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PHMSA Pipeline Risk Modeling Methodologies Public Workshop

Critical Review of Candidate Pipeline Risk Models

Jason Skow
C-FER Technologies (1999) Inc.

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Overview

1. Project Objectives
2. Background & Incentive
3. Project Scope
4. Examples

Project Objectives

Create guidelines for assessing and developing pipeline risk models based on the probabilistic quantitative approach

- A critical review of existing quantitative risk models (including models used in other industries)
- Develop guidelines to define:
  - Standard requirements
    - Identify minimum attributes required for a quantitative risk models
    - Risk measures to be evaluated by the model
  - Levels of analysis
    - Ability to achieve desirable attributes
    - Degree of analytical rigor and data completeness

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Background & Incentive

- Risk models are used to rank pipe segments, identify threats and guide integrity management decisions
- Many current applications are based on qualitative models that measure risk on a subjective scale (e.g. an index between 1 and 10)
- Attributes and weighting factors
  - Attributes sensitive to risk
  - Weighting factors reflect perceived relative importance
  - Results are subjective and context specific

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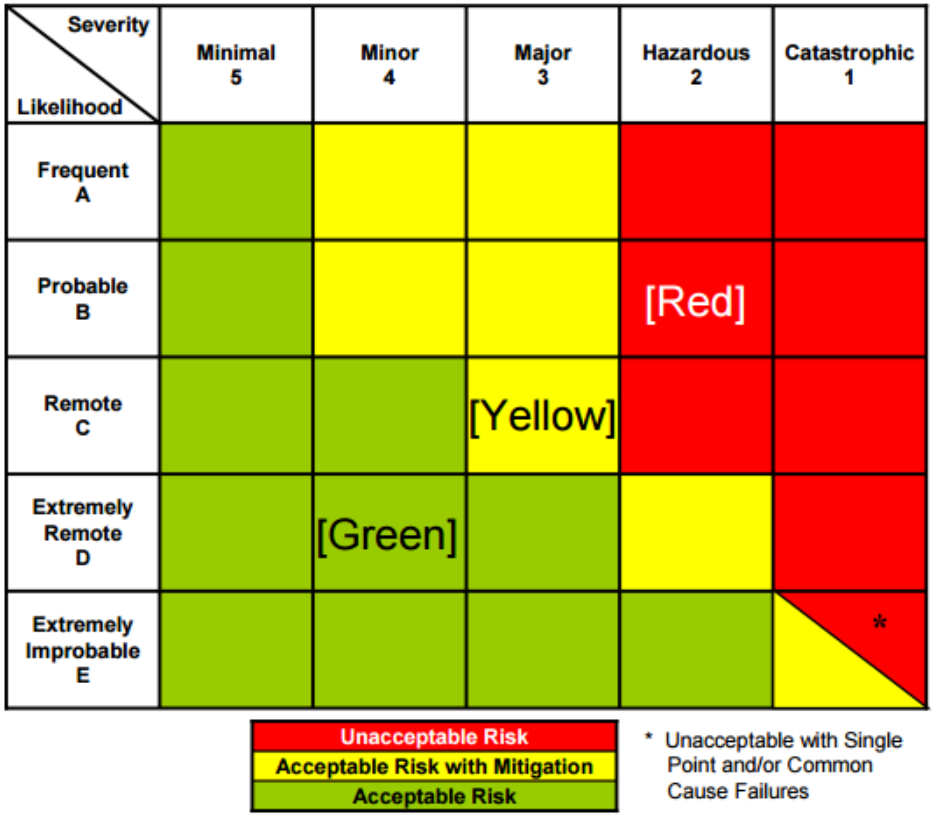
Qualitative Risk Methods



Challenges

- Rank reversal
- Relative distance distortion
- Centering bias
- Categorization errors

Risk (R) = Probability (P) x Consequences (C)

Probabilistic Risk Models

Many of these limitations can be addressed by using a probabilistic quantitative approaches:

- Estimates the risk as the expected value of an objective parameter that measures the consequence of failure

Advantages:

- Results can be used in formal decision analysis
- Links uncertainty in the analysis and conservatism in the results
- Uses objective data and engineering models
- Can be used to model rare events such as interacting threats
- Evaluates the effects of preventive and mitigating activities
- Allows for the assessment of the value of new information
- Can be validated using historical data and compared with other industries

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Scope

- Industry survey
- Review existing models
- An assessment of the desirable model attributes related to:
  - Results
    - fit within decision-making processes
    - format and use of risk acceptance criteria
  - Input requirements
    - flexibility to use existing data
  - Model performance
    - accuracy
    - verifiability
    - transparency and repeatability
    - complexity vs precision
  - Probabilistic framework
    - uncertainty and the value of new information
- Produce Guidelines for quantitative model selection, development, and the evaluation of risk.

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Application

Factors related to the successful application of a risk model

- Data availability
- Ease of implementation
- Flexibility
- Validation requirements
- Consensus on risk evaluation criteria
- Acceptance by the regulator
- Fit within integrity management framework
- Incremental improvements over time

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Example: Levels of Analysis

- SME opinion – converting SME opinion into quantitative probabilities
- Historical-based models – historical failure rates from available databases are used to estimate baseline failure rates which are modified to reflect system specific attributes
- Reliability Analysis Methods – detailed engineering models are used to estimate probability and consequence.

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Example: Model Attributes

- Safety, environmental and costs-related consequence measures
- A minimum list of threats
- Failure modes and their effect on consequences
- Link between mitigation activities reliability estimates
- Risk results by threat and by location

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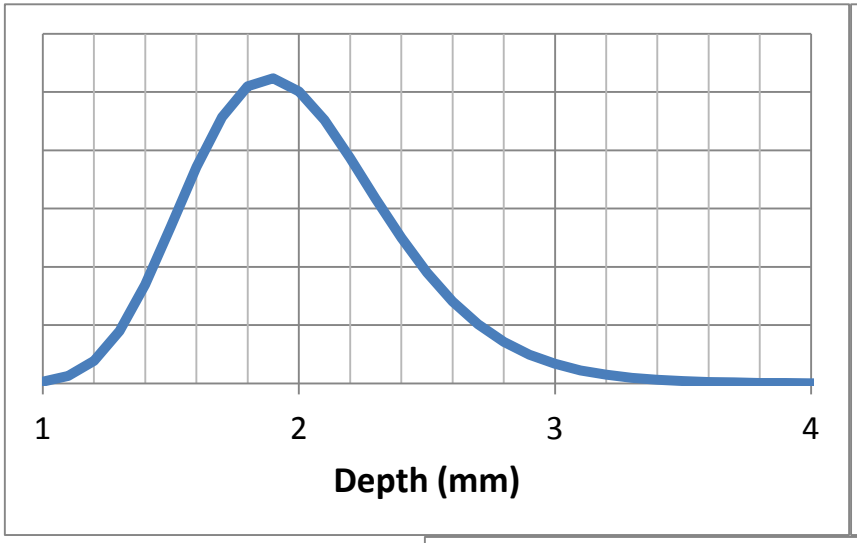
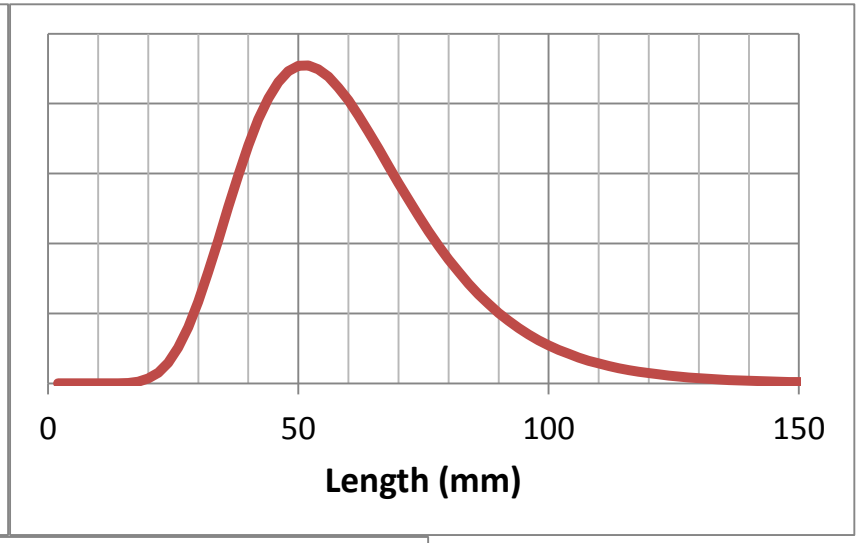
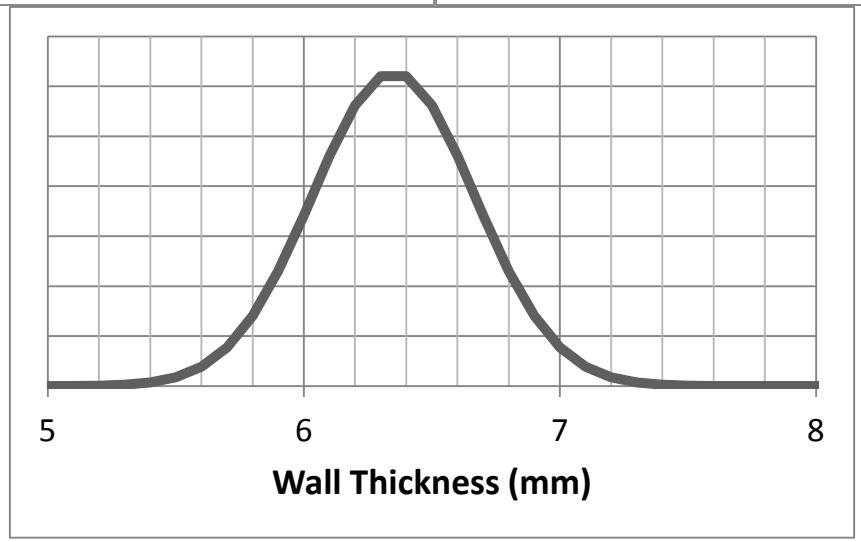
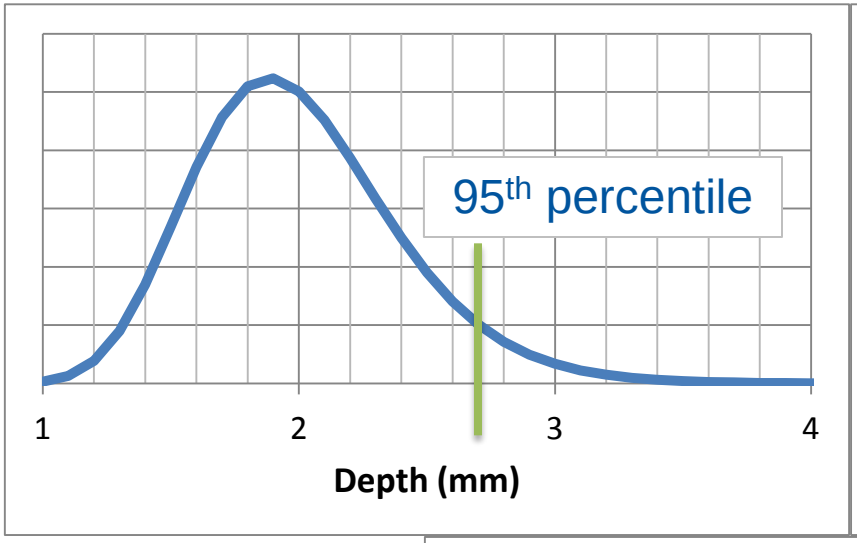
Example: Uncertainty

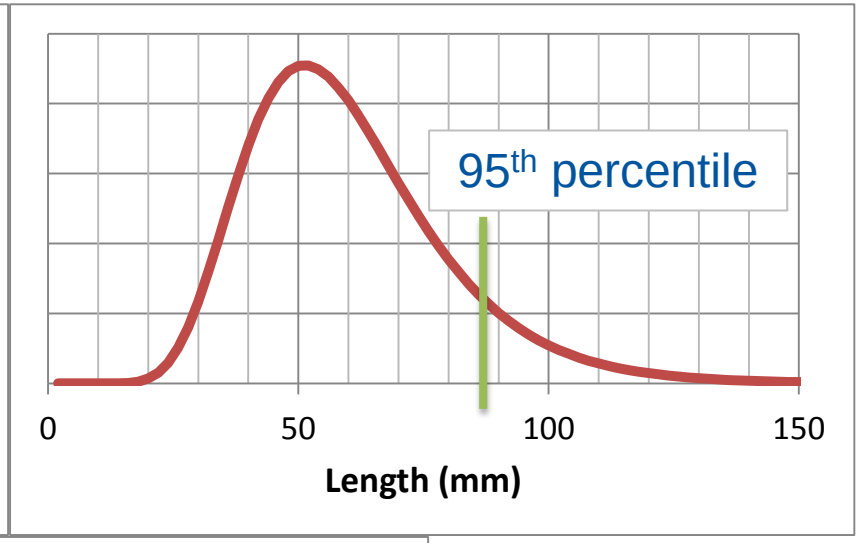


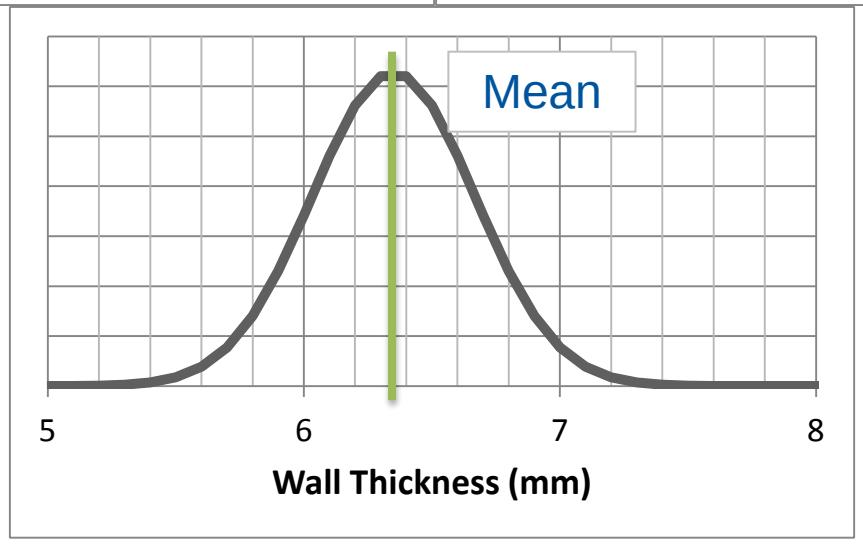




Representative Values







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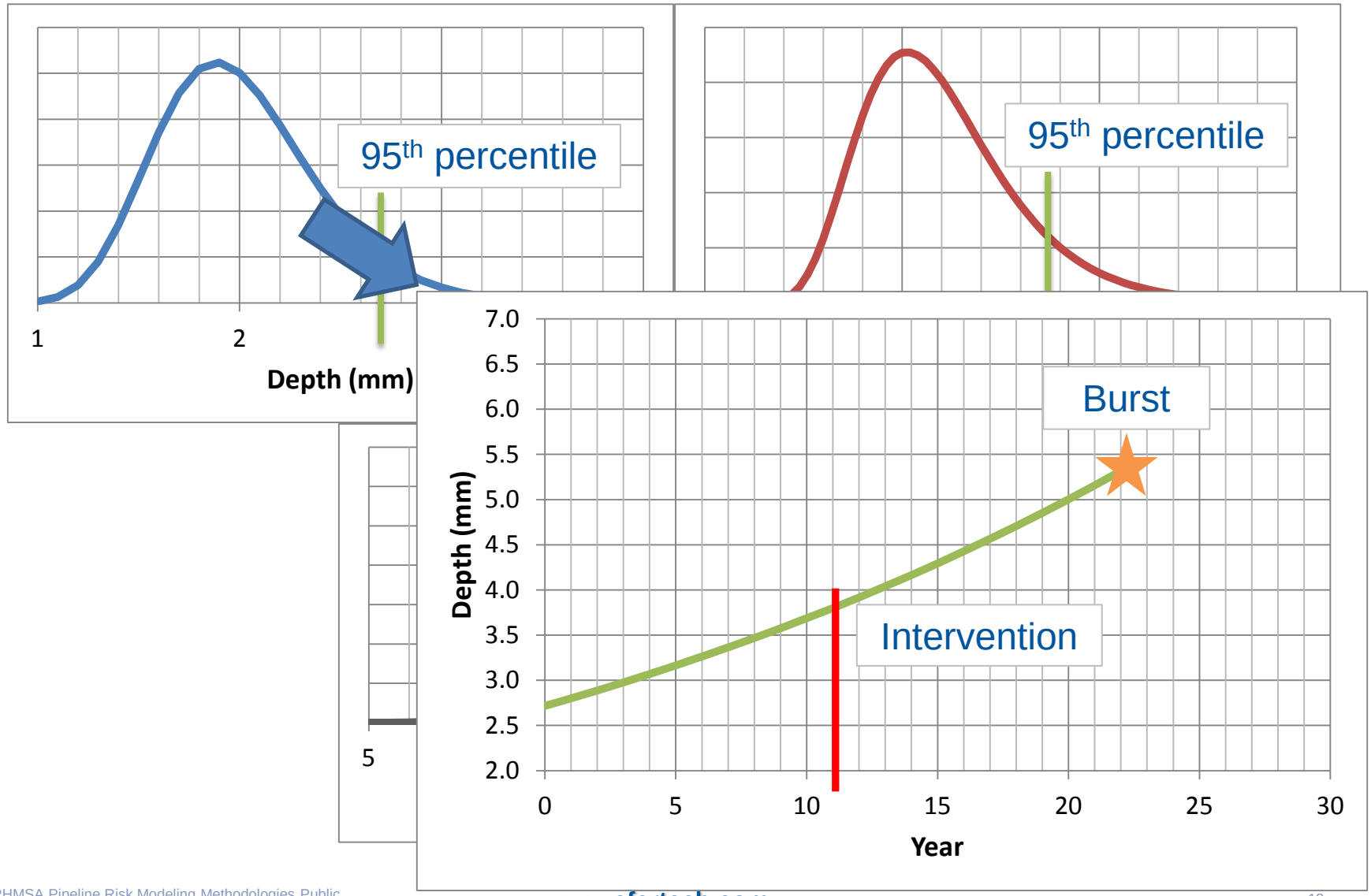
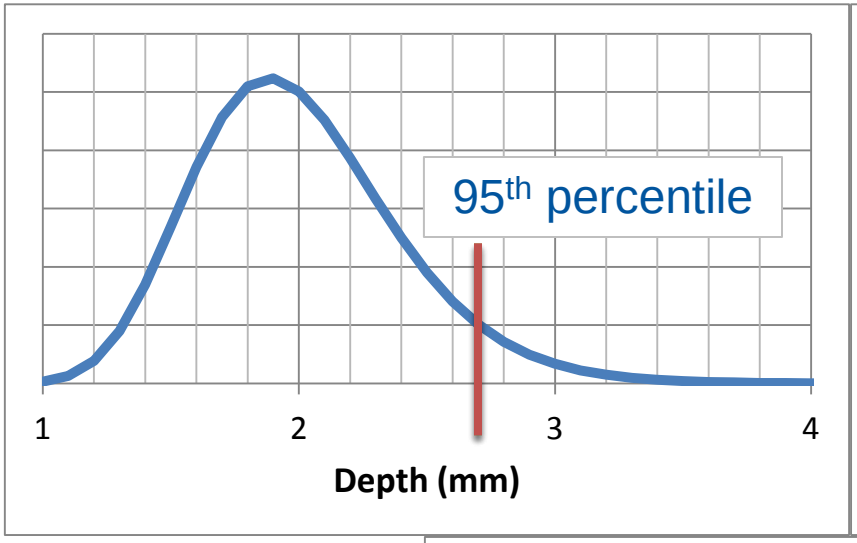
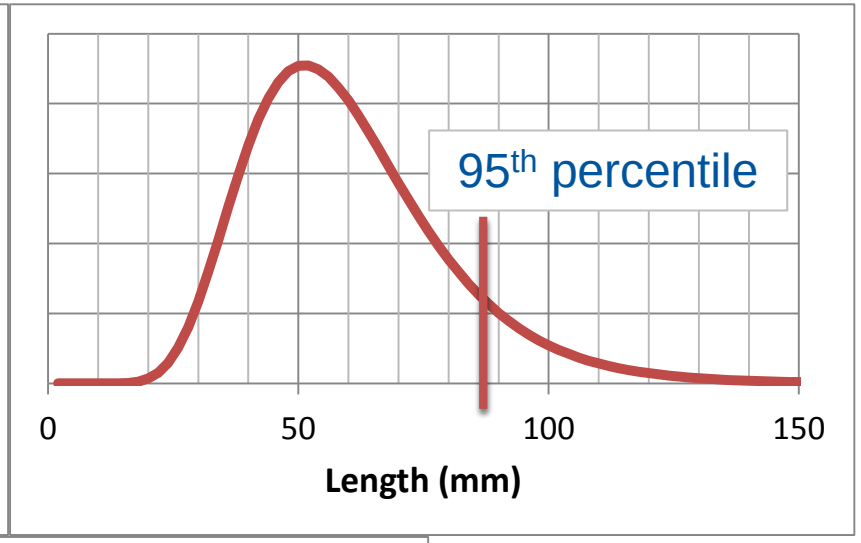
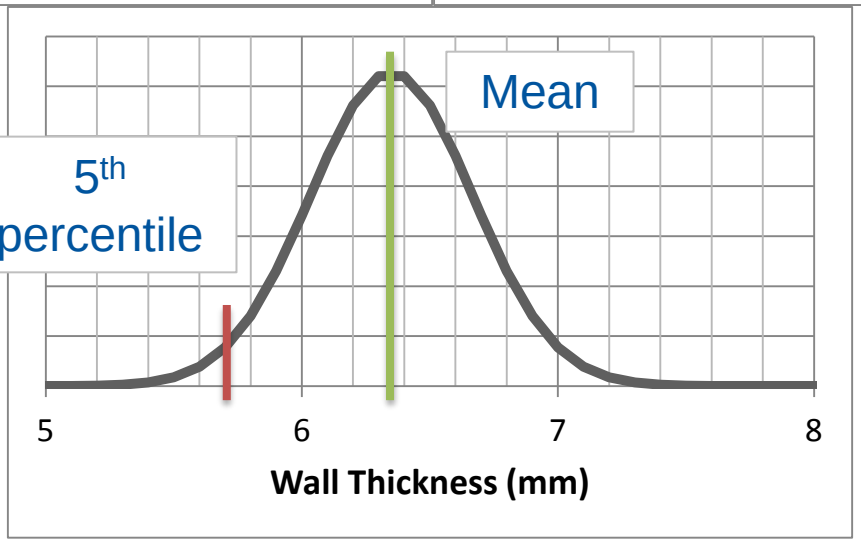
Remaining Life



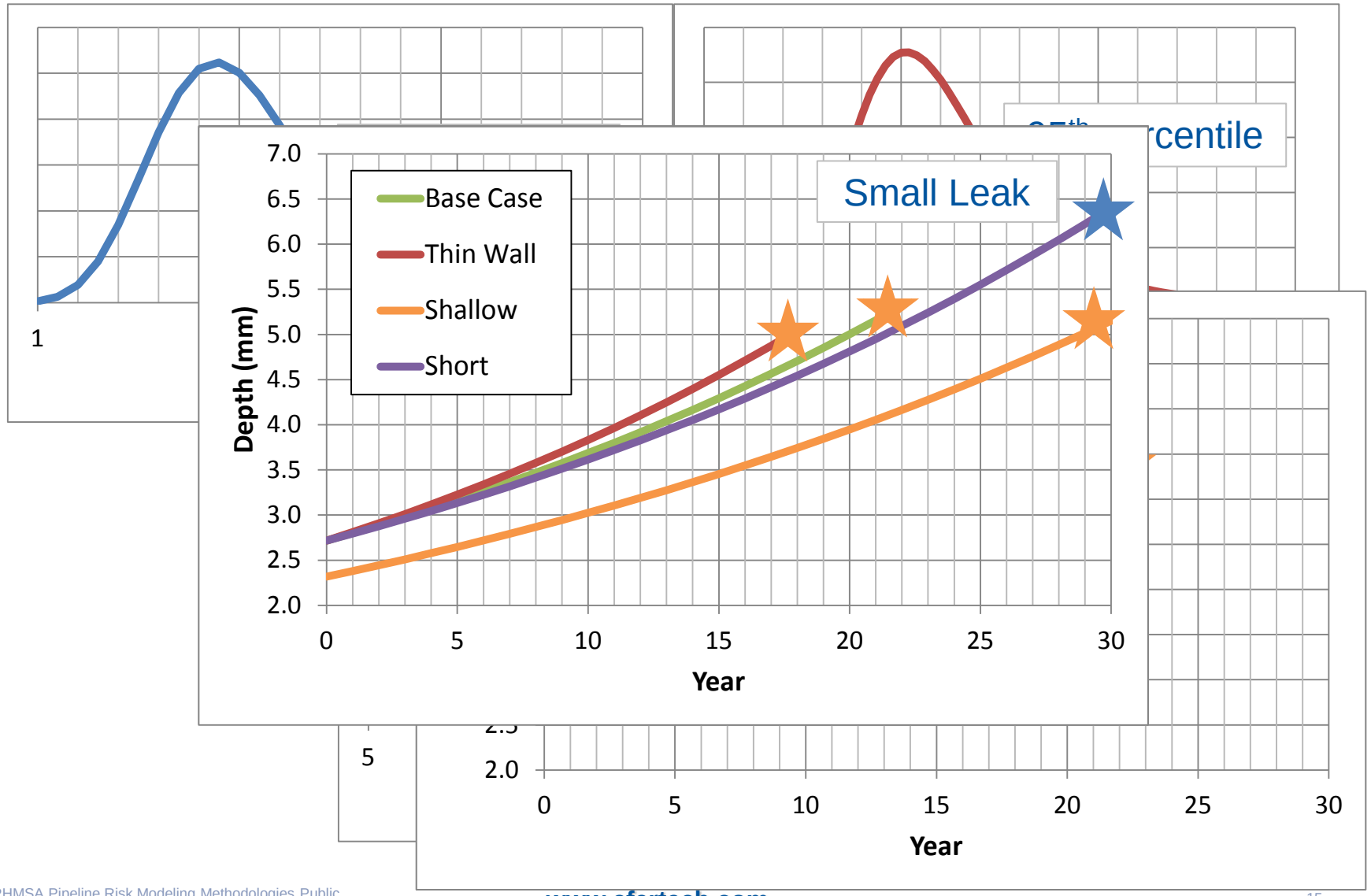
Distributions Revisited



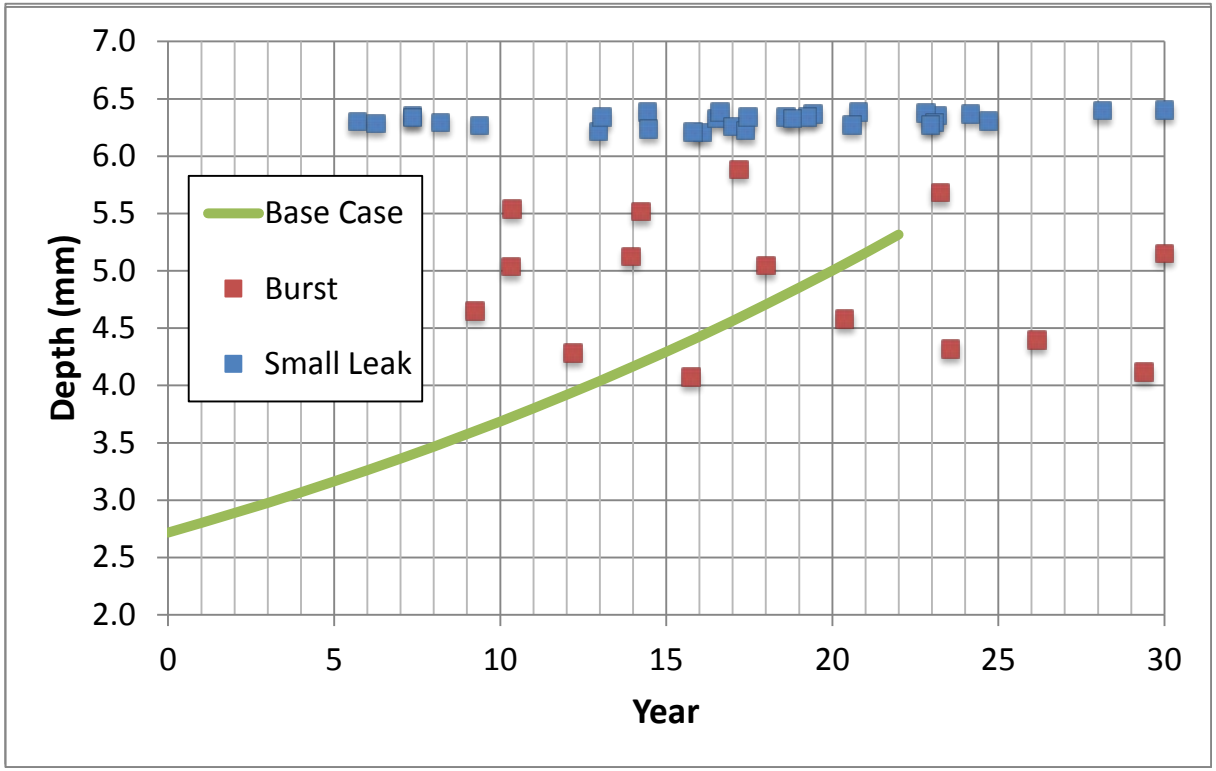




Remaining Life Revisited



Remaining Life Revisited



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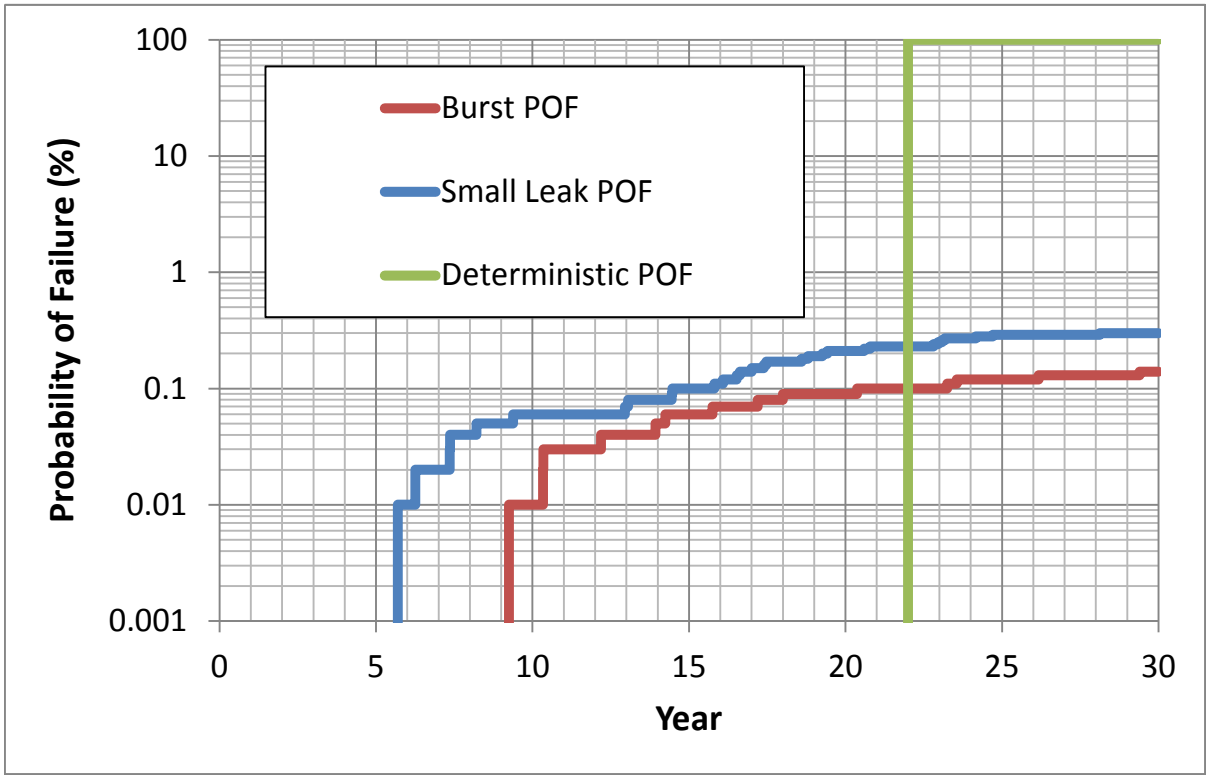
Probability of Failure



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Summary

- Qualitative risk models are insufficient
- Probabilistic risk models can appear more complicated than deterministic models
- Guidelines will help to evaluate, select and develop probabilistic quantitative risk models
- A critical review will include existing risk models in both the pipeline and other industries

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Thankyou!