Australian Government
Australian Radiation Protection and Nuclear Safety Agency

Fact Sheet 24

Specifying the polarity of the polarising voltage of an ionisation chamber

Background

When radiation dose is measured using an ionisation chamber, a polarising voltage is applied across a volume of air in the chamber in order to produce an electrical current from the ionised air. The response of the ionisation chamber depends on the magnitude of the voltage and on the direction of the electric field inside the chamber. The polarising voltage is often quoted in instrument manuals, scientific papers and calibration reports using just the sign and magnitude (eg "-300 V"). However, the direction of the field also depends on which electrode the voltage is applied to, and in therapy dosimetry this is a function of the type of electrometer. To specify the polarising voltage without ambiguity the direction of the field should be stated explicitly (eg "-300 V central electrode positive").

Triaxial Connections to an Ionisation Chamber

Figure 1 illustrates the connections from a triaxial cable to a thimble chamber. The outer electrode is connected to the outer shield of the cable, and the collecting electrode is connected to the central conductor. The inner shield of the cable is connected to a guard electrode which runs inside the stem to the air cavity and stops.

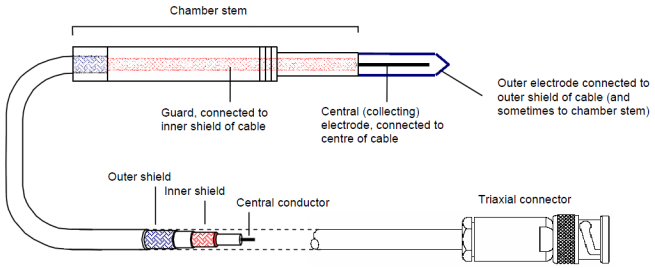

Figure 1: Schematic of a cylindrical ionisation chamber showing connections from triaxial cable to chamber electrodes.

Ground-Referenced and Floating Electrometers

A. Ground referenced electrometers

In these systems, the electrometer input amplifier has the non-inverting input grounded (see Fig. 2). The collecting electrode of the chamber is connected to the inverting input which is kept at virtual ground by the feedback action of the amplifier.

The polarising voltage is applied to the outer shield and outer electrode, which thus represent a shock hazard. Some ionisation chambers have the chamber cap electrically connected to the stem. If these chambers are used with a ground referenced electrometer, the stem then also becomes a shock hazard. (Note that it is essential to isolate the stem of these chambers from ground to avoid shorting the polarising voltage supply. It is desirable to isolate the stem in all cases in order to avoid ground loops).
Ground referenced electrometers were common in the early days of radiotherapy. They can often be recognised by the presence of a shock hazard warning, or a flying lead used to connect the polarising voltage to the outer shield of the cable.

B. Floating Electrometers

Most modern dosemeters are floating. In these systems, the entire input amplifier of the electrometer is electrically isolated and floats at the polarising voltage with respect to the instrument case. The outer shield of the cable and the outer electrode of the chamber are all connected to the instrument case, which is grounded. In these arrangements there is no shock hazard. The ionisation current is still carried on the inner conductor, which is maintained by the feedback action of the input amplifier at "virtual V". The polarising voltage is carried on the inner shield of the cable.

Note that:

- in all cases, the collecting electrode is kept at (virtually) the same potential as the guard by the action of the amplifier
- negative potential applied to the chamber cap results in the same electric field direction inside the chamber as positive potential applied to the guard.

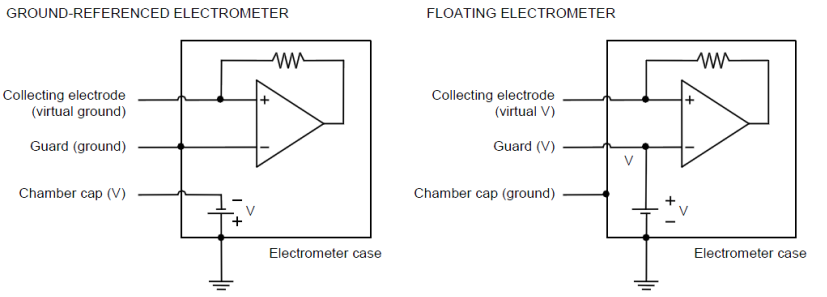

Figure 2: Simplified circuit diagrams for ground-referenced and floating electrometers (shown with polarity of collecting electrode of chamber at a positive potential relative to the cap)

619 Lower Plenty Road, Yallambie VIC 3085
Email: info@arpansa.gov.au | Internet: www.arpansa.gov.au
Telephone: +61 3 9433 2211
Fax: + 61 3 9432 1835
Last updated: May 2011

Polarity Settings: Possibility for Confusion

In many floating electrometers selecting the option for negative voltage results in a positive potential being supplied to the inner shield of the cable. This convention is possibly intended to make polarity settings consistent with older ground-referenced electrometers. Alternatively, the sign of the potential on the electrometer may be intended to refer to the polarity of the charge arriving at the collecting electrode, or the sign of the conventional current flowing onto the collecting electrode, both of which are opposite in sign to the relative polarity of the collecting electrode.

Full Description of the Polarising Voltage

A full description of the polarising voltage includes the magnitude and polarity of the applied potential, and the electrode to which this voltage is applied. One convention is to refer to the relative polarity of the central (collecting) electrode in addition to the polarity of the voltage. For example, "-300 V, Central Electrode Positive" indicates that -300 V is applied to the outer electrode, and "+300 V, Central Electrode Positive" indicates that it must be the inner shield which is at +300 V and the central electrode is at (virtual) +300 V.

In cases where there is no central electrode (such as a parallel plate chamber) the central electrode is taken to be the collecting electrode, ie the electrode connected to the central conductor.

ARPANSA Calibration Reports

The ARPANSA calibration report for an ionisation chamber will have a statement of the polarising voltage which indicates the magnitude and polarity, and the direction of the electric field. For example, "-300 V Central Electrode Positive (CEP)". This statement indicates that the chamber was calibrated with -300 V on the outer electrode. By implication, the ARPANSA electrometer was ground-referenced.

It is standard practice for ARPANSA to issue separate calibration reports for the chamber and electrometer in a dosemeter calibration. In this case, the chamber will have been calibrated using the same direction of the electric field as supplied by the client's electrometer, but may appear to have the wrong sign in the calibration report because the ARPANSA electrometer was ground-referenced. An example is given in Table 1.

In our experience, so long as the field direction and magnitude of the potential is the same, the calibration using a ground-referenced electrometer is valid for a floating electrometer. This assumption is checked during a therapy calibration by performing at least one combined calibration with the chamber connected to the client's electrometer.

Polarity Settings for Some Electrometers

The polarity settings and resulting voltages for a few electrometers are given in Table 2. All of the settings below result in the central electrode being positive (CEP).

Table 1: Polarising voltage at ARPANSA when used to calibrate a chamber for a client

Electrometer	HV Setting	Type	Full description of electric field
Client	"-300 V"	Floating (volts on inner shield)	+300 V, Central Electrode Positive
ARPANSA	"-300 V"	Ground-referenced (volts on outer electrode)	-300 V, Central Electrode Positive

Table 2: Polarising voltage settings and outputs for selected electrometers

PTW-UNIDOS 10002	Rear panel "-". Chamber menu: 300V	"-300 V"	Ground	+300 V	Virtual +300 V
NE2670B	Rear panel jumper "Type A", HV polarity switch in left position, Chamber menu: -250 V	"-250.0 V"	Ground	+250 V	Virtual +250 V
NE2570/1B	"-" and "Normal"	"250.00"	Ground	+250 V	Virtual +250 V
NE2560	Fixed at -200 V	None	-200 V	Ground	Virtual Ground