STATISTICS AND WEATHERING

Using statistics in your weathering or corrosion test program will greatly increase the reliability and usefulness of the results obtained. A basic understanding of statistics is required for the study of weathering performance data. Statistics must be included in the process of decision making. In weathering, there are a great many uncertainties brought about by variability, method precision and bias, and evaluation. Statistics are used to decide which product is better, which test method is more realistic, and how reliable are the results.

The numerical data derived from testing is the raw material from which interpretations, analyses, and decisions are based, and it is essential to know how to extract usable information from such data. The major objective for statistics is to help determine a satisfactory outcome of the test. Many extensive test programs have ended with unhappy consequences because the results were not sufficient to make a decision one way or the other.

In weathering, the objective of getting a useful result is met by applying a conscious effort at statistical control at three distinct stages of the test process.

1. **TEST PROGRAM DEVELOPMENT**

It is important to remember statistics when designing the test program. This will determine:

* How many specimens to test
* How many replicates required
* Length of exposure and number of intervals
* Determination of test end point
* Testing goals and objectives

To achieve results which allow for ability to make a decision outlined by the objective, it is necessary to have a test program which meets certain minimum requirements. Because of the large variability associated with weathering tests, a simple goal of comparing the performance of one material versus another still requires a number of replicates and exposure periods, to allow for statistical comparison and therefore, decision making.

2. **STATISTICAL PROCESS CONTROL**

During test operation it is good practice to monitor the progress by logging the important conditions of influence. This will ensure that the test method has been conducted according to the desired protocol. Tolerances for upper and lower limits within which the test must proceed are charted on a regular basis. This can be weather data for outdoor tests, reference materials data, irradiance levels, temperature, etc.

When the test is completed, the control charts will contain useful information for comparing the relative performance of the material when exposed to those factors of influence.

3. **INTERPRETATION AND ANALYSIS**

This is by far the most recognized use of statistics in weathering. Statistics are employed to compare materials performance: to decide the better candidate, and to determine end use longevity. It is also possible to improve the test protocol by picking out areas which cause the greatest variability, and how to reduce them.

There are a number of statistical methods which can be used to study weathering data. These methods fall into two major categories, depending upon what type of information they require in order to work.

PARAMETRIC statistics require an assumption that the sample data is from a population that has a normal distribution of values, and a given standard deviation.

NON-PARAMETRIC statistics need no assumption about the distribution of the values. These methods are simpler, easier, and less efficient. Non-parametric statistics sometimes carry a stigma that they are not rugged enough and therefore any decisions made are not reliable.

Inference tests include the use of the "null hypothesis", which is a test that is either accepted or rejected. The usual null hypothesis in weathering states that “there is no difference between two sets of data”. Our statistical test is used to see if we can reject the null hypothesis, and therefore find that there is a difference. This is usually done by comparing the mean (average) value of two sets of data, or studying the deviation and distribution of the data.

The Coefficient of Correlation is a measure of the relationship between two variables. The proportion of the total variation of one set of data (y), that can be attributed to its relation to any other factor (x). The coefficient is given a value r, and is a ratio of the variation being examined to the total variation. Its value will always lie between -1 and +1. This value is one of the most widely abused of statistical measures. The value r measures only linear relationships; in weathering, most variables are not linear. This value does not necessarily imply a cause effect relationship.

I trust two very simple yet powerful statistics for use on weathering data. One is used to compare directly two sets of specimens (1), typically a reference material (or control specimen) and the new or experimental specimen. The other statistic is used to see if two different test methods produce comparable data (2).

(1) The student T test can be used to definitively say “yes, these products/materials are different” or show that any changes are actually just random variability/
(2) The rank correlation statistic is used in weathering to verify that an accelerated test is accurate by comparing the results to an outdoor test, usually Florida.

I have a statistics template in Excel spreadsheet form for use with either of these examples above. Simply enter your data into either worksheet and the results will be right there for you to make your decision. You can find that in the TOOLS section on BENCHMARK at www.bestweathertest.com

Statistics are a valuable tool in weathering studies, and correct use can improve the results obtained from tests. A basic knowledge of statistics is vital for designing test programs, and interpreting test results. I would recommend reading ASTM G169 Basic Statistics, for more information.