ANS Issues Clarification on ANSI/ANS-2.5-1984, "Standard for Determining Meteorological Information at Nuclear Power Sites."
(*Nuclear News,* April 2001)

Inquiry:

We are using Section 6.1, "System Accuracy," of ANIS/ANS-2.5-1984 to meet the requirement set forth in Regulatory Guide 1.23 for system accuracy. The second paragraph of Section 6.1 discusses "time-averaged values" and being able to divide the "instantaneous values by the square root of the number of samples used." It goes on to say, "The RSS calculation can then be made." I would really appreciate an explanation of what these two paragraphs in Section 6.1 mean. I have not found any place where the error or accuracy of equipment can be divided by the square root sum of the square calculation. It would seem that all one would have to do to increase the number of samples taken. That does not seem to be correct, so I am confused.

I would very much like to see a write-up on the two paragraphs, and if possible, the proof of these statement, including an example of how they can be used for calculating the system accuracy for a meteorological system. I have discussed this matter with other engineers, both at my plant and at others, and have found no one who can explain, with confidence, what the paragraphs mean.

Response:

This response addresses the assertion contained in ANSI/ANS-2.5-1984 that those parts of the total error that are random can be from their instantaneous value by dividing by the square root of the number of samples used to define time-averaged values. This technique is pertinent because meteorological monitoring systems within the nuclear industry rely on the compilation of time-averaged values from a series of individual readings. This response does not address the use of RSS method to calculate system accuracies for individual readings or observations because this technique is standard industry practice.

Every reading or observation is subject to certain errors that can be classified into systematic (i.e., bias) errors, random errors, or mistakes. For the purposes of this discussion, all errors of observation are assumed to be random and independent.

Visualize a large number of temperature readings or observations taken during a period of time during which the true temperature can be regarded as constant. Every observation can be regarded, statistically, as a specimen drawn from an infinitely large "population." All the observations are measuring the same phenomenon, but since each observation is subject to certain errors, their readings will not be identical. Each reading represents a "sample" drawn from the entire populations of readings. It is common experience that when an observation of a continuous variable is repeated independently a number of times, the various readings are not identical. Each observation is subject to a number of small errors, any one of which is likely to be positive as negative, due to a variety of unrelated causes. Over the whole series of observations, positive and negative errors will tend to cancel out, and the most probable value of the true temperature is the mean of all the readings. With one observation, negative errors may predominate and the actual reading may be lower than the mean; with a second, positive errors may predominate; with a third, positive and negative errors may be equal and the reading may be correct. A sample can give an approximate estimate of the character of the population only, but this estimate of the character of the population only, but this estimate will be more accurate with a large sample.

Any sample mean M can be considered an estimate of the population µ. The difference between the mean of a particular sample and the population mean is said to be a random error, or sampling error. The complete collection of factors that could explain why the sample mean differs from the population mean may be unknown, but can be conveniently lumped together and referred to as a random error. Random errors are those that arise from the difference found between the outcomes of trials, or samples, and the corresponding universe value using the same measurement procedures and instruments. The sizes of the difference are indications of reliability or accuracy.

A measure of the spread of M values around µ is given by the standard error of the mean, ç$_{M,}$ given by:

Equation:

Where *(symbol)* is the population standard deviation (or, in our case, the uncertainty associated with each observation) and n is the sample size. In other words, *(symbol* µ) is a measure of average sampling error in that it measures the amount by which M can be expected to vary from sample to sample. Another interpretation is that *(symbol* µ) is a measure of accuracy with which µ can be estimated using M.

Random errors decrease on the average as sample size n is increased. Therefore, a larger sample size is preferred to a smaller one, all other things being equal; that is, since sampling errors are on the average smaller for larger samples, the results are more reliable or more accurate. The fact that *(symbol* µ) varies inversely with the square root of sample size n means that there is a diminishing return in sampling effort. Quadrupling sample size only halves *(symbol* µ); multiplying the sample size by nine cuts the standard error only to one-third its previous value.

Much of the material presented in this response was extracted from two sources: *Handbook of Statistical Methods in Meteorology* (Reference 1, Chapters 1.3, 1.4, and 7.2) and *Statistical Analysis for Decision Making* (Reference 2, Chapters 4.4 and 5.5).

A more complete example of how ANSI/ANS-2.5-1984 Section 6.1 methodology can be used to calculate meteorological system accuracies is given in “A Methodology for Calculating Meteorological Channel Accuracies” (Reference 3).

References

1. Brooks, C.E.P., and M. Caruthers, *Handbook of Statistical Methods in Meteorology,* London: Her Majesty’s Stationary Office, 1953.
2. Hamburg, Morris, *Statistical Analysis for Decision Making,* 2nd ed. New York: Harcourt Brace Jovanovich, Inc. 1977.
3. Harvey, R. Brad, Nancy Nowlan, and Louis Chairizia. “A Methodology for Calculating Meteorological Channel Accuracies.” Nuclear Utility Meteorological Data Users Group Meeting. Syracuse, 12-14 May 1999.