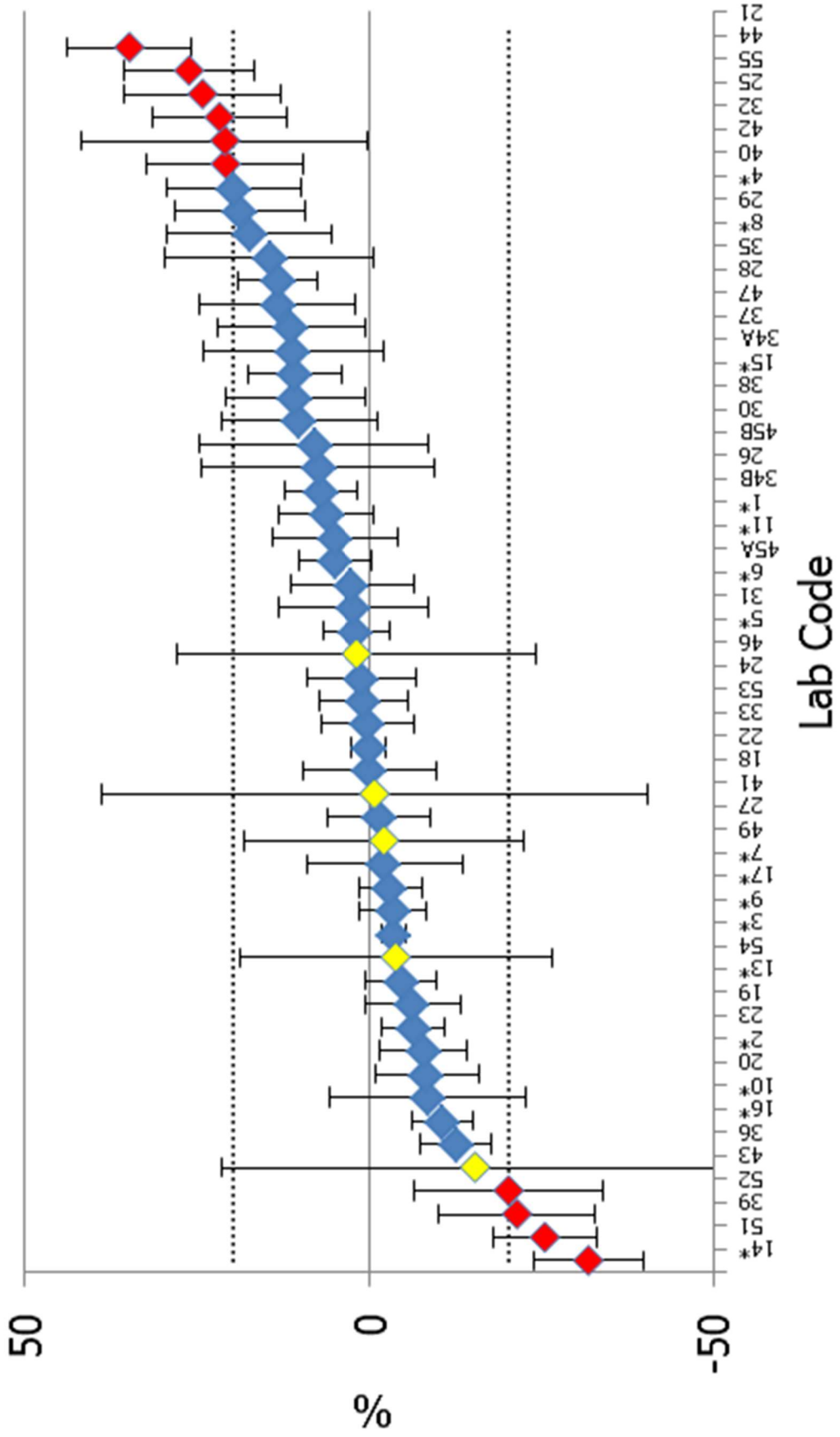

FIG. 5. Cs-137 bias.

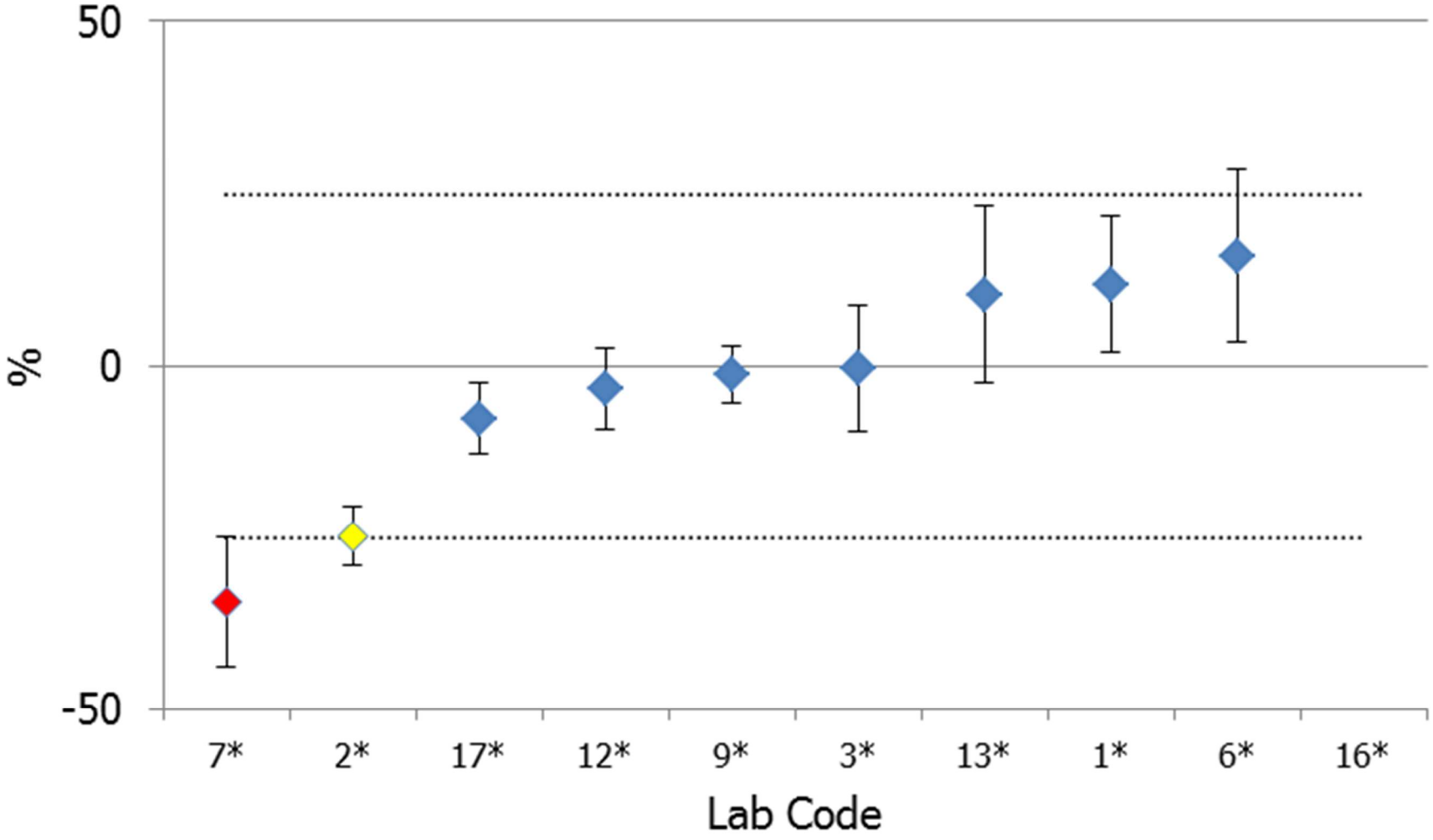

FIG. 6. H-3 bias Japanese participants.

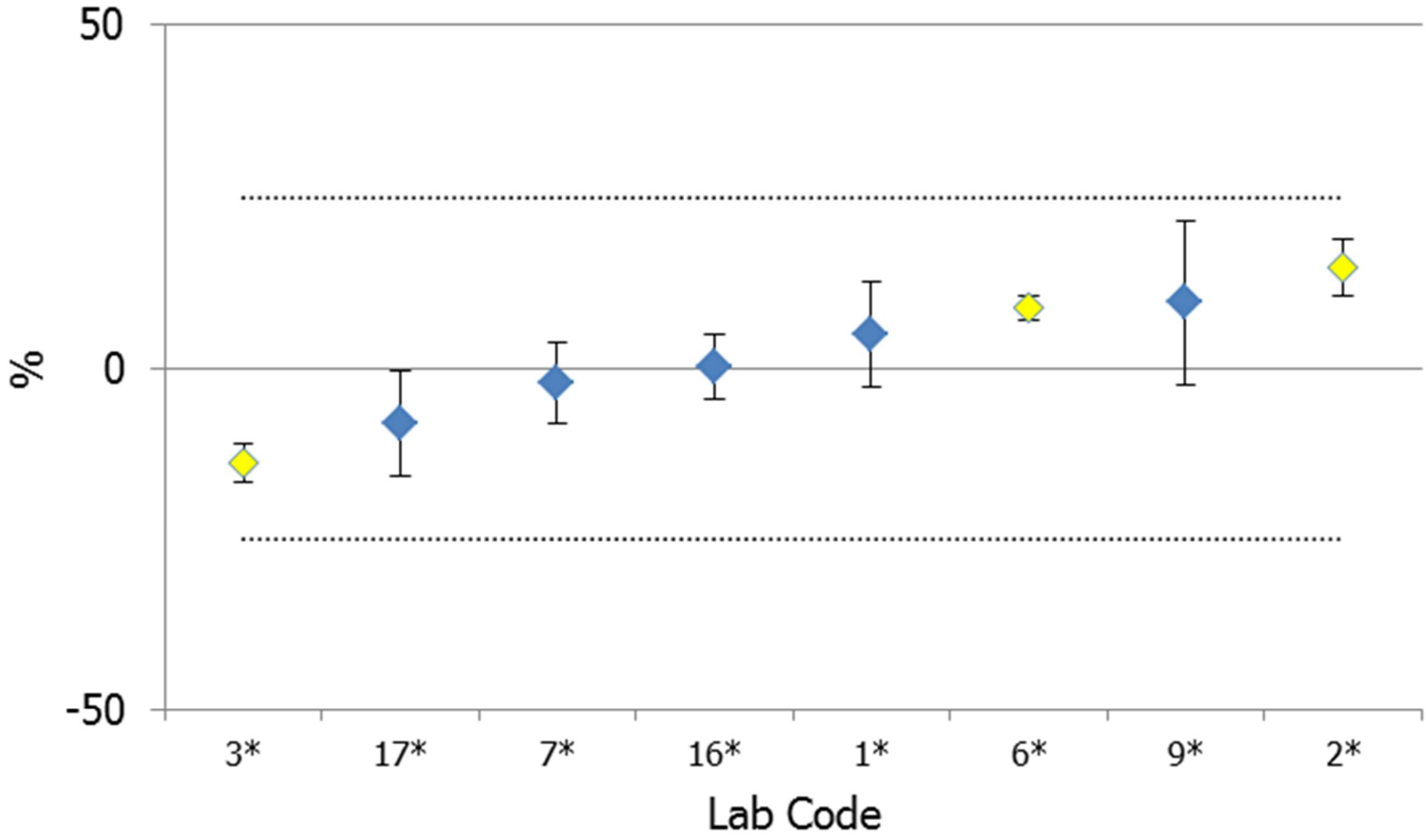

FIG. 7. Sr-90 bias Japanese participants.

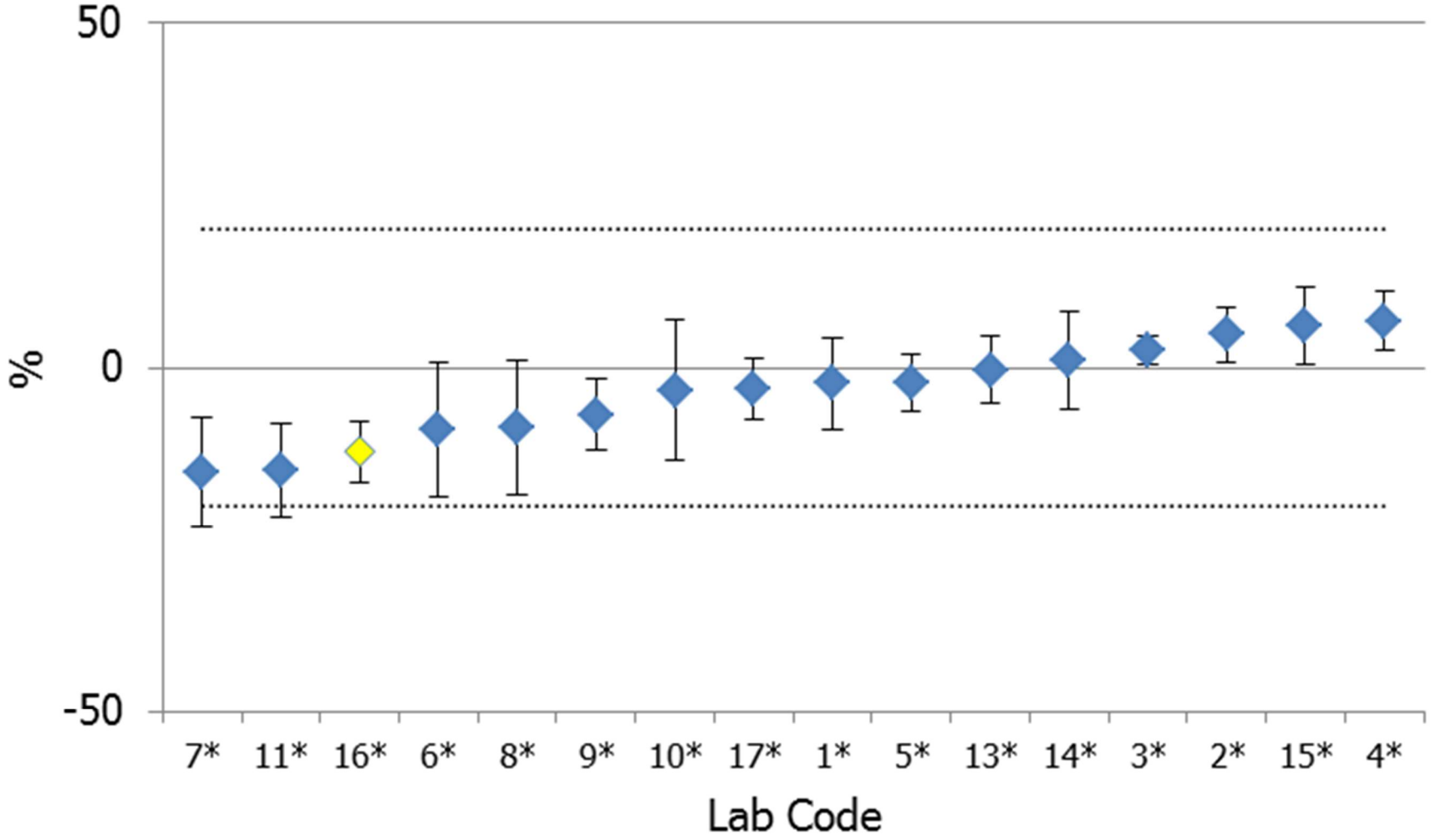

FIG. 8. Cs-134 bias Japanese participants.

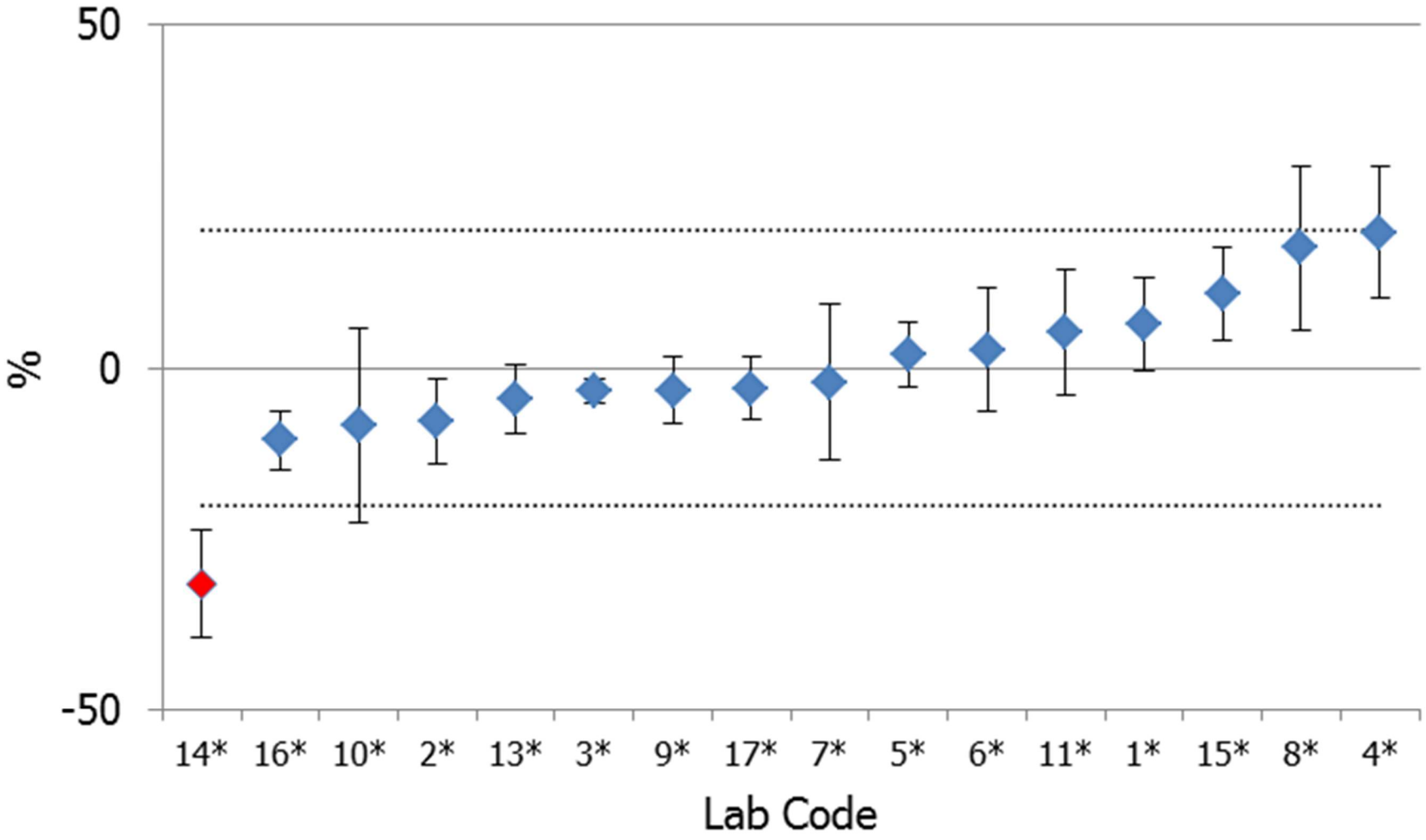

FIG. 9. Cs-137 bias Japanese participants.

APPENDIX II. PERFORMANCE EVALUATION TABLES SORTED BY LABORATORY CODE

TABLE 10. LABORATORY CODE 1*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.57	0.13	1.40	0.04	12	8.9	25	Pass	Pass	Pass	Accepted
^{90}Sr	0.231	0.017	0.2203	0.0016	5	7.4	20	Pass	Pass	Pass	Accepted
^{134}Cs	0.219	0.015	0.2240	0.0009	–2	6.9	17	Pass	Pass	Pass	Accepted
^{137}Cs	0.187	0.012	0.1757	0.0014	6	6.5	18	Pass	Pass	Pass	Accepted

TABLE 11. LABORATORY CODE 2*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.06	0.05	1.41	0.04	–25	5.7	12	Pass	Pass	Fail	Warning
^{90}Sr	0.254	0.009	0.2214	0.0016	15	3.6	11	Pass	Pass	Fail	Warning
^{134}Cs	0.236	0.009	0.2251	0.0009	5	3.8	10	Pass	Pass	Pass	Accepted
^{137}Cs	0.163	0.011	0.1766	0.0015	–8	6.8	16	Pass	Pass	Pass	Accepted

TABLE 12. LABORATORY CODE 3*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.40	0.12	1.41	0.04	0	9.1	23	Pass	Pass	Pass	Accepted
^{90}Sr	0.190	0.006	0.2204	0.0016	–14	3.2	7.2	Pass	Pass	Fail	Warning
^{134}Cs	0.230	0.005	0.2242	0.0009	2.6	2.1	5.5	Pass	Pass	Pass	Accepted
^{137}Cs	0.170	0.003	0.1759	0.0014	–3.3	1.8	4.6	Pass	Pass	Pass	Accepted

TABLE 13. LABORATORY CODE 4*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2218	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.241	0.009	0.2256	0.0009	7	3.9	11	Pass	Pass	Pass	Accepted
^{137}Cs	0.212	0.017	0.1770	0.0015	20	8.0	25	Pass	Pass	Pass	Accepted

TABLE 14. LABORATORY CODE 5*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2211	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.220	0.009	0.2249	0.0009	–2	4.2	11	Pass	Pass	Pass	Accepted
^{137}Cs	0.180	0.008	0.1764	0.0015	2	4.7	12	Pass	Pass	Pass	Accepted

TABLE 15. LABORATORY CODE 6*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.64	0.17	1.42	0.05	16	11	32	Pass	Pass	Pass	Accepted
^{90}Sr	0.242	0.004	0.2222	0.0016	8.8	1.6	4.5	Pass	Pass	Fail	Warning
^{134}Cs	0.206	0.022	0.2260	0.0009	–9	11	25	Pass	Pass	Pass	Accepted
^{137}Cs	0.182	0.016	0.1773	0.0015	3	8.8	23	Pass	Pass	Pass	Accepted

TABLE 16. LABORATORY CODE 7*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	0.93	0.13	1.41	0.04	–34	14	25	Fail	Pass	Fail	Not accepted
^{90}Sr	0.217	0.013	0.2215	0.0016	–2	6.0	15	Pass	Pass	Pass	Accepted
^{134}Cs	0.191	0.018	0.2253	0.0009	–15	9.4	21	Pass	Pass	Pass	Accepted
^{137}Cs	0.173	0.020	0.1767	0.0015	–2	12	29	Pass	Pass	Pass	Accepted

TABLE 17. LABORATORY CODE 8*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.205	0.022	0.2245	0.0009	–9	11	25	Pass	Pass	Pass	Accepted
^{137}Cs	0.207	0.021	0.1761	0.0015	18	10	31	Pass	Pass	Pass	Accepted

TABLE 18. LABORATORY CODE 9*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.39	0.04	1.41	0.04	–1	4.2	11	Pass	Pass	Pass	Accepted
^{90}Sr	0.24	0.03	0.2217	0.0016	10	11	31	Pass	Pass	Pass	Accepted
^{134}Cs	0.210	0.012	0.2254	0.0009	–7	5.6	13	Pass	Pass	Pass	Accepted
^{137}Cs	0.171	0.009	0.1769	0.0015	–3	5.1	13	Pass	Pass	Pass	Accepted

TABLE 19. LABORATORY CODE 10*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2215	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.218	0.023	0.2252	0.0009	–3	11	26	Pass	Pass	Pass	Accepted
^{137}Cs	0.162	0.025	0.1767	0.0015	–8	15	37	Pass	Pass	Pass	Accepted

TABLE 20. LABORATORY CODE 11*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2206	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.191	0.015	0.2244	0.0009	–15	7.9	17	Pass	Pass	Pass	Accepted
^{137}Cs	0.185	0.016	0.1760	0.0015	5	8.7	24	Pass	Pass	Pass	Accepted

TABLE 21. LABORATORY CODE 12*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.36	0.07	1.41	0.04	–3	6.1	15	Pass	Pass	Pass	Accepted
^{90}Sr	–	–	0.2207	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	–	–	0.2244	0.0009	–	–	–	–	–	–	Not reported
^{137}Cs	–	–	0.1761	0.0015	–	–	–	–	–	–	Not reported

TABLE 22. LABORATORY CODE 13*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.56	0.18	1.41	0.05	10	12	33	Pass	Pass	Pass	Accepted
^{90}Sr	–	–	0.2219	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.225	0.011	0.2257	0.0009	0	4.8	12	Pass	Pass	Pass	Accepted
^{137}Cs	0.169	0.009	0.1770	0.0015	–5	5.4	13	Pass	Pass	Pass	Accepted

TABLE 23. LABORATORY CODE 14*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2217	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.228	0.016	0.2255	0.0009	1	7.0	18	Pass	Pass	Pass	Accepted
^{137}Cs	0.121	0.014	0.1769	0.0015	–32	12	20	Fail	Pass	Fail	Not accepted

TABLE 24. LABORATORY CODE 15*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2215	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.239	0.013	0.2253	0.0009	6	5.3	15	Pass	Pass	Pass	Accepted
^{137}Cs	0.196	0.012	0.1767	0.0015	11	6.1	17	Pass	Pass	Pass	Accepted

TABLE 25. LABORATORY CODE 16*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	2.40	0.13	1.41	0.04	70	6.4	26	Fail	Pass	Fail	Not accepted
^{90}Sr	0.222	0.010	0.2215	0.0016	0	4.6	12	Pass	Pass	Pass	Accepted
^{134}Cs	0.198	0.010	0.2252	0.0009	–12	5.0	11	Pass	Pass	Fail	Warning
^{137}Cs	0.158	0.008	0.1767	0.0015	–11	4.9	11	Pass	Pass	Pass	Accepted

TABLE 26. LABORATORY CODE 17*

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.30	0.06	1.41	0.04	–8	5.6	14	Pass	Pass	Pass	Accepted
^{90}Sr	0.203	0.017	0.2209	0.0016	–8	8.4	20	Pass	Pass	Pass	Accepted
^{134}Cs	0.218	0.010	0.2246	0.0009	–3	4.6	12	Pass	Pass	Pass	Accepted
^{137}Cs	0.171	0.008	0.1762	0.0015	–3	4.8	12	Pass	Pass	Pass	Accepted

TABLE 27. LABORATORY CODE 18

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.40	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2203	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.225	0.016	0.2240	0.0009	0	7.1	18	Pass	Pass	Pass	Accepted
^{137}Cs	0.176	0.017	0.1757	0.0014	0	9.7	25	Pass	Pass	Pass	Accepted

TABLE 28. LABORATORY CODE 19

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.22	0.16	1.41	0.04	–13	13	30	Pass	Pass	Pass	Accepted
^{90}Sr	–	–	0.2205	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.219	0.013	0.2243	0.0009	–2	5.9	15	Pass	Pass	Pass	Accepted
^{137}Cs	0.165	0.012	0.1760	0.0014	–6	7.3	18	Pass	Pass	Pass	Accepted

TABLE 29. LABORATORY CODE 20

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	0.203	0.010	0.2214	0.0016	–8	5.0	12	Pass	Pass	Pass	Accepted
^{134}Cs	0.199	0.013	0.2252	0.0009	–12	6.5	15	Pass	Pass	Pass	Accepted
^{137}Cs	0.162	0.013	0.1766	0.0015	–8	8.1	19	Pass	Pass	Pass	Accepted

TABLE 30. LABORATORY CODE 21

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2209	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.20	0.04	0.2246	0.0009	–11	20	46	Pass	Fail	Pass	Warning
^{137}Cs	0.31	0.04	0.1762	0.0015	76	14	63	Fail	Pass	Fail	Not accepted

TABLE 31. LABORATORY CODE 22

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2213	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.210	0.008	0.2251	0.0009	–7	3.8	9.2	Pass	Pass	Pass	Accepted
^{137}Cs	0.177	0.004	0.1766	0.0015	0.2	2.4	6.2	Pass	Pass	Pass	Accepted

TABLE 32. LABORATORY CODE 23

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	0.22	0.04	0.2206	0.0016	1.1	17	44	Pass	Pass	Pass	Accepted
^{134}Cs	0.176	0.010	0.2244	0.0009	–22	5.7	12	Fail	Pass	Fail	Not accepted
^{137}Cs	0.165	0.008	0.1760	0.0015	–6	4.9	12	Pass	Pass	Pass	Accepted

TABLE 33. LABORATORY CODE 24

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.56	0.23	1.41	0.04	11	15	43	Pass	Pass	Pass	Accepted
^{90}Sr	0.200	0.013	0.2214	0.0016	–10	6.3	15	Pass	Pass	Pass	Accepted
^{134}Cs	0.254	0.019	0.2252	0.0009	13	7.5	22	Pass	Pass	Pass	Accepted
^{137}Cs	0.179	0.014	0.1767	0.0015	1	7.9	21	Pass	Pass	Pass	Accepted

TABLE 34. LABORATORY CODE 25

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	0.27	0.05	0.2217	0.0016	22	19	58	Pass	Pass	Pass	Accepted
^{134}Cs	0.240	0.020	0.2254	0.0009	6	8.3	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.220	0.020	0.1769	0.0015	24	9.1	29	Fail	Pass	Pass	Not accepted

TABLE 35. LABORATORY CODE 26

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	< 5.2	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
^{90}Sr	0.252	0.019	0.2213	0.0016	14	7.7	22	Pass	Pass	Pass	Accepted
^{134}Cs	0.220	0.020	0.2251	0.0009	–2	9.1	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.19	0.03	0.1766	0.0015	8	16	44	Pass	Pass	Pass	Accepted

TABLE 36. LABORATORY CODE 27

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.23	0.03	0.2246	0.0009	3	11	30	Pass	Pass	Pass	Accepted
^{137}Cs	0.174	0.013	0.1762	0.0015	–1	7.5	19	Pass	Pass	Pass	Accepted

TABLE 37. LABORATORY CODE 28

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2209	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.210	0.010	0.2246	0.0009	–7	4.8	12	Pass	Pass	Pass	Accepted
^{137}Cs	0.200	0.010	0.1762	0.0015	13	5.1	15	Pass	Pass	Pass	Accepted

TABLE 38. LABORATORY CODE 29

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.38	0.11	1.41	0.04	–2	8.6	22	Pass	Pass	Pass	Accepted
^{90}Sr	0.204	0.013	0.2211	0.0016	–8	6.4	15	Pass	Pass	Pass	Accepted
^{134}Cs	0.220	0.013	0.2249	0.0009	–2	5.8	15	Pass	Pass	Pass	Accepted
^{137}Cs	0.210	0.017	0.1764	0.0015	19	7.9	24	Pass	Pass	Pass	Accepted

TABLE 39. LABORATORY CODE 30

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.43	0.03	1.41	0.04	1	3.8	10	Pass	Pass	Pass	Accepted
^{90}Sr	–	–	0.2216	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.218	0.010	0.2254	0.0009	–3	4.6	11	Pass	Pass	Pass	Accepted
^{137}Cs	0.195	0.020	0.1768	0.0015	10	10	29	Pass	Pass	Pass	Accepted

TABLE 40. LABORATORY CODE 31

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.42	0.05	–	–	–	–	–	–	Not reported
^{90}Sr	0.246	0.013	0.2223	0.0016	10	5.3	15	Pass	Pass	Pass	Accepted
^{134}Cs	0.226	0.017	0.2261	0.0009	0	7.6	20	Pass	Pass	Pass	Accepted
^{137}Cs	0.182	0.019	0.1773	0.0015	2	11	28	Pass	Pass	Pass	Accepted

TABLE 41. LABORATORY CODE 32

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.1	0.3	1.41	0.04	–22	27	55	Pass	Fail	Pass	Warning
^{90}Sr	0.234	0.016	0.2210	0.0016	6	6.9	19	Pass	Pass	Pass	Accepted
^{134}Cs	0.222	0.022	0.2247	0.0009	–1	9.9	25	Pass	Pass	Pass	Accepted
^{137}Cs	0.215	0.017	0.1763	0.0015	22	7.9	25	Fail	Pass	Pass	Not accepted

TABLE 42. LABORATORY CODE 33

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	< 2.0	–	1.42	0.05	–	–	–	–	–	–	Not evaluated
^{90}Sr	0.225	0.023	0.2223	0.0016	1	10	27	Pass	Pass	Pass	Accepted
^{134}Cs	0.235	0.016	0.2261	0.0009	4	6.8	18	Pass	Pass	Pass	Accepted
^{137}Cs	0.178	0.012	0.1773	0.0015	0	6.8	18	Pass	Pass	Pass	Accepted

TABLE 43. LABORATORY CODE 34

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	0.90	0.24	1.41	0.04	–36	27	45	Fail	Fail	Pass	Not accepted
^{90}Sr	–	–	0.2210	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.191	0.014	0.2248	0.0009	–15	7.3	16	Pass	Pass	Pass	Accepted
^{134}Cs	0.191	0.008	0.2248	0.0009	–15	4.2	9.2	Pass	Pass	Fail	Warning
^{137}Cs	0.196	0.023	0.1763	0.0015	11	12	34	Pass	Pass	Pass	Accepted
^{137}Cs	0.189	0.009	0.1763	0.0015	7	4.8	13	Pass	Pass	Pass	Accepted

TABLE 44. LABORATORY CODE 35

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	2.9	0.9	1.41	0.05	106	30	159	Fail	Fail	Pass	Not accepted
^{90}Sr	0.25	0.05	0.2219	0.0016	13	20	58	Pass	Pass	Pass	Accepted
^{134}Cs	0.20	0.03	0.2257	0.0009	–14	14	31	Pass	Pass	Pass	Accepted
^{137}Cs	0.20	0.03	0.1770	0.0015	15	13	39	Pass	Pass	Pass	Accepted

TABLE 45. LABORATORY CODE 36

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.5	0.3	1.41	0.04	9	20	57	Pass	Pass	Pass	Accepted
^{90}Sr	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.186	0.011	0.2246	0.0009	–17	5.8	12	Pass	Pass	Fail	Warning
^{137}Cs	0.154	0.009	0.1762	0.0015	–12	6.0	13	Pass	Pass	Pass	Accepted

TABLE 46. LABORATORY CODE 37

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	0.163	0.019	0.2215	0.0016	–26	12	22	Fail	Pass	Fail	Not accepted
^{134}Cs	0.203	0.019	0.2252	0.0009	–10	9.4	22	Pass	Pass	Pass	Accepted
^{137}Cs	0.197	0.019	0.1767	0.0015	11	9.7	28	Pass	Pass	Pass	Accepted

TABLE 47. LABORATORY CODE 38

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.3	0.4	1.41	0.04	–6	27	66	Pass	Fail	Pass	Warning
^{90}Sr	0.225	0.014	0.2216	0.0016	2	6.3	16	Pass	Pass	Pass	Accepted
^{134}Cs	0.220	0.020	0.2253	0.0009	–2	9.1	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.196	0.018	0.1768	0.0015	11	9.2	26	Pass	Pass	Pass	Accepted

TABLE 48. LABORATORY CODE 39

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	< 0.7	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
^{90}Sr	0.22	0.03	0.2213	0.0016	1	14	36	Pass	Pass	Pass	Accepted
^{134}Cs	0.151	0.018	0.2250	0.0009	–33	12	21	Fail	Pass	Fail	Not accepted
^{137}Cs	0.139	0.020	0.1765	0.0015	–21	14	29	Fail	Pass	Pass	Not accepted

TABLE 49. LABORATORY CODE 40

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	19.6	1.6	1.41	0.04	1286	8.8	292	Fail	Pass	Fail	Not accepted
^{90}Sr	0.190	0.010	0.2216	0.0016	–14	5.3	12	Pass	Pass	Fail	Warning
^{134}Cs	0.190	0.020	0.2253	0.0009	–16	11	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.214	0.020	0.1768	0.0015	21	9.4	29	Fail	Pass	Pass	Not accepted

TABLE 50. LABORATORY CODE 41

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2219	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.18	0.03	0.2257	0.0009	–18	15	31	Pass	Pass	Pass	Accepted
^{137}Cs	0.18	0.07	0.1770	0.0015	–1	40	102	Pass	Fail	Pass	Warning

TABLE 51. LABORATORY CODE 42

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	0.055	0.007	0.2211	0.0016	–75	12	8.1	Fail	Pass	Fail	Not accepted
^{134}Cs	0.21	0.04	0.2248	0.0009	–8	18	42	Pass	Pass	Pass	Accepted
^{137}Cs	0.21	0.04	0.1764	0.0015	21	17	53	Fail	Pass	Pass	Not accepted

TABLE 52. LABORATORY CODE 43

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2217	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.15	0.07	0.2255	0.0009	–33	47	82	Fail	Fail	Pass	Not accepted
^{137}Cs	0.15	0.07	0.1769	0.0015	–15	43	95	Pass	Fail	Pass	Warning

TABLE 53. LABORATORY CODE 44

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	7.0	0.7	1.41	0.04	399	11	134	Fail	Pass	Fail	Not accepted
^{90}Sr	0.107	0.012	0.2204	0.0016	–51	11	14	Fail	Pass	Fail	Not accepted
^{134}Cs	0.208	0.014	0.2241	0.0009	–7	6.5	16	Pass	Pass	Pass	Accepted
^{137}Cs	0.237	0.016	0.1759	0.0014	35	6.6	23	Fail	Pass	Fail	Not accepted

TABLE 54. LABORATORY CODE 45

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	0.225	0.022	0.2210	0.0016	2	10	26	Pass	Pass	Pass	Accepted
^{134}Cs	0.209	0.013	0.2247	0.0009	–7	6.2	15	Pass	Pass	Pass	Accepted
^{134}Cs	0.217	0.019	0.2247	0.0009	–3	8.6	21	Pass	Pass	Pass	Accepted
^{137}Cs	0.185	0.009	0.1763	0.0015	5	5.0	13	Pass	Pass	Pass	Accepted
^{137}Cs	0.19	0.03	0.1763	0.0015	8	15	43	Pass	Pass	Pass	Accepted

TABLE 55. LABORATORY CODE 46

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	< 4.5	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
^{90}Sr	–	–	0.2212	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.19	0.04	0.2249	0.0009	–16	20	44	Pass	Fail	Pass	Warning
^{137}Cs	0.18	0.05	0.1764	0.0015	2	26	67	Pass	Fail	Pass	Warning

TABLE 56. LABORATORY CODE 47

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.34	0.12	1.41	0.04	–5	10	23	Pass	Pass	Pass	Accepted
^{90}Sr	–	–	0.2210	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.210	0.020	0.2248	0.0009	–7	9.5	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.200	0.020	0.1763	0.0015	13	10	29	Pass	Pass	Pass	Accepted

TABLE 57. LABORATORY CODE 48

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	1.27	0.10	1.41	0.04	–10	8.5	20	Pass	Pass	Pass	Accepted
^{90}Sr	0.216	0.013	0.2211	0.0016	–2	6.1	15	Pass	Pass	Pass	Accepted
^{134}Cs	–	–	0.2249	0.0009	–	–	–	–	–	–	Not reported
^{137}Cs	–	–	0.1764	0.0015	–	–	–	–	–	–	Not reported

TABLE 58. LABORATORY CODE 49

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2212	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.28	0.04	0.2249	0.0009	26	13	44	Fail	Pass	Pass	Not accepted
^{137}Cs	0.17	0.04	0.1765	0.0015	–2	21	53	Pass	Fail	Pass	Warning

TABLE 59. LABORATORY CODE 50

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	< 3.3	–	1.41	0.04	–	–	–	–	–	–	Not evaluated
^{90}Sr	–	–	0.2211	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	–	–	0.2249	0.0009	–	–	–	–	–	–	Not reported
^{137}Cs	–	–	0.1764	0.0015	–	–	–	–	–	–	Not reported

TABLE 60. LABORATORY CODE 51

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	0.85	0.08	1.41	0.04	–40	10	16	Fail	Pass	Fail	Not accepted
^{90}Sr	–	–	0.2208	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.137	0.016	0.2245	0.0009	–39	12	18	Fail	Pass	Fail	Not accepted
^{137}Cs	0.132	0.013	0.1761	0.0015	–25	10	19	Fail	Pass	Fail	Not accepted

TABLE 61. LABORATORY CODE 52

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2210	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.161	0.025	0.2248	0.0009	–28	16	29	Fail	Pass	Pass	Not accepted
^{137}Cs	0.141	0.024	0.1764	0.0015	–20	17	35	Fail	Pass	Pass	Not accepted

TABLE 62. LABORATORY CODE 53

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.05	–	–	–	–	–	–	Not reported
^{90}Sr	0.066	0.003	0.2222	0.0016	–70	4.4	3.8	Fail	Pass	Fail	Not accepted
^{134}Cs	0.211	0.011	0.2260	0.0009	–7	5.1	12	Pass	Pass	Pass	Accepted
^{137}Cs	0.179	0.012	0.1773	0.0015	1	6.5	17	Pass	Pass	Pass	Accepted

TABLE 63. LABORATORY CODE 54

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.41	0.04	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2212	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.200	0.020	0.2249	0.0009	–11	10	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.17	0.04	0.1765	0.0015	–4	24	58	Pass	Fail	Pass	Warning

TABLE 64. LABORATORY CODE 55

Radio-nuclide	Lab value (Bq kg^{-1})	Lab uncert. (Bq kg^{-1})	IAEA value (Bq kg^{-1})	IAEA uncert. (Bq kg^{-1})	Relative bias (%)	P (%)	Trueness limit (%)	Accuracy	Precision	Trueness	Final score
^{3}H	–	–	1.42	0.05	–	–	–	–	–	–	Not reported
^{90}Sr	–	–	0.2226	0.0016	–	–	–	–	–	–	Not reported
^{134}Cs	0.246	0.021	0.2264	0.0009	9	8.4	23	Pass	Pass	Pass	Accepted
^{137}Cs	0.224	0.017	0.1776	0.0015	26	7.5	24	Fail	Pass	Fail	Not accepted

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