Calibration check of radionuclide calibrators used for activity measurement of ^{99m}Tc

Freda van Wyngaardt and Bruce Simpson

Radioactivity Standards Laboratory, National Metrology Institute of South Africa (NMISA)

In May 2006, the NMISA Radioactivity Standards (RS) laboratory was requested to provide a ^{99m}Tc standard for the calibration of a number of radionuclide radioactivity calibrators in the Durban area. Since the distance between Cape Town (where our laboratory is situated) and Durban is about 1600 kilometres and the half-life of ^{99m}Tc is only 6.0067 hours, the planning of this project required careful logistics. Our normal strategy of receiving a sample, preparing a standard and then sending it to the client by road was not feasible.

The scheme adopted required that the responsible medical physicist in Durban prepare a vial containing 10 g of ^{99m}Tc solution; he performed measurements on this vial in the various radionuclide calibrators requiring a calibration check and then sent the vial to Cape Town by an overnight flight. The measurements in Durban were carried out over a 3-hour period, with the activity ranging from 1000 MBq to 700 MBq. At the RS laboratory the source was measured using the NMISA Vinten ionization chamber in current (pA) mode to establish a radionuclide factor for future use. In addition, a glass ampoule containing 3.643 g of the solution was prepared so as to match the standard NMISA calibration geometry of 3.6 ± 0.2 ml. The activity of this ampoule was measured using the NPL factor for ^{99m}Tc provided with the Vinten chamber, normalized to the standard NMISA geometry. In Table 1, normalized NPL factors for a number of radionuclides are compared with the NMISA values determined from absolute standardizations. The good agreement obtained gave confidence that the value used for ^{99m}Tc would give reliable results.

Table 1: Comparison of NMISA and normalised NPL ionization chamber calibration factors

Nuclide	NMISA factor	NPL factor	Nuclide	NMISA factor	NPL factor
^{60}Co	6118	6118	^{131}I	1107	1107
^{22}Na	5789	5783	^{75}Se	1106	1089
^{192}Ir	2336	2336	^{139}Ce	0471	0471
^{54}Mn	2230	2252	^{99m}Tc	–	0341
^{137}Cs	1575	1590	^{125}I	0127	0130
^{65}Zn	1444	1449	^{241}Am	0067	0067
^{133}Ba	1181	1180			

The measurements in Cape Town were made 24 hours after those in Durban so that the solution was about 16 times weaker. This was acceptable because the NMISA laboratory is equipped to measure low activities accurately, whereas hospitals generally do not have this capability. The activity of the ampoule was measured to be 23.94 MBq at 12h00 on 25 May 2006. The mass of solution received in the vial was accurately measured to be 9.9985 g, which gave the activity concentration of the solution as 104.8 MBq/g at 12h00 on the day that measurements were made in Durban (24 May 2006). The total uncertainty for the source activity was specified by the RS laboratory as 1.20 %. A detailed uncertainty budget is given in Table 2.

Table 2: ^{99m}Tc uncertainty budget (1 σ)

Current variation	0.06 %
Half-life	0.05 %
Possible Mo-99 breakthrough	0.30 %
Weighing	0.04 %
Uncertainty in NPL factor	0.84 %
Normalisation of NPL factor	0.50 %
Long term variability of IC	0.50 %
Total (in quadrature)	1.20 %

The certified activity of the vial was decay corrected to the time of measurement for each of the hospital measurements and these values compared with the activities specified for each radionuclide radioactivity calibrator. The values are compared in Table 3. Only the PTW Curiementor 2 instruments required re-calibration, possibly due to loss of pressure from the chambers over time.

The comparison demonstrated the feasibility of undertaking a certification exercise of a very short-lived radionuclide over lengthy distances. This comparison exercise was possible because the half-life of ^{99m}Tc is accurately known. Careful planning and preparation was required. A radionuclide factor obtained for the 10 g geometry (0340) will simplify future comparisons. The comparison has clarified which of the hospital calibrators were in fact discrepant. The transfer instrument being developed by the BIPM will be useful to verify the normalised NPL ^{99m}Tc calibration factor for use in the NMISA ionization chamber.

Table 3: All activities are given on 24 May 2006 at the measurement time specified. The certified activity of the vial was 1047.9 MBq at 12h00.

Hospital	Radionuclide calibrator make	Measure-ment time	Activity measured (MBq)	Certified activity (MBq)	Deviation (%)
1	PTW Curiementor 3	11:23	1100	1125	-2.22
1	PTW Curiementor 3	11:26	1096	1119	-2.06
1	Capintec CRC-15R	11:30	1139	1110	2.61
2	PTW Curiementor 2	13:15	731.6	907.2	-19.36
3	Capintec CRC-15R	14:40	781.9	770.3	1.51
4	PTW Curiementor 2	12:42	714.8	966.6	-26.05
5	PTW Curiementor 2	12:31	895.9	987.3	-9.26