Proportionate Inspection Assurance

Balancing The Venn Diagram Intersection Of Credible Defects, Tolerable Size And Potential Consequences

Andrew Wood (CEng), Section Lead - Methods

FESI Beyond Code Safety Requirements Conference

10th April 2019

00

Summary

1. The Challenge
2. Inspection and Assurance Options
3. What is Proportionate / The Venn Diagram
4. Proportionate Inspection Qualification
5. Balancing the Venn Diagram
6. Conclusions

01

The Challenge

1. What inspection is required?
    1. What techniques should I apply?
    2. What acceptance criteria is proportionate?
2. What assurance (eg. demonstrated capability) is required?

Inspection Approach	Inspection Assurance
Code – Follow Prescriptive Rules "Method Based" (eg ASME)	**Code/Standard Assurance** • Capability typically not demonstrated, • Assured through industry/nuclear experience
Code "Plus" – Complementary "Method Based" technique and standard (eg BS/EN/ISO)	
Semi bespoke – As per Code "plus" with **modified/tightened/cross-checked acceptance**	**Limited Demonstration** • For example - DAC checked against planar reflector • Assured through nuclear/industry experience
	Capability Statement : • Physical Reasoning, (limited modelling/open trials)
Bespoke – Datasheet driven inspection	**Qualification Level B** – ENIQ – Recommended Practice 8 • Technical Justification, • Limited Open Trials or Modelling **Qualification Level A** – ENIQ - Highest Assurance • Technical Justification, • Extensive Open Trials or Modelling • May include Blind Trials

03

So What Is Proportionate?

"As to methods there may be a million and then some, but principles are few. The man who grasps principles can successfully select his own methods.

The man, who tries methods, ignoring principles, is sure to have trouble."

— Emerson

EMC.1, 5, 28, 29, 30

Principle:
EMC.30 – [NDT] should be qualified to an **extent consistent with** the **overall safety case** and the **contribution of examination** to **structural integrity aspects** of the safety case

Proportionate:

- Consequence
- Likelihood/Credibility of a Defect
- Significance of a Defect

So What is Proportionate?

Credible Defects

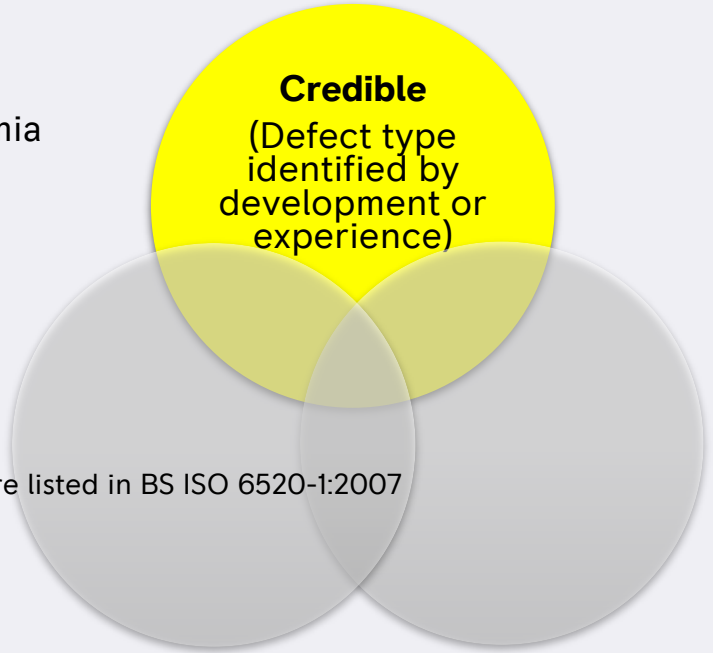
What Defects are Credible:

- Process Development
- Experience
- Industry Experts/Academia
- Expert Elicitation

What is of Interest?

- Defect Orientation
- Defect Size
- Likelihood
- Defect Morphology

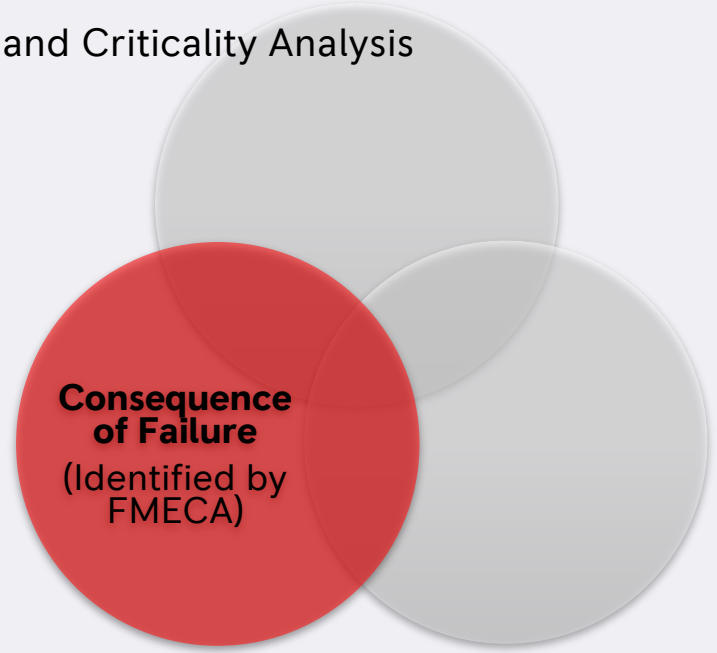
  For example, weld defects are listed in BS ISO 6520-1:2007
  - Lack of Side Wall Fusion
  - Lack of Root Fusion
  - Solidification Cracking
  - Single Pores
  - Clustered Pores



So What is Proportionate?

Consequence of Failure

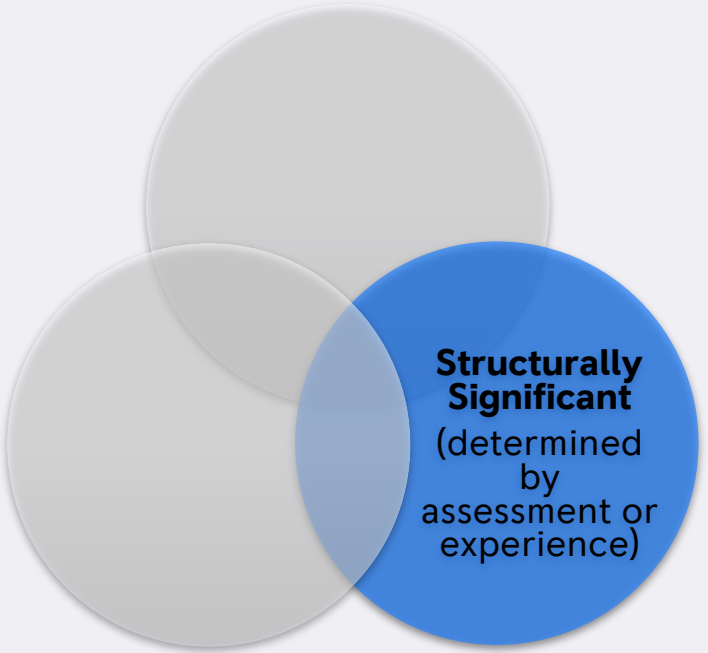
- Gross Failure
- Failure Modes, Effects and Criticality Analysis (FMECA)
- By Region
- By Plane



So What is Proportionate?

Structural Significance

- Fracture assessment
  - R6
- Experience
- Material Testing
- Component Testing



So What is Proportionate?

Example 1 -

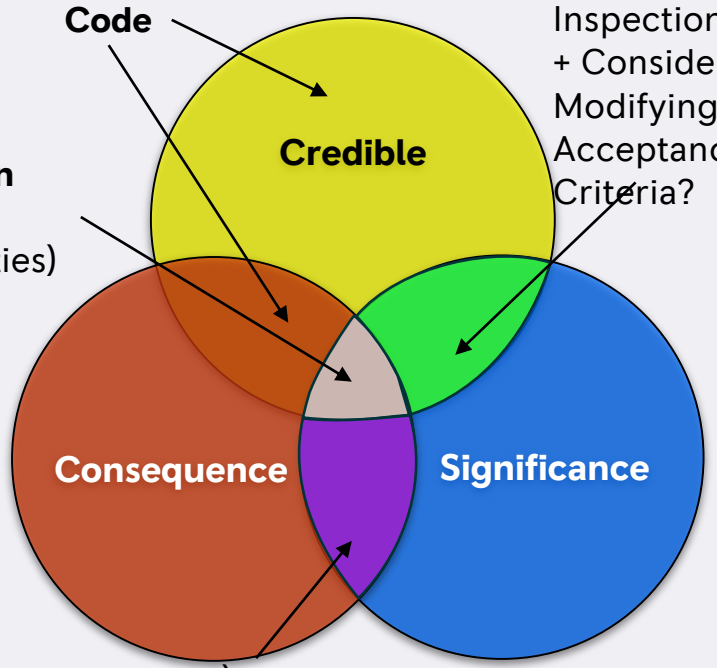
- Lack of Side Wall Fusion
- Multiple weld beads (stacked up - large)
- Defect Grows to Pressure Vessel Weld Failure

Example 2 –

- Isolated Pore
- Small
- Benign

What is Proportionate?

Code "Plus" or Semi Bespoke
+ Supplementary Inspections?
+ Consider Modifying Acceptance Criteria?



Bespoke - Qualification
(Bespoke requirements, specific assurance activities)

Capability Statement
(Could be a qualification for Highest Risk components)

04

Proportionate Inspection Qualification

..... to an extent consistent with the overall safety case

Qualification Level A (QLA): Highest Assurance.

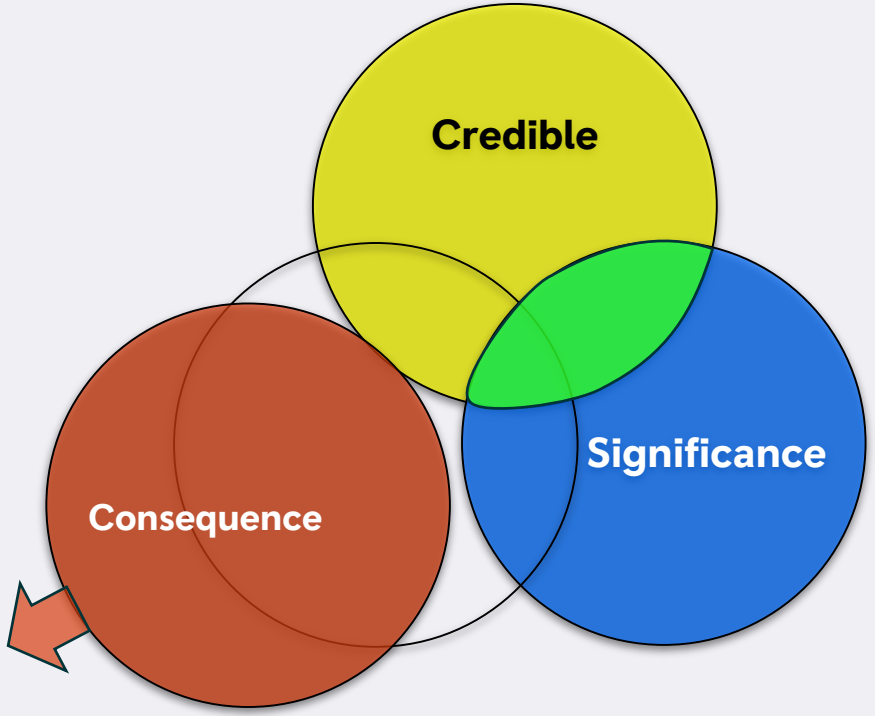
- Qualify full range of specified orientations.
- Target defects which are "**Credible** and of **Structural Significance** and of **Highest Consequence**"
- Also target defects which are of "**Structural Significance** and **Highest Consequence**" (eg principal stress planes).
- Detection and typically sizing of defects at qualification size and above.
- Technical Justification
- Open/Blind Trials/Modelling

Qualification Level B (QLB): Lower Assurance.

- Target defects which are "**Credible** and of **Structural Significance** and of **Highest Consequence**"
- Qualify nominal orientations. Address tilts/skews away from nominal with a capability statement.
- Detection only.
- Proportionate Technical Justification, typically open trials or modelling only.
- Grouping of similar inspections

05

Balancing the Venn Diagram

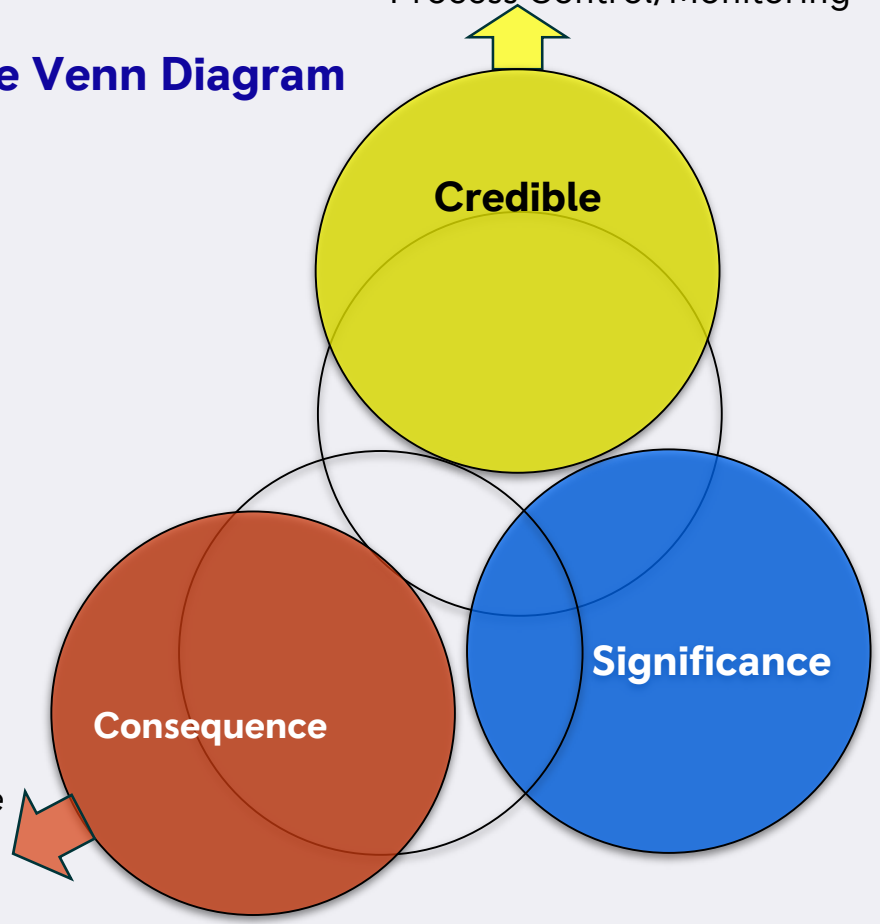


Redundancy (SSC)
Diversity (SSC)
Protection (SSC)
Leak before Break Case
Consequence analysis
Refine the FMECA

05

Balancing the Venn Diagram

Process Change
Material Change
Process Control/Monitoring

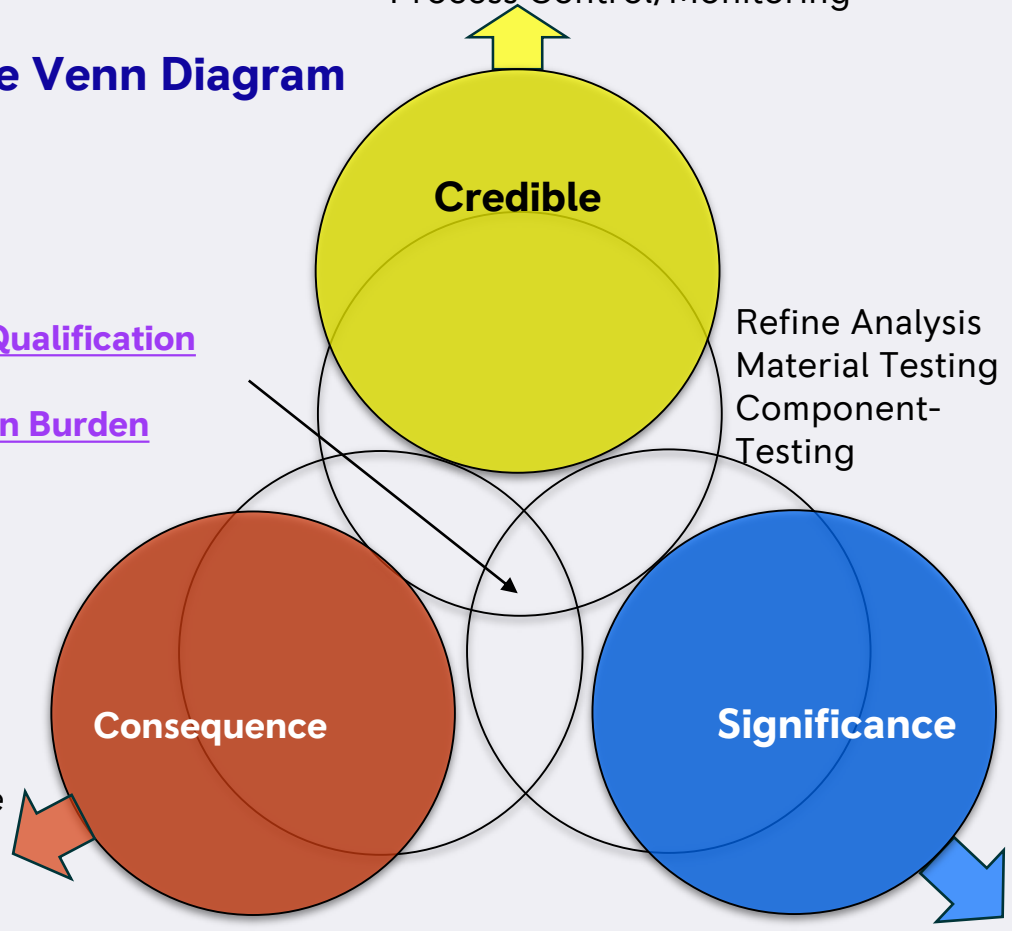


Redundancy (SSC)
Diversity (SSC)
Protection (SSC)
Leak before Break Case
Consequence analysis
Refine the FMECA

05

Balancing the Venn Diagram

Process Change
Material Change
Process Control/Monitoring



Refine Analysis
Material Testing
Component-Testing

Reduced Inspection Qualification Effort
Reduced Inspection Burden

Redundancy
Diversity
Protection
Leak before Break Case
Consequence analysis
Refine the FMECA

06

Conclusions

1. The **complexity and cost** of the total inspection package is dependent on the requirements established by **many engineering functions**. The inspection burden and inspection qualification process can be made more **efficient** by careful consideration of:
    1. Consequence of a Defect (Eg Safety, Design)
    2. Significance of Defects (Eg Structural Integrity/Stress and Materials/Metallurgy)
    3. Credibility of Defects (Eg Manufacturing, Welding etc)
2. Optimising the inspection package requires **good communication** and understanding between different **engineering functions**
3. An **inspection stakeholder** should be involved in the **balancing of the engineering/safety case** long before the inspection requirements are generated
4. **Proportionate Qualification and Assurance Approach** aligns with regulatory principles (EMC.30) and is a potential tool for providing a balanced safety case.

07

Questions?