Use Bow Tie Tool for Easy Hazard Identification

Presented at
14th Asia Pacific Confederation of Chemical Engineering Congress
Singapore, 21-24 February 2012

Syed Zaiful Hamzah
Principal Risk Consultant
ABS Consulting – Singapore
Email: szaiful@absconsulting.com
Who is ABS Consulting?

- Global Integrity, Safety, Risk Management and Inspection Services Company
- Serving the Oil & Gas, Petrochemical, Maritime, Power Generation, Commercial, Public and Insurance/Financial Sectors
- Corporate Headquarters in Houston. Regional HQ in Europe (UK), Middle East (UAE) and Asia (Singapore).
- Over 1,300 employees, with 50+ offices in some 30 countries
- Wholly-owned subsidiary of ABS (a Marine and Offshore Classification Society), founded in 1842.
Range of Services

- Integrity Management
  - Project Quality Management
  - Inspection & Auditing
  - Operational Asset Integrity Management
  - Reliability & Maintenance Management
  - Independent Verification Services

- Safety Management
  - HSE Case / Program Development
  - Process Safety Assessment
  - Safety Culture Assessment
  - Management System Development
  - Safety Training

- Risk Management
  - Enterprise Risk Management
  - Operational Risks
  - Manmade Risks
  - Natural Hazard Risks
Objectives of Hazard Identification & Assessment

- Ensure hazards are known, understood and properly managed
- Risk is reduced to As Low As Reasonably Practicable (ALARP)

Why accidents still happen despite hazard identification & assessment being carried out?
How do you manage risk?

- Identify hazards and potential effects - *Know & understand the hazards*

- Prevent, mitigate & recover from the hazardous events - *Manage the hazards*
Identification of Hazards & Potential Effects

Knowing & understanding Hazards

- What are sources of hazard?

- What hazardous event (top event) could potentially occur when a hazard is released?

- What could release the hazard and cause the top event to occur? What are the “threats”? 

- What are the consequences from the top event? How severe will the consequences be?
Prevention, Mitigation & Recovery

Managing hazards

- How to avoid the threats (or causes)? – prevention or threat barriers

- How to avoid or minimise the consequences – mitigation/recovery barriers

*Only possible if hazards are known and understood*

- All hazard are identified

- The threat (causes) and consequences of top events are known
Managing Hazards – Risk Reduction

Threat Barriers (Prevention)
Avoiding the causes; hence, release of hazard

Mitigation & Recovery Measures
Minimising the consequences
Hazard Identification..... You Must Get It Right

- Having done hazard identification/assessment does not guarantee safety
- Many accidents occurred despite having done hazard identification/assessment

Why?

- Failure to identify hazards
- Failure to manage hazards effectively

Doing it is not enough, you must get it right
How Do You Get It right?

- Identification of hazards and potential effects must be complete
  - All relevant hazards must be identified
  - Threats (causes) & consequences identification (hazard) analysis must be comprehensive

- Threat barriers (prevention) & mitigation/recovery barriers must be adequate
  - They must be known to be or confirmed effective
  - Supported by risk assessment to determine ALARP
BowTie Methodology ...... the Solution

- Simple & pragmatic approach
- Emphasis on effectiveness of risk reduction measures
- Effective visualisation
- Allows better communication of hazards
- Can be applied for all types of hazards
- Increasingly becoming the preferred techniques by regulatory bodies & leading companies
- Efficiently aided by user-friendly softwares
Bow Tie Methodology

- Originated as a technique for developing a “Safety Case” in the Oil & Gas Industry, post the Piper Alpha Incident in 1988
- By linking ‘Hazards’ & ‘Consequences’ to an ‘Event’ it is possible to develop the relationship to include the causes, or ‘Threats’, and the ‘Prevention’ & ‘Recovery Measures’
- Further understanding can be gained by examining the means by which these defenses can fail, and identifying the key components which demonstrate the integrity of these controls
  - Documents and Procedures
  - Control Types and Effectiveness
  - Critical Equipment and Systems
  - Tasks and the persons behind the Tasks
Bow Tie Connections

Bow-tie technique diagrammatically represents hazardous events in such a way to easily show the connections between hazards/threats and their consequences.
Bow Tie Concept
Bow Tie Terminology Definitions

- **Hazard** - Potential source of harm to people, assets, the environment and company reputation
- **Top Event** - The incident that occurs when a hazard is realized
- **Threats** - What could cause the top event to occur?
- **Consequences** - What could happen if the top event occurs?
- **Barrier** - What directly prevents or reduces the likelihood of a threat?
- **Recovery Measure** - What prevents, minimizes or helps recovery from the consequence?
- **Escalation Factor** - What could prevent the barrier or recovery measure from working as intended?
- **Escalation Factor Control** - What prevents or minimizes the chance of barriers or recovery measures becoming Ineffective?
Bow Tie Analysis Steps

1. Define top event
   - The top event is the initial consequence

2. Identify threats
   - Threats are the causes of the top event.

3. Identify barriers for each threat
   - Barriers prevent the threat from leading to the top event.
     - Some barriers are dependent on each other or subject to common failures

4. For each barrier, identify escalation factors and controls
   - Escalation factors cause the barriers to fail
     - Controls prevent the escalation factors from leading to barrier failure

5. Identify consequences
   - Each top event can have several consequences

6. Identify recovery preparedness measures for each consequence
   - Recovery preparedness measures prevent the top event leading to the consequence

7. For each recovery preparedness measure, identify escalation factors and controls
   - Escalation factors cause the recovery preparedness measure to fail
     - Controls prevent the escalation factors from leading to recovery preparedness measure failure

For each Barrier, Recover Preparedness Measure and Escalation factor control identify HSE Critical Tasks
### Major Hazard Classification

- **BowTies** are usually developed for only for Major Hazards – defined using Risk Assessment Matrix

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>CONSEQUENCES</th>
<th>INCREASING LIKELIHOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>People</td>
<td>Assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Has happened in the Organisation or more than once per year in the Industry</td>
</tr>
<tr>
<td>0</td>
<td>No injury or health effect</td>
<td>No damage</td>
</tr>
<tr>
<td>1</td>
<td>Slight injury or health effect</td>
<td>Slight damage</td>
</tr>
<tr>
<td>2</td>
<td>Minor injury or health effect</td>
<td>Minor damage</td>
</tr>
<tr>
<td>3</td>
<td>Major injury or health effect</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>4</td>
<td>PTD or up to 3 fatalities</td>
<td>Major damage</td>
</tr>
<tr>
<td>5</td>
<td>More than 3 fatalities</td>
<td>Massive damage</td>
</tr>
</tbody>
</table>
Typical Major Hazards

- Hydrocarbons – fires/explosions/blowouts/oil spills
- Toxic materials – toxic releases
- Air/marine/land transport – helicopter/boat/road accidents
- Shipping activities – marine collision
- Object under load (structure) – structural failure
- Lifting operations – dropped objects
Managing Barrier Effectiveness – Relating Critical Activities to Barriers
Typical Major Hazard Barriers

- Structures (jackets/decks) – preventive barriers
- Hydrocarbon containment - preventive barriers
- Chemical injection systems - preventive barriers
- Relief systems - preventive barriers
- Fire, gas & smoke detectors – recovery barriers
- Ignition control – recovery barriers
- Shutdown systems – preventive/recovery barriers
- Active & passive fire protection systems – recovery barriers
- Firewater pumps & ringmain – recovery barriers
- Emergency response equipment – recovery barriers
- Emergency communication & power – recovery barriers
- Escape, evacuation & rescue provisions – recovery barriers
- Life/survival equipment – recovery barriers
Bow Tie Allows Optimised Integrity Assurance
Use of Bow Tie for Effective Control of Major Hazard

- Hazard Register
- Major Hazards
- Major Hazard Bowtie
- Safety Critical Element
- HSE Critical Activity Sheets
- Escalation Controls

Tasks necessary to ensure effectiveness of major hazard barriers

ABS Group
Barrier Effectiveness Rating

- Effective
- Partially Effective
- Ineffective
Inputs to Barrier Effectiveness Assessment

- Design standards
- Inspection/maintenance records
- Test performance results
- Asset integrity reporting
- Processes & procedures
- Audit findings
- Incident investigation findings
- Personnel competency
## Barrier Effectiveness Assessment - Example

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Findings</th>
<th>Effectiveness</th>
<th>Remedial Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD system</td>
<td>IR flame detector available but provide only alarms</td>
<td></td>
<td>Provide ESD activation based on confirmed fire detection</td>
</tr>
<tr>
<td>Certified electrical equipment</td>
<td>Newly installed Split unit outdoor unit at substations not Ex-rated, 20-from process area.</td>
<td></td>
<td>Evaluate adequacy of ignition prevention/control at electrical substations in event of hydrocarbon leaks due to presence of non Ex-rated equipment</td>
</tr>
<tr>
<td>Piping system</td>
<td>Reactive approach for gaskets replacement, esp. small bore valves (ref. recent leak incident).</td>
<td></td>
<td>Inspection for small bore piping need to be defined e.g. include UT, not merely visual inspection</td>
</tr>
<tr>
<td>Rotating equipment</td>
<td>Insufficient surface sand management facilities due major sand not anticipated</td>
<td></td>
<td>Identify sand management requirements to ensure sand removal either surface or subsurface</td>
</tr>
</tbody>
</table>

*ABS Group*
Bow Tie vs Other Methods?

- Many other ‘risk techniques’ – where does Bow Tie fit in?

- A Management System tool which takes its knowledge from various sources to represent the ‘risk picture’ in a logical and usable format.

- Not intended as a replacement for any particular method
Management review of overall risks, or risk per location

Sorting to order profile by category

Allows a snapshot of the major exposure items
Generation of Shortfalls to log deficiencies in the Management System

Create and track actions to recover Shortfalls – ensuring barrier effectiveness
Bow Tie Software Demo - Optional