
MEMORANDUM

TO: BARYOHAY DAVIDOFF AND MANUCHER ALEMI
FROM: JULIET CHRISTIAN-SMITH
SUBJECT: STATISTICAL METHODS TO ASSESS DEVICES IN-FIELD
DATE: 9/29/2011
CC: DAVE CEPPPOS

I have been asked to provide language on the statistical methods to assess measurement devices in-field. Section 597.5 of the draft regulation reads:

“d) Existing device or type of device – for compliance under section 597.3 (a) above (measurement at the points of delivery to customers), field testing of a statistically representative sample of existing device types or of an individual device shall be performed by individuals trained in the use of field testing equipment. It is recommended the sample be no less than 10% of existing devices but not to exceed 30 individual devices for any particular device type...”

There are several problems with this draft text. First, the term “statistically representative sample” is not defined, and according to staff cannot be defined without knowing the mean of the entire population. It is therefore relatively unhelpful to water managers. Second, a sample size of 10% of devices may be excessive if the standard deviation amongst measurement devices is small or inadequate if the standard deviation is large. In addition, stating that no more than 30 individual devices should be assessed has no statistical or rational basis. It may have an economic basis, but section 10608.48 of the Water Conservation Act of 2009 clearly separates water measurement and pricing out as mandatory efficient water management practices, not subject to cost-effectiveness.

This part of the regulation provides an opportunity to set up statistical procedures that will help the Department to understand the quality of the data that is being reported. The regulation should require a randomized sample, and the guidelines should set out a clear method for simple random sampling (using a random number generator). In addition, the regulation should describe a clear, statistically-based method for water managers to determine appropriate sampling sizes that will ease and improve implementation.

In order to comply with this regulation, water managers will need to conduct tests of water measurement devices by comparing readings taken by a water measurement device of unknown accuracy with a reference measurement device of known accuracy. Water managers will then need to report on the difference between the two measurements

(or error). While ideally the difference is 0, the draft regulation allows a variation of +/- 10% for devices tested in-field.

After several devices are tested, the water manager can calculate the mean and standard deviation of the sample (s). The regulation should then require water managers to use a statistical approach to determine the appropriate number of additional samples required to achieve a statistical power of at least 80%. Statistical power is the probability of rejecting a null hypothesis when it is indeed false and should be rejected, it is also known as a type II error. Power is particularly important in quality assurance/quality control settings because it reduces the likelihood of accepting a bad product or bad data. In so doing, the likelihood of rejecting a good product or good data slightly increases. However, that is considered a preferable risk. The equation to estimate the required sample size to test the null hypothesis is:

$$\text{number in the sample} = \frac{(s)^2}{(\text{minimal detectable difference})^2} \times (t_{(\alpha, \text{degrees of freedom})} + t_{(\beta(1), \text{degrees of freedom})})^2$$

Notes on the equation:

*minimal detectable difference should be calculated to reflect +/-10% of your sample

**alpha should be .05 (95% confidence)

***since degrees of freedom are dependent on number in the sample, this equation is iterative

Equations and examples could be provided in the guidelines that will accompany the regulation.

Therefore, I suggest the following text:

*“d) Existing device or type of device – for compliance under section 597.3 (a) above (measurement at the points of delivery to customers), field testing of a **randomized sample** of existing device types or of an individual device shall be performed by a **Professional Engineer**. The sample size will be determined by water suppliers in order to achieve a **statistical power of at least 80%**. **Information about the individual measurement devices tested should be reported, including locations, types, date tested, test method, and the device error as both an absolute number in original units and as a percentage of the reference reading.**”*