Calibration Methods for Medical Applications

Larry DeWerd, PhD, FAAPM
University of Wisconsin
ADCL

Disclosure

- **Larry DeWerd has a partial interest in Standard Imaging – manufacturer of Exradin chambers**

Calibration Procedures and Importance

- All calibrations (especially for medical applications) should have a traceability train to a standard
- This provides confidence in the dose given because it was measured and can be traced back to a national standard – at NIST

Hierarchy of Standards

Standards	Calibration
International & National Standards	**Primary Calibration**
↓	
Secondary Standards ADCL	**Secondary Calibration**
↓	
Hospital or Clinical Standards	**Tertiary Calibration**
↓	
Operational Standards	

Calibration

- Calibration of chambers should be done across the energy range of use.
- Generally there is a reference energy in use that is the minimum energy point used.

Choosing X-ray Beams

- All beams should be traceable to a Free-Air chamber measurement (A primary lab)
- "Standard" or useful energies and HVLs should be used, e.g. 80kVp, with a HVL of 3mmAl (70kVp in Europe) 120 kVp – the values that bracket what is expected. I refer you back to the table I showed in the Introduction
- Because of variation in response with energy for chambers a range of calibration is necessary.

Energy Response Variation "Requirements" for a chamber

- Within ± 1% for Mammography range: 24 kVp to 35 kVp, 0.15 to 1.0 mm Al
- Within ± 2 % or 2.5% for entire diagnostic range, up to 150 kVp
- For superficial or orthovoltage (radiobiology) 1 % to 2 % is desirable

Types of chambers

- There are generally two types of chambers
  - Parallel – plate chambers (generally used for x-rays $\leq$ 100 kV) – also can be used at the higher energies as well
  - Cylindrical chambers (to be used only for energies > 100 kV). The wall of the chamber is generally thick enough for full buildup.

Differences Between Parallel Plate and Cylindrical Chambers

- Parallel Plate chambers are directional. The ionization should enter through the window – less variation with energy
- Cylindrical chambers are uniformly sensitive in the cylindrical geometry
- There can be significant differences in energy dependence because of the entrance window material

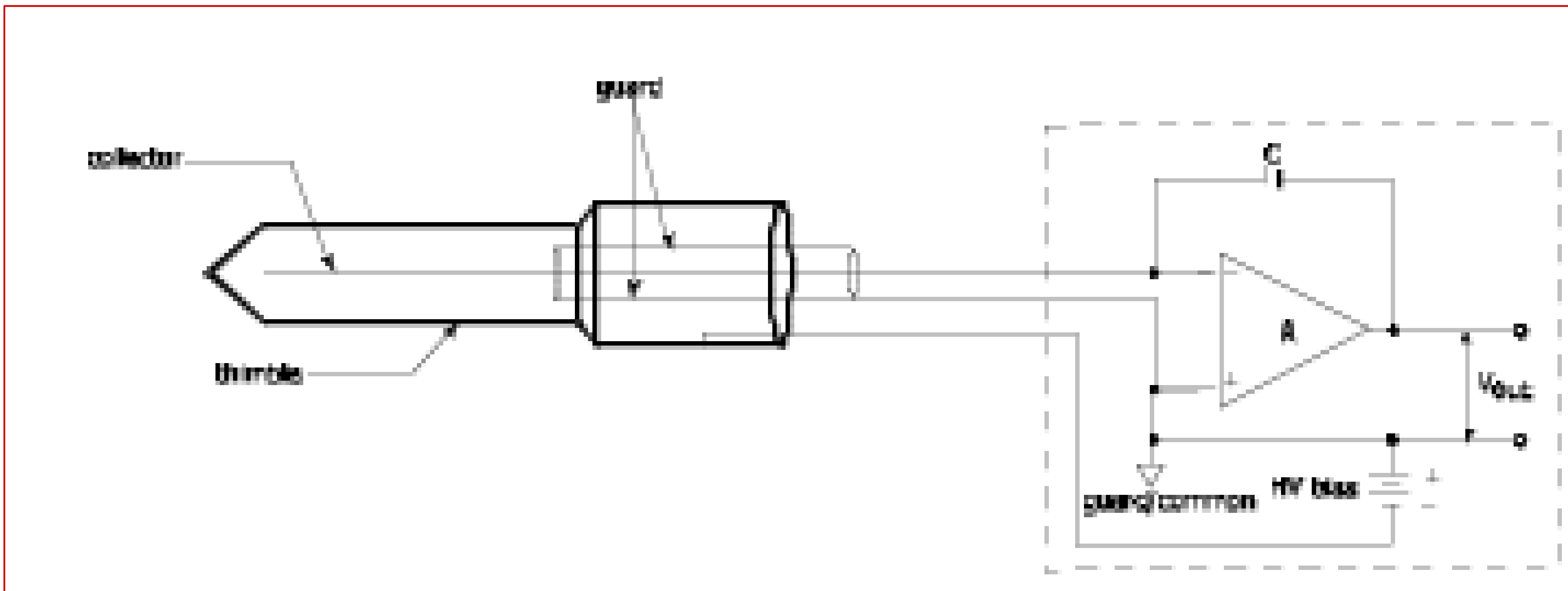
Parallel Plate chambers

Baldwin Farmer 0.6cc Ionization Chamber

Purpose of the Electrometer

- Applies voltage to create an electric field in the ionization chamber
- Measures the charge (or current) produced resulting from the ionization of the mass of material in the cavity
- Electrometer needs calibration also unless combined with chamber as a system.

Schematic of thimble Ionization chamber connected to electrometer



Calibration of chambers

- There can be electron contamination and full buildup is needed for calibration of low – energy ($\leq$ 100kV) clinical beams
- This requires an addition to the "window" to be put over a plane-parallel chamber
- The window of the chamber (for example 2.5 mg / cm^{2}) should be subtracted from the values in the following table for the thickness of the foil for full buildup.

Total wall thickness needed

Tube potential (kV)	Total wall thickness (mg – cm^{-2})
40	3.0
50	4.0
60	5.5
70	7.3
80	9.1
90	11.2
100	13.4

Summary

- A traceable – calibrated chamber is essential so all exposures can be compared.
- The "build-up cap" is very important
- Backscatter factors, etc. need to be provided for determining absorbed dose in water, which is the usual method of dose expression in radiation therapy.