Application of Inherent Safety in Improving the Hazardous Area Classification Framework of Process Plant

by

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Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

JANUARY 2009

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CERTIFICATION OF APPROVAL

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BACHELOR OF ENGINEERING (Hons)
(CHEMICAL ENGINEERING)

Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(DZETI FARHAH BINTI HAJI MOHSHIM)

ACKNOWLEDGEMENTS

I must begin by expressing my most profound gratitude to the highly honored supervisor, Dr. Azmi Mohd Shariff who provided me all necessary custody in carrying out my responsibility throughout the project. Dr. Azmi had fully shown his commitment and responsibility as supervisor by letting me met him even he was busy with his job taking just to make sure I am clear on how to complete this project.

Besides that, I would like to express my heartfelt thanks and gratitude to Mr. Lum Chee Hao, Engineer of Petronas Fertilizer Kedah Sdn. Bhd. (PFK SB). He had strongly support me to this project and was willing to give me any information needed that could consume on this project.

I am also pleased to acknowledge my friends that were under Dr. Azmi supervision which were helping so much to complete this project. They were so committed in trying to help each other especially in the situation of finding the case study. I am greatly indebted to their generous assistance.

Lastly, I would like to thank to my parent and family which are very understanding for their support throughout this project.

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ABSTRACT

This project basically is done for hazardous precautions improvement. Hazardous area classification (HAC) is one of the methods in analyzing hazards into specific class due to the mode of the hazards occurred. Hazardous area can be defined as an area which an unstable gas atmosphere is presents in quantities and needed some special safety precautions.

From the early stage of designing a plant, HAC has been developed but unfortunately, there is no improvisation consecutively to have a safer plant area. In order to attain a less harmful plant area, this project would propose the Inherent Safety approach to the HAC presented.

Inherent Safety concept is an approach to chemical accident prevention that differs fundamentally from secondary accident prevention and accident mitigation. Encouraging the industrial firm to perform an inherent safety opportunity audit to identify where inherently safer technology is needed, a technology options analysis and to identify specific inherently safer options will advance the adoption of primary prevention strategies that will alter production systems so that there are less inherent safety risks.

Based on the HAC framework that has been developed earlier, any method of Inherent Safety concept will then be implemented for a risky area improvement. The method might not suitable to be applied to all area, but it could somehow be appropriate for certain section only.

For the area that could have a safer zone, the technique to handle any installation would be much better out of harm's way. With this way, certain plant region would be more secured towards the plant personnel.

CHAPTER 1: INTRODUCTION

1.1 Background of Study

A century ago, boiler explosions were an all-too-familiar event. But with the universal adoption of the Boiler and Pressure Vessel Codes in 1914, explosions caused by poor design or manufacturing became relics of history. Electrical classification codes had the same effect on safety (Ram K. Saini, 2007).

Hazardous areas exist in every power plant. Following proper design rules and anticipating how the plant will be operated can avoid creating mixtures of gases that could explode or catch fire (Burns and Roe Enterprises Inc, 2007).

According to Charles Emma, hazardous area classification is a rigorous method of determining where an explosive environment may be present. The codes and standards used in this process provide guidance for selecting, building, and installing electrical equipment in that area.

Basically, all plant area can be considered as hazardous area. Hazardous Area Classification generally developed in the beginning phase of designing a plant. Just as it is not possible to build a process plant before it is designed, equipment for use in hazardous area cannot satisfactorily before the designed requirements have been determined.

Hazardous Area Classification (HAC) is the process of providing a design basis by which rational decisions may be made as to use of potential ignition sources in proximity to substances which can ignite or explode in the atmosphere, in order to minimize the risk of ignition (Bruce Phillips, 2008).

Gases, vapors, dusts and mists can all form explosive atmospheres in air with the right temperature and pressure involved. If we look at the size of a refinery or chemical factory and the amount of liquids and gases that circulate the various processes in that plant there must be a certain amount of risk of leaks and other vulnerability. In some cases the gas, vapor or dust is present endlessly or for long periods. Refineries and chemical complexes thus are divided into areas of risk of release of gas, vapor or dust which are known as zones. The type and size of these hazards are determined using area classification.

Each hazardous area should be classified according to applicable industry codes and standards. For example, electrical area classifications explain how to select and install electrical equipment and wiring, right down to the wiring method in order to minimize the likelihood of ignition of a flammable or explosive mixture.

Inherent Safety is a very important concept and methodology in the domain of safety science and technology that mitigates or eliminates hazards at the source by means of avoiding hazards instead of controlling them (REN Yanbin,2000).

The Inherently Safer Design concept was firstly presented by Trevor Kletz (a British professor of chemical engineering) in the late 1970s as a fundamental approach to hazard/risk management which focused on avoiding or limiting hazards at source, rather than relying on add-on safety features or management systems and procedures to control them. Inherent safety is a proactive method that can be incorporated at any stage of design and operation of the plant in the chemical process industries. However, its application at the earliest possible design stages (such as process selection and conceptual design) yields the best results.

The improvement of a hazardous area to a safer zone will be achieved by using Inherent Safety concept. The Inherent Safety Concept is a traditional design approach of a core process to achieve a reasonable outcome that surrounded by safeguards in opposition to the hazards that maybe expected. Hazards can be reduced and eliminated by changing the materials, chemistry and process variables such that the reduced hazard is characteristic of the new condition. The process with reduced hazards is described as inherently safer. This terminology recognizes there is no chemical process that is without risk but all chemical processes can be made safer by applying inherent safety concepts.

1.2 Problem Statement

Hazardous Area Classification is one of a mandatory requirement by law for any process plant. This is purposely to ensure the safety of process plant due to the process involved and the equipment installation at the specific hazardous area. Nowadays, there are no improvisations of HAC since it is assumed to be a standard regulation. Most of the plants are just strengthen the process in order to have a safer plant area. So an improvement of hazardous zone using Inherent Safety Concept will be propose to implement before any design concluded and somehow could minimize the risk for the process by utilizing the HAC framework.

The significance of this project is, in the future, any hazards can be determined and prevented before things going wrong. This HAC framework improvement will also provide a safer plant environment with small hazardous exposure.

1.3 Objective(s)

The objectives of this study are to establish an additional approach to the existed HAC which is being able to:

a) Improve the Hazardous Area Classification (HAC) framework to a less hazardous plant area

b) Implement the Inherent Safety Concept for the developed framework for a selected case study

1.4 Scope of Project

This study involved trying some method of Inherent Safety concept to gauge the effectiveness so as to meet the objectives of this project.

A case study was conducted in Petronas Fertilizer Kedah Sdn. Bhd., PFK (SB), Kedah, Malaysia to assess the effectiveness of Inherent Safety concept approached.

This study included the following limitations:

a) The case study was limited to Petronas Fertilizer Kedah Sdn. Bhd., PFK (SB)
b) The case study was limited to Ammonia and Utility area only
c) This project will be focused on the gas, vapor and liquid chosen area only
d) Inherent Safety Concept is mainly concern on how to minimize the hazards
e) Long term effect cannot be measured

CHAPTER 2: LITERATURE REVIEW

2.1 Hazardous Area Classification (HAC) Definitions and Standards

Feasibility of determining Hazardous Area Classification (HAC) from the first principle has been compared with the boundary implied using some competing standards. HAC is the process of providing a design basis by which rational decisions will be made as to the use of potential ignition sources in proximity to substance which can ignite or explode in the atmosphere in order to minimize the risk of ignition (Ralph Wigg, 2008).

Currently, there is not much development done on HAC. The concept is accepted by worldwide since it becomes a standard. But the current HAC does not include the Inherent Safety Concept which will be covered through this project.

Standards and guidelines exist, but even in combination, they do not always have the answer. The governing standard in Malaysia for HAC is MS 60079.10.2003. MS 60079.10.2003 defines HAC as a method of analyzing and classifying the environment where explosive gas atmosphere may occur so as to facilitate the proper selection and installation of apparatus to be used safely in that environment, taking account into gas groups and temperature classes (Bruce Philips, 2008). The standard covers flammable gases, vapors, liquids and mists. However, certain dusts can be combustible and an analogue, although quite distinct approach is used to classify such situations. There are no Malaysian standard for HAC of combustible dusts but it is likely would be preferred until such time as an equivalent Malaysian standard is published.

According to Bruce Phillips (2008), the classification needs requirements as follows:

- Likelihood of presence of flammable atmosphere
- Physical extent of flammable atmosphere
- Characteristics of flammable atmosphere

The terms flammable, combustible and explosive can be interpreted widely based from Malaysia's governing standard, MS 60079.10:

Table 2.1: Terms and Definitions

Terms	Definition
Flammable Material (substance)	Material which is flammable of itself or is capable of producing a flammable gas, vapor or mist
Flammable Gas/ Vapor	Gas/ Vapor which when mixed with air in certain proportions will form an explosive gas atmosphere
Flammable Liquid	Liquid capable of producing a flammable vapor under any foreseeable operating conditions
Combustible Material	Generally taken as something which is capable of being burned (not defined in MS 60079.10)
Combustible Liquid	Generally taken as any liquid other than flammable liquid that has flash point and fire point that is less than its boiling point (not defined in MS 60079.10)
Explosive Atmosphere	Mixture with air, under atmospheric conditions of flammable substances in the form of gas, vapor, mist or dust in which after ignition, combustion spread throughout the unconsumed mixture
Explosive Gas Atmosphere	Mixture with air, under atmospheric conditions of flammable substances in the form of gas or vapor in which after ignition, combustion spread throughout the unconsumed mixture
Flammable Mist	Droplets of flammable liquid, dispersed in air so as to form an explosive atmosphere

Table 2.2: Hazardous Area Classification Principles from MS 600.79.10 (Gases, vapors and mists):

Area	Definition
Hazardous Area	An area which an explosive atmosphere is present, or may be expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus
Zone 0	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is present continuously or for long periods or frequently
Zone 1	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is likely to occur in normal operation occasionally
Zone 2	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is not likely to occur in normal operation but if it does occur will persist for a short period only

As advertised in Hazardous Area Classification and Control Ignition Sources (2008) homepage, various sources have tried to place time limits on to these zones, but none have been officially adopted. The most common values used are:

- Zone 0: Explosive atmosphere for more than 1000h/yr
- Zone 1: Explosive atmosphere for more than 10, but less than 1000 h/yr
- Zone 2: Explosive atmosphere for less than 10h/yr, but still sufficiently likely as to require controls over ignition sources.

Based on the website, where people wish to quantify the zone classification, these values are the most appropriate, but for the majority of situations a purely qualitative approach is adequate. When the hazardous areas of a plant have been classified, the leftovers will be defined as non-hazardous, sometimes referred to as 'safe areas'. Normally, Zone 0 will be referred to inside tank.

The world recognized Australian and New Zealand standard AS/ NZ 4360 stated that risk management provides a process whereby any hazards can be identified in order to determine corresponding risk and initiate appropriate treatment. There is currently no equivalent Malaysian standard.

The process of determining both the type and extent of any hazardous area falls under the AS/ NZ 4360 category of risk analysis, for which the treatment will be a means of likelihood reduction through the use of engineering controls. By definition, the lower the zone number, the more likely there is to be an explosive atmosphere around the associated source of release.

There is a truism that if release of a flammable substance is sufficiently large, it will eventually find its way to an ignition source. Witness from Flixborough in the UK, Longford and Moomba in Autralia or the Choon Hong III said about chemical tanker explosion (1992) in Port Klang, Malaysia. According to them, HAC does not attempt to provide solutions for massive catastrophic or predictable releases of flammable material such as from vessel rupture. It applies only when equipment is operating within its design parameters.

The role of North American HazLoc Installation Codes (National Electrical Code for U.S., NEC and Canadian Electrical Code for Canada, CEC) can be viewed as the starting point from which all subsequent aspects of the North American HazLoc system are derived. These codes include details on equipment construction, performance and installation requirements and area classification requirements.

Hazardous location as defined in NEC are locations where fire or explosion hazards may exist due to the present of flammable gases, vapors or flammable liquids, combustible dusts or ignitable fibers or flying.

2.2 HAC Reasons

Assuming HAC is legally required in Malaysia, it is an essential document for business owner's occupiers and operators. Ralph Wigg, 2008 stated that:

- HAC required irrespective of whether or not the site has ignition source or there are HSE consequences of an explosion
- HAC required if sufficient inventory of flammable material exists in a plant
- Review inventory regularly for changes to HAC

Occupiers, as stated by Ralph, have the responsibility to classify hazardous areas may be a condition for purchase of electricity.

During preliminary design stages, it is often possible to reduce the degree of hazard by giving proper attention to plant layout and product enclosure to maximize the use of natural ventilation to disperse and diffuse any flammable material that may be released during any operation (AS 3000, Clause 7.9.2.3.3)

On the other hand, based on MS IEC 60079.10 Clause 4.2, it is important to examine those parts of process equipment and systems from which release of flammable material may arise and to consider modifying the design to minimize the likelihood and frequency of flammable material and the quantity and rate of release of those materials.

According to the discussion during the Hazardous Area Conference 2008, by going back to basis, there is large amount of substances handled by industry which have the potential to seize fire or explode with consequent risk to life and extremity not to mention asset damage, production disturbance, material loss, pollution, adverse publicity and other unwanted consequences. It is not just the hydrocarbons industries which face the issue of fire or explosion in the material which are handled in facility. For example, the pharmaceutical industry is a heavy user of ethanol; many chemicals and solvents that are also flammable.

During a period when maintenance is being carried out the normal area classification drawings may not be applicable. If dangerous substances have been removed, it may be possible to treat areas normally classified as hazardous as non-hazardous. Alternatively, if the maintenance creates then larger than normal risk of a release of a dangerous substance, larger areas may need to be treated as hazardous. It is not normally necessary to create new area classification drawings for the duration of the maintenance work.

2.3 HAC Extension

According to the Hazardous Area Classification and Control Ignition Sources (2007) homepage, an area extent and classification study involves due consideration of the following:

- The flammable materials that may be present;
- The physical properties and characteristics of each of the flammable materials;
- The source of potential releases;
- Prevailing operating temperatures and pressures;
- Presence, degree and availability of ventilation (forced and natural);
- Dispersion of released vapors to below flammable limits;
- The probability of each release scenario.

These factors enable appropriate selection of a grouping, temperature class, zone type and zone extent.

Special precautions need to be taken in hazardous areas to prevent equipment from being a source of ignition. In situations where an explosive atmosphere has a high likelihood of occurring, reliance is placed on using equipment with a low probability of creating a source of ignition. Where the likelihood of an explosive atmosphere occurring is reduced, equipment constructed to a less accurate standard may be used. Equipment is categorized depending on the level of zone where it is intended to be used.

2.4 Inherent Safety

In history, a first known application of the inherent safety ideas occurred in 1870 when Ludwig Mond suggested amelioration to the Solvay process for the production of sodium carbonate. At that time solid lime was fed to each batch distillation columns through a manhole at the top of the vessels. The operation was very dangerous because every time the manhole was open and then a hazardous escape of ammonia possibly occurred. The suggested modification consisted in pumping a solution of milk of lime into the columns avoiding leak of the ammonia. From then on, for the sake of overcoming traditional design strategies, numbers of scientists and engineers have worked in integrating safety control measures backward to the invention step of chemical process development and design. These endeavors have lead to the new hazard/risk prevention culture called inherent safety.

Hazardous area basically must be determined before specifying equipment suitable to operate in those areas. Based on Inherently Safer Chemical Process 1996, interest in inherent safety chemical and process plants has grown over the years since 1978 and has been particularly rapid in 1990s. Inherent safety design is also receiving attention from government and regulatory organizations in United State and Europe. Based on the history, process hazards come from two sources:

i) hazards that are characteristics of the materials and chemistry used
ii) hazards that are characteristics of the process variables

Inherent safety is an approach to chemical accident prevention that differs fundamentally from secondary accident prevention and accident mitigation. Sometimes also referred to as "primary prevention," inherent safety depends on the development and deployment of technologies that prevent the possibility of a chemical accident. By comparison, "secondary prevention" reduces the probability of a chemical accident and "mitigation" and emergency responses seek to reduce the seriousness of injuries, property damage, and environmental damage resulting from chemical accidents (Nicholas Askounes Ashford, 1994).

He also added that, secondary prevention and mitigation, by themselves, are unable to eliminate the risk of serious or catastrophic chemical accidents, although improved process safety management can reduce their probability and severity. Most chemical production involves "transformation" processes, which are inherently complex and tightly coupled. "Normal accidents" are an unavoidable risk of systems with these characteristics. However, the risk of serious, or catastrophic, consequences need not be. Specific industries use many different processes. In many cases, alternative chemical processes present which completely or almost completely eliminate the use of highly toxic, volatile, or flammable chemicals. Accidents that do arise in these systems result in significantly less harmful chemical reactions or releases.

Inherent Safety concepts basically enhance overall risk management programs whether directed toward reducing frequency or consequences of potential accidents. Inherent safety design strategies fall primarily in the inherent or passive categories.

The terminology of inherent safety has developed since 1991, with some slightly different words but the same intentions as Kletz (1984). The four main approaches for achieving inherently safer design are:

- **Minimize**: Reducing the amount of hazardous material present at any one time
- **Substitute**: Replacing one material with another of less hazard, e.g. cleaning with water and detergent rather than a flammable solvent
- **Moderate**: Reducing the strength of an effect, e.g. having a cold liquid instead of a gas at high pressure, or using material in a dilute rather than concentrated form

- **Simplify**: Designing out problems rather than adding additional equipment or features to deal with them. Only fitting options and using complex procedures if they are really necessary.

Inherent Safety is a way of thinking; one needs of a fundamental understanding of the development and design processes for new plants or retrofit of existing plants as a single comprehensive system. Process safety is fundamental to the basic practice of chemical engineering thus the concept of inherent safety processes should be instilled in chemical engineering (Ashford, 1993).

The results with regard to the economic factors are very striking in all four cases: inherently safer options were identified that were not only economically feasible, but the overwhelming majority had pay-back times of less than one or two years, even in the existing plants. Thus, while at the beginning the economic imperative is not visible for the adoption of inherently safer technologies, once identified, they do represent economically attractive options (Hendershot, D.C., 1993).

Lachman (1993) include that Inherent safety is similar in concept to pollution prevention or cleaner production. Both attempt to prevent the possibility of harm from accidents or pollution by eliminating the problem at its source. Both typically involve fundamental changes in production technology: substitution of inputs, process redesign and re-engineering, or final product reformulation.

The willingness of companies to adopt and implement inherently safer options was found to be different for new installations, existing installations that will remain in production for several years and for installations that are more or less at the end of their life-cycle.

An inherently safer design is one that avoids hazards instead of controlling them, particularly by reducing the amount of hazardous material and the number of hazardous operations in the plant. Methods developed to date have largely been for the evaluating the safety of a proposed design. In the future the emphasis will be more and more on the synthesis of an inherently safer plant. At the moment it seems that the best practice is not adopted quickly enough by the potential practitioners (Anna-Mari Heikkilä, 1994).

Inherent safety principles apply at all stages in a process life cycle. While the biggest gains are achieved early, through the selection of inherently safer process technology, there are many opportunities for enhancing the inherent safety and reliability of a plant at the detailed design stage (Robert L. Post, 2000).

As we can see, there is no combination HAC and Inherent Safety for a safer plant design. So this project would combine both to achieve the objective of this study.

CHAPTER 3: METHODOLOGY

The researches used to complete this study were explained step by step as shown in the heading below:

3.1 Concept

This study identified the possibilities to improve the hazardous area to a less hazardous area by utilizing the Inherent Safety Concept, such as moderation method.

The concept of Inherent Safety could retain the plant production which somehow also improves the hazardous area. This improvisation would turn out a plant to a safer place for job doing.

3.2 Framework

To start the implementation of Inherent Safety Concept, a basic framework of Hazardous Area Classification is needed. The HAC framework was developed at an early of the stage to design a plant.

With the classification of hazardous area done, the safety committee could use those data and discussed in order to implement the Inherent Safety Concept to the area classified. So, the concept will be analyzed first to understand the behavior involved. Optionally, we can also conduct interview or survey to the employees for further understanding of the hazardous area classified.

With that, the action pant can be established to rectify and improve the hazardous area that would contribute to a safer plant.

The framework of Hazardous Area Classification with Inherent Safety approach is shown in Figure 3.1 below:

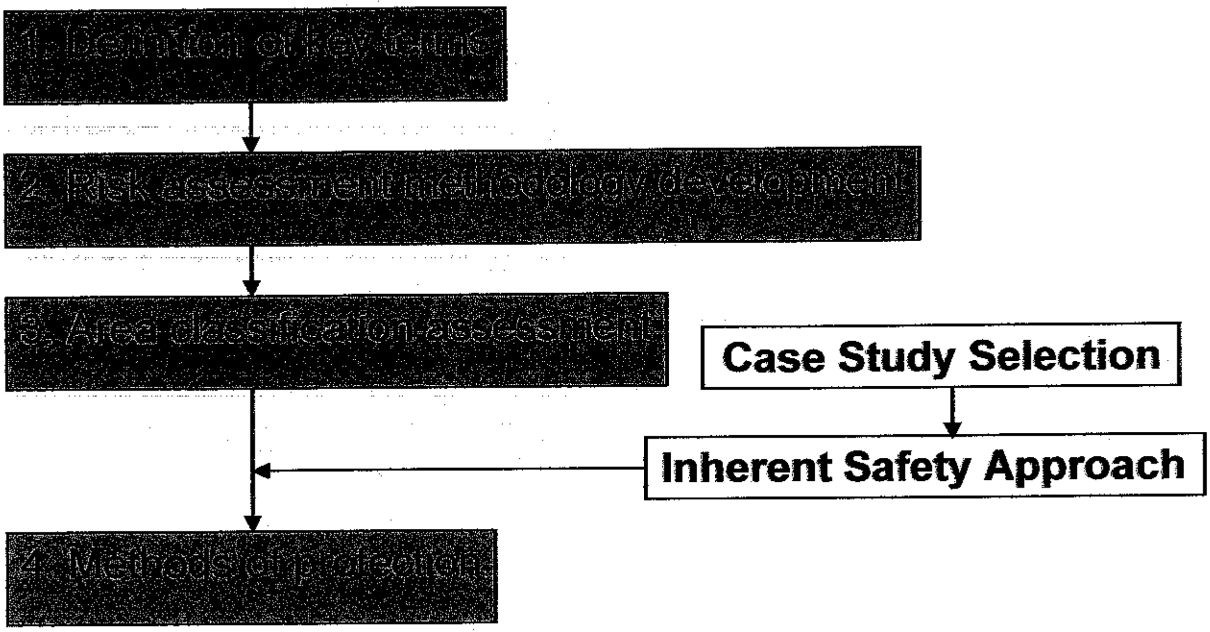


Figure 3.1: Hazardous Area Classification Framework

3.21 Definition of Key Terms

Key definition of terms is required in order to establish the foundation for assessing the classification of an area. Several of these definitions are taken directly word for word from the publications that are listed in the reference section. Paraphrasing is done to assist in the understanding of the intent of the definition.

3.22 Risk Assessment Methodology Development

Risk assessment methodology must be developed earlier to beginning the actual area classification assessment itself. This methodology sets the ground-rules by which the assessment is conducted. The deliverables presented at the completion of the assessment methodology are as follows:

- All potential point source of emissions will be identified
- Determine how the various codes and standards writing organizations will apply
- Determine whether the division or zone concept will be utilized

3.23 Area Classification Assessment

Step 1: Collect some documentation from the assessment methodology. MSDS are the source of process information about each element in the process stream. P&ID provide a lower level view of the process for equipment identification and process arrangements.

Step 2: Conduct a survey to determine the accuracy of the plot plans and verify location of all point sources of emissions. The plot plans will serve as the background for the area classification plan drawings. Area classification background drawings should show all vessels, tanks, pumps, sumps, compressors, building structures, dikes, partitions, levees, and other items that might impact the dispersion of the process material.

Step 3: Determine the extent of the classified area that surrounds each point source of emission.

Step 4: Develop elevation drawings to provide clarity where there are emissions sources located in multilevel process structures. A plan view will be required for each level in the process structure.

Step 5: Create a detailed assessment report that documents the following information:

- The rationale used to classify the areas.
- Special out of the ordinary exceptions that were taken when classifying a particular location.
- A detailed listing of all point sources of emissions that appear on the drawings.
- The critical process material information usually obtained from MSDS.

3.25 Case Study Selection

The selection of case study was at first suggested by the engineer from PFK. Besides, the selection criteria also include:

- Location in Ammonia/ Methanol and Utility Unit only

  - This location has been chosen since the author did the internship and familiar to this area.

- The class of hazardous area

  - The improvisation of the area was proposed to be tried to different class of hazardous area, so, the area chosen was based on Zone 1 and Zone 2 only.

After several discussions were conducted, the areas that have been selected are at:

- Desulphurization Unit

- Methanol Unit, Ammonia Storage Unit
- Cooling Tower Unit.

3.26 Inherent Safety Approach

After case study was selected, the Inherent Safety Approach took place. Hazard can be reduced by changing the materials, chemistry and process variables such that the reduced hazard is characteristic of the new condition. The process is known as Inherently Safer. This terminology recognizes there is no chemical process that is without risk but all chemical processes can be made safer by applying inherently safer concepts. After the inherent hazards are reduced, layers of protection are frequently used to protect the receptors (e.g.: workers, environment).

The Inherent Safety approach has been discussed in *Section 2.4.*

3.3 Tools and Software

Microsoft PowerPoint was used to edit the drawing of hazardous area classification. The given drawing by PFK covered all area which also included the unnecessary part.

To scope on the selected area, Microsoft PowerPoint was used to edit the drawing given so that area needed is clearer.

3.4 Case Study Implementation

Petronas Fertilizer Kedah Sdn Bhd, PFK(SB) is one of the petrochemical plant owned by Petronas. From the commissioning of the plant, the HAC is already generated. The safety team members have completed the step to classify the hazardous area of this plant.

However, the plant was recently planning to revamp and improves some process involved. The safety team members would like to re-do the area classification. So, I took the chance to improve the classification method by implementing the Inherent Safety concept.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Data Gathering and Analysis

For this project proposed, a case study is based from Petronas Fertilizer Kedah (PFK). So the plan of plant safety improvement will be done to the selected areas in PFK. The selection has been discussed in *Section 3.2.5*.

4.1.1 Desulphurization Unit

Desulphurization is located at the Front End of the plant. This unit is basically to remove the Sulphur from the natural gas since Sulphur can be poisoned to the catalyst. This unit contains of three major equipments which are a Hydrogenator (R-11-01) and two Hydrogen Sulphide (H_2S) Absorber (R-11-02A/B). The arrangements of these three equipments are as follow:

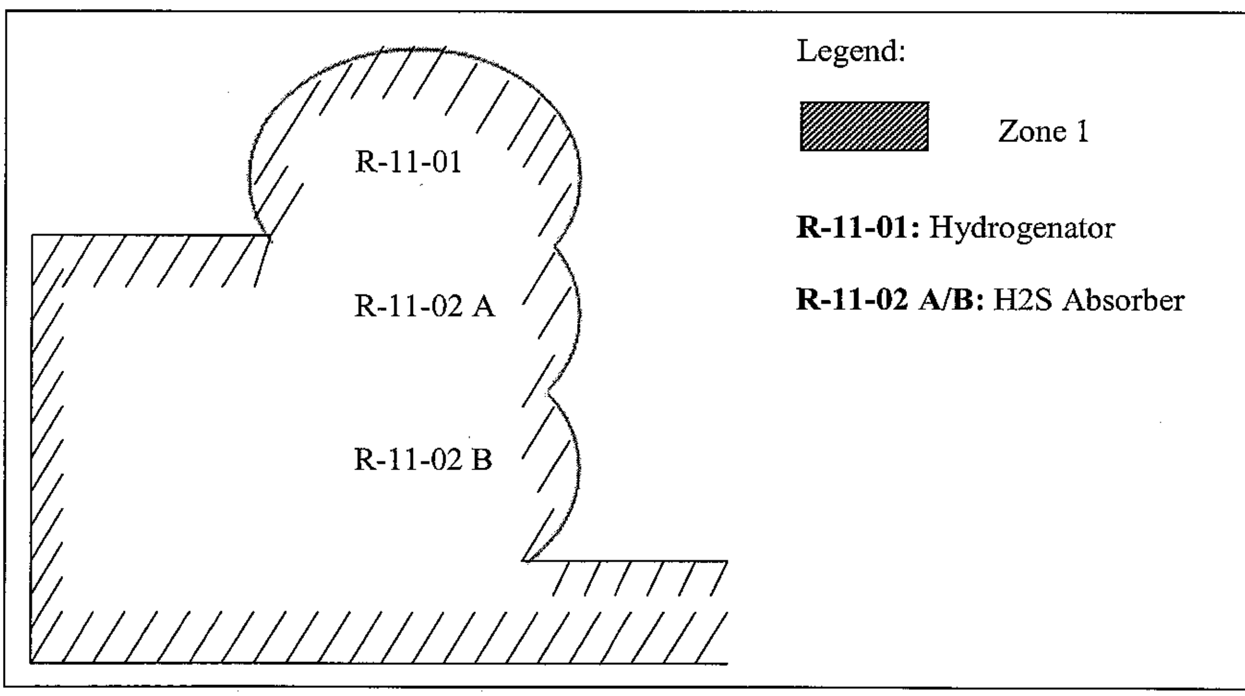


Figure 4.1: Desulphurization Unit

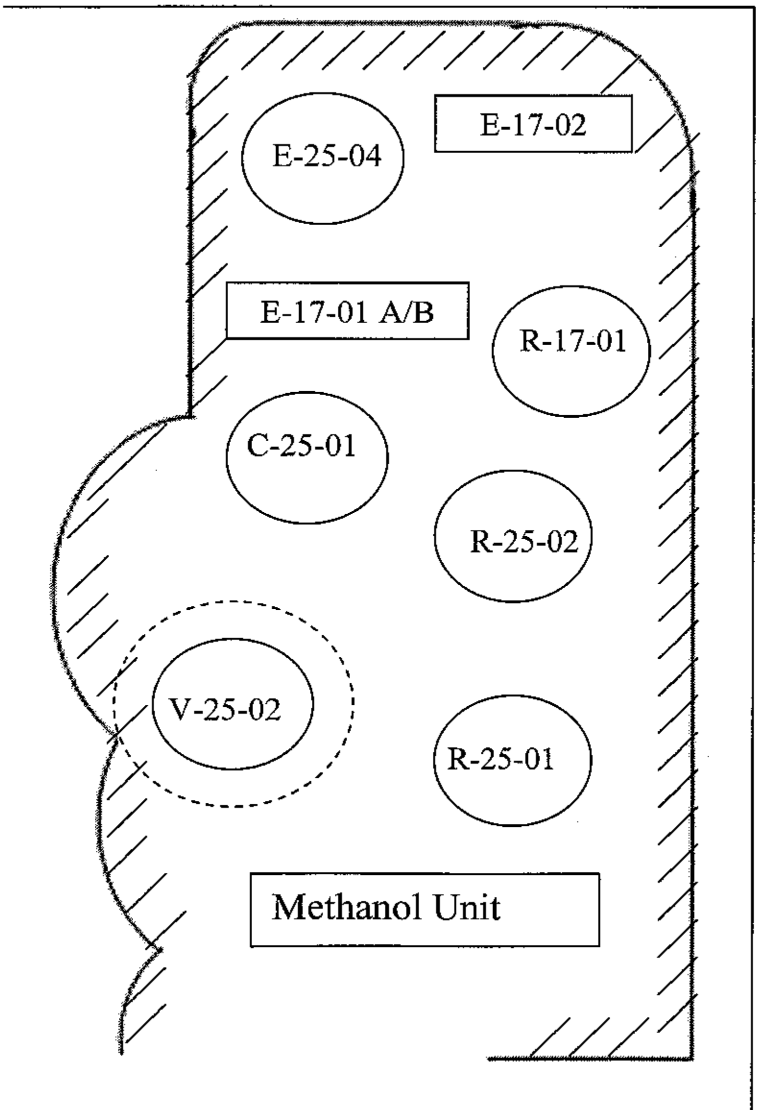
The equipment location of Desulphurization Unit can be referred to Appendix I.

From the figure above, Zone 2 is filled all around of the equipments. For an area improvisation, there is no Inherent Safety method that suitable to be applied here.

The hazardous material involved here is Hydrogen Sulphide (H_2S). It cannot be minimized since the natural gas itself contain unexpected amount of H_2S. Any moderation also cannot be implemented here because the system needs the specific operating condition that cannot be changed. To substitute with a less harmful chemical, there is nothing we can substitute with H_2S since it is naturally come with the natural gas. Same goes to simplifying method, the process involved could also not appropriate for any simplification.

4.12 Methanol Unit

PFK also produced Methanol instead of Ammonia. The figure illustrated below is at Methanol Unit.



Legend:

Zone 2

E-17-01A/B: Methanator Exchanger

E-17-02: Methanator Heater

R-17-01: Methanator

R-25-01: Methanol Reactor

R-25-02: Adiabatic Methanol Reactor

C-25-01: Methanol Separator

E-25-04: Methanol Reactor Trim Heater

V-25-02: Steam Drum

Figure 4.2: Methanol Unit

The general process area of Methanol Unit can be referred to Appendix II.

From the picture, Methanol Unit is surrounded in Zone 2 class. The materials used to produce Methanol are basically Carbon Dioxide (CO_2) and water (H_2O). The Methanol can also be formed from reaction between Carbon Monoxide (CO) and Hydrogen Gas (H_2).

The hazardous chemical involved here are CO_2, CO, H_2 and Methanol. Substitution method of Inherent Safety concept is unfavorably used since the production of Methanol required this material. Neither minimization nor moderation methods of Inherent Safety can be implemented at this unit too. This is because we cannot reduce the amount of hazardous material present at any one time and also cannot reduce the strength of production effect in order to get the forecasted Methanol production.

4.1.3 Ammonia Storage Tank

The Ammonia storage tank is located as in figure below:

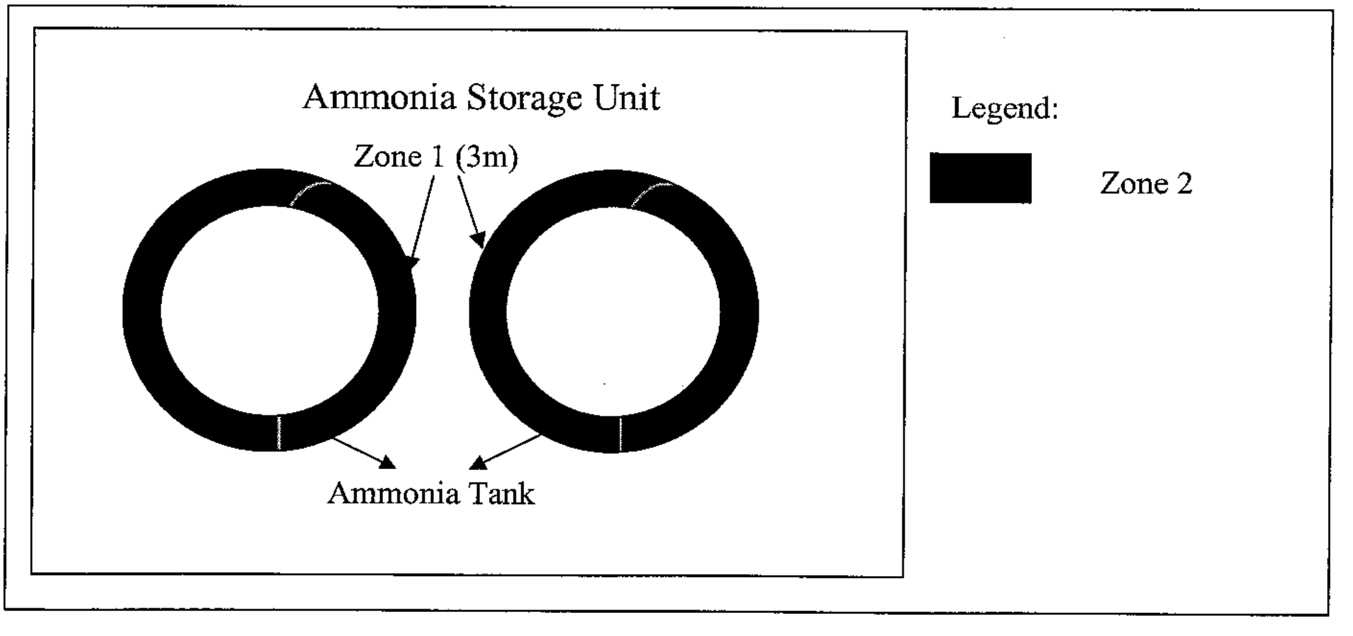


Figure 4.3a: Ammonia Storage Unit

The Ammonia Storage tank location can be referred to Appendix III.

From the figure above, we can see that, Zone 0 created in tank emptying draws air inside the tank, while Zone 1 is filled around the tank.

The Ammonia in the storage tank often represents a major portion of risk in a petrochemical plant like PFK. Material such as Ammonia when released from a storage tank in a liquefied state under pressure will form a jet containing an extremely fine liquid aerosol. The fine aerosol droplets formed may not rain out onto the ground, but instead maybe carried downwind as a dense plumy cloud. The amount of Ammonia contain in the cloud maybe extensively higher than could be imagined.

In order to improve the hazardous area of Zone 1, the **moderate** method of Inherent Safety is used. Basically, hazardous material like Ammonia is stored at or below its atmospheric boiling points with refrigeration. Like the Ammonia storage tank in PFK, the plant do stored the Ammonia at -33°C which is same as it boiling temperature. Refrigerated storage reduces the magnitude of the result of a release from the tank in three ways which are:

i) Reducing the storage pressure
ii) Reducing the immediate vaporization of leaking material and the subsequent progression of vapors from the spilled liquid
iii) Reducing or eliminating liquid aerosol formation from a leak

Refrigeration will also reduces the vapor pressure of the material being stored thus reducing the driving force for a leak to enter the environment. If possible, the hazardous material should be cooled to or below its atmospheric pressure boiling point. At this temperature, the flow rate of a liquid leak will depend only on liquid pressure with no contribution of the vapor pressure. The flow rate through any hole in the vapor space will be small and will be limited as well if it happens to diffuse.

Ammonia that stored under its atmospheric pressure boiling point will have no superheat. Therefore, there will be no initial flash of liquid to vapor in case of a leak. Vaporization will be controlled by the evaporation rate from the pool formed by the leak. This rate can be minimized by the containment dike design. For example, minimizing the surface area of the liquid spilled into the dike area or insulating with concrete dike sides and floors will minimize the rate. Since the spilled material is cold, the vaporization from the pool will be further reduced.

Another way to improve the hazardous area to a safer zone is by dilution of moderating method. Dilution could reduces the hazards associated with the storage and use of a low boiling hazardous material in two ways; by reducing the storage pressure (as refrigeration) and reducing the initial atmospheric concentration if a release occurs.

Material such Ammonia which boils below normal ambient temperature is often stored in pressurized systems under their ambient temperature vapor pressure. The pressure in such a storage system can be lowered by diluting the material with a higher boiling solvent. This reduces the pressure difference between the storage system and the outside pressure thus reducing the rate of release in case of a leak in the system. If there is a loss of containment incident, the atmospheric concentration of the hazardous material at the spill location is reduced. This wills consequences in a smaller hazard zone downwind of the spill.

If a chemical process requires the concentrated form of the material, it maybe possible to store a more dilute form and to concentrate the material by distillation or some other technique in the plant prior to the introduction of the process.

Based on the improvement wished-for, the hazardous area of Zone 1 now could be reduced by Zone 1 will always in Zone 2 which is Zone 2 surrounded around the tank which can be seen as follow:

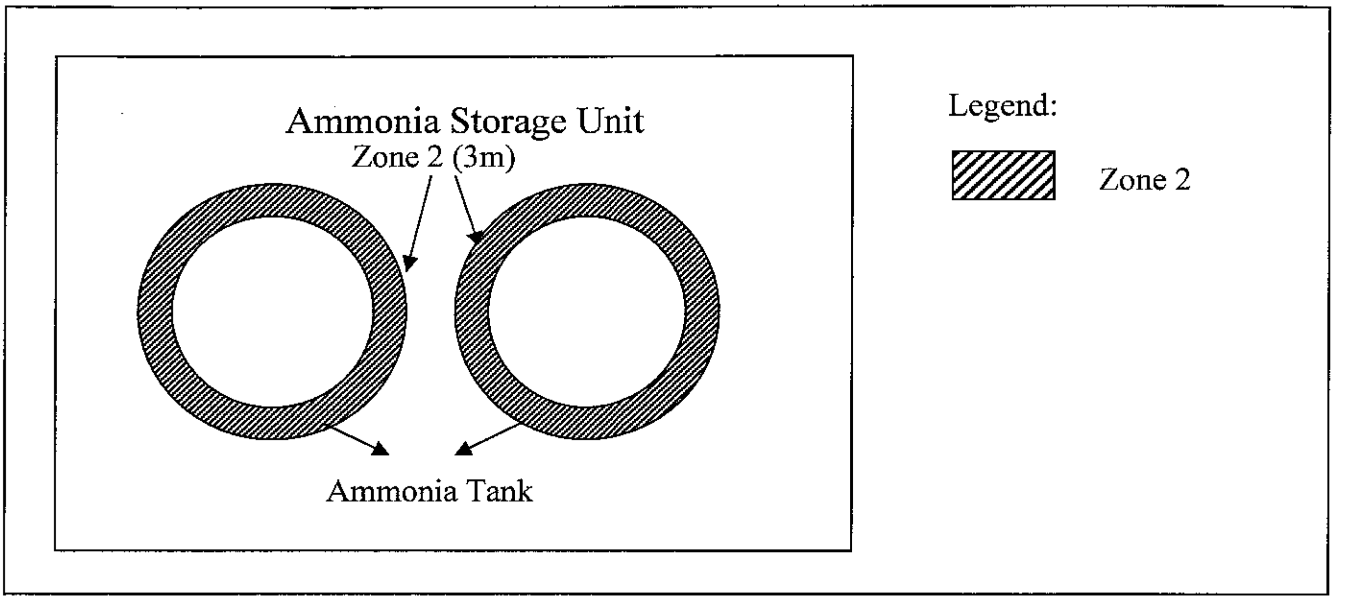


Figure 4.3b: Ammonia Storage Area Improvement

4.1.4 Cooling Tower Unit

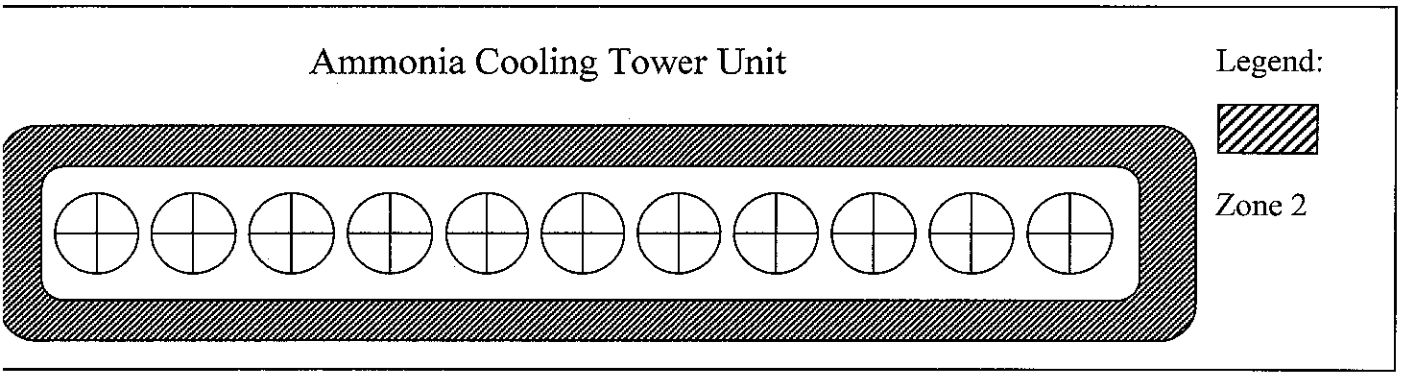


Figure 4.4: Cooling Tower Unit

The Cooling Tower Unit area can be referred to Appendix IV.

There are seven cooling towers provided for Ammonia area. From the figure illustrated, cooling tower itself is in the Zone 2 classification. This area is slightly harmful because the cooling tower is quite deep. No improvisation using Inherent Safety concept can be done inside the tower to make it less risky since the design is good enough for cooling water purpose.

4.2 Discussion

Chosen Area	Hazardous material/ situation involved	Inherent Safety Concept			
		Minimization (Hazardous Material)	**Moderation** (operating condition)	**Substitution** (with less harmful material)	**Simplification** (process)
sulphurization	H_2S	X	X	X	X
ethanol	CO_2, CO, H_2, Methanol	X	X	X	X
nmonia Storage nk	Ammonia	X	/	X	X
oling Tower	Deep water level	X	X	X	X

Table 4.1: Result of Inherent Safety Implementation on Case Study

In order to improve the hazardous area to a safer area, some ideas were developed by utilizing the inherent safety concept. The ideas are all based on Inherent Safety concept. From table 4.1, there is only one area where the inherent Safety Concept can be implemented. Referring to the idea developed in 4.1.3, the method used was moderating. Moderating in Ammonia Storage Unit proved that the Zone 1 hazardous area now become a Zone 2 area which is less harmful area. So, the Ammonia Storage Unit can use the protection type for Zone 2 class.

However, the idea has also been attempted to other portions of the plant. Unfortunately, there is no Inherent Safety Concept could be executed in other section. The concept may not so suitable enough to improve the hazardous area in this plant since it is not match to the process and equipment involved.

Implementing an Inherent Safety review process is one mechanism companies can use to institutionalize the inherent safety. The review process should integrate well with company systems for process safety management, new product development and project execution. Health, safety and environmental considerations in the new product or process development effort can be strengthened via the introduction of the inherent safety review.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Even with the benefits of standards and guidance notes, techniques for HAC vary between organizations and even individuals. The area classification should be carried out by those who have knowledge of the properties of hazardous substances, the process and the equipment in consultation, as appropriate with safety, electrical, mechanical and other engineering personnel.

An inherently safe process has a low level of danger even if things go wrong. It is used in contrast to safe systems where a high degree of hazard is controlled by protective systems. An inherently safer design is one that avoids hazards instead of controlling them, particularly by reducing the amount of hazardous material and the number of hazardous operations in the plant.

Finally, in considering inherently safer design alternatives, it is essential to remember that there are often conflicting benefits and deficiencies associated with the different options. Chemical processes usually have many potential hazards and a change which reduces one hazard may create a new one or increase the magnitude of a different existing hazard. It is necessary that the process designer retain a broad overview of the process when considering alternatives and remains aware of all hazards associated with each process option.

5.2 Recommendation

Inherent safety concept is a good application that should be implemented to a plant. This concept would lead to a safer plan that could benefit to all plant personnel. The inherent safety concept should be complemented by the development of training/education on inherently safer production for policy makers and inspectors in the areas of accident prevention (both for occupational and environmental accidents).

The scope of the use of Inherent Safety is too limited. Because it is seen as only an engineering function and because of both conceptual and institutional barriers for adoption of ISD and the use of Inherent Safety focused on the design of new facilities. As a matter of fact, it should also be used in existing facilities and management systems. In addition, the research on Inherent Safety is previously mainly limited in chemical process industries. It should also actually enter into other accident-prone industries, such as construction, mining, transport and so on.

Because of time constraint, the case study is limited to the some Ammonia and Utility section only. So for further time, it is recommended to improvise some other area in PFK. This may include other portion in Ammonia and Utility section and also Urea section.

Since the concept of Inherently Safer Production can easily include Inherent Health, Safety and Environment (Inherent HSE) this also calls for collaboration between national and international policy-setting bodies concerned with occupational safety and environmental safety. Companies may also build inherently safer design concepts into their existing process safety management system and process hazards review.

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APPENDICES

Appendix I – Desulphurization Unit

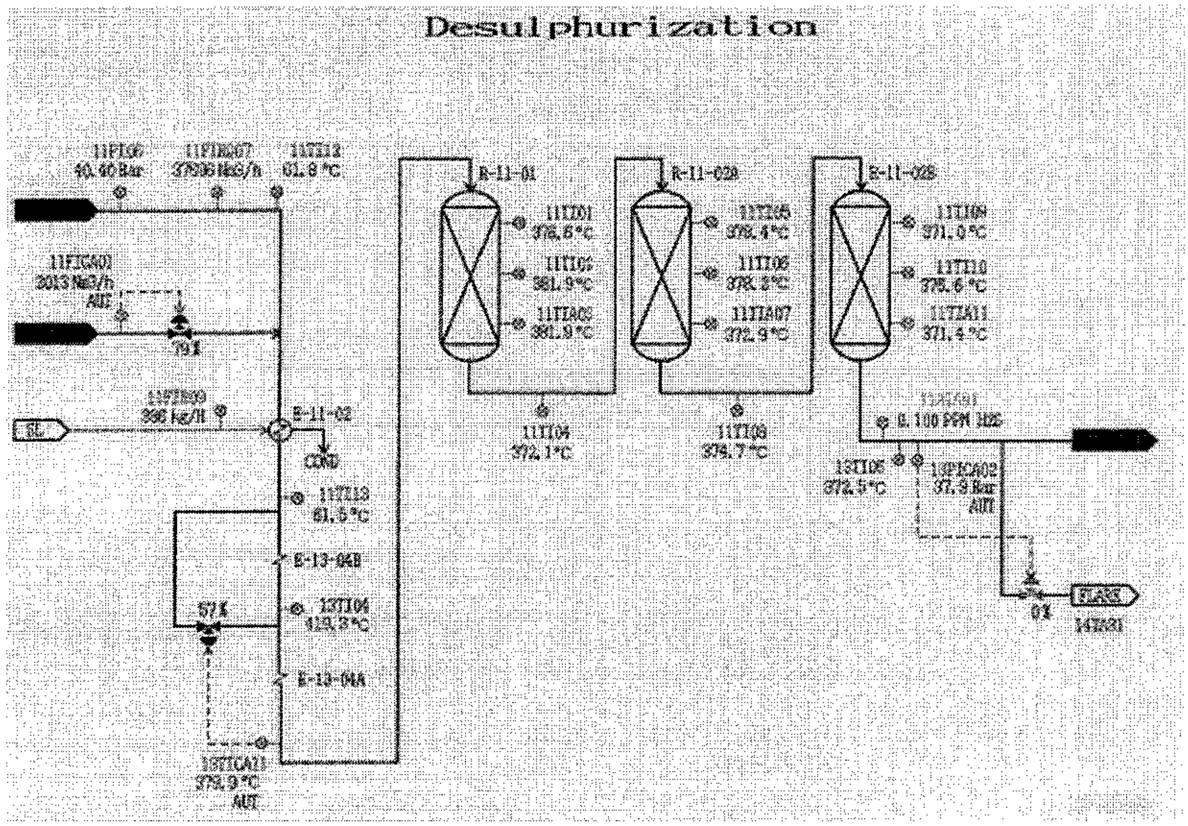

Figure AI: Hydrogenator and Desulphurizer Location in Distributed Control System (DCS)

Appendix II- Methanol Process Area

Methanol Process:

$CO + 2H_2 \rightarrow CH_3OH$

$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$

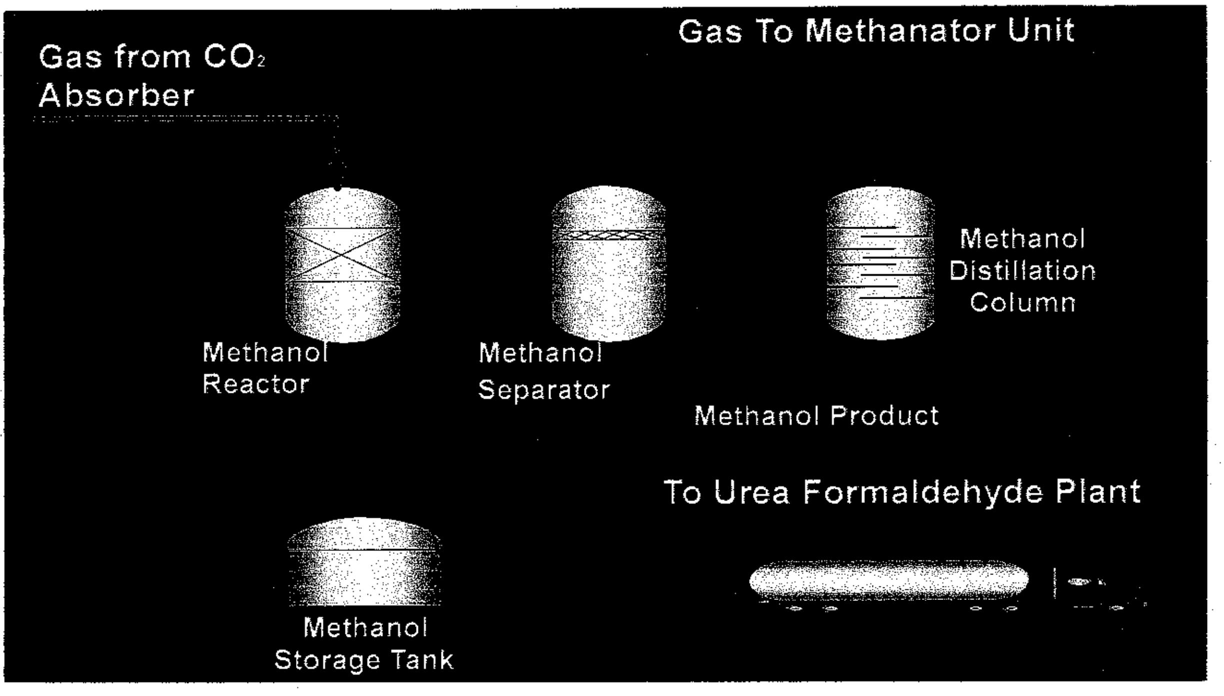

Figure AII: General Process and Area of Methanol Unit

Appendix III – Ammonia Storage Unit

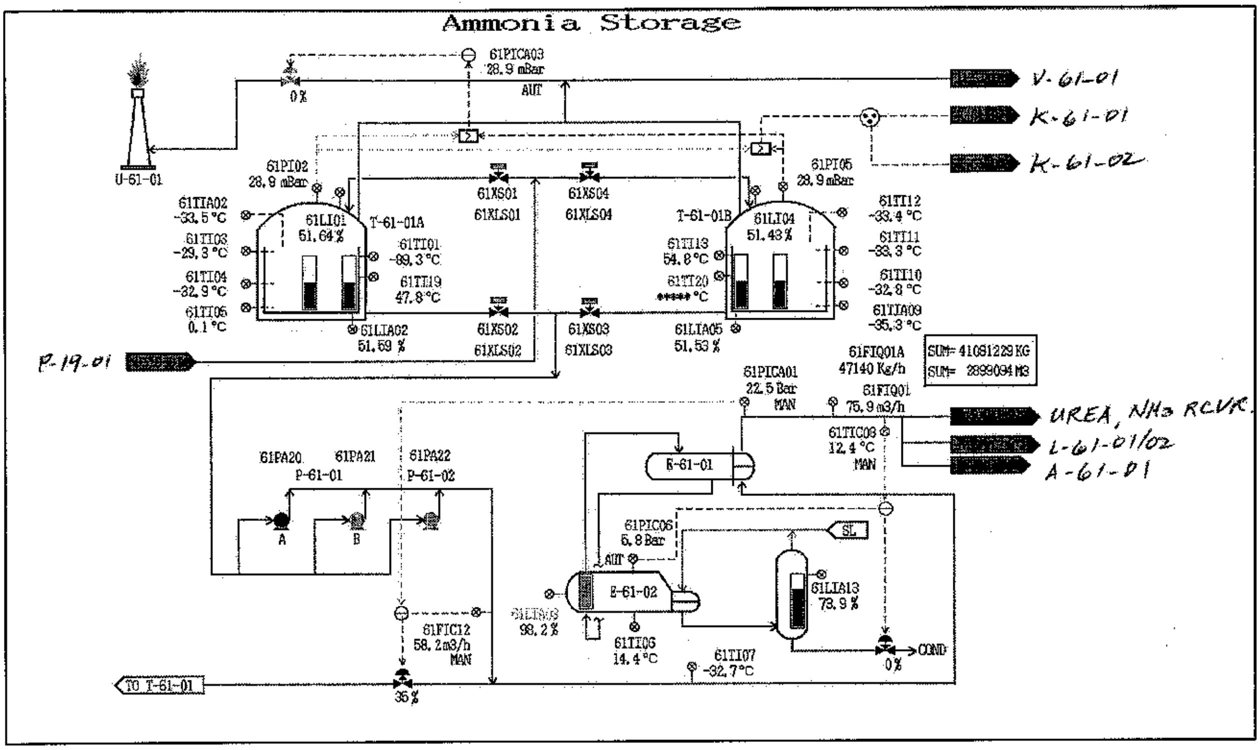

Figure AIII: Ammonia Storage Tank Location in Distributed Control System (DCS)

Appendix IV – Cooling Water Unit

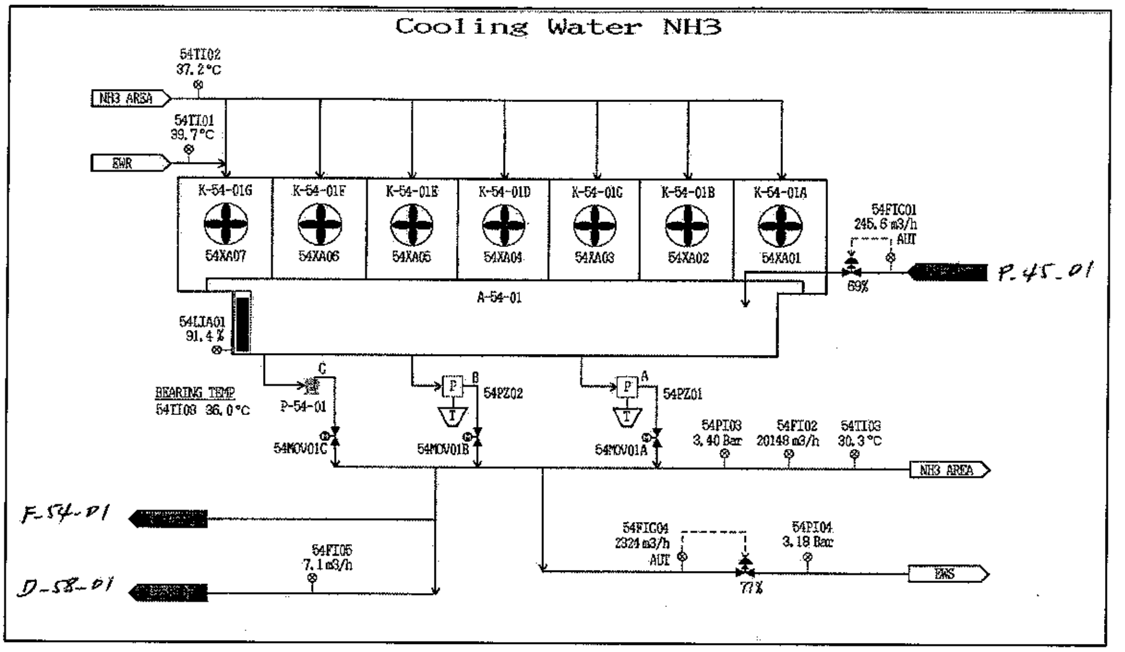

Figure AIV: Ammonia Cooling Tower Location in Distributed Control System (DCS)