Quality Corner

HACH

Quality assurance program—Control and evaluation of the testing

Measuring precision

Precision measures how well the test results can be reproduced. A series of measurements on the same sample for the same parameter are compared to the average measurement. Remember that it is possible to produce test results with high precision but low accuracy. The most commonly used estimates of precision are the *standard deviation (SD)* and the *relative standard deviation (RSD)*. RSD also is known as the *coefficient of variation (CV)*.

Calculating a standard deviation

Many electronic calculators have statistical capability programmed in so that calculating a *SD* is as simple as entering the data and pressing the appropriate keys. The formula for the *SD* calculation is as follows:

$$SD = \sqrt{\frac{\sum X_i^2 - \frac{(\sum X_i)^2}{n}}{n - 1}}$$

WHERE
SD = the standard deviation
$\sum X_i^2$ = sum of the squares of the individual measurements
$\sum X_i$ = sum of individual measurements
n = number of individual measurements

Example 1: A series of replicate analyses on an effluent sample yielded 10.5, 11.7, 12.6, 9.8 and 11.4 mg/L total suspended solids (TSS).

X_i	X_i^2	$(\sum X_i)^2$
10.5	110.25	$(56)^2 = 3136$
11.7	136.89	
12.6	158.76	
9.8	96.04	
11.4	129.96	
56.0	631.90	

The sum of X_i = 56. The sum of X_i^2 = 631.90. n = 5.

$$SD = \sqrt{\frac{631.9 - \frac{3136}{5}}{5 - 1}}$$

$$SD = \sqrt{1.175} = 1.08 \text{ mg/L}$$

The standard deviation measurement has a size or magnitude dependent on the size or magnitude of the data. For example, a TSS measurement for a wastewater influent would be much larger than a TSS measurement for an effluent. Therefore, a *SD* precision measurement for an influent would be much larger than a *SD* precision measurement for an effluent.

Example 2: A series of replicate analyses on an influent sample yielded 245, 230, 255, 247 and 253 mg/L total suspended solids (TSS).

X_i	X_i^2	$(\Sigma X_i)^2$
245	60025	$(1230)^2 = 1512900$
230	52900	
255	65025	
247	61009	
253	64009	
1230	302968	

The sum of X_i = 1230. The sum of X_i^2 = 302968. n = 5.

$$SD = \sqrt{\frac{302968 - \frac{1512900}{5}}{5-1}}$$

$$SD = \sqrt{97} = 9.85 \text{ mg/L}$$

The different size or magnitude of the measurements for example 1 and example 2 gives *SDs* that cannot be compared (1.08 mg/L vs 9.85 mg/L). Calculating an *RSD* (or *CV*) solves this problem by expressing the sample variability as a percentage relative to the average measurement.

Calculating a relative standard deviation

The formula for RSD (or CV) is:

$$RSD = \frac{SD}{\bar{x}}$$

WHERE
RSD = the relative standard deviation
SD = the standard deviation
$\bar{x}$ = the mean or average value of the measurements

Using the values from example 1, we get:

$$\bar{x} = \frac{56 \text{ mg/L}}{5} = 11.2 \text{ mg/L}$$

$$RSD = \frac{1.08 \text{ mg/L } (100\%)}{11.2 \text{ mg/L}}$$

$$RSD = 9.6\%$$

Using the values from example 2, we get:

$$\bar{x} = \frac{1230 \text{ mg/L}}{5} = 246 \text{ mg/L}$$

$$RSD = \frac{9.85 \text{ mg/L } (100\%)}{246 \text{ mg/L}}$$

$$RSD = 4.0\%$$

Comparing precision measurements

The *RSD* gives a percentage value with no units of measurements (notice that mg/L cancels out in the formula). The smaller the value, the higher is the precision of the measurements. The *SDs* are now expressed in a form relative to the average size of the TSS measurements. When the precision of the effluent TSS measurements (9.6%) is compared to the precision of the influent TSS measurements (4.0%), it can be seen that the precision for the influent measurements was approximately twice that of the effluent measurements.

HACH COMPANY
P.O. Box 389
Loveland, Colorado 80539
Telephone: 970-669-3050
Toll-Free: 800-227-4224
Fax: 970-669-2932
Telex: 160840

Lit. No. 6123
Printed in U.S.A.

Reprinted from February 1992 *News & Notes.*