MEASUREMENT UNCERTAINTY
OR
When is a foot not a foot?

'When it's ajar', replied the prominent psychologist, casting himself from a high promontory into the sea.

As even the cat can tell, absolute accuracy in measuring anything, whilst undoubtedly a desideratum, is not often achieved. Fortunately for all of us, it is not often required, either. Varying degrees of precision are necessary, depending upon this and that and what we happen to be doing at the time; one will measure more accurately, and work more precisely, when boring out the block for his Cottin et Desgouttes than he will when making a bird-house.

Measurements can be either direct or indirect (grand revelation, this). Measuring a stick of wood with a tape is an example of the former; measuring the same stick of wood with a laser-beam reflectometer is an example of the latter (as is measuring that stick with a foot-rule, if the stick is several feet long). In all cases there is a certain degree of uncertainty involved.

All it means is:
If you measure something indirectly (such as temperature with a 191 instead of a thermometer) there are several error sources. In this example, in the second, or simple, case there is one error source: the thermometer itself.
In the first case, there are three error sources: the thermocouple, the circuitry converting thermocouple millivolt output to a number to be displayed, and the digital readout displaying the number. (The circuitry can be, and probably is, subdivided into other and smaller error sources.)
So, if each error is equally probable as it will be in this simple case:
Assume the following limits for the components:
Thermocouple, ± 10%
Conversion circuitry, ± 2%
Readout, ± (one least significant digit)

The measurement inaccuracy is the root sum square of the above, or the square root of (.1 x .1) (.02 x .02), plus one. That works out to be .102, or 10.2%, plus one.

Why root *sum* square? Because in a random application it is more likely to be so than root *mean* square. That's why.

Nuf sed.

I remember when tosh like this was all the rage amongst the reliability weenies. They had to prove that their blathering had a 'scientific' background, when all they ever had to go on was by guess and by God, and not much God, and whatever experience they may have had scraping barnacles off hulls.

For those of you who wish to pursue the subject further, and there may be some, we offer a few subjects for googling. The following definitions come from the government and/or academia and are therefore suspect:
Uncertainty of measurement: A parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

- The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence.
- Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of a series of measurements and can be characterized by experimental standard deviations. The other components, which also can be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information.
- It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic

effects, such as components associated with corrections and reference standards, contribute to the dispersion.

Standard uncertainty: The uncertainty of the result of a measurement expressed as a standard deviation.

Type A evaluation of uncertainty: A method of evaluation of uncertainty by the statistical analysis of series of observations.

Type B ditto: A method of evaluation of uncertainty by means other than the statistical analysis of series of observations.

Combined standard uncertainty: The standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighed according to how the measurement result varies with changes in these quantities.

Expanded uncertainty: A quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand.

- The fraction may be viewed as the coverage probability or level of confidence of the interval.
- To associate a specific level of confidence with the interval defined by the expanded uncertainty requires explicit or implicit assumptions regarding the probability distribution characterized by the measurement result and its combined standard uncertainty. The level of confidence that may be attributed to this interval can be known only to the extent to which such assumptions may be justified.

Coverage factor: A numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty.