^3H activity comparison between CPST, VNIIM and LNE-LNHB

P. Cassette[1], P. Butkus[2], A. Gudelis[2], T. Shilnikova[3]

[1]CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), 91191 Gif-sur-Yvette Cedex, France
[2]Ionizing Radiation Metrology Laboratory of the Center for Physical Sciences and Technology, Lithuania
[3]D. I. Mendeleyev Institute for Metrology, VNIIM, St. Petersburg, Russia

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An activity comparison of tritiated water was organized in 2013 between three laboratories: CPST (Lithuania), LNE-LNHB (France) and VNIIM (Russia). The solution was prepared by LNHB and ampoules were sent to the other laboratories. This solution was standardized in terms of activity per unit mass by participant laboratories using the Triple to Double Coincidence Ratio (TDCR) method in Liquid Scintillation Counting (LSC). The tritiated water solution is traceable to the solution prepared by LNHB for the CCRI (II)-K2.H-3 2009 ^3H international comparison.

^3H is a low-energy pure beta radionuclide of great importance, widely monitored in the environment. This radionuclide is produced naturally but the natural levels increased considerably due to nuclear weapons testing that released large amounts into the atmosphere and by the operation of nuclear power plants and fuel reprocessing centres. It is an important tracer in geological and biological processes and is a good indicator of nuclear activities.

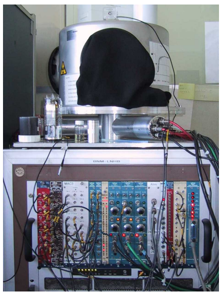
Moreover, this is also a radionuclide of choice to test the instruments and models used in liquid scintillation standardization methods, as its detection efficiency is low. This exercise gave the opportunity for the primary laboratories of Lithuania and Russia to compare their measurement results with the activity values of the key comparison CCRI(II) K2.H-3 2009.

Measurement methods and instruments

- Dilution of the original solution used for CCRI(II) K2.H-3 2009 activity comparison sent by LNE-LNHB to CPST and VNIIM
- Dilution coefficient checked at LNE-LNHB (mass and TDCR measurement)
- The LNE-LNHB result is traceable to the result submitted to the CCRI(II) K2.H-3 2009 activity comparison
- Reference date: 30 September 2013
- ^3H half-life: 12.312 (25) a

CPST counter

VNIIM counter



LNE-LNHB counter

	CPST	VNIIM	LNE-LNHB
Type of counter	Custom-built at CPST	Custom-built at VNIIM	Custom-built at LNHB
Efficiency obtained with an unquenched standard of ^3H	~42 %	~49 %	~50 %
Type of phototubes	Burle 8850	Hamamatsu R331-05	Burle 8850
Operating temperature	22°C	22°C	22°C
Coincidence resolving time	50 ns	40 ns	40 ns
Efficiency variation method	Optical filter (black stripes drawn on the vial)	Chemical quenching	Grey filters
Type of dead-time	Extendable	Extendable	Extendable
Dead-time correction method	Live-time clock	Live-time clock	Live-time clock
Dead-time base duration	50 µs	50 µs	50 µs
Typical count-rate	500-1500 s^{-1}	1500 s^{-1}	1000 s^{-1}
Typical counting time	10 x 60 s	600 s	10 x 90 s
Typical TDCR value	0.4	0.43	0.45
Background counting rate, D	12	16	7
Background counting rate, T	9	11	4
Scintillation cocktail	Ultima Gold LLT	Ultima Gold	Ultima Gold
Volume of scintillator, ml	16	10	10
Number of sources measured	10	10	10
Computer code used to calculate efficiency	TDCR07c	TDCR07c	TDCR07c

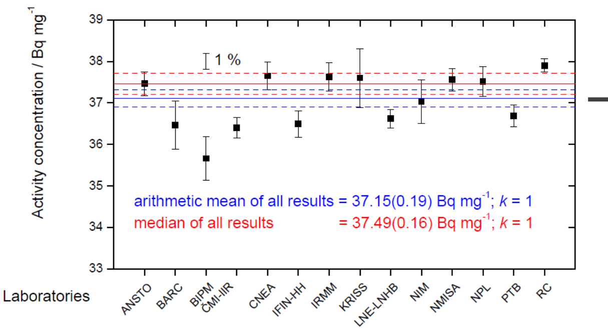
Source preparation and uncertainty budget

	CPST	VNIIM	LNE-LNHB
Balance	BC BL 100	Mettler AE 240	Mettler MT5
Calibration date	6/2013	5/2010	6/2009
Traceability to SI	Standard weights calibrated in Poland	Primary national standard of Russian Federation GET3-2008	8 calibrated mass standards from LNE
Temperature control	Yes	Yes	Yes
Humidity control	Yes	Yes	Yes
Buoyancy correction	Not applied	1.0012 ± 0.0001	1.001077 ± 0.000015
Weighing procedure	Vial weighing	Pycnometer method	Pycnometer method

	CPST		LNE-LNHB		VNIIM	
Contribution due to	u(a) %	Comment	u(a) %	Comment	u(a) %	Comment
Counting statistics	0.4		0.16	Including variability between sources	0.1	
Weighing	0.1		0.01		0.1	
Background	0.1		0.03		0.05	
Dead time			<0.01	Uncertainty of the live-time clock		
Resolving time	0.4			Included in dead-time	-	
Pile-up			0.02	Probability of occurrence of 2 disintegrations during the resolving time	-	
Decay data	0.3					
Half-life			0.01			
Impurities		None detected				
Adsorption						
PMT asymmetry	0.3			Taken into account in the calculation		
Counting time	-					
Ionization quenching and kB	0.2		0.64	kB factor		
Sample stability	0.6					
TDCR model	0.2				-	
TDCR value					0.37	
Combined relative standard uncertainty	0.98		0.66		0.39	

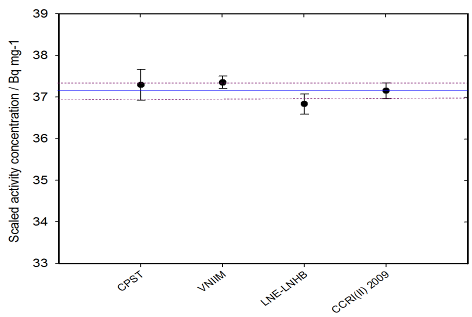
Final results

International comparison of activity measurements of a solution of ^3H
One result per laboratory; one result not included in the potential KCRV



CCRI(II)-K2.H-3 Draft B, G. Ratel, BIPM, 2015

Scaled results of this comparison



Reported results

Participant	a (kBq/g)	u(a) (kBq/g)
CPST	29.21	0.29
VNIIM	29.26	0.12
LNE-LNHB	28.85	0.19

Conclusion

The activity concentrations of the ^3H solution reported by the three participants are consistent within their uncertainties. The activity concentrations reported by CPST and VNIIM are also fully consistent with the reference value of the 2009 CCRI(II) ^3H comparison. The uncertainties reported by the participants are significantly different, despite the fact that the measurements were conducted using similar instruments under similar conditions. This question deserves a more precise study and this will be the goal of the TDCR calculation comparison to be organized in 2015 by the CCRI (II). At the same time, the problem of uncertainty determination will be extensively treated in a Special Issue of *Metrologia*.

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