



UNIVERSITI
TEKNOLOGI
MARA

Cawangan Terengganu
Kampus Bukit Besi

**TITLE: INTEGRATION OF BOW TIE ANALYSIS
AND ALOHA SOFTWARE FOR RISK AND
CONSEQUENCES EVALUATION FOR LIQUID-
VAPOR SEPARATOR (V-100) IN PRODUCTION
OF ACETIC ACID DURING CHEMICAL
PROCESS DEVELOPMENT AND DESIGN**

**SUPERVISOR:
ENCIK MUHAMMAD FIRDAUS BIN HUSIN**

**SCHOOL OF CHEMICAL ENGINEERING
COLLEGE OF ENGINEERING**

2023

ABSTRACT

According to this case study on the production of acetic acid, the compressor, heater, distillation column, separator, and cooler are the equipment used in the procedure. Separator have emerged as the primary issue and focus for this project since it is one of the major contributors to industrial accidents. An industrial accident is an unexpected incident that occurs in the workplace that makes the workplace unsafe and adversely affects many people, including the industry, workers, affected communities and the environment. Many researchers have investigated and introduced numerous safety approaches in order to eliminate and reduce the accidents from occurring in the industry. However, after evaluating the methods, accidents still occur and the methods are less effective to be practiced in the workplace. Therefore, this case study intends to analyse risks and hazards by using the Bow-Tie Analysis and study a consequences analysis via Aloha Modelling Software. Bow-Tie Analysis provide the risk evaluation without a detailed information about the consequences of the accidents while Aloha Modelling Software provide a detailed and precise consequences of the accidents visually. Hence, this project was implemented to integrate both methods in order to create a more comprehensive assessment towards hazard and risk consequences. This project begins with the hazard identification which is to point out the hazards in the selected equipment and assessed stream based on the case study. Then, its continuing with the risk assessment which divided into two which is risk analysis by Bow-Tie Analysis and consequences analysis by Aloha Modelling Software. According to the requirement for the method Bow-Tie Analysis, the risk control will be discussed by using the Inherently Safety Design (ISD). The reduction of hazard and risk should be done to improve the process and unit operation. There are three sources of the accidents base on Aloha Modelling Software but the result from the investigation shows that the worst accident is because of the Direct Source, Toxic Area Of Vapor Cloud. Then, the risky and dangerous substance in the process is Acetic Acid which the accident may expose the poisonous and toxic vapor until 10 kilometres from the location. This accident can claim many lives of workers and civilians who are in the threatened area. This study make the use of Bow Tie analysis and ALOHA software to its full potential by enhancing and combining these two risk and consequence analysis method in the process of safety analysis. As a result, an integrated process safety analysis is developed.

TABLE OF CONTENTS

	Page
AUTHOR'S DECLARATION	2
ABSTRACT	4
TABLE OF CONTENTS	5
CHAPTER ONE BACKGROUND	6
1.1 Introduction	6
1.2 Literature Review	8
1.2.1 Methanol	8
1.2.2 Acetic Acid	9
1.2.3 Propionic Acid	9
1.2.4 Carbon Monoxide	10
1.2.5 Liquid-liquid Separator (V-100)	10
1.2.6 Bow-tie Analysis	13
1.2.7 Inherent Safer Design (ISD)	13
1.2.8 Areal Locations of Hazardous Atmospheres (ALOHA)	14
1.3 Problem Statement	14
1.4 Objectives	15
1.5 Scope of Study	16
CHAPTER TWO METHODOLOGY	17
2.1 Introduction	17
2.2 Hazard Identification	17
2.3 Risk Assessment	18
2.3.1 Risk analysis	18
2.3.2 Consequences analysis	19
2.4 Risk Acceptance	24
CHAPTER THREE RESULT AND DISCUSSION	25
3.1 Introduction	25

3.2	Bow-Tie Analysis	25
3.3	Aloha Result	27
3.3.1	Direct Source	28
3.3.2	Puddle Source (Evaporating Puddle)	34
3.3.3	Puddle Sources (burning)	39
3.3.4	Tank (chemical is not burning as it escapes into the atmosphere)	40
3.3.5	Tank (Chemical is burning as a jet fire)	44
	CONCLUSION AND RECOMENDATION	52
4.1	Conclusion	52
4.2	Recommendation	53
	REFERENCES	53

CHAPTER ONE

BACKGROUND

1.1 Introduction

An industrial accident is an unexpected occurrence in the industry that disrupt the orderly progress of work and have many negative impacts on workers, communities, the environment and the industry. A case study, The Preliminary Stage Of Plant Design in The Production Of Acetic Acid has been given to evaluate and investigate the hazard and risk in that industry as well as the consequences of the accidents. Acetic acid is a hazardous chemical as it can be corrosive, causing severe burn to any exposed tissue when it is contacting with the skin and eye. This clearly shows that the manufacturing process of Acetic Acid are serious which may endanger human physically as well as the internal health. Not only chemicals, equipment can also be one of the causes for accidents to occur in the industry. The wide range of acetic acid production requires many type of equipment such as Compressor, Cooler, Heater, Separator, Distillation Column, Pump, and storage tank. Each of the equipment have the rules that applies to the design, manufacture, assembly, installation, alteration, repair, maintenance, and operation. However, it needs to be aware when designing to prevent any harm and injuries. A Liquid-Vapor Separator has been chosen to be investigated in detail about

the risk and hazards as it is the one of the most harmful equipment in the production of acetic acid which potentially to cause an accidents. Liquid-Vapor Separator is a unit operation used to separate a vapor–liquid mixture into its constituent phases. Accidents will nevertheless happen in the sector for a variety of causes, including damage to the separator and human mistake.

Hazard analysis is a crucial component in designing the process plant since it helps to prevent accidents. To achieve this, Bow-Tie Analysis has been implemented to create awareness and identify the risk that may lead to an accident to happens to the unit operation separator. The Bow-Tie analysis method was used in this project to analyse the risks associated with the case study. It is a graphical representation of the pathways from the causes of an event or risk to its consequences. Bow-Tie Analysis helps to provides detailed information regarding threats, threat barriers, recovery measures, consequences and hazard-related to the top events. According to the requirement of this method, the risk control have been done to prevent the threats of the accidents to occur. One of the possible risk controls provided for the healthy and safe workplace is an Inherently Safer Design (ISD) which consist of four elements which are minimize, moderate, simplify and substitute.

This project continues with the more detail and precise analysis of the consequences from the accidents that occur using one of the safety assessment tools which is Aloha Modelling Software. ALOHA® is the hazard modelling program for the CAMEO® software suite, which is used widely to plan for and respond to chemical emergencies. Aloha Modelling Software allows to enter details about a real or potential chemical release, and then it will predict the threat zone for three types of sources which are Direct Source, Puddle Source, and Tank Source. This method can provide the toxic gas clouds, flammable gas clouds, vapour cloud explosions, jet fire, pool fire and Boiling liquid expanding vapor explosions (BLEVEs). By insert all the information needed by the software, it will estimate what accident that may cause and the extent of the area involved in the accident as well as the effects that can occur on humans such as death, serious accidents, and minor accidents.

The project will proceed to the risk and hazard acceptance process after a risk assessment investigation is performed by Bow-Tie Analysis and Aloha Modelling