Twice Background

Radioactivity is present naturally in the environment. Therefore, when trying to determine whether human activities have resulted in an increased concentration of Naturally Occurring Radioactive Material (NORM) in an environmental sample, it is necessary to be able to subtract the 'natural' level from the sample.

This implies that for any sample producing a reading on a radiation monitoring instrument, usually in counts per second (cps), there is a level above which the sample could be regarded as possessing additional radioactivity and below this it does not possess additional radioactivity.

When using a hand-held instrument it is therefore necessary to be able set a value in terms of the instrument response (cps) as a threshold above which we would like to investigate further, perhaps sending the sample for more detailed laboratory analysis, and below which it is unlikely that the sample contains artificially enhanced concentrations of radioactivity and no further action is required.

A common threshold, above which we assume that a sample is radioactive, is taken as twice background. That is, a sample produces a reading on an instrument that is twice the background radiation level.

What is the justification for this approach?

If we take a sample of soil, radioactivity present naturally in the soil will produce N counts per second on a hand-held instrument. The standard deviation of the count rate is:

$$s = \sqrt{N}$$

We can use this and the properties of the Normal Distribution to set a threshold level.

If we take repeated the measurements (cps) from a sample, say 40 times to produce a sample of 40 measurements, we can analysis the measurement results to determine the average reading which is an estimate of the true sample mean. If we then repeat the measurement to produce 40 separate sets of 40 count rates, then we find that the 'averages' from each of the 40 sets of data will be normally distributed about the true mean.

We can then use the properties of the Normal Distribution – see figure 1 below.

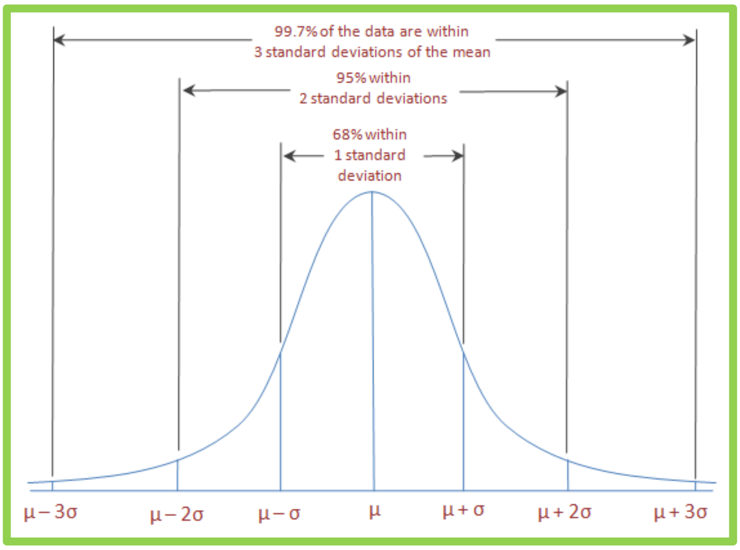

Figure 1 showing the standard Normal distribution with a mean of μ and a standard deviation of σ.

The graph shows that 99.7% of all measurements are within ± 3 standard deviations of the true mean. This means that we would expect the value of the measured cps from a sample that represented an unenhanced natural sample to be with ±3 s of the sample mean. This give a range of values and an upper level above which there is only a small probability that the sample would produce a count rate that high if it was still an unenhanced sample.

We can use our sample standard deviation, s, as an estimate of σ and the fact that $s = \sqrt{N}$ to produce a threshold value.

In relation to determining a threshold for further investigation we can use the average background figure produced by the detector and add 3 x the sample standard deviation, i.e. 3 x s.

For a typical detector looking at background gamma levels from soil, the instrument will produce a background count rate varying from around 5 cps to 11 cps. If we take the average as 9 cps, then the sample standard deviation is $\sqrt{9} = 3$ cps.

If we repeated measurement of the sample cps many times, we would expect a range of values to be produced with the upper value of:

average background (Bgnd) + 3 x s,

which equals 9 +3x3 =18 cps. This means we could expect an unenhanced sample to produce a count rate as high as 18 cps.

If the background (Bgnd) count rate was higher than 9 cps then, say 10 or 11 cps, then we start to see a widening of the gap between the twice background figure and background + 3s figure. The table below shows this slow departure.

Bgnd	**Twice Bgnd**	**Bgnd + 3 S**
9	18	18
10	20	19
11	22	21
12	24	22
13	26	24
14	28	25

The simple measure of ‘twice background’ as a decision threshold is therefore justified on a statistical basis and applies in low background situations, which is the circumstances in which a Radiation Protection Adviser would instruct it’s use. Environmental background count rates are generally low and therefore any error introduced by small differences between the two measures described above are acceptably small for this simple decision threshold.