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AF2903 Road Construction and Maintenance

Pavement Quality Control / Quality Assurance (QC / QA)

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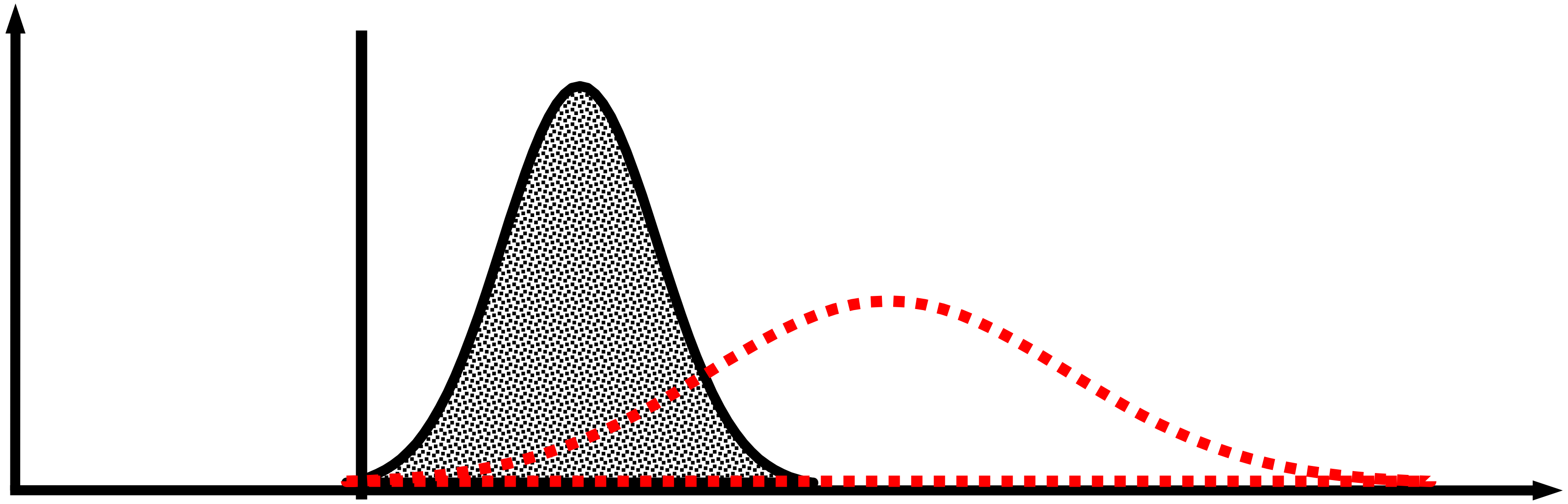

Quality Control (QC)

Testing performed to determine the level of quality of the product being produced; this level of quality consists of two key components:

- Target value. This is the goal set for a certain material characteristic. As a minimum it should conform to standards and be achievable.

- Variability. This describes how much a process varies from item-to-item (or location-to-location).

QC is normally performed by the Contractor.

“Process Control” is latest buzzword.

Quality Control

A quality control program consists of:

- Actions and considerations necessary to assess production and construction processes.
- Setting the end product target value and controlling variability.

In order for a quality control program to be effective it should:

- Base actions and decisions on measurable results.
- Be statistically valid.

Quality Assurance (QA)

Testing performed to make a decision on acceptance of a project and hence to ensure that the product being evaluated is indeed what the owner specified; it is normally performed by the Owner.

Independent Assurance

Verification by a third party (not directly responsible for quality control or acceptance) of the product and/or the reliability of test results obtained from quality control and acceptance testing.

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Acceptance Plan

The key is to appropriately apply acceptance sampling (small number of random samples to draw conclusions about a large amount of material) and its associated statistics to the pavement construction industry to create a viable overall plan. Correct application involves proper implementation of the following acceptance sampling components:

- Acceptance sampling type
- Quality characteristics
- Specification limits
- Statistical model
- Quality level goals
- Risk
- Pay factors

Acceptance Sampling

There are two basic types of acceptance sampling:

- Attribute sampling

Each sample is inspected for the presence of one or several attributes (Quality characteristics); such attributes are compared to a standard then recorded as either passing or failing.

- Variable sampling

Measured quality characteristics are used as continuous variables (measurement values are retained). It takes fewer variable samples to get the same information than attribute sampling. Because of this, most statistical acceptance plans use variable sampling. Usually variable sample plans assume a normal distribution of the measured property.

Specification Limits

Specification limits must be based on sound engineering judgment (target value) and sound statistical analysis (acceptable range). This range is used to account for the various sources of variability inherent in producing and testing HMA; specifically, there are four types of variability to consider (Hughes, 1996):

- Material variability
- Sampling variability
- Testing variability
- Manufacturing and construction variability

"I'm writing you a prescription. Do you want a longer life with less quality or vice versa?"

Measurement of Variability

Statistical Tools:

- Standard Deviation (σ)
- Variance (σ^2)
- Coefficient of Variance (CV)

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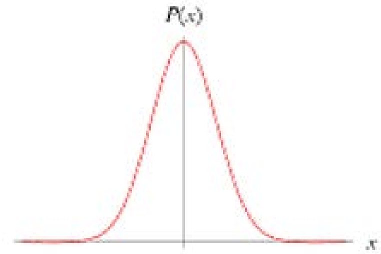
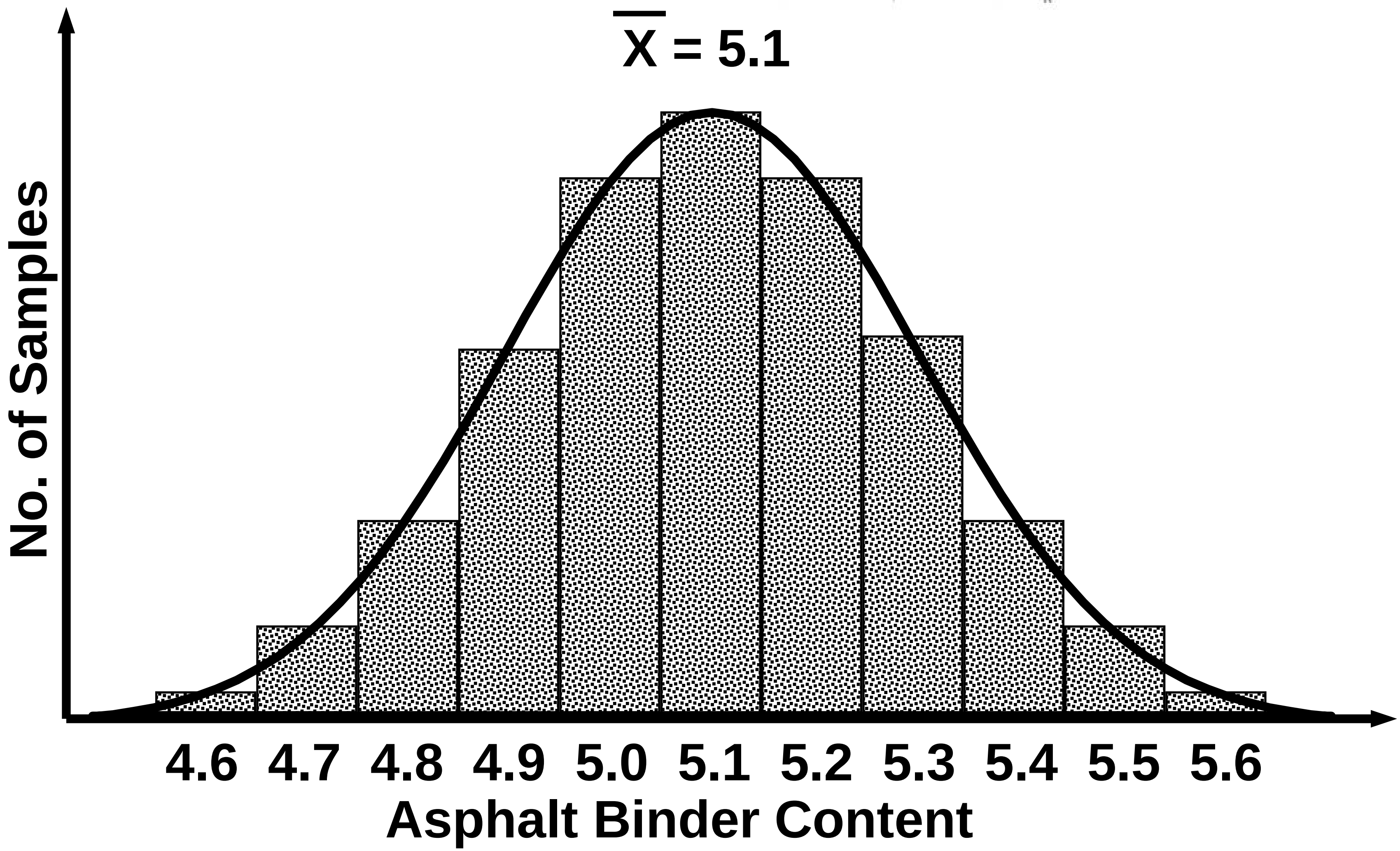
Normal Distribution



$$y = \frac{1}{\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma}$$

μ = Mean
σ = Standard Deviation
$\pi \approx 3.14159$
$e \approx 2.71828$



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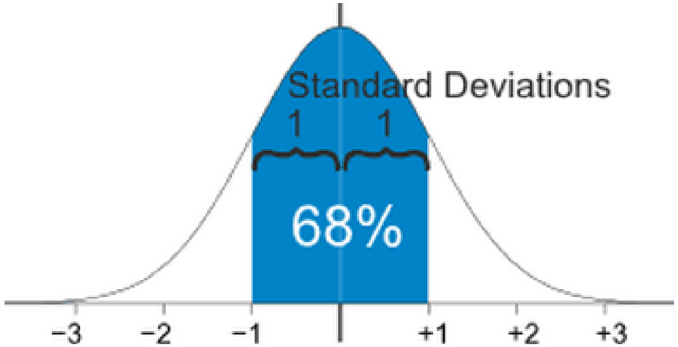
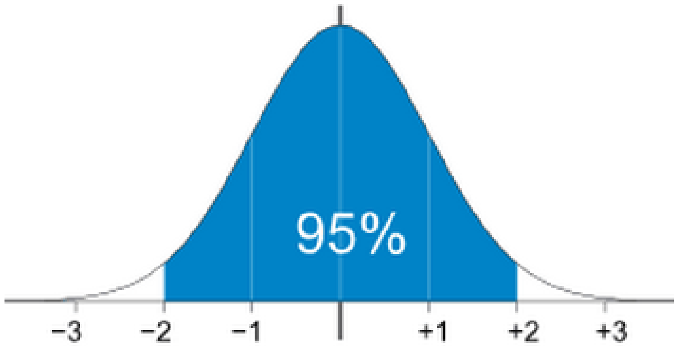
Standard Deviation

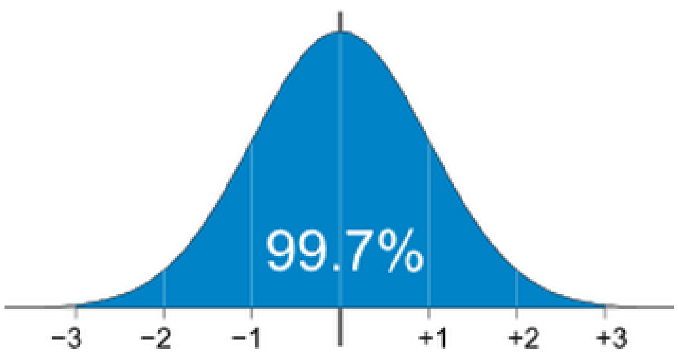
$$\sigma = \sqrt{\frac{\sum (x - x)^2}{n-1}}$$



68% of values are within
1 standard deviation of the mean



95% are within **2 standard deviations**



99.7% are within **3 standard deviations**

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Standard Deviation (σ)

Sublot	Asphalt Binder Content	Difference from Mean $(x - \bar{x})$	Square of Differences
1	4.7	-0.4	0.16
2	5.2	0.1	0.01
3	5.1	0.0	0.00
4	5.4	+0.3	0.09
Sum	20.4		0.26

Mean = $\bar{x}$ = (20.4 ÷ 4) = 5.1

$\sigma = \sqrt{(0.26/3)} = 0.29$

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Variance and Coefficient of Variation

$$\text{Variance} = (0.29)^2 = 0.08$$

$$CV = \left[\frac{\text{Standard Deviation}}{\text{Mean}}\right] \times 100$$

$$CV = \left[\frac{\sigma}{\bar{x}}\right] \times 100$$

$$CV = \left[\frac{0.29}{5.1}\right] \times 100$$

$$CV = 5.7\%$$

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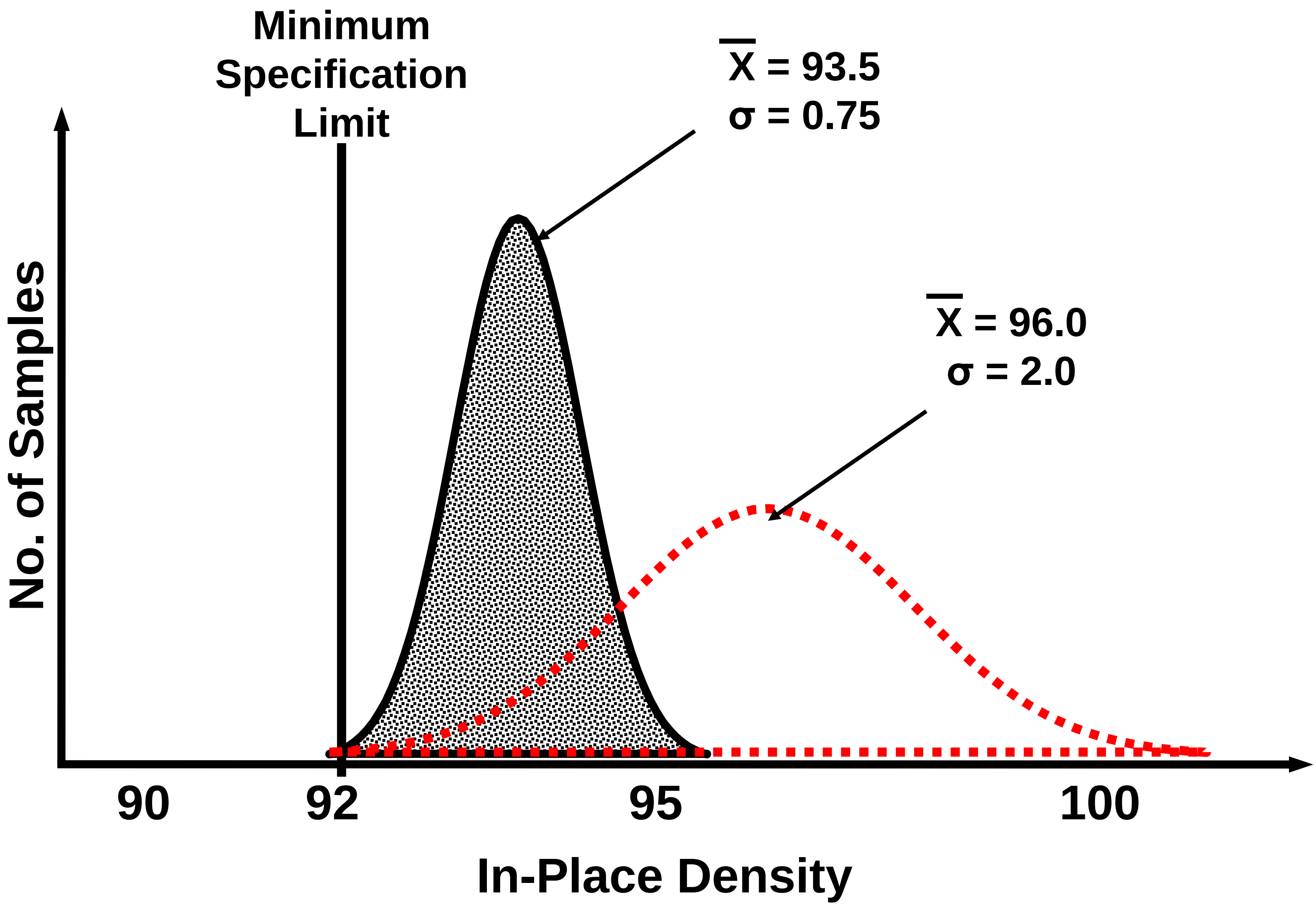
Specifications and Variability



Variability

Material variability is the true random variation of the material; it is a function of material characteristics alone.

Sampling variability is the variation in sample characteristics from sample-to-sample that is attributable to variations in sampling technique.

Testing variability is the lack of repeatability of test results. Operators, equipment condition, calibration, and test procedure all contribute to testing variability.

Manufacturing and construction variability is the variation in material caused by manufacturing and construction process. These variations can be localized (density or thickness of pavement) or global and easily detected (asphalt content or aggregate gradation).

MATERIAL VARIABILITY

Asphalt Binder:

Different Grades (Same Source)

Different Sources (Same Grade)

Uniformity

Aggregates:

Uniformity of Pit or Quarry

Stockpiling

Moisture Content

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MATERIAL VARIABILITY

Quarry Uniformity,
Crushing and Sizing

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MATERIAL VARIABILITY

Stockpiling

SAMPLING VARIABILITY

- Sample Location
- Sample Method
- Sample Size
- Sample Split

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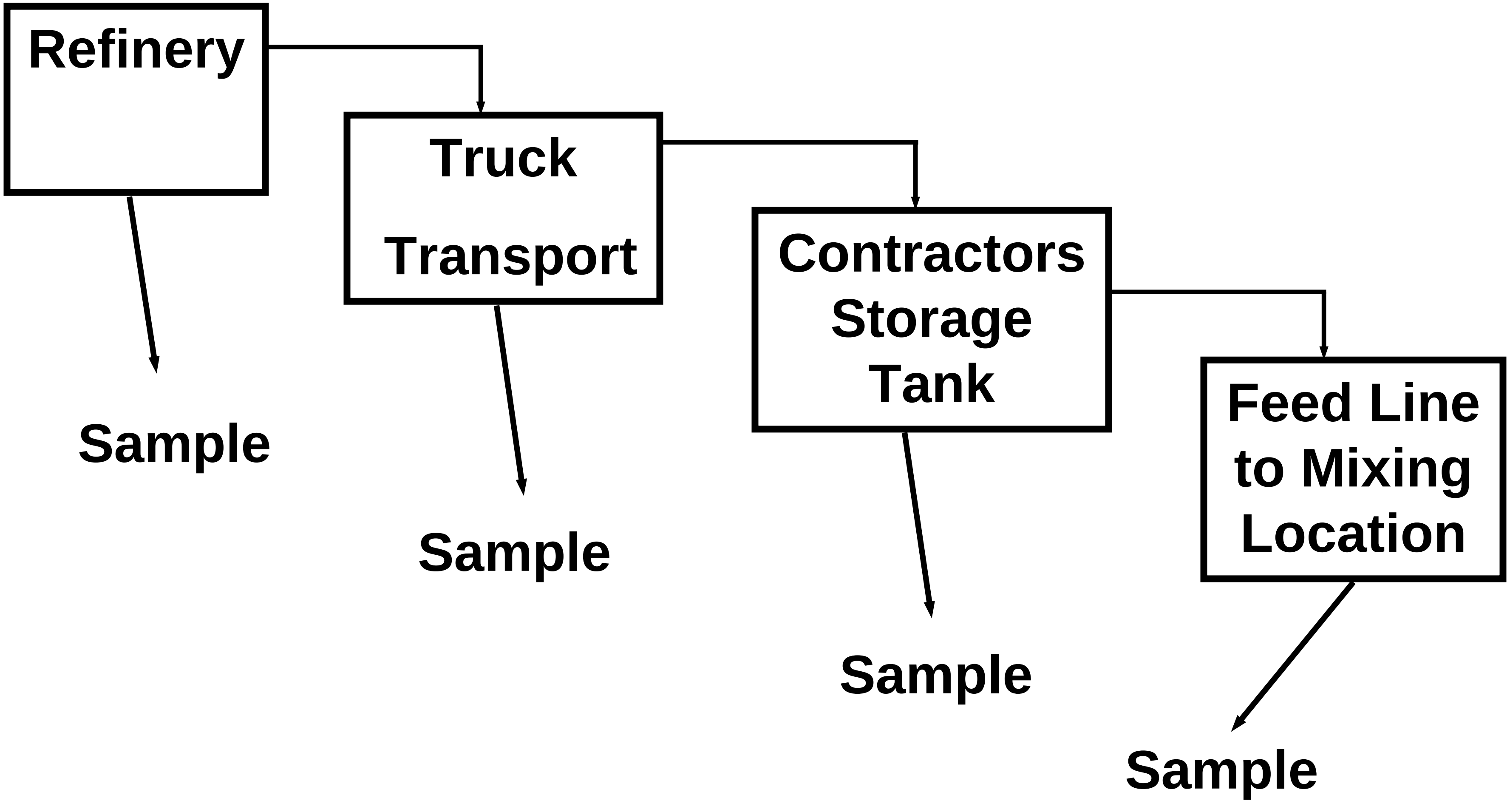
SAMPLING VARIABILITY

Asphalt Binder Sampling Location



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SAMPLING VARIABILITY

Aggregate Sampling Location

Pit or Quarry

- Belt
- Chute
- Stockpile

Contractors HMA Plant

- Stockpile
- Cold Feeds
- Cold Feed Collector Belt

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SAMPLING VARIABILITY

Aggregate Sampling Size

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SAMPLING VARIABILITY

Aggregate Sampling Method

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SAMPLING VARIABILITY

HMA Sampling Location

- Plant Conveyor/Chute
- Truck at Plant
- Hopper in Paver
- Loose Mat (Behind Paver)

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SAMPLING VARIABILITY

HMA Sampling Location

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SAMPLING VARIABILITY

HMA Sampling Location

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SAMPLING VARIABILITY

HMA Sampling split

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TESTING VARIABILITY

- Precision and Bias
- Details of Test Method
- Options within a Test Method

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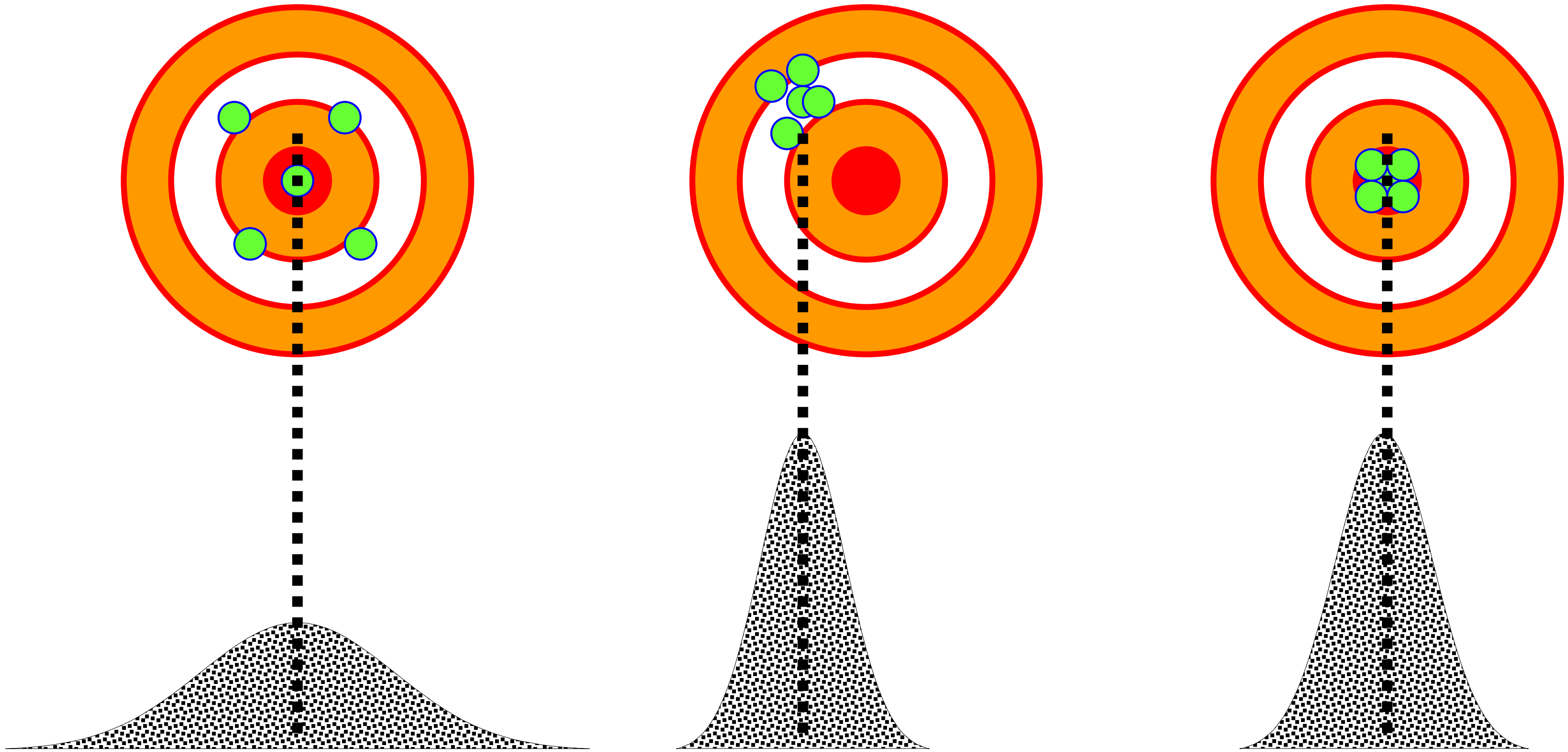
TESTING VARIABILITY

Precision and Bias



Precision:	**poor**	**good**	**good**
Bias:	**low**	**high**	**low**

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TESTING VARIABILITY

Asphalt Binder Content Test

Parameter	Test Method		
	Solvent	Nuclear	Ignition
Precision	Moderate	Moderate	Good
Bias	Low	Moderate	High

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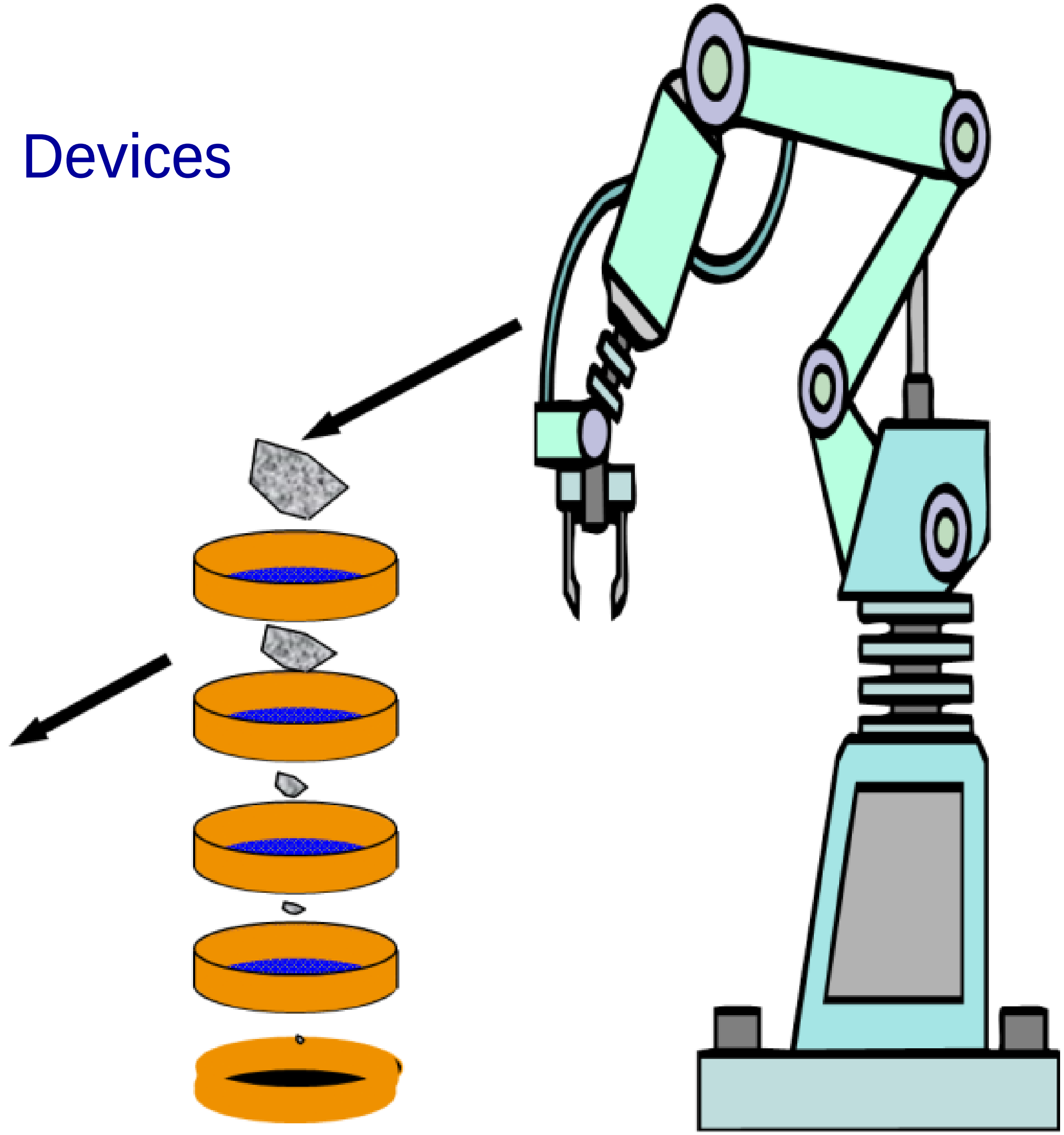
TESTING VARIABILITY

Automatic Gradation Devices

Sieve Size	Cum. % Passing
#4	100
#8	75
#16	57
#30	35
#50	22
#100	15
#200	10



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MANUFACTURING/CONSTRUCTION VARIABILITY

HMA Production

Plant Calibration

Coldfeeds

Belt Scales and Wind Velocity

Baghouse Fines Return System

Conveyors/Chutes

Moisture Content

Storage

Uniformity

MANUFACTURING/CONSTRUCTION VARIABILITY

Coldfeed System

MANUFACTURING/CONSTRUCTION VARIABILITY

Belt Scales and Wind Velocity

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MANUFACTURING/CONSTRUCTION VARIABILITY

Baghouse Return System

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MANUFACTURING/CONSTRUCTION VARIABILITY

Storage

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MANUFACTURING/CONSTRUCTION VARIABILITY

HMA Placement and Compaction

Trucking (Loading/Tarping)

Truck/Paver Interface

Paver Mechanics

Rolling Mechanics

Environment

Uniformity

MANUFACTURING/CONSTRUCTION VARIABILITY

Tack Coat

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MANUFACTURING/CONSTRUCTION VARIABILITY

Binder Delivery

MANUFACTURING/CONSTRUCTION VARIABILITY

Trucking

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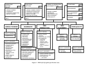
MANUFACTURING/CONSTRUCTION VARIABILITY

Placement/Paver Mechanics

MANUFACTURING/CONSTRUCTION VARIABILITY

Compaction Mechanics

HMA QC/QA SUMMARY



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HMA Field Performance

Greatly affected by Material and Construction Variability

- Rutting
- Fatigue Cracking
- Thermal Cracking
- Durability

Long-term HMA field prediction?

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Questions??

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