

Youden PT Analysis¹ Supplement for OWM PT Reports

Description of the Analysis

The Youden analysis is an assessment of paired data – either from two measurements of the same nominal value made at the same or different times, two measurements of the different types of standards to evaluate and compare operating characteristics and consistency, or from duplicate measurement procedures to evaluate and validate measurement processes.

The graphical presentation includes the following components (See Fig. 1):

- The data are graphed in a scatter plot with one data point on the X axis and the other data point on the Y axis.
- The data are evaluated against the mean or the median values. Median values minimize the effect of extreme data points.
- A 45-degree line, intersecting with the mean or median (as determined) provides a reference for systematic offsets from the selected mean/median value.
- A circle around the selected mean/median represents 2.45 times the standard deviation of the systematic errors to represent approximately 95 % of the measurement results.
- Quadrants are identified as I, II, III, and IV starting at the top left of the graph moving clockwise, with quadrant I in the upper left portion of the graph.

Graph Components and Quadrants

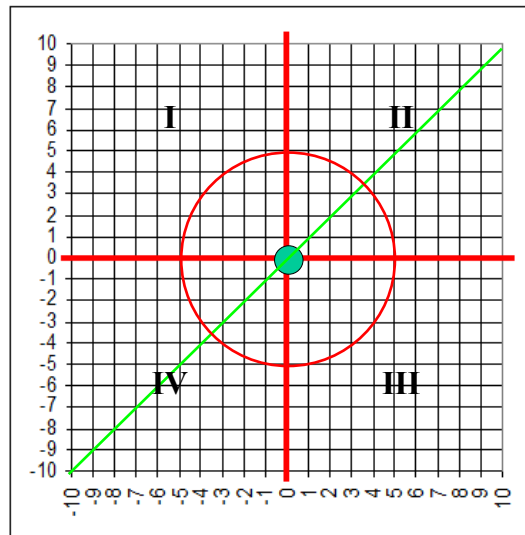


Figure 1. Graph Components and Quadrants.

Observations of paired data:

- Measurement results with ZERO systematic and ZERO random components will be located in the center of the circle at the intersection of the X and Y axis inside the circle.

¹ For more information: Graphical Diagnosis of Interlaboratory Test Results, W. J. YOUDEN, National Bureau of Standards, Washington, D. C. (Reprinted from INDUSTRIAL QUALITY CONTROL, Vol XV, No. 11, May 1959). Posted on the OWM website: <https://www.nist.gov/pml/owm/laboratory-metrology/proficiency-testing>

- Measurement results with ZERO random components and some level of a systematic offset will be located along the 45-degree diagonal line on the chart in quadrants II and IV.
- Measurement results in quadrants I and III show greater random variability, indicating less consistent reproducibility between the paired measurement results.

The calculations include the following:

- Mean, median, standard deviation, adjusted mean, median, and standard deviation when not including values outside of the two standard deviation limits are all calculated using the using calculations, with the sample standard deviation. The “Youden standard deviation” that is presented on the graphs represents the compiled standard deviation of the mean (or median) values for all paired values. The standard deviation of the mean (or median) is generally smaller than the standard deviation of the PT data as it represents the value that is used as the PT mean/median. The combined standard deviation of the mean is used to calculate the diameter of the circle on the graph (representing 2.45 times the value for 95 % representation of the data).
- The error of each pair of measurement results is mathematically calculated with total magnitude of error that is then separated into systematic and random components using equations for a right triangle formed between the center point (mean or median), the paired set of data, and the intercept of the paired data at a 90-degree angle to the diagonal line. See Fig. 1 and Fig. 2.

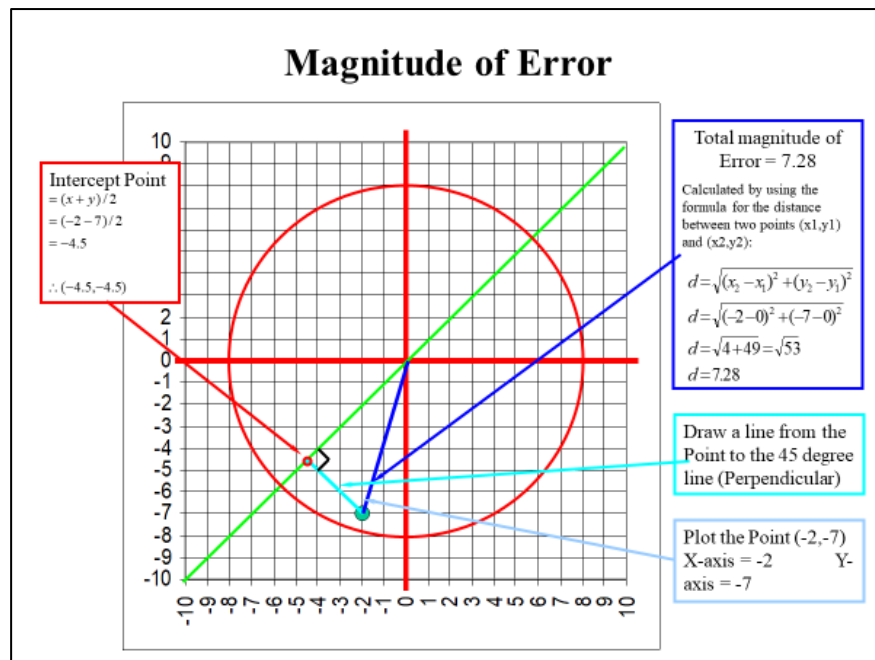


Figure 2. Calculating the Magnitude of Error for Paired Data.

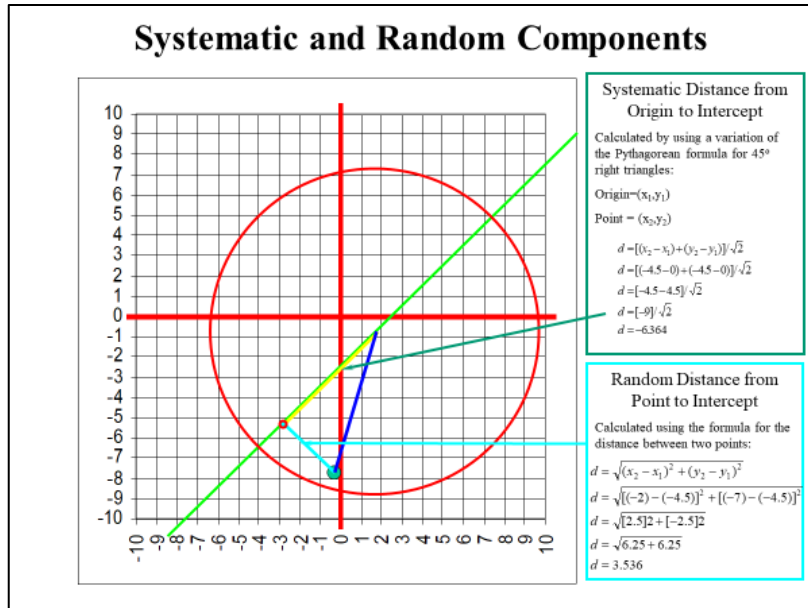


Figure 3. Calculating the Systematic and Random Components.

Cautions with the Youden analysis:

- The analysis includes all entered data points and does not allow for deselection of multiple results from a single laboratory. Thus, a laboratory with 3 or 5 staff members will tend to bias the overall statistics over all other laboratories with only 1 staff member. If all laboratories have the same number of staff or only “official” values (1 per laboratory) are included, the analysis will be more statistically valid. Preselecting data points requires prior analysis.
- The Youden analysis does not graph or analyze uncertainty values or calculate the effect of uncertainty on the random and systematic calculations (or vice versa). Therefore, it is similar to the simple “Difference” or “Z score” from the other OWM PT analyses where the uncertainty of the reported results must be used to evaluate the random or systematic effects. E.g., a laboratory may have submitted an uncertainty that is much greater than the limits shown on the graph, in which case, the observed error in the graph and random and systematic components may not be critical.

Advantages of the Youden analysis:

- Unlike the usual PT analysis where each point is graphed and analyzed individually, the paired assessment allows for evaluation of consistency and reproducibility. It allows evaluation of consistent observed differences (bias) that are observed in the systematic error. It allows for evaluation of consistency or inconsistency in reproducibility of measurement results from multiple calibrations, multiple standards, or alternative procedures, where the random error shows the inconsistency.