IAEA/AQ/2

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Mediterranean Region Proficiency Test on the Determination of Radionuclides in Air Filters

IAEA-CU-2008-02

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Mediterranean Region Proficiency Test on the Determination of Radionuclides in Air Filters IAEA-CU-2008-02

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FOREWORD

The IAEA helps the Member States laboratories to maintain their readiness and improving the quality of the analytical results by producing reference materials, by development of standardized methods for sample collection and analysis, and by conducting interlaboratory comparisons and proficiency tests as a tool for external quality control of analytical results.

The Chemistry Unit of the Physics, Chemistry and Instrumentation Laboratory in the International Atomic Energy Agency's Seibersdorf Laboratories in Austria, has the programmatic responsibility to support global radionuclide measurement systems. To fulfil this obligation and ensure a reliable worldwide, rapid and consistent response, the Chemistry Unit organises interlaboratory studies and proficiency tests.

The activity concentration of radionuclides in the air is a critical factor in assessing the air quality and the potential impact of possible pollutants. Air is in fact one of the main pathways for human exposure to pollutants. Radioactivity may be present in the atmosphere due to natural processes; intentional (low level) anthropogenic release; or as a consequence of nuclear or radiological incident.

Within the frame of the IAEA Technical Cooperation project RER/8/009 "Air Pollution Monitoring in the Mediterranean Region", several Member States expressed their interest in establishing close cooperation among Mediterranean countries in the field of harmonization of air pollution monitoring systems and creation of a common database, since they share geographical position and mutual interest in the environmental conditions of the Mediterranean region. Such cooperation will also promote and enhance the exchange of experience/information.

This report summarizes the results of the IAEA-CU-2008-02 Mediterranean Region proficiency test on the determination of radionuclides in air filters.

The IAEA officer responsible for this publication is A. Shakhashiro of the Agency's Laboratories, Seibersdorf and Headquarters, Austria.

EDITORIAL NOTE

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CONTENTS

1. INTRODUCTION

Within the frame of the IAEA Technical Cooperation project RER/8/009 "Air Pollution Monitoring in the Mediterranean Region", several Member States expressed their interest in establishing close cooperation among Mediterranean countries in the field of harmonization of air pollution monitoring systems and creation of a common database, since they share geographical position and mutual interest in the environmental conditions of the Mediterranean region. Such cooperation will also promote and enhance the exchange of experience/information.

The objective of the TC project RER/8/009 is to contribute to air quality improvement through the establishment of a network for air monitoring and the design of a remedial strategy where the monitoring shows poor air quality. To fulfil the objective of this TC project, a set of systematic measurements is needed for establishing a baseline level for radionuclide and activity concentration in air. The baseline results are important for health-effect evaluation as well as for detection of the increased level of the pollutants resulting from the intentional or accidental release into the environment. Consequently it is rather important to assure that the conclusions of air monitoring studies are based on reliable and validated analytical results and to ensure the comparability of the results of different countries. Hence, this proficiency test was organized to evaluate the analytical performance of the participating laboratories.

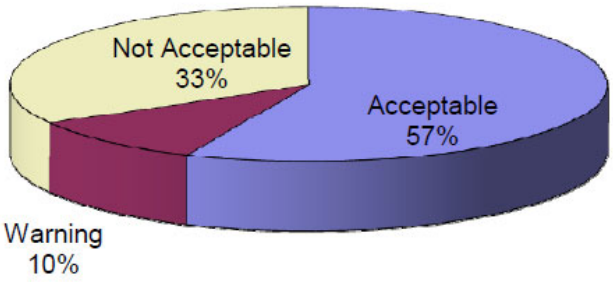
Twenty spiked air filters with known activities of gamma emitting radionuclides, gross α and gross β were prepared by the Department of Energy of the United States of America and used in this proficiency test.

The spiked air filters were distributed to the participating laboratories in June 2008. The deadline for receiving the results from the participants was set at 15 September 2008. The participating laboratories were requested to analyse the samples employing the methods used in their routine work, so that their performance on the test samples could be directly related to the real performance of the laboratory. Each laboratory was given a confidential code to assure the anonymity of the evaluation results. From the 20 initially registered, 19 laboratories reported their results on reference date of 1st of May 2008 to the IAEA. The analytical results of the participating laboratories were evaluated against the reference values assigned to the reference air filter, and a rating system was applied.

Each laboratory performance was reviewed and specific recommendations were proposed to laboratories to rectify shortcomings. The draft of this report was distributed to the participants for comments; the final version of the report reflects the participants' comments and the outcome of the discussions during the final meeting of participants.

In 2006 a PT was organized using air filters containing only gamma emitting radionuclides and the results of the 2006 PT were published. This report presents a comparison of the analytical performance of the laboratories who participated in both PTs of 2006 and 2008.

The following picture reports a summary of performance evaluation of this proficiency test, whereby 57 % of the reported results for all analytes obtained a score of "Acceptable".



2. PROFICIENCY TEST OBJECTIVES

The proficiency test aimed at:

- checking the trueness and precision of the analytical results produced by the participating laboratories for the determination of radionuclides in air filters;
- encouraging the participating laboratories to find remedial actions where shortcomings in analytical performance are detected;
- promoting the implementation of proper quality control measures within individual laboratories;
- providing evaluation and recommendations on the overall performance of participating laboratories.

3. PROFICIENCY TEST MATERIALS

The PT materials used in this exercise were prepared by the Department of Energy's (DOE) Radiological and Environmental Sciences Laboratory (RESL) in the United States of America according to the following methodology:

All radionuclide standard solutions used in the preparation of the air filter samples for this PT study are traceable to the National Institute of Standards and Technology (NIST). The target values for each of the radionuclides contained in the air filters were calculated from the certified values obtained from the certificate. The combined uncertainties were calculated by propagating all random uncertainties incurred anywhere in the preparation process including uncertainties associated with weight and volumetric dilutions. The target values and associated uncertainties are listed in Table 1. It should be noted that the known values are directly traceable to SI (Système International d'unités) through NIST by means of an unbroken chain of calculations and are not experimentally determined by analysis.

3.1. General Preparation

(1) Each individual solution of the specific radionuclide of interest was diluted to an appropriate total weight in 10% (v/v) nitric acid.

(2) A master solution was prepared by combining specific amounts of each of the individual solutions containing the nuclides of interest and diluting to an appropriate final weight.

(3) The master solution containing the radionuclides of interest at known activities was used to spike the individual filter papers samples.

(4) Two filter papers were place on a plastic weighing dish and a known amount of the master solution was volumetrically transferred to the filter paper. The weight, as well as, the volume dispensed was compared for calculation and QC purposes.

The solution weighed onto each filter package was verified and found not to vary by more than about 0.2 % between filter sets, therefore all samples can be considered statistically identical to each other within the uncertainties given for the known values.

5. The filters were dried for 45 minutes under an IR lamp and the third filter was placed on top and the entire package was sealed.

TABLE 1. TARGET VALUES AND ASSOCIATED STANDARD UNCERTAINTIES (u) OF THE PROFICIENCY TEST SAMPLE ON REFERENCE DATE OF 1st of MAY 2008.

Nuclides	Target value [Bq/filter]	Uncertainty (±1σ) [Bq/filter]	Uncertainty(±1σ) [%]
^{54}Mn	1.81	0.04	2.21
^{57}Co	2.53	0.06	2.37
^{60}Co	1.33	0.02	1.50
^{134}Cs	2.81	0.06	2.14
^{137}Cs	1.70	0.03	1.76
Gross α	0.17	0.009	5.29
Gross β	0.29	0.01	3.45

3.2. Verification of the target values

The air filters were measured using HPGe detector type ORTEC GEM-XX185-S (Relative efficiency: 60% at 1332 keV, Energy resolution: 1.81 keV at 1332 keV). The experimental set-up consisted also of Amplifier (CANBERRA 2025), Analogue to digital converter (ADC, CANBERRA 8075), HV supply (ORTEC 660). The used software was CANBERRA Genie2000.

The sample was set on the detector using a dedicated sample holder and was measured for 93346 sec (live time).

For efficiency calibration two standards, which were prepared according to the ANSI method (ANSI N42.14-1999), were used. One is mixed radionuclides (^{241}Am, ^{109}Cd, ^{57}Co, ^{139}Ce, ^{113}Sn, ^{137}Cs, ^{54}Mn, ^{65}Zn, ^{60}Co and ^{88}Y) and the other one is ^{134}Cs.

The radioactivity of the detected radionuclides was calculated by dividing peak count rate of each nuclide by the efficiency which obtained from each nuclide in the standards. The

uncertainties of the analytical results were propagated counting standard deviation and source uncertainty.

The analytical results and obtained gamma-ray spectrum of the filter sample are shown in Table 2 and Fig.1, respectively. Gamma-ray peaks used for the determination of detected radionuclides are listed in the Table.

TABLE 2. VERIFICATION OF THE TARGET VALUES OF THE SPIKED GAMMA AIR FILTERS

Nuclide	Half-life	Energy	Measured Activity	Uncertainty		Measured activity /Spiked activity
	(day)	(keV)	(Bq/filter)	(%)	(Bq/filter)	
^{54}Mn	312.3	834.843	1.82	1.5	0.027	1.01
^{57}Co	271.79	122.061	2.53	0.8	0.020	1.00
^{60}Co	1925.5	1332.502	1.39	1.9	0.026	1.05
^{134}Cs	754.28	604.720	2.90	1.3	0.038	1.03
^{137}Cs	11020	661.660	1.73	1.4	0.024	1.02

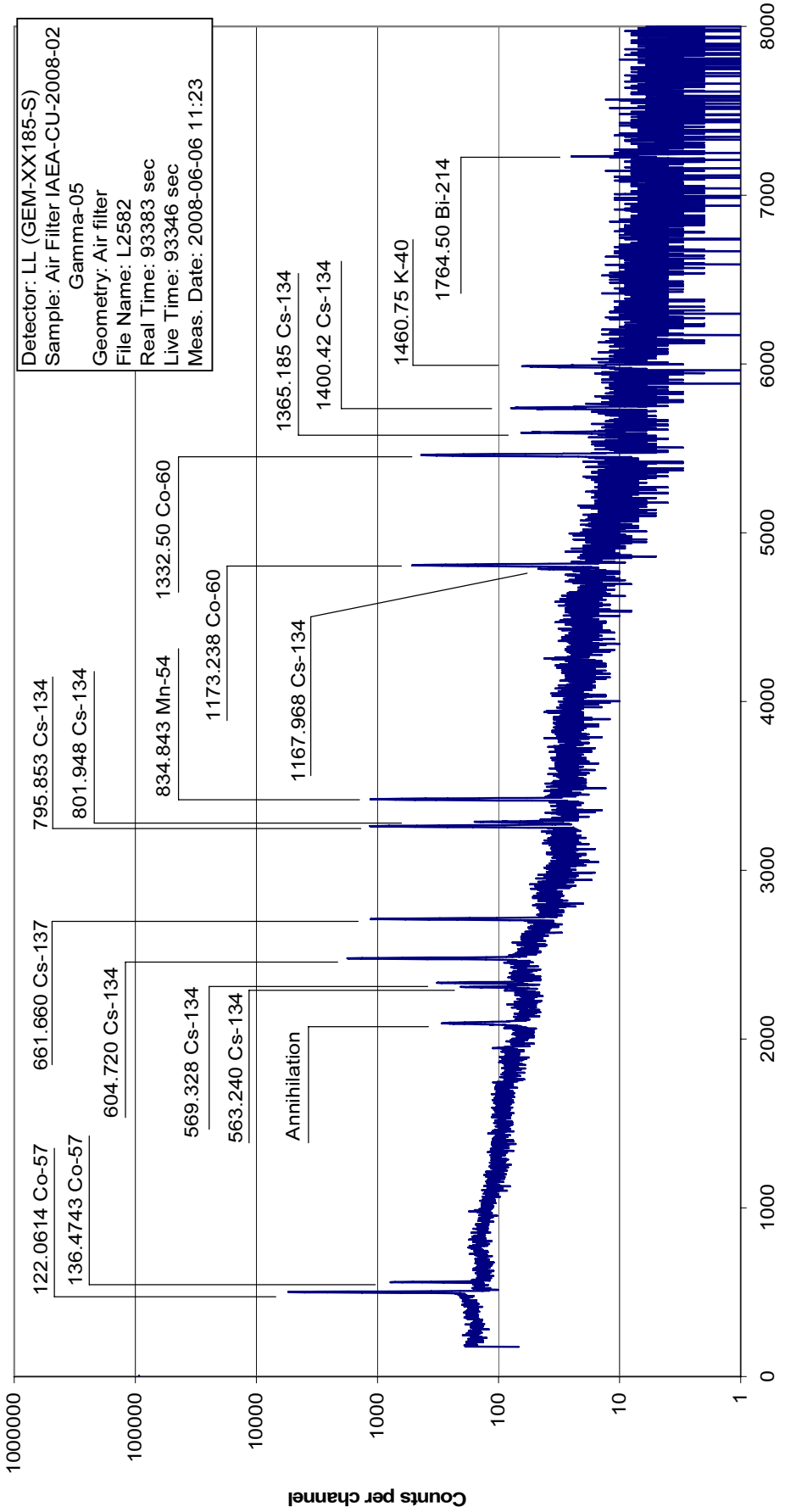


Fig. 1. Gamma-ray spectrum of gamma air filter used in this PT

4. PERFORMANCE CRITERIA

Currently most laboratories produce test results accompanied, at best, with an indication of their repeatability only and provide no indication of their analytical uncertainty. However, standards and guidelines increasingly recommend that laboratories express their measurement uncertainty (e.g. ISO/IEC 17025:2005).

Several rating systems have been developed for determining a laboratory's performance and the meaning of the results of the different scoring systems are not always comparable. Among various statistics, z-scores and u-scores are most often used. The drawback of z-scores is that the uncertainty of the participant's measurement result is not taken into account for the evaluation of performance. In the case of u-scores, the evaluation includes uncertainties of the participant measurements and the uncertainty of the assigned value. Laboratories performing well in classical proficiency testing (z-scores) will not necessarily exhibit the same level of performance when their analytical uncertainties are considered in the evaluation.

The proficiency testing scoring system applied by the Chemistry Unit in the Agency's laboratories takes into consideration the trueness and the precision of the reported data and it includes in the evaluation both the total combined uncertainty associated with the target value of proficiency testing samples and the total uncertainty reported by the participating laboratories. According to the newly adopted approach, the reported results are evaluated against the acceptance criteria for accuracy and precision and assigned the status "acceptable" or "not acceptable" accordingly. A result must pass both criteria to be assigned the final status of "acceptable". The advantage of this approach is that it checks the credibility of the uncertainty statement given by the participating laboratories, and the results are no longer compared against fixed criteria but participants establish their individual acceptance range on the basis of the uncertainties assigned to the values. Such an approach highlights not only methodological problems affecting the accuracy of the reported data but also identifies shortcomings in uncertainty estimation.

In this exercise the performance evaluation of γ emitting radionuclides was performed according to the same procedure used in the 2006 exercise. For gross α and gross β results, a scoring system was applied which fits the purpose of these parameters.

4.1.Scoring system of γ emitting radionuclides

4.1.1. Bias score

To evaluate the bias of the reported results, the relative bias between the analyst's value and the IAEA value is calculated and expressed as a percentage:

$$\text{Relative bias}\,(\%) = \frac{Value_{Analyst} - Value_{IAEA}}{Value_{IAEA}} \times 100 \qquad (1)$$

The result is evaluated as the following:

Acceptable if relative bias ≤ 10, Warning if 10 < relative bias ≤ 20,

Not acceptable if relative bias > 20

4.1.2. The z-score value

The z-score is calculated from the laboratory results, the assigned value and a standard deviation in accordance with the following equation:

$$z_{Score} = \frac{Value_{Analyst} - Value_{IAEA}}{\sigma} \qquad (2)$$

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

$$0.10 \times Value_{IAEA}$$

The laboratory performance is evaluated as satisfactory if $| z_{Score} | \leq 2$; questionable for $2 < | z_{Score} | < 3$, and unsatisfactory for $| z_{Score} | \geq 3$.

4.1.3. The u-score value

The value of the u_{test} was calculated according to the following equation

$$u_{test} = \frac{\left| Value_{IAEA} - Value_{Analyst} \right|}{\sqrt{u_{IAEA}^2 + u_{Analyst}^2}} \qquad (3)$$

This value is compared with the critical value listed in the t-statistic tables to determine if the reported result differs 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 measurement uncertainties when defining the normalized error. This is especially useful when evaluating results, for which uncertainty may overlap with the reference interval.

It should be noted that the choice of the significance level is subjective. For this proficiency test the limiting value for the u-test parameter has been set to 2.58 for a level of probability at 99% to determine if a result passes the test ($u < 2.58$).

4.1.4. Evaluation criteria

The proficiency test results were evaluated against the acceptance criteria for trueness and precision and assigned the status “Acceptable”, “Warning” or “Not Acceptable” accordingly [3].

4.1.4.1. Trueness

The participant result is assigned “Acceptable” status for trueness if:

$$A1 \leq A2$$

where:

$$\text{A1} = \left| Value_{IAEA} - Value_{Analyst} \right|$$

$$\text{A2} = 2.58 \times \sqrt{u_{IAEA}^2 + u_{Analyst}^2}$$

4.1.4.2. Precision

For evaluation of precision an estimator P is calculated for each participant, according to the following formula:

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

P directly depends on the measurement uncertainty claimed by the participant. The limit of acceptable precision (LAP) for each analyte respectively is defined for the respective proficiency test in advance, including any adjustment due to the concentration or activity level of the analytes concerned and the complexity of the analytical problem. Participants’ results are scored as “acceptable” for precision when P ≤ LAP. The LAP value used in the evaluation of all radionuclides is 15%.

In the final evaluation, both scores for trueness and precision are combined. A result must obtain an “acceptable” score in both criteria to be assigned the final score “acceptable”. Obviously, if a score of “not acceptable” was obtained for both trueness and precision, the final score will also be “not acceptable”. In cases where either precision or trueness is “not acceptable”, a further check is applied. The reported result relative bias (R. Bias) is compared with the maximum acceptable bias (MAB). If R. Bias ≤ MAB, the final score will be “warning”, which will reflect mainly two situations. The first situation will be a result with small measurement uncertainty; however its bias is still within MAB. The second situation will appear when results close to the assigned property value are reported, but the associated uncertainty is large. If R. Bias > MAB, the result will be “Not Acceptable”. The MAB value used in the evaluation of all radionuclides is 15%.

4.2. Scoring system of gross α and gross β results

The gross α and gross β results were evaluated based on the relative bias between the analyst's value and the IAEA value, which was calculated and expressed as a percentage according to Eq. (1). The result was evaluated as the following:

4.2.1. Gross α:

Acceptable if relative bias ≤ 75, Warning if 75 < relative bias ≤ 100,

Not acceptable if relative bias > 100

4.2.2. Gross β:

Acceptable if relative bias ≤ 50, Warning if 50 < relative bias ≤ 75,

Not acceptable if relative bias > 75

5. RESULTS AND DISCUSSIONS

5.1. General

Nineteen laboratories reported their results to the IAEA; only one laboratory from the initially registered laboratories, listed in the Participating Laboratories, did not report its results. The participants' data along with the performance evaluation criteria and evaluation scores were compiled and presented in tables which constitute an integral part of this report.

The results submitted by the laboratories were evaluated against the reference values; a scoring system with evaluation criteria was applied and the appropriate score was assigned. The uncertainties claimed by the laboratories were revised and taken into consideration during the evaluation.

The technical information reported by the laboratories regarding the applied analytical procedures was compiled "as received" in Appendix I. Performance evaluation sorted by analyte is reported in Appendix II, while the performance evaluation sorted by laboratory code is presented in Appendix III.

The performance evaluation results showed that 51% of all reported results obtained a score of "Acceptable". Table 3 presents the number of reported results and evaluation scores for each radionuclide.

In the IAEA-2006-11 proficiency test only 11 laboratories reported their results and 74% of all reported results obtained "Acceptable" score. It was found that 8 laboratories participated in both IAEA-2006-11 and IAEA-2008-02 proficiency tests. The overall performance of these laboratories in γ-emitting radionuclides in both PTs was compared. Fig. 2 presents this comparison.
From the comparison of the performance of these 8 laboratories, it can be seen that three of them with codes 8, 10 and 17 (in 2008 PT) had an excellent performance in both PTs, which indicates the stability of the performance of the analytical system in these laboratories.

Laboratories with codes 6, 13 and 16 (in the 2008 PT) were able to improve their performance compared to the 2006 PT results. This is an indication that participation in PTs improves the analytical performance if corrective actions are implemented and their effectiveness is monitored.

Laboratory with code 15 had better performance score in the 2006 PT than in the 2008 PT which might suggest that the quality of results produced by the analytical system in this laboratory is not stable, and a continuous monitoring of the quality and validity of the analytical results should be implemented to detect any abnormality in the analytical system.

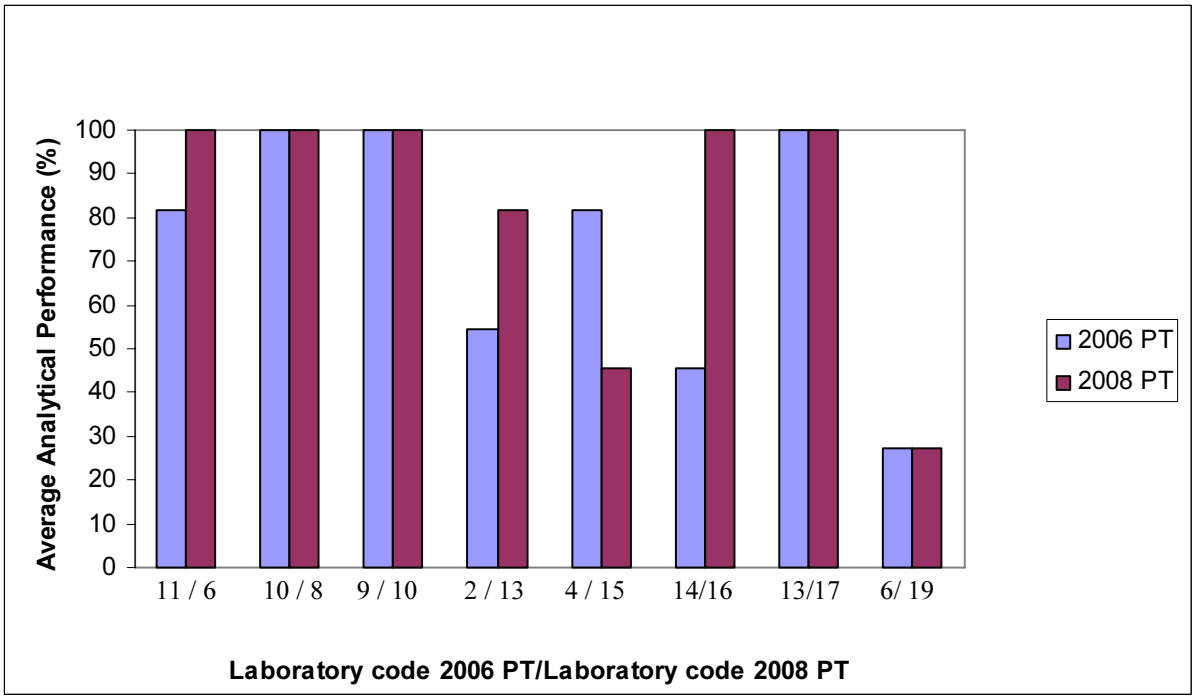


Fig. 2. Comparison of the analytical performance of participating laboratories in both 2006 and 2008 PTs.

Laboratory 19 had a low level of performance in both IAEA-2006-11 and IAEA-2008-02 proficiency tests, which means that the corrective actions implemented after the 2006 PT were not efficient and should be reviewed. The real cause should be investigated and corrective actions to be implemented and validated using the same filters to assure that the analytical system was corrected.

TABLE 3. NUMBER OF REPORTED RESULTS AND EVALUATION SCORES FOR EACH RADIONUCLIDE.

Radionuclides	Number of reported results	Acceptable score (%)	Warning score (%)	Not Acceptable score (%)
^{54}Mn	18	56	11	33
^{57}Co	18	50	11	39
^{60}Co	18	67	11	22
^{134}Cs	18	50	6	44
^{137}Cs	18	61	11	28
Gross α	11	82	18	0
Gross β	13	85	8	8

5.2. Observations on the performance and reported results

Based on the analytical results and available technical information reported by the participants, proposals for corrective actions were given where appropriate. These proposals may help the participating laboratories to consider sources of root cause of discrepancies. Few comments were given with regard to uncertainty estimation, calibration, validation and use of RMs. These points are mostly of a general nature and should not be taken as an exhaustive list.

5.2.1. Uncertainty

Many laboratories underestimated their measurement results uncertainties which resulted in warning scores.

Some possible reasons for different uncertainty estimations/calculations are:

- different and/or incomplete evaluation of uncertainty sources, e.g. limiting uncertainties to counting statistics, weighing, dilution and the nuclear data used;
- not considering possible uncertainty components due to calibration standards, calibration procedure and sample geometry;
- the calibration procedure used.

All sources of the measurement results uncertainty should be listed and estimated according to an internationally agreed method such as the IAEA-TECDOC-1401 [4].

5.2.2. Calibration

In most cases the information on how the efficiency calibration was performed was not clearly specified.

The following calibration methods were mentioned:

- Calibration using multi gamma standard source;
- Calibration using single gamma standard sources;

- Calibration using computational model;
- Calibration using a spiked filter;

It is recommended to the laboratories that the efficiency calibration of the gamma detector should be performed using an appropriate calibration source or a validated computational algorithm, and that the calibration results should be validated, controlled and monitored regularly using reference materials and blank samples.

In order to assess the precision of gamma analysis, a quality control and quality assurance protocol should be produced and used to obtain accurate and valid measurement in the mid- and long term.

It is recommended that institutions dealing with γ-spectrometry run their own inter-comparison exercises at the local or regional level to compare their results on a regular basis with other institutions using in-house reference materials or air filters and to include procedures to assess the accuracy and precision (uncertainty of measurement results) of analyses (e.g. quality control charts data based on quality control materials with known activity level).

According to the QA requirements each laboratory should have readily available information on the calibration method containing at least the following:
- Details of the calibration method and calibration source preparation;
- Description of the traceability of calibration standards to SI;
- Estimation of the uncertainty associated with the activity concentration values of the calibration standards and/or the computational algorithm;
- Validation and evaluation of the trueness of the analytical results using of RMs and CRMs to validate the calibration procedure and/or any used computational algorithm;
- Applied corrections to overcome the differences in physical properties between the calibration standards and analysed samples and their effect on the calibration function.

Some reported results had a systematic negative or positive bias, which might indicate the use of an inappropriate calibration source or a calibration problem. One participant reported the use of Marinelli beaker mixed calibration source as a calibration source for filter analysis, which should be avoided.

5.2.3. Cascade coincidence summing correction of ^{134}Cs

It was noticed that many laboratories did not apply the cascade coincidence correction in the case of ^{134}Cs analysis; the effect of this nuclide is well known and should be corrected properly.

5.2.4. Recommendations to participating laboratories

5.2.4.1. Laboratory 01

Laboratory 01 reported that the Minimum Detection Limit (MDL) was calculated using the formula (4.6*sqr(N)+2.71)/(t*P*Ef), where N is number of counts in blank filter, P is gamma yield, t is the duration of measurement in seconds and Ef is the efficiency on given line.

The reported results for the Blank Filter (BF) were acceptable and demonstrate that the MDL was estimated properly.

With regard to the estimation of the standard uncertainty, laboratory 01 listed the sources of uncertainties included in the uncertainty budget. The estimated uncertainty was within the acceptable range for this exercise.

Laboratory 01 obtained acceptable scores for gross α, gross β, ^{54}Mn, ^{57}Co, ^{60}Co and ^{137}Cs. Only ^{134}Cs result was not acceptable with a negative bias of -25% which could be caused due to summing effect. The application of a proper algorithm for summing effect should be investigated.

5.2.4.2. Laboratory 02

Laboratory 02 did not report any technical information on method validation or uncertainty estimation.

The laboratory reported that a Marinelli Beaker (1:l) mixed calibration source MBSS2 from the Czech Metrological Institute containing ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{137}Cs, ^{113}Sn, ^{85}Sr, ^{88}Y was used for efficiency calibration. This calibration source was used outside its intended scope of application.

Laboratory 02 reported results with a positive bias up to 300%, hence a "not acceptable" score was assigned to the reported results, which might be caused by an inappropriate efficiency calibration procedure.

Laboratory 02 did not report any results for gross α or gross β.

With regard to the estimation of the standard uncertainty laboratory 02 reported an unrealistic small standard combined uncertainty of around 2% at the same level of the *u* of the reference values for four measurands, while the bias of the reported results was very high. The analyst should revisit the estimation of the measurement result uncertainty and should have listed all sources of uncertainty.

It is recommended that the analyst review the efficiency calibration procedure and perform a validation of the method using an appropriate reference material or a standard source with commutable matrix and geometry.

5.2.4.3. Laboratory 03

Laboratory 03 did not report any technical information on how the validation of the method was performed or MDL was estimated.

General information was reported regarding the efficiency calibration. From the reported information, it was not clear how the laboratory performed an efficiency calibration for this specific type of sample. The laboratory stated that certified point sources, certified volume sources, CRM in various geometries or matrices, reduced to the required geometry-matrix by effective solid angle transformation and then averaging estimation was used for calibration.

The performance evaluation results showed that laboratory 03 obtained acceptable scores for gross α, gross β and ^{60}Co. "Not acceptable" results were assigned for the rest of gamma

emitting nuclides; a consistent negative bias of around -20% was observed which indicates a systematic efficiency calibration problem or a systematic calculation error. Warning was assigned to ^{54}Mn and ^{134}Cs due to unrealistic small standard combined measurement result uncertainty *u*, although the bias was more than 10%. The combined *u* was less than 5% for both radionuclides, which clearly indicates an artificially reduced uncertainty budget. It is proposed that the analyst re-evaluate the uncertainty budget.

5.2.4.4. Laboratory 04

Laboratory 04 reported that the gamma measurement system was calibrated using a mixed gamma point source with nuclides ^{57}Co, ^{137}Cs and ^{60}Co. Then, Monte Carlo simulation of the same system (geometry was modelled roughly) for point and disk was performed for obtaining efficiencies for the energies of the nuclides requested by the PT. For total alpha and beta measurement; 2 disc sources, one with ^{241}Am and one with ^{90}Sr were prepared for system calibration.

The performance evaluation results showed that only ^{137}Cs and gross β obtained an acceptable score, while ^{54}Mn, ^{57}Co, ^{60}Co and ^{134}Cs demonstrated not acceptable performance. From the reported information, the Monte Carlo simulation was checked using one control sample containing only ^{137}Cs and this could explain why the evaluation of this radionuclide was acceptable. The Monte Carlo simulation should have been validated for all radionuclides of interest.

5.2.4.5. Laboratory 05

Laboratory 05 performed an efficiency calibration using a standard filter with similar geometry. The filter contained the following nuclides: ^{210}Pb, ^{241}Am, ^{109}C, ^{137}Cs, and ^{60}Co.

^{241}Am and ^{90}Sr standard solutions were used for calibration of gross alpha and gross beta activities respectively. Counting efficiencies were done by counting ^{241}Am and ^{90}Sr deposited onto filters at varying thicknesses separately.

Laboratory 05 analytical performance demonstrated a good level of performance and obtained acceptable scores for all reported results: gross α, gross β, ^{54}Mn, ^{57}Co, ^{60}Co, ^{134}Cs and ^{137}Cs.
The reported standard combined measurement result uncertainty *u* was reasonably estimated and sources of measurement uncertainty were listed.

The analytical results on the blank filter were not reported by laboratory 05, also there is no information reported on method validation. It is proposed that the laboratory performs method validation and estimates the MDL for the nuclides of interest.

5.2.4.6. Laboratory 06

Laboratory 06 reported that the MDL was calculated from blank filter measurement for an acquisition time of 65 000 s. The Currie MDL method with 95% confidence level was used. The MDL was reported in the blank filter report. The repeatability and reproducibility of measurements were <4%. The efficiency calibration was done with mixed gamma standard with same (filter) geometry with the following isotopes: ^{57}Co,^{60}Co ,^{54}Mn ,^{65}Zn ,^{137}Cs, ^{241}Am. Peak-to-total calibration was performed with point calibration source : ^{57}Co, ^{54}Mn, ^{65}Zn, ^{109}Cd, ^{137}Cs ,^{113}Sn.

Laboratory 06 results evaluation demonstrated a good level of performance and obtained acceptable scores for all reported results: ^{54}Mn, ^{57}Co, ^{60}Co, ^{134}Cs and ^{137}Cs.

The reported standard combined measurement result uncertainty *u* was reasonably estimated and sources of measurement uncertainty were listed.

5.2.4.7. Laboratory 07

Laboratory 07 did not report information on method validation, MDLs were not estimated. Efficiency calibration was performed using a QAP 0209 air filter.

Laboratory 07 reported acceptable results for ^{54}Mn. The reported measurement results were negatively biased, ^{57}Co and ^{134}Cs evaluation results were not acceptable most probably due to inappropriate calibration which causes consistent negative bias.

The reported measurement results uncertainties were unrealistically low, even 2-3 times lower than the target values uncertainties. This is why ^{60}Co and ^{137}Cs scored "warning" due to low reported uncertainty, however, the bias of these two nuclides was below the maximum acceptable bias and the results still fit for the purpose.

5.2.4.8. Laboratory 08

Laboratory 08 applied a computational approach where the geometry and sample matrix parameters were determined for the air filter supplied and used to compute the efficiency curve.

The analytical results on the blank filter were not reported by Laboratory 08, also there is no information reported on method validation.

Laboratory 08 results evaluation demonstrated a good level of performance and obtained acceptable scores for all reported results: gross α, gross β, ^{54}Mn, ^{57}Co, ^{60}Co, ^{134}Cs and ^{137}Cs.

5.2.4.9. Laboratory 09

Laboratory 09 did not report any information with regard to method validation and uncertainty estimation. It was not clear why the estimated uncertainty was relatively higher than the maximum acceptable precision for this PT.

The efficiency calibration curves were calculated using mixed source filter paper with range of energies from 88 to 1836 keV. The laboratory relied on software to make the calculations. The laboratory did not report how the results of algorithm calculations were validated and checked for consistency, there is no indication of the use of RM or any appropriate method validation. The QC procedure was mainly to check the FWHM.

Laboratory 09 reported the results of ^{54}Mn, ^{60}Co, and ^{137}Cs with a relatively small bias, but the reported measurement uncertainty was high which resulted in a warning score, which means that the results are still valid but the *u* has to be revised. The results of ^{57}Co and ^{134}Cs were not acceptable due to the bias which was more than 20%. The summing effect of ^{134}Cs should be corrected for since the bias of this nuclide was the biggest ~ -40%.

It is suggested to use un appropriate procedure to validate the whole method for the nuclides of interest, and to re-analyse the sample to verify the effectiveness of the correction actions.

5.2.4.10. Laboratory 10

Laboratory 10 gave no information on the method of efficiency calibration. To calculate the MDL the laboratory used the Ortec formula.

The results for the blank filter were properly reported as MDL.

The evaluation of the Laboratory 10 results demonstrated a good level of analytical performance and obtained acceptable scores for all reported results: gross α, gross β, ^{54}Mn, ^{57}Co, ^{60}Co, ^{134}Cs and ^{137}Cs.

The measurement results uncertainties were perfectly estimated. However, there was no documentation or written indication on which components of uncertainties were taken into account. Documentation of the methodologies and procedures is as important as the measurement results. It would be useful to the rest of participants to profit from more detailed description of the methodologies applied in this laboratory.

Perhaps more discussions will be initiated, if the laboratory agrees, during the final meeting where the PT results will be discussed.

5.2.4.11. Laboratory 11

Laboratory 11 reported only the results of gross α and gross β. The gross α result was acceptable while gross β was not acceptable.

MDLs for both measurands were reported in an appropriate manner. The calibration was performed using a spiked glass fibre filter with standard solutions of ^{239}Pu and ^{90}Sr. Although it is correct to use ^{90}Sr to calibrate gross β, it is not clear why a positive bias of 130% occurred in the gross β result. The laboratory did not report the use of any RM to verify the gross β calibration and this might be the shortcoming in the analytical procedure. As it is known, the calibration should be checked with an independent source prepared from a different calibrant. A correction action should be introduced to correct the situation and to re-measure the same filter to check if the problem was solved.

5.2.4.12. Laboratory 12

Laboratory 12 reported that the energy calibration was performed using an Amersham Multi-Radionuclide Certified Source (QCY 48), and that the efficiency calibration was performed using a filter of the same geometrical characteristics as the one measured for the PT. The calibration filter was provided by the IAEA and it was spiked with the isotopes ^{57}Co, ^{137}Cs, ^{54}Mn, ^{60}Co, ^{134}Cs and ^{241}Am. Thus, there was no need for an efficiency calibration curve, the experimental values of the efficiency were used.

The evaluation of the laboratory 12 results demonstrated a good level of analytical performance and obtained acceptable scores for all reported results of gamma emitting nuclides.

5.2.4.13. Laboratory 13

Laboratory 13 reported that method validation was performed based on a Currie L.A. ANAL CHEM, 1968 and EURACHEM/CITAC GUIDE 2000. The efficiency calibration of gamma spectrometry was performed using commercial source, while for gross beta a spiked filter with ^{90}Sr was used.

The laboratory had acceptable scores for gross β, ^{54}Mn, ^{60}Co, ^{134}Cs and ^{137}Cs. Only the ^{57}Co result had warning due to a negative bias.

The root cause of the low result of ^{57}Co should be investigated and corrected.

5.2.4.14. Laboratory 15

According to the technical information reported by the laboratory, the efficiency calibration of gamma spectrometry was performed using standard solution ERX standards from the Czech Metrological Institute. The information did not specify the geometry of the calibrating source or if a spiked filter was used.

^{241}Am and ^{40}K were used to calibrate gross α and gross β respectively.

The results for ^{57}Co, ^{60}Co, and ^{134}Cs in general were with relatively small bias, while for unclear reasons the results of ^{54}Mn and ^{137}Cs were not acceptable, with a bias of more than 15%.

THE gross β result was assigned a "warning" due to high bias, the calibration procedure should be reviewed. ^{40}K was used for calibration and it is not clear how the reference value of ^{40}K was determined and how the measurement results traceability was assured. The filter should be measured again after the correction of the calibration procedure to find out if this was the root cause of the discrepancy.

5.2.4.15. Laboratory 16

Laboratory 16 did not report any technical details on the applied analytical methods.

The reported results for gross β, ^{54}Mn, ^{57}Co, ^{60}Co, ^{134}Cs and ^{137}Cs were all acceptable. The level of estimated measurement standard uncertainties was reasonable. The bias of all reported results was below 9%. The laboratory did not report a result for gross α.

Documentation of the methodologies and procedures is as important as the measurement results. It would be useful to the rest of participants to profit from a more detailed description of the methodologies applied in this laboratory.

Perhaps more discussions will be initiated, if the laboratory agrees, during the final meeting where the PT results will be discussed.

5.2.4.16. Laboratory 17

Laboratory 17 performed energy and efficiency calibrations by a filter standard source containing the following radionuclides: ^{210}Pb, ^{241}Am, ^{109}Cd, ^{57}Co, ^{51}Cr, ^{113}Sn, ^{85}Sr, ^{137}Cs, ^{88}Y, and ^{60}Co. There was no information on the calibration of gross α and gross β.

All results reported by laboratory 17 were acceptable, only the gross α result had a relatively high bias. It is proposed that the analyst search for the root cause of this discrepancy. The results of the blank filter were not reported, which could suggest that the MDL are not yet estimated.

5.2.4.17. Laboratory 18

Laboratory 18 did not report any technical information related to the methodologies applied in the analysis of air filters in this exercise.

The laboratory reported ^{60}Co and ^{137}Cs with an acceptable score, while ^{54}Mn, ^{57}Co and ^{134}Cs were not acceptable. The results of the blank filter were not reported, which could suggest that the MDL are not yet estimated.

5.2.4.18. Laboratory 19

The laboratory gave a detailed description of the uncertainty components considered in the uncertainty budget, which was reasonably estimated. The laboratory indicated that a computational approach used for the efficiency calibration, but there was no indication of how the calculations were validated.

The laboratory reported ^{57}Co with acceptable score. The results of ^{54}Mn, ^{60}Co, ^{134}Cs and ^{137}Cs were all reported with negative bias, which resulted in not acceptable scores. It is suggested that the mathematical approach used for efficiency calibration could be one of the main reasons for this bias and should be checked and corrected accordingly; other root causes should also be investigated.

5.2.4.19. Laboratory 20

From the technical information reported by the laboratory there is no indication of weather the laboratory performed a method validation for such a type of matrix, MDL were not estimated.

The laboratory did not provide enough information on efficiency calibration.

Laboratory 20 reported gross α and gross β with an acceptable score. The rest of the nuclides had not acceptable scores due to the observed consistent positive bias at around 20%. This is a clear example of a systematic error either in the efficiency calibration or in the calculations. The correction of the bias is feasible when the root cause is located and appropriate corrective actions are implemented. The laboratory could use an in-house spiked filter with known amounts of mixed standard solution to check the trueness of the reported values and to validate the efficiency calibration. Or the over spike technique could be employed and the residual activity could be reported.

6. CONCLUSIONS

The IAEA-2008-02 proficiency test was successfully conducted, where 19 of 20 initially registered participants reported their results back to the IAEA.

The overall performance evaluation showed that 57% of the reported results fulfilled PT criteria. Eight laboratories participated for the second time in a PT within the frame of the TC project RER/8/009. Three of these laboratories proved their excellent performance in both PTs, three laboratories were able to improve their performance and two laboratories were not able to improve their performance.

Most of the laboratories were able to demonstrate the stability of their analytical procedure; the most problematic issue was the biased results from the reference value, *i.e.* the trueness of the reported results.

The observed consistent bias of the analytical results could be related to the application of an inappropriate efficiency calibration; the unavailability of an appropriate calibration source might be the main reason for the frequently observed biased results.

It is recommended that the laboratories perform an efficiency calibration of the gamma detector using an appropriate calibration source or a validated computational algorithm. The calibration results should be validated, controlled and monitored regularly using reference materials and blank samples.

It is also recommended that the laboratories should assess internally the trueness and precision of gamma analysis by implementing a quality control and quality assurance protocol to obtain accurate and valid measurement results in the short and long term.

For the external quality control mechanism, it is recommended to institutions dealing with γ-spectrometry to run their own inter-comparison exercises at the local or regional level to compare their results on a regular basis with other institutions using in-house reference materials or spiked air filters and to include procedures to assess the trueness and precision (uncertainty of measurement results) of analytical results.

The participants, who reported results of “Not acceptable” score are requested to critically review their method, find the root cause of any discrepancy and introduce the needed corrective actions based on the results of this PT. In addition, it could be seen that the awareness among participating laboratories for the importance of QA/QC procedures and method validation is increasing.

This PT has demonstrated that many of the participating laboratories still need training in method validation, measurement results uncertainty estimation and QC in gamma spectrometry.

The need for an appropriate calibration standard source and/or calibration procedure is strongly demonstrated.

APPENDIX I
SUMMARY OF TECHNICAL INFORMATION REPORTED BY THE LABORATORIES

TABLE 4. REPORTED TECHNICAL INFORMATION RELATED TO METHOD VALIDATION AND UNCERTAINTY ESTIMATION

Lab code	Validation	Method Validation Parameters	Approach used in Uncertainty Estimation	Sources of Uncertainty
01	Yes	Minimum detection limit (MDL) is used as a method validation. MDL is obtained using the following formula (4.6*sqr(N)+2.71)/(t*P*Ef), where N is number of counts in background, P is gamma yield, t is the duration of measurement in seconds and Ef is the efficiency on given line. This formula is obtained from Canberra technical guide for users of HPGe detector.	Quoted uncertainty is combined standard uncertainty (1 sigma level) calculated as the square root of the sum of variances of different sources of uncertainty, evaluated using the law of propagation, as recommended. The formula we used is sqr(uN^2+uEf^2) where uN represents a statistical uncertainty and uEf is the uncertainty of efficiency determination.	The sources of uncertainty are statistical uncertainty (peak integration, drift of measurement), quoted uncertainty of efficiency calibration standard, uncertainty of fitted efficiency curve and uncertainty of measurement geometry (for efficiency calibration).
02	No	NR	NR	NR
03	Yes	MDA ~ 0.03 Bq/kg	Software Canberra Genie2k	counting u., calibration sources certificate u., effective solid angle transformation u., coincidence correction u.
04	Yes	MDA values are obtained as 0.04, 0.07, 0.06, 0.06, 0.06 Bq/filter for ^{57}Co, ^{134}Cs, ^{137}Cs, ^{54}Mn and ^{60}Co, respectively. In addition, MDA values are 0.004 and 0.005 Bq/filter for total alpha and total beta, respectively. Gamma measurements are repeated for 3 times and results are obtained with maximum RSD value of 4% (for ^{54}Mn). Total alpha-beta measurements are performed as 7 cycles and results are obtained with RSD values of 5% and 1% for total alpha and total beta, respectively.	For gammas: Square of relative error for activity is equal to sum of relative errors of net peak area, emission probability and efficiency. Error of emission probability and other nuclear data are ignored, the others are obtained analytically. For total alpha-beta: Square of relative error for activity is equal to sum of relative errors of net peak area and efficiency. Errors are obtained analytically. Errors for nuclear data are ignored.	Net peak area (peak and background counting statistics for all), efficiency (counting statistics for all, curve fitting for gammas and Monte carlo simulation SD results for gammas). Errors for nuclear data and time are all ignored.
05	NR	NR	NR	Gamma uncertainty sources: counting statistics, efficiency, true coincidence Gross alpha/beta uncertainty sources: count rate, efficiency, crosstalk

Lab code	Validation	Method Validation Parameters	Approach used in Uncertainty Estimation	Sources of Uncertainty
06	NR	The MDA was calculated from blank filter measurement for acquisition time 65000s. The Currie MDA method with 95% confidence level was used. The MDA is reported in the blank filter report. The repeatability and reproducibility of measurements were <4%	We presented the results with combine standard uncertainty on 1 Sigma level Its obtained by combining the individual standard uncertainties whether arising from type A evaluation and type B evaluation using the law of propagation of uncertainty (root-sum-of squares).Most of individual standard uncertainties are taken in to account by the GENIE2000 but some we add additionally	1-Software : Uncertainty of Counting statistic background correction, efficiency, dead time, decay correction, nuclide data. 2- Additional uncertainty of reproducibility of counting geometry , cascade correction, System stability .
07	Yes	Method for determine MDA= traditional ORTEC	Uncertainty for individual activity from one peak: sn = uncertainty of peak area sc =uncertainty in calibration process	uncertainty of peak area-uncertainty in calibration process
08	No	NR	As described in: Korun, M., 2001. Propagation of uncertainties in sample properties to the uncertainty of the counting efficiency in gamma-ray spectrometry, Appl. Radiate. Isotope. 55, 685 Korun, M., 2002. Propagation of the uncertainties of sample position to the uncertainty of the counting efficiency in gamma-ray spectrometry, Appl. Radiate. Isotope. 57, 415 Glavic-Cindro, D., Korun, M., Vodenik, B., 2000. Quality assurance of automated gamma-ray spectrometric analysis, Appl. Radiat. Isotope. 53, 237	Gamma: Uncertainty in efficiency (which includes uncertainties in calibration, sample position and sample properties), uncertainty in peak area, uncertainties in half-life and abundance, uncertainty in live time, uncertainty due to in homogeneity. Gross Alpha and Gross Beta: Sample, calibration standard and background counting uncertainties, uncertainty in calibration standard activity, uncertainty in mass of calibration standard, uncertainty in half life of the calibration standard.
09	No	NR	NR	NR
10	Yes	Method for determine MDA= traditional ORTEC BKG=the peak background LT=the spectrum live time SENS=the user-set sensitivity in percent (peak cut-off)- usually 50= detection efficiency = gamma/100d	NR	Uncertainty of peak area-uncertainty in calibration process

Lab code	Validation	Method Validation Parameters	Approach used in Uncertainty Estimation	Sources of Uncertainty
11	Yes	MDL alpha 0.069MDL beta 0.089	Uncertainty Components are: instrument readings, blank, efficiency, calibration source. We use the formula of expanded Uncertainty.	same as above
12	No	NR	(1) Random Uncertainty of measurement, obtained by sample photo peak area uncertainty [RSU] (2) Random Uncertainty of measurement, obtained by calibration standard photo peak area uncertainty [RCU] (3) Systematic uncertainty of calibration source (activity uncertainty) [SU] Total Uncertainty was calculated by the square root of the sum of variances of all the aforementioned uncertainties. [TU] = SQRT([RSU]^2 + [RCU]^2 + [SU]^2) In cases where a nuclide's activity was determined by more than one photo peak the quoted result was the weighted mean of the photo peaks' activities, while the uncertainty quoted was the maximum of the internal and external uncertainties obtained (the latter takes into consideration the distribution of the measurements around the weighted mean).	(1) Random Uncertainty of measurement, obtained by sample photo peak area uncertainty (2) Random Uncertainty of measurement, obtained by calibration standard photo peak area uncertainty (3) Systematic uncertainty of calibration source (activity uncertainty)
13	Yes	Performed in gamma spectrometry MDA (^{57}Co-0.05 Bq/filter; ^{60}Co-0.03 Bq/filter; ^{134}Cs-0.18 Bq/filter; ^{137}Cs-0.03 Bq/filter; ^{54}Mn-0.03 Bq/filter)Performed in gross beta LC; LD, MDA; (LC 145 counts; LD 296 counts; MDA 0.0055Bq/filter	CURRIE L.A. ANAL CHEM 1968EURACHEM/CITAC GUIDE 2000 UA= A((N/un)2 + (Ef/uEf)2 + (I/uI)2 + (T1/2/uT1/2)2 +(t/ut)2)1/2	N- counts; Ef- efficiency; I-Abundance gamma ray; T1/2-Halflife; t-count time
15	NR	NR	NR	NR
16	Yes	NR	NR	NR

Lab code	Validation	Method Validation Parameters	Approach used in Uncertainty Estimation	Sources of Uncertainty
17	No	NR	The uncertainties taken into account are the counting uncertainties, the counting uncertainty of the standard source, the uncertainty of standard source activity and the uncertainties due to efficiency determination. The expanded uncertainties are calculated at 2s. The reported uncertainties in this inter-comparison exercise were reported at 1s.	Activity of standard source, peak area measurements, background subtraction and full energy peak efficiency.
18	NR	NR	NR	NR
19	Yes	Validation: Marin Elli baker 0.5 l density 1.0 g/cm3 Analytic parametric Precision (%) ^{241}Am ^{109}Cd ^{137}Cs ^{60}Co(1173) ^{60}Co(1332) 0.84 1.35 0.85 -1.01 -0.76 SD ^{241}Am ^{109}Cd ^{137}Cs ^{60}Co(1173) ^{60}Co(1332) 42.4 3.55 8.03 2.92 3.65 RSD ^{241}Am ^{109}Cd ^{137}Cs ^{60}Co(1173) ^{60}Co(1332) 0.52 1.22 0.36 0.30 0.17 Linearity : a = 0.06 % (s a = 5.7) : b = 0.991 (s b = 1.89E-3) Correlation coefficient r = 1 Range energy: 59 keV do 1332 keV activity : 286 Bq do 8090 Bq Interval. ^{241}Am ^{109}Cd ^{137}Cs ^{60}Co (1173) ^{60}Co(1332), (Bq) 8115 - 8200 287.2 - 294.3 2246 - 2262 969 - 975 971 - 978	We use methods described in EURACHEM/CITAC Guide: Quantifying Uncertainty in Analytical Measurements in process of uncertainty components evaluation. Combined Standard Uncertainty we calculate as: Expanded Uncertainty we calculate as: U=k x where k is coverage factor. The fallowing relations were also used: G - gross area of a peak B - background area of a peak N - net area of a peak N=G - B	· Standard uncertainty of attenuation coefficient · Standard uncertainty of sample weighing · Standard uncertainty of sample net count · Standard uncertainty of blank sample net count · Standard uncertainty of counting time · Standard uncertainty of detection efficiency (standard source + eff. curve fitting) · Standard uncertainty of relative intensity · Standard uncertainty of decay correction
20	Yes	MDA depends on nuclide, geometry, counting time	The formula is taken as listed in the Genie2000 manual.	counting statistics, efficiency uncertainty, branching uncertainty, nuclide decay uncertainty, coincidence summing correction uncertainty

TABLE 5. TECHNICAL INFORMATION REPORTED BY THE PARTICIPANTS RELATED TO THE ANALYTICAL PROCEDURE

Lab code	Sample Preparation	Efficiency and Energy Calibration
01	The sample for gamma spectrometry was placed directly on the window of the detector together with the plastic envelope. For gross alpha-beta measurement, the plastic envelope was removed and the sample was placed in counter with label up. No other preparation was conducted, as recommended.	The efficiency calibration of alpha-beta counter was conducted using a set of standard sources issued by Czech metrological institute type EM 145, no.17012003-355040 and type 445, no. 17012003-655037. For HPGe, the efficiency calibration was conducted using a standard air filter paper IAEA 083 provided by IAEA. Experimental results were then fitted with power function of fourth order and efficiency calibration curve was obtained. Energy calibration was performed using a set of standard sources E.I. du Pont de Nemours & Co. catalogue No. NES-101S, and program GENIE 2000
02	NR	HP Ge gamma -ray spectrometer ORTEC-AMTEK / 25 % relative efficiency and 1.85 keV FWHM for ^{60}Co, shielded with 10 cm lead internally lined with 1.27 mm aluminium/software Gamma Vision 32Calibration /Marin Elli Beaker (1 l) mixed calibration source MBSS2 from Czech Metrological Institute(^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{137}Cs, ^{113}Sn, ^{85}Sr, ^{88}Y)Kind of calibration/Energy calibration, FWHM calibration, Efficiency calibration, Full-energy peak efficiency. Efficiency calibration and spectrum analysis is performed using ORTEC-s Gamma Vision software* We do not have standards solutions (^{54}Mn, ^{60}Co, ^{57}Co, ^{134}Cs, ^{137}Cs...) and alpha/beta equipment.
03	NR	Certified point sources, certified volume sources, CRM in various geometries/matrices, reduced to the required geometry/matrix by effective solid angle transformation, then averaged
04	Samples are counted as presented by IAEA.	For gamma measurements; system is calibrated with a mixed gamma point source with nuclides ^{57}Co, ^{137}Cs and ^{60}Co. Then, Monte Carlo simulation of the same system (geometry is modelled roughly) for point and disk source is performed for obtaining efficiencies for the energies of the nuclides requested by IAEA. Then energy transfer between point and disk source is performed by mixed Monte Carlo Method.(Ratio of experimental and Monte Carlo simulation results for point source is assumed equal to the ratio of experimental and Monte Carlo simulation results for disk source). MCNP is used as MC Code. For total alpha and beta measurement; 2 disk sources, one with ^{241}Am and one with ^{90}Sr are prepared for system calibration.
05	Gamma: The sample and the blank were counted with several HpGe detectors as they come. Gross A/B: The blank and the sample air filters were dried at 105°C for 2 hours to reach constant weight. They were stored in desiccators for about half an hour and weighed. The residue weight was determined by subtracting the blank weight from the sample filter weight.	Gamma: The efficiency calibration was performed with filter with similar geometry. The filter contained the following nuclides: ^{210}Pb, ^{241}Am, ^{109}Cd, ^{137}Cs, and ^{60}Co. Gross A/B: ^{241}Am and ^{90}Sr standard solutions were used for calibration of gross alpha and gross beta activities respectively. Counting efficiencies were done by counting ^{241}Am and ^{90}Sr deposited onto filters at varying thicknesses separately.

Lab code	Sample Preparation	Efficiency and Energy Calibration
06	The filter was transferred on the holder on end cap of the detector. It was measured.	The energy calibration is performed mixed standard source which consist following nuclides ^{57}Co, ^{60}Co, ^{109}Cd , ^{133}Ba,^{137}Cs, ^{241}Am, The efficiency calibration was done with mixed gamma standard with same (filter) geometry with following isotopes: ^{57}Co ,^{60}Co , ^{54}Mn ,^{65}Zn ,^{137}Cs , ^{241}Am ,Peak-to-total calibration was performed with point calibration source : ^{57}Co, ^{54}Mn, ^{65}Zn, ^{109}Cd, ^{137}Cs,^{113}Sn
07	NR	QAP 0209 AIR FILTER
08	Gamma: No preparation was necessary for gamma air filters. Filters were put on detectors with label upwards. Gross Alpha and Gross Beta: Plastic foil was removed from the filter and filter was placed on the counting planchet with the labelled side upwards and measured in low background gas proportional counter for gross alpha and gross beta activity.	Gamma: Our method of detector calibration is such as to allow us to measure and analyze all kinds of cylindrically symmetric samples. The geometry and sample matrix parameters were determined for the air filter supplied and used to compute efficiency curve. The energy calibration is verified routinely after each measurement using well known background energy lines. Gross Alpha and Gross Beta: Blank air filter was measured to determine background. Then it was spiked with ^{241}Am and measured to determine count rate in beta window, which originates from ^{241}Am gamma rays. Then it was spiked with ^{90}Sr and measured to determine efficiency for gross alpha and beta. Both, ^{90}Sr and ^{241}Am were spiked from a certified standard radionuclide solution.
09	We measure samples that are in the plant for radiation monitoring. We collect them once per week. They aren't prepared, we measure charcoals and filter papers which we buy.	We use mixed source filter paper with range of energy's from 88 keV to 1836 keV. We put the source on the detector and measure it for approximately 10000 seconds, we are looking to the ROI's also and we do first energy calibration and the efficiency. Our program calculates everything by himself, we only can choose which curve of the polynom we would like to use. We have a programGenie2K.
10	NR	NR
11	Low volume air pump for sampling. Glass fiber filter GA100, diameter 47 mm. Measurement by low level alpha beta gas proportional counter.	Spike the glass fibre filter by standard solutions of ^{239}Pu and ^{90}Sr.
12	NR	For the energy calibration an Amersham Multi-Radionuclide Certified Source (QCY 48) was used. For the efficiency calibration a filter of the same geometrical characteristics with the one measured for the inter-comparison was used. The calibration filter was provided by the IAEA and it was spiked with the isotopes ^{57}Co, ^{137}Cs, ^{54}Mn, ^{60}Co, ^{134}Cs and ^{241}Am; thus there was no need for an efficiency calibration curve, the experimental values of the efficiency were used.

Lab code	Sample Preparation	Efficiency and Energy Calibration
13	Gamma measurement: we measured separately blank filter and sample filter, together with the foil. They were placed in plastic canister and than on the gamma detector and measured 87000 s. Total beta measurement: 1. measurement blank air filter without plastic foil placed in the measurement geometry (stainless steel discs 2inch) 2. measurement sample air filter without plastic foil placed in the measurement geometry (stainless steel discs 2inch)	Efficiency and energy calibration for gamma performed by MGS-1, and MGS-6 Multi-gamma ray standards produced by Canberra. Total beta measurement: 1. Efficiency determination performed : Blank filter spiked with ^{90}Sr standard solution; measurement
15	Geometry used for measurements was filter paper diameter 5 cm, 3-7 peaces. Sample was placed on top of the detector in its' own plastic bag. (gamma spectrometry)	Gamma spectrometry: Measurements were performed using EG&G ORTEC Ge(Li) coaxial detector (resolution 1,87 keV FWHM at 1,33 MeV 60Co, efficiency 15,4% at 1,33 MeV 60Co) Energy and efficiency calibrations were performed using ERX standards (^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{137}Cs, ^{203}Hg, ^{113}Sn, ^{85}Sr and ^{88}Y from Czech Metrological Institute, Cert. No. :931-OL-276/02) Total Beta: Counter: Anti-coincidental GM counter Calibration: potassium-40 standard Total alpha: Alpha counter "VL MONITOR" Calibration: ^{141}Am
16	NR	NR
17	The filter was measured as it is.	The energy and efficiency calibration was performed by a filter standard source containing the following radio nuclides: ^{210}Pb, ^{241}Am, ^{109}Cd, ^{57}Co, ^{123m}Te, ^{51}Cr, ^{113}Sn, ^{85}Sr, ^{137}Cs, ^{88}Y, and ^{60}Co.
18	NR	NR
19	We counted samples directly on the end-cap of the detector for live time needed to achieve desired net count error.	Describe the efficiency and energy calibration procedure, what sources were used. Energy calibration we perform using 6 point source standards produced by CZECH METROLOGICAL INSTITUTE: ^{57}Co, ^{60}Co, ^{88}Y, ^{133}Ba, ^{137}Cs, ^{152}Eu. Spectrum analysis is performed using ORTEC's Gamma Vision software. Radionuclide activity concentration is determined using a absolute method with comparison to the well-documented

Lab code	Sample Preparation	Efficiency and Energy Calibration
		standard sources Radiation Protection and Monitoring Department also posses complete set of standards of different type, geometry and density, we use for efficiency calibration: 1. Marin Elli beaker standards of 1 litter volume produced by CZECH METROLOGICAL INSTITUTE. 2. Marin Elli beaker standards of 0.5 litter volume produced by CZECH METROLOGICAL INSTITUTE. 3. Cylindrical standards of volume 200 ml for gamma spectrometry produced by CZECH METROLOGICAL INSTITUTE. 4. RM and CRM for gamma spectrometry produced by IAEA. For this Proficiency Test we use software ANGLE (Jovanovich ET al.1997). For detection efficiency determination. References for the software program ANGLE: 1. N. MIHALJEVICH, S. JOVANOVICH, F. DE CORTE, B. SMODISCH, R. JACHIMOVICH, G. MEDIN, A. DE WISPELAERE, P.VUKOTICH, P. STEGNAR, "EXTSANGLE - an extension of the efficiency conversion program SOLANG to sources with a diameter larger than that of the Ge detector", J.Radioanal.Nucl.Chem., Articles, 169 (1993) 209-218. 2. S. Jovanovich, S. DlabaCH, N. MihaljeviCH, P. VukotiCH, "ANGLE - a PC-code for semiconductor detector efficiency calculations", J.Radioanal.Nucl. Chem., Vol. 218 (1997) 13-20. 3. P. VukotiCH, N. MihaljeviCH, S. Jovanovich, S. DapCHeviCH, F. Boreli, "On the applicability of the effective solid angle concept in activity determination of large cylindrical sources", J.Radioanl.Nucl.Chem., Vol.218(1997)21-26. 4. N. MIHALJEVICH, S. JOVANOVICH, F. DE CORTE, P. VUKOTICH, J. FALTEJSEK, J. KUCHERA, D. PICCOT, A. DE WISPELAERE, "Calculation of full energy peak detection efficiencies of semiconductor detectors for some interesting counting geometries", Proceedings of the International co Users Workshop - Gent, September 30 - October 2 1992, Astene, Belgium, 53-57. 5. S. JOVANOVICH, N. MIHALJEVICH, F. DE CORTE, L. VANCRAEYNEST, J. FALTEJSEK, P. VUKOTICH, S. DAPCHEVICH, J. KUCHERA, A.DE WISPELAERE, F. CARROT, C. DARDENNE-DESCHAMPS, N. DESCHAMPS, "Experimental test of MARSANGLE, a computer code to calculate detection efficiencies of Ge-detectors for Marin Elli sources", Proceedings of the International co Users Workshop - Gent, September 30 - October 2 1992, Astene, Belgium, 59-62.

Lab code	Sample Preparation	Efficiency and Energy Calibration
20	Delivered in its final form by IAEA.	Technique: Gamma spectrometry Calibration: we use standardized samples and sources

TABLE 6. REPORTED INFORMATION RELATED TO QUALITY ASSURANCE AND QUALITY CONTROL INFORMATION

Lab code	Formal Accreditation	QAS	Number of analyzed Samples	Quality Control Procedure
01	No	Yes	about 3000 samples per year	Laboratory is certified for gamma spectrometry and gross alpha-beta measurements of environmental samples. External quality control is performed through participation in several international and regional Proficiency tests and Inter-comparison measurements during the last decade.
02	No	No	NR	We have system of quality control include regular measurements of following parameters: Energy calibration check, visual practically every-day check, Resolution - FWHM at 1.33 MeV ^{60}Co, ones in 2 month minimum, Peak Shape (FWTM/FWHM) ^{60}Co, ones in 2 month minimum, Peak to Compton Ration, ^{60}Co, ones per 6 mount minimum, Measurements of standards as samples of unknown activity, Measurements of same sample or standard on all our HP Ge detector Use of Control Charts Regular background spectrum measurements.
03	Yes	Yes	~ 7000	Blanks/background and certified control samples measured in regular intervals.
04	No	Yes	More than 1000	Blank sample measurements are performed for all measurements. One control sample with ^{137}Cs is prepared for checking gamma measurements. Result is obtained with RE of 4.9%One control sample with ^{241}Am and ^{90}Sr mixture is prepared for checking total alpha and total beta measurement. Total alpha result is obtained with RE of 11.7%. Total beta result is obtained with RE of 1%.
05	No	Yes	gamma: 3000, gross alpha/beta: 500	Gamma: ^{137}Cs and ^{226}Ra control samples were prepared and compared with the calibration data. Gross A/B: Background was determined by counting the blank air filter. Control charts were maintained by using both an alpha and a beta standard.
06	NR	NR	approximately 100 environmental samples	Daily check - energy calibration (during measurement the peak position are checked) total spectral weekly checks energy resolution, dead time and reproducibility Quarterly-BGR measurement. All results are presented in control charts.
07	Yes	NR	1000	1. Blank sample 2. Control sample 3. background measurements

Lab code	Formal Accreditation	QAS	Number of analyzed Samples	Quality Control Procedure
08	Yes	Yes	500	Gamma: Blank, i.e. background is measured regularly (on the average at least once a month), a short control measurement using CRM is performed after each routine measurement, repeatability, repeatability and reproducibility is being checked. Gross Alpha and Gross Beta: Blank filter was measured to verify repeatability. The data are Beta count rate: (0.050±0.002) s-1, (0.050±0.002) s-1, (0.049±0.002) s-1Alpha count rate: (0.0020±0.0004) s-1, (0.0020±0.0004) s-1, (0.0018±0.0005) s-1CRM was used for efficiency calibration.
09	No	Yes	approximately one thousand per year	We check our system every day with a check source. We put it on the detector and we measure it for 200 seconds and then we have a programme that checks energy's, FWHM, etc...
10	No	Yes	3000	NR
11	No	Yes	just started the work	We use blank, duplicate and control chart of blank.
12	No	Yes	700	Energy and FWHM calibration is routinely conducted once a month. It is verified with every sample analysis and is repeated whenever deemed necessary (energy shift is not allowed to exceed 1KeV for the highest energy photons in a spectrum while the mean energy shift is not allowed to exceed 0.4KeV). Efficiency calibration is conducted once a year using an Amersham Multi-Radionuclide Certified Source (QCY 48). Background measurements are conducted once a year. Samples are usually analysed in more than one detector for consistency. The laboratory's adopted gamma-spectroscopic techniques are validated via the use of IAEA Certified. Reference Sources (e.g. sample IAEA 373), and also by the frequent participation in Inter-comparisons organised by IAEA (ALMERA Network), NPL and the Greek Atomic Energy Commission.

Lab code	Formal Accreditation	QAS	Number of analyzed Samples	Quality Control Procedure
13	No	Yes	250	At this moment our laboratory don't perform gamma neither gross beta measurement in air filters .On regularly base we perform quality control procedure (monitoring of radioactivity in soil, water and food samples): · Background measurement · Blank measurement · Resolution determination- point sources· Energy calibration -point sources, · Efficiency determination- · Determination of LC, LD and MDA. · RM - used to control performance for routine analysis and evaluation of the method accuracy. · Methods are controlled by participation in inter-comparison exercises and proficiency tests.· Beta Counting · Check source (Electroplated) measurements performed between sample sets· Efficiency determination for total beta activity· Efficiency determination for strontium analysis
15	No	Yes	NR	Blank filter was used as background. For calculation of spectrum was used Gamma vision with incorporated QA package. QA is also performed through inter-comparison measurements
16	No	Yes	100	NR
17	Yes	NR	700	The quality control performed is according to ISO-IEC 17025.
18	NR	NR	NR	NR
19	Yes	Yes	up to 1000	We have system of quality control and which include regular measurements of following parameters: Resolution - FWHM at 1.33 MeV ^{60}Co. · Peak Shape (FWTM/FWHM) ^{60}Co. · Resolution - FWHM at 122 keV ^{57}Co. · Peak to Compton Ratio, ^{60}Co. · Relative efficiency at 1.33 MeV ^{60}Co. · Measurements of standards (RM, CRM, …) as samples of unknown activity. · Measurements of same sample or standard (RM, CRM,) on all our HPGe detectors. · Use of Control Charts. · Regular background spectrum measurements. · Participation in Proficiency tests and Inter-Laboratory studies. SAMPLE: Radiation Protection and monitoring department Control Chart for our HPGe 41% ; Ortec data: FWHM guaranteed 1.90 keV; measured 1.81 keV
20	Yes	Yes	600	Control charts with reference sources in selected geometries (activity, FWHM, background)

APPENDIX II
PERFORMANCE EVALUATION SORTED BY ANALYTE

TABLE 7. REPORTED RESULTS OF ^{54}Mn IN "GAMMA BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	<0.011	0.003	-
02	-	-	NR
03	0.71	0.04	High result for the Blank
04	0.00	0.00	MDL Should be reported
05	-	-	NR
06	0.0735	-	NR
07	<0.0024	-	-
08	<	0.01	MDL Should be reported
09	/	/	NR
10	<0.005	-	-
11	-	-	NR
12	<0.012	-	-
13	<0.03	-	-
15	-	-	NR
16	-0.05	0.02	-
17	-	-	NR
18	-	-	NR
19	0.02	0.003	-
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 8. REPORTED RESULTS OF ^{57}Co IN "GAMMA BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	<0.01	0.01	-
02	-	-	NR
03	0.95	0.04	High result for the Blank
04	0.00	0.00	MDL Should be reported
05	-	-	NR
06	0.0338	-	NR
07	0.0025	0.0014	MDL Should be reported
08	<	0.003	MDL Should be reported
09	/	/	NR
10	<0.003	-	-
11	-	-	NR
12	<0.0074	-	-
13	<0.05	-	-
15	-	-	NR
16	0.06	0.07	-
17	-	-	NR
18	-	-	NR
19	0.0016	0.0002	
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 9. REPORTED RESULTS OF ^{60}Co IN "GAMMA BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	<0.011	0.003	-
02	-	-	NR
03	0.57	0.03	High result for the Blank
04	0.00	0.00	MDL Should be reported
05	-	-	NR
06	0.0887	-	NR
07	0.01	0.0058	-
08	<	0.01	-
09	/	/	-
10	<0.003	-	-
11	-	-	NR
12	<0.015	-	-
13	<0.03	-	-
15	-	-	NR
16	0.02	0.01	-
17	-	-	NR
18	-	-	NR
19	0.02	0.003	-
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 10. REPORTED RESULTS OF ^{134}Cs IN "GAMMA BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	<0.009	0.004	-
02	-	-	NR
03	1.15	0.04	High result for the Blank
04	0.00	0.00	MDL Should be reported
05	-	-	NR
06	0.0953	-	NR
07	<0.0028	-	-
08	<	0.01	MDL Should be reported
09	/	/	NR
10	<0.01	-	-
11	-	-	NR
12	<0.018	-	-
13	<0.18	-	-
15	-	-	NR
16	0.02	0.01	-
17	-	-	NR
18	-	-	NR
19	0.02	0.003	-
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 11. REPORTED RESULTS OF ^{137}Cs IN "GAMMA BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	<0.014	0.003	-
02	-	-	NR
03	0.63	0.04	High result for the Blank
04	0.00	0.00	MDL Should be reported
05	-	-	NR
06	0.059	-	NR
07	0.0032	0.0024	-
08	<	0.01	MDL Should be reported
09	/	/	NR
10	<0.004	-	-
11	-	-	NR
12	<0.012	-	-
13	<0.03	-	-
15	-	-	NR
16	0.02	0.03	-
17	-	-	NR
18	0.09	0.01	-
19	0.02	0.002	-
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 12. REPORTED RESULTS OF GROSS α IN "BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	0.01	0.01	-
02	-	-	NR
03	0.01	0.01	-
04	0.001	0.0001	MDL Should be reported
05	-	-	NR
06	-	-	NR
07	-	-	NR
08	0.0016	0.0003	-
09	/	/	NR
10	0.01	0.001	-
11	0.08	0.02	-
12	-	-	NR
13	MDL	-	MDL Should be reported
15	-	-	NR
16	-	-	NR
17	-	-	NR
18	-	-	NR
19	-	-	NR
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 13. REPORTED RESULTS OF GROSS β IN "BLANK AIR FILTER"

Laboratories Results			
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
01	0.04	0.01	-
02	-	-	NR
03	0.04	0.01	-
04	0.027	0.0003	-
05	-	-	NR
06	-	-	NR
07	-	-	NR
08	0.03	0.002	-
09	0.32	-	High result for the Blank
10	0.03	0.01	-
11	0.20	0.08	High result for the Blank
12	-	-	NR
13	0.10	0.0007	High result for the Blank
15	-	-	NR
16	0.02	0.003	-
17	-	-	NR
18	-	-	NR
19	-	-	NR
20	-	-	NR

NR : Not Reported
MDL: Minimum Detection Limit

TABLE 14. DATA EVALUATION OF ^{54}Mn IN "SPIKED AIR FILTER"

Target value: 1.81 **[Bq/filter]**
Uncertainty: 0.04

Lab. Code	Laboratories Results							Acceptance criteria					Bias score	Final Score
	Value	Uncertainty		Bias(%)	Z-Score	U-Score	Lab/IAEA	Trueness			Precision			
	[Bq/filter]	[Bq/filter]	%					A1	A2	Score	P	Score		
01	1.80	0.20	11.11	-0.55	-0.06	-0.05	0.99	0.01	0.53	A	11.33	A	A	A
02	6.95	0.15	2.16	283.98	28.40	33.11	3.84	5.14	0.40	N	3.09	A	N	N
03	1.54	0.06	3.90	-14.92	-1.49	-3.74	0.85	0.27	0.19	N	4.48	A	W	W
04	1.06	0.06	5.66	-41.44	-4.14	-10.40	0.59	0.75	0.19	N	6.08	A	N	N
05	1.75	0.09	5.14	-3.31	-0.33	-0.61	0.97	0.06	0.25	A	5.60	A	A	A
06	1.90	0.11	5.79	4.97	0.50	0.77	1.05	0.09	0.30	A	6.20	A	A	A
07	1.70	0.02	1.30	-6.19	-0.62	-2.45	0.94	0.11	0.12	A	2.56	A	A	A
08	1.86	0.04	2.15	2.76	0.28	0.88	1.03	0.05	0.15	A	3.08	A	A	A
09	1.73	0.41	23.58	-4.42	-0.44	-0.20	0.96	0.08	1.06	A	23.69	N	A	W
10	1.66	0.09	5.42	-8.29	-0.83	-1.52	0.92	0.15	0.25	A	5.85	A	A	A
12	1.83	0.07	3.55	1.10	0.11	0.26	1.01	0.02	0.20	A	4.18	A	A	A
13	1.68	0.05	2.98	-7.18	-0.72	-2.03	0.93	0.13	0.17	A	3.71	A	A	A
15	2.12	0.05	2.36	17.13	1.71	4.84	1.17	0.31	0.17	N	3.23	A	W	N
16	1.76	0.08	4.55	-2.76	-0.28	-0.56	0.97	0.05	0.23	A	5.05	A	A	A
17	2.00	0.10	5.00	10.50	1.05	1.76	1.10	0.19	0.28	A	5.47	A	W	A
18	1.48	0.04	2.70	-18.23	-1.82	-5.83	0.82	0.33	0.15	N	3.49	A	W	N
19	1.42	0.09	6.34	-21.55	-2.15	-3.96	0.78	0.39	0.25	N	6.71	A	N	N
20	2.22	0.06	2.70	22.65	2.27	5.69	1.23	0.41	0.19	N	3.49	A	N	N

A: Acceptable
W: Warning
N: Not Acceptable

Percentage of acceptable scores	56	56
Percentage of warning scores	22	11
Percentage of not acceptable scores	22	33

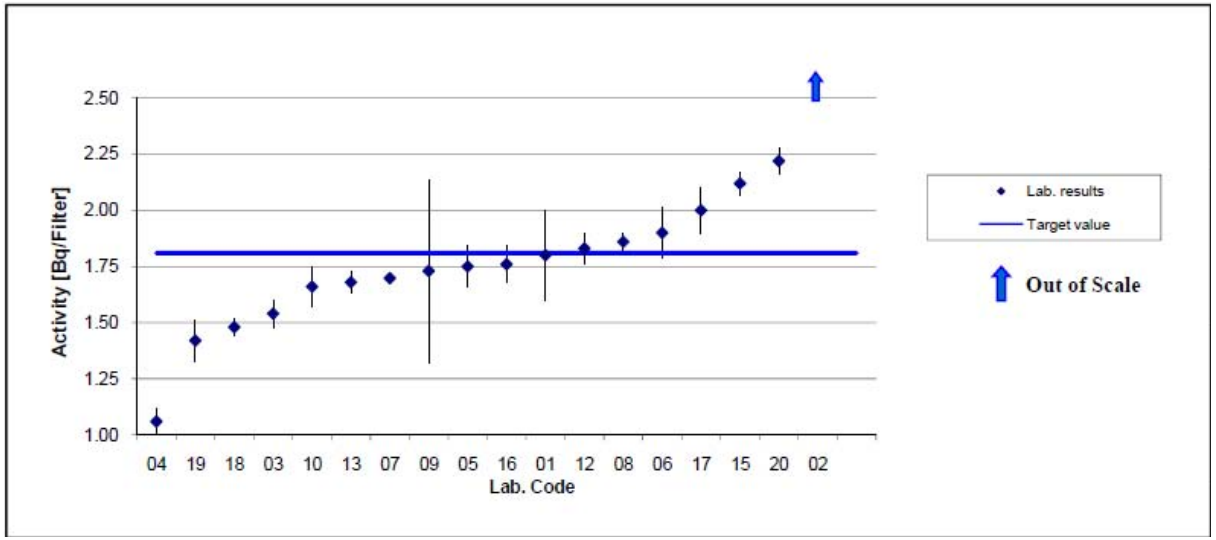


Fig. 3. S-shape chart of ^{54}Mn in "spiked air filter".

TABLE 15. DATA EVALUATION OF ^{57}Co IN "SPIKED AIR FILTER"

Target value: 2.53 **[Bq/filter]**
Uncertainty: 0.06

Lab. Code	Laboratories Results							Acceptance criteria					Bias score	Final Score
	Value	Uncertainty		Bias(%)	Z-Score	U-Score	Lab/IAEA	Trueness			Precision			
	[Bq/filter]	[Bq/filter]	%					A1	A2	Score	P	Score		
01	3.20	0.30	9.38	26.48	2.65	2.19	1.26	0.67	0.79	**A**	9.67	**A**	**N**	**A**
02	11.64	1.88	16.15	360.08	36.01	4.84	4.60	9.11	4.85	**N**	16.32	**N**	**N**	**N**
03	2.02	0.07	3.47	-20.16	-2.02	-5.53	0.80	0.51	0.24	**N**	4.20	**A**	**N**	**N**
04	1.97	0.11	5.58	-22.13	-2.21	-4.47	0.78	0.56	0.32	**N**	6.07	**A**	**N**	**N**
05	2.81	0.13	4.63	11.07	1.11	1.96	1.11	0.28	0.37	**A**	5.20	**A**	**W**	**A**
06	2.62	0.19	7.25	3.56	0.36	0.45	1.04	0.09	0.51	**A**	7.63	**A**	**A**	**A**
07	0.89	0.01	0.56	-65.02	-6.50	-27.32	0.35	1.65	0.16	**N**	2.44	**A**	**N**	**N**
08	2.56	0.06	2.34	1.19	0.12	0.35	1.01	0.03	0.22	**A**	3.33	**A**	**A**	**A**
09	1.96	0.35	17.76	-22.53	-2.25	-1.61	0.77	0.57	0.91	**A**	17.91	**N**	**N**	**N**
10	2.36	0.11	4.66	-6.72	-0.67	-1.36	0.93	0.17	0.32	**A**	5.23	**A**	**A**	**A**
12	2.47	0.10	3.89	-2.37	-0.24	-0.53	0.98	0.06	0.29	**A**	4.55	**A**	**A**	**A**
13	2.20	0.10	4.55	-13.04	-1.30	-2.83	0.87	0.33	0.30	**N**	5.13	**A**	**W**	**W**
15	2.74	0.03	1.09	8.30	0.83	3.13	1.08	0.21	0.17	**N**	2.61	**A**	**A**	**W**
16	2.34	0.10	4.27	-7.51	-0.75	-1.63	0.92	0.19	0.30	**A**	4.89	**A**	**A**	**A**
17	2.65	0.08	3.02	4.74	0.47	1.20	1.05	0.12	0.26	**A**	3.84	**A**	**A**	**A**
18	1.81	0.06	3.31	-28.46	-2.85	-8.49	0.72	0.72	0.22	**N**	4.08	**A**	**N**	**N**
19	2.22	0.11	4.95	-12.25	-1.23	-2.47	0.88	0.31	0.32	**A**	5.49	**A**	**W**	**A**
20	3.13	0.09	2.88	23.72	2.37	5.55	1.24	0.60	0.28	**N**	3.73	**A**	**N**	**N**

A: Acceptable
W: Warning
N: Not Acceptable

Percentage of acceptable scores	39	50
Percentage of warning scores	17	11
Percentage of not acceptable scores	50	44

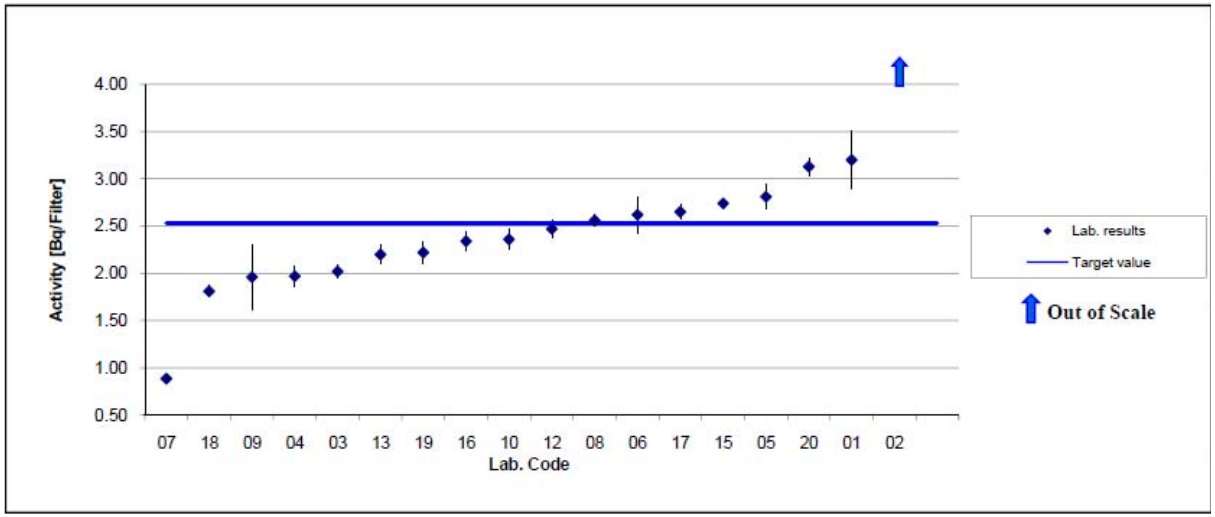


Fig. 4. S-shape chart of ^{57}Co in "spiked air filter".

TABLE 16. DATA EVALUATION OF ^{60}Co IN "SPIKED AIR FILTER"

Target value: 1.33 **[Bq/filter]**
Uncertainty: 0.02

Lab. Code	Laboratories Results			Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria					Bias score	Final Score
	Value	Uncertainty						Trueness			Precision			
	[Bq/filter]	[Bq/filter]	%					A1	A2	Score	P	Score		
01	1.30	0.10	7.69	-2.26	-0.23	-0.29	0.98	0.03	0.26	**A**	7.84	**A**	**A**	**A**
02	4.25	0.10	2.35	219.55	21.95	28.63	3.20	2.92	0.26	**N**	2.79	**A**	**N**	**N**
03	1.22	0.04	3.28	-8.27	-0.83	-2.46	0.92	0.11	0.12	**A**	3.61	**A**	**A**	**A**
04	2.02	0.10	4.95	51.88	5.19	6.77	1.52	0.69	0.26	**N**	5.17	**A**	**N**	**N**
05	1.40	0.05	3.57	5.26	0.53	1.30	1.05	0.07	0.14	**A**	3.88	**A**	**A**	**A**
06	1.38	0.07	5.07	3.76	0.38	0.69	1.04	0.05	0.19	**A**	5.29	**A**	**A**	**A**
07	1.22	0.02	1.63	-7.97	-0.80	-3.75	0.92	0.11	0.07	**N**	2.22	**A**	**A**	**W**
08	1.36	0.03	2.21	2.26	0.23	0.83	1.02	0.03	0.09	**A**	2.67	**A**	**A**	**A**
09	1.22	0.27	22.30	-8.27	-0.83	-0.40	0.92	0.11	0.70	**A**	22.35	**N**	**A**	**W**
10	1.21	0.07	5.79	-9.02	-0.90	-1.65	0.91	0.12	0.19	**A**	5.98	**A**	**A**	**A**
12	1.32	0.04	3.26	-0.75	-0.08	-0.21	0.99	0.01	0.12	**A**	3.59	**A**	**A**	**A**
13	1.27	0.05	3.94	-4.51	-0.45	-1.11	0.95	0.06	0.14	**A**	4.21	**A**	**A**	**A**
15	1.41	0.04	2.84	6.02	0.60	1.79	1.06	0.08	0.12	**A**	3.21	**A**	**A**	**A**
16	1.32	0.04	3.03	-0.75	-0.08	-0.22	0.99	0.01	0.12	**A**	3.38	**A**	**A**	**A**
17	1.44	0.04	2.78	8.27	0.83	2.46	1.08	0.11	0.12	**A**	3.16	**A**	**A**	**A**
18	1.33	0.04	3.01	0.00	0.00	0.00	1.00	0.00	0.12	**A**	3.36	**A**	**A**	**A**
19	1.10	0.06	5.45	-17.29	-1.73	-3.64	0.83	0.23	0.16	**N**	5.66	**A**	**W**	**N**
20	1.62	0.04	2.47	21.80	2.18	6.48	1.22	0.29	0.12	**N**	2.89	**A**	**N**	**N**

A: Acceptable
W: Warning
N: Not Acceptable

Percentage of acceptable scores	78	67
Percentage of warning scores	6	11
Percentage of not acceptable scores	17	22

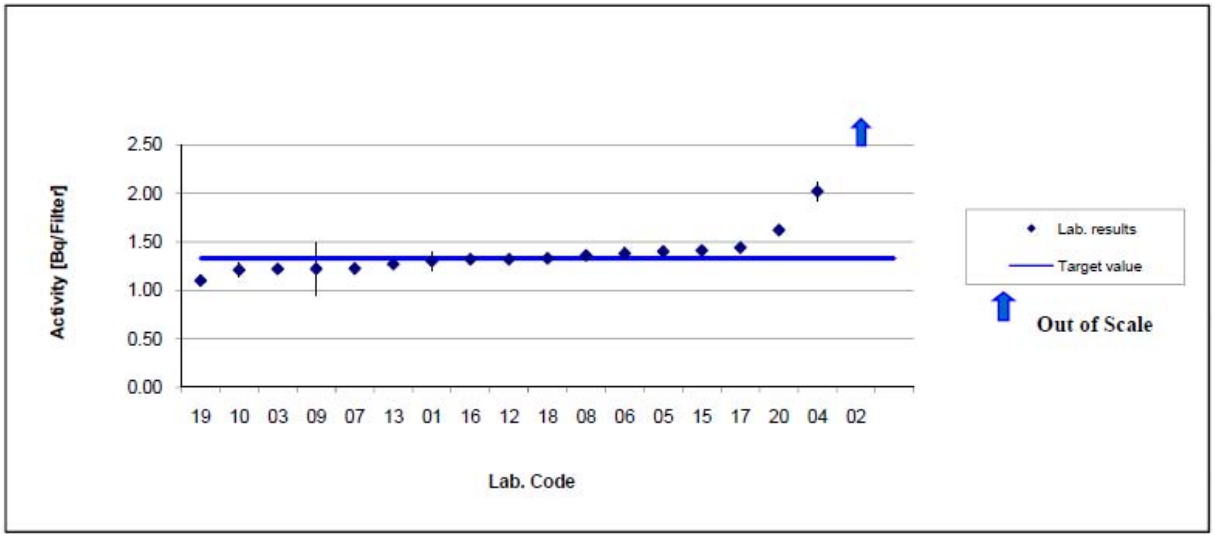


Fig. 5. S-shape chart of ^{60}Co in "spiked air filter".

TABLE 17. DATA EVALUATION OF ^{134}CS IN "SPIKED AIR FILTER"

Target value: 2.81 **[Bq/filter]**
Uncertainty: 0.06

Lab. Code	Laboratories Results			Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria					Bias score	Final Score
	Value	Uncertainty						Trueness			Precision			
	[Bq/filter]	[Bq/filter]	%					A1	A2	Score	P	Score		
01	2.10	0.20	9.52	-25.27	-2.53	-3.40	0.75	0.71	0.54	**N**	9.76	**A**	**N**	**N**
02	8.59	0.20	2.33	205.69	20.57	27.68	3.06	5.78	0.54	**N**	3.16	**A**	**N**	**N**
03	2.53	0.06	2.37	-9.96	-1.00	-3.30	0.90	0.28	0.22	**N**	3.19	**A**	**A**	**W**
04	1.39	0.08	5.76	-50.53	-5.05	-14.20	0.49	1.42	0.26	**N**	6.14	**A**	**N**	**N**
05	2.74	0.13	4.74	-2.49	-0.25	-0.49	0.98	0.07	0.37	**A**	5.20	**A**	**A**	**A**
06	2.92	0.12	4.11	3.91	0.39	0.82	1.04	0.11	0.35	**A**	4.63	**A**	**A**	**A**
07	1.77	0.02	1.25	-37.15	-3.72	-16.34	0.63	1.04	0.16	**N**	2.47	**A**	**N**	**N**
08	2.80	0.06	2.14	-0.36	-0.04	-0.12	1.00	0.01	0.22	**A**	3.03	**A**	**A**	**A**
09	1.71	0.32	18.83	-39.15	-3.91	-3.36	0.61	1.10	0.85	**N**	18.95	**N**	**N**	**N**
10	2.59	0.12	4.63	-7.83	-0.78	-1.64	0.92	0.22	0.35	**A**	5.10	**A**	**A**	**A**
12	2.75	0.07	2.58	-2.14	-0.21	-0.65	0.98	0.06	0.24	**A**	3.35	**A**	**A**	**A**
13	2.77	0.08	2.89	-1.42	-0.14	-0.40	0.99	0.04	0.26	**A**	3.59	**A**	**A**	**A**
15	2.74	0.04	1.46	-2.49	-0.25	-0.97	0.98	0.07	0.19	**A**	2.59	**A**	**A**	**A**
16	2.93	0.05	1.71	4.27	0.43	1.54	1.04	0.12	0.20	**A**	2.73	**A**	**A**	**A**
17	2.90	0.10	3.45	3.20	0.32	0.77	1.03	0.09	0.30	**A**	4.06	**A**	**A**	**A**
18	3.75	0.68	18.13	33.45	3.35	1.38	1.33	0.94	1.76	**A**	18.26	**N**	**N**	**N**
19	1.90	0.10	5.26	-32.38	-3.24	-7.80	0.68	0.91	0.30	**N**	5.68	**A**	**N**	**N**
20	3.32	0.09	2.71	18.15	1.81	4.71	1.18	0.51	0.28	**N**	3.45	**A**	**W**	**N**

A: Acceptable
W: Warning
N: Not Acceptable

Percentage of acceptable scores	56	50
Percentage of warning scores	6	6
Percentage of not acceptable scores	39	44

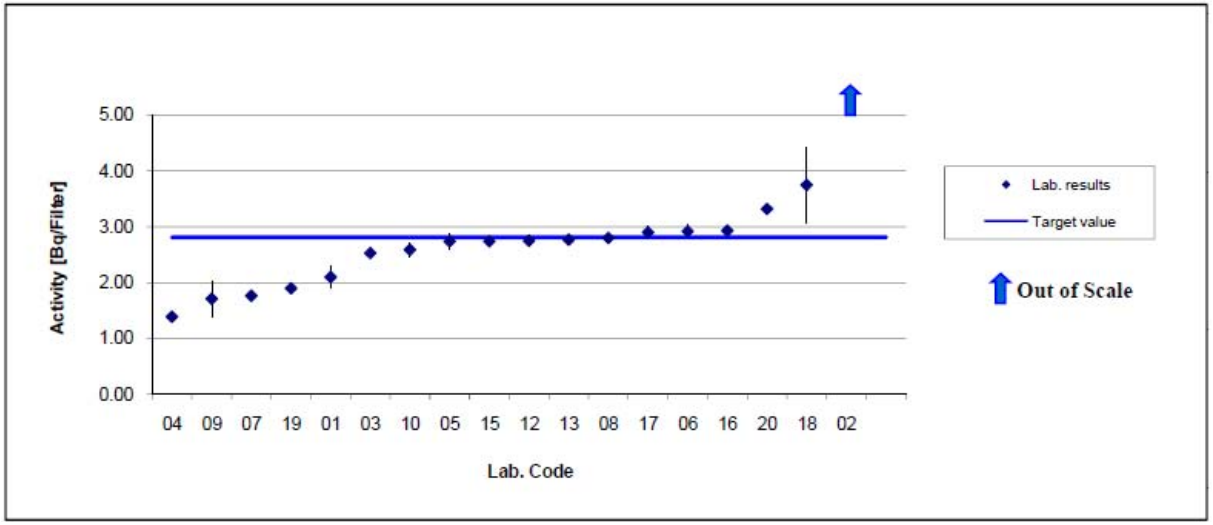


Fig. 6. S-shape chart of ^{134}Cs in "spiked air filter".

TABLE 18. DATA EVALUATION OF ^{137}CS IN "SPIKED AIR FILTER"

Target value: 1.70 **[Bq/filter]**
Uncertainty: 0.03

Lab. Code	Laboratories Results			Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria					Bias score	Final Score
	Value	Uncertainty						Trueness			Precision			
	[Bq/filter]	[Bq/filter]	%					A1	A2	Score	P	Score		
01	1.70	0.20	11.76	0.00	0.00	0.00	1.00	0.00	0.52	**A**	11.90	**A**	**A**	**A**
02	6.53	0.15	2.30	284.12	28.41	31.57	3.84	4.83	0.39	**N**	2.90	**A**	**N**	**N**
03	1.38	0.06	4.35	-18.82	-1.88	-4.77	0.81	0.32	0.17	**N**	4.69	**A**	**W**	**N**
04	1.52	0.09	5.92	-10.59	-1.06	-1.90	0.89	0.18	0.24	**A**	6.18	**A**	**W**	**A**
05	1.86	0.07	3.76	9.41	0.94	2.10	1.09	0.16	0.20	**A**	4.16	**A**	**A**	**A**
06	1.78	0.10	5.62	4.71	0.47	0.77	1.05	0.08	0.27	**A**	5.89	**A**	**A**	**A**
07	1.46	0.02	1.37	-14.18	-1.42	-6.68	0.86	0.24	0.09	**N**	2.23	**A**	**W**	**W**
08	1.73	0.05	2.89	1.76	0.18	0.51	1.02	0.03	0.15	**A**	3.39	**A**	**A**	**A**
09	1.50	0.33	22.00	-11.76	-1.18	-0.60	0.88	0.20	0.85	**A**	22.07	**N**	**W**	**W**
10	1.51	0.09	5.96	-11.18	-1.12	-2.00	0.89	0.19	0.24	**A**	6.22	**A**	**W**	**A**
12	1.68	0.06	3.75	-1.18	-0.12	-0.29	0.99	0.02	0.18	**A**	4.14	**A**	**A**	**A**
13	1.72	0.08	4.65	1.18	0.12	0.23	1.01	0.02	0.22	**A**	4.97	**A**	**A**	**A**
15	1.99	0.04	2.01	17.06	1.71	5.80	1.17	0.29	0.13	**N**	2.67	**A**	**W**	**N**
16	1.85	0.07	3.78	8.82	0.88	1.97	1.09	0.15	0.20	**A**	4.18	**A**	**A**	**A**
17	1.80	0.10	5.56	5.88	0.59	0.96	1.06	0.10	0.27	**A**	5.83	**A**	**A**	**A**
18	1.73	0.05	2.89	1.76	0.18	0.51	1.02	0.03	0.15	**A**	3.39	**A**	**A**	**A**
19	1.33	0.10	7.52	-21.76	-2.18	-3.54	0.78	0.37	0.27	**N**	7.72	**A**	**N**	**N**
20	2.07	0.06	2.90	21.76	2.18	5.52	1.22	0.37	0.17	**N**	3.39	**A**	**N**	**N**

A: Acceptable
W: Warning
N: Not Acceptable

Percentage of acceptable scores	50	61
Percentage of warning scores	33	11
Percentage of not acceptable scores	17	28

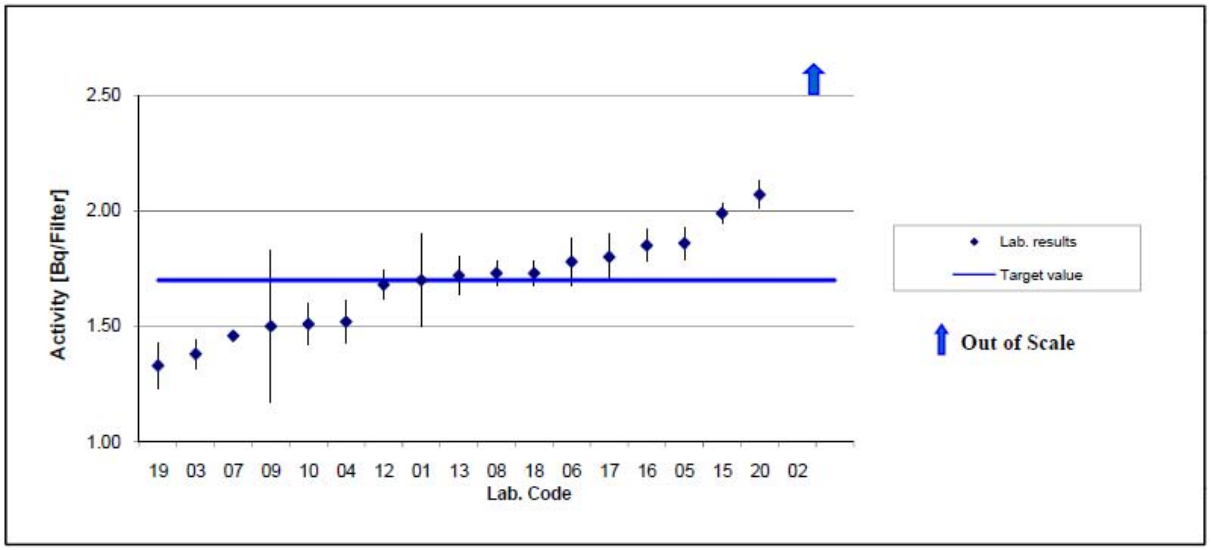


Fig. 7. S-shape chart of ^{137}Cs in "spiked air filter".

TABLE 19. DATA EVALUATION OF GROSS α IN "SPIKED AIR FILTER"

Target value: 0.17 **[Bq/filter]**
Uncertainty: 0.009

Laboratories Results							
Lab. Code	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**%**	**Bias(%)**	**Lab/IAEA**	**Lab/u_lab**	**Final Score**
01	0.10	0.02	20.00	-41.18	0.59	5.0	**A**
03	0.10	0.02	20.00	-41.18	0.59	5.0	**A**
04	0.04	0.01	12.82	-77.06	0.23	7.8	**W**
05	0.097	0.009	9.28	-42.94	0.57	10.8	**A**
08	0.27	0.02	7.41	58.82	1.59	13.5	**A**
09	0.04	0.004	10.00	-76.47	0.24	10.0	**W**
10	0.12	0.01	4.03	-27.06	0.73	24.8	**A**
11	0.19	0.04	22.68	14.12	1.14	4.4	**A**
15	0.20	0.01	3.55	15.88	1.16	28.1	**A**
17	0.07	0.01	16.67	-61.18	0.39	6.0	**A**
20	0.20	0.007	3.55	15.88	1.16	28.1	**A**

A: Acceptable — Percentage of acceptable scores 82
W: Warning — Percentage of warning scores 18
N: Not Acceptable — Percentage of not acceptable scores 0

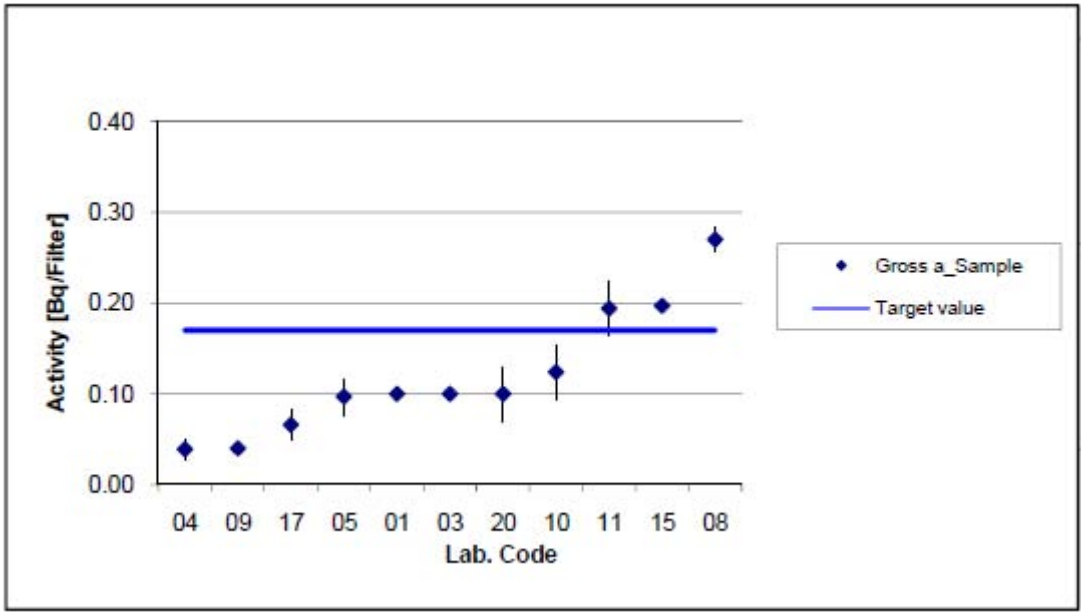


Fig. 8. S-shape chart of gross α in "spiked air filter".

TABLE 20. DATA EVALUATION OF GROSS β IN "SPIKED AIR FILTER"

Target value: 0.29 **[Bq/filter]**
Uncertainty: 0.01

Lab. Code	Laboratories Results Value [Bq/filter]	Uncertainty [Bq/filter]	Uncertainty %	Bias(%)	Lab/IAEA	Lab/u_lab	Final score
01	0.37	0.03	8.11	27.59	1.28	12.33	**A**
03	0.37	0.03	8.11	27.59	1.28	12.33	**A**
04	0.15	0.01	7.48	-49.31	0.51	13.36	**A**
05	0.35	0.005	1.42	21.72	1.22	70.60	**A**
08	0.35	0.02	5.71	20.69	1.21	17.50	**A**
09	0.18	0.02	10.00	-37.93	0.62	10.00	**A**
10	0.35	0.01	2.00	20.69	1.21	50.00	**A**
11	0.68	0.20	29.29	133.10	2.33	3.41	**N**
13	0.39	0.004	1.03	33.55	1.34	96.83	**A**
15	0.45	0.01	2.23	54.48	1.54	44.80	**W**
16	0.41	0.01	3.41	41.72	1.42	29.36	**A**
17	0.28	0.02	6.09	-3.79	0.96	16.41	**A**
20	0.37	0.03	8.11	27.59	1.28	12.33	**A**

A: Acceptable
W: Warning
N: Not Acceptable

Percentage of acceptable scores 85
Percentage of warning scores 8
Percentage of not acceptable scores 8

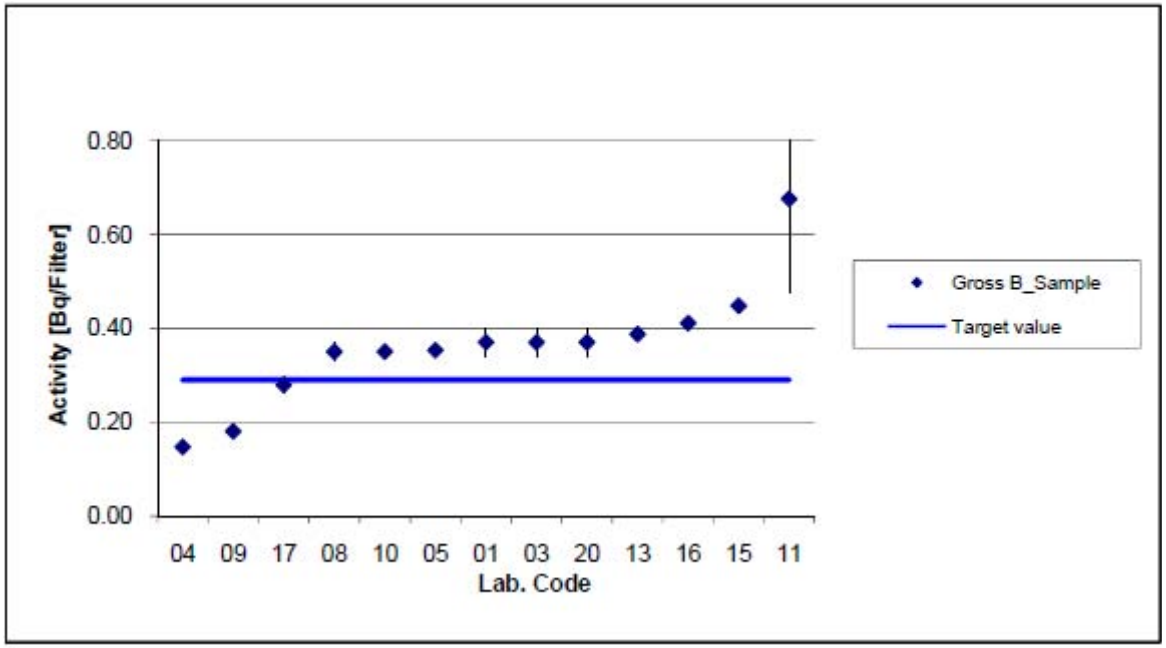


Fig. 9. S-shape chart of gross β in "spiked air filter".

APPENDIX III
PERFORMANCE EVALUATION SORTED BY LABORATORY CODE

Reference date: 2008-05-01

TABLE 21. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 01: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	<0.01	0.01	-
^{60}Co	<0.011	0.003	-
^{134}Cs	<0.009	0.004	-
^{137}Cs	<0.014	0.003	-
^{54}Mn	<0.011	0.003	-
Gross α	0.007	0.006	-
Gross β	0.04	0.01	-

TABLE 22. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 01: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	3.20	0.30	9.38	26.48	2.65	2.19	1.26	0.67	0.79	**A**	9.67	**A**	**A**
^{60}Co	1.33	0.02	1.30	0.10	7.69	-2.26	-0.23	-0.29	0.98	0.03	0.26	**A**	7.84	**A**	**A**
^{134}Cs	2.81	0.06	2.10	0.20	9.52	-25.27	-2.53	-3.40	0.75	0.71	0.54	**N**	9.76	**A**	**N**
^{137}Cs	1.70	0.03	1.70	0.20	11.76	0.00	0.00	0.00	1.00	0.00	0.52	**A**	11.90	**A**	**A**
^{54}Mn	1.81	0.04	1.80	0.20	11.11	-0.55	-0.06	-0.05	0.99	0.01	0.53	**A**	11.33	**A**	**A**
Gross α	0.17	0.01	0.10	0.02	20.00	-41.18			0.59						**A**
Gross β	0.29	0.01	0.37	0.03	8.11	27.59			1.28						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 23. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 02: BLANK AIR FILTER

	Laboratory		
Analyte	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
^{57}Co	-	-	NR
^{60}Co	-	-	NR
^{134}Cs	-	-	NR
^{137}Cs	-	-	NR
^{54}Mn	-	-	NR
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 24. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 02: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	[%]	**R. bias** [%]	**Z-score**	**U-score**	**Lab./IAEA**	**Trueness** A1	A2	Score	**Precision** P	Score	**Final score**
^{57}Co	2.530	0.060	11.64	1.88	16.15	360.08	36.01	4.84	4.60	9.11	4.85	**N**	16.32	**N**	**N**
^{60}Co	1.33	0.02	4.25	0.10	2.35	219.55	21.95	28.63	3.20	2.92	0.26	**N**	2.79	**A**	**N**
^{134}Cs	2.81	0.06	8.59	0.20	2.33	205.69	20.57	27.68	3.06	5.78	0.54	**N**	3.16	**A**	**N**
^{137}Cs	1.70	0.03	6.53	0.15	2.30	284.12	28.41	31.57	3.84	4.83	0.39	**N**	2.90	**A**	**N**
^{54}Mn	1.81	0.04	6.95	0.15	2.16	283.98	28.40	33.11	3.84	5.14	0.40	**N**	3.09	**A**	**N**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	-	-											**NR**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 25. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 03: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	0.95	0.04	High result for the Blank
^{60}Co	0.57	0.03	High result for the Blank
^{134}Cs	1.15	0.04	High result for the Blank
^{137}Cs	0.63	0.04	High result for the Blank
^{54}Mn	0.71	0.04	High result for the Blank
Gross α	0.007	0.006	-
Gross β	0.04	0.01	-

TABLE 26. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 03: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.02	0.07	3.47	-20.16	-2.02	-5.53	0.80	0.51	0.24	**N**	4.20	**A**	**N**
^{60}Co	1.33	0.02	1.22	0.04	3.28	-8.27	-0.83	-2.46	0.92	0.11	0.12	**A**	3.61	**A**	**A**
^{134}Cs	2.81	0.06	2.53	0.06	2.37	-9.96	-1.00	-3.30	0.90	0.28	0.22	**N**	3.19	**A**	**W**
^{137}Cs	1.70	0.03	1.38	0.06	4.35	-18.82	-1.88	-4.77	0.81	0.32	0.17	**N**	4.69	**A**	**N**
^{54}Mn	1.81	0.04	1.54	0.06	3.90	-14.92	-1.49	-3.74	0.85	0.27	0.19	**N**	4.48	**A**	**W**
Gross α	0.17	0.01	0.10	0.02	20.00	-41.18			0.59						**A**
Gross β	0.29	0.01	0.37	0.03	8.11	27.59			1.28						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 27. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 04: BLANK AIR FILTER

	Laboratory		
Analyte	**Value**	**Uncertainty**	
	[Bq/filter]	**[Bq/filter]**	**Comments**
^{57}Co	0.00	0.00	MDL Should be reported
^{60}Co	0.00	0.00	MDL Should be reported
^{134}Cs	0.00	0.00	MDL Should be reported
^{137}Cs	0.00	0.00	MDL Should be reported
^{54}Mn	0.00	0.00	MDL Should be reported
Gross α	0.001	0.0001	MDL Should be reported
Gross β	0.0268	0.0003	-

TABLE 28. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 04: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	**Value**	**Uncertainty**	**Value**	**Uncertainty**		**R. bias**	**Z-score**	**U-score**	**Lab./IAEA**	**Trueness**			**Precision**		**Final score**
	[Bq/filter]	**[Bq/filter]**	**[Bq/filter]**	**[Bq/filter]**	**[%]**	**[%]**				A1	A2	Score	P	Score	
^{57}Co	2.530	0.060	1.97	0.11	5.58	-22.13	-2.21	-4.47	0.78	0.56	0.32	**N**	6.07	**A**	**N**
^{60}Co	1.33	0.02	2.02	0.10	4.95	51.88	5.19	6.77	1.52	0.69	0.26	**N**	5.17	**A**	**N**
^{134}Cs	2.81	0.06	1.39	0.08	5.76	-50.53	-5.05	-14.20	0.49	1.42	0.26	**N**	6.14	**A**	**N**
^{137}Cs	1.70	0.03	1.52	0.09	5.92	-10.59	-1.06	-1.90	0.89	0.18	0.24	**A**	6.18	**A**	**A**
^{54}Mn	1.81	0.04	1.06	0.06	5.66	-41.44	-4.14	-10.40	0.59	0.75	0.19	**N**	6.08	**A**	**N**
Gross α	0.17	0.01	0.039	0.005	12.82	-77.06			0.23						**W**
Gross β	0.29	0.01	0.147	0.011	7.48	-49.31			0.51						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 29. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 05: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	-	-	NR
^{60}Co	-	-	NR
^{134}Cs	-	-	NR
^{137}Cs	-	-	NR
^{54}Mn	-	-	NR
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 30. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 05: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.81	0.13	4.63	11.07	1.11	1.96	1.11	0.28	0.37	**A**	5.20	**A**	**A**
^{60}Co	1.33	0.02	1.40	0.05	3.57	5.26	0.53	1.30	1.05	0.07	0.14	**A**	3.88	**A**	**A**
^{134}Cs	2.81	0.06	2.74	0.13	4.74	-2.49	-0.25	-0.49	0.98	0.07	0.37	**A**	5.20	**A**	**A**
^{137}Cs	1.70	0.03	1.86	0.07	3.76	9.41	0.94	2.10	1.09	0.16	0.20	**A**	4.16	**A**	**A**
^{54}Mn	1.81	0.04	1.75	0.09	5.14	-3.31	-0.33	-0.61	0.97	0.06	0.25	**A**	5.60	**A**	**A**
Gross α	0.17	0.01	0.097	0.009	9.28	-42.94			0.57						**A**
Gross β	0.29	0.01	0.353	0.005	1.42	21.72			1.22						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 31. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 06: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	0.0338	-	NR
^{60}Co	0.0887	-	NR
^{134}Cs	0.0953	-	NR
^{137}Cs	0.0590	-	NR
^{54}Mn	0.0735	-	NR
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 32. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 06: SPIKED AIR FILTER

Analyte	IAEA Value [Bq/filter]	IAEA Uncertainty [Bq/filter]	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Laboratory Uncertainty [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.620	0.19	7.25	3.56	0.36	0.45	1.04	0.09	0.51	**A**	7.63	**A**	**A**
^{60}Co	1.33	0.02	1.38	0.07	5.07	3.76	0.38	0.69	1.04	0.05	0.19	**A**	5.29	**A**	**A**
^{134}Cs	2.81	0.06	2.92	0.12	4.11	3.91	0.39	0.82	1.04	0.11	0.35	**A**	4.63	**A**	**A**
^{137}Cs	1.70	0.03	1.78	0.10	5.62	4.71	0.47	0.77	1.05	0.08	0.27	**A**	5.89	**A**	**A**
^{54}Mn	1.81	0.04	1.90	0.11	5.79	4.97	0.50	0.77	1.05	0.09	0.30	**A**	6.20	**A**	**A**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	-	-											**NR**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 33. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 07: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	0.0025	0.0014	MDL Should be reported
^{60}Co	0.0097	0.0058	-
^{134}Cs	<0.0028	-	-
^{137}Cs	0.0032	0.0024	-
^{54}Mn	<0.0024	-	-
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 34. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 07: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	0.885	0.005	0.56	-65.02	-6.50	-27.32	0.35	1.65	0.16	**N**	2.44	**A**	**N**
^{60}Co	1.33	0.02	1.224	0.02	1.63	-7.97	-0.80	-3.75	0.92	0.11	0.07	**N**	2.22	**A**	**W**
^{134}Cs	2.81	0.06	1.766	0.022	1.25	-37.15	-3.72	-16.34	0.63	1.04	0.16	**N**	2.47	**A**	**N**
^{137}Cs	1.70	0.03	1.459	0.020	1.37	-14.18	-1.42	-6.68	0.86	0.24	0.09	**N**	2.23	**A**	**W**
^{54}Mn	1.81	0.04	1.698	0.022	1.30	-6.19	-0.62	-2.45	0.94	0.11	0.12	**A**	2.56	**A**	**A**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	-	-											**NR**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 35. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 08: BLANK AIR FILTER

	Laboratory		
Analyte	**Value**	**Uncertainty**	
	[Bq/filter]	**[Bq/filter]**	**Comments**
^{57}Co	<	0.003	MDL Should be reported
^{60}Co	<	0.01	-
^{134}Cs	<	0.008	MDL Should be reported
^{137}Cs	<	0.009	MDL Should be reported
^{54}Mn	<	0.009	MDL Should be reported
Gross α	0.0016	0.0003	-
Gross β	0.032	0.002	-

TABLE 36. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 08: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	**Value**	**Uncertainty**	**Value**	**Uncertainty**		**R. bias**	**Z-score**	**U-score**	**Lab./IAEA**	**Trueness**			**Precision**		**Final score**
	[Bq/filter]	**[Bq/filter]**	**[Bq/filter]**	**[Bq/filter]**	**[%]**	**[%]**				A1	A2	Score	P	Score	
^{57}Co	2.530	0.060	2.560	0.060	2.34	1.19	0.12	0.35	1.01	0.03	0.22	**A**	3.33	**A**	**A**
^{60}Co	1.33	0.02	1.36	0.03	2.21	2.26	0.23	0.83	1.02	0.03	0.09	**A**	2.67	**A**	**A**
^{134}Cs	2.81	0.06	2.80	0.06	2.14	-0.36	-0.04	-0.12	1.00	0.01	0.22	**A**	3.03	**A**	**A**
^{137}Cs	1.70	0.03	1.73	0.05	2.89	1.76	0.18	0.51	1.02	0.03	0.15	**A**	3.39	**A**	**A**
^{54}Mn	1.81	0.04	1.86	0.04	2.15	2.76	0.28	0.88	1.03	0.05	0.15	**A**	3.08	**A**	**A**
Gross α	0.17	0.01	0.27	0.02	7.41	58.82			1.59						**A**
Gross β	0.29	0.01	0.35	0.020	5.71	20.69			1.21						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 37. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 09: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	/	/	NR
^{60}Co	/	/	-
^{134}Cs	/	/	NR
^{137}Cs	/	/	NR
^{54}Mn	/	/	NR
Gross α	/	/	NR
Gross β	0.32	-	High result for the Blank

TABLE 38. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 09: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	1.96	0.348	17.76	-22.53	-2.25	-1.61	0.77	0.57	0.91	**A**	17.91	**N**	**N**
^{60}Co	1.33	0.02	1.22	0.272	22.30	-8.27	-0.83	-0.40	0.92	0.11	0.70	**A**	22.35	**N**	**W**
^{134}Cs	2.81	0.06	1.71	0.322	18.83	-39.15	-3.91	-3.36	0.61	1.10	0.85	**N**	18.95	**N**	**N**
^{137}Cs	1.70	0.03	1.50	0.330	22.00	-11.76	-1.18	-0.60	0.88	0.20	0.85	**A**	22.07	**N**	**W**
^{54}Mn	1.81	0.04	1.73	0.408	23.58	-4.42	-0.44	-0.20	0.96	0.08	1.06	**A**	23.69	**N**	**W**
Gross α	0.17	0.01	0.04	0.00	10.00	-76.47			0.24						**W**
Gross β	0.29	0.01	0.18	0.02	10.00	-37.93			0.62						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 39. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 10: BLANK AIR FILTER

	Laboratory		
Analyte	**Value**	**Uncertainty**	
	[Bq/filter]	**[Bq/filter]**	**Comments**
^{57}Co	<0.003	-	-
^{60}Co	<0.003	-	-
^{134}Cs	<0.01	-	-
^{137}Cs	<0.004	0.00	-
^{54}Mn	<0.005	-	-
Gross α	0.005	0.001	-
Gross β	0.03	0.01	-

TABLE 40. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 10: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	**Value**	**Uncertainty**	**Value**	**Uncertainty**		**R. bias**	**Z-score**	**U-score**	**Lab./IAEA**	**Trueness**			**Precision**		**Final score**
	[Bq/filter]	**[Bq/filter]**	**[Bq/filter]**	**[Bq/filter]**	**[%]**	**[%]**				A1	A2	Score	P	Score	
^{57}Co	2.530	0.060	2.360	0.11	4.66	-6.72	-0.67	-1.36	0.93	0.17	0.32	**A**	5.23	**A**	**A**
^{60}Co	1.33	0.02	1.21	0.07	5.79	-9.02	-0.90	-1.65	0.91	0.12	0.19	**A**	5.98	**A**	**A**
^{134}Cs	2.81	0.06	2.59	0.12	4.63	-7.83	-0.78	-1.64	0.92	0.22	0.35	**A**	5.10	**A**	**A**
^{137}Cs	1.70	0.03	1.51	0.09	5.96	-11.18	-1.12	-2.00	0.89	0.19	0.24	**A**	6.22	**A**	**A**
^{54}Mn	1.81	0.04	1.66	0.09	5.42	-8.29	-0.83	-1.52	0.92	0.15	0.25	**A**	5.85	**A**	**A**
Gross α	0.17	0.01	0.124	0.005	4.03	-27.06			0.73						**A**
Gross β	0.29	0.01	0.35	0.007	2.00	20.69			1.21						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 41. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 11: BLANK AIR FILTER

	Laboratory		
Analyte	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Comments**
^{57}Co	-	-	NR
^{60}Co	-	-	NR
^{134}Cs	-	-	NR
^{137}Cs	-	-	NR
^{54}Mn	-	-	NR
Gross α	0.075	0.019	-
Gross β	0.203	0.081	High result for the Blank

TABLE 42. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 11: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	**Value** [Bq/filter]	**Uncertainty** [Bq/filter]	[%]	**R. bias** [%]	**Z-score**	**U-score**	**Lab./IAEA**	**Trueness** A1	A2	Score	**Precision** P	Score	**Final score**
^{57}Co	2.530	0.060	-	-											**NR**
^{60}Co	1.33	0.02	-	-											**NR**
^{134}Cs	2.81	0.06	-	-											**NR**
^{137}Cs	1.70	0.03	-	-											**NR**
^{54}Mn	1.81	0.04	-	-											**NR**
Gross α	0.17	0.01	0.194	0.044	22.68	14.12			1.14						**A**
Gross β	0.29	0.01	0.676	0.198	29.29	133.10			2.33						**W**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 43. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 12: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	<0.0074	-	-
^{60}Co	<0.015	-	-
^{134}Cs	<0.018	-	-
^{137}Cs	<0.012	-	-
^{54}Mn	<0.012	-	-
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 44. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 12: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.47	0.10	3.89	-2.37	-0.24	-0.53	0.98	0.06	0.29	**A**	4.55	**A**	**A**
^{60}Co	1.33	0.02	1.32	0.04	3.26	-0.75	-0.08	-0.21	0.99	0.01	0.12	**A**	3.59	**A**	**A**
^{134}Cs	2.81	0.06	2.75	0.07	2.58	-2.14	-0.21	-0.65	0.98	0.06	0.24	**A**	3.35	**A**	**A**
^{137}Cs	1.70	0.03	1.68	0.06	3.75	-1.18	-0.12	-0.29	0.99	0.02	0.18	**A**	4.14	**A**	**A**
^{54}Mn	1.81	0.04	1.83	0.07	3.55	1.10	0.11	0.26	1.01	0.02	0.20	**A**	4.18	**A**	**A**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	-	-											**NR**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 45. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 13: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Uncertainty [Bq/filter]	Comments
^{57}Co	<0.05	-	-
^{60}Co	<0.03	-	-
^{134}Cs	<0.18	-	-
^{137}Cs	<0.03	-	-
^{54}Mn	<0.03	-	-
Gross α	MDL	-	MDL Should be reported
Gross β	0.1035	0.0007	High result for the Blank

TABLE 46. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 13: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.20	0.10	4.55	-13.04	-1.30	-2.83	0.87	0.33	0.30	**N**	5.13	**A**	**W**
^{60}Co	1.33	0.02	1.27	0.05	3.94	-4.51	-0.45	-1.11	0.95	0.06	0.14	**A**	4.21	**A**	**A**
^{134}Cs	2.81	0.06	2.77	0.08	2.89	-1.42	-0.14	-0.40	0.99	0.04	0.26	**A**	3.59	**A**	**A**
^{137}Cs	1.70	0.03	1.72	0.08	4.65	1.18	0.12	0.23	1.01	0.02	0.22	**A**	4.97	**A**	**A**
^{54}Mn	1.81	0.04	1.68	0.05	2.98	-7.18	-0.72	-2.03	0.93	0.13	0.17	**A**	3.71	**A**	**A**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	0.387	0.004	1.03	33.55			1.34						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 47. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 15: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	-	-	NR
^{60}Co	-	-	NR
^{134}Cs	-	-	NR
^{137}Cs	-	-	NR
^{54}Mn	-	-	NR
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 48. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 15: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.74	0.03	1.09	8.30	0.83	3.13	1.08	0.21	0.17	**N**	2.61	**A**	**W**
^{60}Co	1.33	0.02	1.41	0.04	2.84	6.02	0.60	1.79	1.06	0.08	0.12	**A**	3.21	**A**	**A**
^{134}Cs	2.81	0.06	2.74	0.04	1.46	-2.49	-0.25	-0.97	0.98	0.07	0.19	**A**	2.59	**A**	**A**
^{137}Cs	1.70	0.03	1.99	0.04	2.01	17.06	1.71	5.80	1.17	0.29	0.13	**N**	2.67	**A**	**N**
^{54}Mn	1.81	0.04	2.12	0.05	2.36	17.13	1.71	4.84	1.17	0.31	0.17	**N**	3.23	**A**	**N**
Gross α	0.17	0.01	0.197	0.007	3.55	15.88			1.16						**A**
Gross β	0.29	0.01	0.448	0.010	2.23	54.48			1.54						**W**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 49. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 16: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	0.060	0.07	-
^{60}Co	0.02	0.01	-
^{134}Cs	0.02	0.01	-
^{137}Cs	0.02	0.03	-
^{54}Mn	-0.05	0.02	-
Gross α	-	-	NR
Gross β	0.022	0.003	-

TABLE 50. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 16: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.34	0.10	4.27	-7.51	-0.75	-1.63	0.92	0.19	0.30	**A**	4.89	**A**	**A**
^{60}Co	1.33	0.02	1.32	0.04	3.03	-0.75	-0.08	-0.22	0.99	0.01	0.12	**A**	3.38	**A**	**A**
^{134}Cs	2.81	0.06	2.93	0.05	1.71	4.27	0.43	1.54	1.04	0.12	0.20	**A**	2.73	**A**	**A**
^{137}Cs	1.70	0.03	1.85	0.07	3.78	8.82	0.88	1.97	1.09	0.15	0.20	**A**	4.18	**A**	**A**
^{54}Mn	1.81	0.04	1.76	0.08	4.55	-2.76	-0.28	-0.56	0.97	0.05	0.23	**A**	5.05	**A**	**A**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	0.411	0.014	3.41	41.72			1.42						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 51. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 17: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	-	-	NR
^{60}Co	-	-	NR
^{134}Cs	-	-	NR
^{137}Cs	-	-	NR
^{54}Mn	-	-	NR
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 52. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 17: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.65	0.08	3.02	4.74	0.47	1.20	1.05	0.12	0.26	**A**	3.84	**A**	**A**
^{60}Co	1.33	0.02	1.44	0.04	2.78	8.27	0.83	2.46	1.08	0.11	0.12	**A**	3.16	**A**	**A**
^{134}Cs	2.81	0.06	2.90	0.10	3.45	3.20	0.32	0.77	1.03	0.09	0.30	**A**	4.06	**A**	**A**
^{137}Cs	1.70	0.03	1.80	0.10	5.56	5.88	0.59	0.96	1.06	0.10	0.27	**A**	5.83	**A**	**A**
^{54}Mn	1.81	0.04	2.00	0.10	5.00	10.50	1.05	1.76	1.10	0.19	0.28	**A**	5.47	**A**	**A**
Gross α	0.17	0.01	0.066	0.011	16.67	-61.18			0.39						**A**
Gross β	0.29	0.01	0.279	0.017	6.09	-3.79			0.96						**A**

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TABLE 53. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 18: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	-	-	NR
^{60}Co	-	-	NR
^{134}Cs	-	-	NR
^{137}Cs	0.09	0.01	-
^{54}Mn	-	-	NR
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 54. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 18: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	1.81	0.060	3.31	-28.46	-2.85	-8.49	0.72	0.72	0.22	**N**	4.08	**A**	**N**
^{60}Co	1.33	0.02	1.33	0.04	3.01	0.00	0.00	0.00	1.00	0.00	0.12	**A**	3.36	**A**	**A**
^{134}Cs	2.81	0.06	3.75	0.68	18.13	33.45	3.35	1.38	1.33	0.94	1.76	**A**	18.26	**N**	**N**
^{137}Cs	1.70	0.03	1.73	0.05	2.89	1.76	0.18	0.51	1.02	0.03	0.15	**A**	3.39	**A**	**A**
^{54}Mn	1.81	0.04	1.48	0.04	2.70	-18.23	-1.82	-5.83	0.82	0.33	0.15	**N**	3.49	**A**	**N**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	-	-											**NR**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 55. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 19: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	0.0016	0.00017	MDL Should be reported
^{60}Co	0.019	0.003	-
^{134}Cs	0.019	0.003	-
^{137}Cs	0.017	0.002	-
^{54}Mn	0.021	0.003	-
Gross α	-	-	NR
Gross β	-	-	NR

TABLE 56. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 19: SPIKED AIR FILTER

Analyte	IAEA Value [Bq/filter]	IAEA Uncertainty [Bq/filter]	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Laboratory Uncertainty [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	2.22	0.11	4.95	-12.25	-1.23	-2.47	0.88	0.31	0.32	**A**	5.49	**A**	**A**
^{60}Co	1.33	0.02	1.10	0.06	5.45	-17.29	-1.73	-3.64	0.83	0.23	0.16	**N**	5.66	**A**	**N**
^{134}Cs	2.81	0.06	1.90	0.10	5.26	-32.38	-3.24	-7.80	0.68	0.91	0.30	**N**	5.68	**A**	**N**
^{137}Cs	1.70	0.03	1.33	0.10	7.52	-21.76	-2.18	-3.54	0.78	0.37	0.27	**N**	7.72	**A**	**N**
^{54}Mn	1.81	0.04	1.42	0.09	6.34	-21.55	-2.15	-3.96	0.78	0.39	0.25	**N**	6.71	**A**	**N**
Gross α	0.17	0.01	-	-											**NR**
Gross β	0.29	0.01	-	-											**NR**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

TABLE 57. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 20: BLANK AIR FILTER

Analyte	Laboratory Value [Bq/filter]	Laboratory Uncertainty [Bq/filter]	Comments
^{57}Co	<0.01	0.008	-
^{60}Co	<0.011	0.00	-
^{134}Cs	<0.009	0.00	-
^{137}Cs	<0.014	0.00	-
^{54}Mn	<0.011	0.00	-
Gross α	0.01	0.01	-
Gross β	0.04	0.01	-

TABLE 58. ANALYTICAL PERFORMANCE EVALUATION OF LABORATORY 20: SPIKED AIR FILTER

	IAEA		Laboratory							Acceptance criteria					
Analyte	Value [Bq/filter]	Uncertainty [Bq/filter]	Value [Bq/filter]	Uncertainty [Bq/filter]	[%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{57}Co	2.530	0.060	3.13	0.09	2.88	23.72	2.37	5.55	1.24	0.60	0.28	**N**	3.73	**A**	**N**
^{60}Co	1.33	0.02	1.62	0.04	2.47	21.80	2.18	6.48	1.22	0.29	0.12	**N**	2.89	**A**	**N**
^{134}Cs	2.81	0.06	3.32	0.09	2.71	18.15	1.81	4.71	1.18	0.51	0.28	**N**	3.45	**A**	**N**
^{137}Cs	1.70	0.03	2.07	0.06	2.90	21.76	2.18	5.52	1.22	0.37	0.17	**N**	3.39	**A**	**N**
^{54}Mn	1.81	0.04	2.22	0.06	2.70	22.65	2.27	5.69	1.23	0.41	0.19	**N**	3.49	**A**	**N**
Gross α	0.17	0.01	0.10	0.02	20.00	-41.18			0.59						**A**
Gross β	0.29	0.01	0.37	0.03	8.11	27.59			1.28						**A**

A: Acceptable, W: Warning, N: Not Acceptable, NR: Not reported

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