Calibrating a Survey Meter

By George Dowell

STEP 1:
Check the instrument and probe for contamination. a frisker (pancake probe) should be used so that all types of contamination may be detected.

Step 2: Check for mechanical meter zero and overall mechanical condition of the unit, including battery compartment and terminal corrosion.

Step 3: Determine the level and type of calibration needed. First time use of an instrument can proceed to as-left or final calibration immediately. If the instrument has been in service for a time and in for periodic calibration, AS-FOUND readings must first be taken and recorded before any adjustments are made. This will leave a paper trail for documents that may have had the meter in question used for measurements in the recent past.

Step 4: Measuring the As-Found High Voltage. Connect the meter to a super high impedance Voltmeter of at least 1000 Meg Ohms input impedance. The HV meter in a Ludlum Model 500 Pulser meets this requirement. An ordinary DVM is NOT acceptable. Their low 10 MegOhm impedance will drag down the meter's HV and produce an erroneous reading. ONLY use a super high impedance meter, or an approved adaptor for a regular DVM. Record the As-Found HV reading and the type of instrument used to measure it.

***The following discussion concerns the factors involved in calibrating a handheld radiation detector system "Survey Meter", such as the Ludlum Model 3.
Some of the information may also applicable to other detection systems.***

Exposure Rate Calibration vs. Electronic CPM (Pulser) Calibration.

Exposure Rate Calibration is done in a lab with a Radiation Range. This is usually several milliCuries of Cs-137, enough to flood the entire instrument with a uniform radiation field in the exposure ranges covered by that particular probe-meter combination. Ranges are set up with adjustable attenuators and calibrated distances so that various exposure rates may be employed. All of the parameters for that particular probe, such as input sensitivity, HV operating point, WINDOW adjustment, and deadtime are specific to that probe alone.
Once a calibration is completed with this method, the probe and meter are married together as a unit and will be tagged as such so that no other probe will be used with that meter.
Never forget that most probes/meters will only read exposure rates accurately when exposed to Cs-137. Other isotopes will display more or less than the actual dose rate, depending on the energy response of the probe. See the tutorial entitled: "Radiation Probes and Their Dial Scales"

Electronic or Pulser Calibration. When more than one probe is to be used with a meter, electronic CPM calibration is required. Never forget that a meter scale with dose rate will only be accurate for a specific type of probe. Each different probe will have a particular CPM per mR/H factor that is only good for that one type of probe. See the tutorial entitled: "Radiation Probes and Their Dial Scales"

Next, determine the input sensitivity of the meter unit. Ludlum Model 3's are fixed, and specified for 30 mV +/- 10 mV. Set the Pulser output Voltage adjustment to zero. There will be not reading on the meter unit under test at this point. Adjust the Pulser CPM for mid scale for the range selected. Now slowly increase the output Voltage until the meter under test just starts to respond. Carefully increase or decrease the Pulser output Voltage until the meter is reading steadily and shows 80% of the Pulser's reading. Record this level as the " Input Sensitivity".

If AS-Found readings need to be recorded, adjust the Pulser on each range to read 20% and then 80% of full scale on that range, then record the CPM required to get that reading.
Example: A dial might be 6,000 CPM full scale. Adjust the Pulser so that the needle goes to 1200 CPM, and record the Pulser CPM required to achieve this. Ideally it will be 1200 CPM. Record the actual Pulser CPM and the CPM read on the meter: Pulser>1300 CPM/ Meter> 1200 CPM. Do this for 20% and 80% of each range step,

Use the Ludlum 500 or equivalent Pulser to generate CPM rates that equal 20% and 80% of each range setting. Since there is only one calibration control for each range,
set the 80% mark first then check the 20% mark. If it is within manufacturer's specifications, that range is then calibrated. If the both areas of the scale are not within specifications, an intermediate setting of the calibration control may be found to balance both reading within specifications. If readings can't be adjusted properly, fail the instrument and send it to the repair facility.

Testing the PROBE.

Many types of radiation probes exist. The types we are concerned with for use with Survey Meters all produce pulses, as contrasted to ion-chambers that usually operate in the current mode. Height or amplitude of the pulses generated by the probe are very different depending on the technology employed, and in all cases, the operating parameters for that probe must be matched by the parameters of the meter. A meter set up for a proportional probe will not be interchangeable with a GM probe.

Some typical operating Voltage requirements and pulse heights;
GM Tube of all descriptions: 450, 700 or 900V, pulse of several Volts. No energy information contained in the pulse. All pulses the same.
Scintillator: 600 to 1200V, pulse of 10 mV to 500 or more mV. Pulse height = energy deposited. Especially in NaI(Tl)
Proportional Probe: 1000-2000V, pulse of 2 mV and up, depending on radiation type.

Probes with less than 1 mV output pulses will require charge-coupled amplifiers in the meter, as opposed to the common voltage amplifiers used in most Survey Meters. Charge coupled amplifiers require an adaptor to measure with the Pulser.

PLATEAU and Operating Voltage. Typical operating Voltages are listed in the probe's instruction manual. To make sure the probe is within specifications, a Plateau should be performed.

Set the meter up with normal parameters for the probe type being tested, but turn the HV all the way down. Connect the probe to the meter and expose the probe to a radiation source (test disc). In crease the HV until the probe just starts to count, record this Voltage as the "Start". Further increase the HV until there is noticed a SHARP increase in counts, record this Voltage and label as "Knee or " Threshold of Plateau " ", continue increasing HV and notice that the counts increase very slowly in this "plateau" area, and at some point they level off, hardly increasing at all with higher Voltages. Label this Voltage as "End". If HV is increase above this point, total discharge may take place, damaging the tube. Select the OPERATING POINT as about 25-50V above the "Knee".

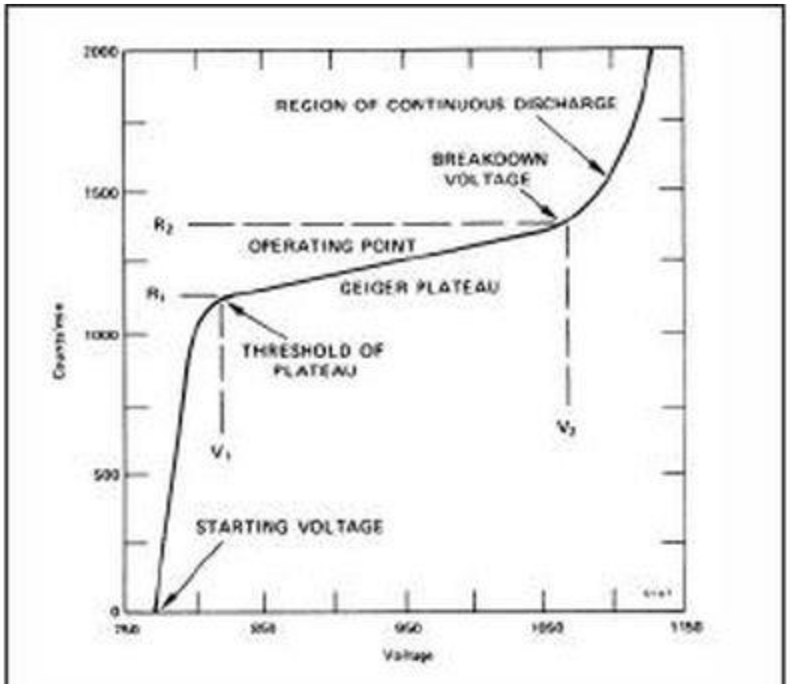

Fig. 2.2. Geiger Tube Plateau.

http://www.ortec-online.com/application-notes/an34/exp02.pdf
Scintillator Operating Points are determined in a similar manner for general-purpose use. Specialized setting may be required when energy determination is the goal.

Once the operating point is determined and the HV set for that level, the probe can be tested for efficiency using NIST calibrated test discs. Various types of radiation and energy levels will be employed, covering all the different regions that the probe is capable of detecting. These isotopes are commonly used:

Beta:
C-14 156 keV Max 44-9 2 Pi efficiency = 10%
Sr-90/Y-90 2.28 MeV Max 44-9 2Pi efficiency = 45%
Tc-99 293 keV Max 44-9 2Pi efficiency = 38%
P-32 1.71 MeV Max 44-9 2Pi efficiency = 65%

Alpha
Pu-239 5 MeV 44-9 2Pi efficiency = 30%

Many GM probes are designed to be used at 900V, making them fully interchangeable on a survey meter set to 900V. NEVER forget that ONLY the CPM scale is universal and all mR/H sales are only for one type of probe.

Ludlum also specs 900V as the typical operating Voltage for many of their scintillator probes, making them somewhat interchangeable with many of their GM probes.

IDEALLY, a probe and a meter with the proper scale on the dial are set up using a radiation range, and that combination of meter and probe are tagged so as to be married together as a unit from that time forward.

George Dowell

New London Nucleonics Laboratory

Comments, criticism and questions will be appreciated and may be directed to the author by email to GEOelectronics@netscape.com