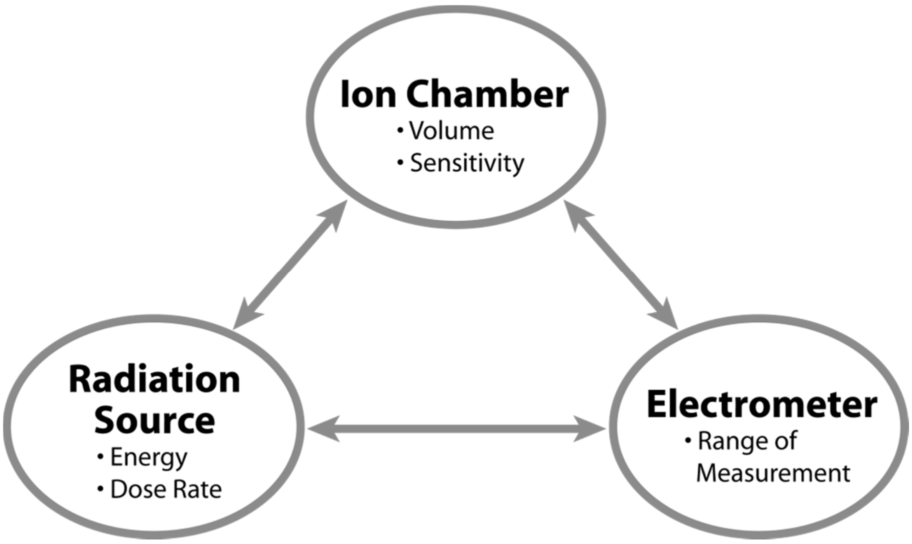
SUBJECT: How to determine an approximated signal from an Ion Chamber

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 –

(1) selecting which chamber to use in various situations to maximize the signal-to-noise ratio
(2) selecting both an ion chamber and electrometer to be used as a “system” for a particular situation
(3) determining the electrometer range setting to prevent damage to its front-end components

The relationships between the ion chamber, electrometer and radiation source all have an impact on this signal determination. They are shown in the diagram below:



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.*

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

What you need to know

- Nominal ^{60}Co calibration factor for the ion chamber
- The dose rate of the radiation source at 100 cm

Assumptions

- Ion chamber has adequate buildup to achieve Charged Particle Equilibrium (CPE)
- Any energy dependence, collection efficiency effects, polarity effects, recombination effects and temperature/pressure effects are ignored

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

– or –

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

where:

- ***ExpectedSignal*** unit is amperes
- ***DoseRate*** unit is Gy/unit-time or R/unit-time (must be Gy/unit-time for water)
- ***Water_^{60}Co_CalFactor*** unit is Gy/C
- ***Air_^{60}Co_CalFactor*** unit is Gy/C or R/unit time (Air Kerma or Exposure, respectively)
- ***TimeConversion***, if necessary, is to convert the unit-time of *DoseRate* into seconds; (1 A = 1 C/sec)

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EXAMPLE CALCULATION

Water Dose Rate = 2.0 Gy/min at 100 cm SSD
Ion Chamber of interest = A12
Nom Abs Dose to Water ^{60}Co Factor for A12 = 4.87 x 10^{7} Gy/C

$$ExpectedSignal\_in\_Water = \frac{2.0[Gy/\min]}{4.87x10^{7}[Gy/C]} * \left(\frac{1[\min]}{60[\sec]}\right)$$

$$ExpectedSignal\_in\_Water = 6.84x10^{-10}\,A$$
$$= 0.684x10^{-9}\,A$$
$$= 684x10^{-12}\,A$$

Because this is an order of magnitude style estimate, signals an order of magnitude above and below this estimate should be considered. Adding an order of magnitude to the expected signal estimated here yields a signal near the upper limit of the Premier; likewise, decreasing this signal by an order of magnitude would be very near the lower limit of the CDX-2000B – neither of these electrometers would be recommended in this example. This expected signal is well suited for MAX 4000 and SuperMAX electrometers.

Below is the list of operating ranges for all Standard Imaging electrometers:

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

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Below is a list of nominal ^{60}Co Calibration Factors for all Exradin Ion Chambers at 100cm SSD:

Exradin Ion Chamber Model	Volume [cc]	Type[1]	Chamber Spot Size[2] [mm x mm]	Nom ^{60}Co Air Kerma Cal Factor [Gy/C]	Nom ^{60}Co Exposure Cal Factor [R/C]	Nom ^{60}Co Absorbed Dose to Water Cal Factor [Gy/C]
1 & 1SL	0.053	T	8.0 x 6.4	5.35×10^{8}	6.09×10^{10}	5.85×10^{8}
2	0.53	T	14.0 x 11.5	5.35×10^{7}	6.09×10^{9}	5.79×10^{7}
3	3.58	S	Ø 22.0	7.95×10^{6}	9.04×10^{8}	not for use in water
4	28.1	S	Ø 40.0	1.00×10^{6}	1.14×10^{8}	not for use in water
5	96.6	S	Ø 64.0	2.90×10^{5}	3.30×10^{7}	not for use in water
6	776.4	S	Ø 122.0	3.65×10^{4}	4.15×10^{6}	not for use in water
7	3240	S	Ø 197.0	8.75×10^{3}	9.95×10^{5}	not for use in water
8	15700	S	Ø 325.0	1.80×10^{3}	2.05×10^{5}	not for use in water
10	0.050	P	Ø 14.2	5.65×10^{8}	6.43×10^{10}	6.31×10^{8}
11	0.62	P	Ø 28.6	4.60×10^{7}	5.23×10^{9}	5.17×10^{7}
11TW	0.93	P	Ø 28.6	3.05×10^{7}	3.47×10^{9}	3.46×10^{7}
12	0.64	T	26.5 x 7.1	4.45×10^{7}	5.06×10^{9}	4.87×10^{7}
12S	0.24	T	13.1 x 7.1	1.15×10^{8}	1.31×10^{10}	1.26×10^{8}
14 & 14SL	0.015	T	5.3 x 6.4	1.90×10^{9}	2.16×10^{11}	2.05×10^{9}
16	0.007	T	3.5 x 3.4	4.05×10^{9}	4.61×10^{11}	4.38×10^{9}
18	0.123	T	10.8 x 6.8	2.30×10^{8}	2.62×10^{10}	2.52×10^{8}
19	0.62	T	26.2 x 7.0	4.60×10^{7}	5.23×10^{9}	5.03×10^{7}
20	0.074	P	Ø 4.9	3.85×10^{8}	4.38×10^{10}	not for use in water
26	0.015	T	Ø 4.3	1.90×10^{9}	2.16×10^{11}	2.08×10^{9}
28	0.125	T	Ø 8.0	2.25×10^{8}	2.56×10^{10}	2.46×10^{8}
A600	1.5	P	25.4 x 25.4	1.90×10^{7}	2.16×10^{9}	not for use in water
A650	3.5	P	38.1 x 38.1	8.20×10^{6}	9.33×10^{8}	not for use in water

[1] Chamber geometry type: T=Thimble, S=Spherical, P=Parallel Plate

[2] Chamber Spot Size *does not* refer to the minimum field size in which the chamber can be used; instead, it is simply provided to assist in visualizing the chamber's volume (i.e. its spacial resolution). Chambers with oval Spot Sizes are listed as L x W, as indicated below; chambers with circular Spot Sizes have their diameters (Ø) listed.

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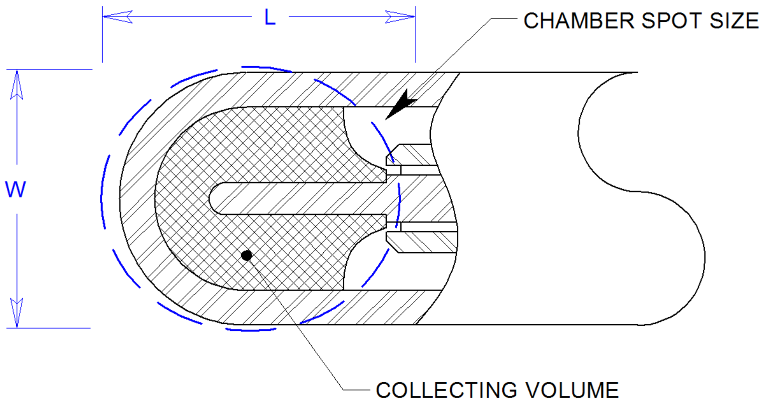

This calculation process to determine an approximated ion chamber signal can be reversed: if one arbitrarily picks a minimum and maximum "allowable signal" based on a particular electrometer's measurement range (while taking into account an acceptable signal-to-noise ratio) and after choosing a particular 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 a reasonable order of magnitude of "cushion" to prevent damage to an electrometer.

Product specifications are subject to change without notice.