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MEASUREMENT SYSTEMS ANALYSIS IN PROCESS INDUSTRIES

To evaluate the adequacy of a measurement system with regard to measurement variability, the standard tool such as the gage R&R study is used. While it is well established and widely used in the discrete manufacturing industry, it is less useful in process industries where the nature of measurements is different, necessitating a different approach to the assessment of measurement systems in these industries. A measurement system, as defined in a gage R&R, consists of a number of operators using a number of gages to measure parts in accordance with some defined procedure. A gage R&R partitions the total measurement variation into the following categories: 1. Gage-to-gage, 2. Operator-to-operator, 3. Replicate-to-replicate, 4. Part-to-part.

The first three categories of variation comprise noise (i.e., undesirable measurement variation), while the fourth category of variation is the quantity that needs to be determined accurately. In general, the desire is that the part-to-part variation is large relative to the sum of the other three categories of variation so a Six Sigma practitioner can be confident of discerning the true part-to-part variation without being swamped by the measurement noise.

The gage R&R thus enables the analyst to assess the ability of the measurement system to discern a within-specification part from an out-of-specification one and to take the appropriate corrective action when necessary. It is the appropriate tool to use when the measurement system is employed in inspecting discrete parts off a production line for conformance to specifications.

In process industries, however, the premise on which the gage R&R is based is not applicable to the many gages that are employed to perform on-line measurements. A typical example from the mining industry would be the belt scale– a gage mounted under a conveyor belt to measure the mass flow (tons per hour) of material being processed. The scale is an automated device producing a continuous measurement that is sampled by a computer. There is typically only one scale at each measurement point in the system and no operator involvement is required to produce a measurement. As a result, gage-to-gage and operator-to-operator variations are non-issues, making it unnecessary to partition the total variation into its various components as with a conventional gage R&R. In the case of an on-line measurement, analysts are interested in two questions:

1. With the measured value of a physical quantity by the gage, what is an estimate of the true value?

2. What is an estimate of the uncertainty or confidence interval around the estimated true value?

In order to answer these two questions, the total measurement error of the gage needs to be partitioned into its systematic and random components. Mathematically, the systematic-error component is characterized by a deterministic function while the random-error component is characterized by its variance. The former enables the analyst to estimate the true value from the measured value while the latter allows the establishment of a confidence interval around this estimated true value.

A process MSA is essentially a special case of a single-factor experiment in which a model equation for the relative output of the process, $(X_M - X_T)$, in relation to its input (X_T) is trying to be established. All the usual precautions of normal experimentation, such as randomization, apply here as well. The MSA is as much an art as a science and requires no small degree of skill and judgment as well as a combination of mathematical, technical and practical knowledge to execute well.