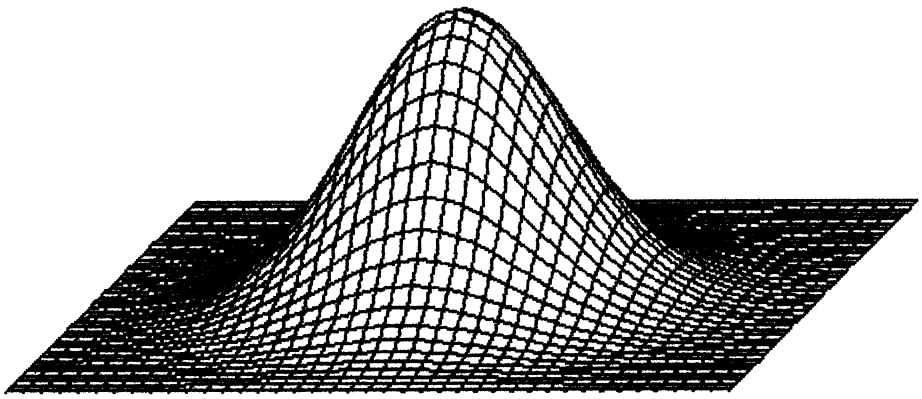
Indeterminate Measurements



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Hypothesis

Many measurement applications in today's high tech world require the use of indeterminate measurements, which can be as important and accepted if performed properly.

Objectives of this term paper:

- Define and explain the importance of indeterminate measurements.
- Identify several important indeterminate measurement applications.
- Explain how these indeterminate measurements can be made acceptably.

Supporting Data/discussion

Defining Indeterminate Measurement

Random House Webster's dictionary defines in-de-ter-mi-nate [1](in di tûr'muh nit) adj.

1. Not precisely fixed or determined; indefinite; vague.
2. Not settled in advance.
3. Having an infinite number of solutions.
3. Math: a. (of a quantity) undefined, as 0/0.
   b. (of an equation) able to be satisfied by more than one value for each unknown.

Where calibration is concerned, indeterminate measurements are those measurements where an evaluation of error in that measurement cannot be evaluated by any logical process and cannot be compared to a higher authority. These errors are generally known to exist by inference and are called systematic errors. Systematic errors that cannot be

[1] Random House Webster's dictionary, (G.& C. Merriam Co., 1973), 579

determined via a logical process such as repeated measurements but that can be evaluated by comparing them to a higher authority, is calibration[2].

Measurement Criteria

We have established that whether systematic error in linear measurement is determinate or indeterminate depends on whether there is a standard available for comparison. We also have established that indeterminate measurements can be made using calibrated instruments but where only a statistical approach will suffice due to the error in the measurement not being able to be evaluated by any logical process. However, we also know that the standard available for comparison should follow the ten-to-one rule (standard 10x more accurate than the part) to provide less than 1% instrument error. In addition, in an actual instrument, the zone of uncertainty should be no more than one quarter of a division to provide less than 1% measurement error based on 3 sigma uncertainty of repeat error[3]. Therefore, the lack of these calibration criteria is also a form of indeterminate measurement criteria. Measurement criteria that may apply to both calibrated and indeterminate measurements are (1) selection of appropriate standards and measuring equipment, (2) identification of equipment used and area measured, (3) training and qualifications of personnel, (4) documented calibration procedures, (5) tool and gage controls, (6) maintenance, modification, storage, and handling of equipment[4].

Undesired Indeterminate Measurement

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[2] Ted Bush, Roger Harlow, Richard Thompson, *Fundamentals of Dimensional Metrology* (Delmar Publishers, NY: 1998), 305.
[3] Ted Bush, Roger Harlow, Richard Thompson, *Fundamentals of Dimensional Metrology* (Delmar Publishers, NY: 1998), 271
[4] James L. Bossert, *Procurement Quality Control* (ASQC Quality Press, 1988), 181.

Undesired indeterminate measurement applications stem from linear measurement applications where comparison to a higher authority is desired but not possible or where systematic error cannot be determined via a logical process due to the following[5]:

- ***Bias***: the tendency to see problems and solutions from one's own viewpoint.
- ***Non-comparable data***: data that come from two populations but are erroneously considered to have come from one.
- ***Uncritical projection of trends***: the assumption that what has happened in the past will continue into the future.
- ***Causation***: the assumption that because two variables are related, one must be the cause of changes in the other.
- ***Improper sampling***: the use of an erroneous method for gathering data, thus biasing results (for example, using electronic mail surveys to get opinions from a population having few individuals with electronic mail services).

Desirable Indeterminate Measurement

Desirable indeterminate measurements stem from applications where complicated interactions apply or where the measurement itself approaches the accuracy of the standard. These measurements are not compared to a higher authority but to themselves via statistics in order to provide acceptance. In other words, rather than stating the measurement with tolerance, the measurement is stated with statistical confidence of being correct. Examples of desirable indeterminate measurements are as follows:

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[5] James Evans, William Lindsay, *The Management and Control of Quality*, (New York; West Publishing Company, 1996), 608

- **Complicated process applications** where indeterminate statistical measurements can provide confidence in output or directional input for improving the output. Interaction effects most commonly complicate these applications.
- **Precision material or chemical measurement applications:**
  1. Where the material to be measured has no distinct start and end. For example, thin film measurements where a few angstroms of one material have been chemically bonded to another material and the bond zone has no distinct start and end. Auger measurements are typically used in these applications according to Surface Science labs[6] and Katz Labs[7].
  2. Where the material to be measured or where the measurement itself approaches the accuracy of the standard.
- **Subjective measurements** like visual attribute measurements such as color determination and subjective defects are very dependent upon other environmental interactions such as from the amount and type of lighting, inspector comfort, the clarity of the human eye, how alert the inspector is, etc[8]. Other subjective measurements might include quantifying relationships between people and or companies such as with quality, cost, and delivery measurements. For example, Philip Crosby mentions Scrap costs as the amount of unplanned scrap produced in dollar value, plus the added value of labor and burden to the point of discard[9]. This leaves a lot to interpretation. The same goes for rework costs, warranty and service

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[6] http://www.surface-science.com/techniques.html
[7] http://www.katzlabs.com/
[8] Bill Wortman, *CQE Primer* (Quality Council of Indiana, IN: 1997), IV - 17.
[9] Philip Crosby, *Quality Is Free*, (New York; McGraw-Hill, 1979), 179.