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Additional Uncertainty in NIST ^{60}Co Absorbed-Dose-to-Water Calibrations

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In November 2000, it was discovered that there was a potential problem with the NIST absorbed-dose-to-water calibration service. For a chamber that had recently been returned in a comparison, the calibration factor was significantly different than the historical factor that had been verified prior to the comparison. Upon careful examination, it was found that the problem was due to differences in the radiation field size.

NIST uses a square metal jig with sides of 50.8 mm to set the jaws on its ^{60}Co Theratron F teletherapy unit. The jig is inserted into the opening, and the jaws are then closed around it to set the jaw openings and hence the filed size. The unit has a set of four knobs to control so-called Abeam trimmers,@ designed to cut individual corners of the field in therapy applications. The two knobs used to manually set the jaw openings are located between three of these trimmer knobs. It appears that two of the trimmer knobs, instead of the jaw knobs, had been accidentally turned, with the effect that the jig was held in place partially by the trimmers. This had the effect of changing the field size set by the jig. When the trimmers were subsequently backed out, the calibration factor was again significantly different than the historical value, but now in the opposite direction. The question then became, were the trimmers out of the way when water-calorimeter measurements were made to establish the absorbed-dose-to-water rate for the NIST source?

After testing, it was determined that for the past three to four years during which the NIST absorbed-dose-to-water calibration service has been offered, and during which the historical calibration factors of the secondary standards were determined, there was at least one trimmer set slightly into the beam. The NIST absorbed-dose-to-water calibration factors have always shown a larger variation in reproducibility in their measurement, and this is due to the fact that the jig has the potential of fitting in the jaws in a number of ways when a trimmer is in the way. It should be noted that this does not effect NIST air-kerma calibrations, as the jig is not used to set the jaws. Therefore, the trimmers would only cut out a very small portion of the beam for these calibrations, and - as will be shown - the effect is negligible.

In 1990/1991 NRCC and NIST participated in an absorbed-dose-to-water comparison. A comparison was again performed in 1998. The same NRCC chamber was used in both comparisons with the following NIST/NRCC results:

	1991	1998
Air kerma	0.9941	0.9940
Absorbed dose	1.0036	1.0048

Very little change is seen in the air-kerma calibrations, but the difference in the absorbed-dose comparison could at least be partially due to a difference in field size. Later in 1998, Penelope Allisy-Roberts of the BIPM reported having had trouble coming full-circle with comparisons she performed independently with NIST and with NRCC, and with the above NIST-NRCC comparison. Again, this might have been due to field-size differences in the comparisons.

Every effort was made to recreate conditions used for Domen's determination of the absorbed dose with the NIST sealed-water calorimeter. Unfortunately, actual field sizes at the measurement distance were not measured at that time, nor was any verification of field size made other than to close the jaws on the jig (*e.g.*, the jaw dial readings were not noted). The only measurement available was a ratio of charges collected with the "set" field size to that with the jaws wide open. However, using the same PL1-11 chamber as in that measurement, the ratio could not be reproduced.

It was finally decided that the field size at the time of the water-calorimeter measurements could not be reliably assured. Plotting field size *vs*. calibration factors for all NIST absorbed-dose ion chambers, a field size (determined by setting the dials, not using the jig) corresponding to dial settings of 10.75 x 10.75 consistently gave the historical calibration factors for the chambers. When the jig was used to set the jaws without any trimmers in the beam, the dials read 10.25 x 10.6. Using these two field sizes, calibration factors for all available chambers varied by 0.7±0.04 %.

Because the true field size for the water-calorimeter measurements cannot be independently determined, no corrections appear possible. Rather, assuming the two settings given above represent the extremes, an additional component of relative uncertainty of 0.7%//3 = 0.4 % has been added in the uncertainty assessment. Thus our relative expanded (k=2) uncertainty has been increased from 0.9 % to 1.2 % for the determination of an absorbed-dose-to-water calibration factor.