



ASHRAE GUIDELINE

Engineering Analysis of Experimental Data

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(This foreword is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

FOREWORD

Guideline 2 was originally created from the material contained in ASHRAE Standard 41.5-75, Standard Measurement Guide: Engineering Analysis of Experimental Data, when it was published in 1986 and reaffirmed with minor editorial changes in 1990 and 1996. Because technology and use of computer programs has increased significantly since 1986, Guideline 2 has been revised to provide a greater focus not only on the analysis of the data but also on how to collect the data to ensure proper analysis. The scope of this guideline is therefore expanded to include engineers and technicians who collect, analyze, and report information on systems covered in ASHRAE standards and other publications.

Although statistics are important in this context, this guideline should not be considered a comprehensive statistical text. An attempt has been made to provide sufficient background and references for the statistics used in this guideline.

1. PURPOSE

The purpose of this document is to provide guidelines for planning, analyzing data, and reporting the uncertainty of experiments.

2. SCOPE

Appropriate terms are defined and statistically based procedures and formulae are recommended for evaluating experimental data related to heating, ventilating, air-conditioning, and refrigeration (HVAC&R). Numerous examples are provided to illustrate analysis of experimental data.

3. DEFINITIONS

accuracy: the difference between a measured value and the true value. The degree of inaccuracy is known as total measurement error and is the sum of bias error and precision error.

bias, fixed, or systematic error: an error that persists and is usually due to the particular instrument or technique of measurement.

confidence level: the probability that a stated interval will include the true value. In analyzing experimental data, a level of 95% is usually used.

confidence limits (used for multi-sample data) and **uncertainty interval** (used for single-sample data): that range of values that can be expected, given a stated probability, to include the true value. For example, a statement that the 95% confidence limit is 5 to 8 means that there is a 95% probability (19 chances out of 20) that the interval between 5 and 8 will contain the true value.

data: information obtained by experimental means, assumed to be in numerical form; recorded values of the variables; readings.

deviation: the difference between a single result and the mean of many results.

error: the difference between the true value of the quantity measured and an observed value. Since the true value is often not known, it is estimated by the mean. The difference between the mean and an observed value is often called its deviation.

experiment: a systematic approach for collecting information on a physical apparatus or system to determine the nature of its operation.

mean: the sum of measurement values divided by the number of measurements. It is considered the best approximation of the true value.

parent population: synonymous with population but emphasizing the relation to a sample.

population: any finite or infinite aggregation of items or individuals (inanimate or animate).

precision: the ability to consistently reproduce measurements of outputs for a given system state (inputs).

propagation of uncertainty: the degree to which the uncertainties in the values of the parameters affect the uncertainty in the result.

random error (or precision error): an error that is due to the unpredictable and unknown variations in the experiment and that causes readings to take random values on either side of some mean value. Measurements may be *precise* or *imprecise* depending on how well an instrument can reproduce the subsequent readings of an unchanged input. There are two types of random errors:

- *additive* errors that are independent of the magnitude of the observations
- *multiplicative* errors that are dependent on the magnitude of the observations

repeatability: the ability to obtain the same observed value in repeated experiments. Lack of repeatability is commonly associated with precision error, the random component of the total error.

replication: repetitions of measurements at the same conditions that are taken to estimate the uncertainty in the results.

sample: a portion, subset, or limited number of items of a population; a set of values, experimentally obtained, that is representative of the parent population.

standard deviation: the square root of the mean of the squares of the deviations.

uncertainty: a measure of the error in a measurement or experimental result that reflects the lack of confidence in the result to a specified level.

uncertainty range (or **confidence interval**): the band for the error in an estimate at a certain confidence level. The greater the acceptable confidence level (e.g., 95% rather than 50%), the wider the uncertainty range.

variance: the square of the standard deviation.