Practical Applications of Precision Statements

ASTM Committee D 04 Workshop on Precision and Bias

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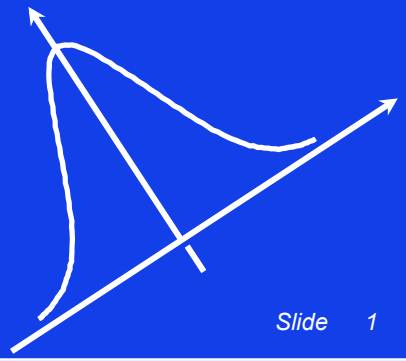

Topics

- D4 Policy
- Definitions
- Basis of Precision Statements and Statistical Overview
- Form of Precision Statements
- Applications and Primary Uses of Precision Statements
  - Quality Control
  - Laboratory Evaluation
  - Review of Quality of Standard(s)
- Not Applicable as Single Element of Specification Compliance
- Discussion

D4 Policy on Precision Statements

- *D4 Policy Statement 01-12-01 Requires Precision Statements For All Standards That Generate Numerical Results*
- *If a Proper Interlaboratory Study (ILS) Has Not Been Conducted to Develop an Acceptable Precision Statement, The Statement Must Include Wording That the Standard Should Not be Used for Purchasing Purposes*
- *Development and Inclusion of Precision Statements Has Been An Ongoing Effort of D4 Since Early or Mid 70's*

Definitions

- *Precision Statement*

  Acceptable Range of Two Results of the Same Test On the Same Material

- *"Practical"*

  - *Relating to, or manifested in practice or action : not theoretical or ideal*

Definitions, Cont'd.

- ***Within-Laboratory Precision ("~~Repeatability~~")***

  Same Material, Operator, Equipment. Repeated Within a Relatively Short Period of Time

- ***Between-Laboratory Precision ("~~Reproducibility~~")***

  Same Material, Different Laboratory, Equipment, Operator Over Relatively Long Period of Time

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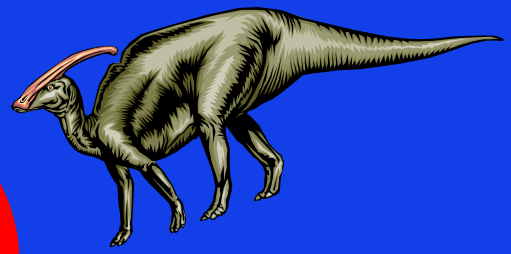

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Basis (Substance) of Precision Statements

Precision Statements Based on Properly Conducted Interlaboratory Studies (ILS) Include and Quantify Effects of Uncontrolled Or Unknown Sources of Variability

- ***Sources of Variability Include temperature, barometric pressure, technician competence, time of day, equipment calibration, line voltage level variability, chemical quality, location in ovens, etc., etc., etc., etc. . . . . .***

  If A Source Can Be Identified, Effect Can Be Quantified With A "Ruggedness Test"

- ***Variability is Quantified By Standard Deviation, s or Coefficient of Variation, CV.***

Statistics Overview

X_i = Measurement or Value
n = Number of Observations

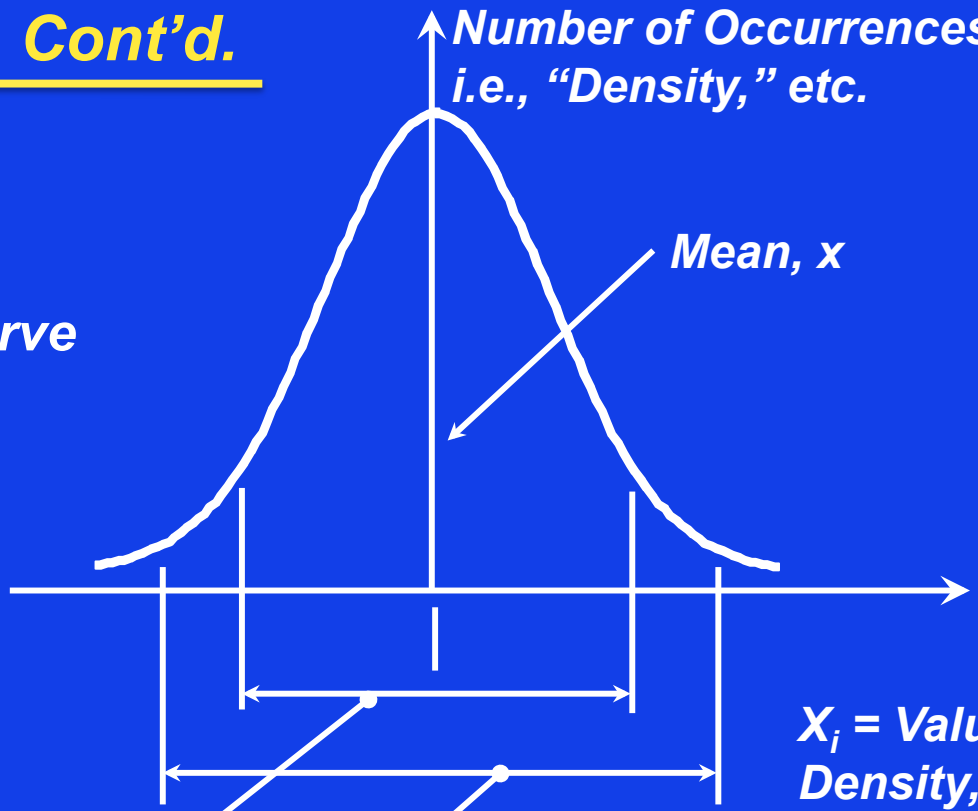
$$\text{Mean} = \bar{X} = \frac{\sum_{I=1}^{n} X_i}{n}$$

$$\text{Standard Deviation} = S = \sqrt{\frac{\sum_{I=1}^{n} (X_i - \bar{X})^2}{(n-1)}}$$

$$\text{Coefficient Of Variation} = CV = 100 \left(\frac{S}{\bar{X}} \right)$$

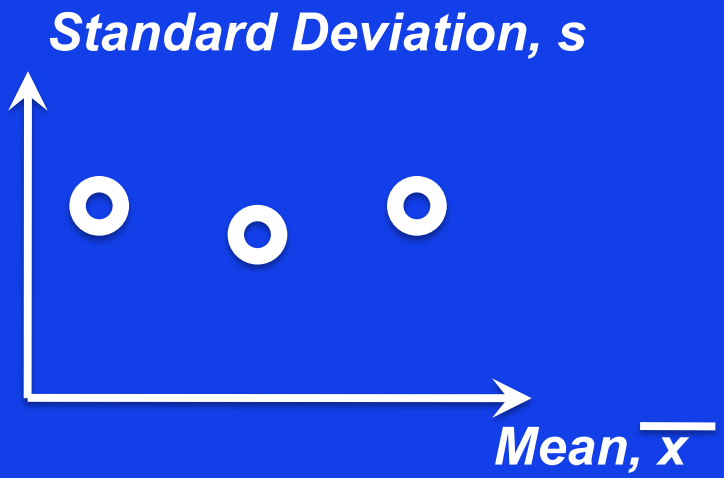
Statistics Overview, Cont'd.

Normal or "Gaussian" Curve



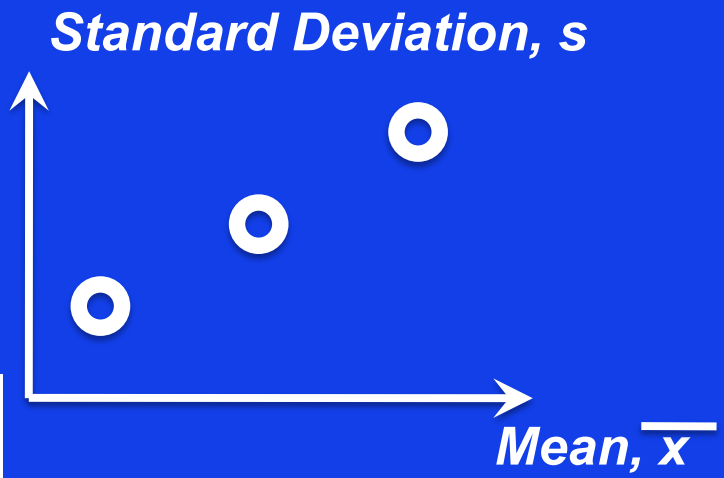
s = Standard Deviation

Form of Precision Statements



CASE 1
Standard Deviation Relatively Constant :

Precision Expressed as Acceptable Difference

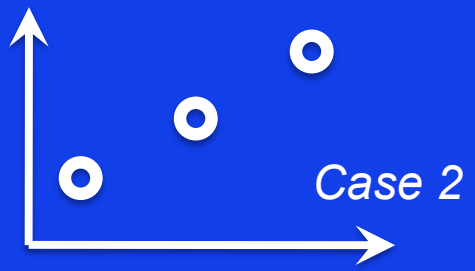


CASE 2
Standard Deviation Varies With Mean :

Use Coefficient of Variation

Precision Expressed as Acceptable Difference as Percent of Mean of Values in Question

Form of Precision Statements, Cont'd.
Within-Laboratory Precision



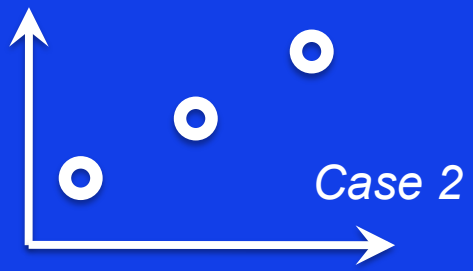
CASE 1

The single-operator standard deviation has been found to be X.XXX .Therefore, results from two properly conducted tests by the same operator on the same material should not differ by more than X.XX

CASE 2

The single-operator coefficient of variation has been found to be X.X%. Therefore, results of two properly conducted tests by he same operator on the same material should not differ by more than X.X% of their mean.

Form of Precision Statements, Cont'd.
Between-Laboratory Precision



CASE 1

The multiple laboratory standard deviation has been found to be X.XXX. Therefore, results of two properly conducted tests from two different laboratories on samples of the same material should not differ by more than X.XX.

CASE 2

The multiple laboratory coefficient of variation has been found to be X.X%. Therefore, results of two different laboratories on identical samples of a material should not differ by more than X.X % of their average.

Applications and Primary Uses of Precision Statements

- *Quality Control of Testing and Measurement*
  - *Within Lab Operator Competence*
  - *Second Laboratory Competence (Operator and Equipment)*
- *Evaluate Quality of Standards*

Applications and Primary Uses of Precision Statements, Cont'd.

Quality Control "Rule - of – Thumb"

- *No Scientific Basis, Just Observations, BUT Serves as Alarm to Investigate for Cause(s) of Differences:*

  Within-Laboratory CV on the order of 10%

  Between-Laboratory CV on the order of 15%

- *It May Be Necessary to Review Research Reports to Determine CV*

Applications and Primary Uses of Precision Statements, Cont'd.

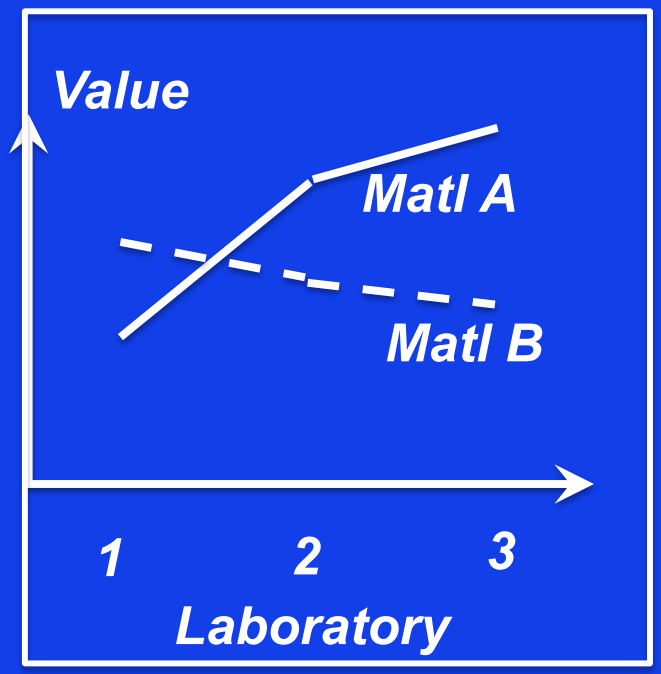
Quality of Standards

Standards With Large CV or Standard Deviations Require Review

1. *Determine Cause(s) of High Variability, i.e., Control of Factors Involved in the Test*
2. *May Need to Design an Interlaboratory Study or Pilot Study to Review the Standard*
3. *May Need to Review Research Report to Determine Possibility of Laboratory by Material Interaction*

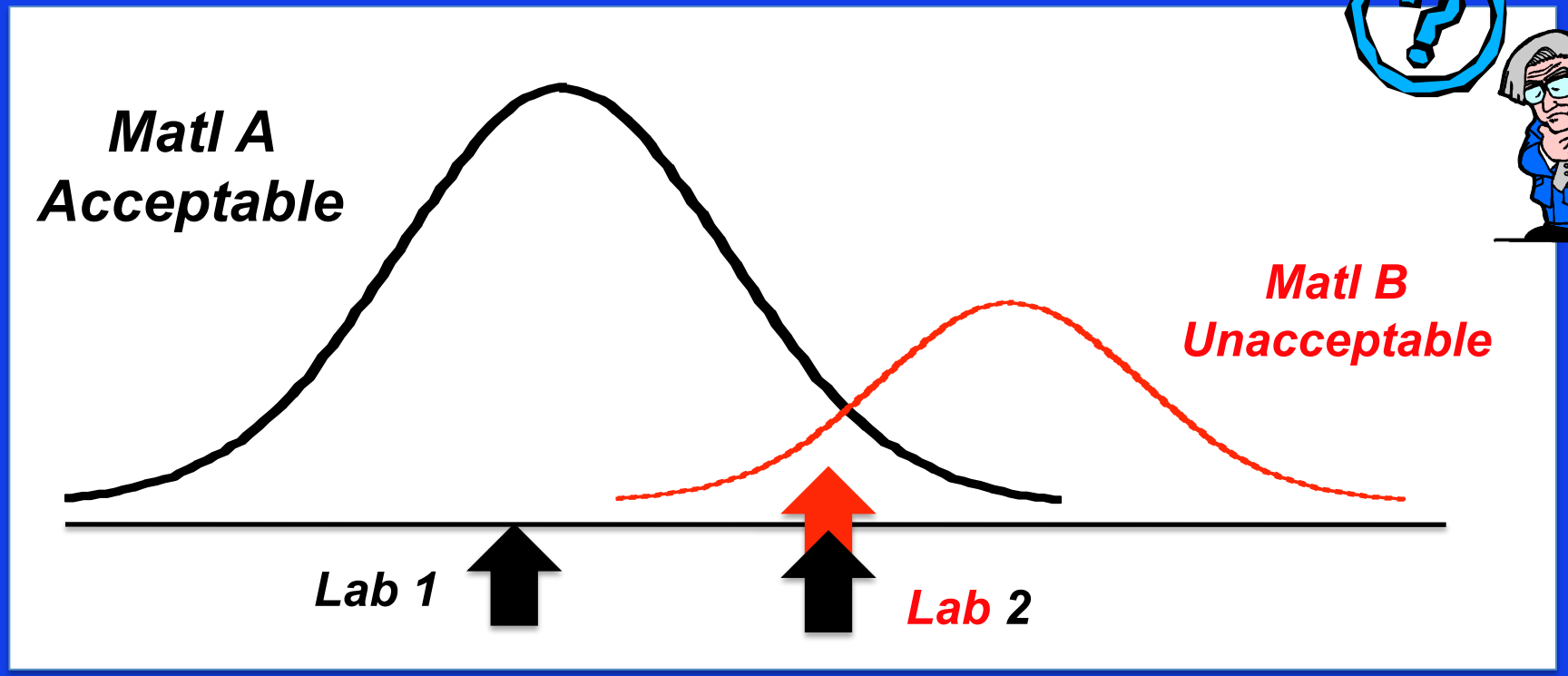
Applications and Primary Uses of Precision Statements, Cont'd.

Laboratory by Material Interaction



- Lab 1 Rates B > A
  Labs 2 & 3 Rate A > B
- Effect Can be Plotted From Data Or Calculated With Analysis of Variance (ANOVA)
- Indicates Two Equally Competent Technologists Interpret Protocol Differently. Standard Wording Probably Needs Clarification

Cannot Use Single Measurement From Two Laboratories For Specification Compliance



If Measurements Are Within Between-Laboratory Precision Limits - Which Material Did Laboratory 2 Test ???

End

Proceed With Erv Dukatz Presentation and Discussion