Inspection Parameters

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Outline

- “Inspection Parameters”
  - Why inspect? & What parameters?
- Failure Mechanisms & Implications
  - Contrast collapse vs fracture control & Essential Inputs
- Discussion relative to IMP (known) / IVP (pending?)
  - One Analyst’s View
- Vendor Specifications & Implications
- Needs / Gaps
- Summary & Conclusions

"Inspection Parameters"

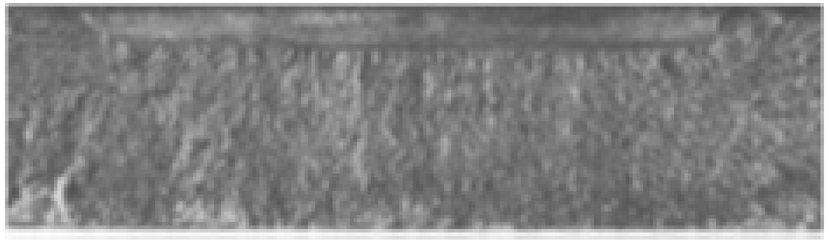
- Why inspect?
  - – Inspection via some tool(s) needed to quantify "condition"
    - - tools include nondestructive practices (ILI vs in-ditch vs above ground) as well as others that can be or are destructive (hydro, grinding for depth, ...) – technologies overlaid on tools (UT ....)
  - – Condition is an input to decision-making:
    - - some decisions relate to mandated actions:
      - - for example aspects of IMP & IVP (although pending/uncertain) open to the need to assess severity as well as response timeline, and involve quantitative practices (EAC / Level 1, 2, 3, Risk, Time/Cyclic Rate, etc)
    - - other decisions are more driven by economics and priorities that can be company specific:
      - - for example where to rehab / & how, and whether to replace / & when, etc
  - – Nature of the decision & related circumstances dictate the parameters needed, and the tool(s) used

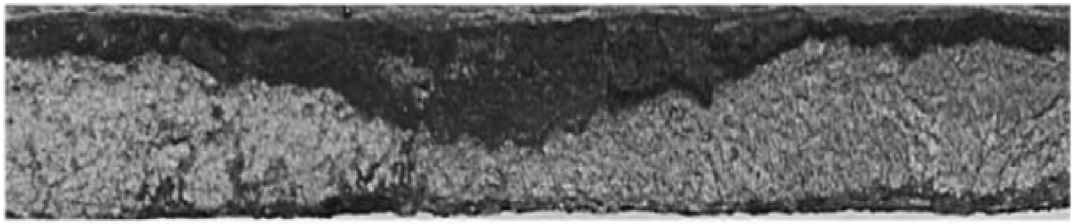
“Inspection Parameters”

- What parameters?
  - – blunt vs sharp (planar vs volumetric)
  - – size, shape, orientation, proximity to other features
  - – how to quantify size or shape? – can by dictated by circumstances (relative to end use, certainty of other key parameters, etc) but often involves maximum length & depth – and an often idealized shape – but also can be “boxed” or grouped by depth intervals
  - – reality is often far from what can be sensed, sized, and simply represented in anomaly reporting
    - - true even for isolated features: more so for adjacent possibly interacting features

“Inspection Parameters”

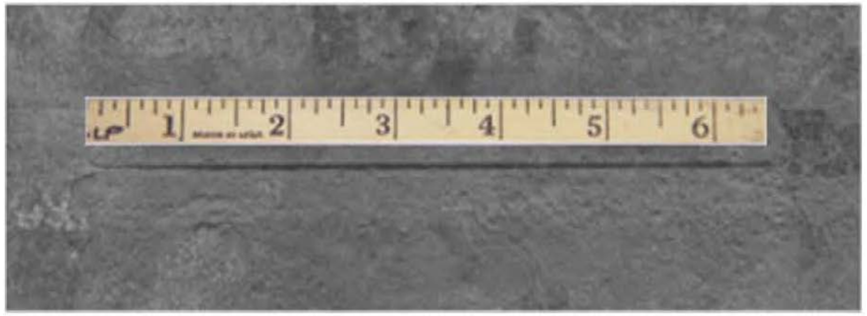
- Examples of reality – Fracture plane

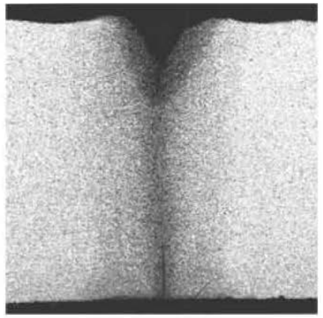


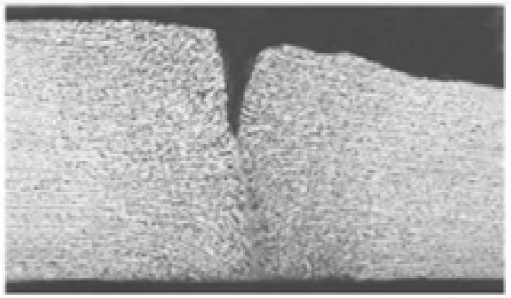



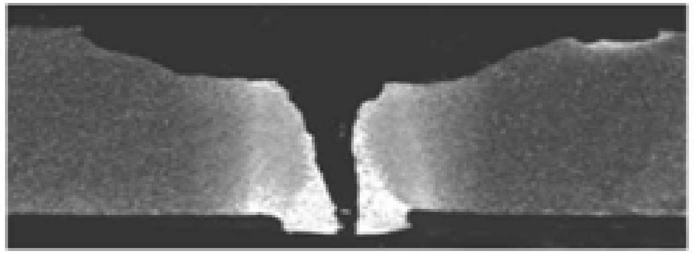

“Inspection Parameters”

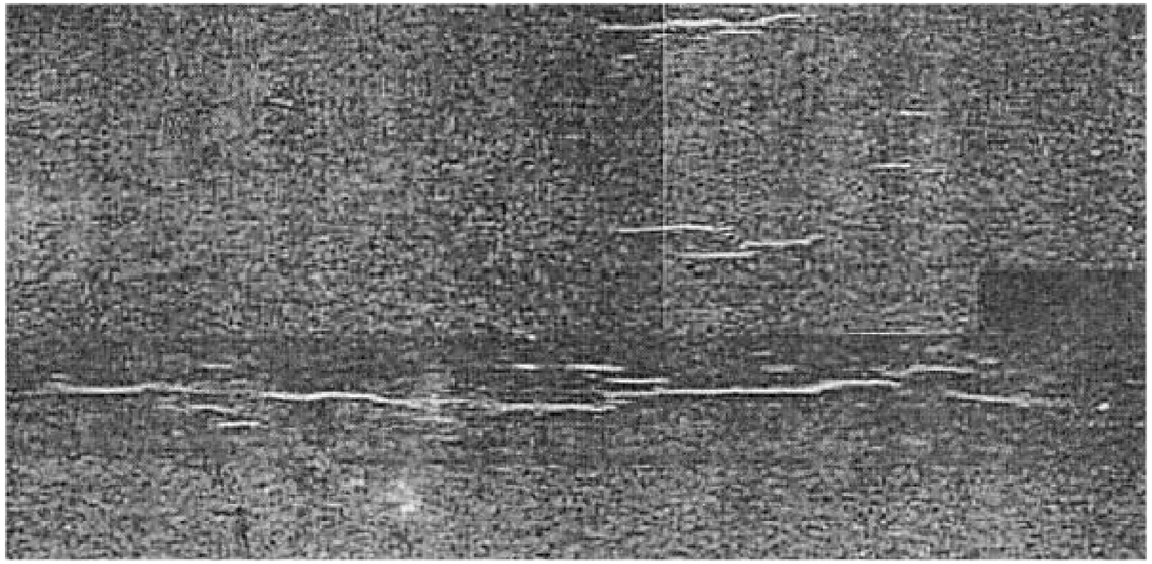
- Examples of reality – EAC











Failure Mechanisms & Implications

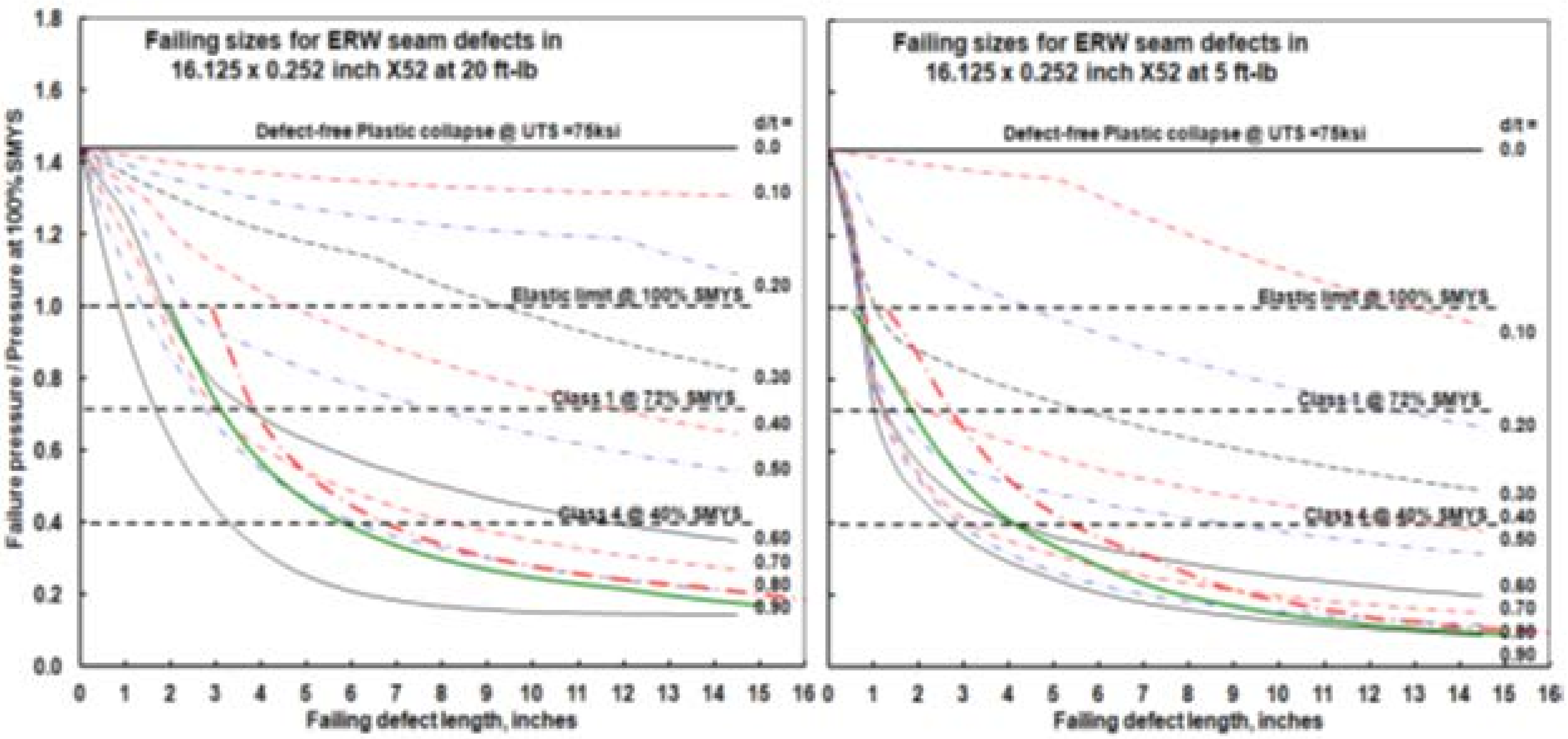
- Collapse vs Fracture Control
  - indications need to be assed regarding severity & rate
  - initially sharp features will blunt in tougher steels – more so for increasingly tough steels
  - net-section collapse (NSC) control (higher toughness)
    - controlled by net-area lost and the ultimate stress (MB31G/B31G)
  - fracture control (lower toughness)
    - controlled by length and depth and the toughness

Failure Mechanisms & Implications

- Essential Inputs for analysis
  - NSC: L & A_{eff} (via Shape Factor)
  - Fracture: L & d_{mx}; shape & axial segmentation more important
  - Proximity dictates interaction between adjacent features
  - Loading, properties, and anomaly size / shape / orientation combine to determine failure behavior & pressure
    - detail & accuracy required from the inspection depend on:
      - the end use / consequences being a key driver
      - the certainty of other key parameters – like toughness or UTS (SMYS/TS)

Implications for Failure

- Sensitivity to input parameters & certainty:

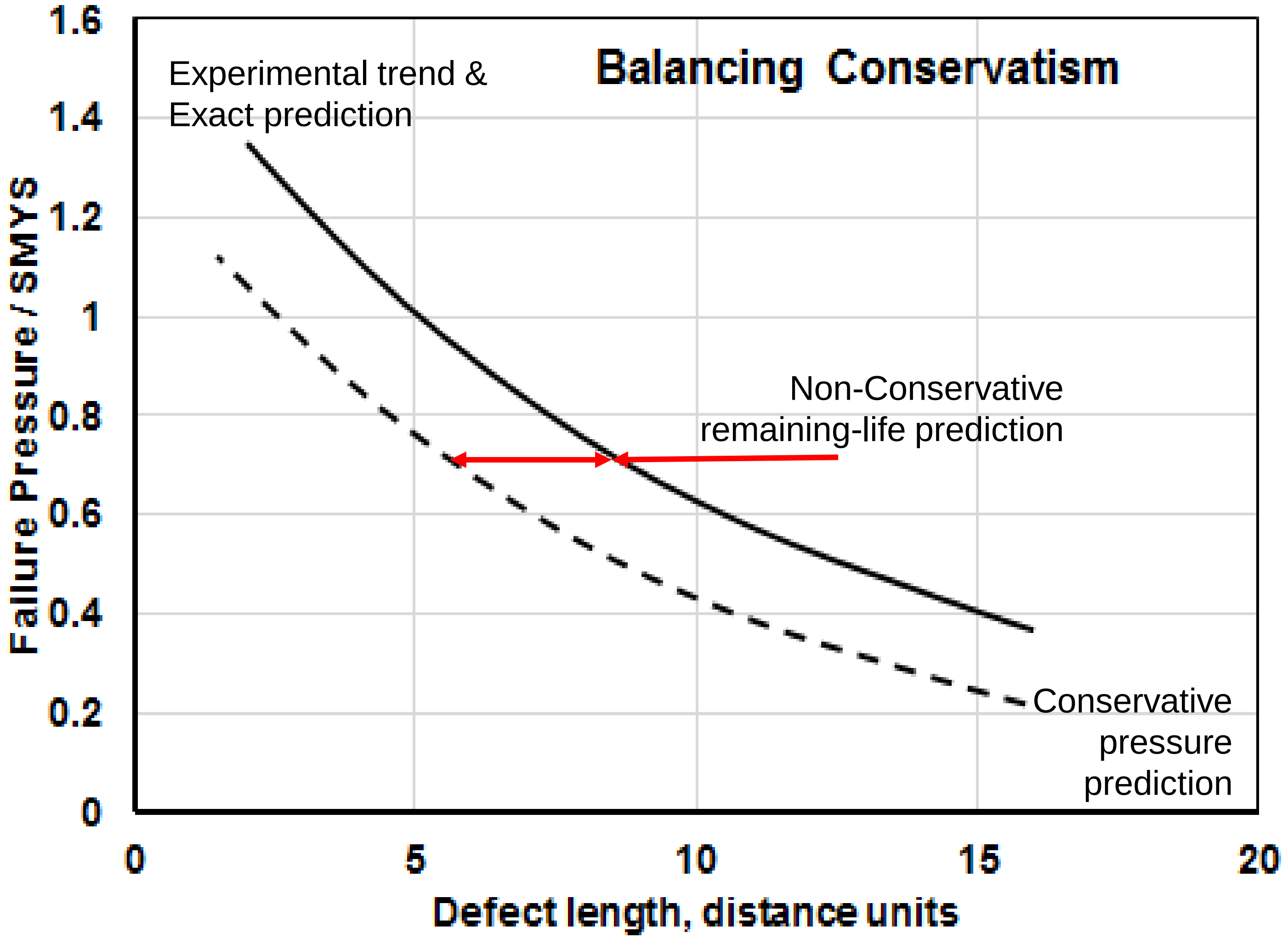


- NSC – shows nested trends but not for fracture
- Toughness
- Length
- Y/T
- Depth

Some views

- One Analyst's Views relative to IMP / IVP
  - – uncertainty in properties – particularly toughness – is a first-order factor driving results (& so also decisions)
  - – role / acceptance of uncertainty in sizing depends on circumstances
    - toughness is a first-order driver – discriminates on failure mechanism and what sizes can fail
    - for longer tougher features length is less important
    - Y/T can be important in regard to shallow features
    - all of the above can be important for timeline assessments via their influence of critical / final defect size

Balancing conservatism



- Can’t offset uncertainty by being conservative in pressure predictions
- Can only balance conservatism by using and accurate model

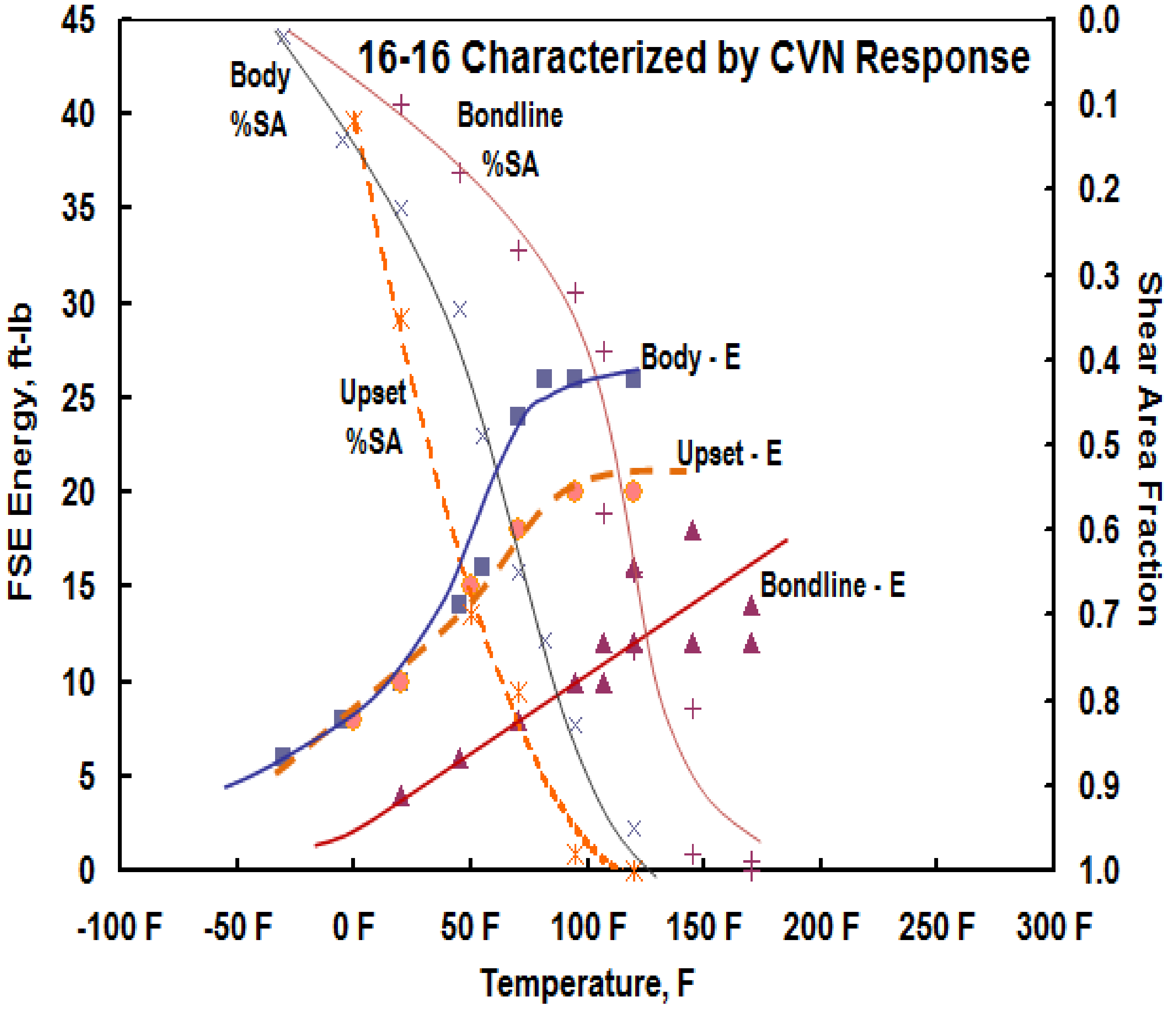
Vendor Specifications & Implications

Illustrative / typical example for a crack tool

	Pipe 16-16 t = 0.252"	Pipe 10-7 t = 0.231"	Pipe 22-11 t = 0.290"
Crack Detection			
Minimum depth (parent material) = 0.04" as d/t	0.159	0.173	0.138
Minimum depth (in long seam) = 0.08" as d/t	0.317	0.346	0.276
Minimum length = 1.57"	<	1.57"	>
Crack sizing			
Depth sizing (±) = 0.15t as d/t	±0.150	±0.252	±0.231
Length sizing (±) = 0.39"	<	0.39"	>
Notes:			
Wall thickness range up to 0.79"			
Orientation to pipe axis is within ±18°			
Other requirements apply that pertain to operations and other factors - see NACE SP0102-2010			

- Fractional specifications can lead to quite different physical sizes (no-brainer) that impact the inspection effectiveness relative to a Hydrotest
- Merits of a tool run thus depend pipe size & its properties
  - Some cases offer little to nothing beyond what is known day to day based on service pressure

Implications of properties



- Location .. Location ... Location
- Significant differences in some applications in regard to where the anomaly is located – bondline, upset, body
- Discrimination is key to severity and timeline

Implications of Some Processes

- Some HF-ERW seams form what is known in Japan and Australia as “paste” welds
  - macro-look is similar to a cold weld
  - micro/SEM views show that there is a bond formed, but it appears structurally weak

- As there is no interface, and little difference otherwise, this can be hard to sense much less size

Needs / Gaps

- More dialog between those that design inspection tools and interpret logs / outcomes with those that assess severity / timeline
  - could open to better feature descriptions
  - could open to improved location with reference to a seam
- ILI or In-ditch technology to quantify toughness
- Better analysis tools to assess real crack shapes & coalescence

Summary & Conclusions

- Current approach to manage the system is viable
  - past failures of recently inspected lines often involved misread anomalies – continuing improvements in sensors & algorithms & broader data integration will help to manage this
  - condition assessment relies on the several technologies, with the outcome likely improved by better inter-collaboration
  - demanding more from inspection tools will not offset the implications of uncertain properties
  - failures reflect the worst-case combination of feature size / shape /orientation with loadings and properties – the worst size / shape /orientation might not control failure, but until mensa-pig comes to life it is not a bad place to start.