Practical HSE Risk Management - An Introduction to the Bow-tie Method

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Purpose of presentation

- Introduce bow-tie method
- Describe its practical uses and benefits
- Outline an example bow-tie
- Provide some tips for successful use
History of bow-tie method

- Exact origins of bow-tie methodology are hazy - believed to originate from ICI in the late 1970’s?
- Royal Dutch/Shell Group first major company to integrate bow-ties fully into business practices
- Use of bow-ties now widely spread between companies, industries, countries and from industry to regulator, e.g.:
  - Abu Dhabi National Oil Company (ADNOC)
  - UK Health and Safety Executive
  - French Government
  - Australian State Regulator
  - Land Transport Safety Authority of New Zealand
  - International standards (e.g. ISO 17776:2000)
  - International Association of Drilling Contractors (IADC)
HSE Management System

An HSE-MS is a structured set of controls for managing HSE risk in a business.
Basic risk evaluation & management model

Risk Tolerability & ‘ALARP’

Identify → Assess → Control → Recover

Document
Link with HSE-MS

Unlike traditional risk evaluation tools, the bow-tie method makes the link between risk controls and the HSE-MS:

Links are made via HSE-critical roles and responsibilities, HSE critical procedures, HSE critical equipment and systems, etc. identified on the bow-tie diagram.
Bow-tie diagram

Identify

- Threat 1
- Threat 2
- Threat 3

Assess

- Consequence 1
- Consequence 2
- Consequence 3

Control

- Hazard and Hazard Source
- Recovery Measure
- Recovery Measure
- Recovery Measure

Recover

- Top Event
- Recovery Measure
- Recovery Measure
- Recovery Measure
Typical application of bow-tie method

Potential Risk Level

- High Risk
- Medium Risk
- Low Risk

Risk Management Objective

- Reduce to medium or low risk
- Demonstrate Risk reduction to ALARP
- Continue to manage for improvement

Level of Analysis & Control

- Detailed Analysis e.g. bow-ties
- Procedures Responsibilities Performance Measurement
- Judgement Standard Competences

But method is equally applicable to routine risks as major risks
## Practical uses

<table>
<thead>
<tr>
<th>Logical structured approach</th>
<th>What are our major risks? Do we have any gaps in risk control?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>How do we engage non-risk specialists?</td>
</tr>
<tr>
<td>Formal demonstration</td>
<td>Can we really demonstrate control of our risks?</td>
</tr>
<tr>
<td>Specific risks</td>
<td>Are these risks properly understood and controlled?</td>
</tr>
<tr>
<td>Critical roles</td>
<td>Do our people know what is expected of them?</td>
</tr>
<tr>
<td>Competencies</td>
<td>Are competence and control requirements aligned?</td>
</tr>
<tr>
<td>Procedures</td>
<td>Are they complete and effective?</td>
</tr>
<tr>
<td>Auditing</td>
<td>How can we focus audits on what really matters?</td>
</tr>
<tr>
<td>Critical systems and</td>
<td></td>
</tr>
<tr>
<td>performance standards</td>
<td>What are they?</td>
</tr>
</tbody>
</table>

Link between bow-ties & HSE-critical tasks

Visually demonstrate and communicate the link between controls and the management system

HSE Critical Tasks

Responsible parties
## HSE-critical task catalogue

<table>
<thead>
<tr>
<th>Client/Project Name</th>
<th>Senior Supervisor</th>
<th>HSE-Critical Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 01.01</td>
<td>Making live and Closing of Hot Work Permits</td>
<td>Ensure that all permits are signed out ‘made live’ and closed by the Authorised Person</td>
</tr>
<tr>
<td>Task 01.02</td>
<td>Ensure that Hot Work is in compliance with permit conditions</td>
<td>Ensure that permit is in compliance with MSN 102L and work is undertaken in safe manor</td>
</tr>
<tr>
<td>Task 02.04</td>
<td>Ensuring that lifting gear is tagged and colour coded</td>
<td>Ensure that lifting gear is coded as per procedure MSN 205L Ensure competence of certifying contractor</td>
</tr>
<tr>
<td>Task 04.04</td>
<td>Confirm portable electrical equipment is fit for purpose and in possession of integrity certification</td>
<td>Ensure that external electrical equipment is tested on a 3 month cycle and internal equipment is tested on a 6 month cycle as per MSN 23L.</td>
</tr>
</tbody>
</table>
Link between bow-ties and competence

Welding performed by certified welders only

Verify that competence and control requirements are aligned
# Accountability pack for each HSE-critical role

## Accountable Sheet

<table>
<thead>
<tr>
<th>Role/Post:</th>
<th>Maintenance Supervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified Safety Critical Role (Document OD-SA-03-46):</td>
<td>Yes, Level 1 and 2</td>
</tr>
</tbody>
</table>

## HSE Critical Task Specification Sheet

<table>
<thead>
<tr>
<th>Task Ref</th>
<th>Task Title</th>
<th>Input / Procedures</th>
<th>Task Verification</th>
</tr>
</thead>
</table>
| BON-06.01.03 | Maintain, test and inspect cargo and crude export pumps, meters and protection systems | • OPRM-2003-0304 : POPM Volume 4 - Oil Storage Handling and Ballast  
• OPRM-2003-0305 : POPM Volume 5 : Oil Metering and Export  
• OPRM-2005-0057 : Maintenance and Inspection Management System Manual | Maintenance plan, maintenance records, test results checked and verified by Operations Supervisor |
| BON-06.01.08 | Maintain, test and inspect the inert gas system | • OPRM-2003-0319 : POPM Volume 19 - Inert Gas  
• OPRM-2003-0203 : Maintenance and Integrity Manual  

## Safety Critical Role Competencies

(Document OD-SA-03-46)

<table>
<thead>
<tr>
<th>Competence Requirements</th>
<th>Prerequisites for Assessment</th>
<th>Assessment Format (Standard)</th>
<th>Assessor / Verifier</th>
<th>Re-Assess. Frequency</th>
<th>Maintenance of Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill at Validating PTW</td>
<td>Computer Based Training to Signatory standard</td>
<td>Computer Based Assessment</td>
<td>PTW Coordinator / Line Verifier</td>
<td>–</td>
<td>Maintained through ongoing daily activities and annual staff appraisal whilst in position</td>
</tr>
<tr>
<td>Skill at Supervising HSE</td>
<td>On the job exposure while completing OIM portfolio</td>
<td>Area Supervisor Competence Assessment Manual</td>
<td>Installation Manager / Line Verifier</td>
<td>–</td>
<td>Maintained through ongoing daily activities and annual staff appraisal whilst in position</td>
</tr>
<tr>
<td>Knowledge of the Nigerian Legislation (Mineral Oils (Safety) Regulations)</td>
<td>Training Course</td>
<td>Demonstration of knowledge</td>
<td>Line Assessor / Line Verifier</td>
<td>–</td>
<td>Maintained through ongoing daily activities and annual staff appraisal whilst in position</td>
</tr>
</tbody>
</table>

## I understand and accept the HSE Critical Tasks and Safety Critical Role Competencies assigned to me.

<table>
<thead>
<tr>
<th>Name</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>Date</td>
</tr>
</tbody>
</table>

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**HSE-critical role**

**HSE-critical tasks, procedures & verification**

**HSE-critical competencies**

**Sign-off**
Link between bow-ties and training & development

Competent people provide resilience against major risks

...to ensure each risk control works...

HSE-critical task

HSE-critical role

Task competencies

Training requirements

HSE-critical task catalogue

Accountability packs

Assess people against requirements

Personal T&D plans

...use Competency Mgmt System
Competency management system

- Personnel information
- Training management
- Competency management
- Document management
- Reporting
## Link between bow-ties and procedures

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible Person/ Task Description</th>
<th>Inputs/ Documents</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC-22.05</td>
<td>Area Supervisor – Maintain Safety Signage</td>
<td>Ensure safety related signs are maintained up-to-date and in good order</td>
<td>- Inspection and Audit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- escape routes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- exit signs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- fire equipment signs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- life saving appliance signs</td>
<td></td>
</tr>
<tr>
<td>ABC-12.03</td>
<td>HSE – Manager – Management of Hazardous Materials</td>
<td>Ensure correct storage and handling of hazardous materials in accordance with the</td>
<td>- HSE audit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>requirements identified in the MSDS</td>
<td>- area inspections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- secure storage</td>
<td>- manifests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- segregation of incompatible chemicals</td>
<td>- non compliance reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- use of PPE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- appropriate means of transport- inventory management</td>
<td></td>
</tr>
<tr>
<td>ABC-06.03</td>
<td>Site foreman – Weekly area Inspections of process facilities</td>
<td>Carry out weekly inspections of all site areas:</td>
<td>- Inspection checklist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- housekeeping</td>
<td>- unsafe act/condition reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- general condition of equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- general condition of structures</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- condition of safety equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- availability</td>
<td></td>
</tr>
</tbody>
</table>

**Verify procedures for conducting HSE-critical tasks are complete and effective**
Link between bow-ties and auditing

HSE - CRITICAL TASK LIST

Responsible Person: Supervisor

Task 1: ...
Task 2: ...
Task 3: ...

AUDIT CHECKLIST

Supervisor
Task 1 ...... ✓
Task 3 ...... ✓

Foreman
Task 5 ...... ✓
Task 9 ...... ✓
Task 11 ...... ✓

Audits can be focused on what really matters
Link between bow-ties and HSE-critical equipment & systems

Establish performance standards for these systems
Maintenance management system should flag HSE-critical systems and tasks
Total hazard control

In the end you must have all connections in place for effective hazard control
Example bow-tie

5.4.4.5 Propane

Hazardous Site: Failure of Stored cylinders

- Internal Corrosion
- External Corrosion
- Overpressure
- Dropped / Fallen Object
- Vehicle Impact
- Human Error

- Fire / Explosion
- Projectile damage from exploding cylinders
- Building damage, possibly extending offsite
**Example bow-tie: threats**

**Hazardous Site:** Failure of stored cylinders

- **5.4.4.5 Propane**

- **Vehicle Impact**
  - LPG storage area designed to HSE Guidelines to minimise vehicle impact possibility
    - W-1.1.06 (Design)
  - LPG cylinders are designed to BS55045 Part 2 as Transportable Gas containers
    - W-2.3.01 (Tan)
  - Fork lift truck drivers are trained and have their competence assessed
    - W-4.1.03 (Prod)

- **Dropped / Fallen Object**
  - Cylinders only moved when strapped in purpose designed pallets (Company Handling)
    - W-4.2.06 (Prod)
  - Fork lift truck drivers are trained and have their competence assessed
    - W-4.1.03 (Prod)
Example bow-tie: consequence
Example bow-tie: complete

Hazardous Site Failure of Stored cylinders

- **Internal Corrosion**
  - Cylinders examined in accordance with company standards and HSE Guidelines
  - LPG Product standard controlled in accordance with HSE Guidelines
  - S.4.4.3 Propane

- **External Corrosion**
  - Cylinders examined in accordance with company standards and HSE Guidelines

- **Overpressure**
  - Storage cylinder design/filling procedures prevent overpressure from environmental heating
  - Propane area storage complies with company standard HSE Guidelines

- **Dropped / Fallen Object**
  - Cylinders only moved when inspecting pressure/data annals (Company Handling)
  - Forklift truck drivers are trained and have their competence assessed
  - W-4.3.06 (Prod)

- **Vehicle Impact**
  - LPG storage area designed to HSE Guidelines to minimise vehicle impact possibility
  - LPG cylinders are designed to BS5045 Part 2 as Transportable Gas containers
  - Forklift truck drivers are trained and have their competence assessed
  - W-2.3.08 (Prod)

- **Fire / Explosion**
  - No smoking policy and monitoring to minimise unnecessary combustibles
  - PTW System and Safe System of work minimise ignition sources
  - W-4.3.01 (Prod)
  - W-4.2.01 (Prod)

- **Electrical Equipment**
  - Design - Electrical Classification
  - W-1.1.02 (Design)

- **Task Related Ignition Sources**
  - Operator intervention - work permit
  - W-2.4.06 (Prod)

- **Electrical Storm - lightning**
  - Copy of Design - Electrical Classification
  - W-1.1.02 (Design)

- **Projectile damage from exploding cylinders**
  - Implement emergency procedures (evacuation, fire response etc.)
  - W-6.1.03 (Prod)
  - Activate Onsite emergency response plan, Offsite Plan if required
  - W-6.1.04 (Prod)
  - W-6.1.03 (Prod)

- **Building damage, possibly extending offsite**
  - Evacuation of area on indication of fire
  - W-2.3.03
  - W-3.4.02 (Eng)
Building bow-ties

Software helps but don’t get hung up on it! Benefits are from approach and involving workforce.
Benefits of bow-tie method

- **Communication** - “a picture paints a thousand words”
- **Ownership** - involves people, gains buy-in, practical approach
- **International application** - overcomes language difficulties
- **All risks** - not just HSE
- **Risk reduction** - identifies where resources should be focussed for risk reduction, i.e. prevention or mitigation
Benefits cont...

- **Fit for Purpose MS** - Links elements of the organisation’s MS to specific control

- **Auditable Trail** - the diagrams and critical tasks provide protocol around which auditing by internal depts focuses on what people are actually doing rather than physical systems
Limitations

- Entirely qualitative
- Does not replace other techniques (JSA, method statements, etc.) – is complementary to them
- Depends on experience of personnel and active workforce involvement
- Ensure controls in bowtie are truly independent

But if you want to remove mystique of risk management and obtain insights into your risk controls that are easy to understand and easy to communicate, there is no better method than bow-ties
Tips for success

1. Keep end objective in mind - pitch at the right level
2. Involve the right people
3. Avoid barrier counting
4. Use method to full potential
5. Verify controls and tasks
Summary

- The **Bow-tie Diagram** is a user-friendly, graphical illustration of how hazards are controlled.

- Effective risk management is only possible if people are assigned responsibilities for controls via HSE-Critical Tasks.

- Visible links are made to HSE-critical systems and competencies and auditing.

- The total methodology demonstrates not only what controls are in place today, but why they will still be there tomorrow.