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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?

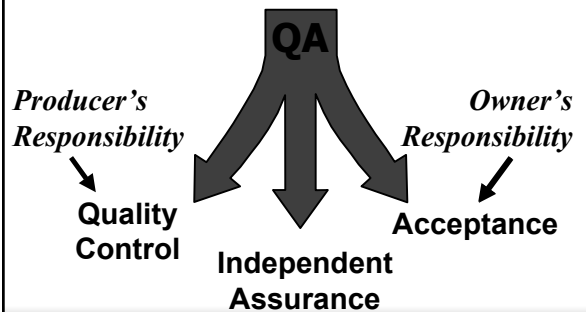


It is **NEITHER!**

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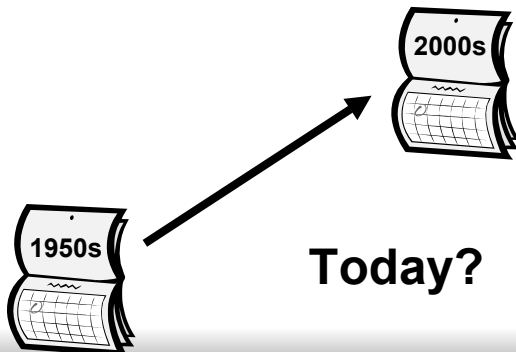
## Quality Assurance



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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**

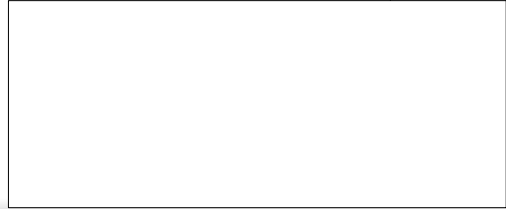
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## QA Specifications

**Quality Control**

**Acceptance Testing**



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## 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**



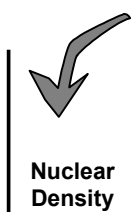
**Smoothness**

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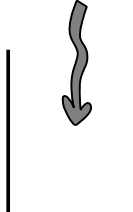
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## Quality Control or Acceptance?

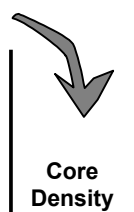
Air Voids      VMA      Asphalt Content  
Stockpile Gradation      Ignition Oven Gradation  
Nuclear Density      Specific Gravity      Core Density



**Quality Control**



**?**



**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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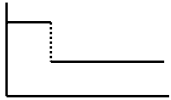
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## Need to Verify Contractor Tests

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

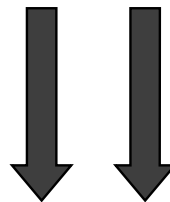
so:

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

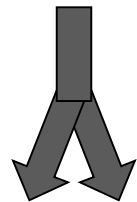
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## Samples



Independent

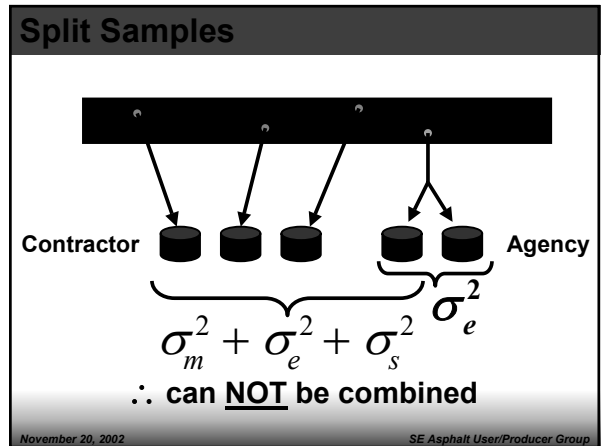
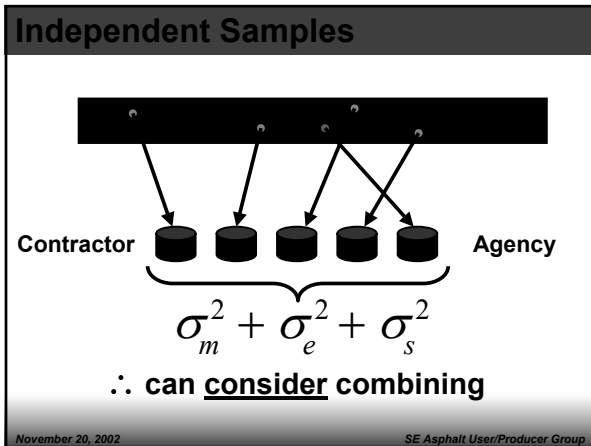
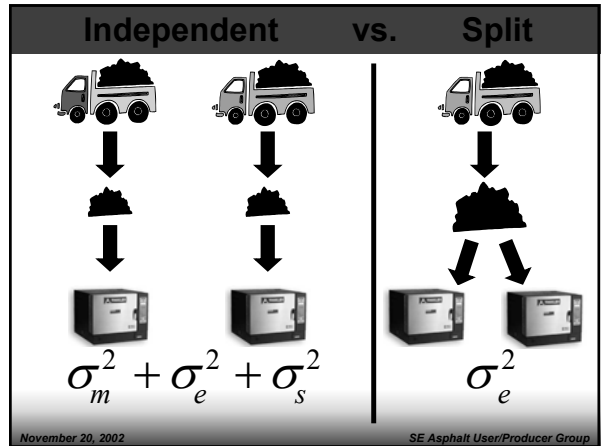
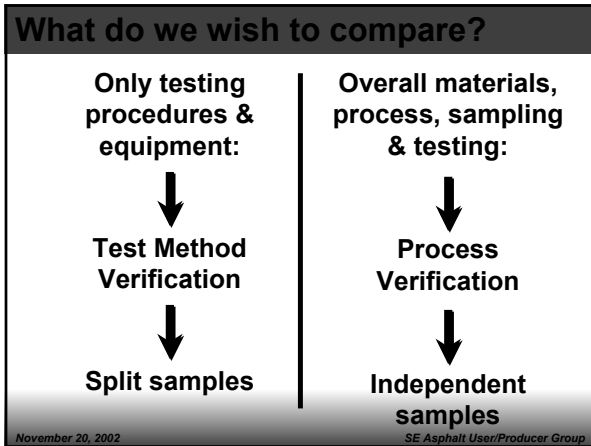


Split

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### 23CFR637b, FHWA QA Program

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

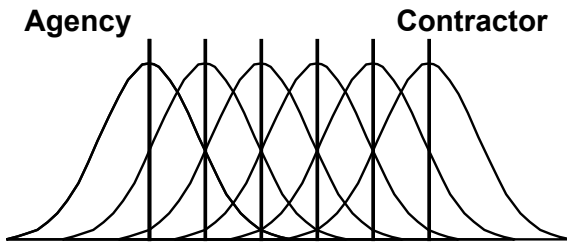
In spite of this, a number of agencies use split samples because procedures are easier to implement

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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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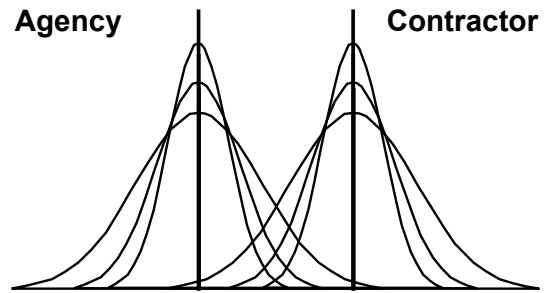
## Example: Difference to Detect



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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!*