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HELCOM-MORS Proficiency Test Determination of Radionuclides in Fish Flesh Sample

IAEA
International Atomic Energy Agency

HELCOM-MORS PROFICIENCY TEST
DETERMINATION OF RADIONUCLIDES
IN FISH FLESH SAMPLE

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FOREWORD

Our society is providing increasing importance to the study and assessment of the state and health of the environment. Organizations involved in such activities rely on the quality of the information provided and, ultimately, on the precision and accuracy of the data on which the information is based. Many laboratories are involved in the production of environmental data in many cases leading to wider assessments. These laboratories may develop and validate new analytical methods, study the environmental impact of human activities, provide services to other organizations, etc. In particular, laboratories are providing data on levels of radioactivity in a variety of marine matrixes such as water, suspended matter, sediments and biota. Because of the need to base scientific conclusions on valid and internationally comparable data, the need to provide policy makers with correct information and the need for society to be informed of the state of the environment, it is indispensable to ensure the quality of the data produced by each laboratory.

Principles of good laboratory practice require both internal and external procedures to verify the quality of the data produced. Quality is verified internally in a number of ways such as the use of laboratory information systems, keeping full records of equipment performance and standardization of analytical procedures. Quality can also be ascertained externally in a number of ways, notably accreditation by an external body under a defined quality scheme but also, amongst others, the use of internationally accepted calibration standards that are traceable to the SI international system of units, the participation in interlaboratory comparison or the regular use of Reference Materials to test laboratory performance.

The Radiometrics Laboratory of the International Atomic Energy Agency's Marine Environment Laboratories has been providing quality products for the last 40 years which include the organization of intercomparison exercises, proficiency tests, production of reference materials and certified reference materials, and training [1, 2]. More than 40 reference materials have been produced, which include a wide range of marine sample matrices and radionuclide concentrations.

As part of these activities, a new PT for the Helsinki Commission’s Project for Monitoring Radioactive Substances in the Baltic Sea (HELCOM-MORS) was organised to test the analytical performance for radionuclides on a fish flesh sample of participating laboratories. Laboratories agreed that, after the completion of the exercise, an IAEA report describing the results of the proficiency test would be issued, including their identities.

We highly acknowledge the participants and laboratories that took part in this proficiency test and contributed their time and facilities to the present work. The IAEA is grateful for the support provided to its Marine Environment Laboratories by the Government of the Principality of Monaco.

The IAEA officers responsible for this publication were M.K. Pham, I. Osvath and J.-A Sanchez-Cabeza of the IAEA Marine Environment Laboratories in Monaco.

CONTENTS

1. INTRODUCTION

The accurate and precise determination of radionuclide concentrations in marine samples is critical to reliable marine radioactivity assessment and the use of radionuclides in studies of oceanographic processes. To address the problem of data quality, the IAEA Marine Environment Laboratories (IAEA-MEL) in Monaco regularly conduct interlaboratory comparisons and proficiency tests (PT) on radionuclides in marine samples as part of their contribution to the IAEA's programme of Analytical Quality support [1,2]. These exercises are open to world-wide participation or can be custom-tailored to the needs of specific collaborative projects. In the latter category, IAEA-MEL has a long-standing collaboration with the Helsinki Commission's Project for Monitoring Radioactive Substances in the Baltic Sea (HELCOM-MORS). During the HELCOM-MORS annual meeting hosted by IAEA-MEL in 2006, the organisation of a PT using a previously characterised fish sample and the collaboration in the production of a Certified Reference Material of bladderwrack (*Fucus vesiculosus*) were discussed and agreed upon as first priorities for the Project group. The organisation and the results of this PT are described in the present report.

2. MATERIAL AND METHODS

2.1. Proficiency test objectives

In 2007-2008, on request from the HELCOM-MORS Project group, a PT on the determination of radionuclides in a marine fish sample was organised by IAEA-MEL. An IAEA Certified Reference Material – IAEA-414 Radionuclides in Fish from Irish and North Seas (Appendix 1) [4] – was used in this exercise, the identity of this sample remaining undisclosed to the participants during the exercise. The results of this exercise are meant to allow the participating laboratories to evaluate their performance in the analysis of the radionuclides in this sample and the comparability of their corresponding monitoring data.

2.2. Participants

A total of 10 laboratories from 8 countries from around the Baltic Sea, all HELCOM-MORS Project Members, have participated in the exercise. The list of participants is given at the end of this publication.

2.3. Material distribution and reporting requirements

Each participant received 100g of fish flesh sample, with massic activities known by the organiser (IAEA-MEL), but kept unknown to the participants throughout the exercise. The material composition and its characterisation were determined and described in [3, 4]. The participants were asked to determine as many radionuclides as possible by radiometric methods and, where possible, by advanced analytical techniques such as ICP-MS (Inductively Coupled Plasma Mass Spectrometry) and AMS (Accelerator Mass Spectrometry). For each radionuclide analysed, the following information was requested:

- Average weight of sample used.
- Number of analyses.
- Massic activity calculated as net values (i.e. corrected for blank, background etc.) and expressed in Bq kg^{-1} dry weight.
- Estimate of the combined uncertainty.

- Description of chemical procedures and counting equipment.
- Reference standard solutions used.
- Chemical recoveries, counting time, half-life used.

The reference date for reporting activities was set to 1 January 1997.

3. PERFORMANCE CRITERIA

The methodology adopted for this PT is the one used in previous IAEA PTs organised by the Chemistry Unit of the Physics, Chemistry and Instrumentation Laboratory in Seibersdorf, described in detail in [5-6]. The scoring system takes into account the trueness and the precision of the reported data and includes in the evaluation both the combined standard uncertainty of the target value and the combined standard uncertainty reported by the participating laboratories. A result must pass both criteria for accuracy and precision to be assigned the status “Acceptable”, otherwise it will acquire the status “Warning” or “Not Acceptable”.

Additionally, 3 other statistical parameters were calculated as complementary information for the participating laboratories: relative bias, z-score and IAEA/Laboratory results ratio.

3.1. Relative bias

The first step in producing a score for a result $Value_{Analyst}$ (either a single measurement or a mean value of more than two measurements of analyte concentration in a test material) is the estimation of the bias. The relative bias (RB) between the Analyst’s value and the IAEA target value is calculated as follows and expressed as a percentage:

$$RB = \frac{Value_{Analyst} - Value_{IAEA}}{Value_{IAEA}} \times 100\,(\%)$$

3.2. PT evaluation criteria

The PT results were evaluated against the acceptance criteria for trueness and precision, and were assigned an ”Acceptable”, “Warning” or ”Not Acceptable” status accordingly [5-7].

3.2.1. Trueness

The participants’ results are scored as “Acceptable” for trueness if:

$$A_1 \le A_2$$

Where:

$$A_1 = \left| Value_{IAEA} - Value_{Analyst} \right|$$

$$A_2 = 2.58 \times \sqrt{Unc_{IAEA}^2 + Unc_{Analyst}^2}$$

3.2.2. Precision

The P precision for each participant is calculated according to the following formula:

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

P directly depends on the measurement uncertainty reported by participants. The Limit of Acceptable Precision (LAP) for each analyte is defined for the respective PT in advance, including any adjustment due to activity concentration level of the analyte concerned and the complexity of the analytical problem. Participants' results are scored as "Acceptable" for precision when P<LAP. The LAP values used in the evaluation, listed in TABLE 1, were assigned based on the activity level of each radionuclide: 15% for radionuclides with activities higher than 5 Bq kg^{-1}, 20% for radionuclides with activities between 1 and 5 Bq kg^{-1} and 25% for those with activities lower than 1 Bq kg^{-1}.

For the final evaluation, both scores for trueness and precision are combined. The result is considered as "Acceptable" if it passed both trueness and precision criteria. In cases where either precision or trueness is "Not Acceptable", a further check is applied. The relative bias (RB) of the reported result is compared with the maximum Acceptable bias (MAB). If RB < MAB, the final score will be "warning". The "warning" status will mainly reflect two situations. The first situation is that the result is reported with a small measurement uncertainty, however its bias is still within MAB. The second situation might appear when the reported result is close to the assigned property value, but the associated uncertainty is large. If RB>MAB, the result will be "Not Acceptable". The MAB values used in the evaluation (TABLE 1), were assigned based on the activity level of each radionuclide: 15% for radionuclides with activities higher than 5 Bq kg^{-1}, 20% for radionuclides with activities between 1 and 5 Bq kg^{-1} and 25% for those with activities lower than 1 Bq kg^{-1}.

If the evaluation approach and/or acceptance criteria applied in this PT are not appropriate for the types of analyses and applications performed in one of the participating laboratories, it is suggested to apply a self-scoring evaluation system which fits specific requirements.

TABLE 1. THE ACCETABLE VALUES FOR LIMIT OF ACCETABLE PRECISION (LAP) AND MAXIMUM ACCETABLE BIAS (MAB) USED FOR THE EVALUATION IN IAEA PROFICIENCY TESTS:

Radionuclide	LAP (%)	MAB (%)
^{40}K	15	15
^{137}Cs	20	20
^{232}Th	25	25
^{234}U	20	20
^{235}U	25	25
^{238}U	20	20
^{238}Pu	25	25
$^{239+240}Pu$	25	25
^{241}Am	25	25

3.3. The Z-Score value

The Z-Score is calculated from the laboratory result, the assigned value and a standard deviation in accordance with the following equation [8]:

$$Z - Score = \frac{Value_{Analyst} - Value_{IAEA}}{\sigma}$$

On the basis of the "fitness for purpose" principle, the target value for the standard deviation (σ) is:

$$0.1 \times Value_{IAEA}$$

The laboratory performance is evaluated as satisfactory if $|Z - Score| \leq 2$; questionable for $2 \leq |Z - Score| \leq 3$, and unsatisfactory for $|Z - Score| \geq 3$.

3.4. The U-Score value

The value of U_{test} was calculated as follows [7]:

$$U_{test} = \frac{|Value_{IAEA} - Value_{Analyst}|}{\sqrt{Unc_{IAEA}^2 + Unc_{Analyst}^2}}$$

Where Unc_{IAEA} is expanded uncertainties calculated using combined uncertainties reported multiplying by a factor of 2 [9-10], which cover 95% of confidence interval.

This value is compared with the critical value listed in the t-statistics tables to determine if the reported results differ significantly from the expected value at a given level of probability. The advantage of the U_{test} is that it takes into consideration the propagation of the measurement uncertainty when defining the normalized error. This is especially useful when evaluating results for which the uncertainty may overlap with the 95% confidence interval.

It should be noted that the choice of significance level is subjective. For this PT, we have set the limiting value for the U-test parameter to 2.58 for a level of probability at 99% to determine if a result passes the test (U_{test} <2.58) [5-7].

4. RESULTS AND DISCUSSION

155 individual measurement results were reported by 10 laboratories from 8 countries, mostly for the following radionuclides: ^{40}K, ^{90}Sr, ^{137}Cs, ^{210}Po, ^{226}Ra, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, ^{241}Am. The evaluation was carried out on the basis of those radionuclides for which certified massic activities were available (Appendix 1) to be used as target values. TABLE 2 shows statistics of reported individual measurement results scored as Acceptable/Warning/Not Acceptable for all evaluated radionuclides.

For the radionuclides ^{40}K, ^{137}Cs, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, for which target values were certified massic activities of IAEA-414 (Appendix 1) [4], 137 individual measurement values were reported. The overall evaluation of these results showed that 88% of all reported measurement results fulfilled the PT criteria of acceptability, while only 7% of

the individual measurement results were not acceptable, the remaining 5% having the warning status.

It should be noted that for some radionuclides, such as ^{90}Sr, ^{210}Po and ^{226}Ra, their target values were defined as information massic activities of IAEA-414 (Appendix 1) [4], not having fulfilled the criteria of certification. In consequence, the results reported by the participants for these radionuclides cannot be used to evaluate their performance. Some laboratories reported ^{99}Tc, ^{129}I, ^{228}Th, ^{230}Th values, but the analysing performance for these radionuclides could not be evaluated because their target values were not known.

TABLE 3 summarises data evaluation sorted by laboratory code and contains some technical notes. The performance evaluation sorted by each analyte is summarised in TABLE 4. The performance evaluation sorted by radionuclides is presented in Appendix 2. The performance evaluation sorted by laboratory code is presented in Appendix 3. Most laboratories reported their values with combined uncertainties with all identified error sources. However, a few laboratories reported too small uncertainties which lead to a warning score.

TABLE 2. SUMMARY EVALUATION OF ALL RADIONUCLIDES REPORTED, FOR WHICH THE PERFORMANCE COULD BE EVALUATED WITH RELIABLE TARGET VALUE.

Nuclide	Number of individual reported results.	Number of laboratories reported	Acceptable (%)	Warning (%)	Not Acceptable (%)	Technical notes
^{40}K	27	9	89	11		Gamma spectrometry.
^{137}Cs	39	10	90		10	10 laboratories used gamma spectrometry, one laboratory used both gamma and beta.
^{232}Th	8	2	100			Alpha spectrometry.
^{234}U	10	3	100			Alpha spectrometry.
^{235}U	8	2	100			Alpha spectrometry.
^{238}U	10	3	100			Alpha spectrometry.
^{238}Pu	12	4	75	25		Alpha spectrometry.
$^{239+240}Pu$	12	4	100			Alpha spectrometry.
^{241}Am	11	4	50		50	Gamma and alpha spectrometry.

TABLE 3. SUMMARY EVALUATION SORTED BY LABORATORY CODE AND TECHNICAL NOTES. LABORATORY CODE ASSIGNMENTS ARE GIVEN ON PAGE 54.

Lab. code	Radionuclides reported	Acceptable (%)	Warning (%)	Not Acceptable (%)	Techniques used	Technical notes
1	^{40}K, ^{137}Cs, ^{241}Am	33	33	33	Gamma	Reported two individual measurement values for each analyte.
2	^{40}K, ^{137}Cs, ^{234}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, ^{241}Am	72	14	14	Gamma, alpha	Reported two individual values.
3	^{40}K, ^{137}Cs	50		50	Gamma	Reported two individual value.
4	^{40}K, ^{137}Cs	100			Gamma, beta	Reported 6 individual values.
5	^{40}K, ^{137}Cs, ^{238}Pu, $^{239+240}$Pu	100			Gamma, alpha	Reported 2 individual values.
6	^{40}K, ^{137}Cs, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, ^{241}Am	100			Gamma, alpha	Reported 6 individual values for K, Cs. Reported 2 individual values for others.
7	^{40}K, ^{137}Cs, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, ^{241}Am	100			Gamma, alpha	Reported 6 individual values.
8	^{40}K, ^{137}Cs	100			Gamma	Reported 2 individual values.
9	^{40}K, $^{13\,7}$Cs,	100			Gamma	Reported 2 individual values.
10	^{137}Cs	100			Gamma	Reported 9 individual values.

TABLE 4. SUMMARY EVALUATION OF THE HELCOM-MORS PROFICIENCY TEST.

Institute name and country	Lab. code	^{40}K	^{137}Cs	^{232}Th	^{234}U	^{235}U	^{238}U	^{238}Pu	$^{239+240}$Pu	^{241}Am
Federal Maritime and Hydrographic Agency (BSH), Germany.	1	W	A	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	N.A.
Radiation and Nuclear Safety Authority (STUK), Finland.	2	A	A	n.r.	A	n.r.	A	W	A	N.A.
Estonia Radiation Protection Centre, Estonia.	3	A	N.A.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Institute of Meteology and Water Management, Poland.	4	A	A	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Central Laboratory for Radiological Protection, Poland.	5	A	A	n.r.	n.r.	n.r.	n.r.	A	A	n.r.
Institute of Fishery Ecology, Germany.	6	A	A	A	A	A	A	A	A	A
Risoe National Laboratory, Denmark.	7	A	A	A	A	A	A	A	A	A
Radiology Division, Lithuania	8	A	A	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
V.G. Khlopin Radium Institute, Russia	9	A	A	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Swedish Radiation Safety Authority, Sweden	10	n.r.	A	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.

A: Acceptable measurement results, W: Warning, N.A.: Not Acceptable, n.r.: not reported results.

5. CONCLUSIONS

The summary evaluation of the HELCOM-MORS PT for radionuclides in fish (TABLE 4 IV) was carried out based on laboratory means for ^{40}K, ^{137}Cs, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, ^{241}Am and target values given by the certified massic activities of the material used in this PT. In overall, 88% of the laboratory means were acceptable, 5% were in the warning status and 7% were not acceptable.

90% of the participants reported ^{40}K massic activities, 89% of which were acceptable, with only one laboratory receiving warning.

100% participants reported ^{137} Cs massic activities, with 90% acceptable. This shows the very good performance of the group of laboratories in the determination of this radionuclide, for which mostly direct gamma-ray spectrometry was used.

20-30% of the participants reported ^{232}Th, ^{234}U, ^{235}U and ^{238}U massic activities and most of them were acceptable, showing good radiochemical separation of Th and U followed by alpha spectrometry. The same observation holds for Pu isotopes: among the 40% participants having reported Pu results only one was assigned the warning status, as it failed the test for measurement precision. For ^{241}Am, of the 40% of the participants having reported results only 50% were acceptable. Determined either by direct gamma spectrometry or alpha spectrometry with prior radiochemical separation, the difficulty to measure this radionuclide using its low-energy gamma ray is obvious.

Performance for ^{90}Sr, ^{210}Pb and ^{226}Ra could not be evaluated due to lack of adequate target values. Similarly, some laboratories reported ^{99}Tc, ^{129}I, ^{228}Th, ^{230}Th values, but the performance on these radionuclides could not be evaluated because target values were not known.

Appendix 1: IAEA-414 Reference Sheet

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Analytical Quality Control Services
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REFERENCE SHEET

CERTIFIED REFERENCE MATERIAL

IAEA-414

RADIONUCLIDES IN MIXED FISH FROM THE IRISH SEA AND NORTH SEA

Date of issue: October 2006

Certified Massic Activities

(Based on dry weight)

Reference date for decay correction: 1st January 1997

Radionuclide	Certified Value Bq/kg	95% Confidence Interval Bq/kg	N*
^{40}K	481	470 - 486	19
^{137}Cs	5.18	5.12 - 5.22	16
^{232}Th	0.028	0.025 - 0.031	6
^{234}U	1.22	1.15 - 1.26	8
^{235}U	0.050	0.045 - 0.055	9
^{238}U	1.11	1.07 - 1.15	9
^{238}Pu	0.0230	0.0221 - 0.0250	11
$^{239+240}Pu$	0.120	0.116 - 0.123	14
$^{241}Am^{\#}$	0.197	0.193 - 0.204	9

Information Massic Activities

Radionuclide	Information Value Bq/kg	95% Confidence Interval Bq/kg	N*
^{90}Sr	0.28	0.10 - 0.54	6
$^{210}Pb(^{210}Po)^{\$}$	2.1	1.8 - 2.5	11
^{226}Ra	1.4	0.6 - 1.6	9
^{239}Pu	0.066	0.055 - 0.073	10
^{240}Pu	0.047	0.046 - 0.051	10
^{241}Pu	2.0	1.8 - 2.3	11

*Number of accepted laboratory means used to calculate the information massic activities and the corresponding confidence intervals.
^{210}Pb and ^{210}Po are considered to be in equilibrium.

The values listed above were established on the basis of statistically valid results submitted by laboratories which had participated in an international intercomparison exercise organized between 2000 and 2001, as well as results obtained from expert laboratories participating in the certification procedure. Details concerning the criteria for certification can be found in [1-2]. Both documents are available free of charge upon request.

Description of the material

About 350 kg of mixed fish species were collected in the eastern Irish Sea by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, U.K., in 1996. The skin was removed, the fish filleted, freeze-dried and subsequently sent to IAEA-MEL for processing. The sample, which was reduced by freeze-drying to about 69 kg, was then ground to powder, sieved through a 0.5 mm mesh and homogenized by mixing in a nitrogen atmosphere. The sample was freeze-dried once more, ground and sieved at 250 µm to obtain a final amount of 10 kg. The sample was then mixed with 100 kg of North Sea fish powder (fraction below 250 µm). To ensure homogenization of the final sample, both samples were mixed by jet pulverizing in a nitrogen atmosphere. The samples were then packed into bottles under nitrogen gas, sealed with polyethylene caps and labelled with the code IAEA-414. The bottles containing 100 g of fish powder each were sterilized according to ISO standards [3] at 10 kGy in an irradiation facility.

Intended use

The Certified Reference Material can be used for quality assurance/quality control of the analysis of radionuclides in fish sample, for the development and validation of analytical work and for training purposes with nine certified values (^{40}K, ^{137}Cs, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu and ^{241}Am).

Instructions for use

The reference material is supplied in 100g units.

Sample homogeneity:

Sample homogeneity was checked by measuring the activity of ^{40}K, ^{137}Cs, ^{210}Po, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu and ^{241}Am of 16-30 bottles randomly chosen. Gamma spectrometry measurements were performed on 30 to 100 g aliquots. ^{210}Po, ^{235}U, ^{238}U, ^{238}Pu, $^{239+240}$Pu and ^{241}Am were determined by alpha spectrometry on 0.1 to 20 g aliquots. Homogeneity of these results was checked using one-way analysis of variance. The coefficient of variation was below 10% for radionuclides measured by gamma and alpha spectrometry. The "between samples" variances showed no significant differences from the "within sample" variances for all radionuclides tested. Thus the material could be considered sufficiently homogeneous for the tested radionuclides at the range of weights used.

Dry weight determination:

The average moisture content of the lyophilized sample after bottling, determined by drying several aliquots in an oven at 80 °C to constant weight (1-2 days), was found to be approximately 3%. Since the moisture content can vary with ambient humidity and temperature, it is recommended that the water content should be checked prior to analysis and that all results should be reported on a dry weight basis.

Legal disclaimer

References

[1] M.K. Pham, J. La Rosa., S.-H. Lee, P.P. Povinec, Report on the Worldwide Intercomparison IAEA-414: Radionuclides in Mixed Fish from Irish Sea and the North Sea, *IAEA/AL/145, IAEA/MEL/73 (2004).*

[2] M.K. Pham, J.A. Sanchez-Cabeza, P.P. Povinec *et al.* Certified reference material for radionuclides in fish flesh sample IAEA-414 (mixed fish from the Irish Sea and North Sea). *Applied Radiation and Isotopes 64 (2006) 1253-1259.*

[3] ISO, Proficiency Testing and Interlaboratory Comparisons, Guide 43, ISO/IEC, Geneva (1997).

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Appendix 2: Performance evaluation tables sorted by radionuclides.

TABLE 1: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{40}K IN IAEA-414 (TARGET VALUE: 481 ± 16 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	425	4	0.9	11.64	-1.16	3.40	0.88	56	42.6	Failed	3.5	Passed	Warning
2	490	53	10.8	-1.87	0.19	-0.16	1.02	9	142.8	Passed	11.3	Passed	Acceptable
3	467.5	47.7	10.2	2.81	-0.28	0.27	0.97	13.5	129.8	Passed	10.7	Passed	Acceptable
4	474.5	19.3	4.1	1.35	-0.14	0.26	0.99	6.5	64.7	Passed	5.3	Passed	Acceptable
5	517.5	14.4	2.8	-7.59	0.76	-1.70	1.08	36.5	55.5	Passed	4.3	Passed	Acceptable
6	462	15	3.2	3.95	-0.40	0.87	0.96	19	56.6	Passed	4.6	Passed	Acceptable
7	502	50	10.0	-4.37	0.44	-0.40	1.04	21	135.4	Passed	10.5	Passed	Acceptable
8	438	36	8.2	8.94	-0.89	1.09	0.91	43	101.6	Passed	8.9	Passed	Acceptable
9	513	35	6.8	-6.65	0.67	-0.83	1.07	32	99.3	Passed	7.6	Passed	Acceptable

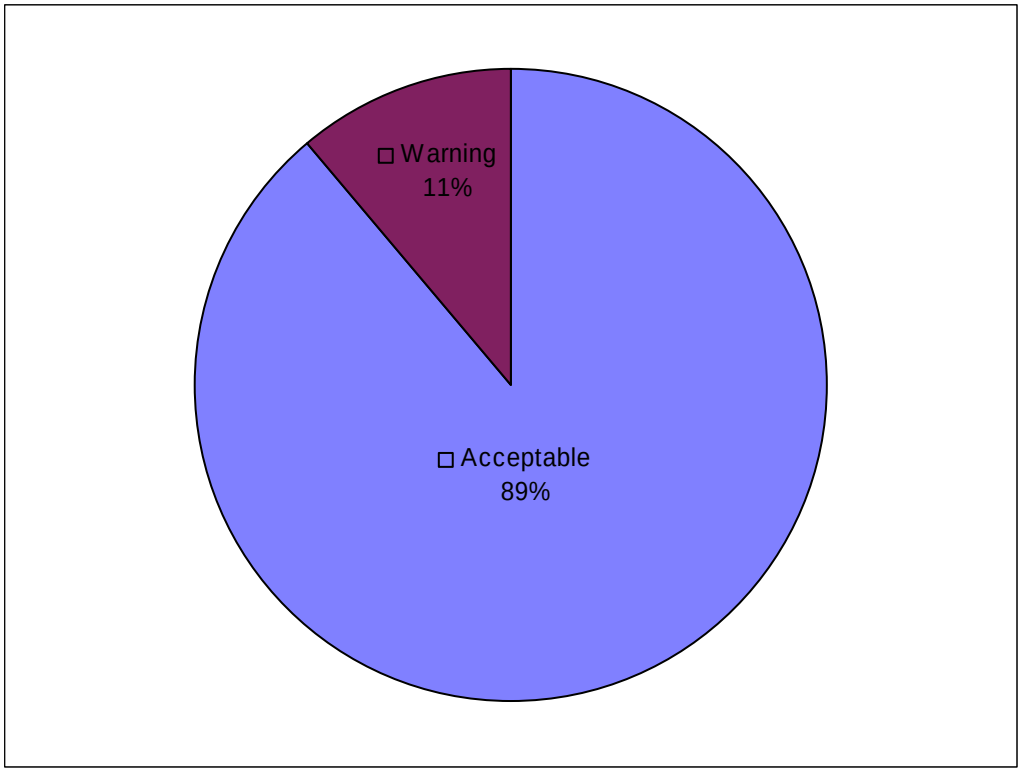

FIG. 1. Evaluation results of ^{40}K in IAEA-414.

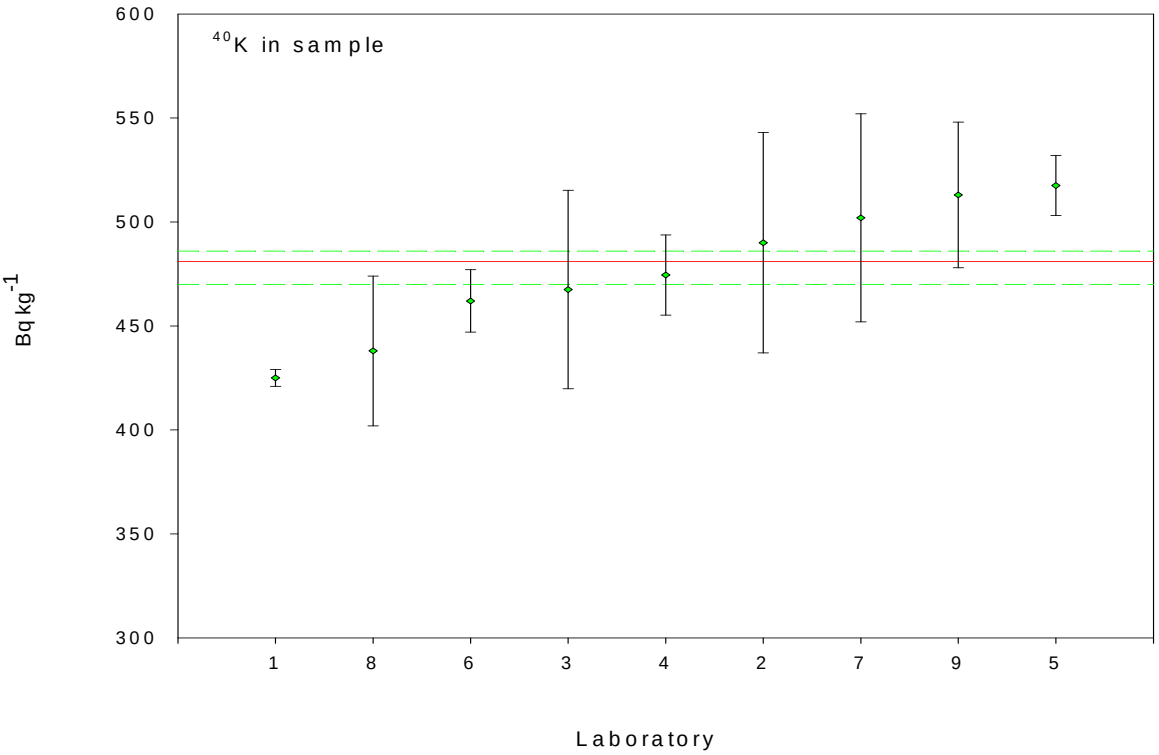

FIG. 2. Data evaluation of ^{40}K in IAEA-414.

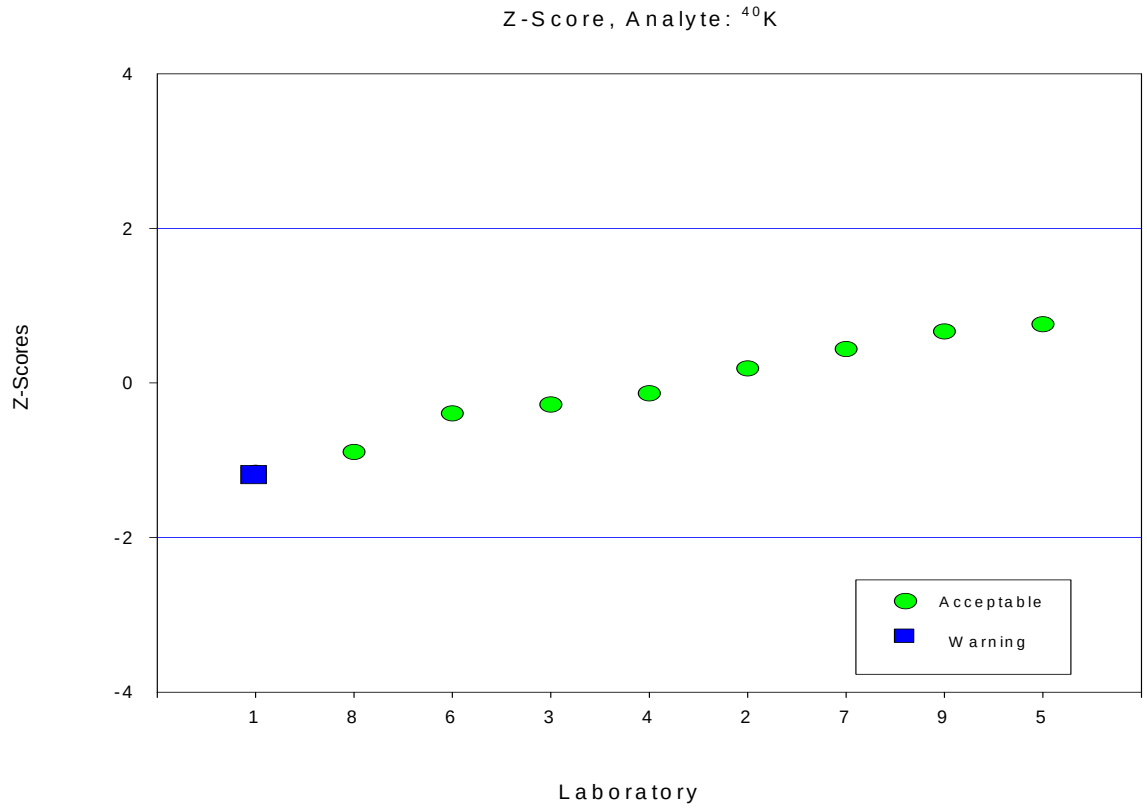

FIG. 3. Z-Score of ^{40}K in IAEA-414.

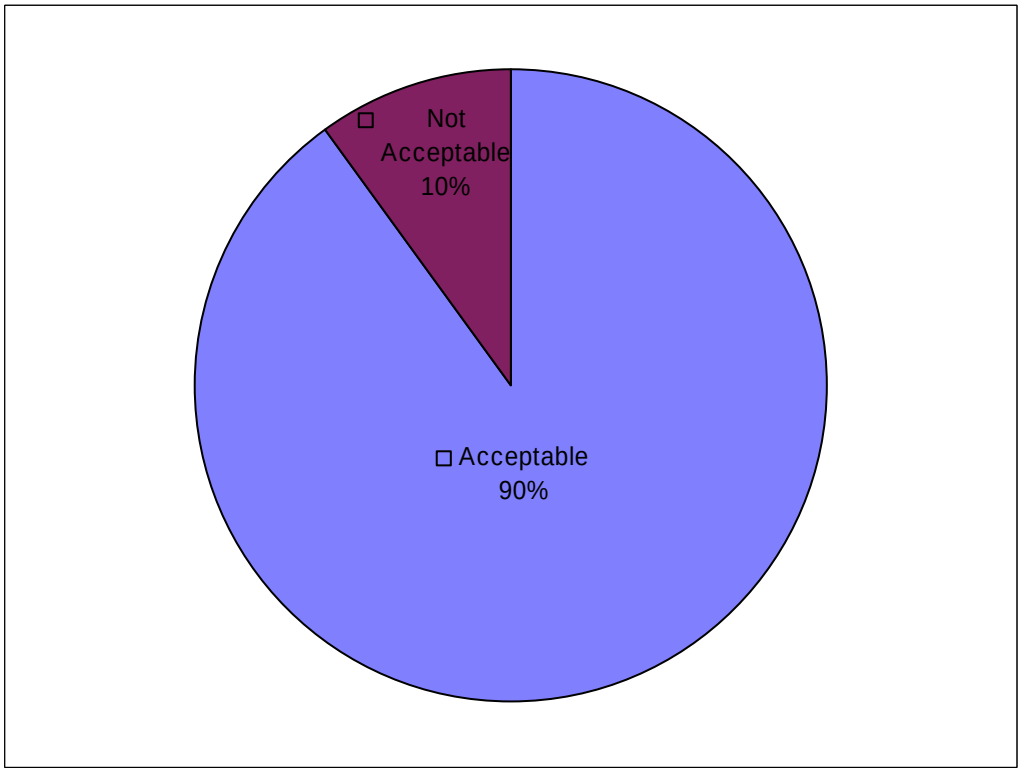

FIG.4. Evaluation results of ^{137}Cs in IAEA-414.

TABLE 2: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{137}Cs IN IAEA-414 (TARGET VALUE: 5.18 ± 0.10 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	5.25	0.17	3.2	-1.35	0.14	-0.35	1.01	-0.07	0.51	Passed	3.8	Passed	Acceptable
2	5.42	0.72	13.3	-4.63	0.46	-0.33	1.05	-0.24	1.88	Passed	13.4	Passed	Acceptable
3	6.5	1.5	23.1	-25.5	2.55	-0.88	1.25	-1.32	3.88	Passed	23.2	Failed	Not Acceptable
4	5.06	0.64	12.6	2.32	-0.23	0.19	0.98	0.12	1.67	Passed	12.8	Passed	Acceptable
5	5.15	0.2	3.9	0.58	-0.06	0.13	0.99	0.03	0.58	Passed	4.3	Passed	Acceptable
6	5.36	0.21	3.9	-3.47	0.35	-0.77	1.03	-0.18	0.60	Passed	4.4	Passed	Acceptable
7	5.02	0.43	8.6	3.09	-0.31	0.36	0.97	0.16	1.14	Passed	8.8	Passed	Acceptable
8	5.28	1.05	19.9	-1.93	0.19	-0.09	1.02	-0.1	2.72	Passed	20	Passed	Acceptable
9	5.87	0.65	11.1	-13.3	1.33	-1.05	1.13	-0.69	1.70	Passed	11.2	Passed	Acceptable
10	5.23	0.68	13	-0.97	0.10	-0.07	1.01	-0.05	1.77	Passed	13.1	Passed	Acceptable

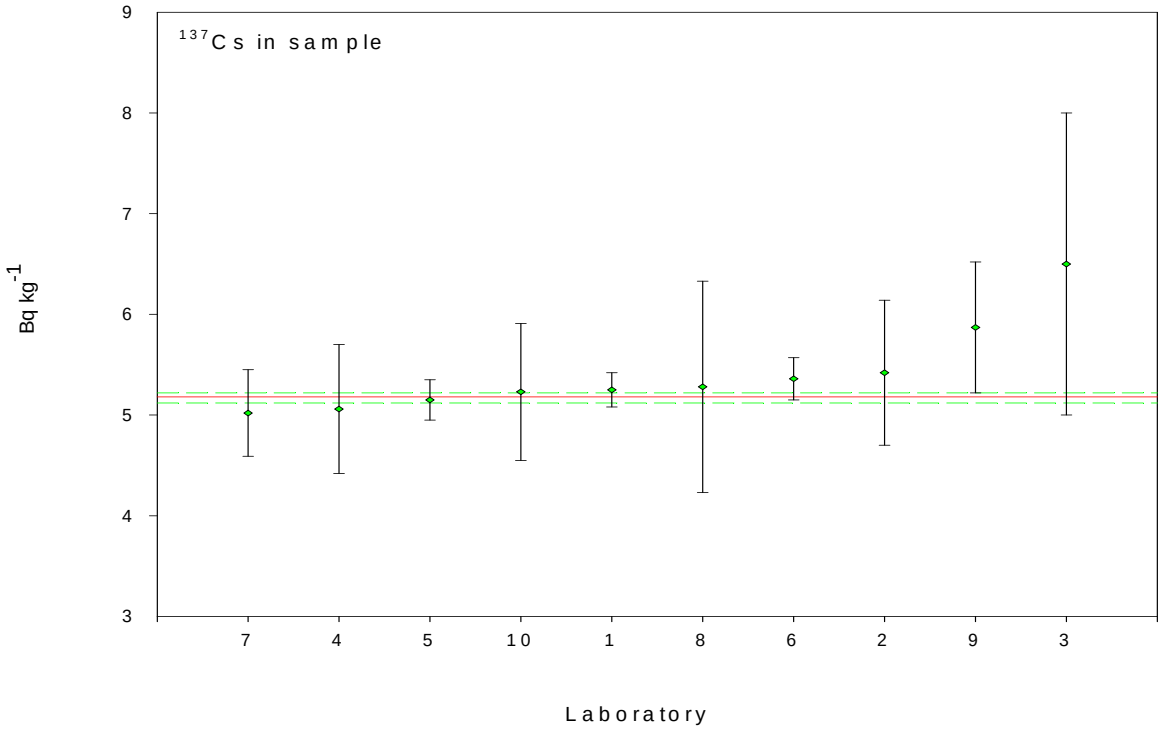

FIG. 5. Data evaluation of ^{137}Cs in IAEA-414.

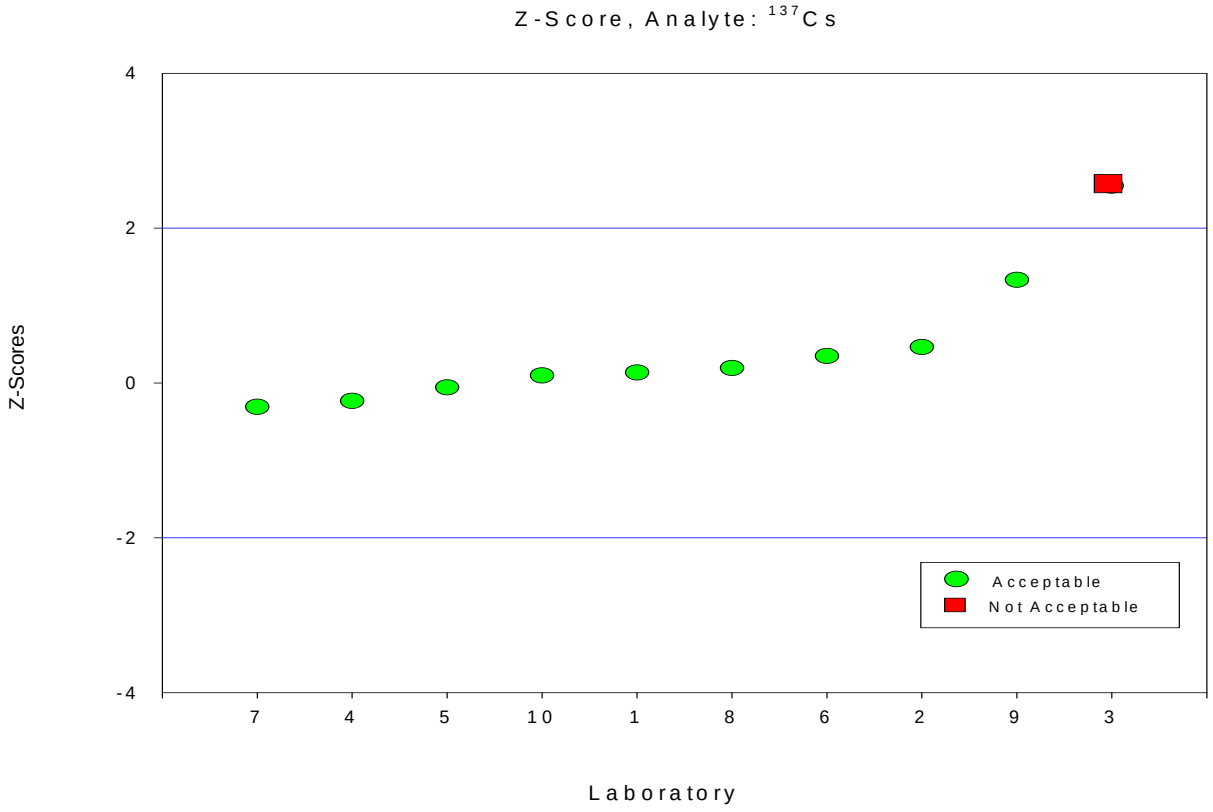

FIG. 6. Z-Score of ^{137}Cs in IAEA-414.

TABLE 3: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{232}Th IN IAEA-414 (TARGET VALUE: 0.028 ± 0.003 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	0.0274	0.0056	20.4	2.14	-0.21	0.07	0.98	0.0006	0.02	Passed	23.1	Passed	Acceptable
7	0.029	0.0029	10.0	-3.57	0.36	-0.15	1.04	-0.001	0.02	Passed	14.7	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

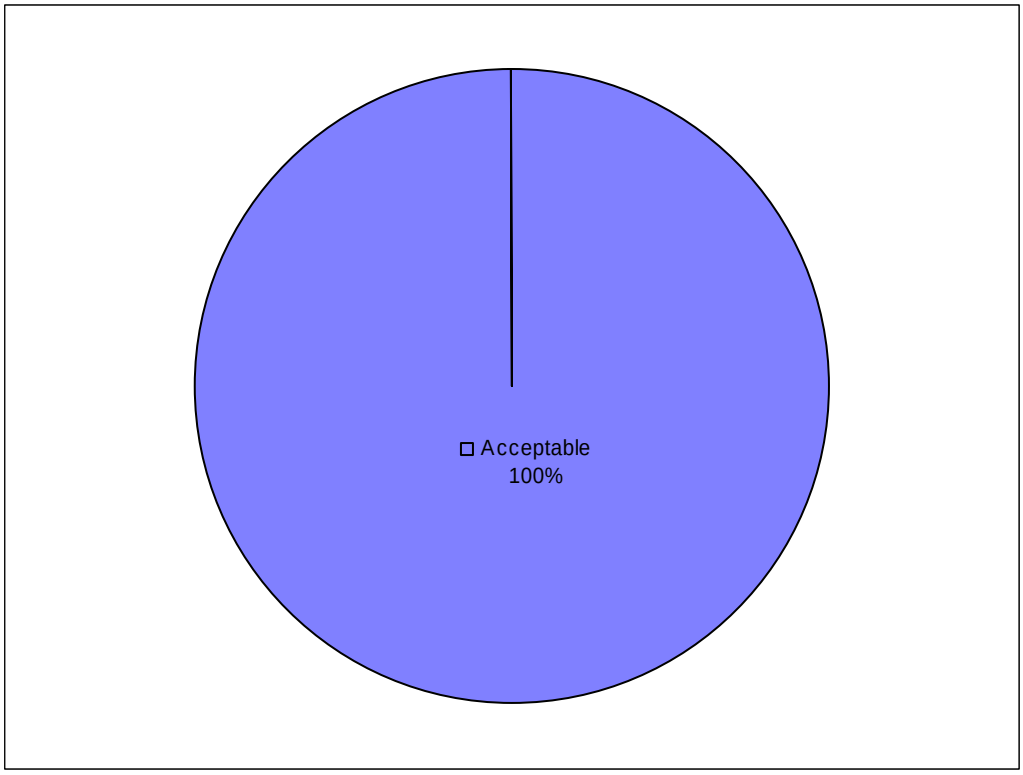

FIG. 7. Evaluation results of ^{232}Th in IAEA-414.

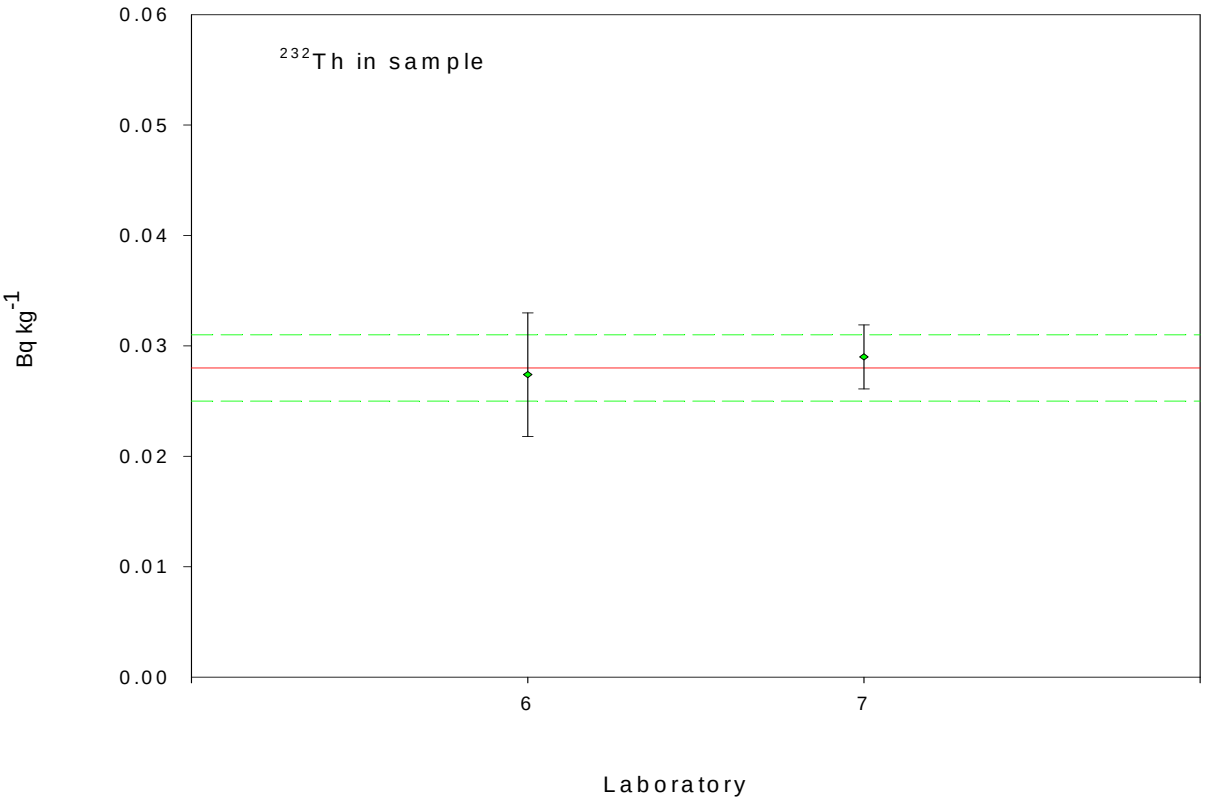

FIG. 8. Data evaluation of ^{232}Th in IAEA-414.

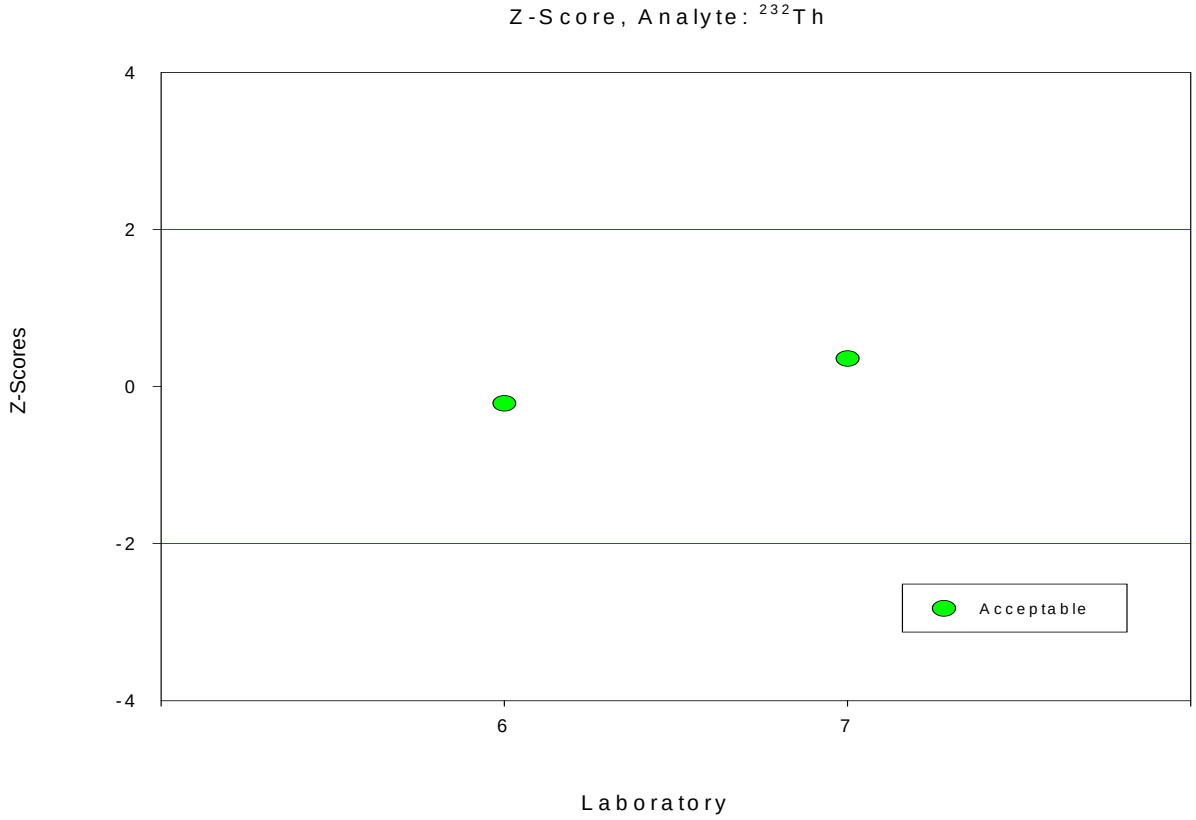

FIG. 9. Z-Score of ^{232}Th in IAEA-414.

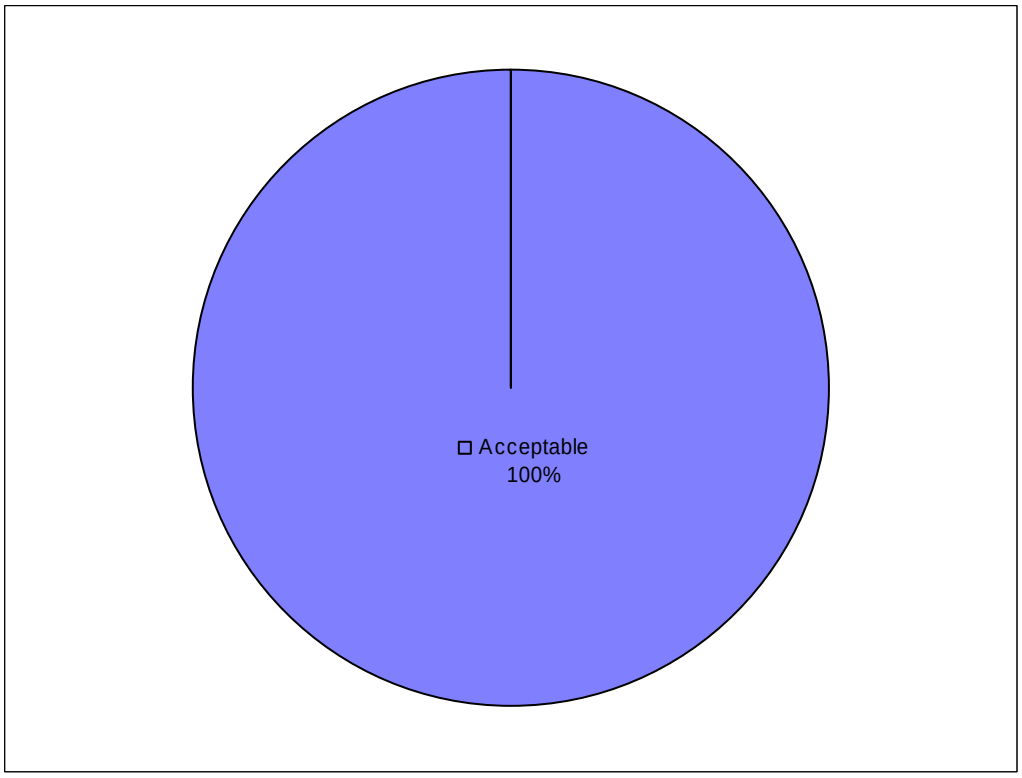

FIG. 10. Evaluation results of ^{234}U in IAEA-414.

TABLE 4: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{234}U IN IAEA-414 (TARGET VALUE: 1.22 ± 0.11 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.21	0.21	17.4	0.82	-0.08	0.04	0.99	0.01	0.61	Passed	19.6	Passed	Acceptable
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	1.195	0.07	5.8	2.05	-0.20	0.19	0.98	0.025	0.34	Passed	10.7	Passed	Acceptable
7	1.25	0.13	10.4	-2.46	0.25	-0.18	1.02	-0.03	0.44	Passed	13.8	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

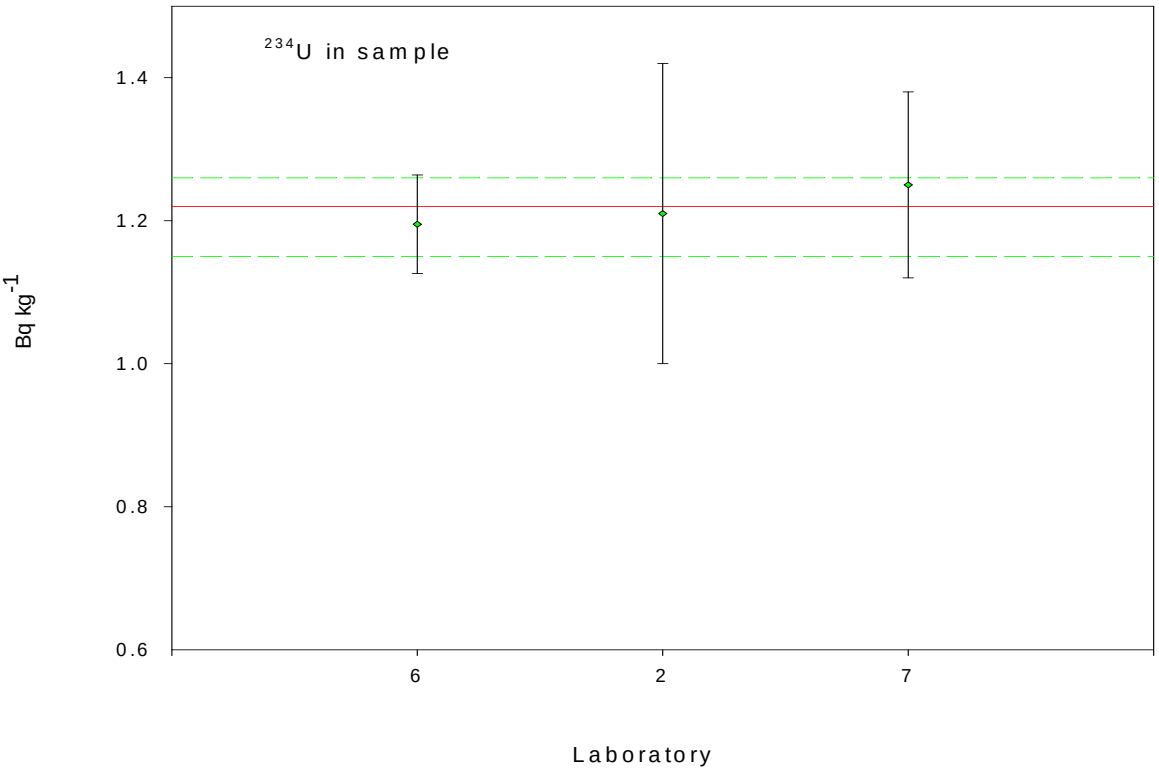

FIG. 11. Data evaluation of ^{234}U in IAEA-414.

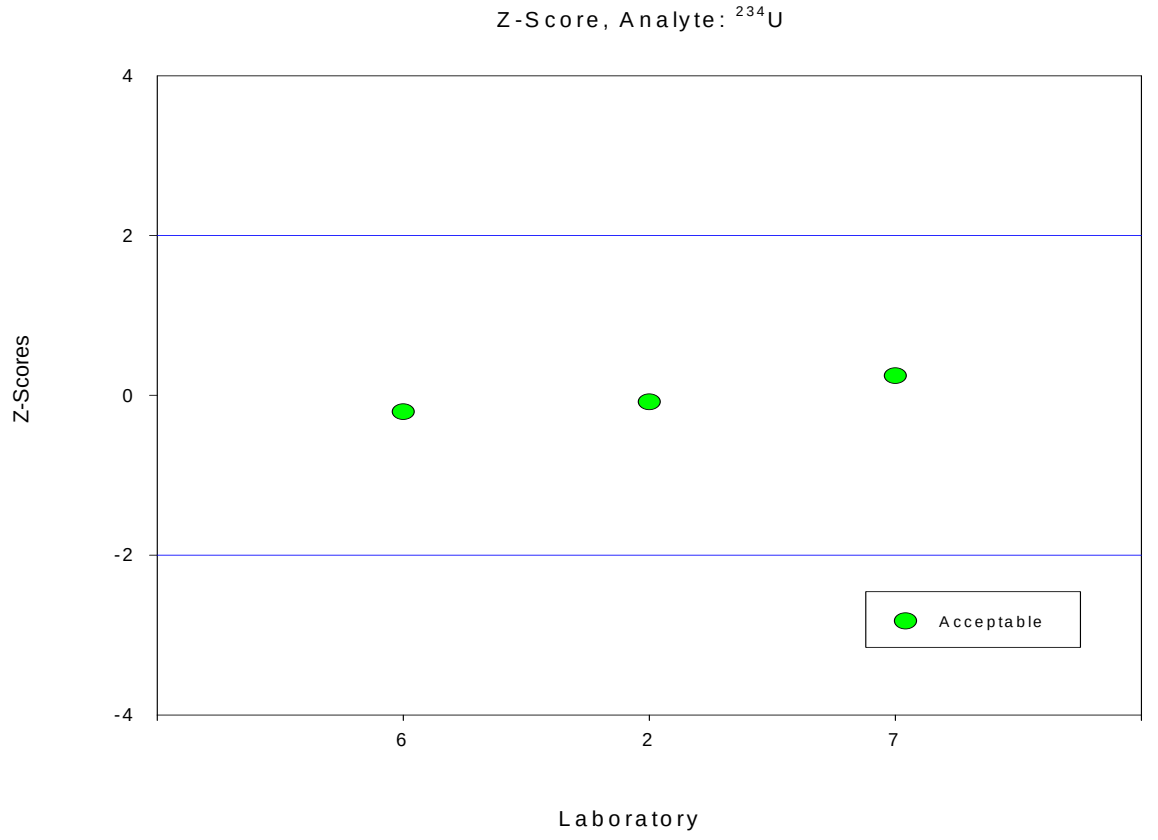

FIG. 12. Z-Score of ^{234}U in IAEA-414.

TABLE 5: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{235}U IN IAEA-414 (TARGET VALUE: 0.05 ± 0.01 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	0.049	0.006	11.6	1.40	-0.14	0.06	0.99	0.0007	0.03	Passed	11.6	Passed	Acceptable
7	0.044	0.004	9.9	11.20	-1.12	0.51	0.89	0.0056	0.03	Passed	9.9	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

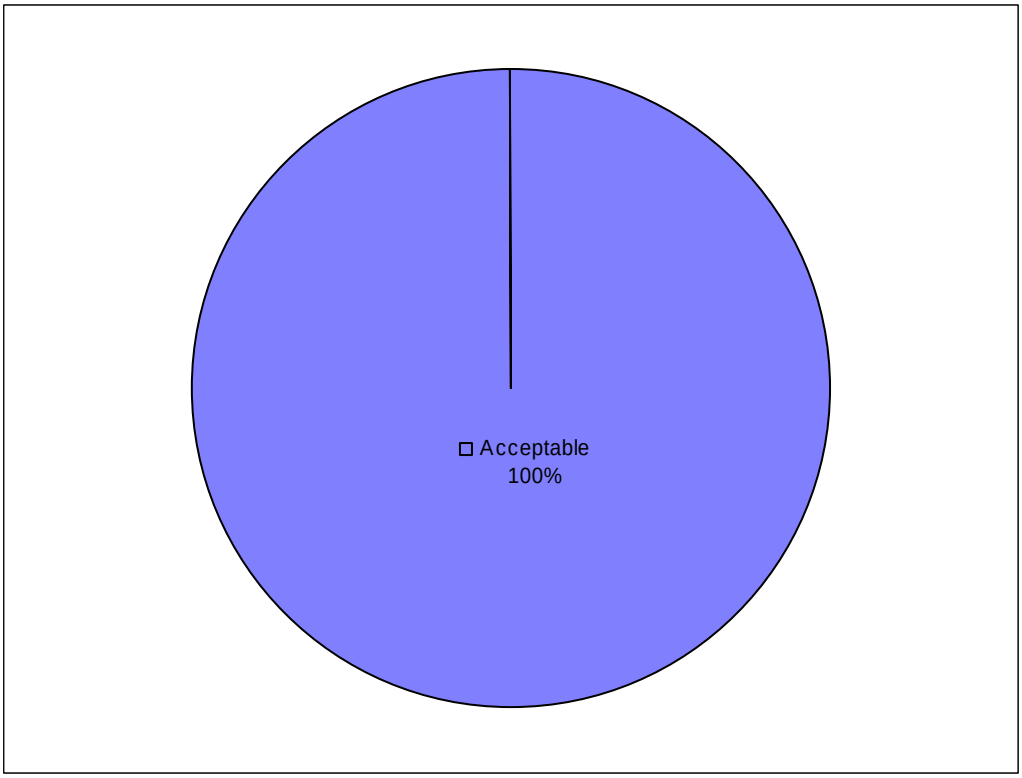

FIG. 13. Evaluation results of ^{235}U in IAEA-414.

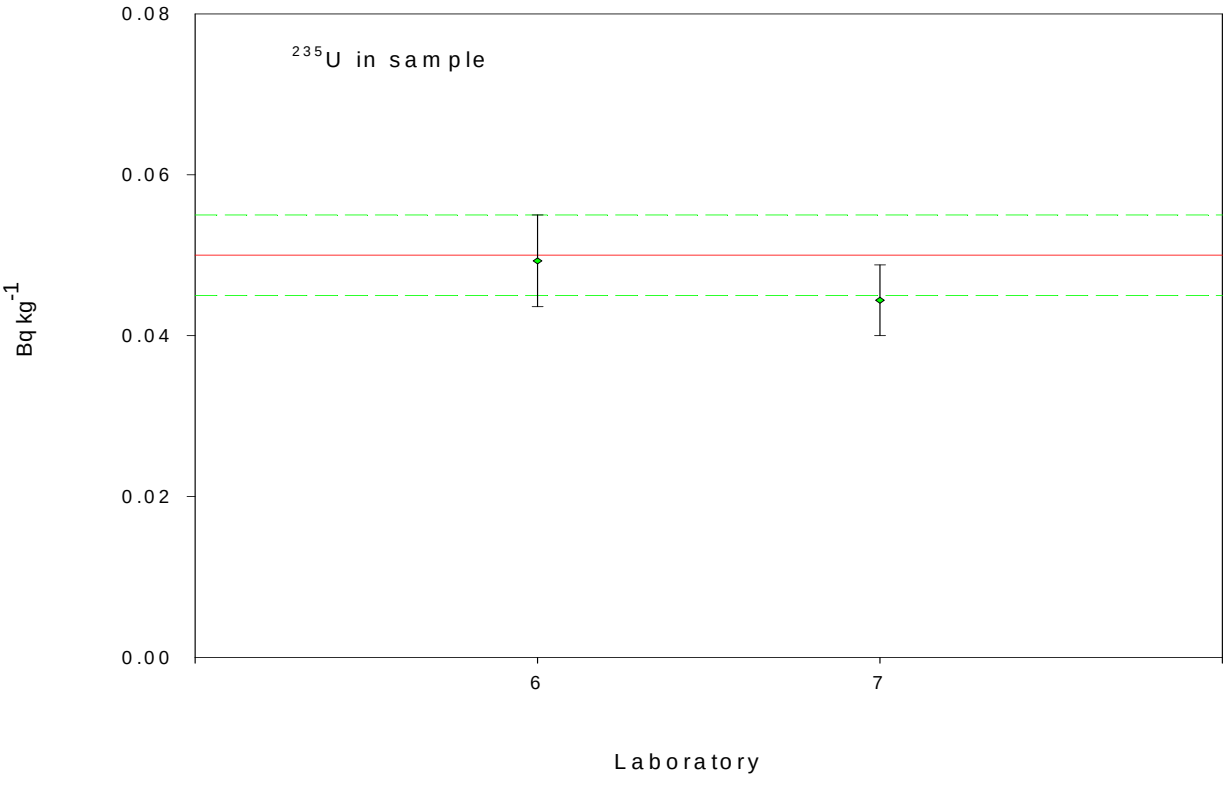

FIG. 14. Data evaluation of ^{235}U in IAEA-414.

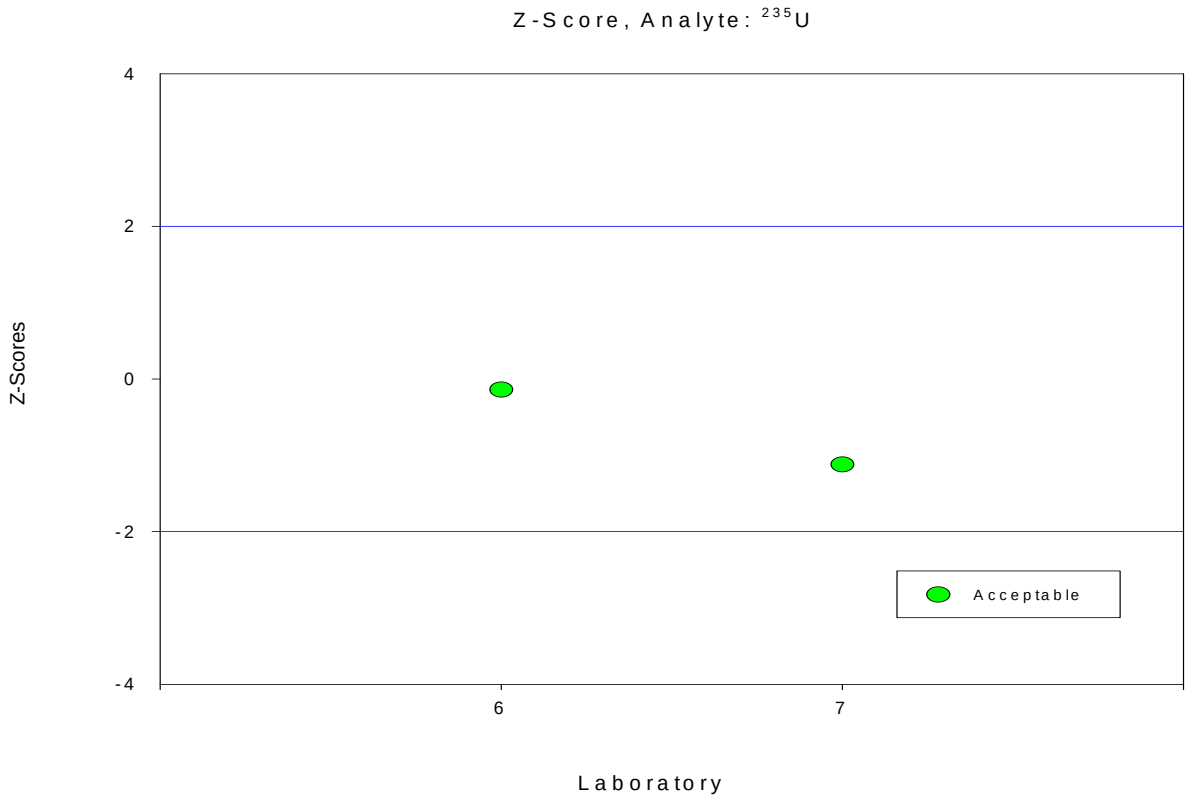

FIG. 15. Z-Score of ^{235}U in IAEA-414.

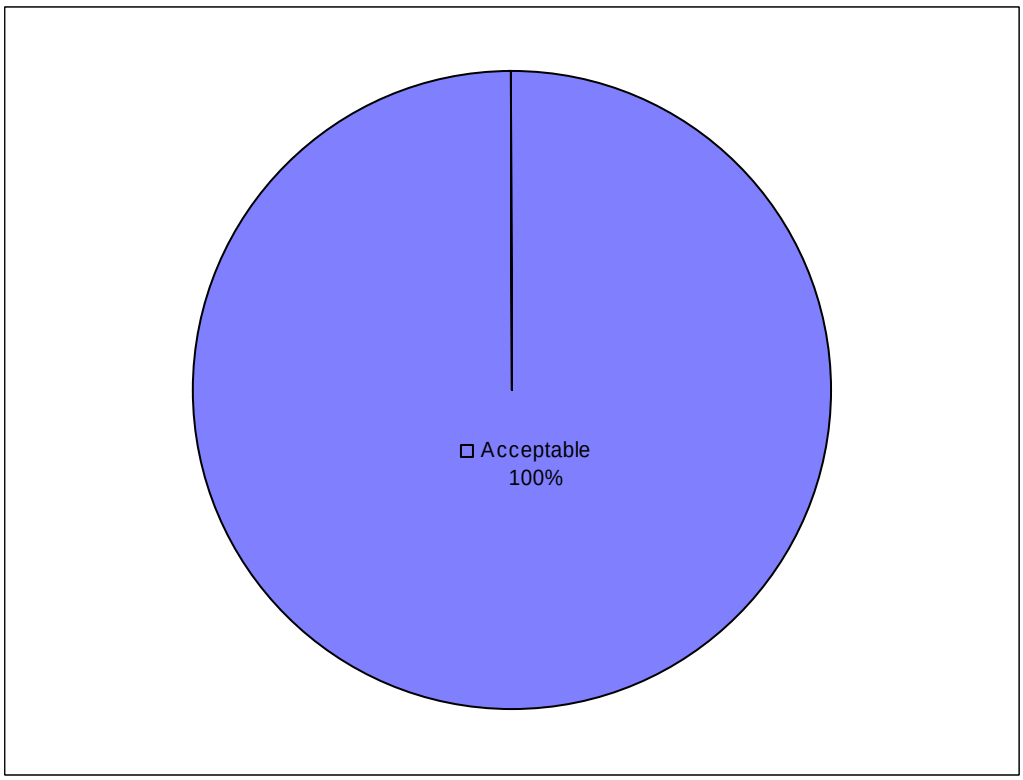

FIG. 16. Evaluation results of ^{238}U in IAEA-414.

TABLE 6: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{238}U IN IAEA-414 (TARGET VALUE: 1.11 ± 0.08 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.03	0.16	15.5	7.21	-0.72	0.45	0.93	0.08	0.46	Passed	17.1	Passed	Acceptable
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	1.125	0.093	8.3	-1.35	0.14	-0.12	1.01	-0.01	0.32	Passed	11	Passed	Acceptable
7	1.16	0.12	10.3	-4.50	0.45	-0.35	1.05	-0.05	0.37	Passed	12.6	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

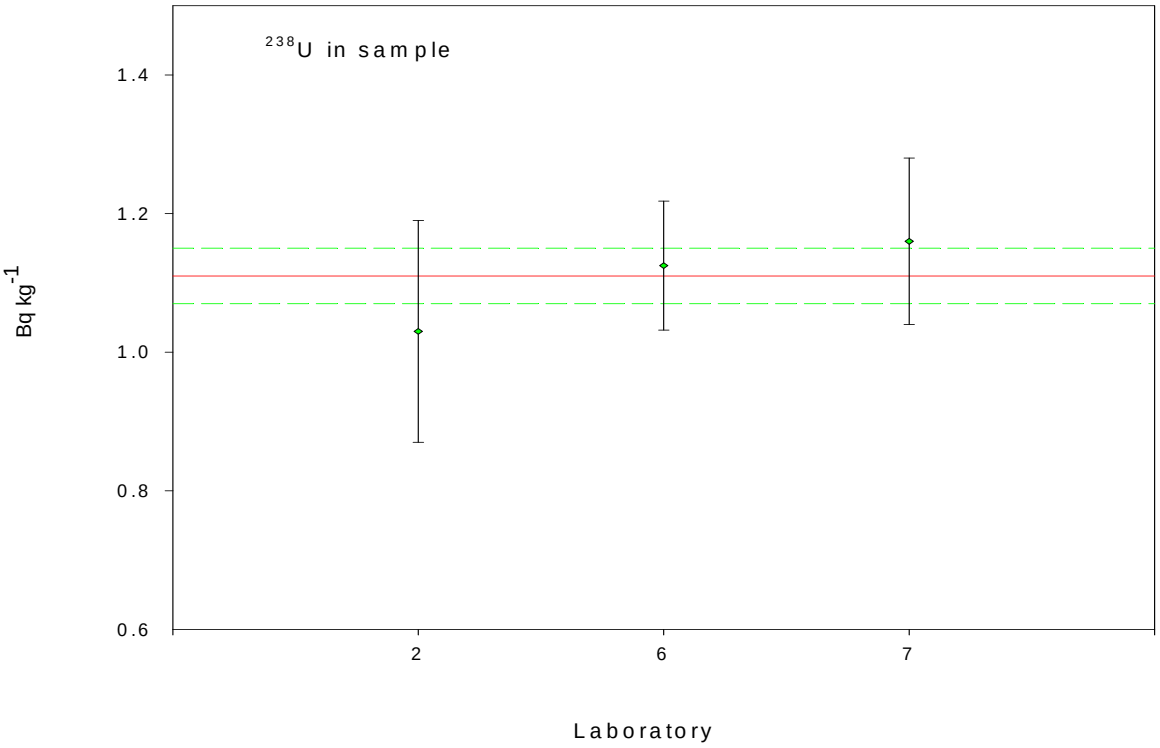

FIG. 17. Data evaluation of ^{238}U in IAEA-414.

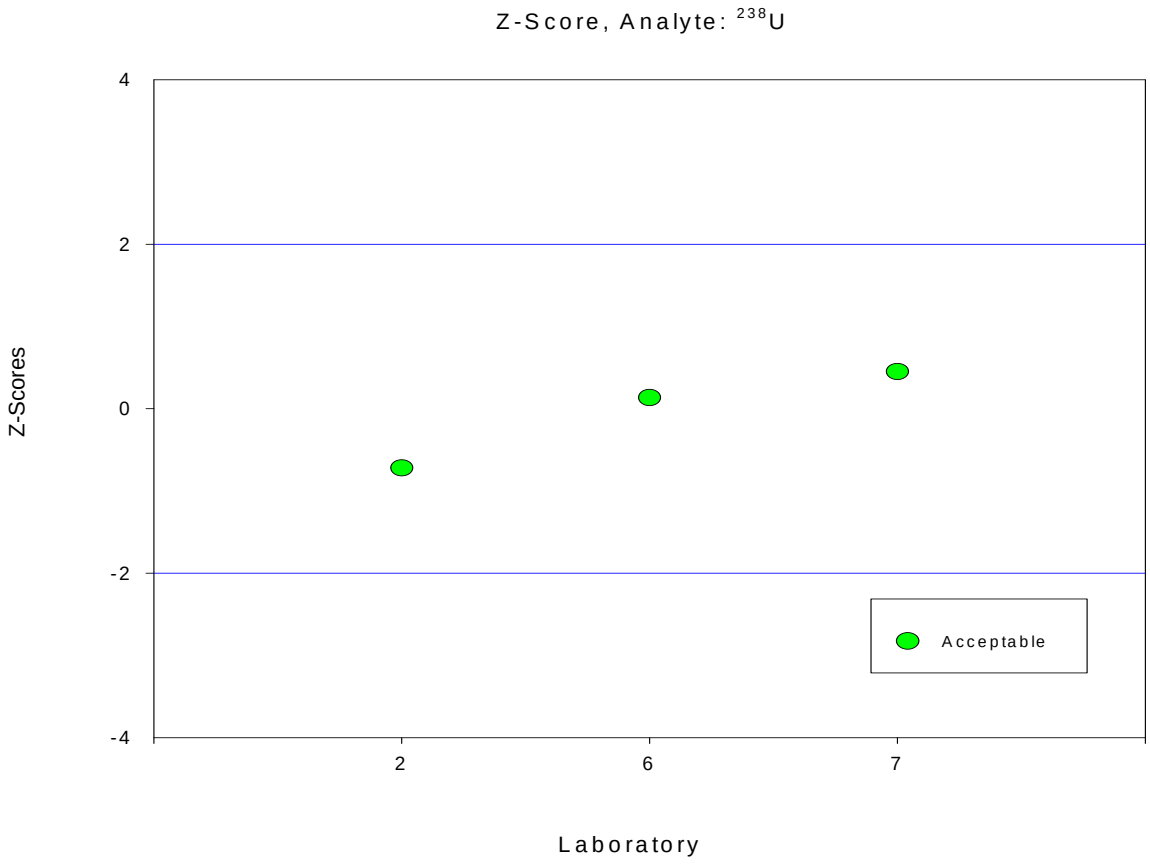

FIG. 18. Z-Score of ^{238}U in IAEA-414.

TABLE 7: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{238}Pu IN IAEA-414 (TARGET VALUE: 0.023 ± 0.003 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	0.0205	0.0089	43.4	10.87	-1.09	0.27	0.89	0.0025	0.02	Passed	45.2	Failed	Warning
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	0.023	0.003	13.0	0.00	0.00	0.00	1.00	0	0.01	Passed	18.1	Passed	Acceptable
6	0.0219	0.0039	17.8	4.78	-0.48	0.23	0.95	0.0011	0.01	Passed	21.8	Passed	Acceptable
7	0.0215	0.0024	11.2	6.52	-0.65	0.40	0.93	0.0015	0.01	Passed	16.8	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

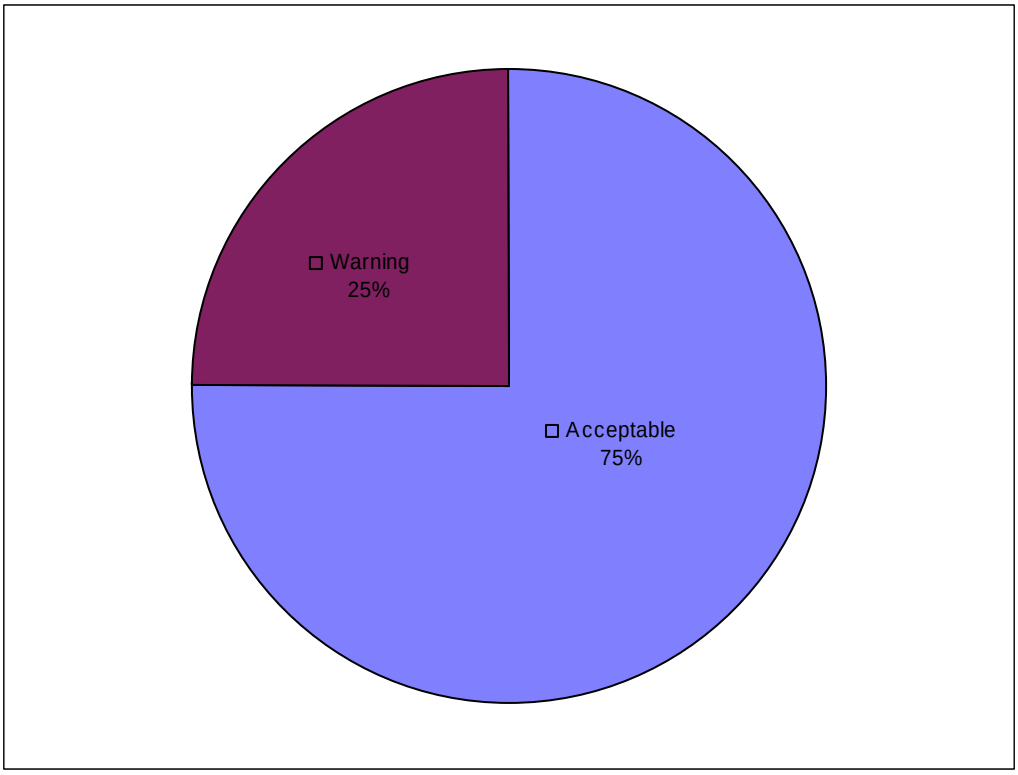

FIG. 19. Evaluation results of ^{238}Pu in IAEA-414.

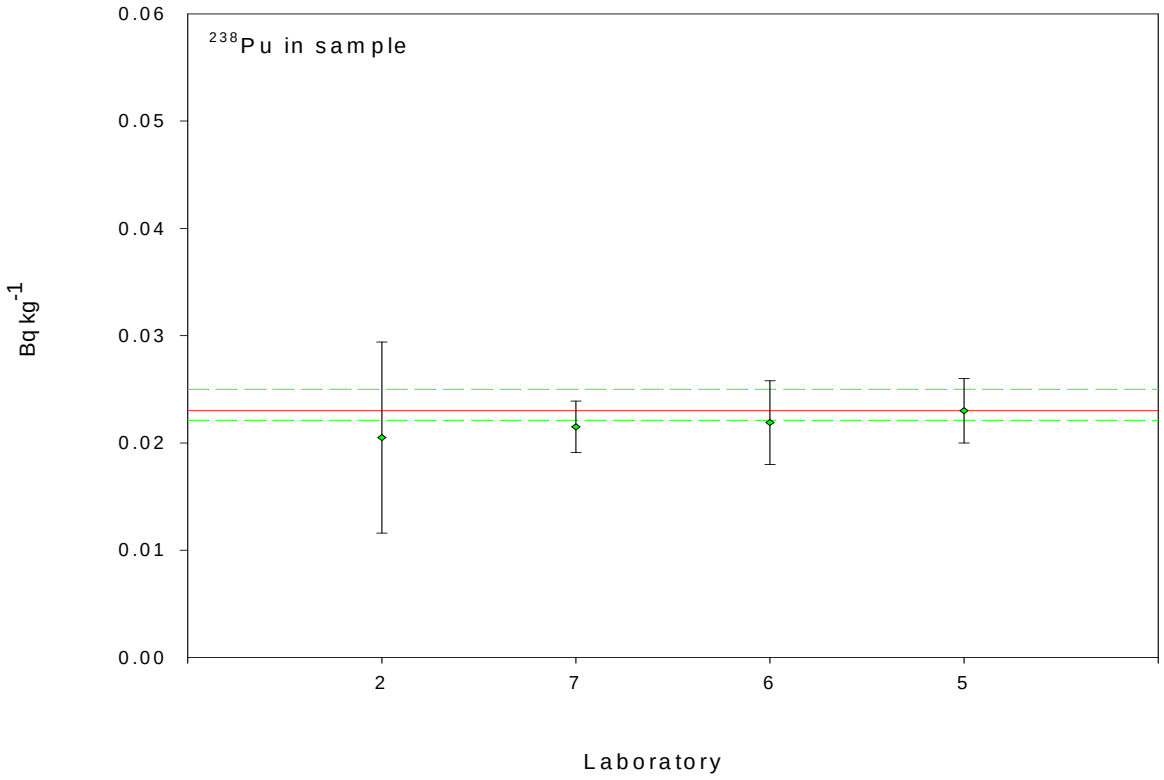

FIG. 20. Data evaluation of ^{238}Pu in IAEA-414.

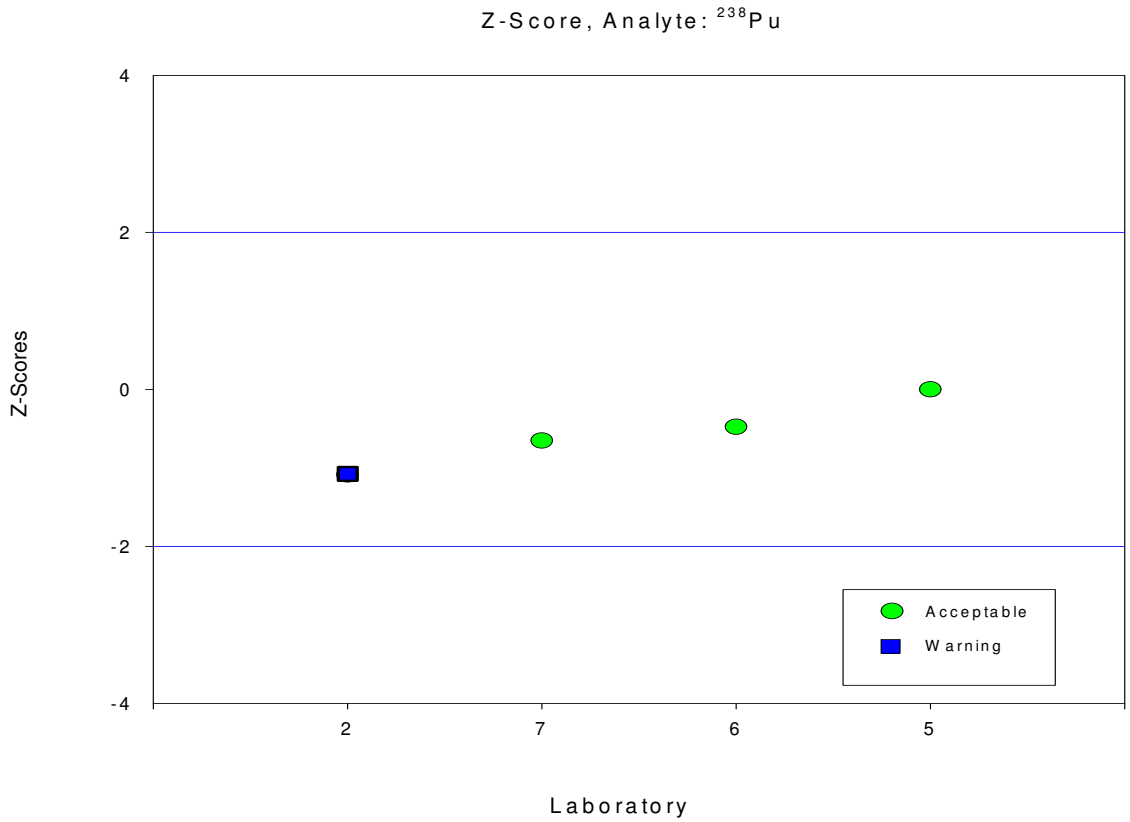

FIG. 21. Z-Score of ^{238}Pu in IAEA-414.

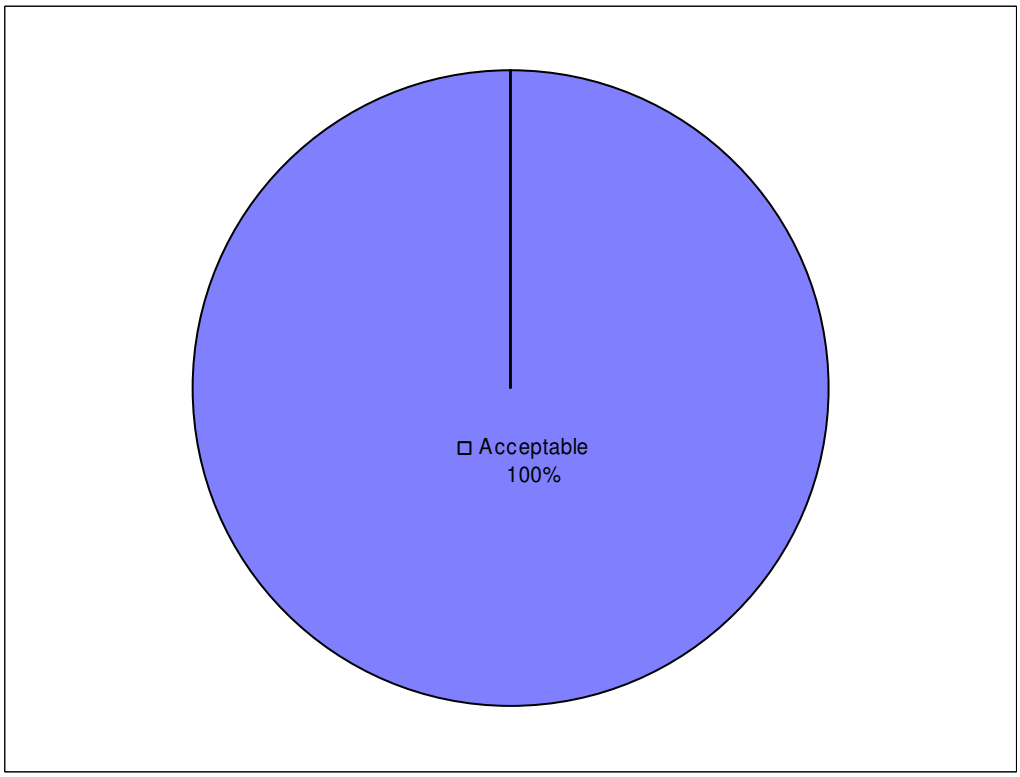

FIG. 22. Evaluation results of $^{239+240}Pu$ in IAEA-414.

TABLE 8: EVALUATION RESULTS FOR PROFICIENCY TEST OF $^{239+240}$Pu IN IAEA-414 (TARGET VALUE:0.120 ± 0.007 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	-	-	-	-	-	-	-	-	-	-	-	-	-
2	0.12	0.025	20.8	0.00	0.00	0.00	1.00	0	0.07	Passed	21.6	Passed	Acceptable
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	0.14	0.008	5.7	-16.7	1.67	-1.88	1.17	-0.02	0.03	Passed	8.2	Passed	Acceptable
6	0.1165	0.0097	8.3	2.92	-0.29	0.29	0.97	0.0035	0.03	Passed	10.2	Passed	Acceptable
7	0.125	0.012	9.6	-4.17	0.42	-0.36	1.04	-0.005	0.04	Passed	11.2	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

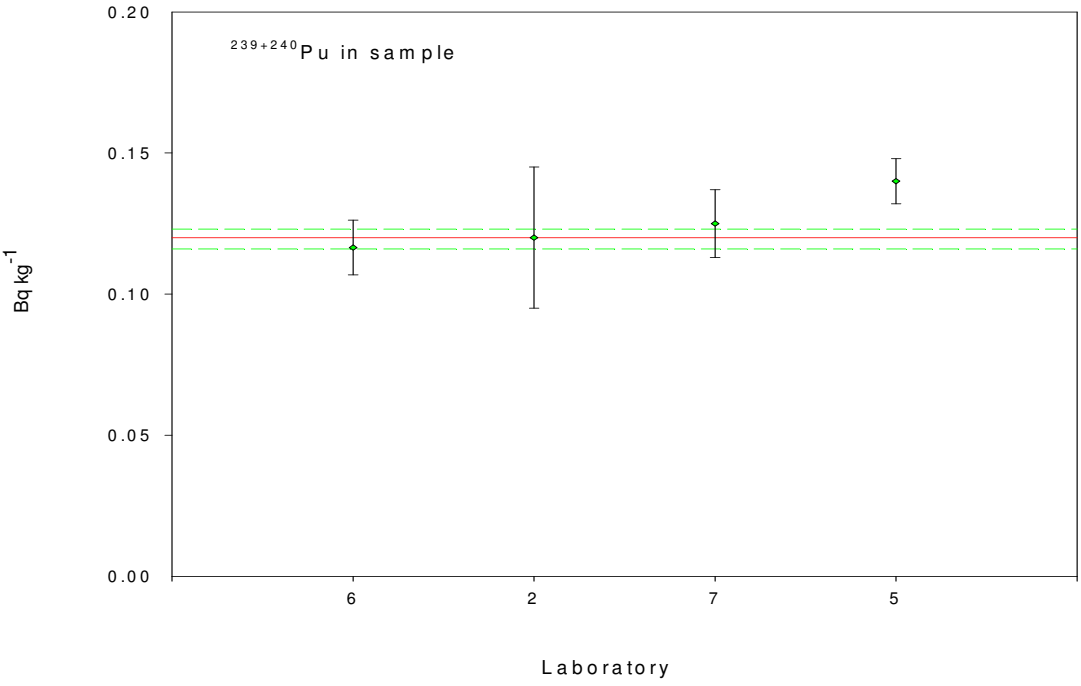

FIG. 23. Data evaluation of $^{239+240}$Pu in IAEA-414.

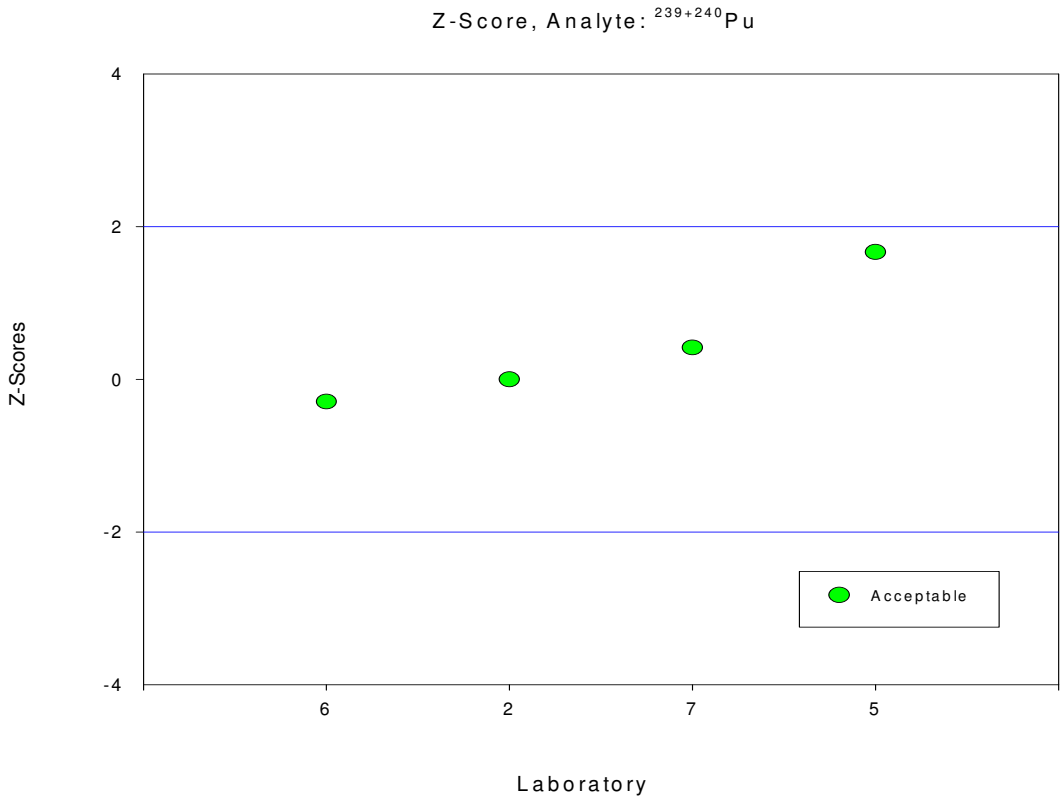

FIG. 24. Z-Score of $^{239+240}$Pu in IAEA-414.

TABLE 9: EVALUATION RESULTS FOR PROFICIENCY TEST OF ^{241}Am IN IAEA-414 (TARGET VALUE: 0.197 ± 0.011 Bq kg^{-1})

Lab Code	Lab Value	Lab Unc.	Unc. (%)	Rel. Bias	Z-Score	U-Test	Ratio	A1	A2	Trueness	P	Precision	Final Score
1	0.7	0.2	28.6	-255	25.53	-2.51	3.55	-0.503	0.52	Passed	29.1	Failed	Not Acceptable
2	0.318	0.183	57.5	-61.4	6.14	-0.66	1.61	-0.121	0.47	Passed	57.8	Failed	Not Acceptable
3	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	0.199	0.019	9.5	-1.02	0.10	-0.09	1.01	-0.002	0.06	Passed	11.1	Passed	Acceptable
7	0.204	0.02	9.8	-3.55	0.36	-0.31	1.04	-0.007	0.06	Passed	11.3	Passed	Acceptable
8	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-

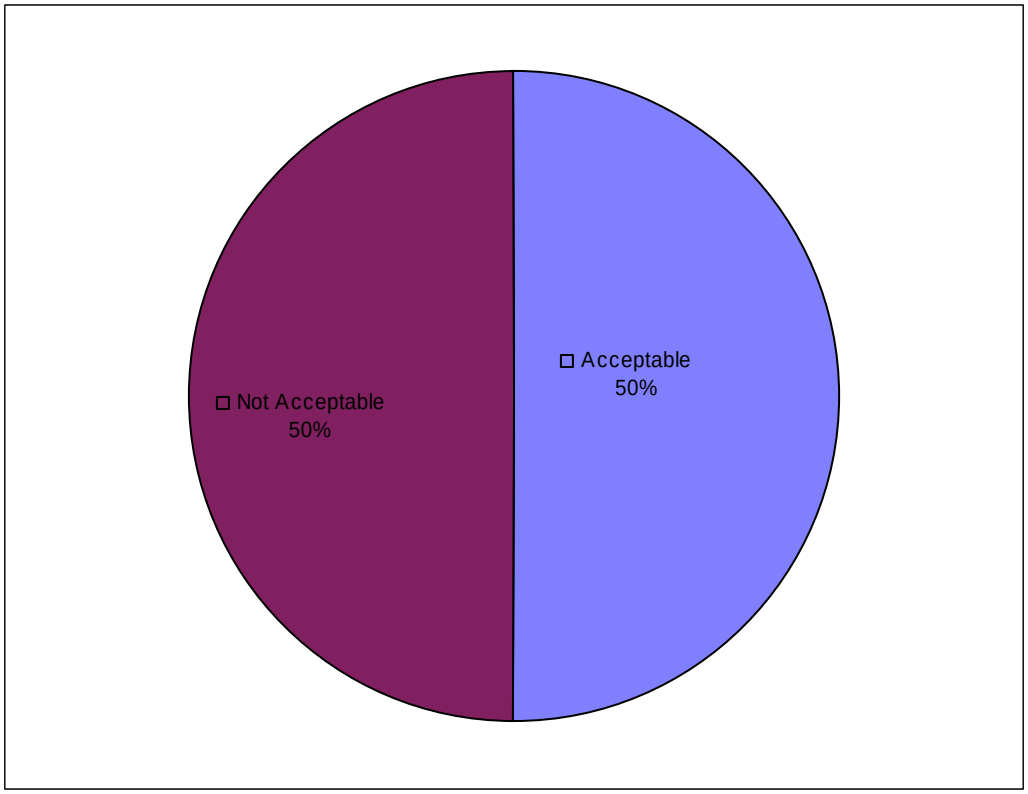

FIG. 25. Evaluation results of ^{241}Am in IAEA-414.

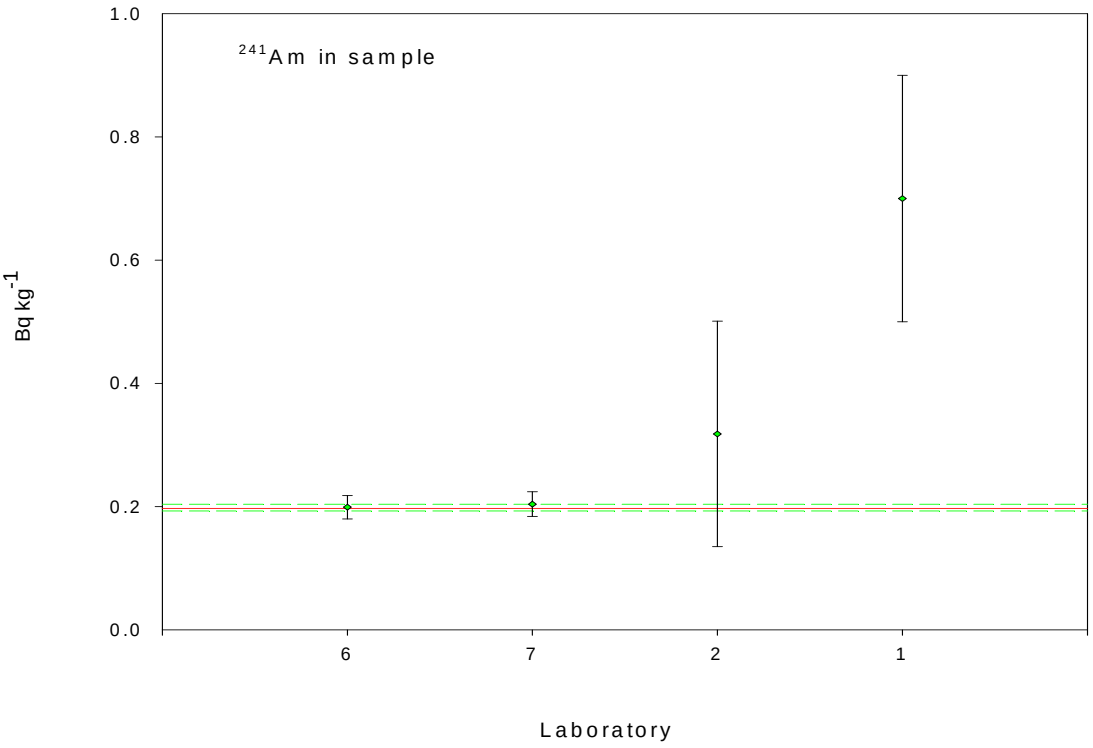

FIG. 26. Data evaluation of ^{241}Am in IAEA-414.

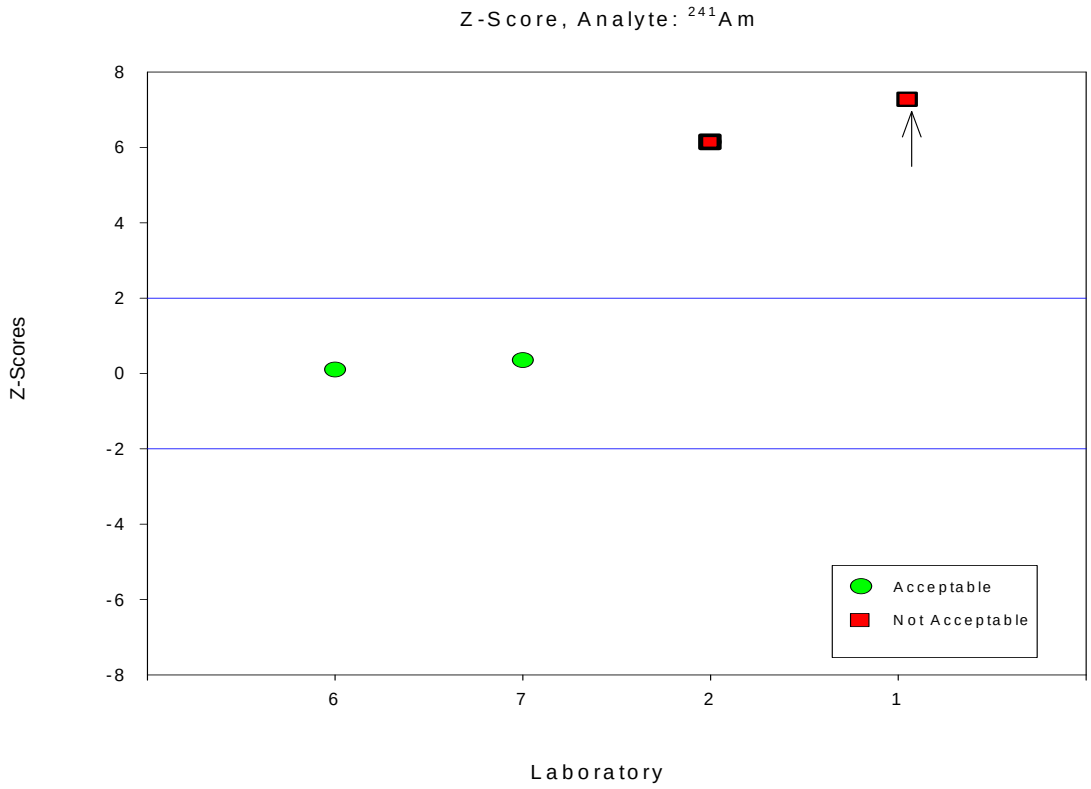

FIG. 27. Z-Score of ^{241}Am in IAEA-414.

Appendix 3: Performance evaluation tables sorted by laboratory code

HELCOM-MORS proficiency test on the determination of radionuclides in fish flesh sample IAEA-414.

Laboratory N^{o}1, Federal Maritime and Hydrographic Agency, Hamburg, Germany.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z- Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P(%)	Precision	Final Score
^{40}K	481	16	425	4	0.9	11.64	-1.16	3.40	0.88	56	42.6	Failed	3.5	Passed	Warning
^{137}Cs	5.18	0.10	5.25	0.17	3.2	-1.35	0.14	-0.35	1.01	-0.07	0.51	Passed	3.8	Passed	Acceptable
^{241}Am	0.197	0.011	0.7	0.2	28.6	-255	25.53	-2.51	3.55	-0.5	0.52	Passed	29.1	Failed	Not Acceptable

Note: This laboratory reported two values of ^{241}Am, one is under the LLD. The “Lab. Values” of ^{40}K and ^{137}Cs in the table are the mean values of two reported individual determinations.

HELCOM-MORS proficiency test on the determination of radionuclides in fish flesh sample IAEA-414.

Laboratory N^{o}2, STUK- Radiation and Nuclear Safety Authority, Helsinki, Finland.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z-Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P(%)	Precision	Final Score
^{40}K	481	16	490	53	10.8	-1.87	0.19	-0.16	1.02	9	143	Passed	11.3	Passed	Acceptable
^{137}Cs	5.18	0.10	5.42	0.72	13.3	-4.63	0.46	-0.33	1.05	-0.24	1.88	Passed	13.4	Passed	Acceptable
^{234}U	1.22	0.11	1.21	0.21	17.4	0.82	-0.08	0.04	0.99	0.01	0.61	Passed	19.6	Passed	Acceptable
^{238}U	1.11	0.08	1.03	0.16	15.5	7.21	-0.72	0.45	0.93	0.08	0.46	Passed	17.1	Passed	Acceptable
^{238}Pu	0.023	0.003	0.0205	0.0089	43.4	10.9	-1.09	0.27	0.89	0.0025	0.02	Passed	45.2	Failed	Warning
$^{239+240}$Pu	0.120	0.007	0.120	0.025	20.8	0.00	0.00	0.00	1.00	0	0.07	Passed	21.6	Passed	Acceptable
^{241}Am	0.197	0.011	0.318	0.183	57.5	-61.4	6.14	-0.66	1.61	-0.121	0.47	Passed	57.8	Failed	Not Acceptable

Note: The “Lab. Values” of all radionuclides in the table are the mean values of two reported individual analyses.

HELCOM-MORS proficiency test on the determination of radionuclides in fish flesh sample IAEA-414.

Laboratory N^{o}3, Estonian Radiation Protection Centre, Tallinn, Estonia.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z- Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P(%)	Precision	Final Score
^{40}K	481	16	467.5	47.7	10.2	2.81	-0.28	0.27	0.97	13.5	129.8	Passed	10.7	Passed	Acceptable
^{137}Cs	5.18	0.10	6.5	1.5	23.1	-25.48	2.55	-0.88	1.25	-1.32	3.88	Passed	23.2	Failed	Not Acceptable

Note: The “Lab. Values” of ^{40}K and ^{137}Cs in the table are the mean values of two reported individual analyses.

HELCOM-MORS proficiency test on the determination of radionuclides in fish flesh sample IAEA-414.

Laboratory N^{o}4, Institute of Meteorology and Water Management, Maritime Branch, Gdynia, Poland.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z- Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P(%)	Precision	Final Score
^{40}K	481	16	474.5	19.3	4.1	1.35	-0.14	0.26	0.99	6.5	64.68	Passed	5.2	Passed	Acceptable
^{137}Cs	5.18	0.10	5.06	0.64	12.6	2.32	-0.23	0.19	0.98	0.12	1.67	Passed	12.8	Passed	Acceptable

Note: The “Lab. Values” of ^{40}K and ^{137}Cs in the table are the mean values of three and six reported individual analyses, respectively.

HELCOM-MORS PROFICIENCY TEST ON THE DETERMINATION OF RADIONUCLIDES IN FISH FLESH SAMPLE IAEA-414.

Laboratory N^{o}5, Central Laboratory for Radiological Protection, Warsaw, Poland.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z- Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P(%)	Precision	Final Score
^{40}K	481	16	517	14	2.8	-7.59	0.76	-1.70	1.08	36.5	55.5	Passed	4.3	Passed	Acceptable
^{137}Cs	5.18	0.10	5.15	0.20	3.9	0.58	-0.06	0.13	0.99	0.03	0.58	Passed	4.3	Passed	Acceptable
^{238}Pu	0.023	0.003	0.023	0.003	13.0	0.00	0.00	0.00	1.00	0	0.01	Passed	18.1	Passed	Acceptable
$^{239+240}$Pu	0.120	0.007	0.140	0.008	5.7	-16.67	1.67	-1.88	1.17	-0.02	0.03	Passed	8.2	Passed	Acceptable

Note: The “Lab. Values” of ^{40}K, ^{137}Cs, ^{238}Pu and $^{239+240}$Pu in the table are the mean values of two reported individual analyses.

HELCOM-MORS PROFICIENCY TEST ON THE DETERMINATION OF RADIONUCLIDES IN FISH FLESH SAMPLE IAEA-414.

Laboratory N°6, Institute of Fishery Ecology, Hamburg, Germany.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z-Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P (%)	Precision	Final Score
^{40}K	481	16	462	15	3.2	3.95	-0.40	0.87	0.96	19	56.6	Passed	4.6	Passed	Acceptable
^{137}Cs	5.18	0.10	5.36	0.21	3.9	-3.47	0.35	-0.77	1.03	-0.18	0.60	Passed	4.4	Passed	Acceptable
^{232}Th	0.028	0.006	0.0274	0.0056	20.4	2.14	-0.21	0.07	0.98	0.0006	0.02	Passed	23.1	Passed	Acceptable
^{234}U	1.22	0.11	1.195	0.069	5.8	2.05	-0.20	0.19	0.98	0.025	0.34	Passed	10.7	Passed	Acceptable
^{235}U	0.05	0.01	0.049	0.006	11.6	1.40	-0.14	0.06	0.99	0.0007	0.03	Passed	11.6	Passed	Acceptable
^{238}U	1.11	0.08	1.125	0.093	8.3	-1.35	0.14	-0.12	1.01	-0.015	0.32	Passed	11	Passed	Acceptable
^{238}Pu	0.023	0.003	0.0219	0.0039	17.8	4.78	-0.48	0.23	0.95	0.0011	0.01	Passed	21.8	Passed	Acceptable
$^{239+240}$Pu	0.120	0.007	0.1165	0.0097	8.3	2.92	-0.29	0.29	0.97	0.0035	0.03	Passed	10.2	Passed	Acceptable
^{241}Am	0.197	0.011	0.199	0.019	9.5	-1.02	0.10	-0.09	1.01	-0.002	0.06	Passed	11.1	Passed	Acceptable

Note: The “Lab. Values” of ^{40}K and ^{137}Cs are the mean values of six reported individual analyses. The “Lab. Values” for all other radionuclides are the mean values of two reported individual analyses.

HELCOM-MORS PROFICIENCY TEST ON THE DETERMINATION OF RADIONUCLIDES IN FISH FLESH SAMPLE IAEA-414.

Laboratory N^{o}7, Riso National Laboratory, Roskilde, Denmark.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z-Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P (%)	Precision	Final Score
^{40}K	481	16	502	50	10.0	-4.37	0.44	-0.40	1.04	21	135.4	Passed	10.5	Passed	Acceptable
^{137}Cs	5.18	0.10	5.02	0.43	8.6	3.09	-0.31	0.36	0.97	0.16	1.14	Passed	8.8	Passed	Acceptable
^{232}Th	0.028	0.006	0.029	0.0029	10.0	-3.57	0.36	-0.15	1.04	-0.001	0.02	Passed	23.6	Passed	Acceptable
^{234}U	1.22	0.11	1.25	0.13	10.4	-2.46	0.25	-0.18	1.02	-0.03	0.44	Passed	13.8	Passed	Acceptable
^{235}U	0.05	0.01	0.0444	0.0044	9.9	11.20	-1.12	0.51	0.89	0.0056	0.03	Passed	9.9	Passed	Acceptable
^{238}U	1.11	0.08	1.16	0.12	10.3	-4.50	0.45	-0.35	1.05	-0.05	0.37	Passed	12.6	Passed	Acceptable
^{238}Pu	0.023	0.003	0.0215	0.0024	11.2	6.52	-0.65	0.40	0.93	0.0015	0.01	Passed	16.8	Passed	Acceptable
$^{239+240}$Pu	0.120	0.007	0.125	0.012	9.6	-4.17	0.42	-0.36	1.04	-0.005	0.04	Passed	11.2	Passed	Acceptable
^{241}Am	0.197	0.011	0.204	0.02	9.8	-3.55	0.36	-0.31	1.04	-0.007	0.06	Passed	11.3	Passed	Acceptable

Note: The “Lab. Values” of all radionuclides in the table are the mean values of four to six reported individual analyses.

HELCOM-MORS PROFICIENCY TEST ON THE DETERMINATION OF RADIONUCLIDES IN FISH FLESH SAMPLE IAEA-414.

Laboratory N°8, Radiology Division, Environmental Research Department, Vilnius, Lithuania.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z-Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P (%)	Precision	Final Score
^{40}K	481	16	438	36	8.2	8.94	-0.89	1.09	0.91	43	101.6	Passed	8.9	Passed	Acceptable
^{137}Cs	5.18	0.10	5.28	1.13	8.6	3.09	-0.31	0.36	0.97	0.16	1.14	Passed	8.8	Passed	Acceptable

Note: The “Lab. Values” of all radionuclides in the table are the mean values of two reported individual analysis.

HELCOM-MORS PROFICIENCY TEST ON THE DETERMINATION OF RADIONUCLIDES IN FISH FLESH SAMPLE IAEA-414.

Laboratory N^{o}9, V.G. Khlopin Radium Institute, Saint-Petersburg, Russia.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z-Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P (%)	Precision	Final Score
^{40}K	481	16	513	35	6.8	-6.65	0.67	-0.83	1.07	32	99.3	Passed	7.6	Passed	Acceptable
^{137}Cs	5.18	0.10	5.78	0.65	11.1	-13.32	1.33	-1.05	1.13	-0.69	1.70	Passed	11.2	Passed	Acceptable

Note: The “Lab. Values” of all radionuclides in the table are the mean values of two reported individual analyses.

HELCOM-MORS PROFICIENCY TEST ON THE DETERMINATION OF RADIONUCLIDES IN FISH FLESH SAMPLE IAEA-414.

Laboratory N°10, Swedish Radiation Safety Authority, Sweden.

Reference Date: 01 January 1997

Analyte	IAEA Value [Bq kg^{-1} d.w.]	IAEA Unc. [Bq kg^{-1} d.w.]	Lab. Value [Bq kg^{-1} d.w.]	Lab. Unc. [Bq kg^{-1} d.w.]	Lab. Unc. (%)	Rel. Bias (%)	z-Score	u- Test	Ratio Lab/IAEA	A1	A2	Trueness	P (%)	Precision	Final Score
^{137}Cs	5.18	0.10	5.23	0.68	13	-0.97	0.10	-0.07	1.01	-0.05	1.77	Passed	13.1	Passed	Acceptable

Note: The “Lab. Value” of ^{137}Cs in the table is the mean value of nine reported individual analysis.

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