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Use of Contractor Test Data for Acceptance Decisions

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Topics

- ❑ Definitions and Terminology
- ❑ Evolution of Specifications
- ❑ QC or Acceptance?
- ❑ Contractor Acceptance Testing
 - ❖ Sources of Variability
 - ❖ Independent vs. Split Samples
- ❑ Verification Testing

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The Question?

- ❑ Is it QC/QA or QA/QC?

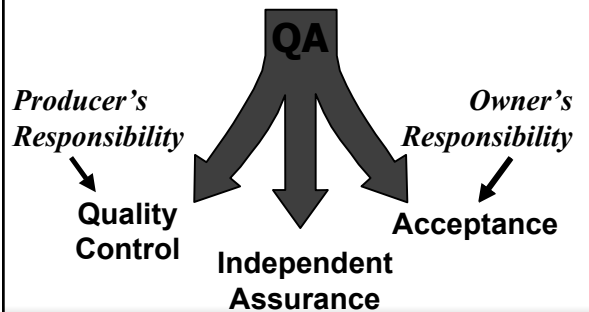


It is **NEITHER!**

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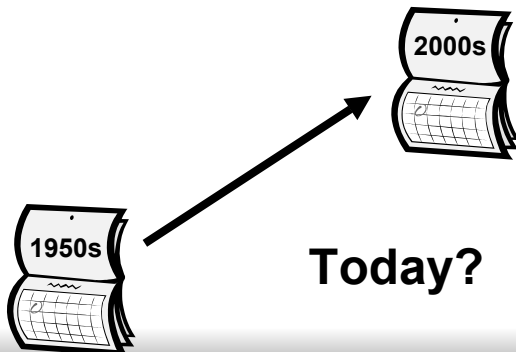
Quality Assurance



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Evolution of Specifications



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Method Specifications

Maximum Control by

Recipe

Cookbook
by
DOT



Specifying Agency

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End-Result Specifications

**AASHO Road Test
1958**

**Realization of Variability
Testing the Final Product**

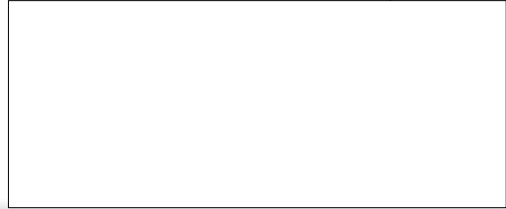
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QA Specifications

Quality Control

Acceptance Testing



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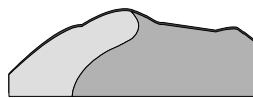
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Quality Control Characteristics

**Measured during the process!
Early indicator of
product quality.**



Nuclear Density



Stockpile Gradation

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Acceptance Characteristics

Measure of the in-service product.

**Measured as close
as possible to the
finished product.**



Core Density



Smoothness

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Quality Control or Acceptance?

Air Voids VMA Asphalt Content
Stockpile Gradation Ignition Oven Gradation
Nuclear Density Specific Gravity Core Density

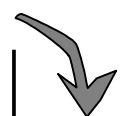


**Nuclear
Density**

Quality Control



?



**Core
Density**

Acceptance

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A Very Important Decision

**Who will perform the
acceptance tests?**



Contractor?



Agency?



Third Party?

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Contractor Acceptance Testing?



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Contractor Acceptance Testing

- Why have the contractor perform the acceptance tests?
~~—They do a better job?—~~
Personnel constraints!

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Contractor Acceptance Testing

- Is it ethical?
Why not?
- Is it effective?
Depends!
- Is it legal?
YES!

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23CFR637b, FHWA QA Program

states that agencies "... will permit the use of data from Contractors' ~~quality control~~ sampling and testing programs in acceptance programs if the results from the States' verification sampling and testing programs confirm the quality of the material."

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Remember

- The purpose for which the test result will be used determines whether it is a QC or an Acceptance test.
- NOT who performs the test!

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23CFR637b, FHWA QA Program

Requires that the sampling and testing be "...performed by qualified laboratories and qualified sampling and testing personnel."

Many agencies meet this by establishing "certification" programs.

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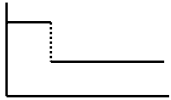
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Need to Verify Contractor Tests

Are Contractor acceptance test results valid?

$$X_{contr} \leftrightarrow X_{agency}$$

Tests/Lot



Time

Early in the process:
Higher test frequencies?

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Do Differences Exist?

- The greater the number of tests
- The greater is the ability to identify statistically-valid differences
- Therefore, you may want more agency testing early in the project

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Sources of Variability

$$\sigma_o^2 = \sigma_m^2 + \sigma_t^2$$

overall material testing

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Testing Variability

$$\sigma_t^2 = \sigma_e^2 + \sigma_s^2$$

testing test method sampling

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Overall Variability

$$\sigma_o^2 = \sigma_m^2 + \sigma_t^2$$

and $\sigma_t^2 = \sigma_e^2 + \sigma_s^2$

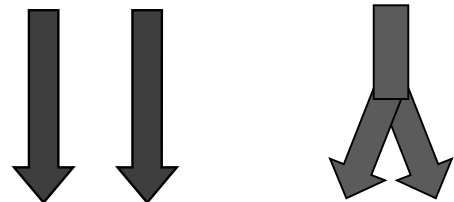
so:

$$\sigma_o^2 = \sigma_m^2 + \sigma_e^2 + \sigma_s^2$$

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Samples



Independent

Split

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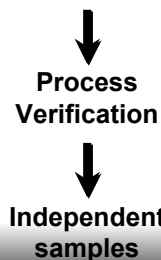
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What do we wish to compare?

Only testing procedures & equipment:



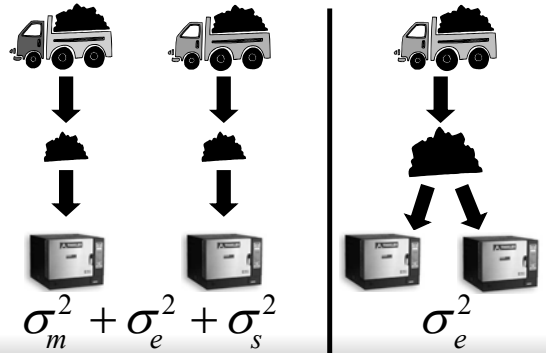
Overall materials, process, sampling & testing:



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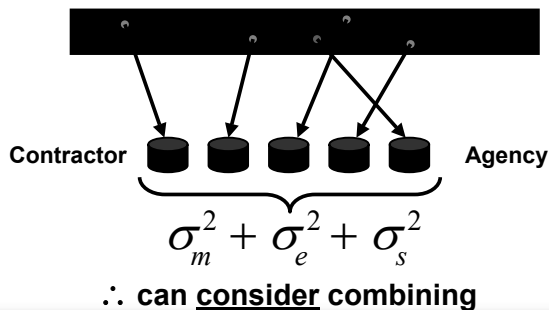
Independent vs. Split



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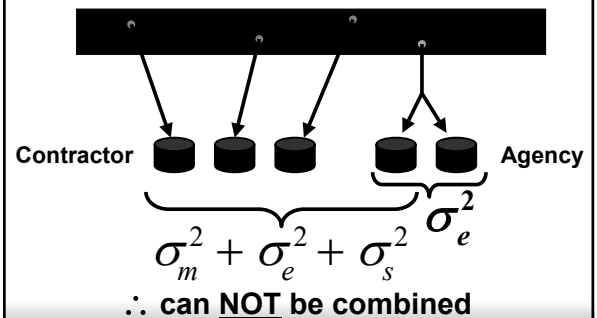
Independent Samples



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Split Samples



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23CFR637b, FHWA QA Program

“The verification shall be performed on samples that are taken independently of the quality control samples.”

In spite of this, a number of agencies use split samples because procedures are easier to implement

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Verification Testing

Number of samples required depends upon:

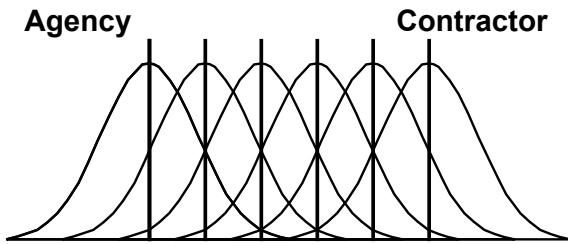
- Size of difference you wish to be able to detect
- Level of risk of making a wrong decision that you can “live with”

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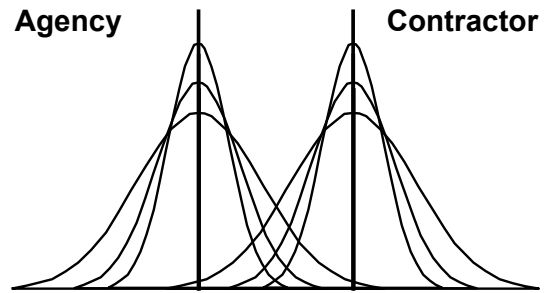
Example: Difference to Detect



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Example: Sample Size



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Sample Size Example

If asphalt content has a standard deviation of 0.15%

- To be 99% confident of detecting a difference of 0.30% between contractor and agency results 95% of the time
- You need about 8 contractor tests and 8 agency tests

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Sample Size Example

If asphalt content has a standard deviation of 0.15%

- To be 99% confident of detecting a difference of 0.15% between contractor and agency results 95% of the time
- You need about 20 contractor tests and 20 agency tests!

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Verification — Split Samples

Maximum allowable difference between split samples:

$$|X_c - X_a| \leq D_{max}$$

May use precision statement to determine D_{max} *

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Verification — Split Samples

Using Precision Statements

- Simplest comparison method
- Least powerful
- Only two individual tests are compared



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Verification — Split Samples

Paired t-test:

$$\begin{array}{r} X_{c1} - X_{a1} = X_{d1} \\ X_{c2} - X_{a2} = X_{d2} \\ \downarrow \quad \downarrow \quad \downarrow \\ X_{cn} - X_{an} = X_{dn} \\ \bar{X}_d \end{array}$$

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Verification — Split Samples

Assumptions:

- ❖ Contractor and Agency testing populations have the same standard deviations
- ❖ Contractor and Agency are using the same testing procedures

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Verification — Independent Samples

Compare Variances with the *F*-test and the *F*-statistic

Based on ratio of sample variances:

$$s_c^2 \text{ \& } s_a^2$$

Compare Means with the *t*-test and the *t*-statistic

Based on difference between sample means:

$$\bar{X}_c \text{ \& } \bar{X}_a$$

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Verification — Independent Samples

Assumptions

- ❖ Random sampling
- ❖ Same time period
- ❖ Same sampling and testing procedures

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Verification

Identifies if a difference exists, **NOT** the cause

The cause of the difference must then be determined by investigation

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Verification — Bottom Line

- ❑ Verification procedures are complicated
- ❑ However, they can easily be computerized
- ❑ Large numbers of tests may be required to find statistically-valid differences

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Contractor Acceptance Testing

- ❑ Allowed by FHWA
- ❑ Agency personnel may not wish to relinquish control
- ❑ Requires Agency verification
- ❑ Should be with independent samples
- ❑ May require large sample sizes to be able to detect differences

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Thanks for having me!