DEVELOPMENT OF PROCESS SAFETY MANAGEMENT SYSTEM FOR WATER-NATURAL GAS SEPARATION SYSTEM

by

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11052

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved by,

____
(Assoc. Prof. Dr. Azmi Mohd Shariff)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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.

(LAVIN RAJ A/L S.KRISHNAN)

ABSTRACT

The purpose of this dissertation is to introduce and record the development of Process Safety Management System (PSMS) for the Water-Natural Gas Separation System of UTP Baromia Project. The objective of the project is to develop the PSM system along the fourteen elements (6 Process Elements and 8 Database Elements) for Compressor V-470 and Water Tank V-450 with accordance to OSHA PSM Standard 1910.119. Problem pertaining to Process Safety Management Systems in the current practice of PSM implementation is it does not fully involve all of its fourteen elements and there are still no tools that can integrate all the PSM elements into one practical and effective system where all the information of the company is available to be maneuvered. There are basically many scope of work which ranges from creating Process Elements for equipments, improvising the PSM interface using Microsoft Visual Basic and completing the other Database Elements needed for the system to comply with the standards provided by the safety administration. The methodology of this project revolves around seeking information from literatures, developing the framework for each element, developing the interface for the system and finally gathering data for the compressor V-470 and Water Tank V-450.

ACKNOWLEDGEMENT

The progression of this project would not have been complete without the co-operation and help of many parties. Firstly, I would like to thank my Supervisor Assoc. Prof. Dr. Azmi Mohd. Shariff for his wonderful guidance and support. I would also like to take this opportunity to thank my friends and collugues who have been very supportive and helpful for me in completing this project especially Mr. Rafizi who have guided me from the beginning of the project. Finally, I would like to thank each one every party involved in making this project a success.

TABLE OF CONTENTS

CERTIFICATION			ii
ABSTRACT			iv
ACKNOWLEDGEMENT			v
CHAPTER 1:	**INTRODUCTION**		1
	1.1	Background of Study	1
	1.2	Problem Statement	2
	1.3	Objectives and Scope of Study	3
	1.4	Relevancy & Feasibility of Project	4
CHAPTER 2: 4	**Literature Review**		**5**
	2.1	PSM Basics	5
CHAPTER 3:	**METHODOLOGY**		5
	3.1	Procedures	11
	3.2	Process Elements	12
	3.3	Database Elements	18
	3.4	Gantt Chart	24
	3.5	Tools Required	24
CHAPTER 4:	**RESULTS AND DISCUSSION**		11
	4.1	Process Elements Result & Analysis	25
	4.2	Database Elements Results & Analysis	30
	4.2	Database Analysis & Discussion.	31
CHAPTER 5:	**CONCLUSION AND RECOMMENDATION**		31
	5.1	Conclusion	31
	5.2	Recommendations	33
REFERENCES			25

APPENDICES 34

LIST OF FIGURES

Figure 1: Management System and Implementation Flowchart 6

Figure 2: Example of Case Study on Heat Exchanger 7

Figure 3: Design Process Flowchart 8

Figure 4: Main Interface of PSM System 25

Figure 5: Safe Operating Limits Interface for Compressor V-470 26

Figure 6: Electrical Classification for Water Tank V-450 27

Figure 7: Normal Operation OP for Compressor V-470 28

Figure 8: Normal Operation Documents for Compressor V-470 28

LIST OF TABLES

Table 1 PSM Elements Table 11

Table 2 Regulatory Requirements Table 13

Table 3 Process Elements Table 25

Table 4 Database Elements Table 30

CHAPTER 1: INTRODUCTION

The title of this project is Development of Process Safety Management System for Water-Natural Gas Separation System. In this section a brief study and introduction on the Process Safety Management System and its element will be discussed. The background, problem statement, objectives and scope of work of project will also be covered.

1.1 BACKGROUND

Safety and Hazard Management is a very crucial element in a process plant and is given priority in almost all organisations especially chemical plants. Safety is defined as the prevention of accidents through the use of appropriate technologies to identify the hazards of a chemical plant and eliminate them before an accident occurs. [1]

Major chemical plants accidents in the past have been a real eye opener to many parties. For instance is the Bhopal Incident which claimed approximately 3800 lives due to methyl isocyanate (MIC) gas leakage from the Union Carbide India Limited (UCIL) plant. Learning from the past, the U.S. Occupational Safety and Health Administration (OSHA) has issued the Process Safety Management (PSM), a regulation which contains requirements for the management of hazards associated with processes using highly hazardous chemicals (HHC) to help assure safe and healthy workplaces.

Over the last few years, Process Safety Management Systems (PSMS) has evolved into a higher level and this has aided the efforts to prevent chemical plant accidents. A Process Safety Management System is an analytical software or tool focused on preventing hazards for equipments and processes running in a chemical plant.

The PSMS currently being developed for the High Gravitational Natural Gas Dehumidification System of Universiti Teknologi Petronas is being developed using Microsoft Visual Basic. The main purpose of developing this system is to simplify the work for employee regarding searching and updating information about PSM. It complete the PSM element by integrating them where can be more effective to manage than the conventional way. [2]

1.2 PROBLEM STATEMENT

One of the problem pertaining to Process Safety Management Systems is the current practice of PSM implementation does not fully involve all of its fourteen elements and there are still no tools that can integrate all the PSM elements into one practical and effective system where all the information of the company is available.

To fully develop a Process Safety Management System in a particular chemical plant, many studies, assessments and elements which are vital for the regulations set by Occupational Safety & Health Administration (OSHA) must be included in the system. An important element which includes in PSMS is the Process Hazard Analysis.

Process Hazard Analysis (PHA) is a systematic identification, evaluation and mitigation of potential process hazards that could endanger the health and safety of humans and cause serious economic loss. [3] Thorough research and study of PHA must be done for each equipment and process to fulfil the safety requirement.

Thorough research and study of each process elements must be done for each equipment and process to fulfil the safety requirement according to OSHA PSM Standards (29 CFR 1910.119).

1.3 OBJECTIVES

The objectives of this project are:

1. To develop Process Safety Information data in accordance with OSHA PSM Standard 1910.119(d) for Compressor V-470 and Water Tank V-450

2. To develop Operating Procedures in accordance with OSHA PSM Standard 1910.119(f) for Compressor V-470

3. To develop Mechanical Integrity data in accordance with OSHA PSM Standard 1910.119(j) for Compressor V-470 and Water Tank V-450

4. To develop the eight Database Elements in accordance with OSHA PSM Standards for the High Gravitational Natural Gas Dehumidification Unit of Universiti Teknologi Petronas

5. To develop and improvise Process Safety Management System Interface and data according to OSHA PSM standards for the High Gravitational Natural Gas Dehumidification Unit of Universiti Teknologi Petronas

1.4 SCOPE OF WORK

In the project of developing Process Safety Management System for High Gravitational Natural Gas Dehumidification Unit there are basically many scope of work which ranges from creating Process Elements for equipments, improvising the PSM interface using Microsoft Visual Basic and completing the other Database Elements needed for the system to comply with the standards provided by the safety administration.

The Process Elements which needs to be developed consists of few vital elements to be included such as Process Safety Information, Operating Procedures, Mechanical Integrity and Process Hazard Analysis. All these elements will be developed for two case studies which are the Compressor V470 and water tank V450. The information and data needed to develop for the compressor will be gathered by implementing various studies and research.

1.5 RELEVENCY & FEASIBILITY OF PROJECT

The project is very relevant to the current implementation of Process Safety Systems as it intent is to provide data within the formal structure of a defined framework, thus the subject matter experts will more efficiently and effectively act and communicate to identify, select and implement appropriate control measures for enhanced safety. As such, these programs comprise a framework of formal risk management systems for accidental releases of hazardous materials.

The system needs to comply with all the written regulations under the OSHA PSM Standard, and can be pilot tested in the actual system once an initial auditing of the performance and compliance of the system has been done. By complying with the regulations the objective can be achieved and the system can be incorporated to practice.

CHAPTER 2: LITERATURE REVIEW

Process Safety Management (PSM) of Highly Hazardous Chemicals standard, 29 CFR 1910.119 was established in the United States of America by Occupational Safety and Health Administration (OSHA). It is a standard that has been practiced in various industries all around the world (U.S OSHA, 1992). It was developed in response to the occurrence of large catastrophic accidents such as those at Bhopal Incident in 1984 and the Philips and Arco plant incident in the 1990's at USA. These major accidents were the incentive that incited OSHA to develop a standard that would significantly bound the likelihood of such events repeating. Ahead of the applicability, the major significant regulatory requirements of PSM as published include, 14 elements that needs to be complied.

The primary purpose of PSM standard is to prevent or minimize the consequences of a catastrophic release of toxic, reactive, flammable, or explosive Highly Hazardous Chemical from a process. It is the only OSHA standard that mandates a systems safety approach to controlling hazards and also stands in contrast to other OSHA standards that have been bitterly opposed by industry (Mason, 2001) It was designed specifically to address employee safety by managing the system that attempts to unify multiple individual activities (DeWolf, 2003). The intent is that within the formal structure of a defined framework, subject matter experts will more efficiently act and communicate to identify, select and implement appropriate control measures for enhanced safety. As such, these programs comprise a framework of formal risk management systems for accidental releases of hazardous materials.

M.M Abu Khader (2004) presented that involvement of various elements of human and organisational factors and the presence of different interaction levels within the working environment can influence safety performance. In developed countries, the regulations for the construction of process safety management (PSM) and a risk management program (RMP) are well established by the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency

(EPA). These regulations were based on matured and evolved industrial safety practices. [4]

Rodger Holsworth (2003) has documented that to achieve the goals and objectives established by the management system team and establish a management system where actual performance can be measured against documented practice, the management system team must:

1. Determine what management system standards apply to the organization.
2. Reach a consensus on how to format and structure the overall management system.

For processes to continuously improve, an analysis of processes must be performed at various levels within the organization. To measure process variations relating to safety, environment and quality, management systems rely on process analysis and statistical process control techniques to provide the data required to make adjustments or improvements to processes that are not functioning to specified requirements.

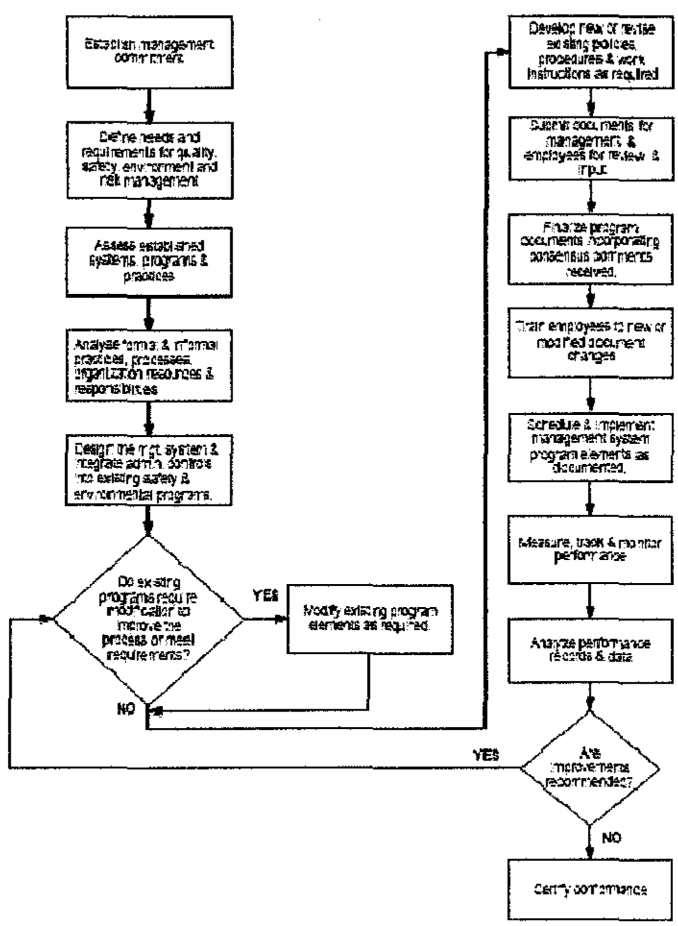


Figure 1: Management System Development and Implementation Flowchart [5]

P. John Palmer (2004) documented that The evolution of process hazard analysis has occurred within the overall development of the field of process safety management or loss prevention, itself a relatively new engineering discipline, and has been well documented by those who were present for the entire genesis of the field.

An example PHA was conducted for a process including a feed stream to a reactor with a heat exchanger. The example includes specific areas of underperformance. The large oval over the causes relates to a failure to assess any human error or external event issues. Only equipment based causes are included and figure 3 below shows the causes. The two smaller ovals on the second cause and related safeguard relates to a possible failure to address a cause that could render the safeguard ineffective. [6]

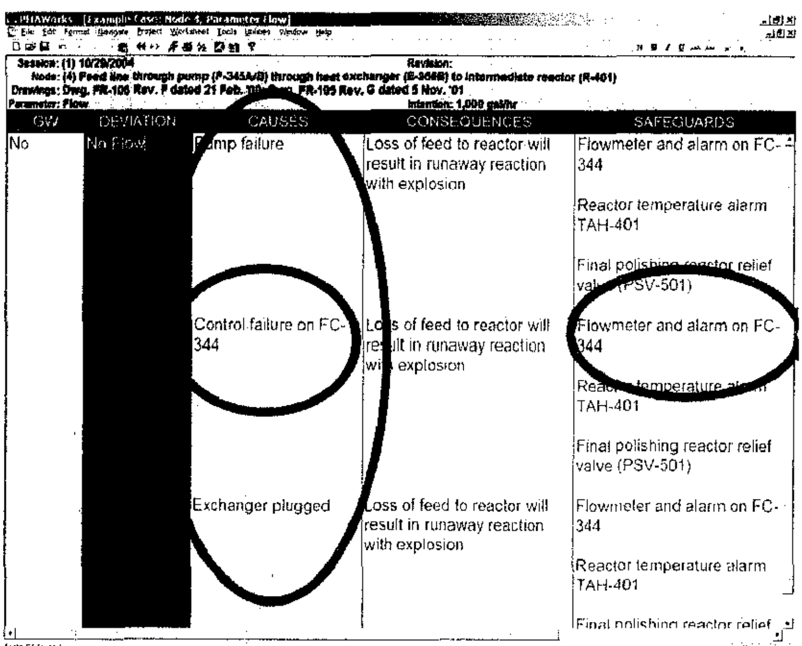


Figure 2: Example of Case Study on Heat Exchanger

The managements system needs to cover all aspects of the work, throughout its complete lifecycle. Resources in this context include the provision of suitably qualified staff and would include such issues as training. Auditing is used to ensure the various activities of the management system are implemented correctly. This is an ongoing activity that continuously strive s for improvement throughout a process of iteration. The overall operation of a quality assurance system is depicted in figure 4 below (Storey, 1996).

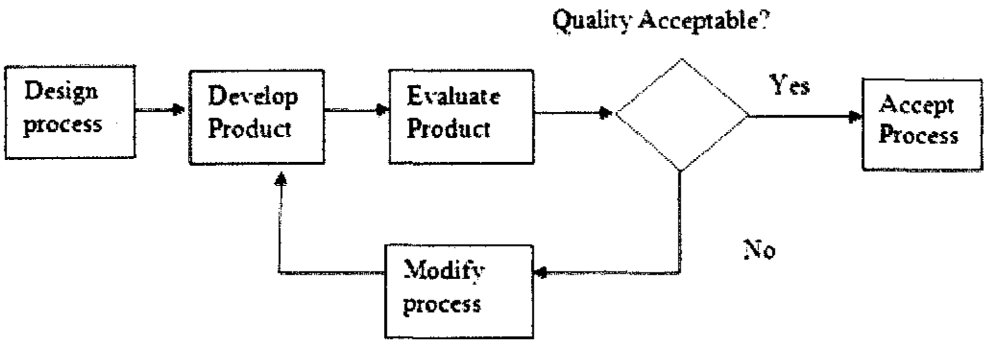


Figure 3: Design Process Flowchart

According to clarifications from OSHA, electronic storage or computerized storage of records and information required by the PSM standard is permissible as long as it is readily accessible and easily understood (29 CFR 1910.119) (OSHA , 1995). The elements covered for the project are listed below with a brief description and its respective OSHA PSM Standard:

1. **Process Safety Information (PSI) - 1910.119(d):** Occupational Safety & Health Administration (OSHA) states that PSI is "Complete and accurate written information concerning process chemicals, process technology, and process equipment." It is the information necessary for implementation of all other aspects of PSM. Complete information on every chemical involved in the process, including intermediates, is required. Process technology includes not only Process Flow Diagrams (PFDs) and Piping & Instrumentation Diagrams (P&IDs), but operating and storage conditions as well as operating procedures (see below) and operating history (for existing processes). Process equipment information should include the underlying codes and standards relied upon, in addition to information about the specific equipment used in the process.

2. **Operating Procedures - 1910.119(f):** Operating procedures include not only the steps for normal operations, but for upset conditions, temporary operations, start-up, and shutdown. Very important safety information must also be included in operating procedures. Such information includes basic hazards of exceeding operational limits, appropriate response to upset conditions, safety and health information, and emergency operations. The procedures need to be up to date and reliable. They are also a critical element in training of personnel.

3. **Mechanical Integrity - Standard 1910.119(j):** Employers are required to have a written program to ensure the integrity of processes and equipment. Aspects include listing applicable equipment, training of maintenance personnel, inspection and testing, and maintenance of such systems as controls, vessels, piping, safety systems, and emergency systems. Development and modifications to the mechanical integrity program should be made based on operational experience, relevant codes, and industry standards.

4. **Process Hazard Analysis – 1910.119 (e):** Process Hazard Analysis (PHA) is defined as the systematic identification, evaluation, and mitigation of potential process hazards that could endanger the health and safety of humans and cause serious economic losses associated with processing of hazardous chemicals. The main purpose is to identify hazards that are an inherent feature of the process is called hazard identification and besides that to evaluate the consequences and likelihood of hazards - is called hazard assessment

5. **Management of Change – 1919.119 (l):** MOC system requires that any change be evaluated prior to its implementation. The level of evaluation can depend on the degree of change and its criticality to the safety of the operation. In addition to the evaluation and approval of a change, MOC requires that suitable training be conducted (if necessary) and the relevant PSI be updated.

6. **Pre-Startup Safety Review – 1919.119 (i):** The Pre-Startup Safety Review is done before startup of a new operation or startup following a change in the process. It is a means for ensuring that all essential action items and recommendations from the PHA have been completed prior to beginning operations. It is also the point at which the design parameters and standards used for construction are verified. If training or modifications to PSI are necessary, completion of these items is also verified during the PSSR. Startup should not be allowed to occur until all safety-critical PSSR items have been completed.

CHAPTER 3: METHODOLOGY

3.0 PROCEDURE

The elements in PSM are basically divided into two groups based on the characteristics of the elements which are Process Elements & Database Elements respectively. For the first half of this final year project, the process elements will be developed first and followed with the database elements the next half. The table below lists the categories of PSM elements:

1) Database Element	• Employee Participation • Training • Contractors • Hot Work Permit • Incident Investigation • Emergency Planning and Response • Compliance Audit • Trade Secrets
2) Process Element	• Process Safety Information • Process Hazard Analysis • Operating Procedures • Pre-Start-up Safety Review • Mechanical Integrity • Management of Change

There are several procedures to be followed in order to progress and achieve the objective of the project. The procedures are planned systematically as the semester progresses to ensure project completion move as planned within the timeframe. The procedure is listed below:

1. Literature review on the following:
   i. Process Elements of PSM
   ii. Standards pertaining to PSM Process Element
2. Develop Framework for Process Elements
3. Develop data and information for Process Elements from experimental work and Operation Manual
4. Develop the PSM interface based on the framework
5. Include the data and information for 2 case studies:

i. Compressor V-470

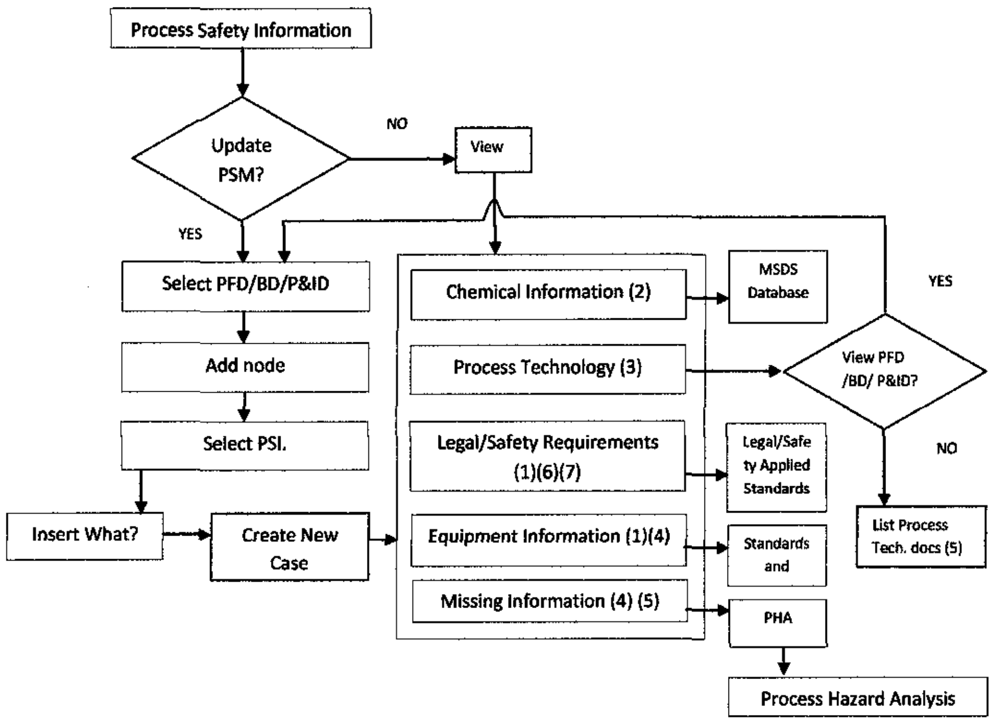
ii. Water Tank V-450

6. Analyze result and improvise
7. Thesis Write Up

3.1 FRAMEWORKS FOR PSM PROCESS ELEMENTS

Before a particular element is being developed on the Process Safety Management System, a framework of the element must be developed initially to ease the interface development and avoid from making changes to the final interface. Other than that, the framework also enables us to have a clear image on how the particular element must be developed and the data required for the case studies. Below are the frameworks for the elements developed so far before the commencement of interface development:

3.11 Process Safety Information (PSI) Framework



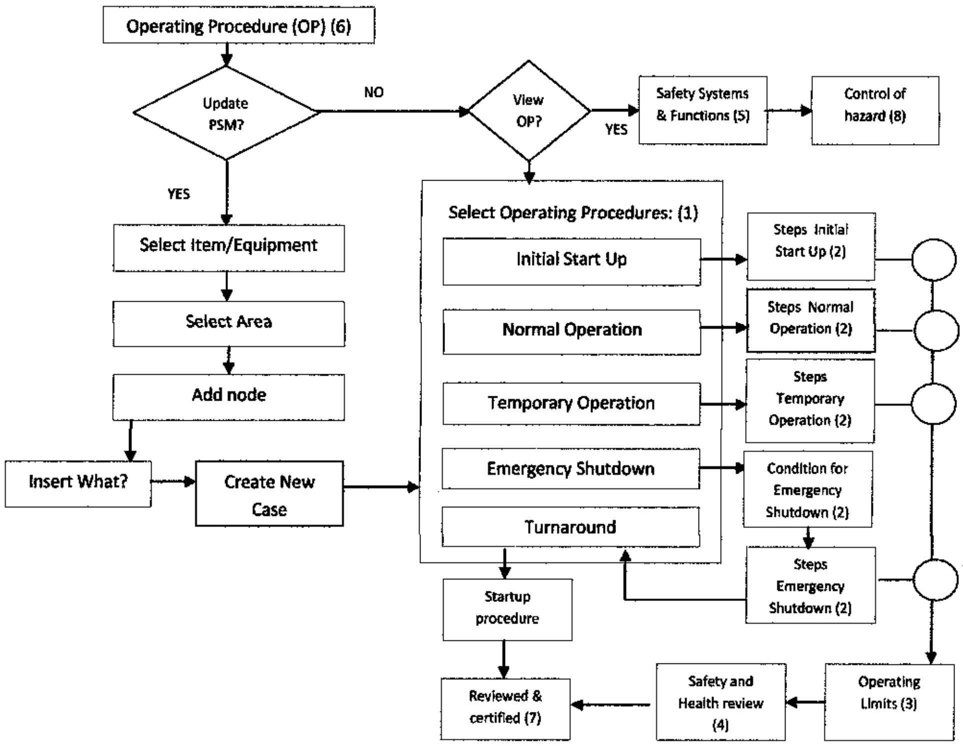
Regulatory Requirements (29 CFR 1910.119)			
1	1910.119 (d)	5	1910.119 (d)(3)(i)(A)-(H)
2	1910.119 (d)(1)(i)-(vii)	6	1910.119 (d)(3)(ii)
3	1910.119 (d)(2)(A)-(E)	7	1910.119 (d)(3)(iii)
4	1910.119 (d)(2)(ii)		

Explanation of PSI requirements for PSM:

- Compilation of Material Safety Data Sheets (MSDS) for each hazardous chemicals with addition of Corrosivity Data which are absent in MSDS
- Include process chemistry of particular equipment including material balance
- Specify Safe Operating Limits for equipment (i.e. Pressure, Temperature)
- Include Deviation Consequences which are the effects of not complying the safe operating limits for parameters and safety measures for components
- Specify equipment information such as material of construction, electrical classification, relief system, ventilation system, codes and standards.

The PSI information are organised in a way where it is accessible to perform the principal functions intended for it under the OSHA standards. Employee access to all information related to PSM must be wide to support the development of other process elements of the system. Documentation should exist to verify that existing equipment is installed and operated in conformance with accepted practices and standards.

3.1.2 Operating Procedures (OP) Framework

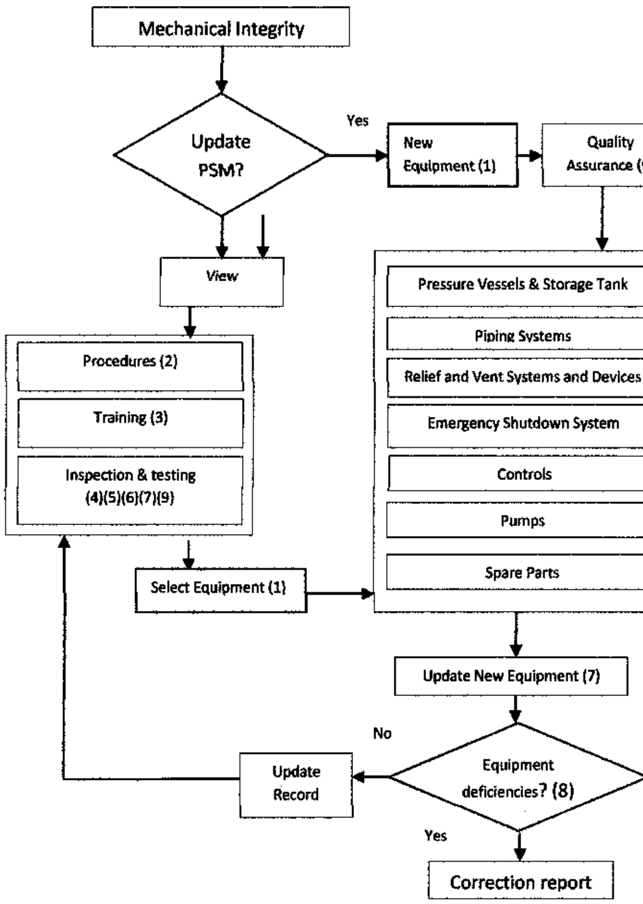


Regulatory Requirements (29 CFR 1910.119)			
1	1910.119 (f)(1)	5	1910.119 (f)(iv)
2	1910.119 (f)(1)(i)	6	1910.119 (f)(2)
3	1910.119 (f)(1)(ii)	7	1910.119 (f)(3)
4	1910.119 (f)(1)(iii)	8	1910.119 (f)(4)

Explanation of OP requirements for PSM:

- Include Initial Startup, Normal Operations, and Normal Shutdown procedures *for equipments*
- Specify Emergency Shutdown and Emergency Operation procedures for equipment
- Upload Startup After Turnaround/Emergency procedures and Safe Work Practices of Equipments

3.1.3 Mechanical Integrity (MI) Framework



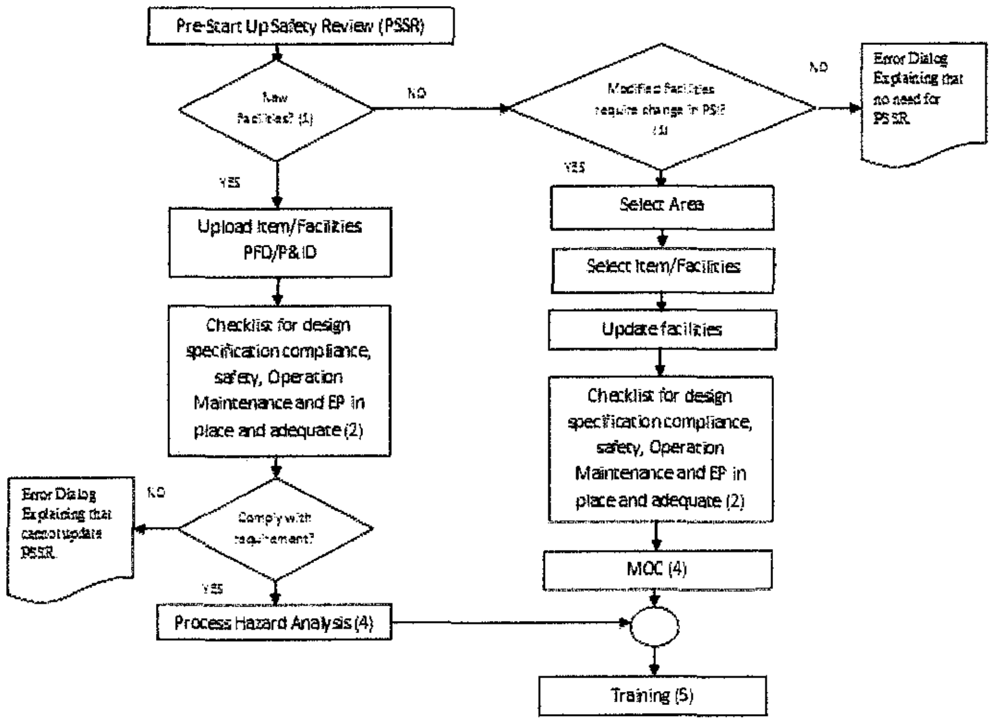
Regulatory Requirements (29 CFR 1910.119)			
1	1910.119 (j)(1)	7	1910.119(j)(4)(iv)
2	1910.119(j)(2)	8	1910.119(j)(5)
3	1910.119(j)(3)	9	1910.119(j)(6)(i)
4	1910.119(j)(4)(i)	10	1910.119(j)(6)(ii)
5	1910.119(j)(4)(ii)	11	1910.119(j)(6)(iii)
6	1910.119(j)(4)(iii)		

Explanation of MI requirements for PSM:

- Upload written documents regarding Tests & Inspections of equipments, the frequency of inspections, Maintenance Materials and Spare Parts of equipments and its components

- Include Quality Assurance and Good Engineering Practices of equipments
- Specify Equipment Deficiencies such as components failure in an equipment

3.1.4 Pre-Startup Safety Review (PSSR) Framework

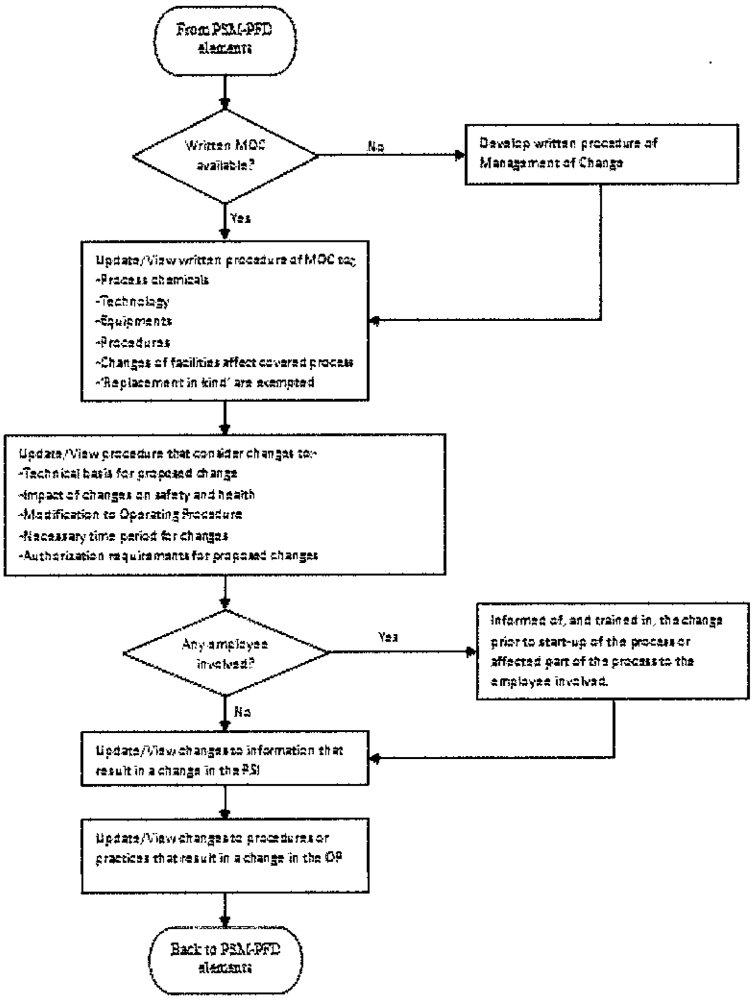


Regulatory Requirements(29 CFR 1910.119)	
1	1910.119 (1)
2	1910.119 (i)(2)(i)
3	1910.119 (i)(2)(ii)
4	1910.119 (i)(2)(iii)
5	1910.119 (i)(2)(iv)

Explanation of PSSR requirements for PSM:

- Include PSSR Procedure for easier review
- Upload a blank PSSR Checklist/Form
- Include Completed PSSR Checklist/Form for specific equipment

3.1.5 Management of Change (MOC) Framework



Regulatory Requirements (29 CFR 1910.119)			
1	1910.119 (l)(1)	7	1910.119(l)(2)(v)
2	1910.119(l)(2)	8	1910.119(l)(3)
3	1910.119(l)(2)(i)	9	1910.119(l)(4)
4	1910.119(l)(2)(ii)	10	1910.119(l)(5)
5	1910.119(l)(2)(iii)		
6	1910.119(l)(2)(iv)		

Explanation of MOC requirements for PSM:

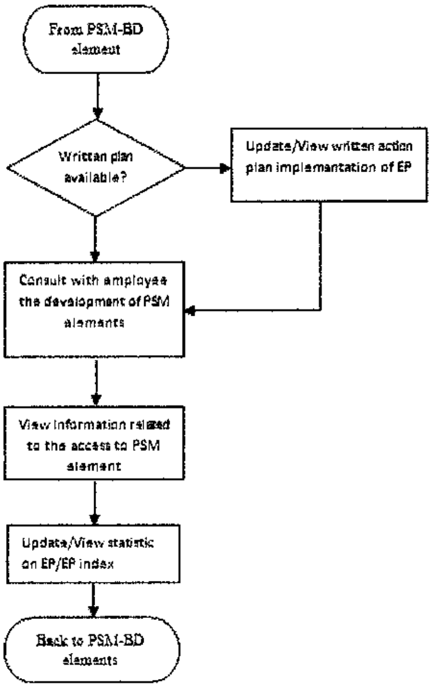
- Procedures should exist to require an assessment of the effects changes may have on safety and health

- The purpose, scope and objective for process changes must be documented
- The technical basis for the change should include a description of why the change is necessary

3.2 PSM FRAMEWORK FOR DATABASE ELEMENTS

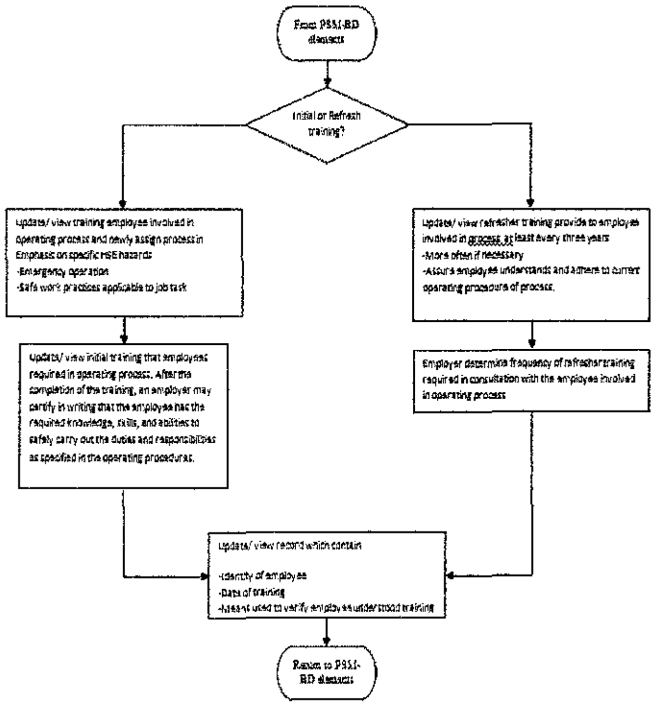
Before a particular element is being developed on the Process Safety Management System, a framework of the element must be developed initially to ease the interface development and avoid from making changes to the final interface. Other than that, the framework also enables us to have a clear image on how the particular element must be developed and the data required for the case studies. Below are the frameworks for the database elements developed so far before the commencement of interface development:

3.2.1 Employee Participation Framework



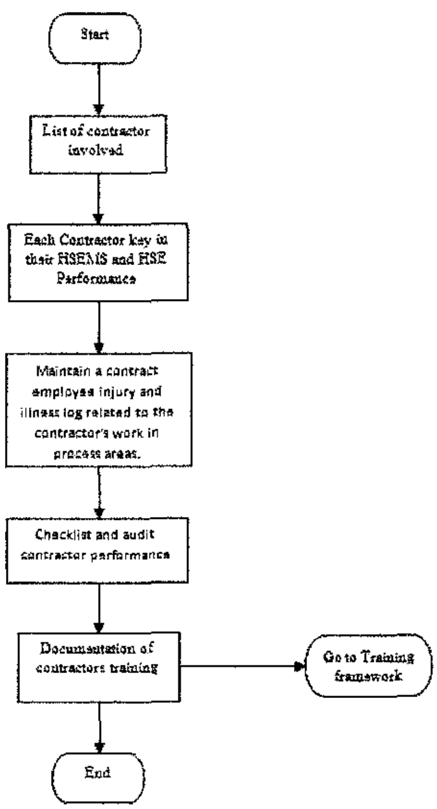
Regulatory Requirements (29 CFR 1910.119)	
1910.119 (c)	1910.119(c)(2)
1910.119(c)(1)	1910.119(c)(3)

3.2.2 Training Framework



Regulatory Requirements (29 CFR 1910.119)	
1910.119(g)(1)(i)	1910.119(g)(1)(ii)
1910.119(g)(2)	1910.119(g)(3)

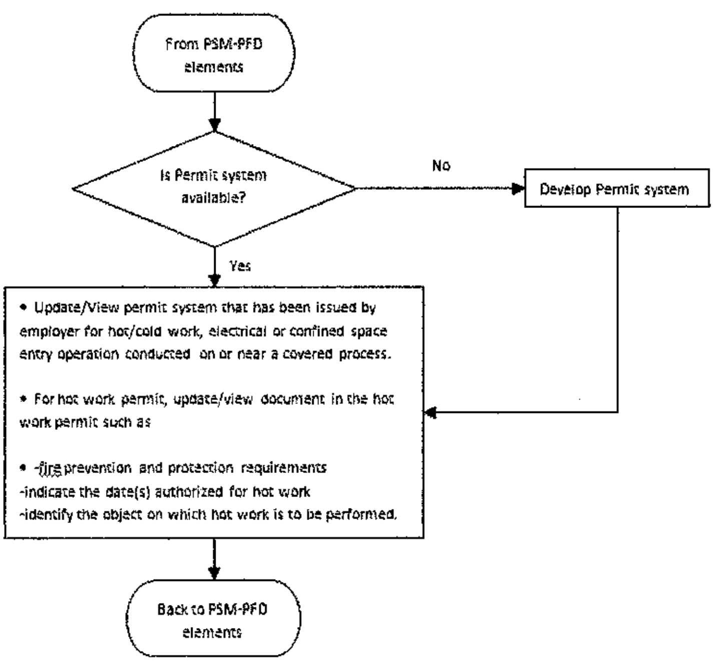
3.2.3 Contractors Framework



Regulatory Requirements (29 CFR 1910.119)			
1	1910.119(h)(1)	7	1910.119(h)(2)(vi)
2	1910.119(h)(2)(i)	8	1910.119(h)(3)(i)
3	1910.119(h)(2)(ii)	9	1910.119(h)(3)(ii)
4	1910.119(h)(2)(iii)	10	1910.119(h)(3)(iii)
5	1910.119(h)(2)(iv)	11	1910.119(h)(3)(iv)
6	1910.119(h)(2)(v)	12	1910.119(h)(3)(v)

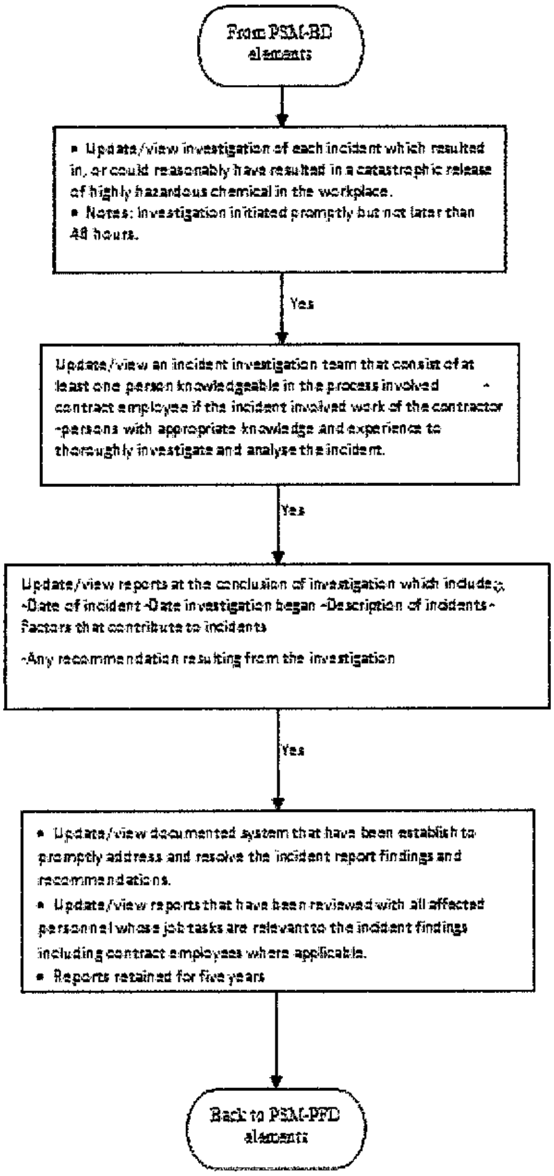
3.2.4 Hot Work Permit Framework

Hot work means work involving electric or gas wielding, cutting, brazing or similar spark producing activities. The figure below shows the framework for permit:



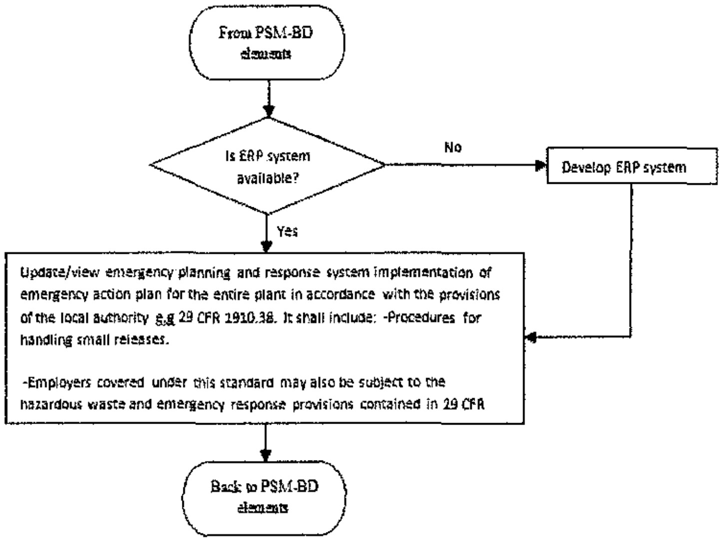
Regulatory Requirements (29 CFR 1910.119)			
1	1910.119(k)(1)	2	1910.119(k)(2)

3.2.5 Incident Investigation Framework



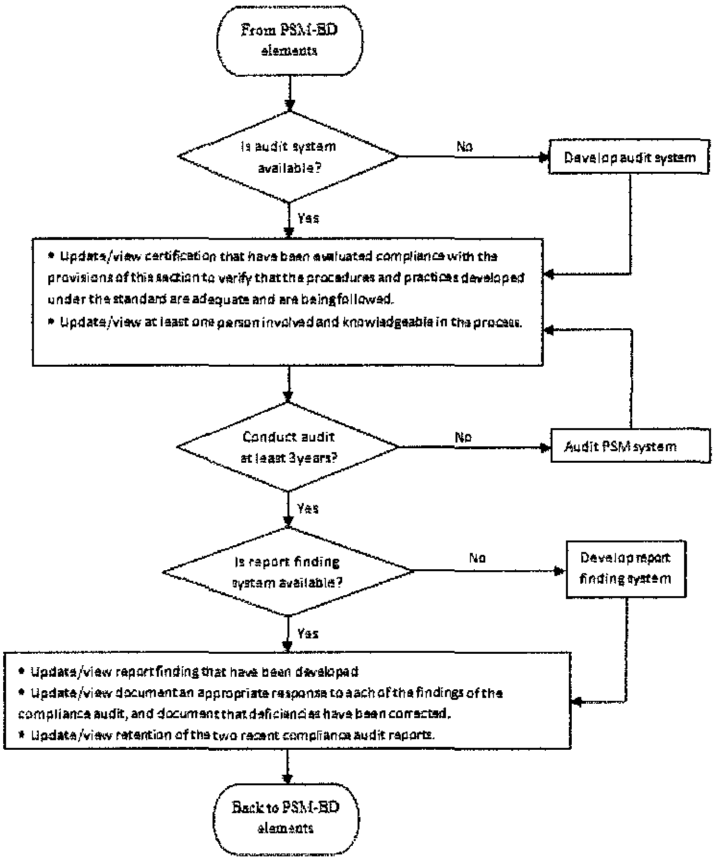
Regulatory Requirements (29 CFR 1910.119)			
1	1910.119(m)(1)	7	1910.119(m)(2)
2	1910.119(m)(3)	8	1910.119(m)(4)(i)
3	1910.119(m)(4)(ii)	9	1910.119(m)(4)(iii)
4	1910.119(m)(4)(iv)	10	1910.119(m)(4)(v)
5	1910.119(m)(5)	11	1910.119(m)(6)
12	1910.119(m)(7)		

3.2.6 Emergency Planning & Response Framework



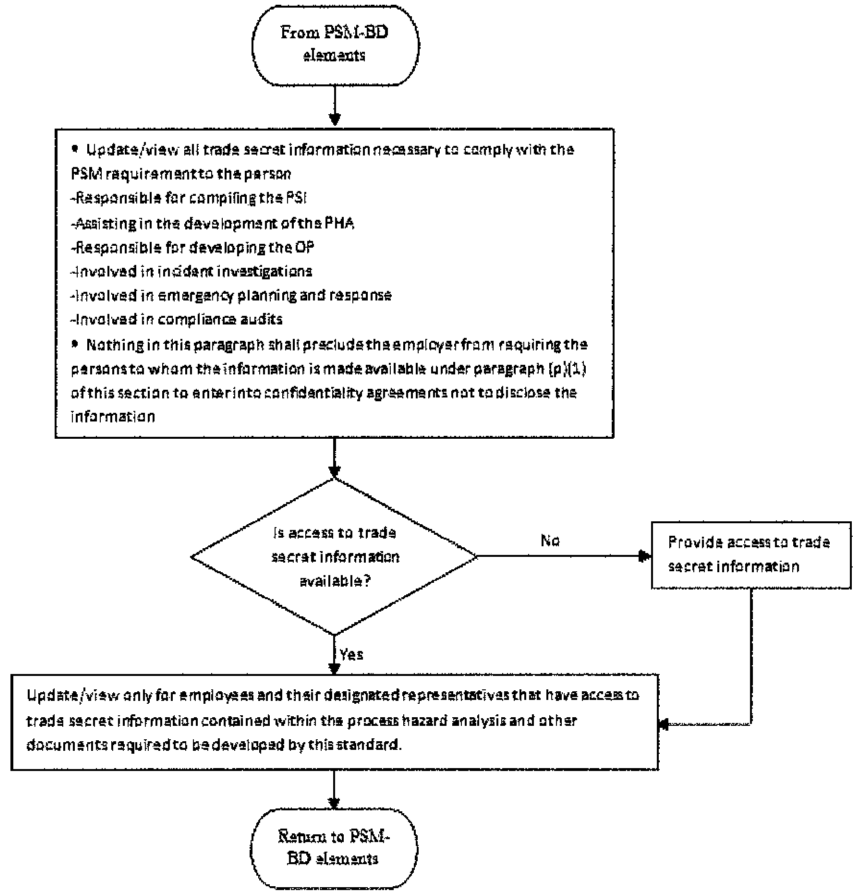
Regulatory Requirements (29 CFR 1910.119)	
1	1910.119(n)

3.2.7 Compliance Audit Framework



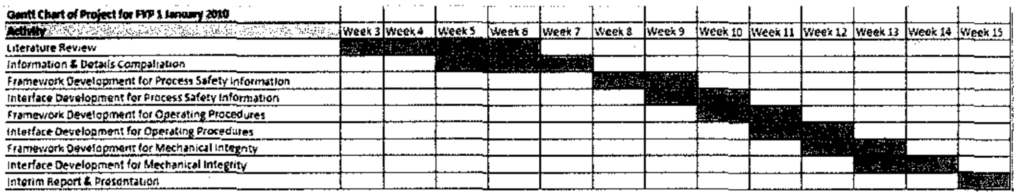
Regulatory Requirements (29 CFR 1910.119)			
1	1910.119(0)(1)	4	1910.119(0)(4)
2	1910.119(0)(2)	5	1910.119(0)(5)
3	1910.119(0)(3)		

3.2.8 Trade Secret Framework



Regulatory Requirements (29 CFR 1910.119)			
1	1910.119(p)(1)	3	1910.119(p)(3)
2	1910.119(p)(2)		

3.3 GANTT CHART OF PROJECT



3.4 TOOLS REQUIRED

Listed below are the tools required for developing the PSM System.

1. Microsoft Office Word & Power Point – To develop frameworks
2. Microsoft Visual Basic – To develop system software
3. Microsoft Access – To develop database

CHAPTER 4: RESULTS & DISCUSSIONS

Based on the framework developed on the methodology above, the process elements of two equipments in the Water-Natural Gas Separation System of UTP which are the compressor V-470 and Water Tank V-450 were developed and the data was collected to comply with the standards set by OSHA. The table below shows the data collected for each element and equipment.

4.1 PROCESS ELEMENTS

Process Elements	Compressor V-470	Water Tank V-450
PHA	✓	✓
PSI	✓	✓
OP	✓	✓
MI	✓	✓
MOC	✓	✓
PSSR	✓	✓

The figure below shows the working prototype of the PSM system developed by using Microsoft Visual Basic.

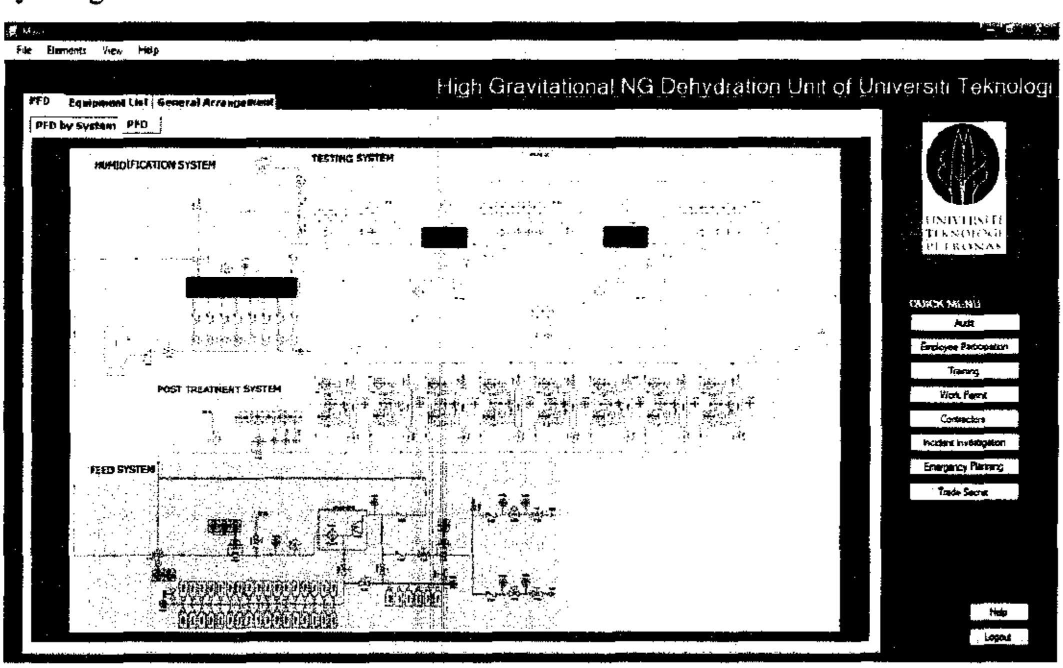


Figure 4: The Main Interface of the PSM System

The sub points below are some examples of the data collected for process elements of the particular equipments. Other data are provided in the appendix.

4.1.1 Process Safety Information

Process Safety Information data for both compressor V-470 and Water Tank V-450 were gathered by various methods such as by operating manual reviews, experiment results, and direct interaction with the operator in charge at the lab. The figures below shows an example of the initial interface drafted to insert the gathered data.

4.1.1 Process Safety Information for Compressor V-470

- Example of Safe Operating Limits Interface of:
  PSM→ Process Elements → PSI → Compressor V-470

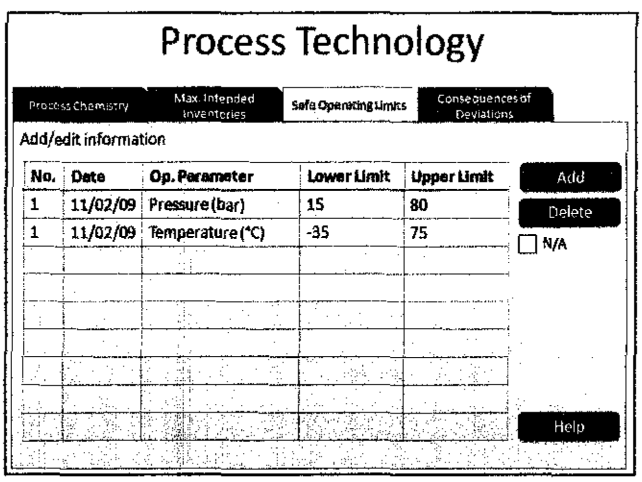


Figure 5: Safe Operating Limits Interface for Compressor V-470

- Example of Electrical Classification for Water Tank V-450
  PSM → Process Elements → PSI → Water Tank V-450

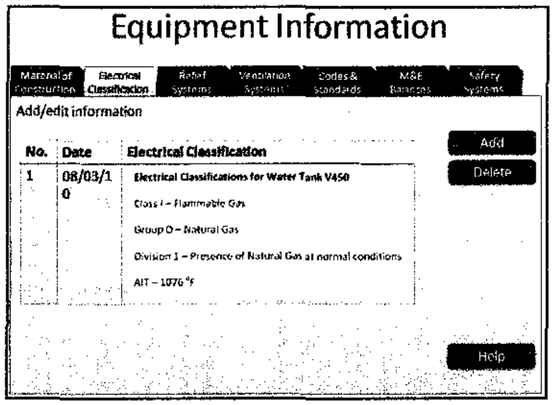


Figure 6: Electrical Classification for Water Tank V-450

The final working prototype interface of the PSM system-PSI:

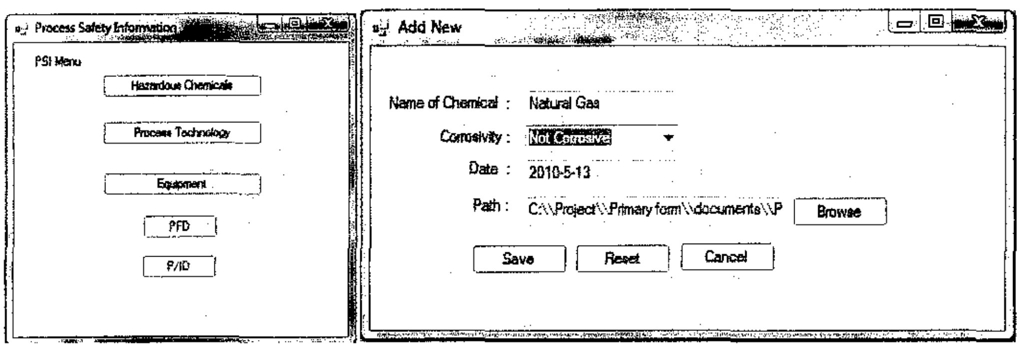


Figure 7: Process Safety Information Interface on the PSM system

4.1.2 Operating Procedures

The operating procedures were produced for the equipment and uploaded in to the interface. The operating procedure consists of eight different criteria as mentioned in the methodology. The files are uploaded as a link at the interface and will open the particular document. The figure below shows some of the initial interface for the compressor V-470.

- Example of Normal Operation Interface for Compressor V-470
  PSM → Process Elements → OP → Compressor V-470

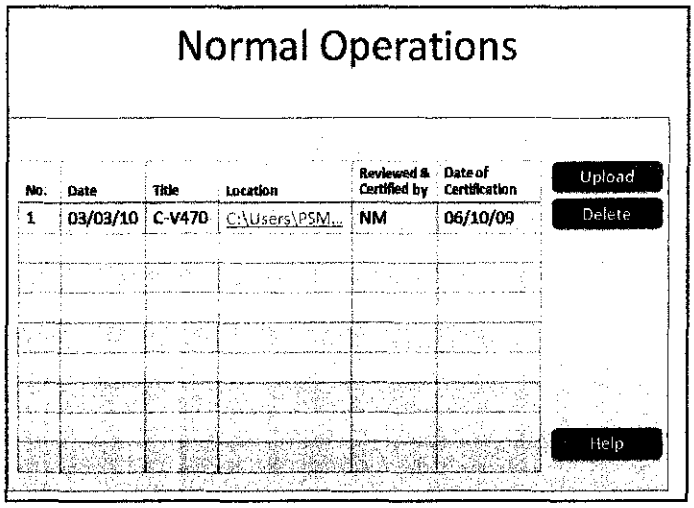


Figure 8: Normal Operation OP for Compressor V-470

Clicking on the link on the location tab opens the document:

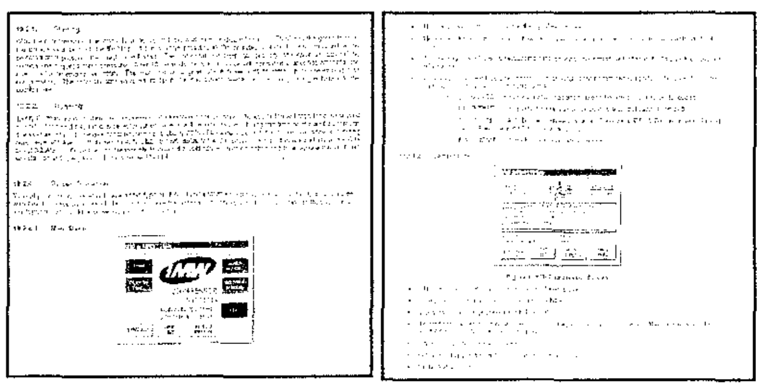


Figure 9: Normal Operation Documents for Compressor V-470

The final working prototype interface of the PSM system – Operating Procedures:

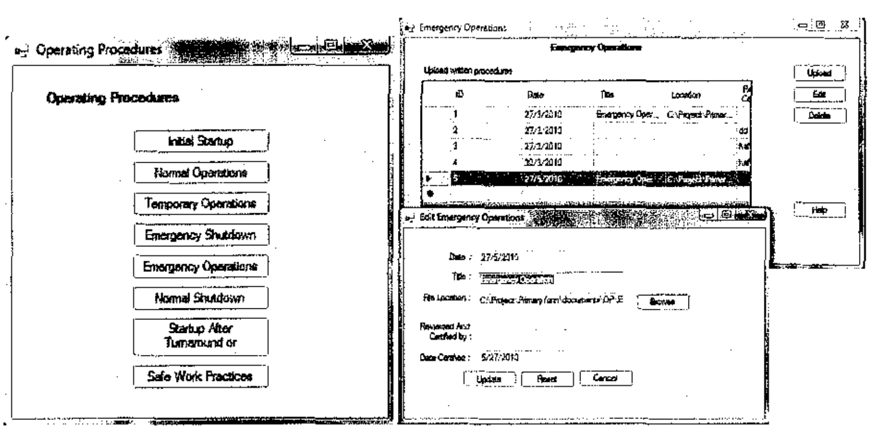


Figure 10: Operating Procedures Interface on the PSM system

4.1.3 Mechanical Integrity

The mechanical integrity data of compressor and water tank were produced and uploaded in to the interface. The data and information for mechanical integrity of the equipments were gathered from various sources such as the equipment guidelines, instruction manuals and contract documentations. The figure below shows the working prototype of the Mechanical Integration element in the PSM System.

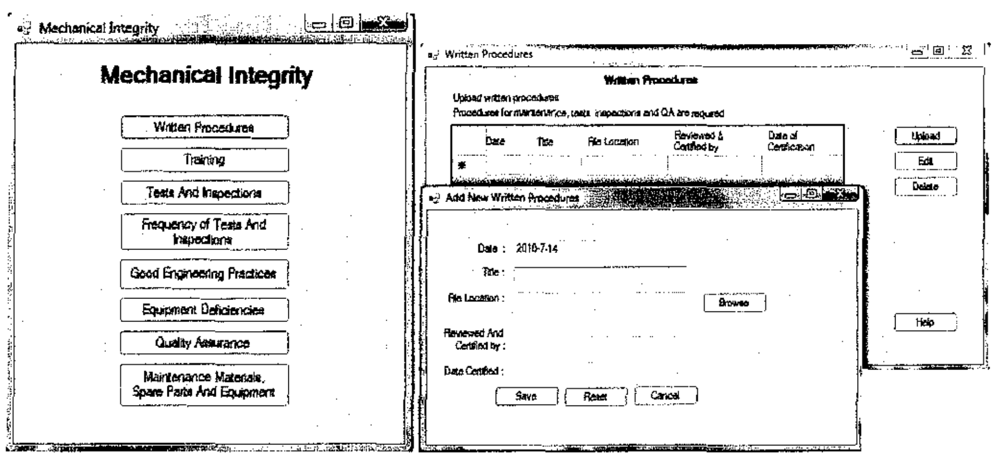


Figure 11: Mechanical Integrity Interface on PSM System

4.1.4 Pre-Startup Safety Review (PSSR)

The pre-startup safety review element contains two major sections which are PSSR Procedure and PSSR checklist / form. The procedure contains the guidelines on how a PSSR checklist should be filled and audited. The figure below shows the interface of the PSSR menu in the PSM system.

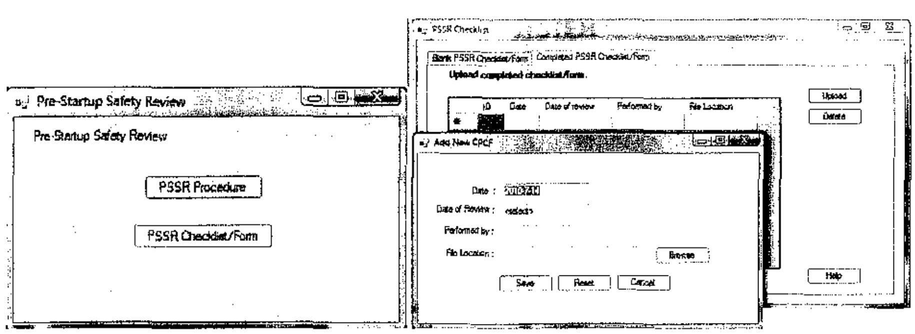


Figure 12: Interface of PSSR of the PSM System

The implementation of these PSM elements for the High Gravitational Natural Gas Dehumidification Unit of Universiti Teknologi Petronas various type of effectiveness has been made in a very short period. Its full effectiveness can be tabulated after the full application. The number of major industrial accident including the number of fatalities can be reduced after PSM implementation.

4.2 DATABASE ELEMENTS

Database Elements	**Information/Data**
Employee Participation	✓
Training	✓
Contractors	✓
Hot Work Permit	✓
Incident Investigation	✓
Emergency Planning & Response	✓
Compliance Audit	✓
Trade Secret	✓

4.2.1 Employee Participation (EP)

The employee participation (EP) database element enables employers to upload a written plan of action regarding the access to process hazards analyses and to all other information required to be developed under this standard. The figure below shows the screenshot of the proposed employee participation interface.

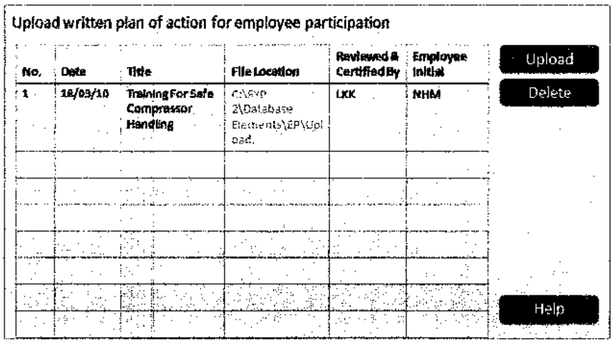


Figure 13: Screenshot of Employee Participation draft interface

Documents such as the training report, equipment inspection results and PHA data are uploaded in the EP interface to comply with the requirements.

4.3 DATABASE ANALYSIS

Some of the databases in the system are not available in the lab or insufficient data were provided by the manufacturer. The author and administrator of the laboratory need to develop the data according to the requirement of the regulation and this also proves that this tool can aid the administrator to recognize which of document they are lacking and require complying with the regulations.

It is also very vital for the administrator to have vast knowledge in process and safety studies as it revolves around hazardous chemicals and highly perilous processes. Besides that, the administrator must also be able to differentiate between parameters such as node, system and equipment, where the administrator will be handling various tasks such as uploading, arranging and editing data. Knowledge of safety and health related issues are also necessary when the administrators are utilising the system as they need to resolve the other elements of particular database to its appropriate requirements.

CHAPTER 5: CONCLUSION & RECCOMENDATIONS

5.1 CONCLUSION

Process Safety Management System (PSM) is an integral part of a chemical plant and its importance is very elevated since preventive measures for big accidents such as the Bhopal disasters can be developed. The PSM development for the High Gravitational Natural Gas Dehumidification Unit of Universiti Teknologi Petronas can be a benchmark for future Petronas Safety Management integrations.

Inclusions of all obligatory elements in Process Safety Management System are very imperative in the development of a dependable chemical process system. Regulations and standards set by several safety administrations like OSHA has made the addition of HSE elements such as Process Safety Information, Operation Procedures & Mechanical Integrity.

The case study of implementing PSM system in High Gravitational Natural Gas Dehydration Unit Lab showed that the programme has been very highly efficient and have a constructive response, where the user can easily retrieve the data after the database was completed. The users are also provided with simple and efficient steps to add information and data. The task of complying the required standards was simplified by the need to only upload the supporting data where the main framework specifies. On the whole, the PSM system was practical and convenient. With more upgrades, tweaks and add-ons this system can benefit an organisation to a very high extent and can also avoid major accidents from occurring.

5.2 RECOMMENDATIONS

Process Safety Management System is a very novel and crucial part of chemical plants, thus its development must be improvised and up to standards. One of the improvisations which need to be done is the interactivity of the data uploaded in the system. For example, the user must be able to edit or render some of the document or data in the system by using Microsoft Word or Excel in order to gain full advantage of the system. This can be done by doing more research on Microsoft visual basic and its programming language.

Besides that, the system can also be improvised by adding a "note" column to enable the users to comment or type suggestions on each element. By adding this feature any flaws or wrong data can be easily traced and notified to the moderator.

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Process Safety Management Regulation for Highly Hazardous Chemicals. - 1910.11. 1992. U.S. Department of Labor Occupational Safety and Health Administration.

Daniel A. Crowl, Joseph F. Louvar (2002), "Chemical Process Safety, Fundamentals & Applications", Prentice Hall International Series

Mohd. Rafizi Bin Roslan (2009), "Development of Framework in Process System Management (PSM) Expert System", Ph.D in Chemical Engineering Symposium Paperwork, Universiti Teknologi Petronas

Kletz, T.A (1986), "Hazop & HAZAN Notes on the Identification and Assesment of Hazards", Institution of Chemical Engineers

M.M Abu Khader (2004), "Impact of Human Behaviour on Process Safety Management in Developing Countries", Institution of Chemical Engineers

Rodger Holsworth (2003), "Practical Applications Approach to Design, Development and Implementation of an Integrated Management System", Journal of Hazardous Materials 104 (2003) 193–205

P. John Palmer (2004), "Evaluating and Assessing Process Hazard Analyses, Journal of Hazardous Materials 115 (2004) 181-192

DeWolf, G.B (2003). Process Safety Management in the Pipeline Industry: Parallels and Differences Between The Pipeline Integrity Management (IMP) Rule of the Office of Pipeline Safety and the PSM/RMP Approach for Process Facilities. *Journal of Hazardous Materials.* Elsevier 104, 169-192.

Mason, E.(2001). Elements of Process Safety Management. *Chemical Health & Safety.* Elsevier Science Inc. PII S1074-9098(01)00214-3.

APPENDIX A – Flowchart and Milestone Attachment

1.

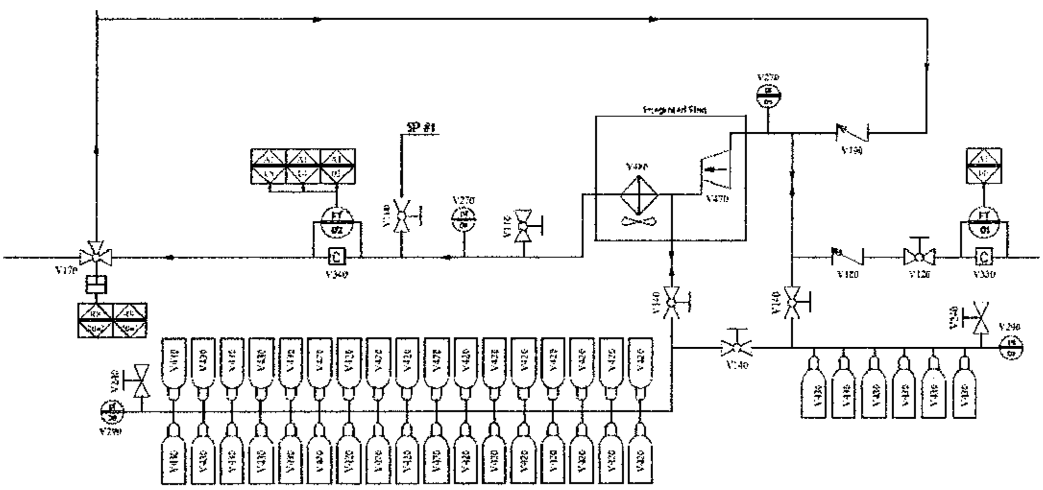


Figure 4: Process Flow Diagram of the High Gravitional Natural Gas Dehumidification, Feed System

2.

No	Detail/Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14
1	Selection of Project Topic	■	■								Mid-semester break					
2	Preliminary Research Work		■	■	■											
3	Submission of Preliminary Report				●											
4	Project Work					■	■	■	■	■						
5	Submission of Progress Report								●							
6	Seminar (compulsory)								●							
7	Project work continues											■	■	■	■	■
8	Submission of Interim Report Final Draft															●
9	Oral Presentation											During study week				

Figure 5: Gantt Chart & Milestones

3.

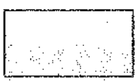
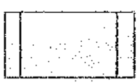
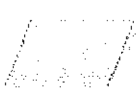
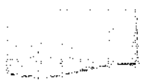
Symbol	Symbol Name (Alternate Shape Name)	Symbol Description
	Terminator (Terminal Point, Oval)	Terminators show the start and stop points in a process. When used as a Start symbol, terminators depict a *trigger action* that sets the process flow into motion.
	Process	Show a Process or action step. This is the most common symbol in both process flowcharts and business process maps.
	Predefined Process (Subroutine)	A Predefined Process symbol is a marker for another process step or series of process flow steps that are formally defined elsewhere. This shape commonly depicts sub-processes (or subroutines in programming flowcharts). If the sub-process is considered "known" but not actually defined in a process procedure, work instruction, or some other process flowchart or documentation, then it is best not to use this symbol since it implies a formally defined process.
	Decision	Indicates a question or branch in the process flow. Typically, a Decision flowchart shape is used when there are 2 options (Yes/No, No/No-Go, etc.)
	Data (I/O)	The Data flowchart shape indicates inputs to and outputs from a process. As such, the shape is more often referred to as an I/O shape than a Data shape.
	Document	Pretty self explanatory - the Document flowchart shapes any process flow step that produces a document.

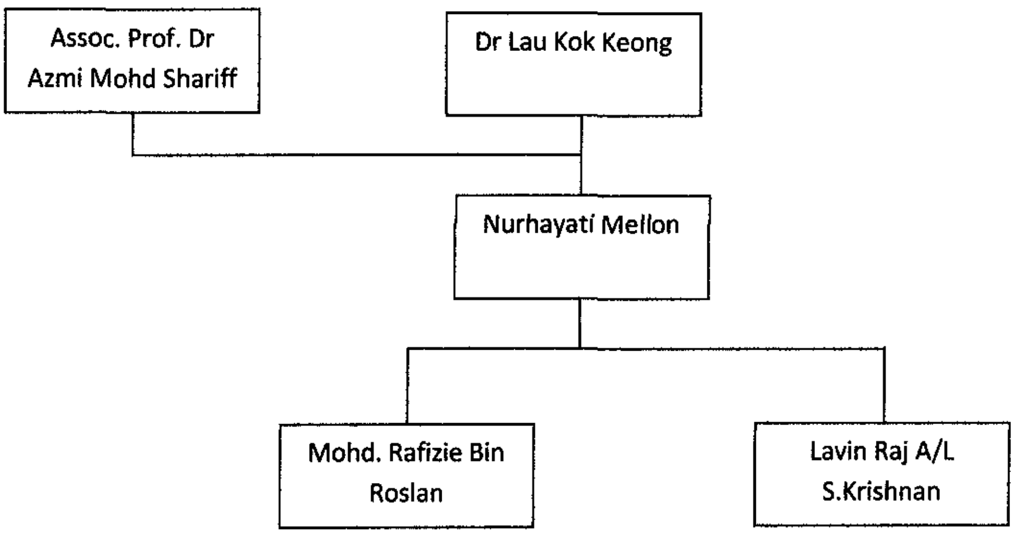
Figure 6: Flowchart Symbol Definition

APPENDIX B – Data Collected for Process Elements of Compressor V-470 and Water Tank V-450

Process Hazard Analysis

Team Members

1. Assoc. Prof. Dr Azmi Mohd Shariff
2. Dr Lau Kok Keong
3. Nurhayati Mellon (Head Of Operations)
4. Mohd. Rafizie Bin Roslan
5. Lavin Raj A/L S.Krishnan



PHA Meeting

1. 12/02/2010 Development of Fault Tree Analysis for Compressor
2. 17/02/2010 Operation & Maintenance Review & Discussion

Process Hazards

1. Highly Compressed Gases with large amount of energy
2. Rotating Machine Parts
3. Exposed Wires & Live Parts
4. Electrical Protective Conductors
   *Link to A.pdf

Previous Incidents

1. Small leakage in gas outlet

PHA Schedule

1. Development of HAZOP – 26/04/2010
2. Safety Audit – 4/06/2010
3. Checklist Assessment – 17/07/2010

Human Factor

1. Storage of inflammable materials near compressor unit
2. Interruption of electrical protective conductors
3. Replacement of bolts after work in panel
4. Smoking nearby the equipment
5. Wrong order of procedure

Facility Siting

1. Away at least 15metres from possible heat/spark producing devices, equipments or area
2. Strictly No Smoking Area
3. No direct access to Unauthorised/General Workers
4. Easily manoeuvrable and accessible

Control Measures

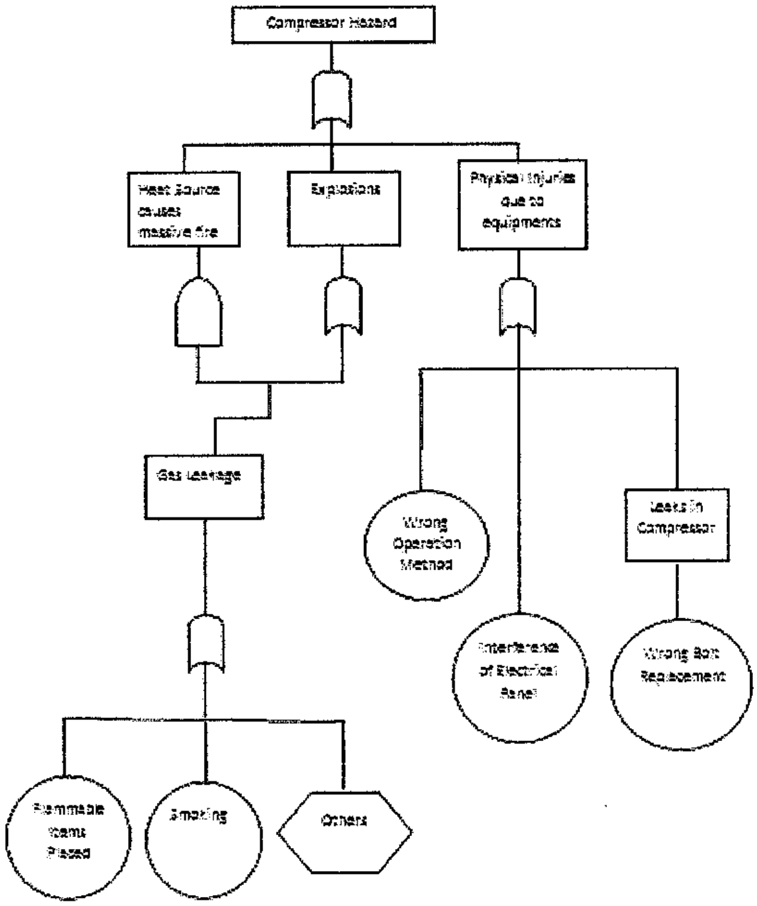
1. Carry out maintenance & repair on vented pressure system in case of gas leakage
2. Covers and guards must not be removed of rotating machine parts

   *Link to B.pdf

HSE Effect

1. High Pressure Explosion leading to big fire
2. High voltage Electric Shock
3. Injuries due to rotating equipments
4. Health issues and vulnerability to fire thru leakage of gases

HSE Method (FTA)



Process Safety Information

Codes & Standards for Compressor V470

1. WO-AD -2007-001
2. WI-SV-2009-001
3. WI-MF-2008-004
4. DIN EN ISO 10440-1
5. ISO 10440-1
6. CSA 12.8-00-02

Electrical Classifications for Compressor V470

Class I – Flammable Gas

Group D – Natural Gas

Division 2 – Presence of Natural Gas at abnormal conditions

AIT – 1076 °F

Material of Construction for Compressor V470

1. Cast Iron (Head)
2. Forged Carbon Steel
3. Forged aluminium alloy with Teflon/carbon piston rings (Piston)
4. Stainless steel (Valves)

Consequences of Deviation for Compressor V470

No.	Date	Deviation	Consequences
1	12/10/09	Temperature	Explosion and fire
2	12/10/09	Pressure	Explosion

Safe Operating Limit for compressor V470

No.	Op. Parameter	Lower Limit	Upper Limit
1	Temperature (oF)	-40	140
2	Pressure (bar)	10	410

Maximum Intended Inventory for Compressor V470

No	Date	Item	Maximum Inventory
1	24/02/2010	Natural Gas Cylinder	2
2	07/03/2010	Fire Extinguisher Type ABC	2
3	07/03/2010	Lubrication Oil V470	2

Operating Procedures

Initial Startup of Compressor V-470

With the compressor online and all alarms cleared, the screen will indicate "Ready to Run" and the green lamp in the compressor skid will be flashing. If the storage pressure in the selected storage bank/s drops below the selected start pressure the machine will start. The cooler fan will start; the recovery tank valve will open if the suction line requires more pressure. After 10 seconds the suction valve will open and 2 seconds after that the main motor or engine will start. The main motor is given about 5 seconds to ramp up to speed and start compressing. The recovery tank valve will re-open (if it was closed) feeding any recovery tank gas back into the suction line.

Normal Operations

19.2.1. Starting

With the compressor online and all alarms cleared, the screen will indicate "Ready to Run" and the green lamp on the compressor skid will be flashing. If the storage pressure in the selected storage bank/s drops below the selected start pressure the machine will start. The cooler fan will start, the recovery tank valve will open if the suction line requires more pressure. After 10 seconds the suction valve will open and 2 seconds after that the main motor or engine will start. The main motor is given about [illegible] seconds to ramp up to speed and start compressing. The recovery tank valve will re-open (if it was closed) feeding any recovery tank gas back into the suction line.

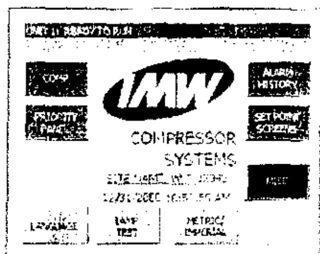
19.2.2. Running

Every 20 minutes of continuous compression on air-cooled compressors, the cooler fan will stop for a 30 second period. If the skid has the gas detector option, a leak will become evident during this time as the air flow through the skid will stop. If the gas concentration rises above 20% LEL (factory default), the screen will show a Warning Gas Level #1 Alarm. If it rises to 40% LEL (factory default) the compressor will shut down and show the Gas Level #2 Alarm. Once the compressor shuts down the vent fan will turn on continuing to evacuate the skid and will stay on until the gas level drops below 5% LEL.

19.2.4. Screen Operation

Typically the control panel will have some type of HMI (Human Machine Interface) usually in the form of a screen with function keys as shown below. In this case the screen is touching sensitive. This means that you simply touch certain areas of the screen to perform a function.

19.2.4.1. Main Menu



- The compressor status is shown at the top of each screen.
- The center of the main menu will show the compressor serial number, site name (if available) and date / time.
- By touching one of the corresponding function keys the screen will change to display the required information.
- [illegible] constant keys at the bottom and will perform the same function on each screen. These will do functions such as:
  1. "LANGUAGE" (on some projects): toggles between English and a different language.
  2. "LAMP TEST": When pushed illuminates all lamps on the control cabinet and skid.
  3. "METRIC / IMPERIAL": toggles between imperial (Pressure in PSI & Temperature in F) and metric (Pressure in BAR & Temperature in C).
  4. "MAIN MENU": Returns to main menu (shown above).

19.2.4.2. Compressor

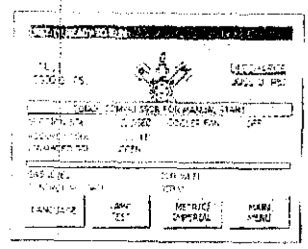


Figure 4: HMI Compressor Screen

- The compressor status is shown at the top of each screen.
- Compressor Suction (inlet) pressure in PSI or BAR.
- Compressor Discharge pressure in PSI or BAR.
- [illegible] touch the picture of the compressor. (The compressor will not start if it is not ready to run, or if storage is full.)
- Valve and fan status are displayed.
- Gas level displayed in %LEL (Lower Explosive Limit).

Mechanical Integrity

Frequency of Test & Inspection for Compressor V-470

No.	Date	Type	Rec. Freq	Reference file
1		Compressor V-470 Filters	2 Weeks	WI-AD-2008-04(i)
2		Compressor V-470 Relief Valves	1 Year	WI-AD-2008-04(ii)
3		Compressor V-470 Recovery Tank	3 Weeks	WI-AD-2008-04(iii)
4		Compressor V-470 Technical Inspection	6 Months	WI-AD-2008-04 (a)
5		Water Tank V-450 Technical Inspection	1 Year	API-653

Good Engineering Practices

No.	Date	Documents
1		ASTM F1052 - 09 Standard Test Method for Pressure Testing Vapour Protective Ensembles
2		WI-AD-2008-004-Natural Gas Compressor Safety Manual
3		NFPA 22 Standard for Water Tanks for Private Fire Protection
4		DIN EN ISO 10440-1-Natural Gas Industries-Gas Compressor Safety
5		47 CFR 73.508 - Standards of good engineering practice for Chemical Plants
6		NFPA 30 Flammable and Combustible Liquids Code
7		ASTM E487-09 - Standard Test Method for Constant-Temperature Stability Of Chemical Materials in Chemical Plants

Training for Baromia Process Equipments (Water Tank V-450)

Date: 07 November 2010

Participants: Nurhayati Mellon, Mohd. Rafizie Bin Roslan, Lavin Raj A/L S.Krishnan

Training Module:

- Screw Tank Hardware and Components
- Storage Process
- Fire Hazards
- Oil Management
- Troubleshooting and Maintenance
- Other Safety Issues
- Case Studies

Item	IMW Factory Recommended Maintenance Items	Every 2 Weeks	Monthly	500 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	Check the [illegible] Service History [illegible]	•									
2	Check/record compressor inlet [illegible]	•									
3	Check/record [illegible] pressures and temperatures [illegible] discharge pressure [illegible]	•									
4	Check/record [illegible] temperatures	•									
5	Visually inspect compressor [illegible] abnormalities	•									
6	Visually inspect [illegible]	•									
7	Listen for any abnormal [illegible]	•									
8	Check [illegible] for proper function	•									
9	Check oil levels on compressor [illegible] drive engine [illegible]	•									
10	Check [illegible] for compressor [illegible] engine (if applicable)	•									
11	Check coolant pump [illegible]	•									
12	Check all belts [illegible]	•									
13	Drain interstage [illegible]	•									
14	Drain recovery tank [illegible]	•									
15	Visually inspect [illegible] failure or leakage		•								
16	Verify ESD [illegible]		•								
17	Verify [illegible]			•							
18	Check all pressure [illegible]			•							
19	Verify inlet control valve operation			•							

Water Tank V-450 Inspection Result

Customer: Universiti Teknologi Petronas

Model # 2465 SUP/2

Serial # 0235438

Customer Report and/or Complaint :

Analysis of Failure: Refer Attachment

Date of Inspection: 03/02/2010

Inspected by: N.M

VALVE CONDITION OK **CHROMED** XXXX **METALIZED**

VALVE SPINDLE OK

CONDITION OF PIPINGS

(M) Worn (M) OK

(F) Worn (F) OK

SUCTION HEAD Good

APPROXIMATE OPERATION HOURS N/A

FLANGES PRESENT:

Suction Yes Discharge Yes

Management Of Change

MOC Form

Date Of Submission		
Equipment		
Activity	Mechanical Changes in Compressor V-470	
Reference Number	3000 HP NGC/001	
Details: Change of compressor block pistons to manage higher pressure of gas		
Reference Documents:	IMW Natural Gas Compressor Block Maintenance Result	
Reviewer Name: JCH Email: jacko@petronas.edu.my		
Signature		[signature]

Good Engineering Practices

No.	Date	Documents
1	05/12/2009	ASTM F1052 - 09 Standard Test Method for Pressure Testing Vapour Protective Ensembles
2	05/12/2009	WI-AD-2008-004-Natural Gas Compressor Safety Manual
3	05/12/2009	NFPA 22 Standard for Water Tanks for Private Fire Protection
4	08/03/2010	DIN EN ISO 10440-1-Natural Gas Industries-Gas Compressor Safety
5	08/03/2010	47 CFR 73.508 - Standards of good engineering practice for Chemical Plants
6	27/03/2010	NFPA 30 Flammable and Combustible Liquids Code
7	27/03/2010	ASTM E487-09 - Standard Test Method for Constant-Temperature Stability Of Chemical Materials in Chemical Plants

Pre-Startup Safety Review

PSSR Guidelines

PSSR is an abbreviation for Pre-startup safety review, an element in OSHA's Process Safety Management (PSM) regulations. These regulations require that the employer shall perform a PSSR for new facilities and for modified facilities when the modification is significant enough to require a change in the process safety information.

Process Technical Services can provide experienced and qualified personnel that have either lead or participated as a member of PSSR teams, and are available to help clients.

OSHA suggests that for new processes, the employer will find a PHA (Process Hazards Analysis) helpful in improving the design and construction of the process from a reliability and quality point of view. The safe operation of the new process will be enhanced by making use of the PHA recommendations before final installations are completed. P&IDs are to be completed along with having the operating procedures in place and the operating staff trained to run the process before startup. The initial startup procedures and normal operating procedures need to be fully evaluated as part of the PSSR to assure a safe transfer into the normal operating mode for meeting the process parameters.