BUREAU INTERNATIONAL DES POIDS ET MESURES

International comparison of activity measurements of a solution of ^{3}H (January 2009)

Participating laboratory:

$T_{½}$ = (4 496.862 d; u = 9.131 d)*

Ampoule number _ _ _ _ _ _

Mass of solution, according to distributing laboratory _ _ _ _ _ g

Name(s) of the person(s) who carried out the measurements:

Date:

Please send the filled-in form and any additional information to the BIPM
not later than ***May 31, 2009.***

* M.M. Bé et al., ***Monographie BIPM-5***, Table of radionuclides, **Vol. 3**, 2006, 210 pp, p. 1

A. **Preliminary measurements**

A.1. Method used for preliminary measurements

- calibrated ionization chamber	YES □	NO □
- well crystal	YES □	NO □
- other method	YES □	NO □

A.2. Results obtained

Radioactivity concentration, in kBq g^{-1} (2009-05-31, 0 h UTC)

- before opening the original ampoule _ _ _ _ _
  date of this measurement _ _ _ _ _

- after transfer to another ampoule _ _ _ _ _
  date of this measurement _ _ _ _ _

Total mass of solution found in the ampoule_ _ _ _ _ g

A.3. Adsorption tests

Please take into account the adsorption tests in the evaluation of the final results.

A.3.1. *Adsorption tests carried out with liquid-scintillation counting*

- Count-rate after two rinsings: _ _ _ _ _ _ _ _ _ _ _ _ s^{-1}

(converted to activity by applying the measured detection efficiency).

Thus, activity remaining in the “empty” original ampoule :_ _ _ _ _ _ _ _ _ _ _ _ Bq.

Date of this test: _ _ _ _ _ _ _ _ _ _ _.

Number of additional rinsings _ _ _ _ _ _ _ _ _ _ _ _ _

Final residual count-rate: _ _ _ _ _ _ _ _ _ _ _ _ _

Thus, final residual activity: _ _ _ _ _ _ _ _ _ _ _ _ _

Date of final test measurements: _ _ _ _ _ _ _ _ _ _ _ _ _.

Please explain the measuring procedure used:

A.3.2. *Adsorption tests carried out with proportional counting*

Please rinse the ampoule with an aggressive solution to remove most of the activity and prepare solid source(s) to measure this residual activity.

Activity remaining in the “empty” original _ _ _ _ _ Bq.
Date of this test _ _ _ _ _.

A.4. Impurity checks* :
Method of measurement _,
Nuclide _ _ _ _ _ _ _ _ ,
Impurity to ^{3}H ratio _ _ _ _ _ _ _ _ _ _ _ and its uncertainty _ _ _ _ _ _ _ _ _ _ _
at reference date (2009-05-31, 0 h UTC).

Please note that any impurity determination is considered to be an important part of the comparison.

* Please give this information for each impurity found.

B. Source preparation

B.1. Methods used for source preparation:

Possible remarks about drying, precipitation, foils used (gold-coated or not, number, etc.), type of balance used…

B.2. Solutions, sources

B.2.1. *For photon counting and electron counting (if relevant)*

Diluent:

	dilution number		
	1	2	3 ...
- dilution factor	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
possible remarks	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
- number of sources prepared	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _
- disposed mass of solution (approx.)	_ _ _ _ _	_ _ _ _ _	_ _ _ _ _

B.2.2. *For liquid-scintillation counting*

Diluent	_ _ _ _ _	
Dilution factor	_ _ _ _ _	
Scintillator used to prepare the sources	_ _ _ _ _	
Volume of scintillator used	_ _ _ _ _	cm^3
Chemicals used to stabilize the solution	_ _ _ _ _	
Substances used as quenching agent	_ _ _ _ _	
Type of vials used	_ _ _ _ _	

C. Procedures used for the activity measurements

Method of measurement used

(e.g. efficiency tracing method with a pressurized proportional counter, efficiency tracing method with a liquid-scintillation spectrometer, CIEMAT/NIST or TDCR method or by means of any other experimental devices)

Please list the values for all the decay-scheme parameters (branching ratios, transition intensities, internal conversion coefficients, etc.) relevant to your measurements.

In case you used more than one method, please assemble the relevant information on separate sheets.

D. Detectors, counting equipment

D.1. Photon counting

D.1.1. *Scintillator detector*

Crystal material	_ _ _ _ _ _ _ _ _	Solid angle	_ _ _ _ _ sr
Number of crystals	_ _ _ _ _ _ _ _ _	Well type YES ☐	NO ☐
Crystal diameter	_ _ _ _ _ mm	Crystal height	_ _ _ _ _ mm
Well diameter	_ _ _ _ _ mm	Well depth	_ _ _ _ _ mm
Window material	_ _ _ _ _ _	Thickness	_ _ _ _ _ mm
Distance between photon counter and source			_ _ _ _ _ mm
Resolution at	_ _ _ _ _ keV,	FWHM* _ _ _ _ _ %,	_ _ _ _ _ keV

Please add a typical pulse-height spectrum.

D.1.2. *Semiconductor detector*

Nature	_ _ _ _ _ _ _ _ _	Solid angle	_ _ _ _ _ sr
Number of detectors	_ _ _ _ _ _ _ _ _	Well type YES ☐	NO ☐
Type	_ _ _ _ _ _ _ _ _	Coaxial ☐	Planar ☐
Diameter	_ _ _ _ _ mm	Volume	_ _ _ _ _ cm^3
Window material	_ _ _ _ _	Window thickness	_ _ _ _ _ mm
Distance between photon counter and source			_ _ _ _ _ mm
Resolution at	_ _ _ _ _ keV,	FWHM* _ _ _ _ _ %,	_ _ _ _ _ keV

Please add a typical pulse-height spectrum and an efficiency curve.

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* full width at half maximum

Radionuclides used for an efficiency determination (if relevant)

	P_{γ} (%)
_ _	_ _ _ _ _
_ _	_ _ _ _ _
_ _	_ _ _ _ _
_ _	_ _ _ _ _
_ _	_ _ _ _ _
_ _	_ _ _ _ _

D.1.3. *Other detectors used*

D.2. Photon and/or electron counting

D.2.1. *Proportional counter* _ _ _ _ _

Solid angle _ _ _ _ _ sr

Wall material _ _ _ _ _ Height of each half _ _ _ _ _ mm

Anode

Nature _ _ _ _ _

Wire diameter _ _ _ _ _ mm Wire length _ _ _ _ _ mm

Distance from source _ _ _ _ _ mm

Voltage applied _ _ _ _ _ kV

Gas

Nature _ _ _ _ _

Pressure

(above atmospheric pressure) _ _ _ _ _ MPa

Remarks

D.2.2. *Liquid-scintillation equipment*

D.2.2.1. *CIEMAT/NIST method*

D.2.2.1.1. *Characterization of the liquid-scintillation counter (LSC)*

Type of the counter _ _ _ _ _

Age _ _ _ _ _

Quench parameter _ _ _ _ _

Nuclide used as external standard _ _ _ _ _

Efficiency obtained with an unquenched standard of ^{3}H _ _ _ _ _

Background (unquenched standard in toluene scintillator,
0 to 2000 or more keV) _ _ _ _ _

Options used (e.g. low-level counting) _ _ _ _ _

D.2.2.1.2. *Characterization of the tracer* (e. g. ^{54}Mn)

Standard used and its origin _ _ _ _ _

Uncertainty on the standard _ _ _ _ _

Date of preparation of the tracer samples _ _ _ _ _

Chemical composition of the tracer samples _ _ _ _ _

D.2.2.2. *TDCR method*

D.2.2.2.1. *Characteristics of the experimental equipment*

Type of phototubes _ _ _ _ _

Operating temperature _ _ _ _ _

Coincidence resolving time _ _ _ _ _

Type of dead time extending □ non-extending □

Minimum dead-time length _ _ _ _ _ μs

Efficiency variation method:

- defocusing _ _ _ _ _
- grey filters _ _ _ _ _
- chemical quenching _ _ _ _ _
- other ones (please describe) _ _ _ _ _

External standard (^{3}H or other) used
for the determination of the figure of merit _ _ _ _ _

D.2.2.3. *Other method(s)*

(For other detector or additional channels, please give information on appropriate sheets.)

D.4. Parameters of counting equipment

(Give a brief description, e.g. in the form of a block diagram.)

D.4.1. *Photon counting*

a) Discrimination level _ _ _ _ _ keV
(or window)

b) Dead times and their uncertainties (standard deviation)

Dead time τ_1 = _ _ _ _ _ _ µs; u = _ _ _ _ _ _ µs

Type of dead time extending □ non-extending □

Method used for measurement _

D.3.2. *Electron counting*

a) Discrimination level _ _ _ _ _ keV
(or window)

b) Dead times and their uncertainties (standard deviation)

Dead time τ_2 = _ _ _ _ _ _ µs; u = _ _ _ _ _ _ µs

Type of dead time extending □ non-extending □

Method used for measurement _

D.4.3. *Coincidence unit (if relevant)*

Coincidence resolving time τ_R = _ _ _ _ _ _ µs; u = _ _ _ _ _ _ µs

Method used for measurement _

_ _

_ _

_ _

D.4.4. *Other modules used*
(for LSC see section D.2.2.)

E. Relevant data, corrections and uncertainties

E.1. Date of measurement of ^{3}H

(Mean date on which your measurements were carried out)

E.2. Measuring data

E.2.1. *Photons*

Dead time	_ _ _ _ _	μs	Number of sources measured	_ _ _ _ _	
Background rate	_ _ _ _ _	s^{-1}	Typical count rate	_ _ _ _ _	s^{-1}
Typical time for one measurement			_ _ _ _ _ s		
Discrimination threshold or window			_ _ _ _ _ keV		

E.2.2. *Electrons*

Dead time	_ _ _ _ _	μs	Number of sources measured	_ _ _ _ _	
Background rate	_ _ _ _ _	s^{-1}	Typical count rate	_ _ _ _ _	s^{-1}
Typical time for one measurement			_ _ _ _ _ s		
Discrimination threshold or window			_ _ _ _ _ keV		

E.2.3. *Extrapolation of efficiency function*

Maximum achieved efficiency _ _ _ _ _ %

Method used for varying the efficiency

Number of degrees of freedom _ _ _ _ _

Please add a figure, if possible.

E.2.4. *Liquid-scintillation parameters*

Numerical codes used _ _ _ _ _

kB value _ _ _ _ _ unit _ _ _ _ _

Formula used to calculate the ionization quenching correction factor $Q(E)$ _ _ _ _ _

_ _

_ _

Are M, N, ... captures taken into account? _ _ _ _ _

Are M, N, ... x-ray and Auger electrons taken into account? _ _ _ _ _

Model used to evaluate the interaction probability of
the photons with the scintillator _ _ _ _ _

Values used for cross section of interaction _ _ _ _ _

E.2.5. *Calculated data for the liquid-scintillation method*

Total efficiency ^{3}H _ _ _ _ _

E.2.6. *Corrections applied*

E.2.7 *Uncertainty components**, in % of the activity concentration, due to

		Sensitivity factors	Type A or B method	Remarks
counting statistics	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _	_ _ _ _ _
weighing	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _	_ _ _ _ _
dead time	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _	_ _ _ _ _
background	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
pile-up	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
counting time	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
adsorption	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
impurities	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
tracer	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
input parameters and statistical model	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _
quenching	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _
interpolation from calibration curve	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _
decay-scheme parameters	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
half life ($T_{1/2}$ = 4 496.862 d; u = 9.131 d)	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	
self absorption	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _
extrapolation of efficiency curve	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _
other effects (if relevant) (explain)	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _
combined uncertainty (as quadratic sum of all uncertainty components)	_ _ _ _ _	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _	_ _ _ _

* The uncertainty components are to be considered as approximations of the corresponding standard deviations (see also *Metrologia*, 1981, **17**, 73 and *Guide to expression of uncertainty in measurement,* ISO, corrected and reprinted 1995).

F. Combination of individual results

(obtained from the individual dilutions, source preparation, etc.)

How have the individual results been used for arriving at the final result (statistical weights)?

G. Final result for a given method

(Please, for each method used, give the following information)

The radioactivity concentration of the ^{3}H solution on the reference date

(2009-05-31, 0 h UTC) is

_ _ _ _ _ _ _ _ _ kBq g^{-1},

and the combined uncertainty is

_ _ _ _ _ _ _ _ _ kBq g^{-1}, _ _ _ _ %

Remarks

H. Laboratory final result

If several measuring methods were used, please indicate below the value to be considered for the evaluation of the degree of equivalence (according to the CIPM MRA), and its method of calculation.

The radioactivity concentration of the ^{3}H solution on the reference date (2009-05-31, 0 h UTC) is

_ _ _ _ _ _ _ _ _ kBq g^{-1},

and the combined uncertainty is

_ _ _ _ _ _ _ _ _ kBq g^{-1}, _ _ _ _ %

Remarks