SIIC063

DYNAMIC SAFETY RISK ANALYSIS OF WATER PLANT CHLORINATION USING DYNAMIC BOW-TIE APPROACH

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Abstract:
Chlorine is one of the hazardous materials and needs to be handled carefully. In water chlorination system at water treatment plant (WTP), there was potential hazard to the workers and the population nearby the water treatment plant. To identify this hazard, risk assessment is the one of the techniques that can be used to eliminate the hazard and measure the risk other than to identify the hazard. But due to the limitation of being static of conventional risk assessment, many researchers were study to update the conventional risk assessment to the dynamic risk assessment. This paper was aimed to update the conventional bow-tie analysis to the dynamic one by mapping bow-tie (BT) into bayesian network (BN) using Genie software. Posterior probability was used to replace the prior probability in this study to update the conventional to the dynamic. Three time interval was mapping into BN to show the dynamic failure updating by assuming lack of maintenance. To conduct this study, Kelar water treatment plant was chosen as the case study. Failure mode effect analysis (FMEA) was used to determine the potential hazard in the water chlorination system. Chlorine leakage from drum was chosen as the worst-case accident for this study of the top event to map the BT and BN. Besides that, ALOHA modeling software was also being used to determine the area concentration of chlorine emission nearby the population of Kelar WTP if there was a chlorine leakage. The worst cases of the accident was a leaking from 5 mm hole of body drum that would affected about 15 villages nearby the Kelar WTP. By implementing this approach, the accident can be prevented as well as eliminated.

***Keywords*:**
FMEA, Bow-tie,, Bayesian network, ALOHA, Genie Software

Objectives:

- To determine the potential hazard at the Kelar water chlorination plant by conducting the hazard survey using failure mode effect analysis.
- To illustrate the bow-tie (BT) diagram approach in water chlorination plant by combining fault tree (FT) on the left hand-side as a top event to represent the causes and event tree (ET) on the right hand-side as the possible consequences to occur.
- To develop Bayesian network (BN) modelling in order to update the BT diagram due to its limitation being static. Other than that, ALOHA modelling is used to estimate the chlorine gas emission surrounding the Kelar WTP.

Methodology:

Visit water treatment plant	•Kelar Pasir Mas, Kelantan water treatment plant was chosen for case study •Study the process flow diagram of water chlorination system (Hazard surveys)
Identify the hazard for the water chlorination system using.	•Failure Mode Effect Analysis (FMEA)
Illustrate the Bow-Tie modelling	•Fault tree analyis •Event tree analysis
Bow-Tie Updating on Risk Assessment	•Bayesian Network •ALOHA modelling

Results:

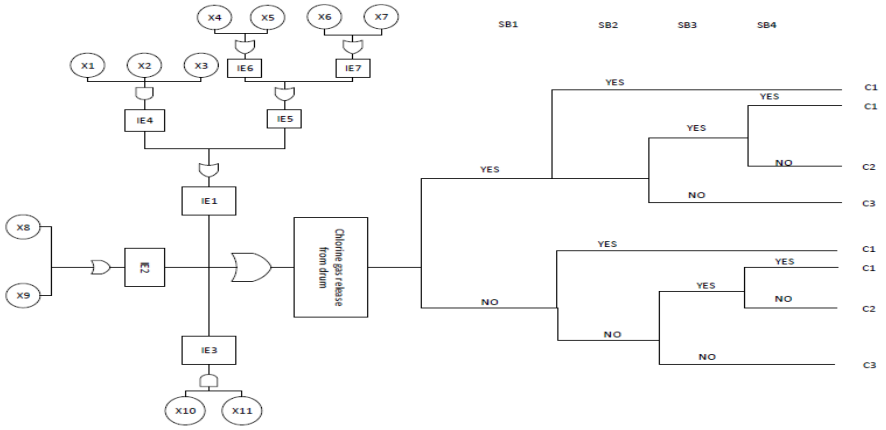

Figure 1: Accident scenario modelling of chlorine gas leakage from drum using Bow-tie approach

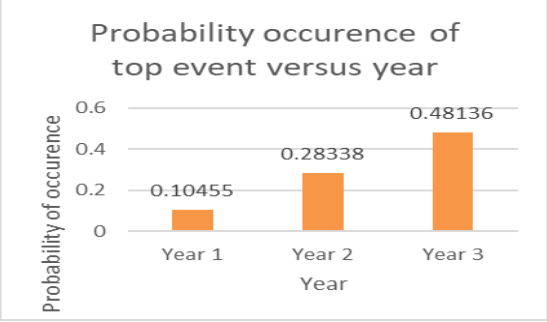

Figure 2: Probability occurrence of top event (Chlorine gas release from drum) versus year

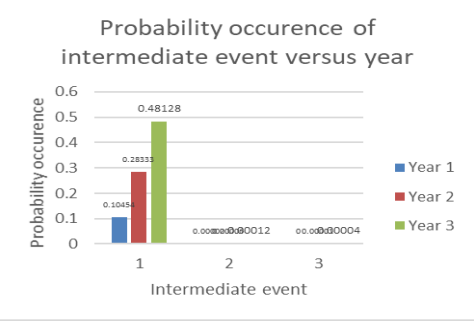

Figure 3: Probability occurrence of intermediate event versus year

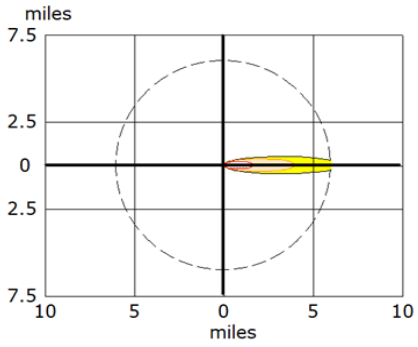

Figure 4: ALOHA modelling

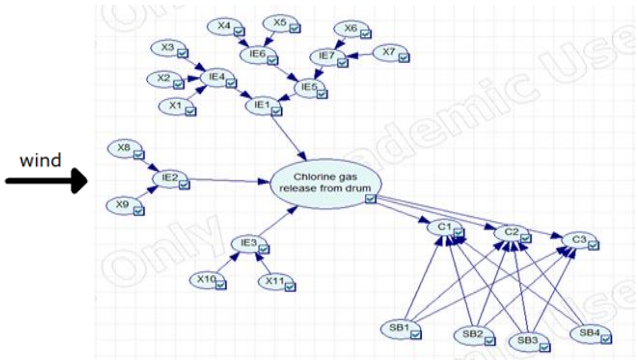

Figure 5: Bayesian network modeling

Conclusion:

In a nutshell, the objective of this research which were to identify hazard at Kelar water treatment plant using Failure mode effect analysis, to mapping the bow-tie diagram and to update to the dynamic safety risk analysis using dynamic bow-tie approach (bayesian network) and ALOHA modelling was successfully achieved. The safety risk analysis need be conducted in the water chlorination at water treatment plant to prevent and minimize the bad accident from occurred since chlorine is the dangerous chemical that need to be handled carefully. Failure mode effect analysis was used in this study for the hazard analysis and for the purpose to choose the top event for bow-tie and bayesian network analysis. Bow-tie diagram was drawn first and then due to the limitation of being static, bow-tie was convert into bayesian network. The bow-tie was illustrates the logical of causes of the top event and consequences through the safety barriers. From the bow-tie result it can be concluded that the higher probability potential consequences was form the mist pool or toxic release. This study was used three time year interval to mapping the bayesian network using GeNIe software to update the static bow-tie to the dynamic. From ALOHA modelling, it can be concluded that if there was a chlorine leakage from Kelar water treatment plant, it can be estimate that the population that will be affected of that toxicity according to the threat zone respectively. By conducting this research at Kelar water treatment plant, it can be concluded that the accident to occur can be predicted in a real time interval and may be prevent or minimized by applying a dynamic safety risk analysis. For this case study, it can be concluded that if there was no maintenance for three years at drum chlorine vessel, the possible of chlorine released due to drum body failure to occur was higher. That is why it is very important for the management to do the maintenance job to ensure no bad accident from occurred. For the better future research, used the PHAST software to estimate the chlorine released to the surrounding.