Using Modified Risk Assessment Methods to Communicate Risk
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Abstract
A conventional Bow Tie Analysis is a combination of a fault tree and event tree analysis used to provide a clear illustration of the risk pathways and control measures in place for situations that do not require a full fault tree analysis. Bow Tie analysis typically lacks risk scoring mechanism. The effectiveness of control measures is not reflected in the analysis (high level controls such as substitution and engineering are not clearly distinguished from lower level controls). To address the potential shortfall, the authors would like to present a Modified Bow Tie Analysis with Risk Scoring and “Striped” Bow Tie Analysis with Hierarchy of Controls and Layer of Protection Analysis.

Methods
Bhopal disaster Bow Tie analysis with risk scoring is presented. To further improve upon the conventional Bow Tie Analysis model, several additions were made by the authors to include a hierarchy of controls concept along with a Layers of Protection Analysis. The “Striped Bow Tie” analysis was developed to analyze and determine whether there are sufficient preventive controls as well as reactive measures for the undesired event or scenario.

Learning Objectives
To illustrate the use of modified Bow Tie analysis to effectively communicate pathways of risk from hazards to consequences. Understand the importance of Prevention through Design (PdC) hierarchy of controls.

Conventional Bowtie Method

Modified Bowtie Method – Bhopal Disaster
The Bow-Tie method provides a big picture overview of a hazard scenario and its relationships between hazards and causes, barriers to prevent occurrence, and mitigating controls to reduce the impact should an event occur. The beauty of a Bow-Tie is its ability to provide a clear, visual roadmap of how hazards are managed and risks reduced.

A conventional Bow-Tie Analysis is qualitative tool, however, some quantification is possible. Pathways are independent, controls are reliable, and probability of a consequence is known. For pathways and controls that are not independent, or control effectiveness is unknown, quantification is less effective.

Often times it is necessary to use multiple risk assessments tools to identify, analyze, evaluate, control and communicate the risks.

Hazard Identification - PHA

Often times brainstorming, Preliminary Hazard Analysis (PHA) or FMEA are used upfront to identify hazards, causes, existing controls and escalating factors for a particular scenario. A Modified PHA is presented here.

Risk Assessment Matrix

Next, the Bhopal event is shown again with the Modified Bowtie diagram that includes PID HoC that could have prevented the disaster. Comparing the two sets of data, we can develop problem solving solutions and observe the effects of adding the preventive measures and layers of protection.

Using the Modified Bowtie Diagram

To further improve upon the conventional Bow Tie Analysis model, several additions were made by the authors to include a hierarchy of controls concept along with a Layers of Protection Analysis (LCPA).

Risk Reduction

The risk level estimates used from the current state (at the time of the accident) and possible solutions is compared utilizing the Risk Reduction spreadsheet in order to evaluate risk reduction percentage and compare the effects that the control measure could have had on the hazards.

Stripes Bow-Tie Analysis

The “Striped Bow Tie” analysis was developed to analyze and determine whether there are sufficient preventive controls (left hand side) as well as reactive measures (right hand side) for the undesired event or scenario. Preventive controls or frequency-reducing measures in general should have higher priority than reactive or consequence-reducing measures since they are intended to reduce the frequency of one or more hazardous events thus preventing the resulting consequences.

Results

This example of a modified Bow Tie Analysis which has added severity and probability risk factor ratings and prevention effectiveness ratings for each hazard risk provided the ability to evaluate, compare, and rank risks. The “Striped” Bow Tie Analysis included preventive and reactive measures that are accounted for and analyzed for adequacy in the model. The ranked control columns help to communicate and emphasize the need/preference for high-level controls, while the layers of protection diagram provides means of evaluating overall control of the scenario.

Conclusions

The results of the modified Bow Tie model and the “Striped” Bow Tie Analysis can serve as the primary input to risk responses whereby hierarchy of controls are examined, a response strategy formulated, and risk mitigation plans developed. Modified risk assessment methods can be successfully utilized to communicate risk.