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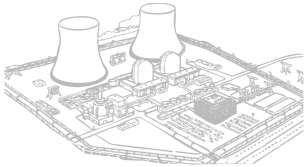

Assessing risk controls using bow-ties

Eric Marsden

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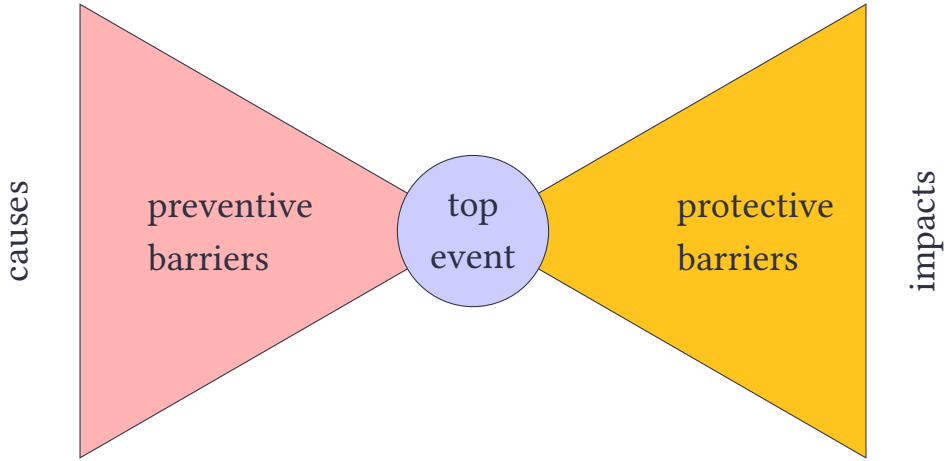
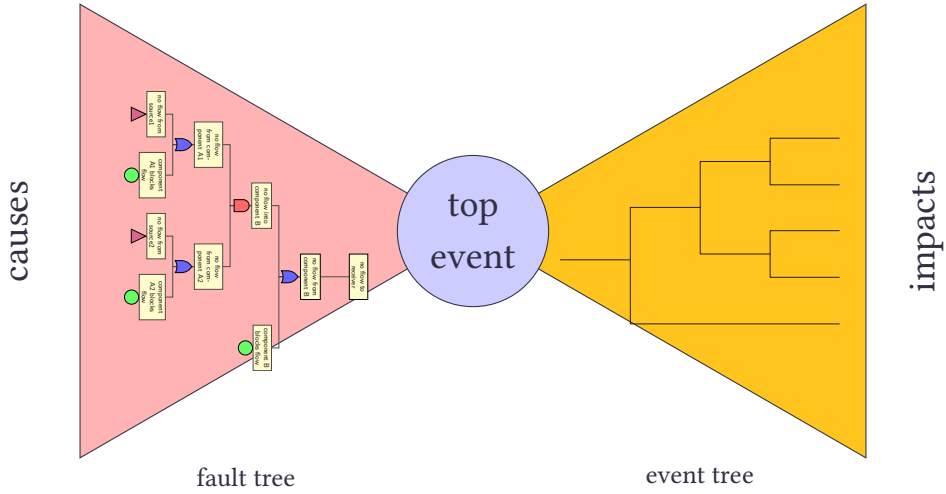
Concept


causes
preventive barriers
top event
protective barriers
impacts

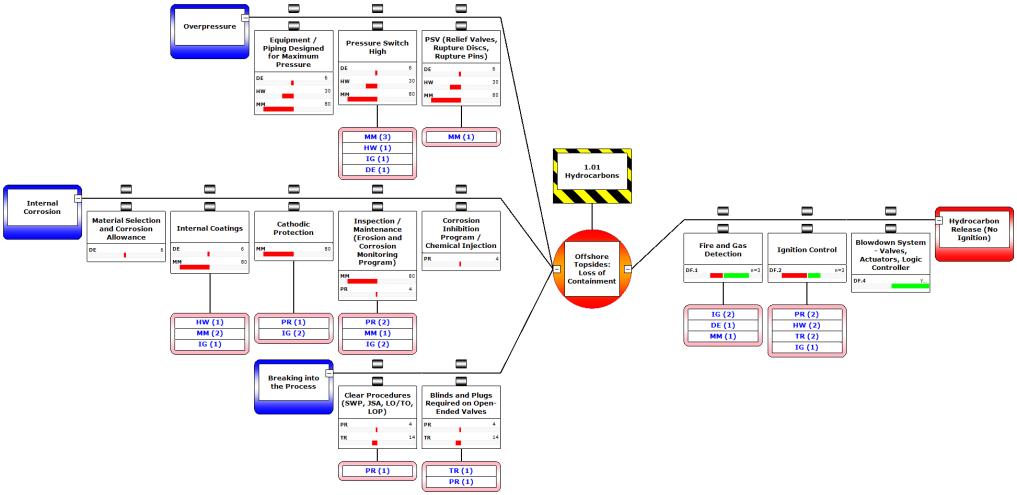
Concept



History

- A graphical and mostly qualitative method to **assess risk** and **analyze barrier effectiveness**
- Probably originated in ICI (a UK chemical company) in the late 1970s
  - based on notions of defence in depth, fault tree analysis, event-tree analysis and Reason's Swiss cheese accident causation model
- Royal Dutch Shell was first major company to integrate bow-ties into business practices
- Gained popularity as an intuitive graphical manner of **presenting accident scenarios** and **explaining importance of barriers**

Concept

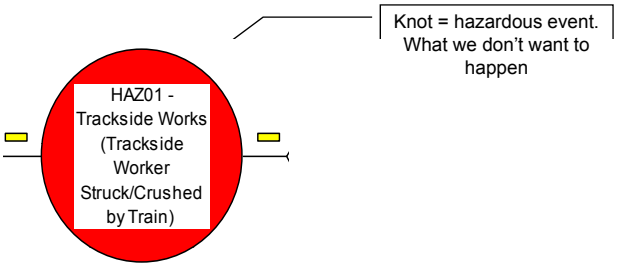

Overpressure
Equipment / Piping Designed for Maximum Pressure
DE 6
HW 30
MM 80
Pressure Switch High
DE 6
HW 30
MM 80
MM (3)
HW (1)
IG (1)
DE (1)
PSV (Relief Valves, Rupture Discs, Rupture Pins)
DE 6
HW 30
MM 80
MM (1)
Internal Corrosion
Material Selection and Corrosion Allowance
DE 6
Internal Coatings
DE 6
MM 80
HW (1)
MM (2)
IG (1)
Cathodic Protection
MM 80
PR (1)
IG (2)
Inspection / Maintenance (Erosion and Corrosion Monitoring Program)
MM 80
PR 4
PR (2)
MM (1)
IG (2)
Corrosion Inhibition Program / Chemical Injection
PR 4
Breaking into the Process
Clear Procedures (SWP, JSA, LO/TO, LOP)
PR 4
TR 14
PR (1)
Blinds and Plugs Required on Open-Ended Valves
PR 4
TR 14
TR (1)
PR (1)
1.01 Hydrocarbons
Offshore Topsides: Loss of Containment
Fire and Gas Detection
DF-1 n=3
IG (2)
DE (1)
MM (1)
Ignition Control
DF-2 n=3
PR (2)
HW (2)
TR (2)
IG (1)
Blowdown System - Valves, Actuators, Logic Controller
DF-4 7
Hydrocarbon Release (No Ignition)

Hazard

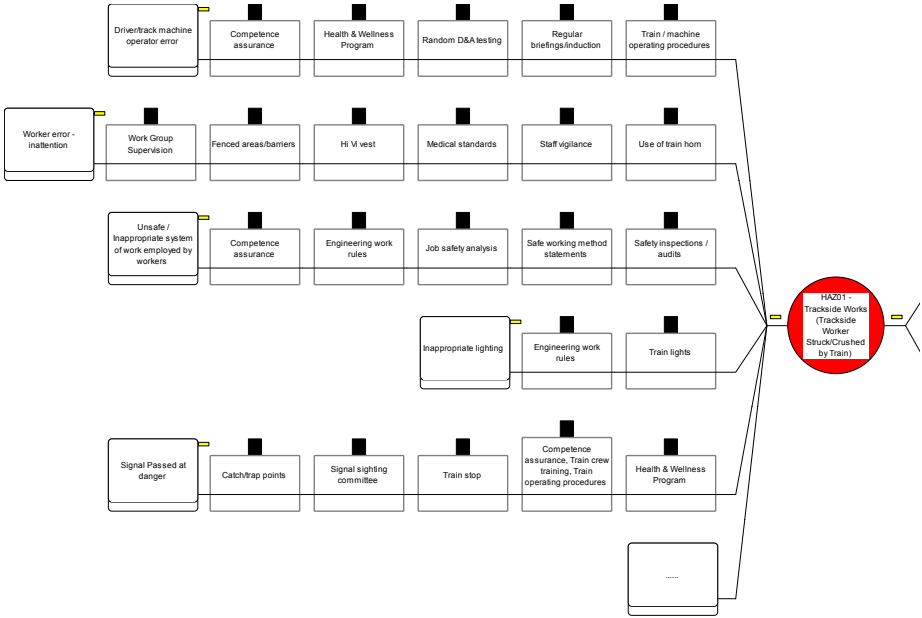
Start by identifying the **hazard** and the **top event** (typically some form of loss of control or loss of containment)

Example:

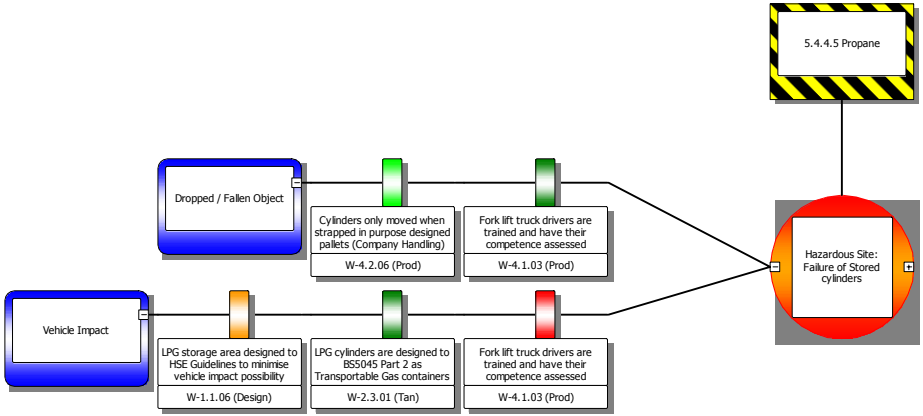
- Hazard: mechanical energy of train during trackside works
- Top event: trackside worker struck by train



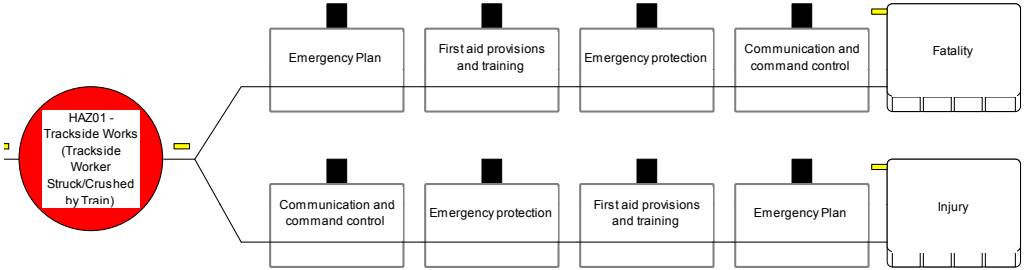
Threats and preventive controls



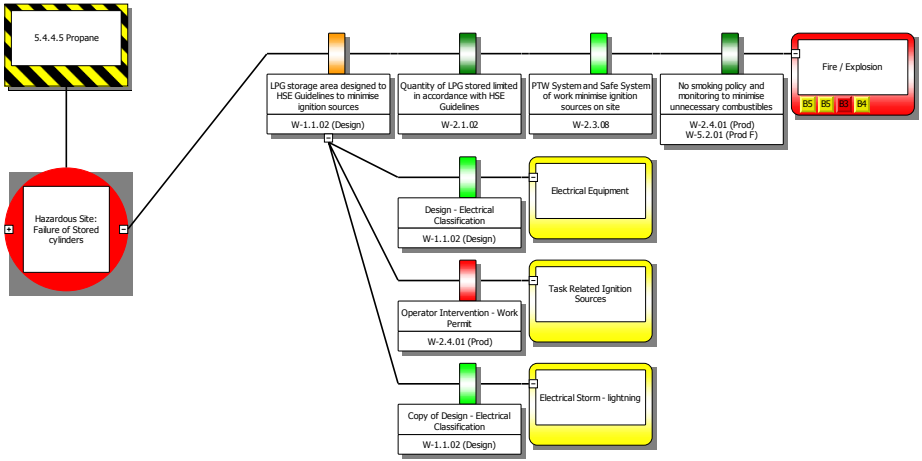
Threats and preventive controls



Consequences and mitigation controls

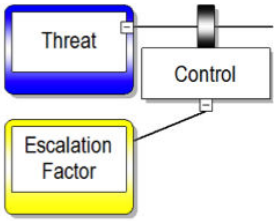


Consequences and mitigation controls



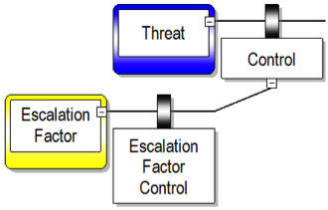
Escalation factors

- Escalation factor: a condition that **leads to increased risk** by defeating or reducing the effectiveness of controls
- Controls are seldom 100% effective
- An escalation factor cannot directly cause the top event or consequence
  - it increases the likelihood that the scenario will progress because the associated control will be degraded or fail

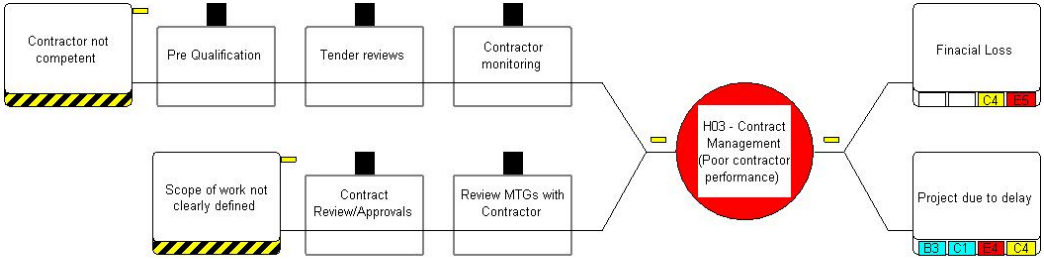


Escalation factor controls

- Escalation factor control: a control that manages the conditions which reduce the effectiveness of other controls
- Though notion is in theory recursive (escalation factor controls can be themselves affected by escalation factors), recommended to stay with one level of escalation factor controls

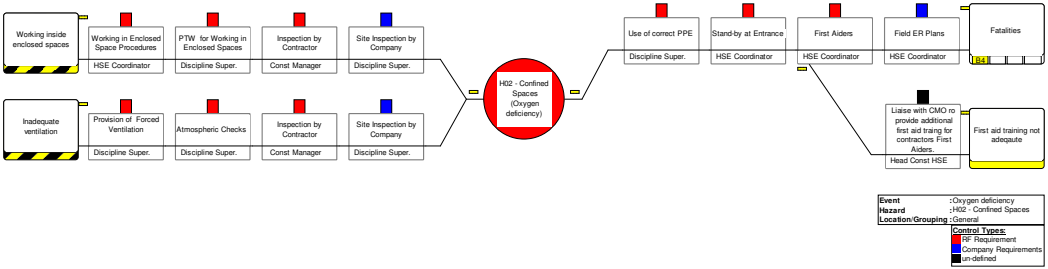


Example: poor contractor performance

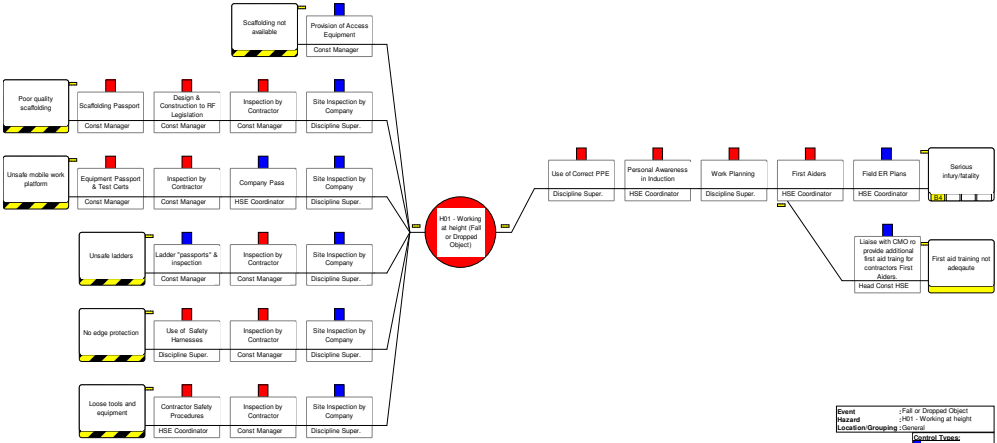


Event	: Poor contractor performance
Hazard	: H03 - Contract Management
Location/Grouping	: General

Example: work in confined space



Example: work at height



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Applications of the bow-tie tool

- Communicating risks, accident scenarios, importance of barriers
- Can be integrated with semi-quantitative risk analysis techniques such as LOPA
- Identify and assess safety barriers (risk reduction measures)
- Make a link between critical safety tasks and the SMS
- Identify elements for safety audits

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Link the tasks to barriers back to SMS

- How will the barrier fail?
- Can we improve the effectiveness of control?
- What tasks or actions do we need to do to make sure the control continues to work?
- Who is currently doing the task?
- Who is currently doing the task?
- Is the staff competent for doing the task?

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Managing critical HSE tasks

Client/Project Name		Senior Supervisor	
Task 01.01	Making live and Closing of Hot Work Permits	Ensure that all permits are signed out 'made live' and closed by the Authorised Person	Permit register Records of Hot Works Safety Meetings
Task 01.02	Ensure that Hot Work is in compliance with permit conditions	Ensure that permit is in compliance with MSN 102L and work is undertaken in safe manor	Permit register Walk round check/inspection of works Pre-job briefing sign off Safety meeting actions Daily records
Task 02.04	Ensuring that lifting gear is tagged and colour	Ensure that lifting gear is coded as per procedure MSN 205L Ensure competence of certifying contractor	Audit and Inspection Sign off from certifying company.
Task 04.04	Confirm portable electrical equipment is fit for purpose and in possession of integrity certification	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.	Visual check Audit of Portable appliances

HSE-Critical Role

HSE-Critical task

HSE-critical procedure

Verification

Source: *Practical HSE Risk Management – An Introduction to the Bow-tie Method*, Gareth Book, Risktec Solutions

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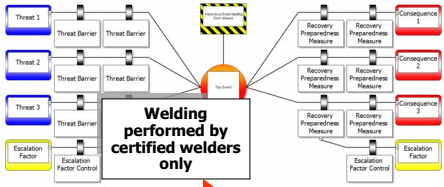
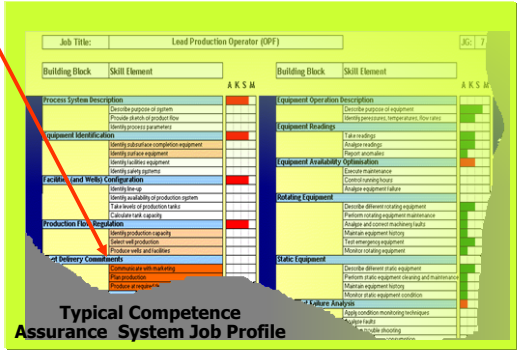
Links with competency management



Verify that competence and control requirements are aligned



Source: *Practical HSE Risk Management – An Introduction to the Bow-tie Method*, Gareth Book, Risktec Solutions

Links with procedures and audits

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

Verify procedures for conducting HSE-critical tasks are complete and effective

Source: *Practical HSE Risk Management – An Introduction to the Bow-tie Method*, Gareth Book, Risktec Solutions

Conclusions

- Bowtie representation of scenarios provides better understanding of incident/accident sequences
- Improves communication, especially between different levels of the organisation
- Helps to prioritise the importance of control measures, support the managers / management's need to oversee a broad spectrum / scope / different types of risk that they own
- Link the safety critical activities back to the Safety Management System and effective monitoring and control of risks

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