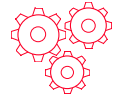




The Blacksmith's Anvil



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ACCURACY AND PRECISION

Look over the shoulder of hunters as they take their trusty rifle to the local shooting range during the weeks before they commence their annual pilgrimage as deer hunter. You'll quickly observe the art of hitting the bulls-eye of a target is not an inherited trait passed along through the genes of modern man. Aspiring Nimrods take a shot or two and then adjust their rifle shots as they scatter lead over the target and miss the bulls-eye. They foolishly chase unknown problems until their shoulders are raw and their wallets empty while blaming their problems on the rifle, ammunition, wind, etc. Amateurs can't fix their problems of accuracy and precision as can marksmen:

Accuracy is how close you group your shots to the center of the bulls-eye. Accuracy is conformity to the true value of the standard. Accuracy avoids bias with calibration or adjustment corrections.

Precision is how close you group your shots together. Precision measures scatter among measurements. Precision is the small random error of individual attempts, which are uncorrectable by calibrations or adjustments.

Repeatability is how well you repeat the results each time with the same rifle, ammunition, etc. Repeatability is closeness of agreement between successive results using the same method, same operator, same materials, etc.

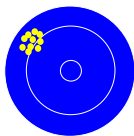
Reproducibility is how well another person uses your rifle, ammunition, etc. Reproducibility is similar to repeatability using identical materials but under different conditions such as different operators, different times, etc.

Wise Nimrods make three to five shots before they analyze their problems. If the problem involves accuracy, they adjust sights on the rifle. If the problems involves precision, they don't adjust sights but work on the assignable problems within the process of shooting their rifles. Then they repeat the study sequence with three to five more shots followed by specific revisions for fixing specific problems. Wise Nimrods separate chance events involving precision from assignable causes involving accuracy. When they have solved the correct problems, then they work on repeatability in their shooting. You can't adjust rifle sights to correct precision problems. *Knowing differences between accuracy and precision lets you fix specific problems correctly the first time.*

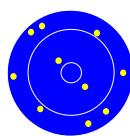
Machine operators have the same problems as aspiring Nimrods. They must understand the separate concepts of accuracy and precision so they make machine tool adjustments correctly. We calibrate (reduce the bias) measuring instruments as we make accuracy corrections. However, inherent precision (scatter) of the measuring instrument is built into the measuring process which involves the person, procedure, instrument, etc. Knowing the differences between accuracy and precision helps speed set-ups, reduces times lost for unnecessary adjustments, and reduces scrap by not hitting the bull's-eye of conformance. *Precision problems arise from randomness in every measurement and every manufacturing activity. Accuracy problems arise from errors in the aim point.*

The randomness of precision problems causes confusion as operators ask: Is this an accuracy problem? Is this a precision problem? These questions delay making the correct decision about altering the process to control the machine to achieve conformance. Solving the precision problem requires control of many small errors to make the scatter small. Solving the accuracy problems requires knowing the aim point and adjusting the aim point so that it is near the mid point of the tolerance. ***The bull's-eye for manufacturing is the middle 1/4 of the tolerance zone.*** The key to success is simple. *First, aim for the bull's-eye. Second, control scatter in the measurements.* It is easy to say but hard to do. Compare target examples below to understand the difference between accuracy and precision.

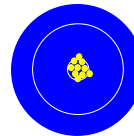
Accuracy and Precision is: Setting priorities for problem solving and understanding the scatter in measurements. Accuracy and precision separates a craftsman's skill from the amateurs excuses. Nimrods and machine operators keep their shots in the bulls-eye. Hitting the bulls-eye every time provides jobs and security for you and me.



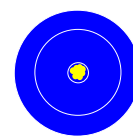
Precise but not accurate



Accurate but not precise



Accurate and precise



Accurate and very precise