



Understanding End Result Specifications

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Introduction

- Types of Specifications
 - Method
 - Equipment, Operations, and Materials
 - **End Result**
 - Desired Outcome
 - Ride
 - Density
 - Asphalt Content
 - **Quality Assurance**
 - Test Properties
 - Rutting
 - Cracking
 - Performance Related
 - Performance Based



PWL Specifications

- The Primary Reasons for PWL Specifications:
 - Acceptance based on results
 - **Assess risk for contractor and owner**
 - Rewards consistency
 - Rewards quality
- What would lead industry to believe it is not a good deal?
 - Misapplications
 - Misunderstandings

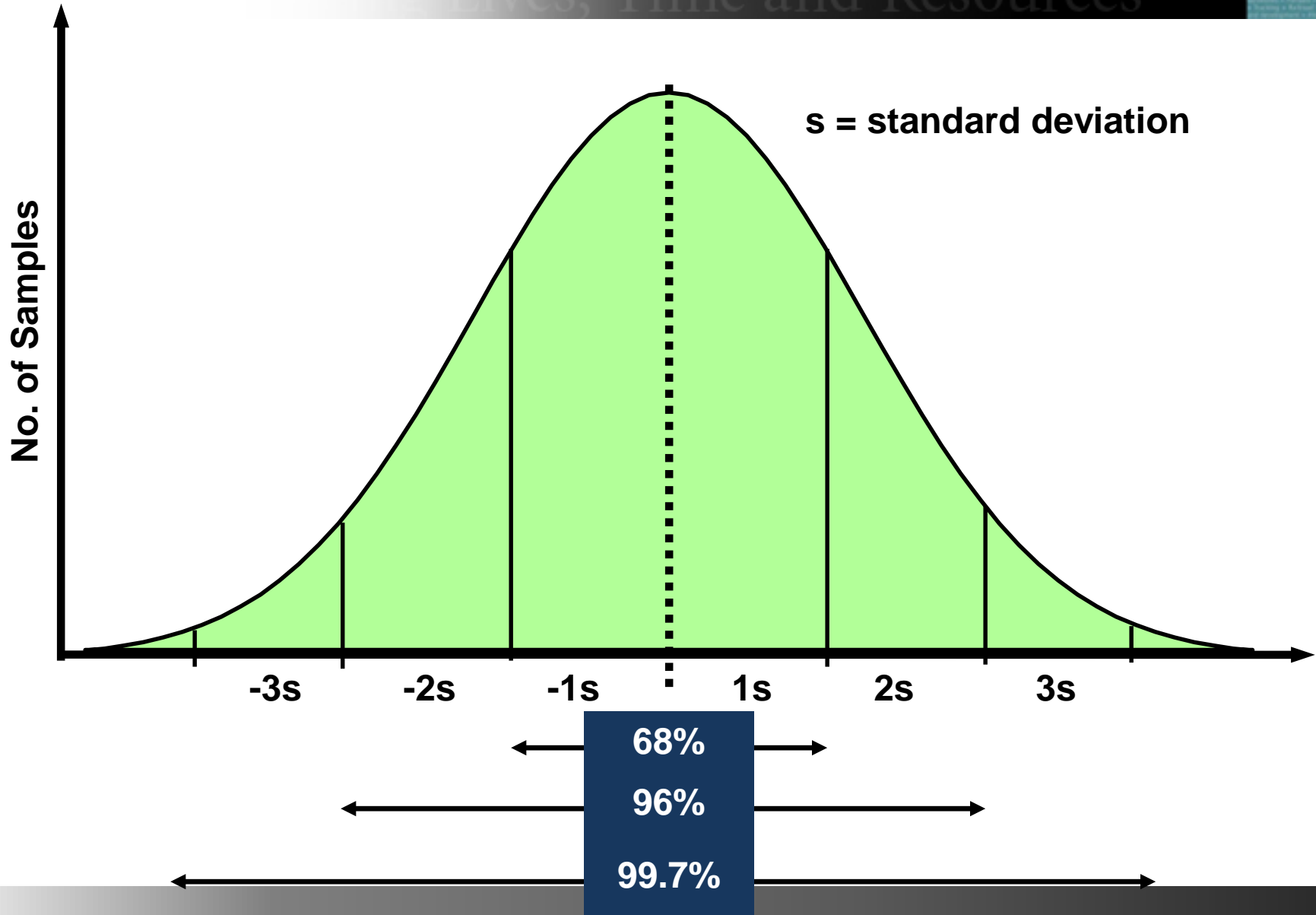
Statistical (QA) Specs

Variability

Risks



Standard Deviation



Sources of Variability



Material

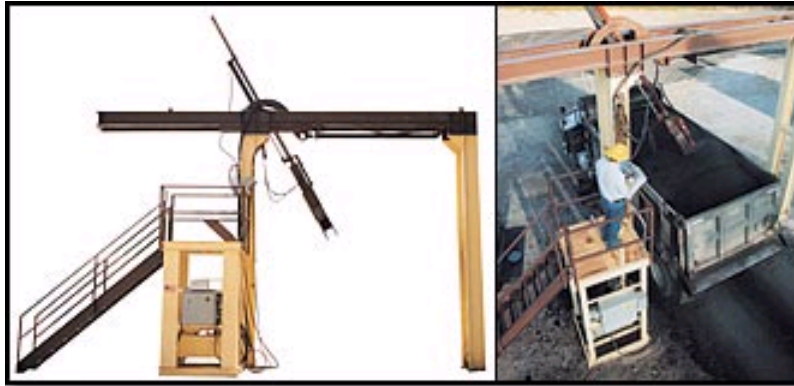
Sources of Variability



Process



Sources of Variability



Sampling



Sources of Variability



Testing





Variability

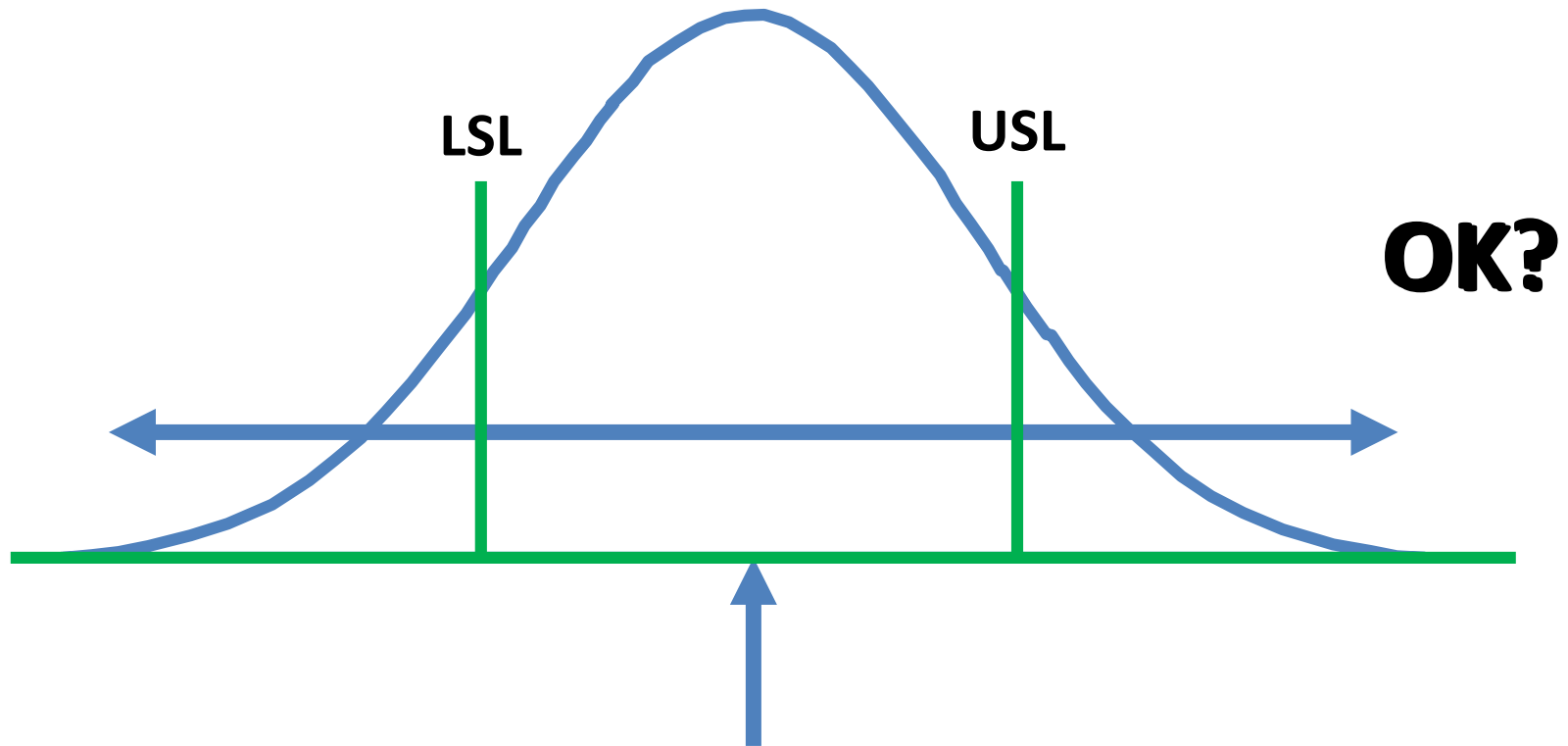
- The overall variability, which is used by the DOT to establish the spec limits, must include:
 - Limited material variability.
 - Limited process variability.
 - Standard sampling variability.
 - Standard testing variability.

Statistical Specs

- Measure (control) both the center (*mean*) **and** spread (*standard deviation*).
- Controlling one is not sufficient.
- Controlling each separately is also not sufficient!

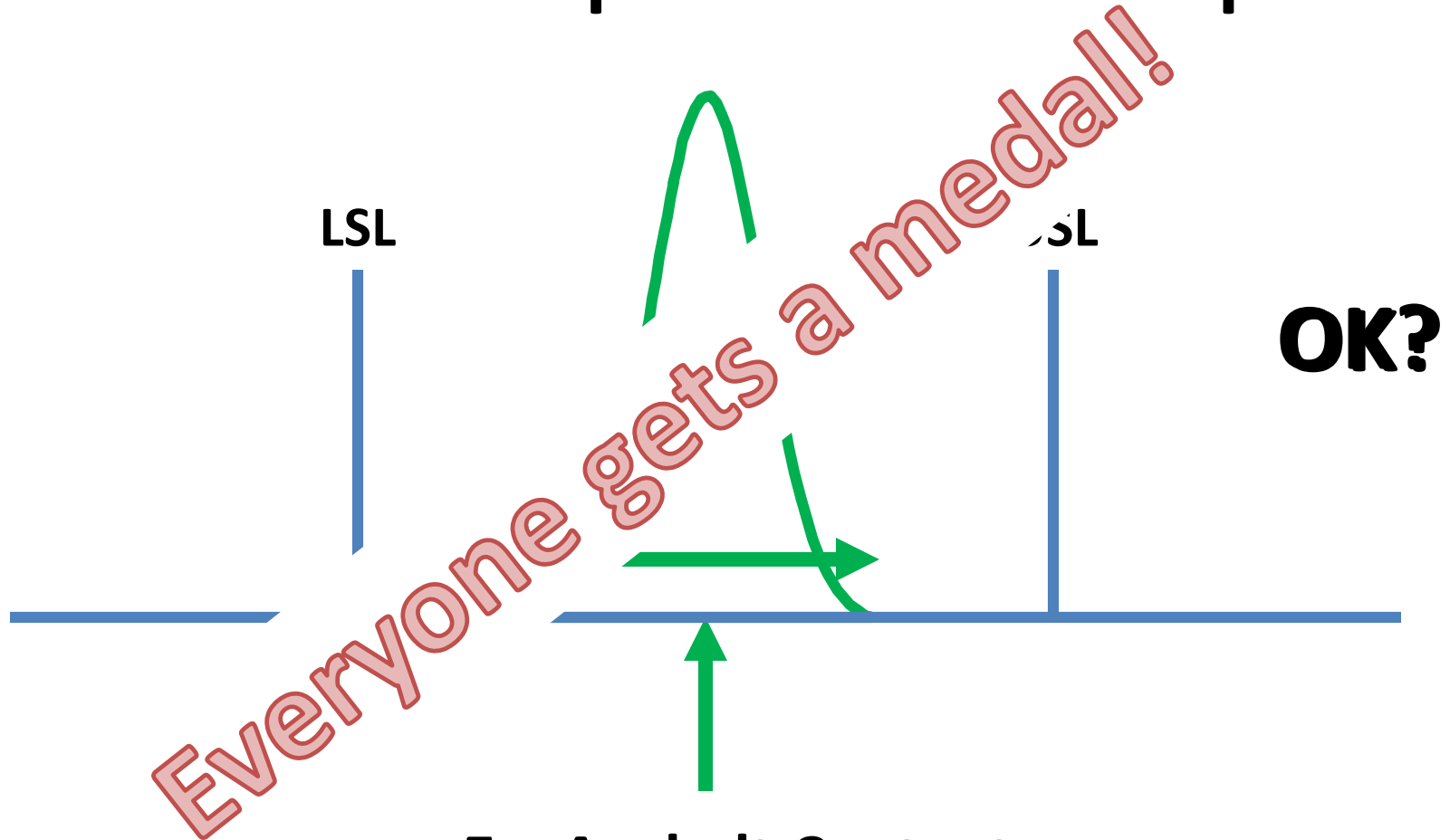


Center & Spread Relationship



Ex: Old Airfield Specs

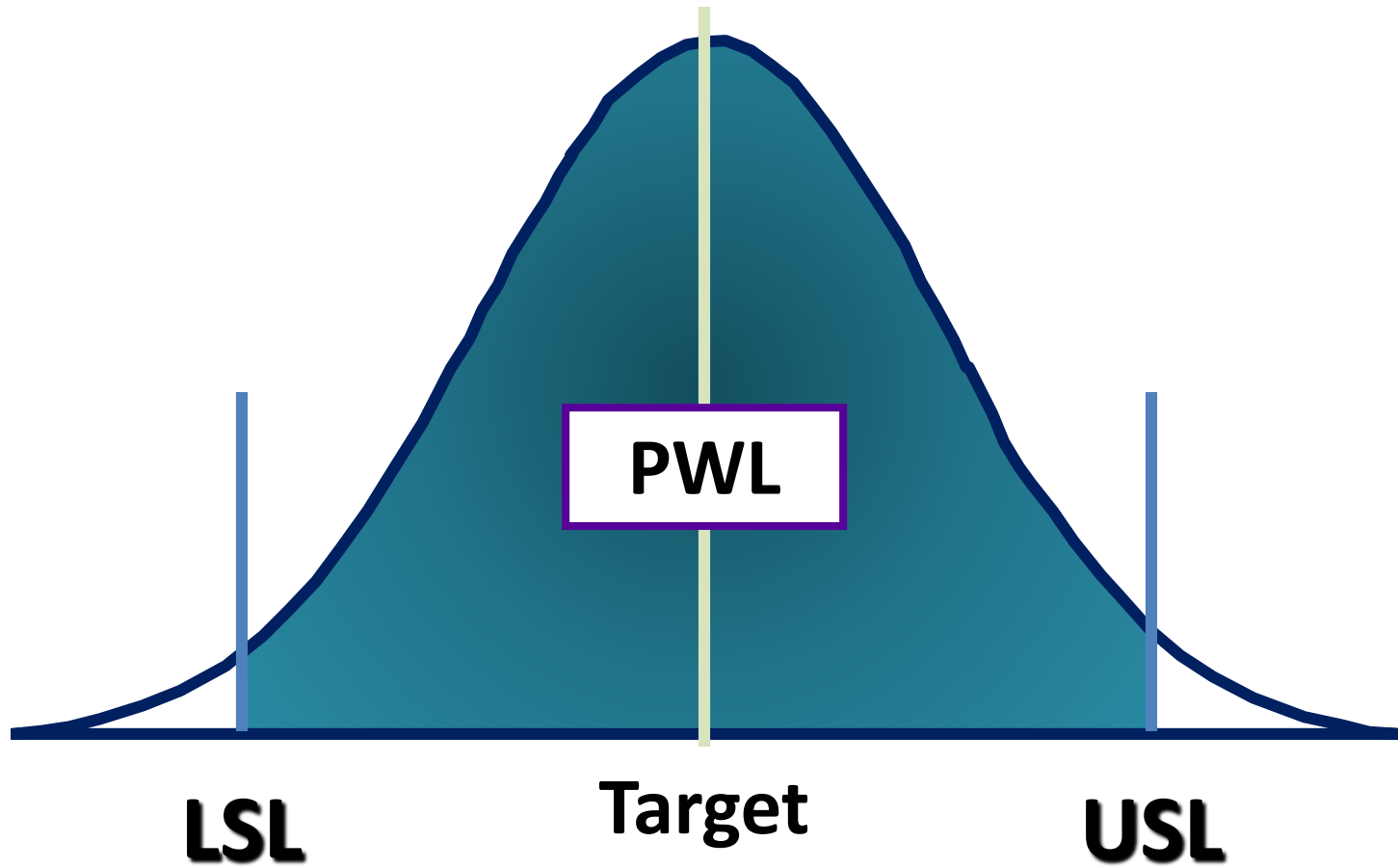
Center & Spread Relationship



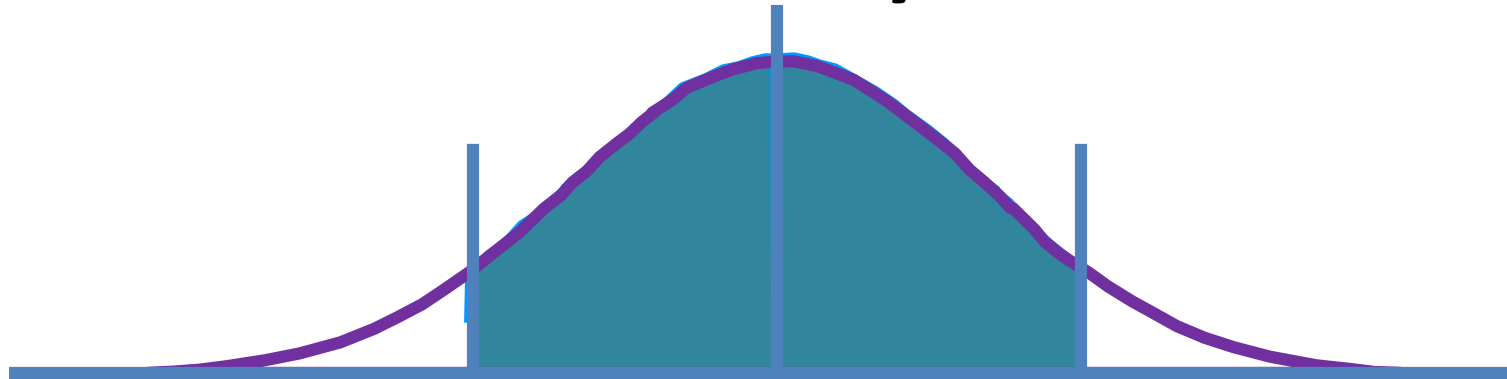
Ex: Asphalt Content



Percent Within Limits (PWL)

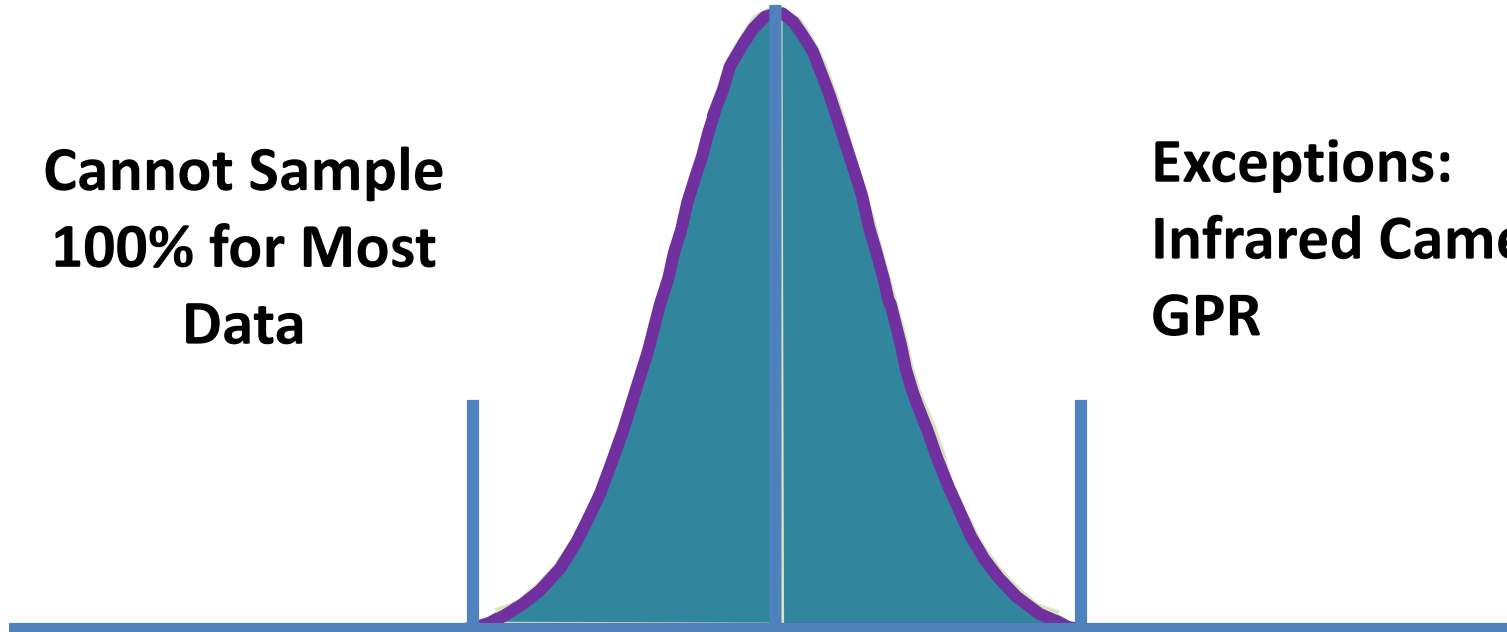


PWL as a Quality Measure



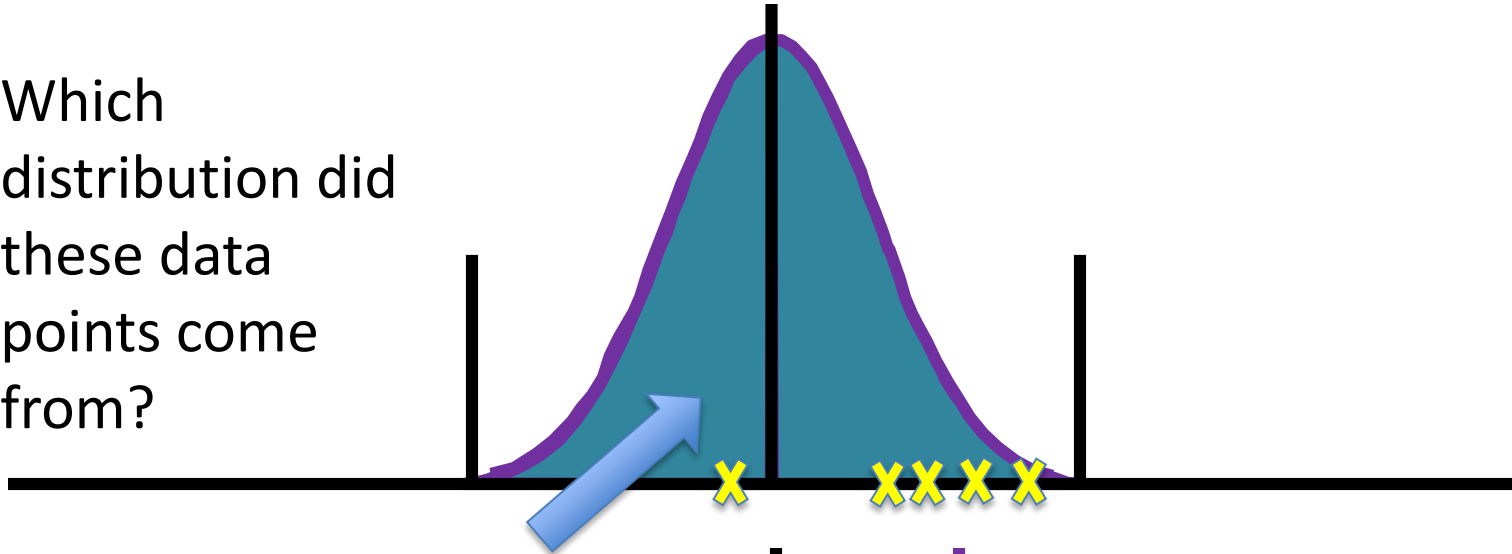
**Cannot Sample
100% for Most
Data**

**Exceptions:
Infrared Camera
GPR**

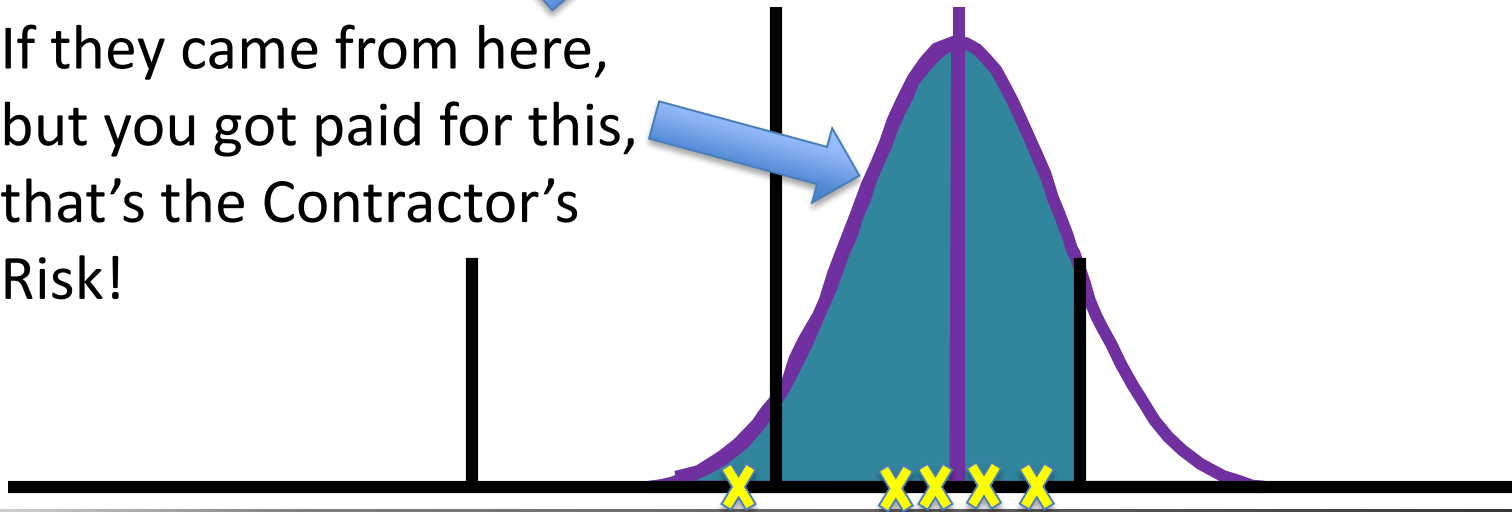


PWL as a Quality Measure

Which
distribution did
these data
points come
from?

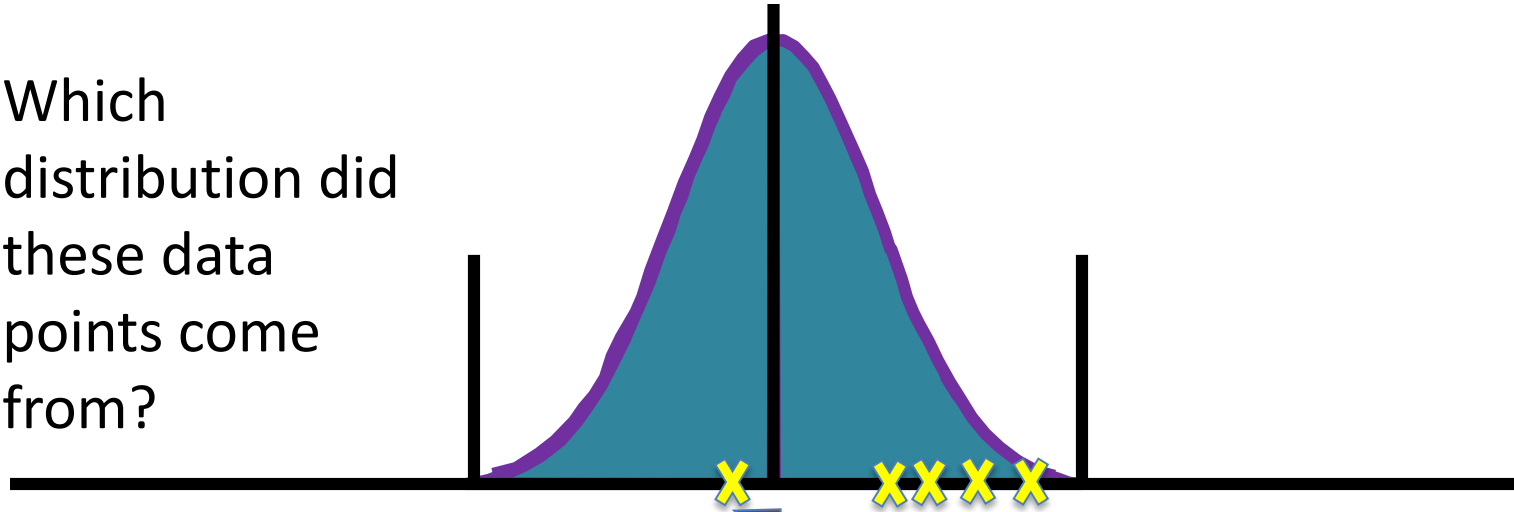


If they came from here,
but you got paid for this,
that's the Contractor's
Risk!

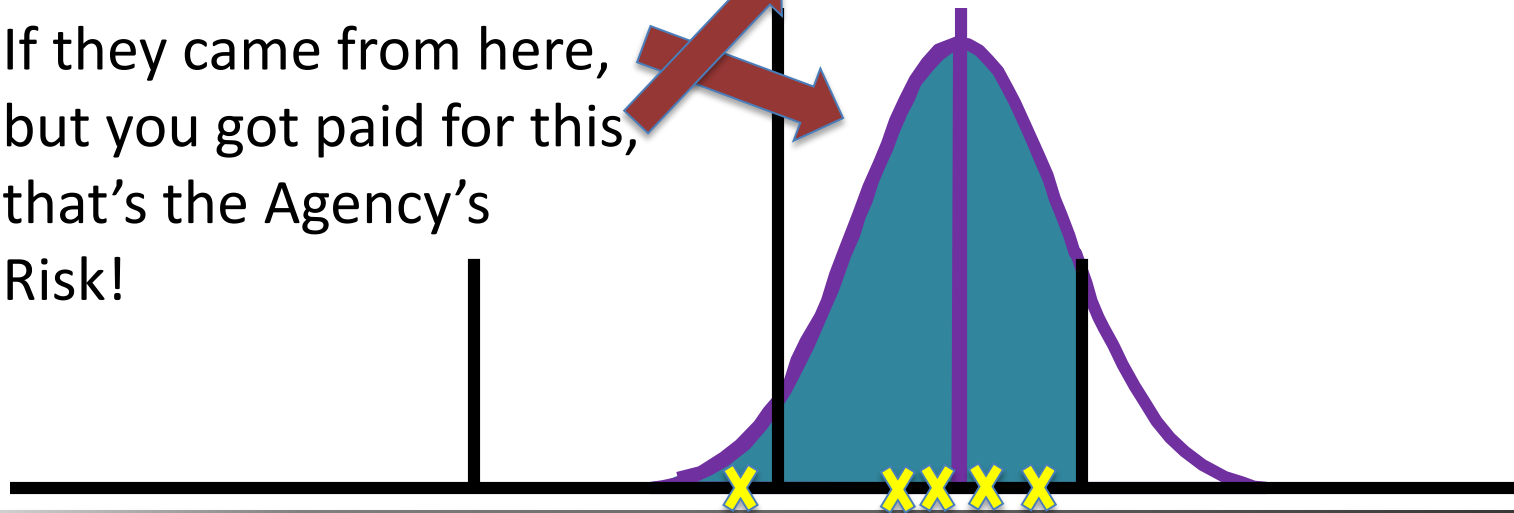


PWL as a Quality Measure

Which
distribution did
these data
points come
from?



If they came from here,
but you got paid for this,
that's the Agency's
Risk!



Determining “Typical” Variability

- State should use a “typical” variability to set spec limits.
- Should be based on variability data from a large number of projects.
- There is no single “correct” way to do this.



Process Adjustments

- “I can’t wait to plot a control chart. I need to make an adjustment after each test is in.”
- “With PWL I can’t adjust my process because I get a penalty if I do.”

Process Adjustments

- The natural tendency for someone who does not understand variability is to **over adjust** a process!
- To adjust, or not to adjust, that is the question.



vs.



Process Adjustments?

- Too much process adjusting leads to increased standard deviations (*no tweaking!*)
- Leading to smaller Q values
- Leading to lower PWL values
- Leading to lower payment!



Buyers' and Sellers' Risks

- Buyer's risk is the probability that an inferior product is accepted.
- Seller's risk is the probability that an acceptable product is rejected.
- These risks exist regardless of whether the specification is statistically based or not.
- They can be quantified with statistics so you know where you stand.
- A good specification has a reasonable level of risk for both parties.



What are your risks?

- 2.8 Million people die in a **typical non-pandemic** year in the U.S.
 - 2.6 Million of disease
 - 0.2 Million of accidents
 - Overall 0.9% or about 1 in 117
- Accidents 170,000
 - Motor vehicle: 34,000
 - Commercial airline: 0
 - Falling out of bed: 450
 - Lightning strike: 29

What are your risks?

- Disease
 - Heart disease: 647,457
 - Mad cow: 0
 - Cancer: 599,108
 - Flu: 55,672
- Hedging your bets
 - Don't drink and drive!
 - Don't text and drive!
 - Don't smoke!
 - Eat healthy!



Risks

- The future price of asphalt.
- The future price of aggregate.
- The cost of transportation.
- The cost of concrete pavement.
- The cost of labor.
- The price you get for HMA.
- The penalty or bonus.



Desirable Specification Features

- Must be understandable and biddable.
- Product expectations are clearly stated.
- Risks are clearly defined.
- Points of sampling, frequency and tests are unambiguous.



Desirable Specification Features

- Characteristics tied to performance.
- Historical records used for quality level and variability.
- Precision and bias accounted for in tolerance.
- Interdependence of variables accounted for.



Desirable Specification Features

- All assumptions are clearly stated.
- Do not stifle innovation.
- Provide quick results of QA testing.
- It is a **LIVING DOCUMENT!**



What not to do. . .

- Set limits according to testing variability instead of all sources of variability.
- Have small sample sizes with narrow limits.
- Set pay adjustments with steep step functions.
- Apply spec to materials it wasn't intended for.



What not to do. . .

- Implement PWL without defining risks (OC curves).
- Have penalties without bonuses.
- Have pay factors based on subplot results.
- Use PWL on noncontinuous projects – driveways, turn lanes, etc.
- Use on small projects.
- Use on unusual projects.

The Bottom Line

- PWL Specs are not your enemy ...
- If you understand them!
- **They should reward contractors with low process variabilities.**
- They should penalize contractors with high process variabilities.



Don't reward under-achievers!!



Some Observations

- There are no statistical specs with $n=1$.
- As n increases, risks go down for both contractors and agencies.
- Need realistic targets and limits:
 - Two-sided
 - One-sided
- **Cannot have PF that penalizes without PF incentives.**
- **It is a LIVING Document – change as needed.**



Do We Know What Makes a Pavement Perform?

This is not white sand!

