SUBJECT: How to determine an approximated signal from an Ion Chamber

The following information is provided as a service to our users and customers:

Determining an approximated signal of an ion chamber in air or water can be useful for many reasons – some include (1) determining the electrometer range setting to prevent damage to its front-end components, (2) selecting which chamber to use in various situations to maximize the signal-to-noise ratio or (3) selecting both an ion chamber and electrometer to be used as a "system" for a particular situation.

Some information needs to be known and a few assumptions need to be made in order to determine an expected signal. *This approximated ion chamber signal is to be treated as an "educated estimate" (within an order of magnitude) and in no way should be used as a substitute to using an ion chamber in the actual radiation source.*

Comparing this approximated ion chamber signal to the measurement range of an electrometer will help decide if the ion chamber/electrometer pair is appropriate for a particular situation.

Need to know

- Nominal Co-60 calibration factor for the ion chamber (air or water)
- The dose rate of the radiation source at 100cm (in units of Gy/time)

Assumptions

- Any energy dependence behavior is ignored
- Collection efficiency, polarity effects, recombination effects and temp/pressure effects are ignored

$$ExpectedSignal\_in\_Water = \frac{Water\_DoseRate}{Water\_{}^{60}Co\_CalFactor} * (TimeConversionFactor)$$

– or –

$$ExpectedSignal\_in\_Air = \frac{airKERMA\_DoseRate}{airKERMA\_{}^{60}Co\_CalFactor} * (TimeConversionFactor)$$

where:

- *ExpectedSignal* unit is amps
- *DoseRate* unit is Gy/unit time
- ^{60}*Co_CalFactor* unit is Gy/C
- *TimeConversionFactor* is the factor necessary to convert the unit time of the *DoseRate* into seconds; remember that 1 amp = 1 columb/second

Be sure to correctly use dose rates for the given media (water or air) with the appropriately matched calibration factor in the same media.

EXAMPLE CALCULATION

Water Dose Rate = 2.0 Gy/min at 100cm SDD
Ion Chamber of interest = A12
Nom Abs Dose to Water Co-60 Factor for A12 = 4.9 x 10^7 Gy/C

$$ExpectedSignal\_in\_Water = \frac{2.0[Gy/\min]}{4.9x10^{7}[Gy/C]} * \left(\frac{1[\min]}{60[\sec]}\right)$$

$$\begin{aligned} ExpectedSignal\_in\_Water &= 0.68x10^{-9} A \\ &= 6.80x10^{-10} A \\ &= 680x10^{-12} A \end{aligned}$$

This expected signal is well suited to the Low Current Range of the MAX 4000 and SuperMAX electrometers. After adding an order of magnitude to this signal, it would be near the upper limit of the Premier 3000; likewise, decreasing this signal by an order of magnitude would be very near the lower limit of the CDX-2000B – either of these electrometers would not be recommended in this example.

Below is the list of operating ranges for all Standard Imaging Electrometers.

Electrometer Model	Low Current Range	High Current Range
CDX-2000B	$0.01x10^{-9}$ – $195.00x10^{-9}$ amp	**this is a one-range device*
Premier 3000	$0.01x10^{-12}$ – $19.50x10^{-9}$ amp	**this is a one-range device*
Max-4000	$0.001x10^{-12}$ – $999.99x10^{-12}$ amp	$0.001x10^{-9}$ – $500.00x10^{-9}$ amp
SuperMAX	$0.001x10^{-12}$ – $500.00x10^{-12}$ amp	$0.001x10^{-9}$ – $500.00x10^{-9}$ amp

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Below is a list of nominal Co-60 Calibration Factors for the Exradin Product Line.

Exradin Ion Chamber Model	Volume [cc]	Nominal Co-60 Air KERMA Cal Factor [Gy/C]	Nominal Co-60 Absorbed Dose to Water Cal Factor [Gy/C]
1 & 1SL	0.056	5.5×10^8	6.0×10^8
2	0.53	5.5×10^7	6.0×10^7
3	3.6	8.0×10^6	not for use in water
4	30	1.0×10^6	not for use in water
5	100	3.0×10^5	not for use in water
6	800	3.8×10^4	not for use in water
10	0.051	5.1×10^8	5.6×10^8
11	0.62	4.2×10^7	4.6×10^7
11TW	0.93	3.0×10^7	3.3×10^7
12	0.65	4.5×10^7	4.9×10^7
12S	0.25	1.1×10^8	1.2×10^8
14 & 14SL	0.016	2.3×10^9	2.5×10^9
16	0.007	3.6×10^9	3.9×10^9
18	0.125	2.5×10^8	2.7×10^8
19	0.62	4.5×10^7	4.9×10^7

This calculation process to determine an approximated ion chamber signal can be reversed: if one arbitrarily picks a minimum and maximum “allowable signal” based on a particular electrometer’s measurement range (while taking into account an acceptable signal-to-noise ratio) and after choosing a particular ion chamber – one can calculate the minimum and maximum dose rate for that particular ion chamber to be exposed to in order to (a) have a large enough signal not to be lost in the noise/leakage of the ion chamber-extension cable-electrometer system and (b) have a low enough signal not to overload the input of the electrometer for that particular measurement range.

Again, this calculation process is an approximation and should be given an order of magnitude of “cushion” to prevent damage to an electrometer.