Testing various Geiger Mueller Tubes

by George Dowell

Using the CS-137 @ 5 uCi, which gives off some Betas but primarily a 661.6keV Gamma. A homemade aluminum capsule filters the Beta, effectively yielding a pure Gamma source.

Another isotope frequently used to test GM tubes is Co-60.

For testing, a smoke detector (assembled/intact) makes another good Gamma source @ about 60keV. Do not remove or expose Am241 pellet inside as this is a Federal offense according to the NRC.
The metal housing screens out all the Alphas, leaving only the Gamma ray coming through.

The only legal man-made Alpha disc source is Po-210, but you can also own any of the natural Thorium sources. I use both Th230 and Th232.

The other disc used here is Sr-90 @ .1 uCi, which is a Beta emitter.

Testing all probe tubes on the same calibrated Eberline RM-20 Geiger Counter set at 40 mV threshold
(not that it matters for GM tubes-all pulses are strong and the same usually 5+ Volts) , the following readings were obtained (Those not mentioning any Alpha are not Alpha capable. Any windows must be open for Beta detection):

THIN SIDE WALL GM cylindrical or Hot-Dog Tubes plus Pancake for comparison:

Tube Type 1B85
Window Open/CS-137- 90,000 cpm
Window Closed CS-137- 9,000 cpm
Window Open SR-90- 27,000 cpm

Tube Type 6306
Window Open/CS-137- 20,000-35,000 cpm Asymmetric
Window Closed CS-137- 17,000 cpm
Window Open SR-90- 7,000 cpm

Tube Type LND725
Window Open/CS-137- 27,000 cpm
Window Closed CS-137- 6,000 cpm
Window Open SR-90- 4,000 cpm

Tube Type Raytheon #1021
Window Open/CS-137- 90,000 cpm
Window Closed CS-137- 9,000 cpm
Window Open SR-90- 25,000 cpm

Tube Type 6993 Black
Window Open/CS-137- 44,000 cpm
Window Closed CS-137- 4,000 cpm
Window Open SR-90- 13,000 cpm

Tube Type 6993 yellow
Window Open/CS-137- 41,000 cpm
Window Closed CS-137- 4,400 cpm
Window Open SR-90- 11,000 cpm

Tube Type T/A P-10 (LND 721)
Window Open/CS-137- 20,000 cpm
Window Closed CS-137- 4,500 cpm
Window Open SR-90- 8,000 cpm

Tube Type Pancake LND 7311
Window Open/CS-137- 170,000 cpm
Window Closed CS-137- 14,000 cpm
Window Open SR-90- 45,000 cpm

All the above tests ran @ 900V DC, the "standard" operating voltage of all these series of GM tubes.
1B85 and 6306 are the thin aluminum housing hot-dog tubes typically used in 1950's era Geiger Counters, like Precision and Heathkit. They show remarkable sensitivity, but are very fragile.
The LND 725 is the modern equivalent, but has a sturdy metal (stainless steel) housing and is used in GEO-270hp, Ludlum 44-6 and Eberline HP-270 hand probes.
All three of these tubes have a single pin at the bottom for anode connection, and the body itself is the
cathode connection. In the photo (FILES section) you can see the disassembled EberlineHP-270
hand probe housings with sliding Beta window.
Three pin connectors are used on the 1021, 6993, and the T/A 721 tube. All these are metal hot-dogs except the Raytheon 1021 which is glass.
Typical CDV-700 comes with a 6993 tube in the hand probe, the LND 720 being the modern commercial equivalent.

END-WINDOW type tubes:
Here we are having fun (Photo in FILES section) testing end-window GM tubes on the same setup we used
before to test the sidewall and pancake tubes Test source #1 is a CS-137 @ 5 uCi /Test Source # 2 is a Sr-90 @ .1 uCi, which is a Beta emitter.
Testing some probe tubes on the same calibrated Eberline RM-20 Geiger Counter set at 40 mV threshold,
the following readings were obtained:

Probe type Ludlum 44-7*
Window Open/CS-137- 90,000 cpm
Window Closed CS-137- 5,000 cpm
Window Open SR-90- 20,000 cpm

Probe Type LND 7232 *
Window Open/CS-137- 90,000 cpm
Window Closed CS-137- 5,000 cpm
Window Open SR-90- 23,500 cpm

Probe Type Technical Associates P6A*
Window Open/CS-137- 90,000 cpm
Window Closed CS-137- 7,000 cpm
Window Open SR-90- 25,000 cpm

Probe Type Vic 489-35
Window Open/CS-137- 115,000 cpm
Window Closed CS-137- 5,500 cpm
Window Open SR-90- 24,000 cpm
Note: This tube has a*VERY* thin window and is extraordinarily sensitive to Alpha particles.

Probe Type PDR27T**
Window Open/CS-137- 70,000 cpm
Window Closed CS-137- 4,000 cpm
Window Open SR-90- 12,000 cpm
Note: this tube is more rugged than most end window types, but the thicker window yields it insensitive to Alpha particles.

All the above tests ran @ 900V DC, the "standard" operating voltage of all these series of GM tubes,
except for the PDR 27 probe, which we reset the HV to 700V.
*** Even though the same tube, LND 723 used in these probes, differences in housing and screens makes reading different by a small amount. .**
****PDR 27 uses QPL 5979 tube. 700V rating.**

Easy to see why I like the Pancake probes so much. Their super sensitivity to Alpha, Beta and Gamma radiation is well balanced with a minimum of background pickup. A homemade Beta window was fashioned from 1/10" aluminum plate, but you can simply turn the probe over backwards and use the housing itself as a Beta shield.
A pressure difference of 200-220 mm of mercury exists across the mica window, the interior being of lower pressure than atmospheric. If barometric pressure changes, as in driving over mountains, or any air transportation, the window will flex just as the bellows of a barometer do.
Eventually cracks will develop in the brittle mica, causing ingress of air, which will destroy the tube. Any kind of puncture will immediately render the tube window broken as well, so

extreme caution is needed in transportation and handling. I find them reasonably rugged, and have lost only a few to pressure conditions.

These results again point out the futility of measuring radiation vs. detecting radiation. Each of the above probes is giving its own reading for a particular type of radiation, and these readings will be consistent from tube to tube, of a certain type number. Different type numbers yield vastly different readings, making quantitative measurements impossible. The only way I see to assay a sample, is to have another sample of Calibrated activity, and then you could only be sure of comparing the exact same materials.
Specifications for all the above tubes can be found at the LND site. They make the tubes used by many different probe manufacturers.
http://www.lndinc.com/product.htm

Pay attention to the Gamma Sensitivity numbers in the specification sheets and charts (also reproduced in the FILES section for selected tubes). This figure gives a clue as to how sensitive a certain tube is compared to another tube. The number indicated how many pulses you would get from a uniform flux of Cs-137 or C0-60, in counts per second/per mR/H. Multiply times 60 for CPM.
The other factor is energy response, and different tubes will respond to varying energy levels according mainly to the construction materials used, and volume of fill gas (size of tube). In general, low energy Gammas must be of sufficient strength (meaning energy level, not number of disintegrations) to penetrate the housing material. A Z number is used to indicate density of any material, based on atomic makeup. Once inside the tube, lower energy Gammas are much more likely to cause an interaction, and therefore be counted. At some point as the energy level increases, the ray will simply pass out of the tube and not be counted. These facts account for the whipsaw shape of the energy response curves of all GM tubes. External filtering may be applied to compensate for this nonlinear effect, resulting in a probe that is called" energy compensated". Be aware that this procedure knocks all the response down to the lowest level, and that although now nearly perfectly linear, such a probe will give lower reading than you may be used to from the more common "energy dependent" probes.

Making a rough estimate of activity may be found by applying this formula:
@1 meter 1Ci= .381 R

where 1uCi=10^-6 Ci

and using the inverse squared law:
@ 1/2 meter = X4
@1/4 meter = X 16
@ 1/8 meter= X64
@ 1/16 meter = X256
etc.

1 uCi is always equal to 3.7 X 10^4 DPS (disintegrations per second) or 2.22 X10^6 DPM no matter what type of radiation is involved.

http://www.sizes.com/units/curie.htm
http://www.radcon.arizona.edu/training/RSPC-CH.pdf

When the term 4Pi is used, it refers to disintegrations in all directions, as in a sphere. Most probes can only see from one direction and as such are 2Pi (1/2 of a sphere). GEOMETRY is the term used to indicate the area that the radiation fills in relation to the probe. Technically it is the angle subtended by the probe.
Best geometry is achieved if the probe is 10X its own diameter away from the source.
4Pi or near 4Pi can be achieved with hollow probes (as in WELL probes) where the radioactive sample is placed inside. Liquid scintillators are also 4Pi, as the sample is inside the liquid.

Have Fun
George Dowell