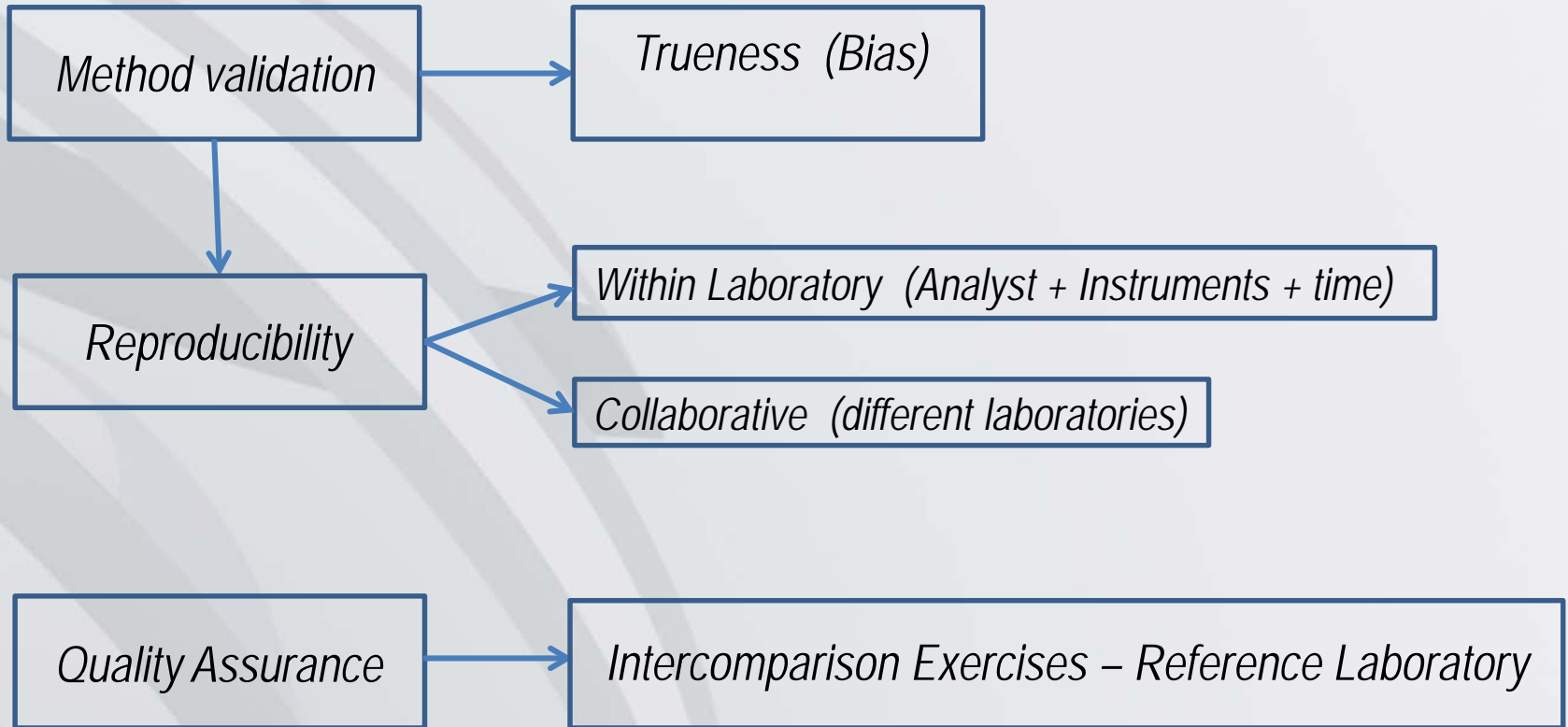


*THE ROLE OF INTERCOMPARISON
EXERCISES IN THE CORRECTION
FOR BIAS OF TRITIUM
DETERMINATION IN ENVIRONMENTAL
WATER SAMPLES*

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METHOD VALIDATION / QUALITY ASSURANCE (QA)



INTERCOMPARISON EXERCISES

Nuclide H-3 Year	NIST Value (Bq/l)	% U_E (K=2)	ARN Value (Bq/l)	% U_E (K=2)	Difference %
2006	17150	1,16	15700	2,55	-8,5
2007	4306	0,75	4330	3,0	+0,6
2008	15320	1,16	15400	9,1	+0,5
2009	10170	1,2	10270	10,3	+1,0
A11-01	6297	1,7	6385	5,2	+1,4
A11-02	30800	1,7	31209	5,2	+1,3
A11-03	48740	1,7	49389	5,2	+1,3
PW1	98,5	1,46	102,0	8,9	+3,5
PW2	171,9	1,46	177	7,3	+3,0
PW3	244,3	1,46	253	5,5	+3,6

NIST: 2006-2009

NIST: 2011

NIST: 2014



INTERCOMPARISON EXERCISES

NIST: 2014

Nuclide H-3	NIST Value (Bq/l)	% U_E (K=2)	ARN Value (Bq/l)	% U_E (K=2)	Difference %
PW4	320,1	1,46	327	5,0	+2,2
PW5	392,6	1,46	402	3,6	+2,4

Criterion ANSI 42.22 to claim traceability to standard 4926E:

$$|V_{ref} - V_{lab}| < 3 \times \sqrt{u_{Ref}^2 + u_{Lab}^2}$$

V_{ref} : Assigned reference value

V_{lab} : Laboratory value

u_{Ref} : standard uncertainty of the assigned value

u_{Lab} : standard uncertainty of the laboratory



INTERCOMPARISON EXERCISES

Another criterion to assess proficiency include both, precision and bias

I.A.E.A

BIAS EVALUATION

$$A1 = |Value_{IAEA} - Value_{Lab}| \qquad A2 = 2.58 \times \sqrt{u_{IAEA}^2 + u_{Lab}^2}$$

Participant is scored "Acceptable" If $A1 \leq A2$

PRECISION EVALUATION: estimator P is calculated

$$P \leq \sqrt{\left(\frac{u_{IAEA}}{Value_{IAEA}}\right)^2 + \left(\frac{u_{Lab}}{Value_{Lab}}\right)^2} \times 100$$



INTERCOMPARISON EXERCISES

P directly depends on the measurement uncertainty claimed by the participant

There is an Acceptance Limit (LAP) defined by IAEA in advance and participants are scored "Acceptable" for Precision

If $P \leq LAP$

In case of both, bias and precision are scored "Not Acceptable" the final result is " Not Acceptable "

If only bias is scored "Not Acceptable " then the relative bias R_B obtained is compared to a Maximum Acceptable Bias (MAB) also defined in advance.



INTERCOMPARISON EXERCISES

$$R_B \leq \frac{||Value_{IAEA} - Value_{Lab} ||}{Value_{IAEA}}$$

Bias is scored "Acceptable " if $R_B \leq MAB$

*If either Precision or Bias is the only accepted value
the result is scored "Warning"*

What does "Warning" reflect?

- 1) Situation: Biased result with small uncertainty, however still within MAB*
- 2) Situation: Result close to the Assigned value but associated to a large uncertainty*



EXPERIMENTAL

Working solutions range: 12 to 80 Bq/L
100 to 400 Bq/l
9700 to 37000 Bq/l

Reproducibility within laboratory conditions

3 Analysts (3 replicates each analyst for each concentration level)

2 Liquid Scintillation Counters

2 Measurement modes: Optimized region and Non optimized region (Full Spectrum)

6 Months (approximately)

Standards were prepared by weighing aliquots of original CRM sent from the NIST for the previous exercises.

Uncertainties of weights were negligible so the final concentration of the standards is assumed to keep the original percentage of uncertainty than the CRM's



EXPERIMENTAL DATA

TR2550 + TR3180										
(12,06 +/- 0,09) Bq/l		(18,00 +/- 0,13) Bq/l		(25,04 +/- 0,18) Bq/l		(39,99 +/- 0,29) Bq/l		(79,97 +/- 0,58) Bq/l		
Full spectrum	Optimized	Full Spectrum	Optimized	Full Spectrum	Optimized	Full Spectrum	Optimized	Full Spectrum	Optimized	
17,00	17,20	16,20	17,00	25,40	25,2	42,50	44,30	82,50	82,00	
14,20	14,80	18,40	17,70	28,00	29,6	46,50	44,40	84,60	85,20	
13,30	13,50	19,40	19,50	23,60	23,1	39,00	38,70	87,20	86,10	
13,50	12,70	18,30	17,60	26,50	25,6	46,20	44,50	77,60	78,10	
11,90	11,10	18,50	19,20	23,00	22,9	44,60	41,90	82,30	81,70	
12,70	13,60	17,80	17,20	25,90	25,1	44,90	42,20	75,60	75,30	
10,68	7,72	23,45	15,47	27,59	18,93	43,41	34,55	84,13	70,71	
10,41	5,74	17,07	18,33	26,69	23,69	34,88	32,91	84,79	78,81	
10,14	16,07	24,01	16,15	30,25	20,2	41,49	31,37	82,50	76,06	
14,02	9,86	27,49	16,12	32,06	17,29	41,1	35,16	87,08	77,29	
19,43	7,14	22,97	12,46	25,3	15,62	46,53	30,84	86,93	71,10	
20,7	10,16	22,56	17,67	27,06	20,56	48,48	34,26	87,35	74,27	
11,85	9,92	15,15	13,06	23,17	21,62	37,28	36,62	74,39	69,46	
19,29	15,33	21,37	20,48	29,97	28,49	41,06	42,09	79,23	74,56	
15,82	15,58	22,34	20,48	28,19	27,95	34,92	33,46	84,54	77,51	
13,8	13,9	14,8	15,9	22,2	24,5	36,2	36,2	78,6	80	
11,8	12,9	13,5	14,7	21,9	23,8	39,6	40,9	74,5	75,8	
9,4	8,8	18,2	18,7	23,4	24,5	38	39,9	81	79,7	
Average	13,9	12,0	19,5	17,1	26,1	23,3	41,5	38,0	81,9	77,4
Stnd.Deviat.	3,35	3,34	3,72	2,27	2,92	3,74	4,22	4,64	4,38	4,63

$$\%S_R = \frac{Sr}{\sqrt{18}} \times \frac{100}{Avg}$$

$$\overline{\%S_R} = \sqrt{\frac{\sum \%S_R^2}{5}}$$

Full Spectrum = **3,75%**
Optm. Spectrum = **4,05%**



EXPERIMENTAL DATA

TR2550AB + TR3180SL								
(163,5 +/- 1,2) Bq/l		(228,5 +/- 1,7) Bq/l		(298,9 +/- 2,2)Bq/l		(366,6 +/- 2,7)Bq/l		
Full Spectrum	Optimized	Full Spectrum	Optimized	Full Spectrum	Optimized	Full Spectrum	Optimized	
167,97	159,04	247,75	232,70	312,43	292,42	389,96	366,0	
173,62	163,47	236,96	222,08	300,0	282,48	386,31	364,38	
160,46	153,11	235,89	221,7	310,97	293,76	378,9	356,62	
166,9	165,1	225,4	222,4	304,4	303,2	363,4	360,1	
165,8	165,9	233,7	230,6	297,1	295,6	372,4	373,7	
170,5	168,5	219,4	221,3	299,9	296,5	369,4	367	
164,5	158,7	240,3	235,6	311,6	306,5	377,2	374,8	
167	166,6	237,9	231,4	310,8	304,6	366,7	361,2	
173,4	172,3	235,1	235,6	311,6	310,8	373,2	369,8	
160,6	159,7	229,6	228,70	300,1	299,3	365,1	365,9	
160,2	161,8	228,5	226,7	298,0	298	367,3	365,8	
161,2	161,4	227,2	228,2	298,5	299,7	365,0	367,3	
160	158,5	222,6	221,4	298,3	297,7	377,3	373,4	
159,5	159,1	230	228,9	296,6	297,8	376,2	376,6	
159	159,3	220,8	221,6	294,1	295	371,7	372,5	
160	161,3	229,3	226,9	295	295,5	361,5	367,4	
159,9	160,9	231,5	233,1	295,6	295,6	369	371	
161,1	159	229	229,7	299,5	300,5	375,1	375,7	
Average	164,0	161,9	231,2	227,7	301,9	298,1	372,5	368,3
Std. Deviat.	4,90	4,47	7,15	4,99	6,52	6,12	7,67	5,63

$$\%S_R = \frac{Sr}{\sqrt{18}} \times \frac{100}{Avg}$$

$$\overline{\%S_R} = \sqrt{\frac{\sum \%S_R^2}{4}}$$

Full Spectrum = **0,62%**
Optm. Spectrum = **0,51%**



EXPERIMENTAL DATA

TR2550AB + TR3180SL						
(9735 +/- 88) Bq/l		(19743 +/- 168) Bq/l		(37929+/-322)Bq/l		
Full Spectrum	Optimized	Full Spectrum	Optimized	Full Spectrum	Optimized	
9555,30	9484,2	19574,7	19429,00	37665	37413,6	
9733,6	9663,3	19754,9	19664,5	37761,6	37739,1	
9664,9	9595,9	19570,1	19481,8	37162,9	37016,3	
9649,8	9616,31	19721,5	19634,36	37678,9	37569,75	
9464,4	9438,62	19397,3	19353,87	37234,8	37123,03	
9432,5	9283,8	19241,7	19008,9	36655,3	36180,6	
9337,2	9177,9	19135,5	18873,8	36784,9	36299,3	
9646,8	9559,5	19391,8	19328,5	37306,9	37096	
9621,4	9484,2	19343,8	19429	37340,6	37413,6	
9899,50	9698,7	20207	19944,30	38558	38259,9	
9664,2	9734	19877,2	19890,9	38067,6	37995,3	
9812,4	9649,9	20148,6	19647,2	38354,5	37897,9	
9708,3	9861,5	19786,7	20086,7	38115,4	38356,7	
9715,5	9635,9	19989,9	19779,4	38256,8	37859,8	
9812,4	9789,7	20207	20049,8	38558	38326,5	
97,15,5	9679,3	19877,2	19934,3	38067,6	38156,7	
9708,3	9649,9	19786,7	19647,2	38115,4	37897,9	
9657	9595,1	19725,2	19617,6	37977,6	37715,4	
Average	9652,0	9588,8	19707,6	19600,1	37759,0	37573,2
Std.Deviat	142,06	167,91	321,31	332,54	572,06	635,51

$$\%S_R = \frac{Sr}{\sqrt{18}} \times \frac{100}{Avg}$$

$$\overline{\%S_R} = \sqrt{\frac{\sum \%S_R^2}{3}}$$

Full Spectrum = **0,36%**
 Optm. Spectrum = **0,40%**



TREATMENT OF DATA

NORDTEST TR 537 – ed 3.1

5.0 Method and Laboratory bias

5.2 Interlaboratory comparisons

All bias can be used to obtain the RMS_{Bias} :

$$\%RMS_{Bias} = \sqrt{\frac{\sum(\%Bias)^2}{N}}$$

The uncertainty percent of CRM's is obtained from the average of the uncertainty percent of the CRM's assayed in the intercomparison exercises

$$\%u_{CRM} = \frac{\sum \%u_{CRM}}{N}$$

$$N = 12$$

$$\%u_{Bias} = \sqrt{\%RMS_{bias}^2 + \%u_{(CRM)}^2}$$



TREATMENT OF DATA

From the data obtained of 12 test samples (CRM) and their corresponding Bias

$$\overline{\%u(CRM)} = 0.69 \quad (k=1)$$

$$\%RMS_{Bias} = 1,6$$

$$\%U_{bias} = \sqrt{1,6^2 + 0,69^2} = 1,74 \% \quad (k=1)$$

The sample uncertainty corrected by bias is:

$$\%U_{sample\ corrected} = \sqrt{\%u_{sample}^2 + \%u_{Bias}^2} \quad (k=1)$$



Mean Bias and mean %Reproducibility Standard Deviation

Concentration Range (12,06 +/- 0,09) – (79,97 +/- 0,58) Bq/L

Full spectrum

$$\overline{Bias} = +1,61 \text{ Bq/l}$$

Optimized spectrum

$$\overline{Bias} = - 1,56 \text{ Bq/l}$$

Concentration Range (163,5 +/- 1,2) – (366,6 +/- 0,6) Bq/L

$$\overline{Bias} = +3,02 \text{ Bq/L}$$

$$\overline{Bias} = +0,03 \text{ Bq/l}$$



Mean Bias and mean %Reproducibility Standard Deviation

Concentration Range (12,06 +/- 0,09) – (79,97 +/- 0,58) Bq/L

Full spectrum

$$\overline{Bias} = +1,61 \text{ Bq/l}$$

$$\overline{\%S_R} = \sqrt{\frac{5,68^2 + 4,87^2 + 2,65^2 + 2,4^2 + 1,26^2}{5}} = 3,75\%$$

Optimized spectrum

$$\overline{Bias} = - 1,56 \text{ Bq/l}$$

$$\overline{\%S_R} = \sqrt{\frac{6,58^2 + 3,13^2 + 3,78^2 + 2,88^2 + 2,57^2}{5}} = 4,05\%$$



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (12,06 +/- 0,09)Bq/L

Full spectrum

$$[Bq/l]_{Bias\ corrected} = 13,9 - 1,6 = 12,3\ Bq/l$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 3,75^2} = 4,14\% \quad (K=1)$$

$$u_{corrected} = \frac{4,14 \times 12,3}{100} = 0.5\ Bq/l$$



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (12,06 +/- 0,09) Bq/L

Optimized spectrum

$$[\text{Bq/l}]_{\text{Bias corrected}} = 12,0 + 1,56 = 13,56 \text{ Bq/l}$$

$$\%u_{\text{corrected}} = \sqrt{\%u_{\text{Bias}}^2 + \%Sr^2} = \sqrt{1,76^2 + 4,05^2} = 4,41\% (K=1)$$

$$u_{\text{corrected}} = \frac{4,41 \times 13,56}{100} = 0,60 \text{ Bq/l}$$



Application of criteria for acceptance of results

NIST

Full spectrum

$$|12,3 - 12,06| = 0,24$$

$$3 \times \sqrt{0,09^2 + 0,5^2} = 1,52$$

Optimized spectrum

$$|13,56 - 12,06| = 1,50$$

$$3 \times \sqrt{0,09^2 + 0,6^2} = 1,82$$

According ANSI 42.22 traceability is claimed in both measurement modes



Application of criteria for acceptance of results

IAEA

Full spectrum

$$|12,3 - 12,06| = 0,24$$

$$2,58 \times \sqrt{0,09^2 + 0,5^2} = 1,31$$

Optimized spectrum

$$|13,56 - 12,06| = 1,50$$

$$2,58 \times \sqrt{0,09^2 + 0,6^2} = 1,56$$

Laboratory scored: "Acceptable"

Estimator P: depends on the Limit of acceptability (LAP) set in advance



Application of criteria for acceptance of results

ISO 17043

$$\text{Estimator zeta } (\zeta) = \frac{|V_{Ref} - V_{Lab}|}{\sqrt{u_{Ref}^2 + u_{Lab}^2}}$$

$(\zeta) < 2$ Acceptable

$2 > (\zeta) < 3$ Questionable

$(\zeta) > 3$ Not Acceptable

Full spectrum

$$\frac{|12,3 - 12,06|}{\sqrt{0,09^2 + 0,5^2}} = 0,47$$

Optimized spectrum

$$\frac{|13,56 - 12,06|}{\sqrt{0,09^2 + 0,6^2}} = 2,47$$



Application of criteria for acceptance of results

ISO 13528

$$\frac{|V_{Ref} - V_{Lab}|}{\sqrt{U_{Exp(Ref)}^2 + U_{(ExpLab)}^2}} < 1$$

Full spectrum

$$\frac{|12,3 - 12,06|}{\sqrt{0,18^2 + 1,0^2}} = 0,24$$

Acceptable

Optimized spectrum

$$\frac{|13,56 - 12,06|}{\sqrt{0,18^2 + 1,2^2}} = 1,24$$

Not Acceptable



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (79,97 \pm 0,58) Bq/L

Full spectrum

$$[Bq/l]_{Bias\ corrected} = 81,9 - 1,6 = 80,3\text{ Bq/l}$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 3,32^2} = 3,76\% (K=1)$$

$$u_{corrected} = \frac{3,76 \times 80,93}{100} = 3,04\text{ Bq/l}$$



Reported sample value and corrected uncertainty (Effect on the lower and upper limits of the range)

Concentration (79,97 \pm 0,58) Bq/L

Optimized spectrum

$$[Bq/l]_{Bias\ corrected} = 77,4 + 1,56 = 78,96\text{ Bq/l}$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 4,05^2} = 4,41\% (K=1)$$

$$u_{corrected} = \frac{4,41 \times 78,96}{100} = 3,48\text{ Bq/l}$$



Application of criteria for acceptance of results

NIST

Full spectrum

$$|80,3 - 79,97| = 0,33$$

$$3 \times \sqrt{3,32^2 + 0,58^2} = 10,11$$

Optimized spectrum

$$|78,96 - 79,97| = 1,01$$

$$3 \times \sqrt{3,48^2 + 0,58^2} = 10,58$$

According ANSI 42.22 traceability is claimed in both measurement modes



Application of criteria for acceptance of results

IAEA

Full spectrum

$$|80,3 - 79,97| = 0,33$$

$$2,58 \times \sqrt{3,32^2 + 0,5^2} = 8,66$$

Optimized spectrum

$$|78,96 - 79,97| = 1,01$$

$$2,58 \times \sqrt{3,48^2 + 0,6^2} = 9,11$$

Laboratory scored: "Acceptable"



Application of criteria for acceptance of results

ISO 17043

$$\text{Estimator zeta } (\zeta) = \frac{|V_{Ref} - V_{Lab}|}{\sqrt{u_{Ref}^2 + u_{Lab}^2}}$$

Full spectrum

Optimized spectrum

$$\frac{|80,3 - 79,97|}{\sqrt{3,32^2 + 0,5^2}} = 0,23$$

$$\frac{|78,96 - 79,97|}{\sqrt{3,48^2 + 0,6^2}} = 0,29$$

Acceptable

Acceptable



Application of criteria for acceptance of results

ISO 13528

$$\frac{|V_{Ref} - V_{Lab}|}{\sqrt{U_{Exp(Ref)}^2 + U_{(ExpLab)}^2}} < 1$$

Full spectrum

$$\frac{|80,3 - 79,97|}{\sqrt{3,32^2 + 1,0^2}} = 0,1$$

Acceptable

Optimized spectrum

$$\frac{|79,97 - 78,96|}{\sqrt{3,48^2 + 1,2^2}} = 0,3$$

Acceptable



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (163,5 +/- 1,2) Bq/L

Full spectrum

$$[Bq/l]_{Bias\ corrected} = 164 - 3,02 \quad \boxed{161,0 Bq/l}$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 0,62^2} = 1,87\% \quad (K=1)$$

$$u_{corrected} = \frac{1,87 \times 161}{100} \quad \boxed{= 3,0 Bq/l}$$



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (163,5 +/- 1,2) Bq/L

Optimized spectrum

$$[Bq/l]_{Bias\ corrected} = 161,9 - 0,03 = 162 \text{ Bq/l}$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 0,62^2} = 1,87\% \quad (K=1)$$

$$u_{corrected} = \frac{1,87 \times 161,9}{100} = 3,0 \text{ Bq/l}$$



Application of criteria for acceptance of results

NIST

Full spectrum

$$|163,5 - 161| = 2,5$$

$$3 \times \sqrt{1,2^2 + 3,0^2} = 9,7$$

IAEA

$$|163,5 - 161| = 2,5$$

$$2,58 \times \sqrt{1,2^2 + 3,0^2} = 8,33$$

Optimized spectrum

$$|164 - 163,5| = 0,5$$

$$3 \times \sqrt{1,2^2 + 3,0^2} = 9,7$$

$$|164 - 163,5| = 0,5$$

$$2,58 \times \sqrt{1,2^2 + 3,0^2} = 8,33$$



Application of criteria for acceptance of results

ISO 17043

$$\text{Estimator zeta } (\zeta) \leq \frac{|V_{Ref} - V_{Lab}|}{\sqrt{u_{Ref}^2 + u_{Lab}^2}}$$

Full spectrum

$$\frac{|163,5 - 161|}{\sqrt{1,2^2 + 3,0^2}} = 0,73$$

Optimized spectrum

$$\frac{|165,3 - 162|}{\sqrt{1,2^2 + 3,0^2}} = 1,02$$

$(\zeta) < 2$ Acceptable

ISO 13528

$$\frac{|163,5 - 161|}{\sqrt{2,4^2 + 6,0^2}} = 0,39$$

$$\frac{|163,5 - 162|}{\sqrt{2,4^2 + 6,0^2}} = 0,23$$

$$\frac{|V_{Ref} - V_{Lab}|}{\sqrt{U_{Exp(Ref)}^2 + U_{(ExpLab)}^2}} < 1$$



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (366,6 +/- 2,7) Bq/L

Full spectrum

$$[Bq/l]_{Bias\ corrected} = 372,5 - 3,02 = \boxed{369,5 Bq/l}$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 0,51^2} = 1,83 \% \quad (K=1)$$

$$u_{corrected} = \frac{1,83 \times 372,5}{100} = \boxed{6,8 Bq/l}$$



Reported sample value and corrected uncertainty

(Effect on the lower and upper limits of the range)

Concentration (366,6 +/- 2,7) Bq/L

Optimized spectrum

$$[Bq/l]_{Bias\ corrected} = 368,3 - 0,03 = \boxed{368,3\ Bq/l}$$

$$\%u_{corrected} = \sqrt{\%u_{Bias}^2 + \%Sr^2} = \sqrt{1,76^2 + 0,51^2} = 1,83\ \% \quad (K=1)$$

$$u_{corrected} = \frac{1,83 \times 368,3}{100} = \boxed{6,7\ Bq/l}$$



Application of criteria for acceptance of results

NIST

Full spectrum

$$|369.5 - 366,6| = 2,9$$

$$3 \times \sqrt{2,7^2 + 6,9^2} = 22$$

IAEA

$$|369,5 - 366,6| = 2,9$$

$$2,58 \times \sqrt{2,7^2 + 6,9^2} = 19$$

Optimized spectrum

$$|368,3 - 366,6| = 1,7$$

$$3 \times \sqrt{2,7^2 + 6,7^2} = 21,7$$

$$|368,3 - 366,6| = 1,7$$

$$2,58 \times \sqrt{2,7^2 + 6,7^2} = 18,6$$



Application of criteria for acceptance of results

ISO 17043

$$\text{Estimator zeta } (\zeta) \leq \frac{|V_{Ref} - V_{Lab}|}{\sqrt{u_{Ref}^2 + u_{Lab}^2}}$$

Full spectrum

$$\frac{|369,5 - 366,6|}{\sqrt{2,7^2 + 6,8^2}} = 0,40$$

Optimized spectrum

$$\frac{|368,3 - 366,6|}{\sqrt{2,7^2 + 6,7^2}} = 0,24$$

$(\zeta) < 2$ Acceptable

ISO 13528

$$\frac{|369,5 - 366,6|}{\sqrt{5,4^2 + 13,6^2}} = 0,20$$

$$\frac{|368,7 - 366,6|}{\sqrt{5,4^2 + 13,4^2}} = 0,14$$

$$\frac{|V_{Ref} - V_{Lab}|}{\sqrt{U_{Exp(Ref)}^2 + U_{(ExpLab)}^2}} < 1$$



Conclusion

Traceability to a reference standard in a range of concentrations from almost the quantification limit of a method, is enough to prove, that the laboratory bias is in control, if the laboratory Standard combined uncertainty is reasonably large to comply with the acceptance criteria of ANSI 42.22

An evaluation of the Inter laboratories Reproducibility (S_R) is a valuable tool which could be used by a laboratory (having performed satisfactorily in the comparisons) as the standard uncertainty of the analysed parameter, provided that uncertainty covers all relevant components and steps.

The application of the NORDTEST method provided us the chance of including both, the bias uncertainty as well as the Reproducibility “within laboratory” as the final standard combined uncertainty by application of the results of intercomparison participation with only one laboratory.

However, measurements of low activities such as shown, should be carried on in the Full Spectrum mode due to the results in Optimized mode are close to the traceability Limit and failed to pass ISO 17043 and ISO 13528 acceptance tests.



Thank you very much for your attention

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