FORMULAS

The following formulas are used in various systems manufactured by TSA Systems, Ltd. They are provided to assist in verifying system operation and to give our customers a better understanding of how the systems operate.

This is a general list, but most systems use some of these formulas.

ACTIVITY FROM COUNTS

$$\text{Activity} = \frac{\text{N}}{\text{Eff} * 37}$$

Where:

Activity = Activity in nCi
Eff = Decimal efficiency (i.e. 10% = 0.10)
N = Net counts per second (cps - background cps)
37 = bq per nCi

EFFICIENCY

$$\text{E} = \frac{\text{N}}{37 * \text{activity}}$$

where:

N = cps with source - background cps
activity = test source activity in nCi

N*Sigma Alarm Level

Used to calculate the alarm level on instruments using n*sigma alarm algorithm. Most systems that use n*sigma alarm levels operate in counts/second.

$$\text{Alarm Level} = \left(N * \sqrt{bkg} \right) + bkg$$

where:

bkg = Background counts
Sigma = 1bkg
N = N*Sigma value

RELIABLE DETECTABLE ACTIVITY (RDA) FORMULA

This formula calculates the minimum activity, in disintegrations per minute, that can be reliably detected under a given set of operational conditions.

$$F = \left(\frac{CON + \sqrt{CON^2 + 4\left(FA\sqrt{BKG} + BKG\right)}}{2} \right)^2$$

$$G = \frac{F - BKG}{CT}$$

$$RDA = \frac{2200 * G}{37 * E}$$

BKG = total background counts per count time
CON = confidence sigma
CT = count time in seconds
E = Decimal efficiency (i.e. 10% = 0.10)
F = false alarm level in cps
FA = false alarm sigma
G = intermediate variance
RDA = reliable detectable activity in DPM

SIGNAL TO BACKGROUND RATIO

The following formula is helpful in determining the optimum discriminator settings. Always perform a variance test at the final setting of the lower-level discriminator to ensure that system noise is not being introduced into the amplifier stage.

$$Q = \frac{S^2}{B}$$

where:

Q = Quality factor
S = Net signal (count with source - background)
B = Background count

Higher values of Q result in better sensitivity.

VARIANCE

The variance analyzer mode is used to check whether the counts seen by the controller are actually from the proper distribution. If the distribution approaches normal, the resulting number will approach 0. Any significant deviation from the normal distribution will result in a larger number.

The two most common problems resulting in variance failure are light leaks in the detectors, and periodic noise in the electronics. Periodic noise will result in a number of about 1, a light leak will usually result in a number larger than 2. The number displayed during a variance test is the absolute value of the average of a number of these tests, with one test being performed every nn seconds. The data is valid after three iterations of nn seconds. The pass/fail criteria varies from unit to unit and is included in the variance section of the manual on most units.

$$\overline{C} = \frac{\sum C}{N}$$

$$S^2 = \frac{\sum \left(C - \overline{C} \right)^2}{N - 1}$$

$$R = \frac{S^2 - \overline{C}}{\overline{C}}$$

$$\overline{R} = \frac{R}{I}$$

where:

C = counts per sample time

$\overline{C}$ = mean counts

I = number of iterations

N = number of samples taken

R = sample variance modified to equal 0, rather than 1, for Gaussian distribution

$\overline{R}$ = mean variance, this term is referred to as variance in TSA's manuals

S2 = sample variance