Investigation of Process Safety Management (PSM) Approach for Process Industries: Operating Procedures (OP)

by

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

DECEMBER 2012

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CERTIFICATION OF APPROVAL

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Approved by,

_____

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TRONOH, PERAK
DECEMBER 2012

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.

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PUTERI SHAZANNA ZAWIYAH BTE MOHD YUSAH

ABSTRACT

Unexpected releases of highly hazardous chemicals have occurred numerous times in process industries. One of the keys contributing factors that could prevent these accidents are by managing operating procedures according to established standards. One of the established industrial standards to manage Operating Procedures (OP) is specified under the code of federal regulations Chapter 29 Section 1910.119(f) in Process Safety Management (PSM) regulations. However, accident still can happen if the requirements of the standard not implemented as intended. Investigations revealed that despite the prevention efforts, the classical safety management approach is not effective enough to prevent major accidents from happening. The unavailability of easy technique for industries to comply with PSM requirements had delayed industries' efforts to accomplish best practices of PSM.

This study proposes a structured system to simplify the working process of OP that complies with OSHA PSM 29 CFR 1910.119(f). Piping and Instrumentation Diagram (P&ID) is used as a foundation for OP data management. It act as the basis to manage documentation, track required actions related and captures critical information pertaining to the process and thus prevent the missing of information related to Operating Procedures.

With a structured and systematic way in implementing the OP element of PSM, it is expected that best practices of PSM program helped to achieve operational excellence, manifesting in increased productivity, higher quality of deliverables, reduced waste, lowered operational costs, enhanced business performance and prevent major accidents.

ACKNOWLEDGEMENTS

First and foremost, all praises to The Almighty as for His mercy and grace, I was able to complete my Final Year Project at Universiti Teknologi PETRONAS. I would like to seize this opportunity to thank all parties who have contributed along the project's journey.

Firstly, I owe my deepest gratitude to Assoc. Prof. Dr. Azmi Mohd. Shariff, who have been a remarkable Supervisor for his encouragement, support and guidance from the first day I've started this project until the last day of its completion. Thank you for all the untiring guidance, assistances, knowledge and experiences shared.

I am also indebted to the rest of team members; Mrs. Haniza Aziz, Mrs. Diana, Ms. Balqees Zailani, and Ms. Mazlinda; for their endless support, teachings and mentoring that contribute to my self-development, knowledge and attitude towards achieving the same goal. Their friendliness creates a harmonious working environment and made me feel as a part of team under the supervision of Assoc. Prof. Dr. Azmi Shariff.

Last but not least, I would like to show my gratitude to Dr. Anis Suhaila, Dr. Norhayati Mellon and to the rest of FYP Committee member for conducting talks and briefings, giving useful materials and not to forget the kind assistance, as well as encouragement to ensure all the requirements for FYP I and II are being fulfilled.

It has been a bittersweet journey, yet the endless support from my fellow friends and family, have helped me completed my final year project successfully. Finally, thank you all for those who have contributed directly and indirectly for the past two semesters in achieving project's intended objective.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND STUDY

Safety experts and regulatory bodies believe that catastrophic events such as Flixborough explosion, Bhopal toxic plume release and other examples of major disasters could be prevented by a proper application of process safety management techniques. To address and handle the issue legally, the Congress of Occupation Safety and Health Act of 1970 has created Occupational Safety and Health Administration (OSHA) to assure safe and healthful working conditions for men and women by setting and enforcing standards through training, education and assistance. According to OSH Act, employers must comply to OSHA regulations which requires them to keep their workplace free of major recognized hazards [1].

One of the established standards developed by OSHA that highlight the importance of safety in process industries is Process Safety Management (PSM) 29 CFR 1910.119 of Highly Hazardous Chemicals (HHC). The purpose of the PSM standard is aligned with the OSHA's objective that is to prevent or minimize the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals [2].

In present study, the main element that will be discussed thoroughly is Operating Procedures, CFR 1910.119(f). Due to the fact that all of those elements are interlinked and interdependent with each other, the other 13 elements will also be described interchangeably to meet PSM requirements. Each of the 14 elements contributes information or utilizes information from other elements in order to be completed [3].

With a structured and systematic way in handling associated risks from highly hazardous chemicals, best practices of PSM program helped to achieve operational excellence, manifesting in increased productivity, higher quality of deliverables, reduced waste, lowered operational costs and enhanced business performance [4].

1.2 PROBLEM STATEMENT

A common thread in all major incidents is the complexity of process plant operations. Therefore, a written standard operating procedure must be compiled and comprehend to ensure safe operation when performing any related activities. Written operating procedure must be consistent with the data embedded in process safety information.

Despite the abundant precautions and stringent regulation provided worldwide on PSM program, incidents continue to occur on a regular basis due to insufficient understanding the urgency to identify best practices and drive for process safety improvements in the organization [5].

Designing and implementing by using a complete work process for PSM-related activities can help to maintain an effective PSM program [6]. However, a major challenge is unavailability of easy technique for industries to comply with PSM requirements and maintain the effective process safety programs. Thus, there is a need to develop a system towards a smooth implementation of PSM program in process industries to ensure safe operation with respect to the compliance of PSM requirements.

1.3 OBJECTIVE(S)

The main objective to be achieved by the end of this study is to develop a structured system to manage Operating Procedures and its compliance with OSHA PSM 29 CFR 1910.119(f). It is supported by few sub-objectives listed below which are;

- To analyse PSM requirements for Operating Procedures [29 CFR 1910.119(f)]
- To develop framework of OP
- To develop database prototype tool for easy implementation
- To conduct case study for concept validation

1.4 SCOPE OF WORK

For the project to be feasible within the time frame of 14 weeks, it will be divided into two parts. The first part will be covered in FYP1 as shown below:

The second part will be covered later in FYP2 which are:

The first part will covers from step 1 until step 2, which is element's compliance up until development of model based on framework.

The study is mainly to develop a standard system which is able to simplify the working process of the proposed standard. Current PSM standard requirement will be used and transformed to prototype tool. Validation of data from specific case studies will be obtained from real plant in process industries or any other different resources.

CHAPTER 2
LITERATURE REVIEW

2.1 PREVIOUS MAJOR ACCIDENT(S)

Unexpected releases of toxic, reactive or flammable liquids and gases in processes involving highly hazardous chemicals have been reported for many years. In order to be sustainable, the chemical, petroleum and other industries must strive for a balance between optimal performance of process operations and process safety, which must be treated as an integrated part of the plant operations [7].

In the late 1980s, many facilities experienced events which lead to catastrophic results that caused loss of life and properties. Pattern of the catastrophes began to emerge and make its appearance. Macza M. (2008) described the explosion of BASF plant, Germany in 1921 that destroyed the plant itself which had killed at least 430 people and damaging approximately 700 houses nearby.

Later in 1947, another plant known as Monsanto Chemical Company's SS Grandcamp in Texas City was caught in fire and exploded which killed over 430 people as well. However, no specific legislative response was taken with respect to these incidents. The disaster happened in Flixborough UK (1974) and Bhopal Gas Disaster (1984) has been a wake-up call to the world industrial leaders to take action and ensure the industries follow best practices in preventing and mitigate risk of incidents [8].

Studied conducted by Kidam et al. [9] stated that majority of accidents happened in the chemical process industry were mainly caused by technical and engineering failures. Statistical analysis has been performed which shown in Figure 2.1.

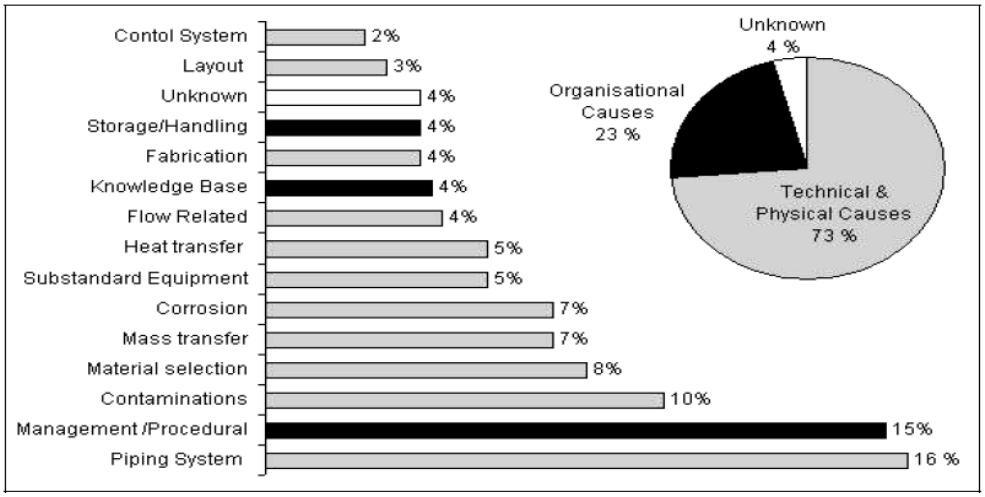


Figure 2.1 The general (pie chart) and immediate (bar chart) causes of accidents

From the above figure, it indicates that majority of the accidents are caused by technical failures (73%), followed by organizational (23%) and unknown (4%). Special attention is given on 'human engineering error' since it will resulted into technical failures. Among typical examples of 'human engineering error' is wrong work instruction, confusing control panel display and wrong labeling/specification.

A similar study was conducted by PETRONAS Carigali Sdn. Bhd for their five (5) years effort in integrating process safety aspects in a HSE Management System. The study on process-related incidents is focus mainly on hydrocarbon release (HCR) covered incidents from 2004 to 2008 in PETRONAS Carigali domestic region. Findings are listed below in Table 2.1.

Table 2.1 Severity and Frequency of HCR Incidents for Region P from year 2004 to 2008
[Source: SPE Asia Pacific Health, Safety, Security & Environment Conference and Exhibition]

Severity	**No. of causes**
Minor	388
Major	0
Serious	11
Total	399

The roots causes for the incidents were as follows:-

- 52% were caused by erosion and corrosion
- 42% were caused by equipment failures such as seals leak, loose fittings/gasket
- 6% were contributed by human error

Major failure identified was maintenance management. This contributed 67% to the total number of incidents. The other major failures were Hardware (11%), Design (7%) and Procedures (7%). The findings showed that process safety aspects have not been well understood and implemented [10].

PETRONAS Carigali has taken action to integrate Process Safety aspects with their existing HSE Management System by making it consistent with Process Safety Managements requirements as described in OSHA standard.

2.2 PROCESS SAFETY MANAGEMENT (29 CFR 1910.119)

PSM regulations is specified by the Occupational Safety and Health Administration (OSHA) in the code of federal regulations Chapter 29 Section 1910.119 (CFR 29 1910.119) [1]. OSHA's proposed standard emphasized the management of hazards associated with processes that uses highly hazardous chemicals (HHC).

PSM, according to 29 CFR 1910.119 applies to 162 chemicals at or above the specified threshold on the OSHA PSM standards Appendix A list. In addition, it is also applies to a process that involves a flammable liquid or gas on site in one location in a quantity of 10, 000 pounds or more [11]. However, PSM is exempted from retails facilities, petroleum operations and last but not least, unoccupied remote facilities.

Eileen M. (2012) had emphasized that structured approach of PSM is needed to ensure safe operation by understanding 14 interrelated core elements in PSM that define the process system as shown in Table 2.2:

Table 2.2 PSM elements and standards

No.	PSM Elements	PSM Standards
1	Employee Participation	CFR 1910.119(c)
2	Process Safety Information	CFR 1910.119(d)
3	Process Hazard Analysis	CFR 1910.119(e)
4	Operating Procedures	CFR 1910.119(f)
5	Training Requirements	CFR 1910.119(g)
6	Contractors	CFR 1910.119(h)
7	Pre-startup Safety Review	CFR 1910.119(i)
8	Mechanical Integrity	CFR 1910.119(j)
9	Hot Work Permits	CFR 1910.119(k)
10	Management of Change	CFR 1910.119(l)
11	Incident Investigation	CFR 1910.119(m)
12	Emergency Planning and Response	CFR 1910.119(n)
13	Compliance audits	CFR 1910.119(o)
14	Availability of trade secret information	CFR 1910.119(p)

2.2.1 Operating Procedures, 29 CFR 1910.119(f)

Written operating procedures are necessary to ensure related activities are conducted in a safe manner. The employer need to develop and implement written procedures with a crystal clear instructions involving process activities that is consistent with respect to process safety information [12]. There are four sub-elements covered under Operating Procedures which are; operating phase, operating limits, safety and health considerations and safety systems and their functions.

For operating phase, procedures must be developed for critical activities such as initial start-up, normal and temporary operations, normal and emergency shutdown, start-up following a turnaround, or after an emergency shutdown. Each of the operating phases should define operating limits that covers the consequences of deviations and required means to correct or avoid deviation.

Thirdly, the safety and health considerations should at least include hazards properties due to the chemical used in the process, necessary means to prevent exposure and its control measures, as well as the quality control for raw materials and the hazardous chemical inventory levels.

Lastly, operating procedures should be readily accessible for easy reference by the employees. It must be up-to-date and reviewed as often as necessary to reflect the current operating practice. Employer must also develop and implement safety work practices to provide hazards control during operations which applies to employees and contractors.

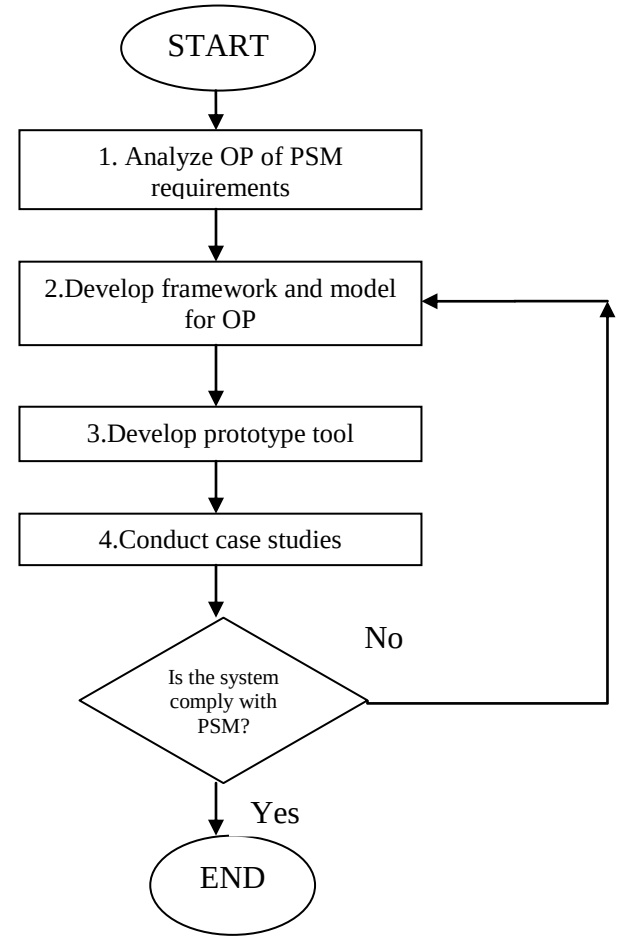
Despite the principles and essential features of OSHA PSM to operate facility safely, the established practices are not being followed [13]. Klein (2005) says that even the most technologically advanced plant in the world will not have a safe operating track record unless the individuals are dedicated and committed towards safe operations. This could be achieved through this study by proposing a simplified prototype tool and easy implementation of PSM system.

CHAPTER 3
METHODOLOGY

3.1 WORKING PROCESS

In developing Operating Procedures Management System, author must study and understand PSM standard as has been stated in the OSHA's requirements. From earlier discussion, it is observed that some of PSM elements have an inter-connection with each other, but the scope of study will only covers one element; Operating Procedures.

In general, the workflow of the process is illustrated below:



3.2 ANALYSIS THE REQUIREMENTS OF OPERATING PROCEDURES

Basically, the project is started with analysing the requirements of the OP element of PSM standard. Analysing OP requirements of PSM is important to discover the requirements to comply with the 29 CFR 1910.119(f). Analysing phase has taken half of the semester period in conducting FYP I before continuing to develop OP framework. Among the ways to analyse OP requirements are by reading through related PSM articles, journals and also can be obtained through online resources.

3.3 DEVELOPMENT OF FRAMEWORK

Author proceeds in constructing the framework for OP which is quite similar to the flowcharts constructed by OSHA. The frameworks is developed using an engineering standpoint and in the same time, operates without violating OSHA PSM regulations. It is considered the backbone of the project that summarizes vital information and clear strategy in implementing proposed technique. The framework illustrates step by step process that need to be perform according to the OP requirements. Enhanced P&ID has been used as a basis for OP information management.

Frameworks have been sent to AP Dr. Azmi M. Shariff, who has been assigned to supervise this project. After review and modification phase is done and frameworks have been approved by him, the author will implement the frameworks using computer programming aid as a working interface known as Microsoft Access software.

3.4 DEVELOPMENT OF OPERATING PROCEDURE MANAGEMENT SYSTEM (OPMS) AS PROCESS MODEL

Several tools are used to assist author in developing the prototype model. Listed below are the required tools towards the project's completion:

(a) Microsoft Office Word – To develop framework

(b) Microsoft Office Excel – To develop model

(c) Microsoft Office Access – To develop prototype tool

Interface system is developed using Microsoft Office Access has the flexibility to allow any changes on the latest information provided. Incomplete information also will be detected and hence, shows an alert that calls necessary actions to be taken.

3.5 CASE STUDY

The best option in validating the proposed concept for OP implementation is by using the real process plant data. A case study was conducted using data from a refinery Plant X in the oil and gas industry in Malaysia. The industrial data collected from LPG Treating Unit on 23rd October 2012 was used to study the removal of Hydrogen Sulfide (H2S) and reduction of Mercaptan (R-SH) content in various LPG blendstock (C3 & C4). Since LPG is known as hazardous substance according to OSHA 29 CFR 1910.1200, therefore Plant X is obliged to comply with OSHA PSM standards and regulations. Table 3.1 describes the implementation strategies that were used in conducting case studies at Plant X.

3.5.1 Case Study 1: Amine System

In Amine Section, there are 3 Phase Separators equipped with fiber-filmTM contactor where the LPG get benefit from contacting with fresher amine when moving from the third, second and lastly to the first separator. LPG feed is then introduced into top of separator shroud. MDEA in the fiber-filmTM contactor flows downward adhering to the fibers till it enter aqueous phase. LPG concurrently flow & disengages upon entering hydrocarbon phase. H2S is removed to amine stream. The process flow for Amine Section is simplified in Figure 3.1 below:

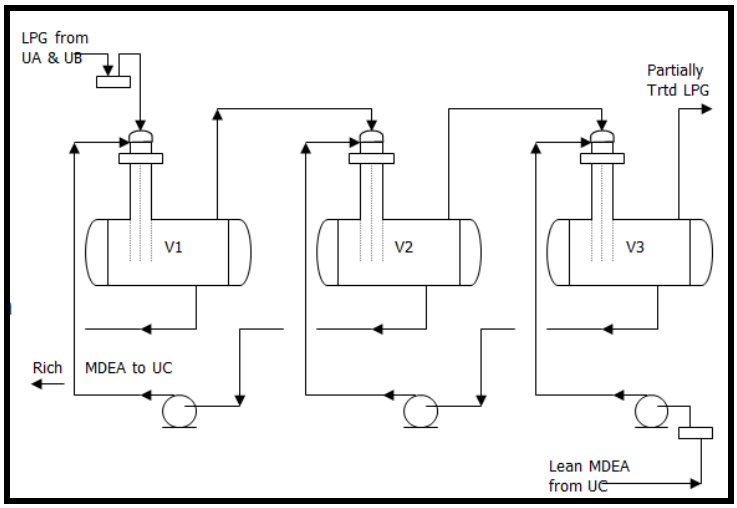


Figure 3.1 Simplified Process Block Diagram for Amine Section

3.5.2 Case Study 2: Caustic System

For Caustic Section, there are two Phase Separators that equipped with fiber-film contactor. 20^{o}Be caustic is used to extract Mercaptan (R-SH). Mercaptan in LPG is extracted to sodium mercaptide and transferred to caustic stream. Treated LPG is then exit the second Separators to Unit A for further separation or direct to rundown. The process flow for Caustic Section is simplified in Figure 3.2 below:

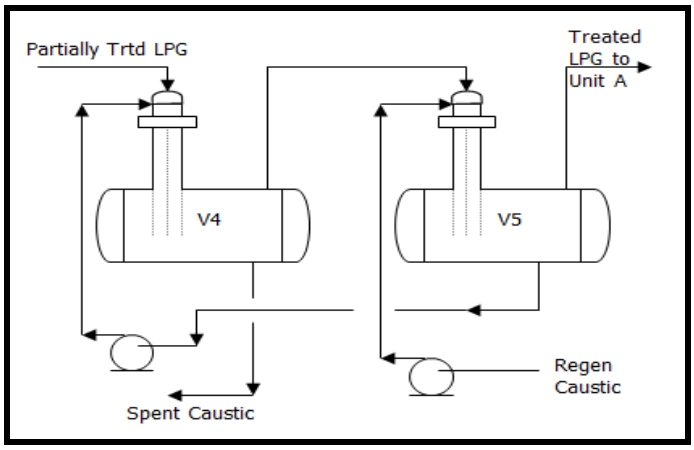


Figure 3.2 Simplified Process Block Diagram for Caustic Section

Table 3.1 OP Implementation strategy for Plant X

Sub-standard	OP requirement	OP for Plant X
29 CFR 1910.119(f)(1)	Develop written operating procedures	Develop initial operating procedure for each operating phase
29 CFR 1910.119(f)(1)(i)	For each operating phase, below are the operating procedures that needs to be fulfill;	Evidence documents to prove OPs exist
29 CFR 1910.119(f)(1)(i)(A)	Initial startup	
29 CFR 1910.119(f)(1)(i)(B)	Normal operations	
29 CFR 1910.119(f)(1)(i)(C)	Temporary operations	
29 CFR 1910.119(f)(1)(i)(D)	Emergency shutdown	
29 CFR 1910.119(f)(1)(i)(E)	Emergency operation	
29 CFR 1910.119(f)(1)(i)(F)	Normal shutdown	
29 CFR 1910.119(f)(1)(i)(G)	Startup following a turnaround, or after an emergency shutdown.	
29 CFR 1910.119(f)(1)(ii)	Each operating procedures must address operating limits as below:	
29 CFR 1910.119(f)(1)(ii)(A)	Consequences of deviation	Ensure deviation of each operating limits address its consequences and corrective measures
29 CFR 1910.119(f)(1)(ii)(B)	Steps required to correct or avoid deviation.	
29 CFR 1910.119(f)(1)(iii)	Each operating procedures must consider safety and health as below:	
29 CFR 1910.119(f)(1)(iii)(A)	Properties of chemicals hazards used in the process	
29 CFR 1910.119(f)(1)(iii)(B)	Precautions to prevent chemical exposure, including engineering controls, administrative controls, and personal protective equipment;	

29 CFR 1910.119(f)(1)(iii)(C)	Control measures to be taken if physical contact or airborne exposure	
29 CFR 1910.119(f)(1)(iii)(D)	Quality control for raw materials and hazardous chemical inventory levels	
29 CFR 1910.119(f)(1)(iii)(E)	Any unique/special hazards	
29 CFR 1910.119(f)(1)(iv)	Safety systems and their functions.	Safety related system in Plant X
29 CFR 1910.119(f)(2)	Operating procedures shall be readily accessible to employees who work in or maintain a process.	
29 CFR 1910.119(f)(3)	(a) Operating procedures review frequently to assure that they reflect current operating practice, that results from changes in process chemicals, technology, equipment, and changes to facilities.	Monitoring existing OP to ensure that they capture changes in current operating practice
	(b) Operating procedures are certify annually	Track, update and re-certified OP of Plant X every year
29 CFR 1910.119(f)(4)	(a) Develop safe work practices to provide for the control of hazards during operations such as lockout/tagout; confined space entry; opening process equipment or piping	Ensure safe work practices exists
	(b) Develop safe work practices to provide for the control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel.	
	(c) These safe work practices apply to employees and contractor employees.	Retain OP as documentation for reference

3.6 PROJECT'S ACTIVITIES & SCHEDULE

For this semester, project's activities will focus on developing prototype tool by using Microsoft Access. Apart from that, author will also demonstrate and validate case studies using data obtained from the industry. The initial prototype tool is changing from time to time depending on the case studies so that the model is fit-for-purpose for process industries. Table 3.2 below shows suggested project's milestone for Final Year Project II.

Table 3.2 Key milestone for FYP II

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Topic Selection & Research Work	FYP 1						Mid-semester break	FYP 1							
2	Analysis of element OP requirements															
3	Develop framework and model															
4	Develop prototype tool using Microsoft Access															
5	Gather industrial data															
6	Validate case study															
7	Submission of Progress Report								5/11							
8	Project Work Continues															
9	Pre-SEDEX											26/11				
10	Submission of Draft Report												3/12			
11	Submission of Dissertation (soft bound)													10/12		
12	Submission of Technical Paper													10/12		
13	Oral Presentation														19-25/12	
14	Submission of Project Dissertation (Hard bound)															11/1

CHAPTER 4
RESULTS AND DISCUSSION

4.1 REQUIREMENTS OF OSHA PSM CFR 1910.119(F)

The element of Operating Procedures in process industries should follow the standards outlined by OSHA PSM 29 CFR 1910.119. Table 4.1 shows the essential keys in the element of OP that used as a backbone to develop the OP framework.

Table 4.1 Standards of OP in CFR 1910.119(f)

Standards	Description
1910.119(f)(1)	The employer shall develop and implement written operating procedures that consistent with the process safety information and address the following elements: (i) Steps for each operating phase: (A) Initial startup; (B) Normal operations; (C) Temporary operations; (D) Emergency shutdown (E) Emergency Operations; (F) Normal shutdown; and, (G) Startup following a turnaround, or after an emergency shutdown. (ii) Operating limits: (A) Consequences of deviation; and (B) Steps required to correct or avoid deviation. (iii) Safety and health considerations: (A) Chemical hazard properties (B) Precautions/Prevention of exposure (C) Control measures (D) Quality control (E) Any special or unique hazards (iv) Safety systems and their functions

1910.119(f)(2)	Operating procedures readily accessible to employees or contractors.
1910.119(f)(3)	The operating procedures shall be reviewed regularly and shall certify annually.
1910.119(f)(4)	The employer shall develop and implement safe work practices such as lockout/tagout; confined space entry; opening process equipment or piping; and control over entrance into a facility by any support personnel.

4.2 FRAMEWORK FOR OPERATING PROCEDURES PSM CFR 1910.119(F)

4.2.1 Compliance with OP 29 CFR 1910.119(f)

Figure 4.1 in the next page explains how development of OP framework helps to design OP Management System. The framework starts by checking the availability of written Operating procedures in the pilot plant. If they are not available, management must first develop them and if they are available, the process continues to update and review written operating procedures from operating phase, operating limits, safety and healthy consideration and last but not least, safe work practices.

According to OSHA PSM, all the requirements stated in the Operating Procedures must be consistent with Process Safety Information, CFR 1910.119(d). After that, management must ensure the written operating procedure is certified annually. These two steps must be repeated at updating and reviewing phase if the data is not consistent or if Operating Procedures not certified annually. Lastly, written Operating Procedures have to be easily accessible by end users for their perusal.

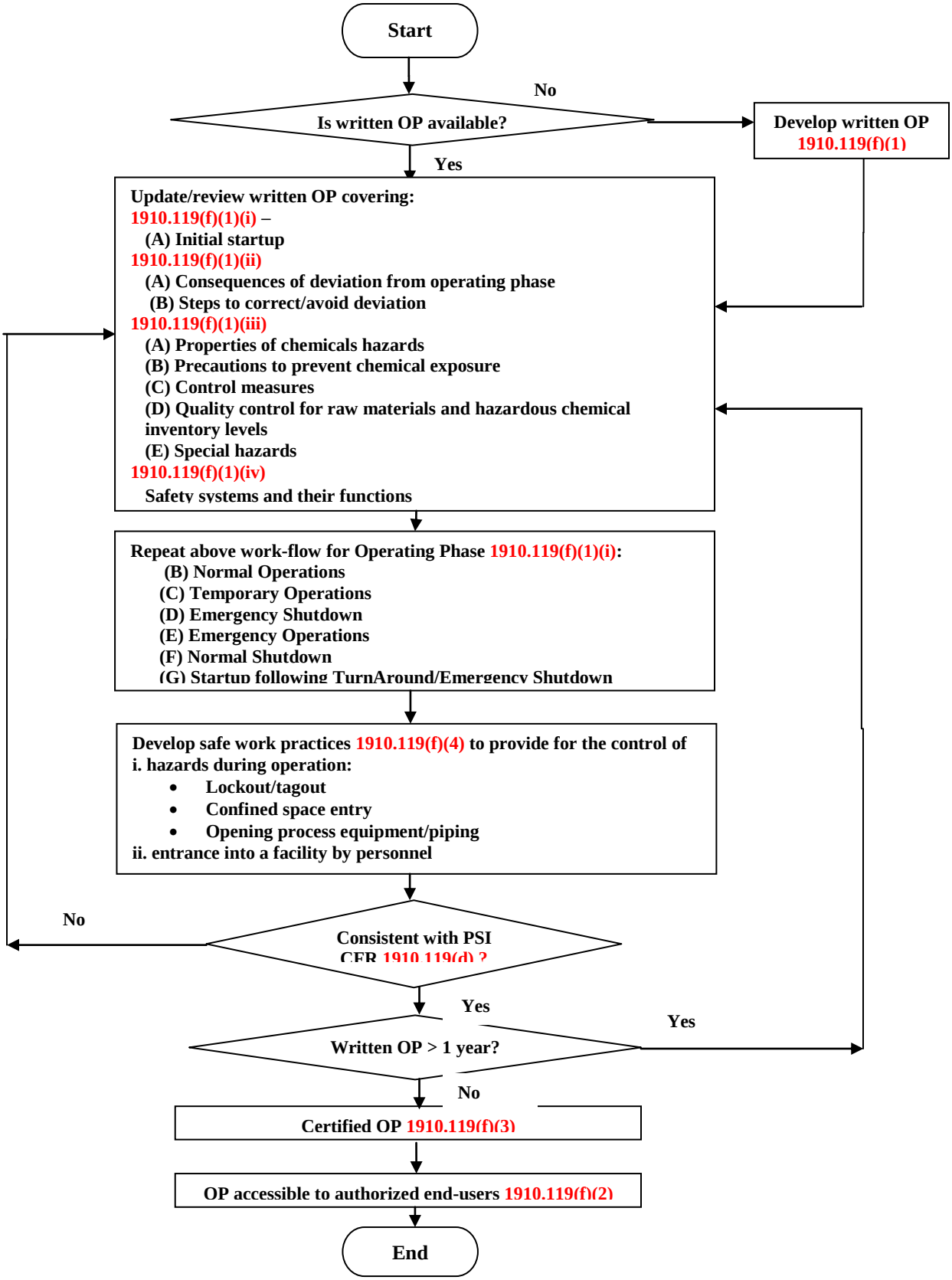


Figure 4.1 Framework of OP based on CFR 1910.119(f)

4.2.2 Using P&ID as Foundation for Data Management

Process and Instrumentation Diagram (P&ID) is being used widely in all types of process plants, therefore it will be the basis to manage documentation and track required actions related to Operating Procedure. The P&IDs is the appropriate diagram that gives details and display information for piping engineer and other engineering staff. Software programs that can use P&IDs or other useful diagrams may help to fulfil and achieve the OSHA standards and requirements. Process Instrumentation & Diagrams (P&IDs) used as the basis for data management to track and manage all required information. This will improve end users acceptance since P&IDs is used commonly in any process plant.

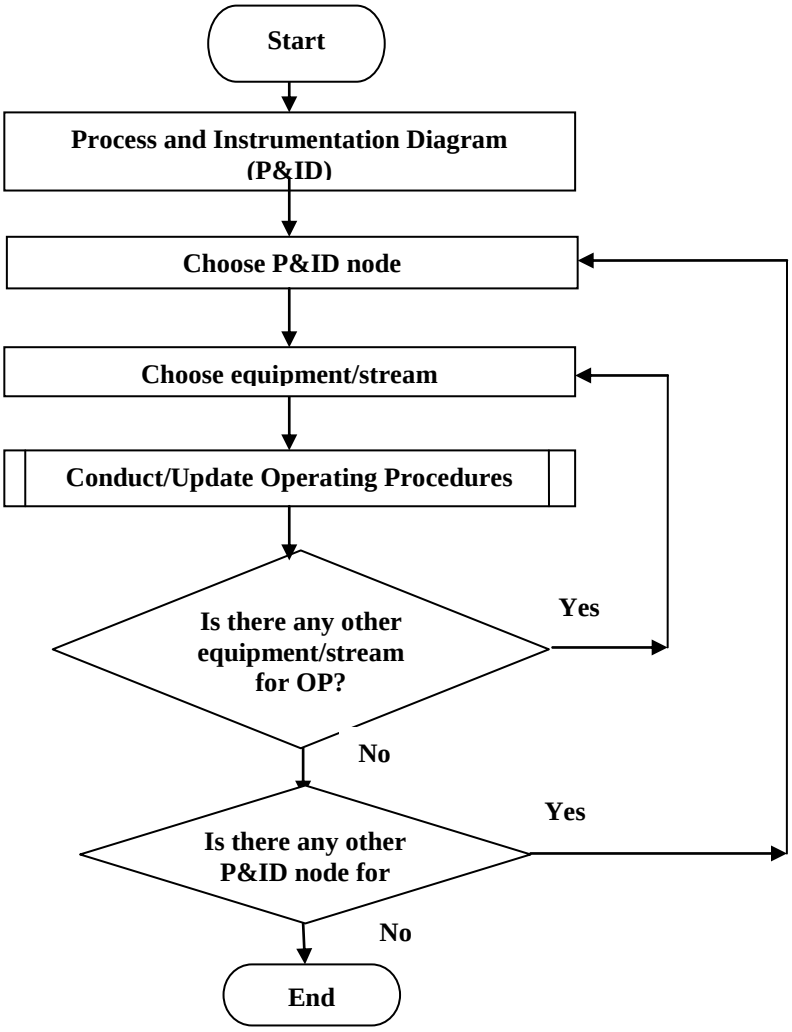


Figure 4.2 Framework of OP using P&ID as a Foundation

4.3 OPERATING PROCEDURES MANAGEMENT SYSTEM (OPMS)

Even though OP requirements can be completed manually, it is better to compile necessary information into one specific database. Extraction and tracking will be much easier and less time-consuming. Thus, the technique has been transformed into a computer database prototype system known as Operating Procedures Management System (OPMS), which articulately demonstrate the concept.

The OPMS is successfully developed in an interactive Microsoft Access environment. In general, there are nine (9) interfaces that follow OP framework developed earlier which are; Development of Operating Procedures, Initial Start-up, Normal Operation, Temporary Operation, Emergency Operation, Emergency Shutdown, Normal Shutdown, Start-up following a turnaround or after emergency shutdown and last but not least, Safe Work Practices.

Establishment of the system will assist auditing process to be smooth if the system is proven to achieve the project's objective. It will have the potential to be commercialized since it helps industries to comply with OSHA regulations and requirements.

4.4 CASE STUDY

To demonstrate the implementation of OP element using OPMS, two case study has been conducted on selected nodes of the LPG Treating Unit (LTU) including Amine system and Caustic system will be discussed further in this section.

4.4.1 Case Study 1: OPMS for Amine System

By referring to the concept illustrated in Figure 4.2, the P&ID for LTU section is divided into three nodes according to design intention. Figure 4.3 shows the selected node consists of amine treater (V-1) with inlet and outlet stream. Author then proceeds to the next stage which is to conduct and update Operating Procedures documentation for (V-1).

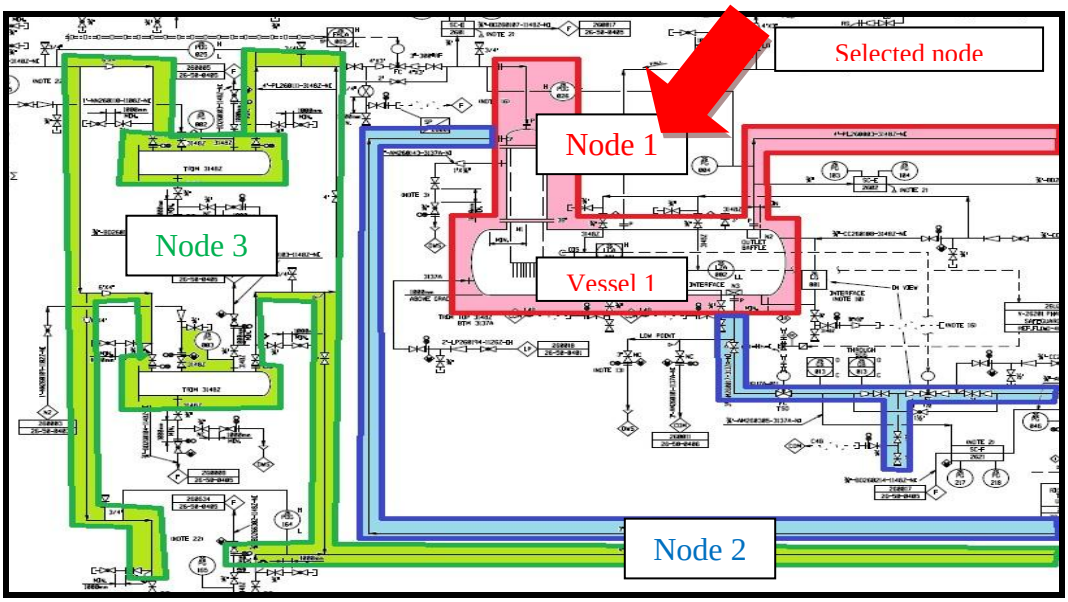


Figure 4.3 Part of the overall P&ID showing Amine Section

i) Development of Operating Procedures 29 CFR 1910.119(f)

Figure 4.4 shows the 'Development of OP' interface that consists of 'Sub-standard', 'Description', 'Complete', 'Incomplete' and 'Remarks' columns. This main interface can be used to assess and monitor all sub-standards of CFR 1910.119(f) easily. Important data will be captured and will be stored in a centralized database.

Any comments such as specific incomplete information or conditions can be included in 'Remarks' column. In a brief, the model actually works as a systematic checklist to ensure end users compliance with OP of PSM requirements.

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Complete	Incomplete	Remarks
CFR 1910.119(f)(1)(i)(A)	Initial start up	☑	☐	Comply
CFR 1910.119(f)(1)(i)(B)	Normal operation	☐	☑	Not available
CFR 1910.119(f)(1)(i)(C)	Temporary operation	☐	☑	Not available
CFR 1910.119(f)(1)(i)(D)	Emergency operation	☐	☑	Not available
CFR 1910.119(f)(1)(i)(E)	Emergency shutdown	☑	☐	Comply
CFR 1910.119(f)(1)(i)(F)	Normal shutdown	☑	☐	Comply
CFR 1910.119(f)(1)(i)(G)	Startup following a turnaround or after emergency shutdown	☐	☑	Not available
CFR 1910.119(f)(4)	Safe work practices	☐	☑	Not comply

Figure 4.4 Amine System: Development of OP

ii) Initial Start-up CFR 1910.119(f)(1)(i)(A)

Figure 4.5 covers operating phase for Initial Start-up procedure. The listed sub-standard of CFR 1910.119(f)(i-iii) in this window provides guideline to end-users about the critical information that needs to be compiled according to OSHA PSM regulations which can be found in the 'Requirement' column.

Authorized personnel must check whether the required information are already completed or not completed yet using systematic checklist. Authorized personnel ensure completeness of collected information through status indicated by 'Complete' checkbox. It is important as it highlights which task is yet completed and hence requires further attention. This is done by assigning a qualified employee under 'Action By' column and a dateline under 'Reply Date' column. Consequently, outstanding tasks can be monitored and completed on time.

The written procedures have to be reviewed so that the latest or updated procedures are kept on the track for affected employees, PSM team reference and auditing purpose as refer to 'Evidence Location' column. Apart from storing data inside the database, the system also allows information to be kept in hardcopy folder such as logbook, plant layout, reports and so on. Date and the person who approved the revised documents must be extracted and to be filled in the 'Revision Date' and 'Approved by' tab.

End users can plan the date for the documents to be revised annually, as intended by PSM regulations in 'Revalidate' column. Assessment on written OP should be done to ensure the consistency of operating limit with updated process safety information. From the comments in the 'Remarks' column, authorized personnel can take any required actions timely in order to fulfil with the OP requirements.

The template window for Figure 4.5 works the same for all the other operating phase which are; **Normal Operation (Figure 4.6), Temporary Operation (Figure 4.7), Emergency Operation (Figure 4.8), Emergency Shutdown (Figure 4.9), Normal Shutdown (Figure 4.10)** and lastly, the **Start-up following a turnaround or after emergency shutdown (Figure 4.11).**

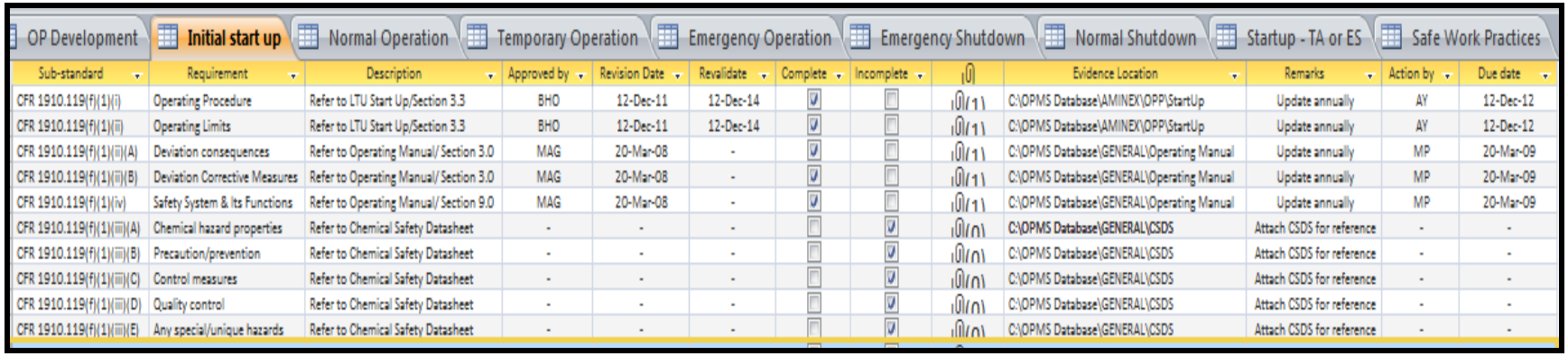
Based on case study for Amine System that has been conducted, there are a few operating phases that is found to be incomplete. For V-1 in Study Node 1 for Amine System, operations for normal, temporary, emergency conditions as well as start-up following a turnaround or after emergency shutdown are not available for V-1.

One of the gaps that have been captured in the 'Remarks' column is that, the existed operating procedures need to be updated annually. To ensure its validity, authorized personnel must follow date suggested in "Due Date" column to provide up-to-date document for end-users.

In addition, the Chemical Safety Datasheet might be existed for V-1 but the management of Plant X is not able to provide CSDS existence in their online database system. Thus, authorized personnel have to take action and must attach or provide evidence location of the required chemical safety datasheet for future reference.

Last but not least, the only requirements that has not been fulfilled is CFR 1910.119(f)(4) which is Safe Work Practices. This is due to document unavailability for opening process equipment or piping. However, this can be solved by developing the module for the specific safe work practices and once it has been approved, all the information must be updated in the system by authorized personnel.

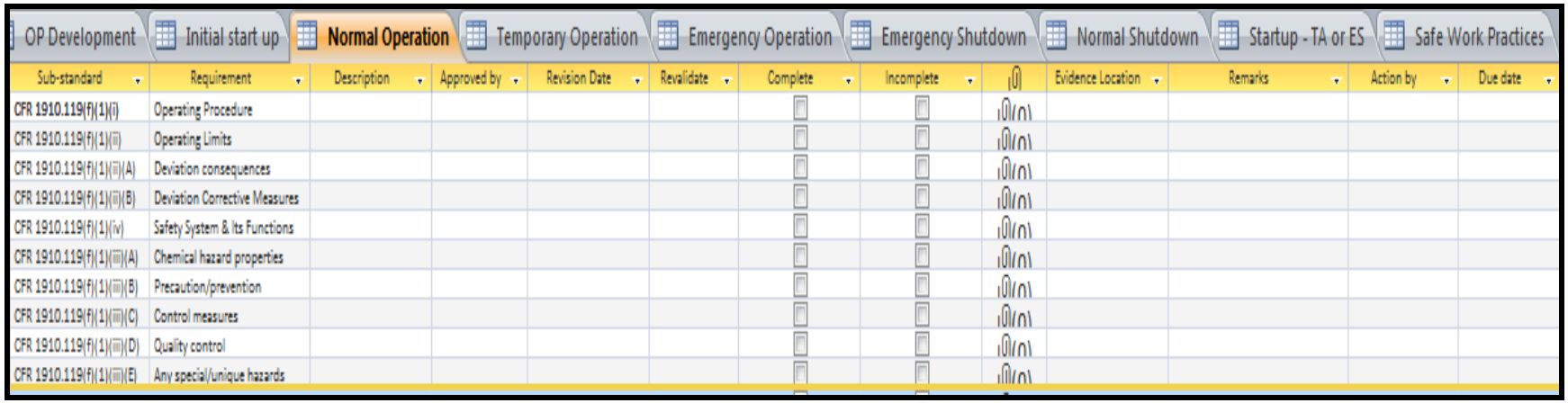
In brief, gaps for Operating Procedures that was found on Node 1 that explained as above can be overcome by taking further action such as provides a complete OP documentation for all operating phases, ensure document validity, attach required documents and also develop module for safe work practices that are not available for V-1.



OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to LTU Start Up/Section 3.3	BHO	12-Dec-11	12-Dec-14	☑	☐	0/1	C:\OPMS Database\AMINEX\OPP\StartUp	Update annually	AY	12-Dec-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to LTU Start Up/Section 3.3	BHO	12-Dec-11	12-Dec-14	☑	☐	0/1	C:\OPMS Database\AMINEX\OPP\StartUp	Update annually	AY	12-Dec-12
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	0/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	0/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	0/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

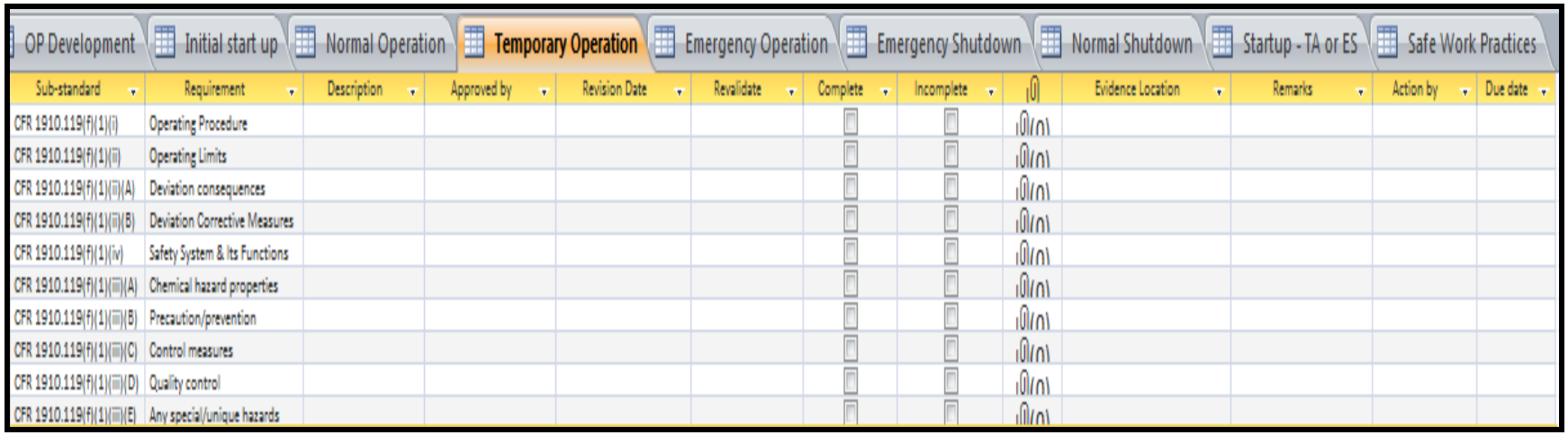
Figure 4.5 Amine System: Initial Start-up of OPMS



OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

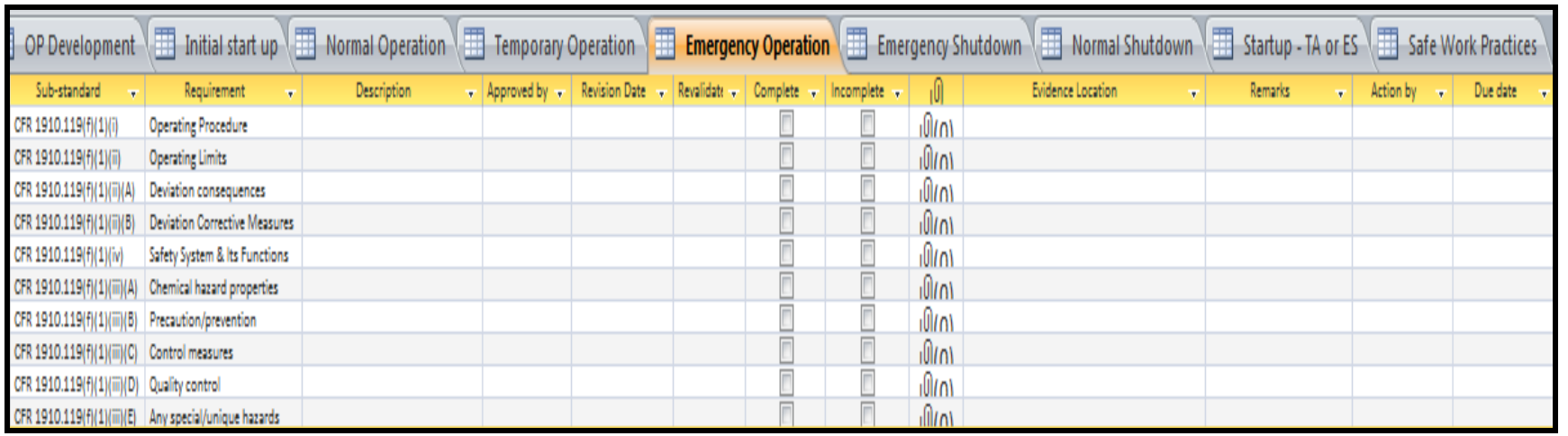
Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure					☐	☐	0/0				
CFR 1910.119(f)(1)(ii)	Operating Limits					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures					☐	☐	0/0				
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(C)	Control measures					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(D)	Quality control					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards					☐	☐	0/0				

Figure 4.6 Amine System: Normal Operation



Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure											
CFR 1910.119(f)(1)(ii)	Operating Limits											
CFR 1910.119(f)(1)(ii)(A)	Deviation consequences											
CFR 1910.119(f)(1)(ii)(B)	Deviation Corrective Measures											
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions											
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties											
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention											
CFR 1910.119(f)(1)(iii)(C)	Control measures											
CFR 1910.119(f)(1)(iii)(D)	Quality control											
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards											

Figure 4.7 Aminex System: Temporary Operation



Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure											
CFR 1910.119(f)(1)(ii)	Operating Limits											
CFR 1910.119(f)(1)(ii)(A)	Deviation consequences											
CFR 1910.119(f)(1)(ii)(B)	Deviation Corrective Measures											
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions											
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties											
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention											
CFR 1910.119(f)(1)(iii)(C)	Control measures											
CFR 1910.119(f)(1)(iii)(D)	Quality control											
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards											

Figure 4.8 Aminex System: Emergency Operation

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | **Emergency Shutdown** | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplet		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to Emergency Shutdown due to fire/Section 1.0	BHO	4-Mar-11	4-Mar-11	☑	☐	1/1	C:\OPMS DatabaseAMINEX\OPP\Emergency Shutdown	Update annually	AY	4-Mar-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to Operating Manual/ Section 3.1	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(ii)(A)	Deviation consequences	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(ii)(B)	Deviation Corrective Measures	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

Figure 4.9 Aminex System: Emergency Shutdown

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | **Normal Shutdown** | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to LTU Shutdown/Section 5.0	BHO	30-May-11	30-May-14	☑	☐	1/1	C:\OPMS Database\Aminex\OPP\Shutdown	Update annually	AKAB	30-May-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to Operating Manual/Section 3.1	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(ii)(A)	Deviation consequences	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(ii)(B)	Deviation Corrective Measures	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

Figure 4.10 Aminex System: Normal Shutdown

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | **Startup - TA or ES** | Safe Work Practices

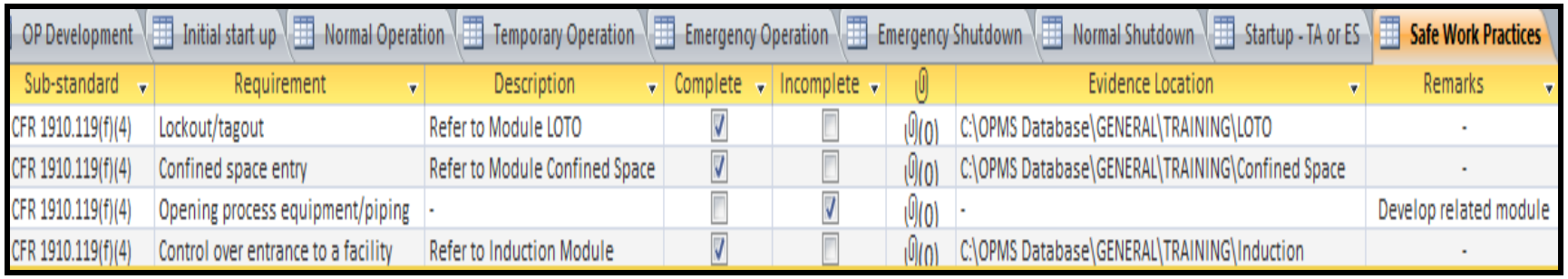
Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure					☐	☐	0/0				
CFR 1910.119(f)(1)(ii)	Operating Limits					☐	☐	0/0				
CFR 1910.119(f)(1)(ii)(A)	Deviation consequences					☐	☐	0/0				
CFR 1910.119(f)(1)(ii)(B)	Deviation Corrective Measures					☐	☐	0/0				
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(C)	Control measures					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(D)	Quality control					☐	☐	0/0				
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards					☐	☐	0/0				

Figure 4.11 Aminex System: Start-up following a turnaround or emergency shutdown

iii) Safe work practices CFR 1910.119(f)(4)

The last requirement of OP element stated in OSHA PSM is the existence of safe work practices that applies to all end users. These safe work practices must be developed and implemented to ensure the control of hazards during operations. Similar to operating phases discussed earlier, interface for safe work practices has similar features as other OP. However, there are only four sub-standards required for safe work practices which are; lockout/tagout, confined space entry, opening process equipment/piping and last but not least, control over entrance to a facility by working personnel.

Authorized personnel must check whether the information required are already completed or have not completed yet. The person must fill in 'Evidence Location' tab to monitor and track the documents. Apart from storing data inside the database, the system also allows information to be kept in hardcopy folder such as logbook, reports and so on. The experts or the responsible person must assess each of the requirement items qualitatively and incorporated comments have to be filled in the 'Remarks' column. This can be captured in Figure 4.12.


OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Complete	Incomplete	(0)	Evidence Location	Remarks
CFR 1910.119(f)(4)	Lockout/tagout	Refer to Module LOTO	☑	☐	(0)	C:\OPMS Database\GENERAL\TRAINING\LOTO	-
CFR 1910.119(f)(4)	Confined space entry	Refer to Module Confined Space	☑	☐	(0)	C:\OPMS Database\GENERAL\TRAINING\Confined Space	-
CFR 1910.119(f)(4)	Opening process equipment/piping	-	☐	☑	(0)	-	Develop related module
CFR 1910.119(f)(4)	Control over entrance to a facility	Refer to Induction Module	☑	☐	(0)	C:\OPMS Database\GENERAL\TRAINING\Induction	-

Figure 4.12 Aminex System: Safe work practices

4.4.2 Case Study 2: OPMS for Caustic System

Similar to Amine System, the same workflow applies for Caustic System. By following the framework in Figure 3.2, Author proceeds to the next stage which is to conduct and update Operating Procedures documentation for V-4 in Study Node 4, as the chosen equipment for study purpose. Figure 4.13 shows the part of the overall P&ID showing Caustic Section.

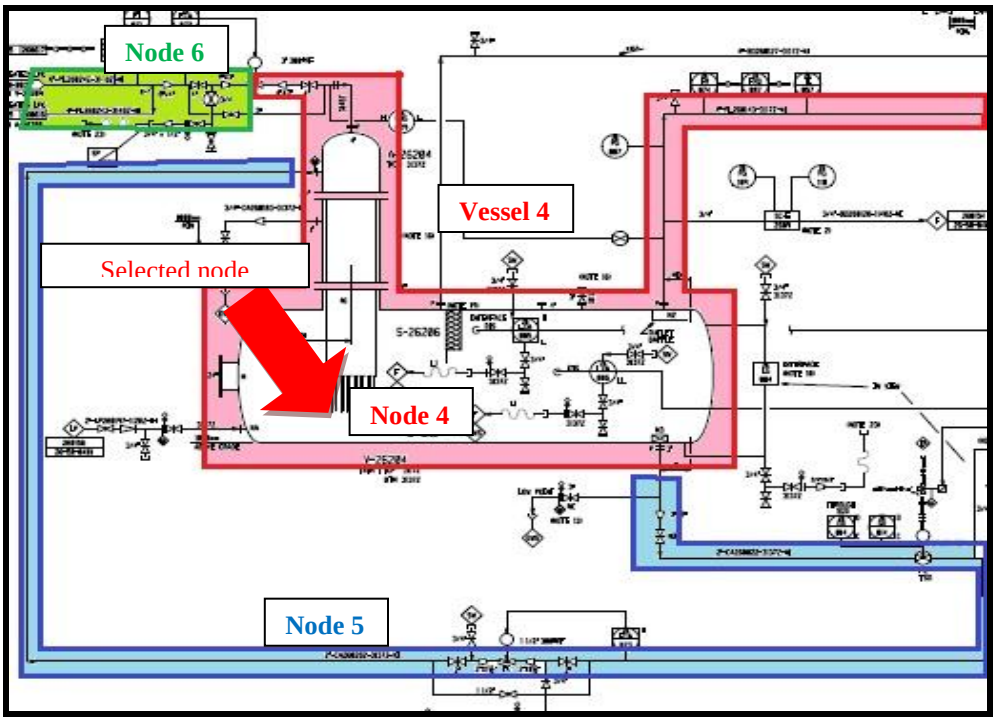


Figure 4.13 Part of the overall P&ID showing Caustic Section

Since OPMS model works the same for all case studies, Author will directly provide a series of screenshots for OP analysis that was conducted on V- 4 for Caustic System.

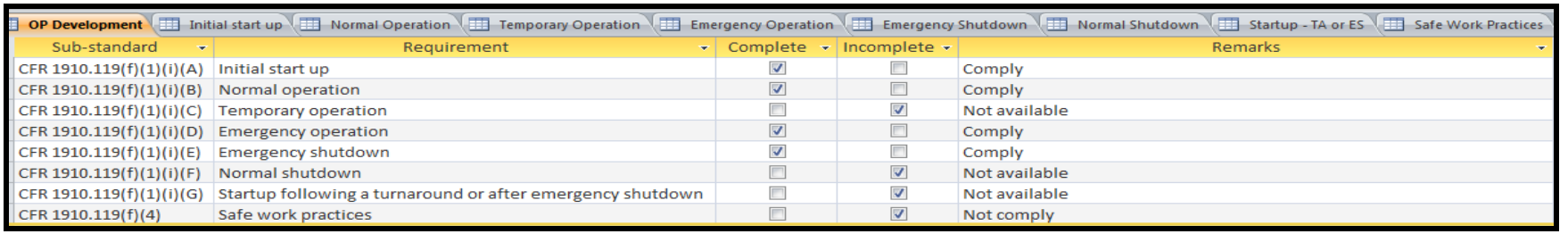
Based on study conducted on Node 4, there are a few operating phases that is found to be incomplete. Three operating phases are not available for V-4 such as temporary operation, normal shutdown and start-up following turnaround. This might be due to the reason that all of these operating phases are not applicable for the vessel itself.

Among the gaps that are found and captured in the ‘Remarks’ column is that, the existed operating procedures need to be updated annually. The management of Plant X has scheduled to review OP documentation almost every three years but OSHA PSM standard has stated that written operating procedures must be updated annually to maintain its validity. Therefore, authorized personnel must suggest a new suitable date in the ‘Due Date’ column to provide up-to-date document as intended by OSHA.

In the Chemical Safety Datasheet (CSDS), it contains the sub-standard for safety and health consideration, CFR 1910.119(f)(1)(iii). However, it was found that the CSDS for V-4 is not available. Although it might be existed but Plant X is not able to provide in their online database system. Authorized personnel have to take action and attach the required chemical safety datasheet for future reference.

Apart from that, requirements for Safe Work Practices has not been fulfilled as specified in CFR 1910.119(f)(4). This is due to document unavailability for opening process equipment or piping. However, this can be solved by developing the module for the specific safe work practices and once it has been approved, all the information must be updated in the system by authorized personnel.

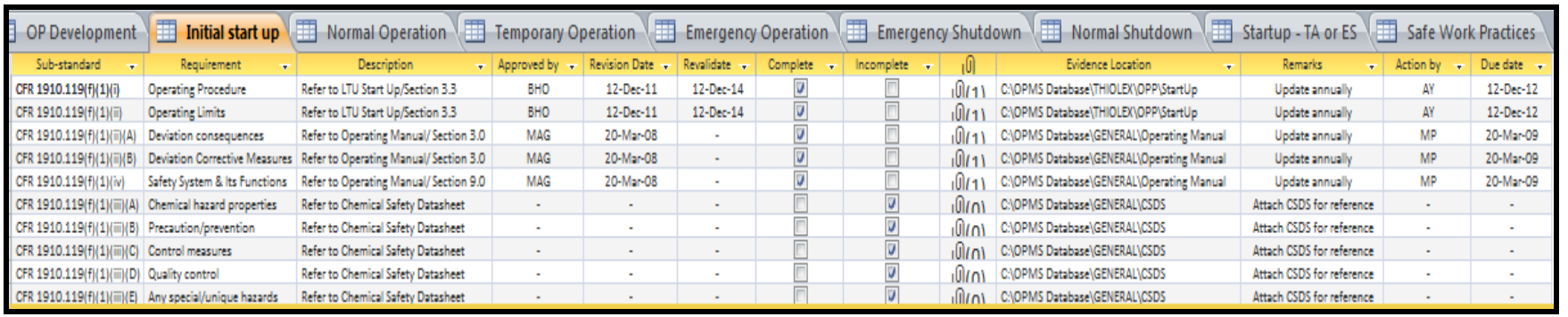
In short, all the gaps found for V-4 in Study Node 4 can be minimize by taking proper actions as suggested in the ‘Remarks’ column. Operating Procedures documentation for V-4 can be updated by reviewing OP regularly to maintain its annual validity, provide the required chemical safety datasheet and last but not least, ensure the module for Safe Work Practices are all available.



OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Complete	Incomplete	Remarks
CFR 1910.119(f)(1)(i)(A)	Initial start up	☑	☐	Comply
CFR 1910.119(f)(1)(i)(B)	Normal operation	☑	☐	Comply
CFR 1910.119(f)(1)(i)(C)	Temporary operation	☐	☑	Not available
CFR 1910.119(f)(1)(i)(D)	Emergency operation	☑	☐	Comply
CFR 1910.119(f)(1)(i)(E)	Emergency shutdown	☑	☐	Comply
CFR 1910.119(f)(1)(i)(F)	Normal shutdown	☐	☑	Not available
CFR 1910.119(f)(1)(i)(G)	Startup following a turnaround or after emergency shutdown	☐	☑	Not available
CFR 1910.119(f)(4)	Safe work practices	☐	☑	Not comply

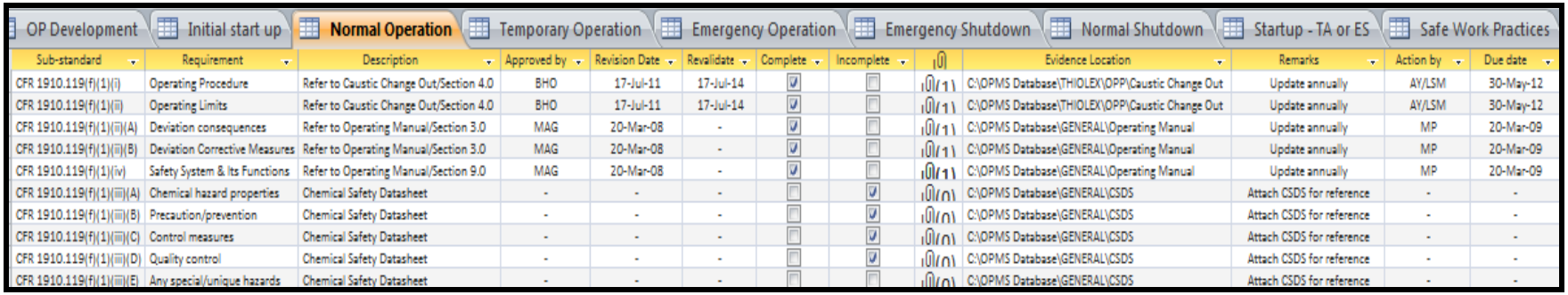
Figure 4.14 Caustic System: Development of OP



OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to LTU Start Up/Section 3.3	BHO	12-Dec-11	12-Dec-14	☑	☐	1/1	C:\OPMS Database\THIOLEX\OPP\StartUp	Update annually	AY	12-Dec-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to LTU Start Up/Section 3.3	BHO	12-Dec-11	12-Dec-14	☑	☐	1/1	C:\OPMS Database\THIOLEX\OPP\StartUp	Update annually	AY	12-Dec-12
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

Figure 4.15 Caustic System: Initial Start-up



OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to Caustic Change Out/Section 4.0	BHO	17-Jul-11	17-Jul-14	☑	☐	1/1	C:\OPMS Database\THIOLEX\OPP\Caustic Change Out	Update annually	AY/LSM	30-May-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to Caustic Change Out/Section 4.0	BHO	17-Jul-11	17-Jul-14	☑	☐	1/1	C:\OPMS Database\THIOLEX\OPP\Caustic Change Out	Update annually	AY/LSM	30-May-12
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences	Refer to Operating Manual/Section 3.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures	Refer to Operating Manual/Section 3.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/Section 9.0	MAG	20-Mar-08	-	☑	☐	1/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Chemical Safety Datasheet	-	-	-	☐	☑	0/1	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Chemical Safety Datasheet	-	-	-	☐	☐	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

Figure 4.16 Caustic System: Normal Operation

OP Development | Initial start up | Normal Operation | **Temporary Operation** | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete	Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure					☐	☐				
CFR 1910.119(f)(1)(ii)	Operating Limits					☐	☐				
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences					☐	☐				
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures					☐	☐				
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions					☐	☐				
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties					☐	☐				
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention					☐	☐				
CFR 1910.119(f)(1)(iii)(C)	Control measures					☐	☐				
CFR 1910.119(f)(1)(iii)(D)	Quality control					☐	☐				
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards					☐	☐				

Figure 4.17 Caustic System: Temporary Operation

OP Development | Initial start up | Normal Operation | Temporary Operation | **Emergency Operation** | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidat	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to Instrument Air Failure/Section 1.0	BHO	1-Jul-12	1-Jul-15	☑	☐	0/1	C:\OPMS Database\THIOLEX\OPP\Instrument Air Failure	Update annually	JML	4-Jul-13
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to Operating Manual/Section 2.1, 3.2	MAG	20-Mar-08	-	☑	☐	0/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences	Refer to Hazop Worksheet/Page 19-24	-	15-Aug-12	-	☑	☐	0/1	C:\OPMS Database\GENERAL\HAZOP Worksheet	-	-	-
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures	Refer to Hazop Worksheet/Page 19-24	-	15-Aug-12	-	☑	☐	0/1	C:\OPMS Database\GENERAL\HAZOP Worksheet	-	-	-
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/Section 9.4.1.5	MAG	20-Mar-08	-	☑	☐	0/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

Figure 4.18 Caustic System: Emergency Operation

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | **Emergency Shutdown** | Normal Shutdown | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to Emergency Shutdown due to fire/Section 1.0	BHO	4-Mar-11	4-Mar-11	☑	☐	0/1	C:\OPMS Database\THIOLEX\OPP\Emergency Shutdown	**Update annually**	AY	11-Apr-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Not available	-	-	-	☐	☑	0/0	-	To prove document is exist	-	-
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences	Not available	-	-	-	☐	☑	0/0	-	To prove document is exist	-	-
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures	Not available	-	-	-	☐	☑	0/0	-	To prove document is exist	-	-
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/Section 9.1	MAG	20-Mar-08	-	☑	☐	0/1	C:\OPMS Database\GENERAL\Operating Manual	Update annually	-	-
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	-	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	-	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	-	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	-	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0/0	-	Attach CSDS for reference	-	-

Figure 4.19 Caustic System: Emergency Shutdown

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | **Normal Shutdown** | Startup - TA or ES | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure	Refer to LTU Shutdown/Section 5.0	BHO	30-May-11	30-May-14	☑	☐	0	C:\OPMS Database\THIOLEX\OPP\Shutdown	Update annually	AKAB	30-May-12
CFR 1910.119(f)(1)(ii)	Operating Limits	Refer to Operating Manual/Section 3.1	MAG	20-Mar-08	-	☑	☐	0	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	0	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures	Refer to Operating Manual/ Section 3.0	MAG	20-Mar-08	-	☑	☐	0	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions	Refer to Operating Manual/ Section 9.0	MAG	20-Mar-08	-	☑	☐	0	C:\OPMS Database\GENERAL\Operating Manual	Update annually	MP	20-Mar-09
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(C)	Control measures	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(D)	Quality control	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards	Refer to Chemical Safety Datasheet	-	-	-	☐	☑	0	C:\OPMS Database\GENERAL\CSDS	Attach CSDS for reference	-	-

Figure 4.20 Caustic System: Normal Shutdown

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | **Startup - TA or ES** | Safe Work Practices

Sub-standard	Requirement	Description	Approved by	Revision Date	Revalidate	Complete	Incomplete		Evidence Location	Remarks	Action by	Due date
CFR 1910.119(f)(1)(i)	Operating Procedure					☐	☐	0				
CFR 1910.119(f)(1)(ii)	Operating Limits					☐	☐	0				
CFR 1910.119(f)(1)(iii)(A)	Deviation consequences					☐	☐	0				
CFR 1910.119(f)(1)(iii)(B)	Deviation Corrective Measures					☐	☐	0				
CFR 1910.119(f)(1)(iv)	Safety System & Its Functions					☐	☐	0				
CFR 1910.119(f)(1)(iii)(A)	Chemical hazard properties					☐	☐	0				
CFR 1910.119(f)(1)(iii)(B)	Precaution/prevention					☐	☐	0				
CFR 1910.119(f)(1)(iii)(C)	Control measures					☐	☐	0				
CFR 1910.119(f)(1)(iii)(D)	Quality control					☐	☐	0				
CFR 1910.119(f)(1)(iii)(E)	Any special/unique hazards					☐	☐	0				

Figure 4.21 Caustic System: Start-up following a turnaround or emergency shutdown

OP Development | Initial start up | Normal Operation | Temporary Operation | Emergency Operation | Emergency Shutdown | Normal Shutdown | Startup - TA or ES | **Safe Work Practices**

Sub-standard	Requirement	Description	Complete	Incomplete		Evidence Location	Remarks
CFR 1910.119(f)(4)	Lockout/tagout	Refer to Module LOTO	☑	☐	1	C:\OPMS Database\GENERAL\TRAINING\LOTO	-
CFR 1910.119(f)(4)	Confined space entry	Refer to Module Confined Space	☑	☐	1	C:\OPMS Database\GENERAL\TRAINING\Confined Space	-
CFR 1910.119(f)(4)	Opening process equipment/piping	-	☐	☑	0	-	Develop related module
CFR 1910.119(f)(4)	Control over entrance to a facility	Refer to Induction Module Staff & Contractor	☑	☐	2	C:\OPMS Database\GENERAL\TRAINING\Induction	-

Figure 4.22 Caustic System: Safe work practices

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

This project proposes a systematic method for a smooth management of operating procedure at a process plant in order to comply with PSM OP CFR 1910.119(f). Several objectives of this study which is to analyse PSM requirements for Operating Procedures, developing framework for Operating Procedures and developing database prototype tool has assisted end-users to easily track information and documents, determine gaps and provide quick solutions in a structured manner according to OP of PSM requirements as captured in Remarks column of every OPMS interfaces.

Although analysing industrial data took some time to achieve the intended objective, yet the proposed system of Operating Procedure Management System is proven to be user-friendly, practical and has the potential to be commercialized in any process industry.

As a conclusion, the applied Operating Procedures tool for PSM technique designed in this study may aid industry in their efforts towards safe operation and prevention of catastrophic incidents in the workplace and surrounding community.

Recommendations:

1. Apart from Operating Procedures, similar research should be studied for the other thirteen (13) PSM elements and combine them together into one specific database system to ensure effective implementation of Process Safety Management program.

2. Continuous research should be conducted at Plant X or at any other process industries while given a longer time frame to study Operating Procedures CFR 119.1910(f) more process units and/or major process equipment.

3. Responsible custodian must develop and maintain high security for the expert system to prevent information break-outs by irresponsible individuals.

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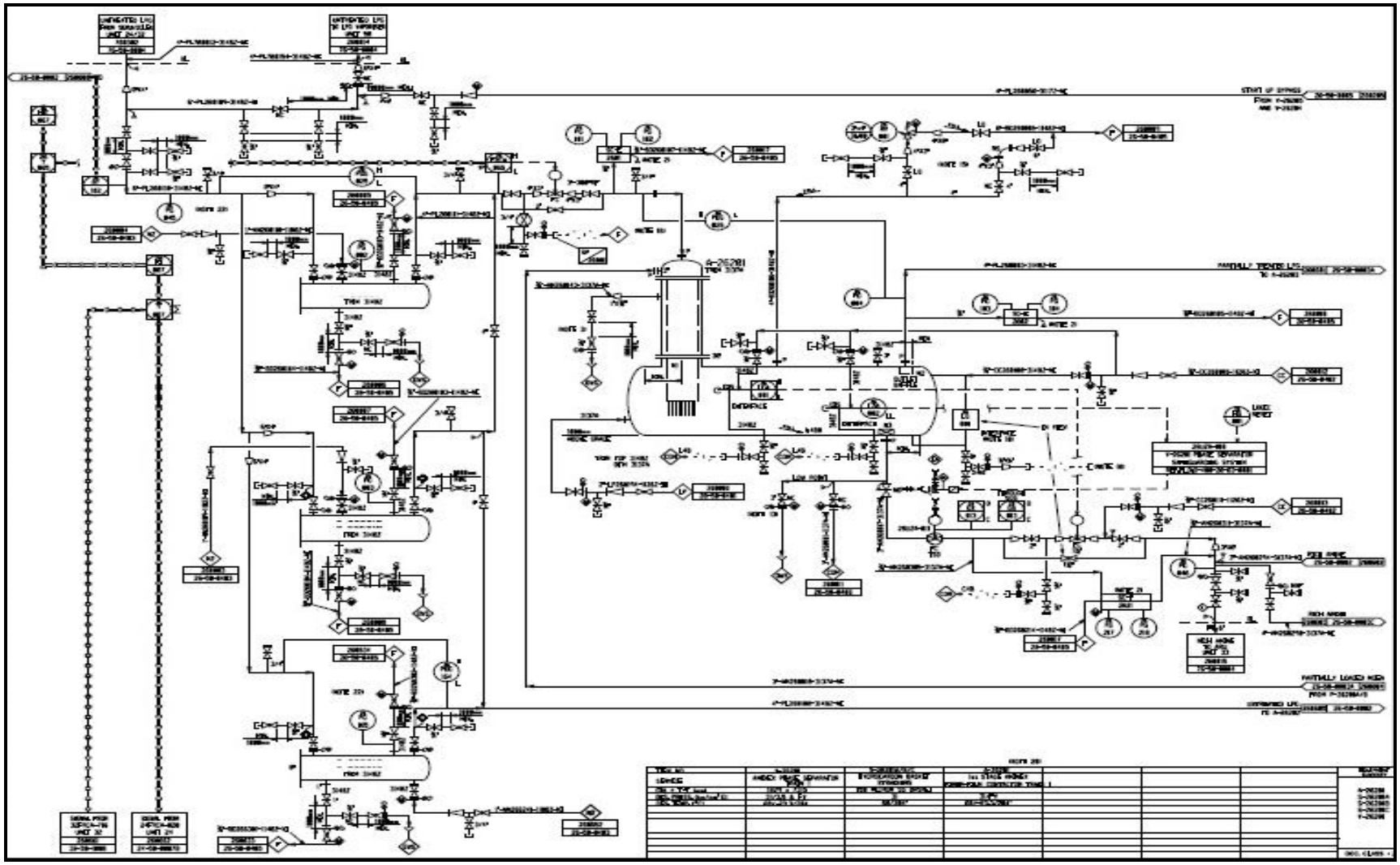
APPENDICES

Appendix 1: Overall P&ID for Aminex System



Appendix 2: Overall P&ID for Thiolex System