UNEXPECTED DEADTIME LOSSES IN A MODIFIED RECTILINEAR SCANNING SYSTEM

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Larger than expected deadtime losses were experienced with a rectilinear scanner interfaced with a multichannel analyzer in part due to inability to use the built-in livetime clock. Correction factors developed experimentally for these losses are presented.

To help us develop a system for quantitative whole-body scanning, an Ohio-Nuclear 54FD dual-head rectilinear scanner was interfaced (*1*) with a Technical Measurement Corp. 401 D multichannel analyzer operated in the analog mode (Fig. 1). The pulses from both Ohio-Nuclear single-channel pulse-height analyzers are dispatched to the multichannel analyzer's single-channel input and assigned to 100 successive channels determined by the detector position. This position is sensed by a ten-turn potentiometer which feeds a ramp voltage into the analog input of the multichannel analyzer as the detectors move across the table. At the end of each traverse, a controller interface transfers the channel counts accumulated to a Datamec 2020 magnetic tape unit as a single record of 100 six-digit words.

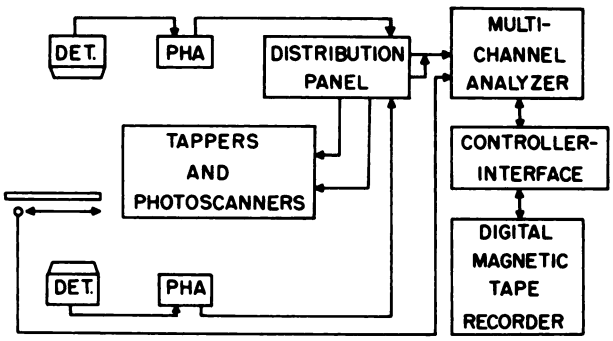

FIG. 1. Block diagram of scanner-interface-tape recorder showing signal flow from detection to storage.

While calibrating the system, we experienced count losses at rates lower than one usually associates with scintillation counting equipment. Therefore, an analysis was initiated to determine deadtime correction factors. When the observed counts were corrected for instrument deadtime by conventional techniques (*2*), correction was adequate for low but not for high counting rates. We therefore determined our correction factors empirically. For this purpose, ten sets of paired radioactive samples with known

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TABLE 1. DEADTIME CORRECTION FACTORS FOR INDIVIDUAL AND PAIRED SAMPLE COUNTS

Sample activity (μCi)	Group*	OCR† (cpm)	cpm/μCi	Correction factor (CF)
0.16	I	2,298	14,366	0.99
0.32	P	4,566	14,269	1.00
0.40	I	5,636	14.090	1.01
0.80	P	10,984	13,730	1.04
0.80	I	11,046	13,808	1.03
1.60	P	21,346	13,341	1.07
1.60	I	21,310	13,319	1.07
3.20	P	40,632	12,698	1.12
4.00	I	50,300	12,575	1.13
8.00	P	88,619	11,077	1.29
8.00	I	88,180	11,022	1.29
16.00	P	141,940	8,871	1.61
16.00	I	141,475	8,842	1.61
32.00	P	198,917	6,216	2.29
40.00	I	218,358	5,459	2.61
80.00	P	276,539	3,457	4.12
80.00	I	275,361	3,442	4.14
160.00	P	301,704	1,887	7.55
160.00	I	301,766	1,886	7.55
320.00	P	324,251	1,013	14.06

* I—Average of separate counts of pair; P—Pair counted together.

† Observed counting rate.

relative intensities were prepared by pipetting duplicate samples containing 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, and 20 ml from a solution containing 8 μCi of ^{131}I per ml. Each sample was then diluted to 20-ml final volume. The paired samples were examined by counting the first plus a nonradioactive blank, the first and second, and then the second plus a blank (*2*). For this study the multichannel analyzer was operated as described above. The detectors remained stationary, and the collimators were removed. At least 20,000 counts were collected in duplicate for at least 1 min realtime. This means that counts of low-activity sources took as long as 10 min while counts of high-activity sources totaled as many as 325,000 counts in 1 min. The relative activities were verified in a large sample counter constructed according to the plans of Gibbs and Hodges (*3*). In the large sample counter, higher counting rates were decreased by interposing absorbers between the sources and the detectors and then recounting these sources with less active pairs.

The results appear in Table 1 which shows the sample activities determined from the large sample counter, the counting rates from the multichannel analyzer, the counting rates per unit activity, and the correction factors. The average of the three pairs of highest cpm/μCi represents unity correction. The ratio of this average to each of the other such values is the correction factor. A plot of the correction factor as a function of the counting rate appears in Fig. 2. The solid lines were drawn from exponential equations determined by successive approximations. They relate the deadtime correction factor (CF) to the observed counting rate (OCR).

Up to 283,000 cpm, the correction factor is

$$CF = 0.993 \times e^{(0.0000018 \times OCR)} + 0.075 \times e^{(0.00001309 \times OCR)} - 0.075.$$

Above 283,000 cpm, the correction factor is

$$CF = 0.00177 \times e^{(0.00002674 \times OCR)}.$$

Correction factors less than one are set equal to one.

Storage cycle time of the multichannel analyzer in analog mode consumes 32 μsec according to the manufacturer's specifications. Multiplying this by the natural log base e gives the resolving time of the multichannel analyzer for randomly spaced pulses (*2*). Calculations based on this resolving time, however, give deadtime correction factors (dotted line in Fig. 2) that are less than our experimental results.

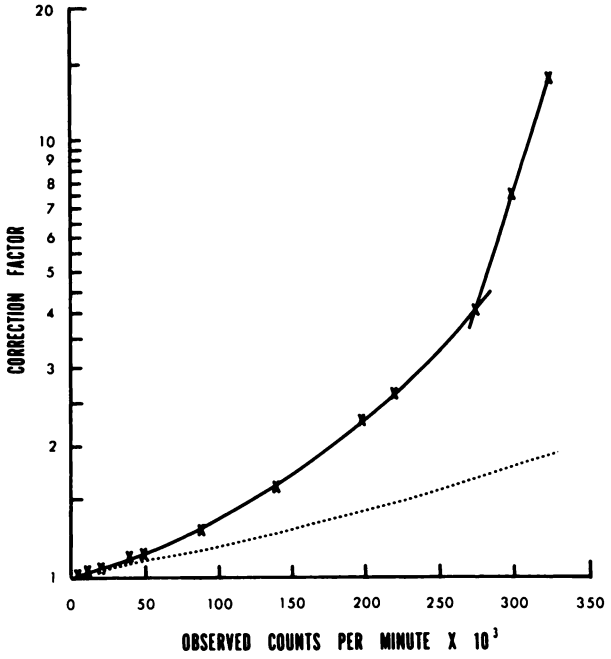

FIG. 2. Deadtime correction factors plotted as function of observed counting rate. (X — X derived deadtime factors, . . . theoretical deadtime factors.)

The reason for the experimental curve deviating from the theoretical curve was not pursued. The main point to be made is that such a difference can occur when an instrument is used in a manner slightly different from its designed purpose. The multichannel analyzer compensates for deadtime losses with a built-in clock which accumulates data in instrument livetime. Our system cannot use this livetime function since the detector traverse speed cannot be varied according to deadtime losses and no additional collection time is provided for counting. The losses of data therefore become larger as the counting rate increases and correction factors must be applied at data input rates which are quite low in the usual context of scintillation spectrometry.

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