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NBS TECHNICAL NOTE 791

Dose Calibrator Pilot Study

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Dose Calibrator Pilot Study

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DOSE CALIBRATOR PILOT STUDY

S. B. Garfinkel* and G. J. Hine**

Results of measurements of six sources in dose calibrators used in nuclear medicine facilities at eight hospitals in the Washington metropolitan area are given.

Key words: Dose calibrators; indium-113m; molybdenum-99; nuclear medicine; radiopharmaceuticals; technetium-99m; tin-113.

The radionuclide dose calibrator is an instrument which has become very important in the assay of radiopharmaceuticals in the clinical nuclear-medicine laboratory. It is particularly useful for measurements of 6.0-hour technetium-99m and 104-minute indium-113m, wide availability of which is made possible by the use of "generators", ion-exchange columns charged with 66.7-hour molybdenum-99 or 118-day tin-113 (parents of the above-named short-lived radionuclides). The dose calibrator is also used for the assay of many of the other frequently used radiopharmaceuticals. The instrument is composed of an ionization chamber with a re-entrant well, and an electronic current measuring device, the readout of which is usually of the digital type.

The electronic circuits are designed so that no calculations are required by the operator. Depending on the type of instrument, he

(1) selects a switch position which corresponds to the particular radionuclide being measured,

(2) sets a multi-turn potentiometer (with a digital-type dial), or

(3) plugs into the instrument a small module (which actually contains only a resistor) identified for a given radionuclide.

After having performed one of the above operations, the radioactive sample is placed into the ionization chamber, and the activity, in micro- or millicuries is displayed on the readout, in a matter of seconds.

It was considered useful to conduct a pilot study of dose calibrators that are currently in use in nuclear-medicine facilities at 8 hospitals in the Washington, D. C., area. Arrangements were made with the personnel at these laboratories and all measurements were made on June 2, 1971.

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Six sources were used in the study, five of which had been calibrated at the National Bureau of Standards beforehand. The sixth, technetium-99m, was obtained at the first hospital visited, and then calibrated at the National Bureau of Standards on the following day.

Five of the hospitals (D, E, F, G, and H) had instruments made by the same manufacturer and designated as type "d". Hospital H had a newer version (d_1). Hospitals A, B, and C had instruments made by three other manufacturers.

The results of the measurements are presented in table 1. The first five entries in column one identify the National Bureau of Standards' sources with their respective activities in parentheses (micrograms for radium, microcuries or millicuries for the four other sources). The technetium-99m source was 10.8 millicuries at the start of the day. The second set of data for this same source is given to show the scale-factor errors on those instruments which have an additional "^{99m}Tc x 10" switch position (as most instruments do, but for ^{99m}Tc only). It is also interesting to note the small extent of the nonlinearity (with activity) in the instruments as shown by the differences in the measurements of the two radium-226 sources.

Six of the hospitals had reference sources which are supposed to be used in conjunction with a calibration-adjustment circuit to correct for gain changes in the electronics. The entries in the "Hospital-reference correction factor" row in table 1, show that in hospitals A and G, instruments were out of adjustment by +6.8 and -5.3 percent respectively. We made no adjustments to the equipment and so the ratio in the first row for each sample reflects differences in the results obtained with the various instruments used. These differences are possibly due to initial poor calibration by the manufacturer which should, however, have been detected by the day-to-day quality-control procedures. The ratio in the second row for each sample has been calculated to show the relationship of the instrument's reading to that of the National Bureau of Standards' value, after having taken into account the reading of the local reference source.

The unadjusted results, with the exception of those for ^{226}Ra for Hospitals A and C, are within +9% to -11% of the NBS values, and the adjusted results are within +10% to -15%; adjustment to 40% of the data showed increased divergence indicating, perhaps, the presence of impurities leading to different instrument response with time, or possibly that initial reference standard calibrations were in error. This, considering the state of the art and the needs of nuclear medicine laboratories, is not too unsatisfactory. However, it would appear, that the development of calibration sources compatible with these instruments, which would enable the user either to generate his own calibration settings or to correct for instabilities, would be desirable.

From the point of view of simplicity of operation, instrument type "d" is probably preferable, since it is quickest to set up for a given radionuclide (it has a 15-position switch; each position unambiguously labeled). But its accuracy and stability depend, among other things, on the correct value and quality of the fixed resistors wired to the switch. If the manufacturer has, for example, not used an accurate radioactivity standard for a given radionuclide when he assembled the circuitry, then it is quite inconvenient to change the appropriate resistors should he find that the instruments in the field need recalibrating. He can, of course, notify all owners to correct readings for the given radionuclide by some factor, but this negates the advantage of having a direct-reading of the activity.

In the case of instrument types "a" and "b" which utilize the multi-turn digital dial, the recalibration is obviously much easier to achieve. The manufacturer simply notifies his customers to use dial setting "427" instead of the previously recommended "410" for radionuclide X. Note that these instruments require the operator to read, from a chart, a different number setting corresponding to each radionuclide. This is considered inconvenient and more subject to error than types "c" and "d".

The third type "c", which employs the modules, combines advantages of both. The modules are easily replaced by the manufacturer should recalibration be necessary, but module insertion and removal are not as convenient as a multiposition switch.

Since these instruments are used in hospitals, medical laboratories and research centers throughout the world, it would be advantageous to examine more thoroughly certain characteristics of the different models, such as stability, linearity, accuracy, geometry effects, temperature-pressure-humidity effects, variation of the time constant, etc. The development of calibration sources compatible with these instruments should also be given high priority.

Table 1

SOURCES USED IN STUDY (NBS Values at t_o)	A	B	C	D	E	F	G	G	H
Hospitals / Instruments	a	b	c	d	d	d	d	d	d_1
^{226}Ra (21.2 μg)	2.71 2.53	1.01	1.25	1.05 1.06	1.01 1.03	1.02 1.03	1.00 1.05	1.05 1.04	1.03
^{226}Ra (177.8 μg)	2.73 2.54	1.01	1.21	1.08 1.09	1.00 1.02	1.05 1.06	1.02 1.07	1.06 1.05	1.05
^{131}I (681 μCi)	0.95 0.89	1.04	1.01	1.09 1.10	1.04 1.06	1.07 1.08	1.03 1.08	1.08 1.07	1.08
^{60}Co (98.0 μCi)		1.00		1.07 1.08	0.96 0.98	0.98 0.99	0.96 1.01	1.00 .99	
^{137}Cs (190.3 μCi)	0.91 0.85	0.93		1.03 1.04	0.97 0.99	0.99 1.00	0.95 1.00	0.99 0.98	0.98
^{99m}Tc (10.8 mCi)	0.92 0.86	0.95	0.89	0.98 0.99	0.92 0.94	0.96 0.97	0.94 0.99	0.97 0.96	
^{99m}Tc (10.8 mCi) on x 10 scale	0.94 0.88			0.98 0.99	0.89 0.91		0.93 0.98	0.96 0.95	0.97
Hospital Reference Correction Factor*	0.932			1.006	1.017	1.013	1.053	0.994	

Row 1: the ratio, R, of the Hospital dose calibrator value to NBS value for a given source at t_o.

Row 2: R x (Ratio of certified value of hospital's reference source to the dose-calibrator value of the same source) at t_o.

* This factor is the ratio applied to R in Row 2.

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The work described herein was done at the suggestion of NSI subcommittee N44-3, Nuclear Medicine, because of the widespread use of dose calibrators in the assay of radiopharmaceuticals in clinical nuclear medicine laboratories.

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