Integrity Management Planning through populating the FMECA with Root Causes

Jerry Baker

SPIM Conference – 1st December 2011
Contents

• The COINS JIP, and why...
• COINS workscope
• Some early results
• Benefits of the outcomes
• The future for COINS
The COINS JIP

- **Cause-Orientated Inspection System – Demonstration Project**
- Established in response to ITF programme call for submissions:
  - Asset Integrity 2007
- Supported by:
  - BP
  - Chevron
  - Nexen
  - Total
- Kicked off in 2010, originally for 12 month programme
- Now in closing stages of current workscope
- Aim: to enhance risk-based integrity management by applying Root Cause Failure Analysis to range of potential failure modes applicable to all segments of subsea systems
- Energy Institute: “Guidelines for the management of integrity of subsea facilities” published April 2009, written by Atkins
Why COINS?

- Risk-Based Integrity Management commonly accepted norm
- Fundamental process: risk assessment
- Common model: Failure Modes Effects and Criticality Analysis
- Qualitative or semi-quantitative
- Purpose:
  - Identify failure modes and failure causes
  - Assign probability of failure
  - Assign consequence (severity) of failure
  - Hence determine risk
  - Prioritise
  - Identify mitigation
- The mitigation activities, in priority order, effectively constitute the Integrity Management Plan
Management of Mitigations

- Problem – in many cases failure causes defined at too high level
- Difficult to:
  - assign probability or consequence in qualitative FMECA
  - clearly define mitigation activity
  - determine whether mitigation actually reduces risk
- As basis of IMP, mitigations need to be Manageable:
  - Meaningful, Monitor-able, Measurable
- Premise of JIP: to achieve manageability, need to drill down to root causes of potential failure
- Illustrative examples from making the original case...
Some Root Causes of Internal Corrosion

- No Chemical Available
- Unsuitable Chemical
- Incompatible Chemical
- Incorrect Dose Rate
- Scale, Wax in Pipeline
- Changes in Production
- Valve Failure
- Pump, IRCD Failure
- Umbilical Core Failure
- Connector Failure

Inadequate Inhibition → Internal Corrosion → Leak to Environment
Root Causes of the Dropped Object Event

Organisational & Human Factors: scope for control & measurement

These can be calculated for likely cases

Inspection identifies event only at this point

Impact Damage

Level of Platform Activity → Probability of Dropped Object → Probability of Hitting Pipeline → Probability & Type of Damage

External Corrosion
Fatigue
Degradation
Remedial Measures

These can be calculated for likely cases

Inspection identifies event only at this point

Impact Damage

Level of Platform Activity → Probability of Dropped Object → Probability of Hitting Pipeline → Probability & Type of Damage

External Corrosion
Fatigue
Degradation
Remedial Measures
JIP Scope

- A process aimed at investigating the application of root cause analysis, and understanding the benefits thereof, to integrity management

- **Identify root causes of potential failure because:**
  - At this level mitigating activities can be clearly defined
  - Specific responsibilities can be allocated

- **Effective management requires information, therefore investigate for each root cause:**
  - What parameters provide useful data
  - Possible methods for acquiring data
  - Existing data streams
  - Potential data streams that could be developed
Initial Work – Define Typical System

Also:
• Crossings
• Landfalls
• Control system

- Pig trap(s)
- Chemical injection
- Production riser(s)
- EHC umbilical riser
- Water Injection riser
- Gas lift riser
- Static EHC umbilical

- Production tree
- Subsea booster
- Jumpers
- Production flowline(s)
- SSIV
- Manifold
- Water injection tree
- Water injection flowline
- Gas lift flowline
## Threat Matrix Concept

<table>
<thead>
<tr>
<th>Threats</th>
<th>Pipeline Headers and Pipework</th>
<th>Flowline Jumpers</th>
<th>Small bore pipework (CS)</th>
<th>Small bore pipework (SS)</th>
<th>Valves, instrumented pressure protection</th>
<th>Valves, flow control, isolation, etc</th>
<th>Hoses, plastic (incl. reinforced)</th>
<th>Flanges</th>
<th>Mechanical connectors (other than flanges)</th>
<th>Umbilical termination units</th>
<th>Umbilical/control jumpers</th>
<th>Subsea Control Modules</th>
<th>Protective structure, steel</th>
<th>Protective structure, composite</th>
<th>Lids with hinges/locks</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Damage (Fishing Activity)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Damage to tie-in spools, protection, etc</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Exposed members create fishing risk</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Excessive spanning of tie-in spools, etc</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reduced operability</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escape of hydrocarbons (environmental threat)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escape of control fluids</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Blistering of plastic</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escape of control fluids</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lack of operating data at Control Room</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escape of hydrocarbons (environmental threat)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Valves - stem seal leaks; damage to position indicators</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reduced operability; possible field shut-in</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escape of chemicals, control fluids, etc</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>External corrosion of Pipeline components</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escape of hydrocarbons (environmental threat)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lack of protection against external damage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Taken from “Guidelines for the management of integrity of subsea facilities”, Energy Institute, April 2009
# COINS Threat Matrix

**Threats / Failure Modes / Causes**

<table>
<thead>
<tr>
<th>Segments / Components</th>
<th>Threats / Failure Modes / Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>![Threat Matrix Table]</td>
</tr>
</tbody>
</table>

- Yellow cells are valid intersections
- Fault tree required for each of these
- Certain cases selected as representative
- Full population addressed through cosine similarity methods subsequently

*Approximately 1/6 of the full Threat Matrix*
Create Root Cause Trees

Trees created using Fault Tree + from Isograph Ltd
Another Typical Example

- This is one section of one tree
- Some trees cover from 8 to 14 sections
- In excess of 100 trees created
- To create all trees for all yellow intersections of Threat Matrix would be a huge task and, as Demonstrator project has shown, not necessary
• Result of creating trees is large population of root causes
• As far as possible aim for consistency in nomenclature
• Look for common root causes across the whole population
• Create a ‘unique set’ – i.e. only one of each root cause
• Behind unique set is a full set of root causes from trees created
• But – the trees created represent of the whole threat matrix
• Create ‘global’ (hypothetical) population through cosine similarity methods
• This is relevant when assessing the relative importance of different root causes, as will be seen
Process *continued*

- Unique set of approximately 1,200 root causes
- Full set of approximately 3,000 root causes
- Global set of approximately 10,500 root causes
- Assessment of results concentrates on unique level
- Demonstrator project:
  - Results not *the* answer – only *an* answer
  - Others might define fault trees, or even threat matrix, differently
  - Some areas – e.g. control systems – require further development
  - Scope for expansion and adaptation
Assessment

• Seeking manageability
• First pass sort
  • Class 0 – root causes that are ‘fixed’ within project phase
  • Class 1 – root causes that are variable, but ‘fixed’ by circumstances
  • Class 2 – root causes that are variable within operations phase
• Second pass sort – addresses class 2 root causes

<table>
<thead>
<tr>
<th></th>
<th>Direct</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Possible</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

• Variable root causes can be grouped into these four categories
• These are the ones that can be managed – approximately 600
• Individual failure modes may have multiple root causes, and different types of management
Types of Management

- Root causes can be managed given data
- Data can be acquired via a number of methods
  - Checking
  - Measurement
  - Inspection
  - Monitoring
  - Sampling
  - Testing
- For each method, parameters can be defined
- Ongoing COINS work consists of defining these parameters for different failure modes and determining whether/how they can be measured
Benefits

- Drilling down to root causes brings the following:-
- **Enhanced value of FMECA:**
  - Easier to assign qualitative probability or consequence
  - Mitigation activities clearly defined, with responsibility
  - Effect on risk, post mitigation, is clearer
- **Enhanced integrity management through:**
  - Better understanding of manageability
  - Recognising data streams currently tapped
    - Direct information
    - Information by inference
  - Understanding data streams of potential benefit (i.e. not yet tapped)
  - Cost-benefit analysis to determine whether value in pursuing these
- **More robust and cost-effective integrity management**
Future of COINS

• **Short term**
  - Still working through the data generated
  - Some outstanding work to be completed
  - Working with participants to understand their processes in light of findings to date
  - Final report to be completed

• **Longer term**
  - Work with participants to apply the outcomes to their individual systems
  - Determine, with participants, best way to roll out to industry
  - Consider standard list of MMM root causes (Comprehensive List of Causes)
Thanks to participants – BP, Chevron, Nexen and Total

Thanks to you, the audience, for your attention