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Seam Weld Defect Assessment - Process Elements and Importance Ranking

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The Assessment Process

Key Elements

- Find existing defects
- Size existing defects
- Assess existing defects at time of detection
  → identify defects requiring immediate remediation
- Project future defect sizes
- Assess existing defects at future times
  → determine time to defect remediation or re-inspection

The Assessment Process

Key Issues

- Find existing defects
  - Detection capability of inspection technology
- Size existing defects
  - Sizing accuracy of inspection technology
- Assess existing defects at time of detection
  - Accuracy of failure prediction model & uncertainty with model inputs
- Project future defect sizes
  - Accuracy of growth rate model & uncertainty with model inputs
- Assess existing defects at future times
  - Accuracy of failure prediction model & uncertainty with model inputs

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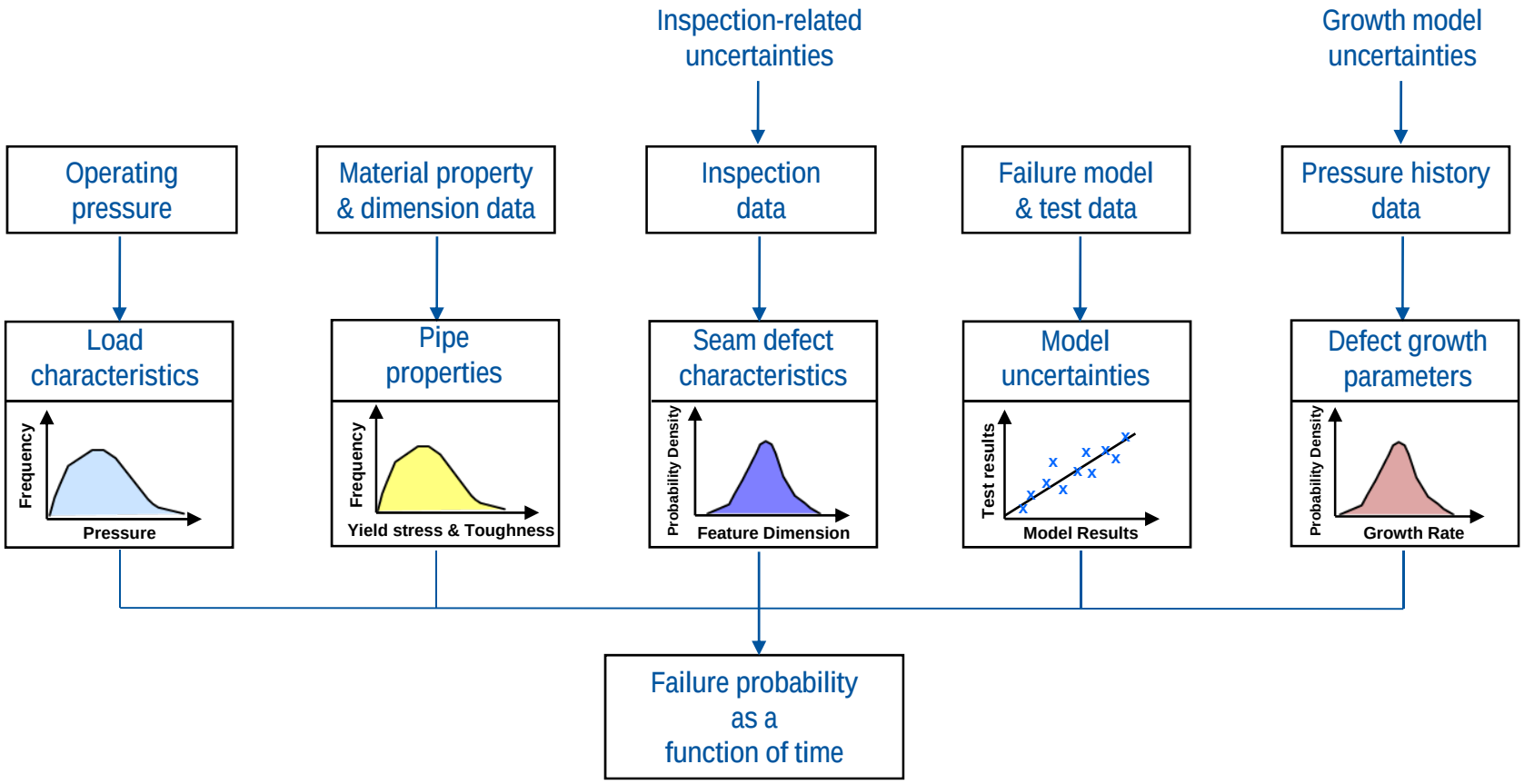
Quantitative Reliability Estimation of Seam Weld Defects

- Formally characterize parameter/model uncertainties using probability distributions
- Calculate defect failure probability using standard techniques

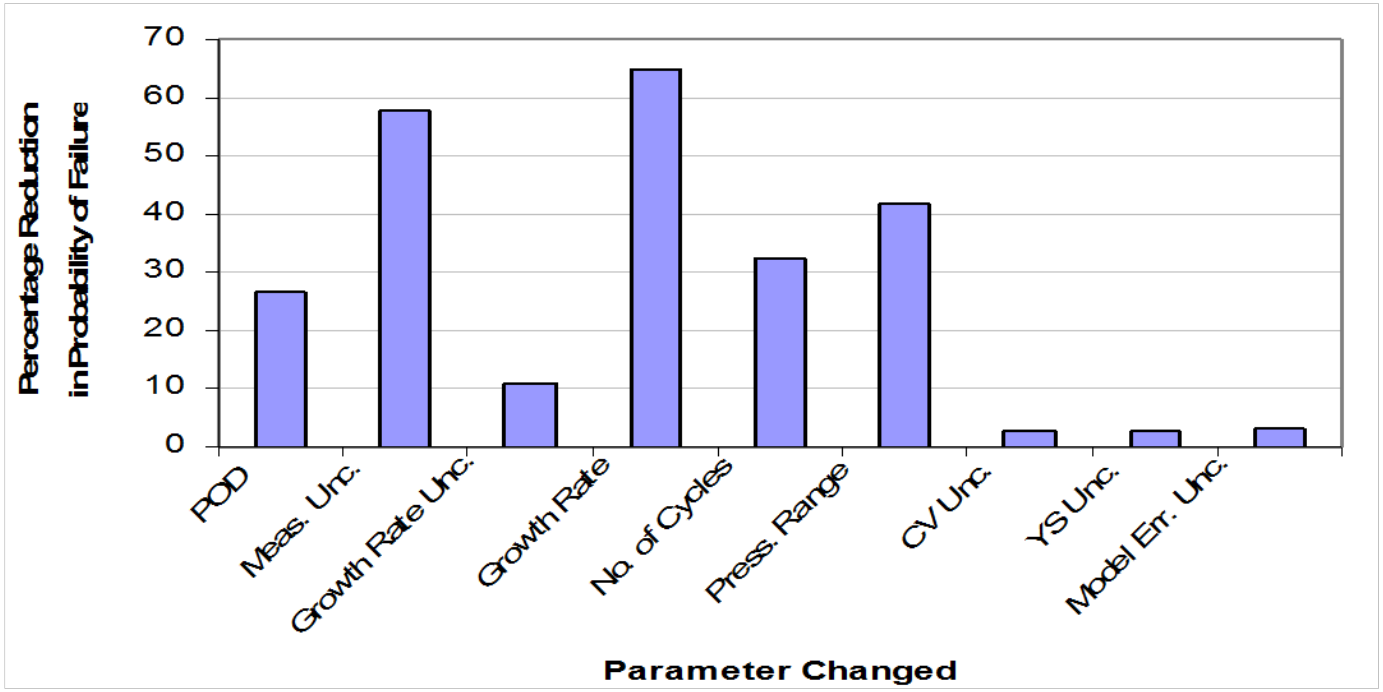


Features of Probabilistic Analysis

- Higher model uncertainty and/or high input parameter uncertainty will result in an increase in the calculated probability of failure
- The relative significance of the accuracy of a given model or the level of uncertainty associated with a given input parameter can be assessed based on its relative impact on calculated failure probability
- Can perform sensitivity analysis on model accuracy and input parameter uncertainties to rank the importance of key inputs
  - Systematically evaluate how much reduction or removal of parameter uncertainty reduces the calculated probability of failure

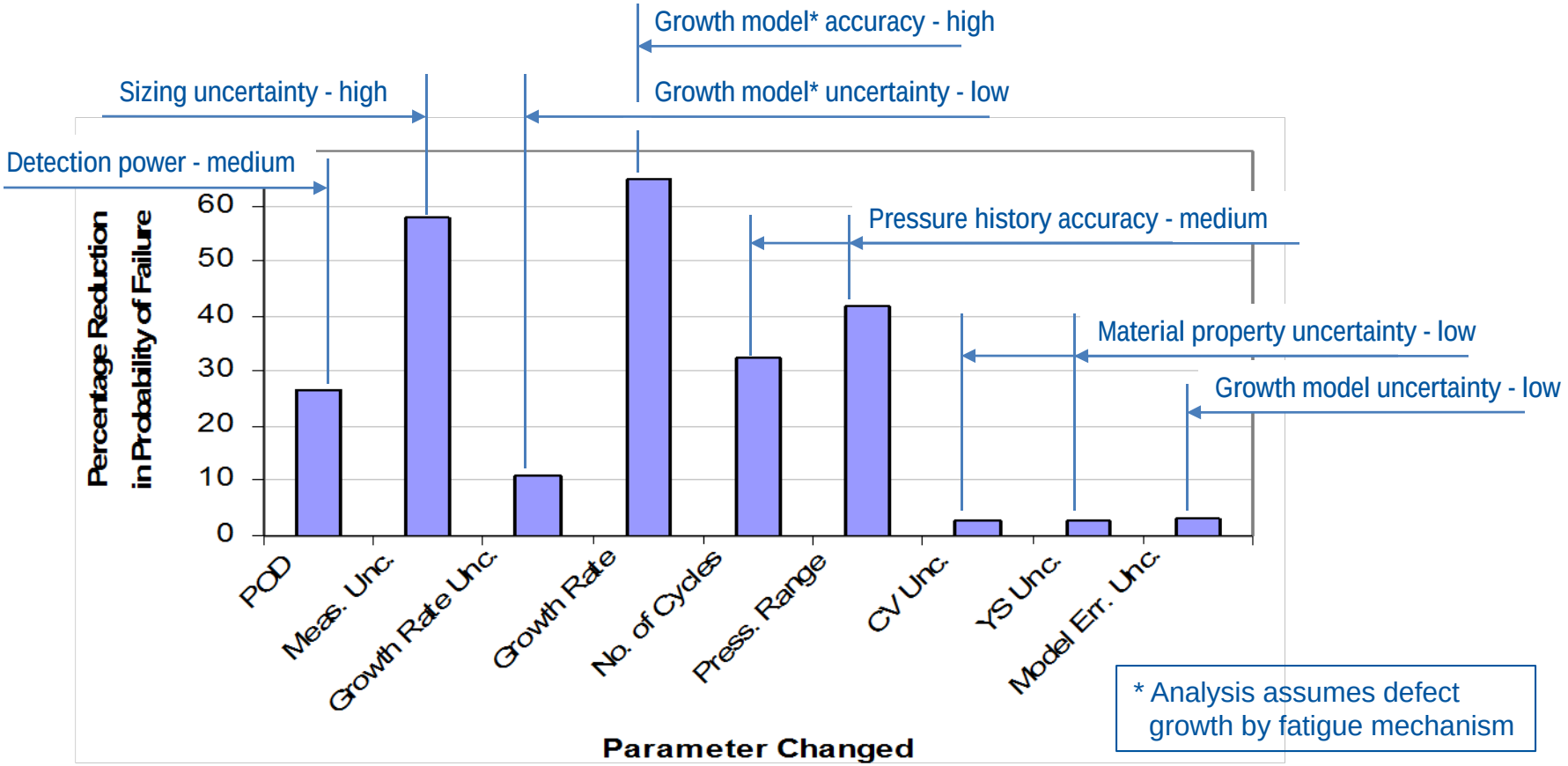
Results of Sensitivity Analysis

- Reduction in probability of failure given selective removal or reduction of parameter uncertainty – for a representative analysis case
  (adapted from Damage Management for Operating Pipelines – Gap Analysis, prepared for PRCI by C-FER Technologies, Catalog # L52246, Nov 2007)



Results of Sensitivity Analysis

- Importance ranking based on impact on probability of failure



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Importance Ranking of Key Elements of Assessment Process

- Find existing defects
  - Detection capability of inspection method – MEDIUM
- Size existing defects
  - Sizing accuracy of inspection method – HIGH
- Assess existing defects at time of detection
  - Accuracy of failure model & uncertainty with model inputs – LOW
- Project future defect sizes
  - Accuracy of growth model – HIGH
  - uncertainty associated with growth model inputs – MEDIUM
- Assess existing defects at future times
  - Accuracy of failure model & uncertainty with model inputs - LOW

Note: Findings should be interpreted as illustrative and informative since importance ranking of process elements is sensitive to analysis assumptions and the conditions associated with the adopted reference analysis case – see referenced PRCI report for details

Implications for Advancement of the Defect Assessment Process

- Should focus development efforts on issues that have the biggest impact on failure probability
  - Technologies with improved feature detection & sizing accuracy
  - Methods and models for accurately predicting defect growth

- Comments on failure prediction models
  - More accurate models are always preferred
  - However:
    - Sensitivity analysis indicates that model accuracy is less important for seam defects because fatigue driven defect growth is exponential (late stage defect growth is very rapid and time to failure is less sensitive to variations in assumed critical defect size)
    - The relative importance of model accuracy and failure prediction model inputs will be greater where defect growth is more linear or where defect sizing is inferred from hydrostatic test pressure