Development of Process Safety Management System (PSMS) for Process Industries Implementation: Mechanical Integrity (MI)

By

Mazlinda Binti Muhamad

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(Chemical Engineering)

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UNIVERSITI TEKNOLOGI PETRONAS

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CERTIFICATION OF APPROVAL

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Chemical Engineering Programme
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Approved by,

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(AP. DR. Azmi Mohd. Shariff)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
September 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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MAZLINDA BINTI MUHAMAD

ABSTRACT

Accident is one of the big issues that occur repeatedly in the process industries today though there is numerous application of the variety safeguarding measures that have been introduced. Equipment failure is identified as one of the root causes of these major accidents. One of the established standards that address the above issue is Mechanical Integrity (MI) element of Process safety Management System (PSM) 29 CFR 1910.119 (j). It is believed that most of the process industries already recognized the standard but unavailability of effective technique to implement the PSM elements had delay the implementation of this standard. This research study is conducted to introduce a systematic technique to implement MI elements of PSM in process industries to achieve high level of safety in workplace as well as to prevent any accident. This study covered analysis of requirements of the standard, development of framework and prototype tool as well as concept validation through case study from real process plant data. Implementation of this technique will help employer to control the hazards and minimize process hazards that could prevent major accidents such as fire, explosion and toxic release and compliance with the PSM standard simultaneously.

ACKNOWLEDGEMENTS

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A heartfelt appreciation is extended to Refinery X for allowing me to use and utilize the data from the process plant in order to prove the concept validation of the system hence make the system effectively proven. Finally, not to forget to Universiti Teknologi PETRONAS and also fellow friends who cared to offer tips, advice and cooperation towards completing this project. Thank you so much for all of your kindness.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Most of the reported accidents in industries resulted from human factor. Humans are the one who govern and accomplish all of the activities necessary to control the risk of accidents. Human not only cause accidents (unintentionally) by making errors related to the process itself, but they also contribute to error by creating deficiencies in the design of the equipment and the implementation of management systems. Because of that, it may contribute to the equipment failure and consequently lead to accident. Process safety is all about controlling risk of failures and errors; the concern of controlling risk is primarily about reducing the risk from human. All elements in Process Safety Management (PSM) in return help to reduce the chance of human error or else help to limit the impact of human error in order to prevent catastrophic releases of hazardous substances that lead to any accident.

PSM standard has 14 specific interrelated management elements that need to be implemented to prevent catastrophic releases of hazardous substances. These include Process Hazard Analysis (PHA), Pre-Startup Safety Review (PSSR), Operating Procedures (OP), Mechanical Integrity (MI), Process Safety Information (PSI), and Management of Change (MOC), Training, Hot Work Permit, Employee Participation, Contractors, Incident Investigation, Emergency Planning & Response, Trade Secrets and Compliance Audits. This project is focusing only on Mechanical integrity (MI) 29 CFR 1910.119(j) element of PSM. Though PSM has been introduced, in particular time, the accidents still happen in the process industries. Deficiency in implementation of the MI element of PSM had contributed to the highlighted issue. Thus there is a need to develop a systematic system for easy implementation of MI element in order to provide a safe workplace in process industries.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

Unexpected thing never alarmed us. Many cases of unexpected releases of flammable liquids and gases, reactive materials, and toxic in processes that involve highly hazardous chemicals that killed workers and cause injuries have been reported for many years. Regardless of the industry that uses these highly hazardous chemicals, there is a possibility for an accidental release at any time if they are not properly managed and controlled. In return, it creates the possibility of disaster. Before it brings in the unwanted tragedy, prevention is better than cure.

PSM 29 CFR 1910.119 has been introduced in the process industries to ensure the process facilities that have hazardous chemicals on site are operated safely. However, a major challenge is unavailability of easy technique for industries to implement PSM and comply with the requirements. PSM standard was not properly understand and followed by employer. In addition the identified hazards information was not accessible by effected personnel. Thus the implemented safety program was misleading to control and minimize the hazards and risk within process plant.

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1.2.2 Significance of the Project

This project is significant to assist the process industries in order to have a better implementation technique of PSM in preventing the catastrophic accidents that lead to loss of life, significant property loss, as well as damage to the environment. The introduced well-structured technique hopefully can benefit the end users priority to the safety at the workplace.

1.3 OBJECTIVE AND SCOPE OF STUDY

The objectives of the project are stated as below:

i. To analyze the requirements for Mechanical Integration (MI) 29 CFR 1910.119(j)
ii. To establish framework of MI
iii. To develop prototype tool for easy explanation and implementation based on the framework and model.
iv. To conduct case studies for concept validation.

1.4 SCOPE OF STUDY

This project is a comprehensive research study about the development of Process Safety Management System (PSMS) for implementation in process industries focusing on the MI element of PSM. Analyze on the MI of PSM has been done through the study of the requirements and identifying a necessary documentation. This is followed by development of framework and model for the focused element. Then, the develop concept is transformed into computer database prototype system. To prove the validity of the system, case study is conducted using real process plant data.

1.5 RELEVANCY &FEASIBILITY OF THE PROJECT

The project is relevant to the process industries out there as the result that will be yielded from this project can be utilized by the industries to enhance the safety management system by implementing the introduced techniques approach to the elements of PSM in order to reduce the frequency of accidents in the workplace and perhaps to prevent the world's worst industrial disaster involving life of workers like one that occur in Bhopal, India. It is believed that with a strong will, this project is able to come into completion with a successful result.

CHAPTER 2

LITERATURE REVIEW

Major accidents have been defined as “an occurrence such as a major emission, fire or explosion resulting from uncontrolled developments in the course of the operation of any establishment and leading to serious danger to human health and/or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances” [1]. The recent major accidents or disasters that have been reported include the 1984 Bhopal, India which resulting in more than 2,000 deaths; the October 1989 Phillips Petroleum Company, Pasadena, TX incident resulting in 23 deaths and 132 injuries; the July 1990 BASF, Cincinnati, OH incident resulting in 2 deaths, and the May 1991 IMC, Sterlington, LA, incident resulting in 8 deaths and 128 injuries [2].

Definitely, there are the reasons behind all the accidents that happen in the process industries. Most of the studies stated that the main factors that lead to major accidents are equipment failure [3, 4] and human factor [5]. Figure 1 shows the immediate causes of accidents notified to Major Hazards Bureau in petrochemical sector for the 17 years period from 1985 to 2002. It represented that equipment failure was the major cause of the accidents with 44%. 40% of the major accidents notified have causes either exclusively (19%) or partially (21%) attributed to human factor. Natural phenomena like floods or thunderstorms and environment conditions like low temperature or humidity were the 7% of causes either directly (3%) or in combination with equipment failure (4%). In 9% of the cases, immediate causes have not yet been defined [6]. Same figure which indicate that equipment failure contribute to the highest factor in Petroleum industries is display in the Figure 2 [4].

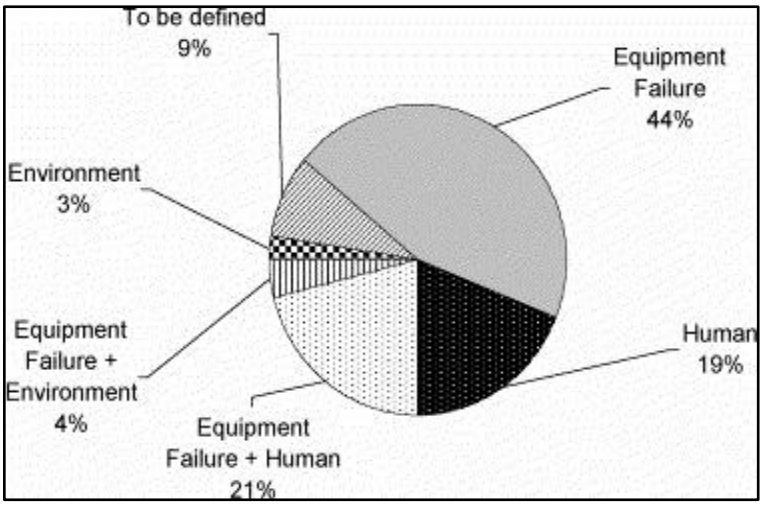


Figure 1: Immediate causes of accidents in the petrochemical industry for the period 1985–2002.

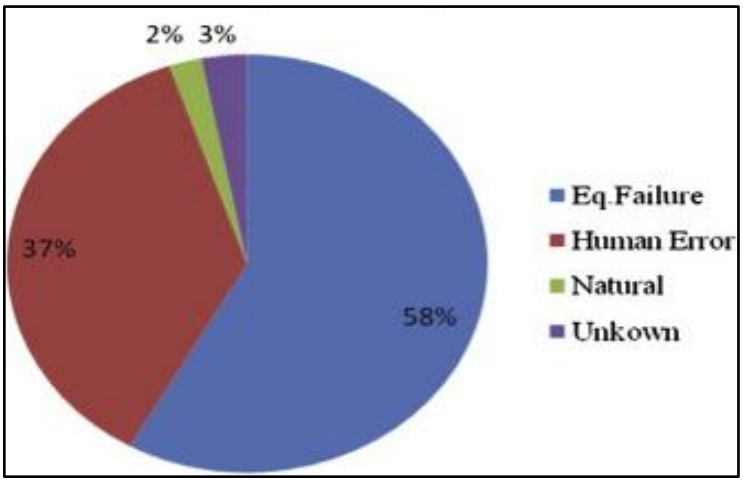


Figure 2: Different causes of failures leading to reported petroleum incidents (1994-2009).

In response to the major accidents that repeatedly occur worldwide, Occupational Safety & Health Administration (OSHA**)** has issued the Process Safety Management (PSM) of Highly Hazardous Chemicals standard (29 CFR 1910.119) in 1992 to help ensure safe and healthful workplaces. PSM is known to be a collection of management systems and their implementation with the purpose of controlling the risk

of major accidents; PSM focuses on preventing the accidents that originate from process hazards such as release and explosion of flammable gases or liquids, release of toxic, etc. [7].

In addition, a major accident in an industrial plant or in the transportation of a hazardous material is always originated by a loss of containment. The loss of containment possibly due to the catastrophic collapse or the explosion of a tank, the rupture of a pipe, a leak trough a flange, a hole or a safety valve, etc. [8]. Both equipment failure and loss of containment related to one of the elements of PSM which is Mechanical Integrity (MI). MI is the programming implementation of activities necessary to ensure that important equipment will be suitable for its intended application throughout the life of operation [9]. OSHA believes it is important to maintain the mechanical integrity of critical process equipment to ensure it is designed and installed correctly and operates properly. There is a great advantage for industries to comply with PSM regulation to prevent those accidents.

The PSM Standard states in 29 CFR 1910.119(j) (1) that the MI element is applicable to the following process equipment: i) Pressure vessels and storage tanks , ii) Piping systems (including piping components such as valves), iii) relief and vent systems and devices, iv) emergency shutdown systems, v) controls (including monitoring devices and sensor, alarms, and interlocks) and vi) pumps. The other 5 sub elements of MI that should be address are written procedures, training, inspection and testing, equipment deficiencies and Quality assurance (QA).

Nevertheless, the results of PSM audits show that MI receiving a large number of citations at most facilities which indicate that it has been a difficult element facility to implement. In some cases, it has been the last PSM element to be fully addressed [10]. Chemical national emphasis program (NEP) has tabulated the most cited PSM elements as in Table 1 below [11]. It shows that the MI element of PSM is the most frequently violated. The data gives indication that inadequate technique was apply in the industry

which contribute to the violation of the MI element. It is undeniable that MI programs have already existed in the process industry but there is some lacking where the complete integrated MI management system programs that address all of the sub-elements of MI cannot be achieved. Furthermore, the performance-based regulatory and voluntary consensus of the MI element of the PSM standard presents their requirements in very broad and hard-to-interpret language [12].

Table 1: Chemical national emphasis program (NEP) most frequently cited PSM elements [11].

Element	Description	Percentage of Total Violations (%)
J	Mechanical integrity (MI)	22.5
D	Process safety information (PSI)	21.6
E	Process hazard analysis (PHA)	17.9
F	Operating procedures (OP)	12.1
G	Operator training	4.4
L	Management of change (MOC)	4.3
H	Contractors	3.5
O	Compliance audits (CA)	3.5
C	Employee participation	3.0
M	Incident investigation (II)	2.5
N	Emergency planning and response	2.3
I	Prestartup review	1.6
K	Hot work	0.7

Most of the industries attempt to enhance the MI program but the problem is there is no proper technique introduced to them to establish and implement the program. For example, one case study has outlined the process used at the Super Octanos/ MTBE for the development of a highly successful MI. The major goal of the initiative was to develop an effective, reliable and practical mechanical integrity program in support of the company's overall asset management objectives. However, they have faced the major challenges which included the lack of existing guidelines for the development of a mechanical integrity program [13].

Typically, there are systems that already existed in managing the MI program. Computerized maintenance management system (CMMS) is one of the computer systems that are being used to manage the MI program in the industries [9]. CCMS used to accomplish the individual Inspection, testing and preventive maintenance (ITPM) task and equipment repair and replacement task. Besides, CCMS also frequently used to assist facilities with the QA of spare parts and maintenance material. Other additional features of CMMS that helpful are failure coding, cost tracking and report generation. In addition to the CCMS, there is other software that used to manage the aspect of MI; training management software, document management software and risk management software.

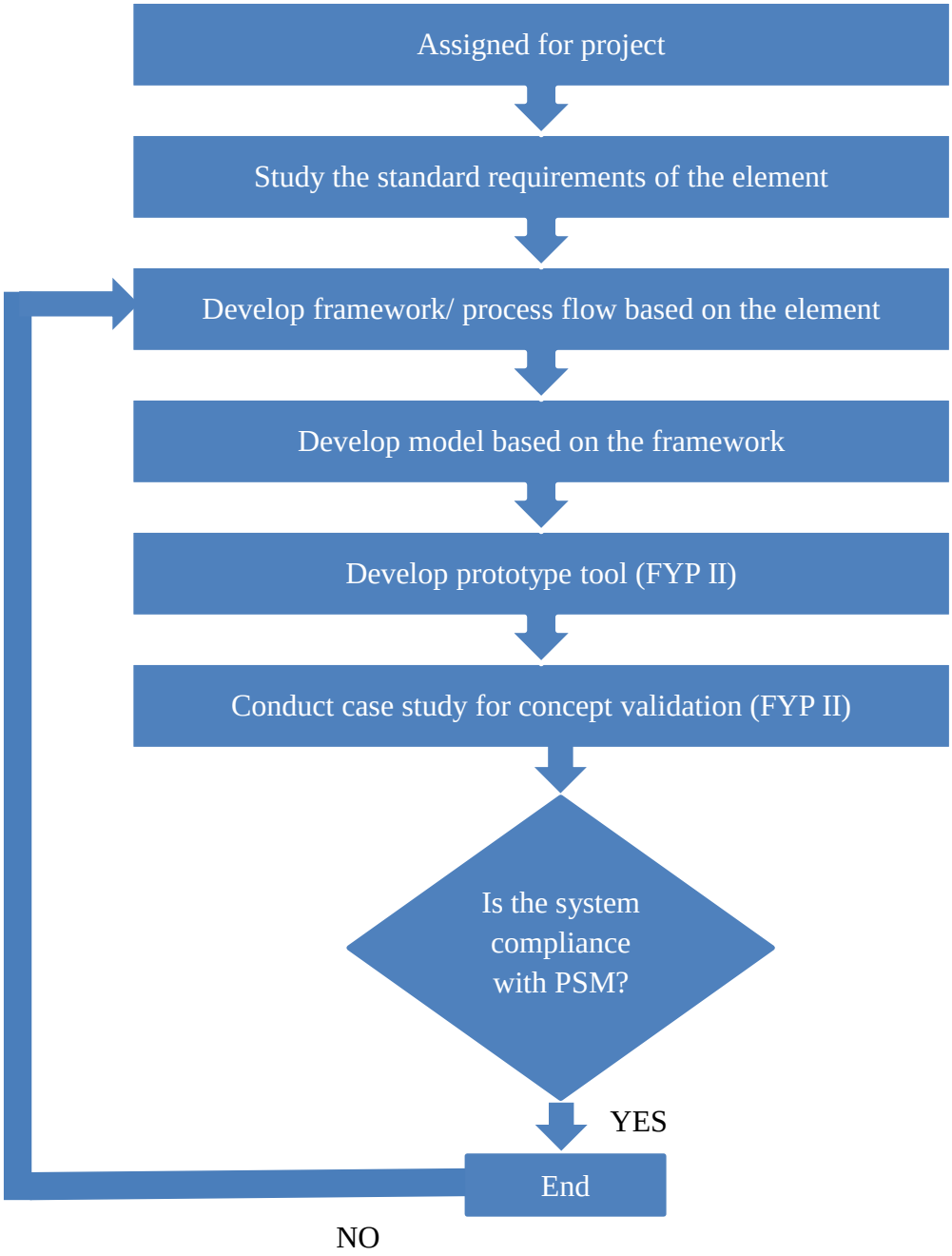
Besides, a number of sophisticated methods have been developed for managing the inspection program in the process industry since 1990s. These methods are known as risk-based inspections (RBIs) [14]. RBI method estimates a risk value for each equipment item resulting from the combination of the consequences of the failure and likelihood of the failure. RBI also required an adequate risk analysis. It should be implemented by a professional team and will not work well and not yield any advantage if the personnel are unskilled. Unfortunately, RBI gives benefits to the major industries only and not suitable to minor one since it is difficult to implement when there is unskilled personnel and poor understanding and evaluation of the risks. Furthermore CCPS 2006 [9] stated that RBI is not applied to other MI program activities.

The existent of systems in industries focus on certain sub-standard of the MI requirements only. Thus, a system that covers all the subs-standards in the MI should be implemented in a better way in order to comply with the PSM requirements since none of the above tools cover all the requirements of MI.

CHAPTER 3

METHODOLOGY

3.1 PROJECT ACTIVITIES



Stage I (Compliance with PSM standard)

Basically, the project is started with analyzing the requirements of the MI element of PSM standard. Analyzing MI requirements of PSM is important to discover the minimum requirements to comply with the MI standard. Once the requirements are properly interpreted, the framework or process flow has been developed compliance with the MI of PSM regulation. The framework illustrates step by step process that need to be perform according to the MI requirements.

Stage II (Development of PSMS for MI)

A model has been created using Microsoft Office Excel that represents the framework. Instead of Microsoft Excel, other computerized software which is Microsoft Office Access has been used in development of the database prototype tool for easy explanation of the developed concept and implementation of MI element. In this research study, Piping & Instrumentation Diagram (P&ID) is used as the basis to manage and trace the data related to MI. Using P&ID as an interface for this technique also could enhance end users' acceptance since it is commonly used in a process plant.

Stage III (Concept validation of study)

A case study was conducted to optimize and verify the develop system. A prove for the concept validation is required in encouraging the end users to implement this system. To have more impactful results in validating the concept, the real data from the process plant was used.

3.2 TOOLS REQUIRED

The main tools required in completing the project are as the following:

i. *Microsoft Office*

This software is used to present the framework and for the purpose of report writing.

ii. *Microsoft Office Excel*

This software is used for the development of the model as the main interface according to the framework/ process flow of the MI element.

iii. *Microsoft Office Access*

For the purpose of the database prototype system development, this software has been applied and used instead. This software is more practicable as it can import or link directly to data stored in other applications and databases. It is also flexible as it enables any changes for latest information provided by the end users.

3.3 GANTT CHART & KEY MILESTONES

For Final Year Project I (FYP I), the main activities are focusing on the searching for related resources for PSM implementation. Other than that, it is aiming on the 2 objectives of the project which are analyzing of the requirements of MI PSM as well as development of framework and the model. Table 2 shows the suggested milestone for the first semester of Final Year Project.

Table 2: Gantt chart for semester 1

Activities / Week	May		June				July				August			
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
First meeting with coordinator and supervisor							Mid semester break							
Preliminary research work (background, literature review, methodology)														
Submission of Extended Proposal Defence														
Proposal Defence														
Analyze the requirements of the MI element														
Development of framework and model for MI														
Submission of Interim Draft Report														
Submission of Interim Report														

For second semester, the project is more details on developing the prototype tool using Microsoft Access and concept validation through the case study conducted from real process plant data. Table 3 represents the Gantt chart for second semester.

Table 3: Gantt chart for second semester

Activities / Week	September		October				November				December				
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
Develop prototype tool using Microsoft Access							Mid semester break								
Collect industrial data															
Validate case study															
Submission of progress report															
Project work expansion • Analyze case study • Optimize prototype															
Pre-EDX															
Submission of draft report															
Submission of dissertation (soft bound)															
Submission of technical paper															
Oral presentation															
Submission of project dissertation (hard bound)															

CHAPTER 4

RESULTS & DISCUSSION

4.1 REQUIREMENTS FOR MI OF PSM

PSM standard has outlined 6 sub-elements of MI that need to be applied by process industries in managing the ongoing integrity of the industries. Table 4 shows the requirements of the MI element.

Table 4**:** Requirements of Mechanical Integrity (MI) element based on Process Safety Management (PSM) standard

Sub – elements	**Requirements**
Application CFR 1910.1199 (j) (1)(i-vi)	- Apply to: i. Pressure vessel & storage tank ii. Piping systems iii. Relief and vent systems and device iv. Emergency shutdown systems v. Controls (alarm, interlocks) vi. Pumps
Written procedures CFR 1910.1199 (j) (2)	- Should be established and implemented by employer to maintain on-going integrity.
Training for process maintenance activities CFR 1910.1199 (j) (3)	- Employer shall train each employee involved in o an overview of that process o its hazards o Procedures applicable to job task to assure that the employee can perform the job tasks in a safe manner

Inspection & testing CFR 1910.1199 (j) (4)(i-iv)	i. Should be performed on process equipment ii. Procedures follow RAGAGEPs iii. Consistent frequency of inspections & test iv. Proper documentation 1) Date of inspection 2) Inspectors name 3) Serial no. of equipment 4) Inspection methods 5) Inspection results
Equipment deficiency CFR 1910.1199 (j) (5)	- Correct deficiency before further use or in a safe and timely manner
Quality assurance CFR 1910.1199 (j) (6)(i-iii)	i. In the construction of new plant/equipment, assure that equipment as it is fabricated is suitable for process application. ii. Appropriate check and inspection performed during installation. iii. Assure maintenance materials, spare parts and equipment suitable for process application

4.2 FRAMEWORKS FOR MI OF PSM

4.2.1 Compliance with Mechanical Integrity (MI) 29 CFR 1910.119(j).

The frameworks of the project indicate that the process flow that need to be addressed in order to achieve the minimum requirements of the MI element of PSM standard. By having these frameworks, they provide a correct pathway for the development of model or prototype of the proposed technique. The framework in Figure 3 summarized the important information and strategy necessary to implement MI as required by CFR 1910.119(j).

As refer to the framework of MI implementation strategy, for the first step we need to check the application of the process equipment. Then, the equipment has to be identified whether it is existing or new equipment. For the existing equipment it has to follow CFR 1910.119(j) (2) until CFR 1910.119(j) (5). Meanwhile for new equipment, it has to pass the Quality Assurance requirement first before it can be installed in the plant. For the next cycle or next inspection, it has to undergo the same process as existing equipment.

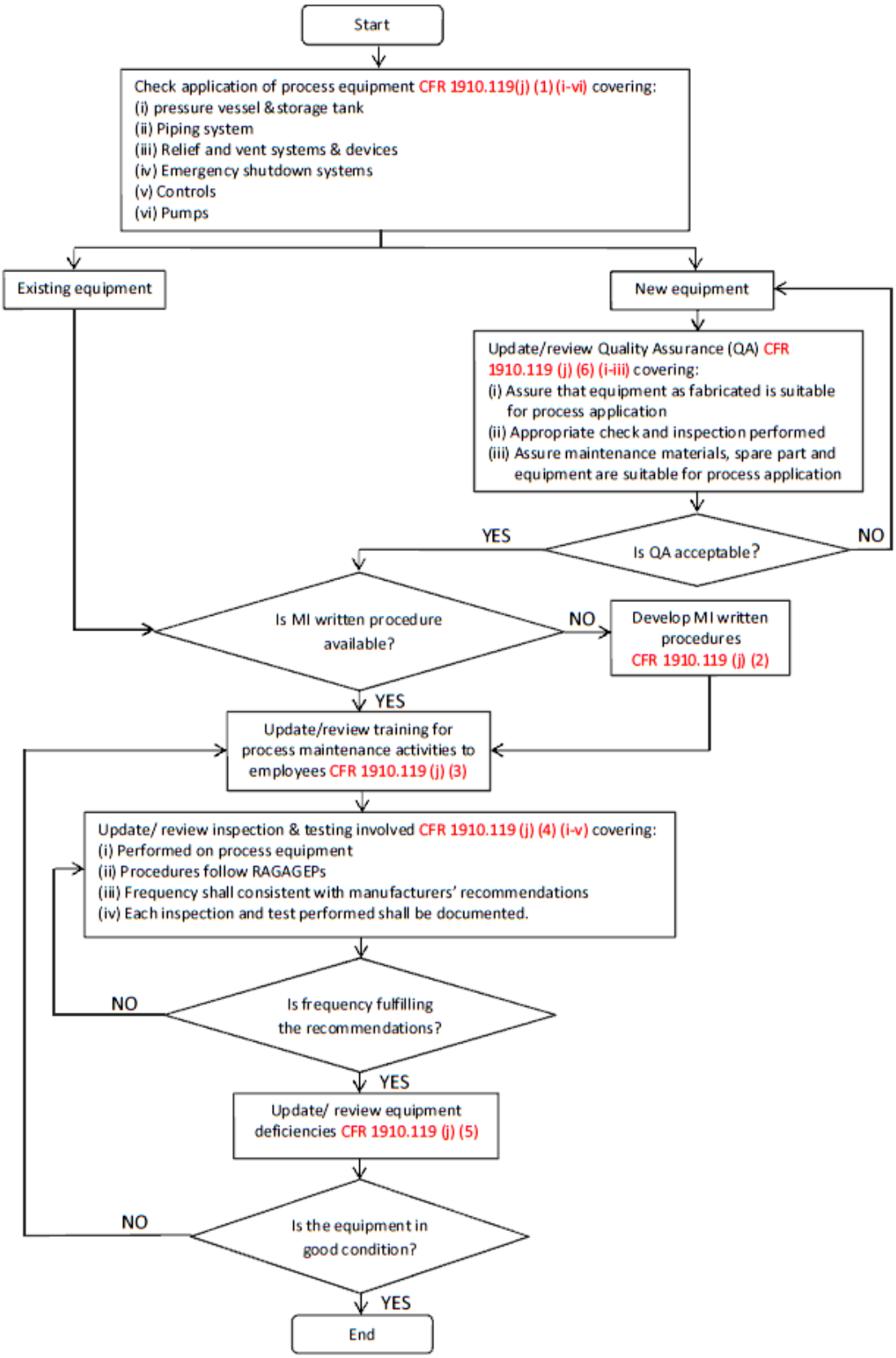


Figure 3: Framework of Mechanical Integrity (MI) Management based on CFR 1910.119 (j)

4.2.2 Using P&ID as Foundation for Data Management

P&ID is used as a foundation in managing and tracking the data for the concept validation of the MI implementation. For the ease of accessing the required data, the P&ID is divided into several nodes. The node is divided into the intended function of the unit. In the node itself, there will be several equipment or streams that need to be considered. Choose an equipment or stream and then perform the MI program. Once the information regarding the equipment or stream within the selected node has been reviewed or updated, the end users might choose another node. This process will continue until all nodes in the P&ID are completed.

The significant of using P&ID is that it prevents missing of data or MI program for the related equipment. Figure 4 shows the frameworks on how to apply or utilize P&ID in managing the MI element within the process plant.

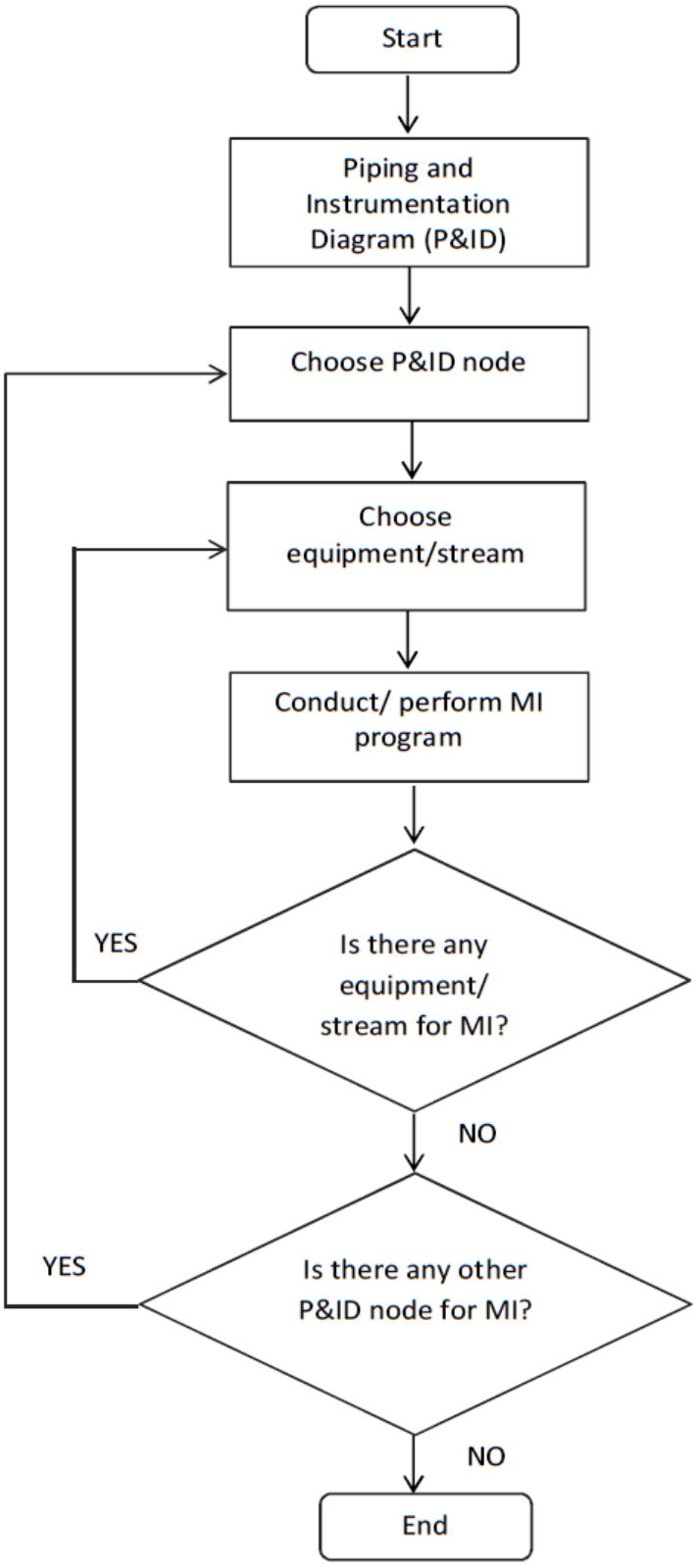


Figure 4: Framework of Mechanical Integrity (MI) using P&ID as a basis for the study.

4.3 CASE STUDY

For Final Year Project II (FYP II), the work continued with the development of prototype database management system named Mechanical Integrity Management System (MIMS) using Microsoft Access. For concept validation and demonstration, 2 case studies have been conducted utilizing real process plant data from refinery X involving existing and new equipment.

4.3.1 Case Study 1: Activated Carbon filter (V-5)

For demonstration, a case study for Activated Carbon Filter (V-5) using MIMS is illustrated. As referred to Figure 4, the P&ID is divided into several nodes according to design intention. Figure 5 shows the selected nodes for this case study, which consist of Activated Carbon Filter (V-5). The function of the V-5 is to remove free chlorine or organic compound in the water from the Feed Water Buffer Tank (T-5). The organics should be removed from the water to prevent common organic acids from reacting with the chlorine to form trihalomethanes which is a class of known carcinogens. The outlet of the filter will undergo another step of treatment before being used or discharged.

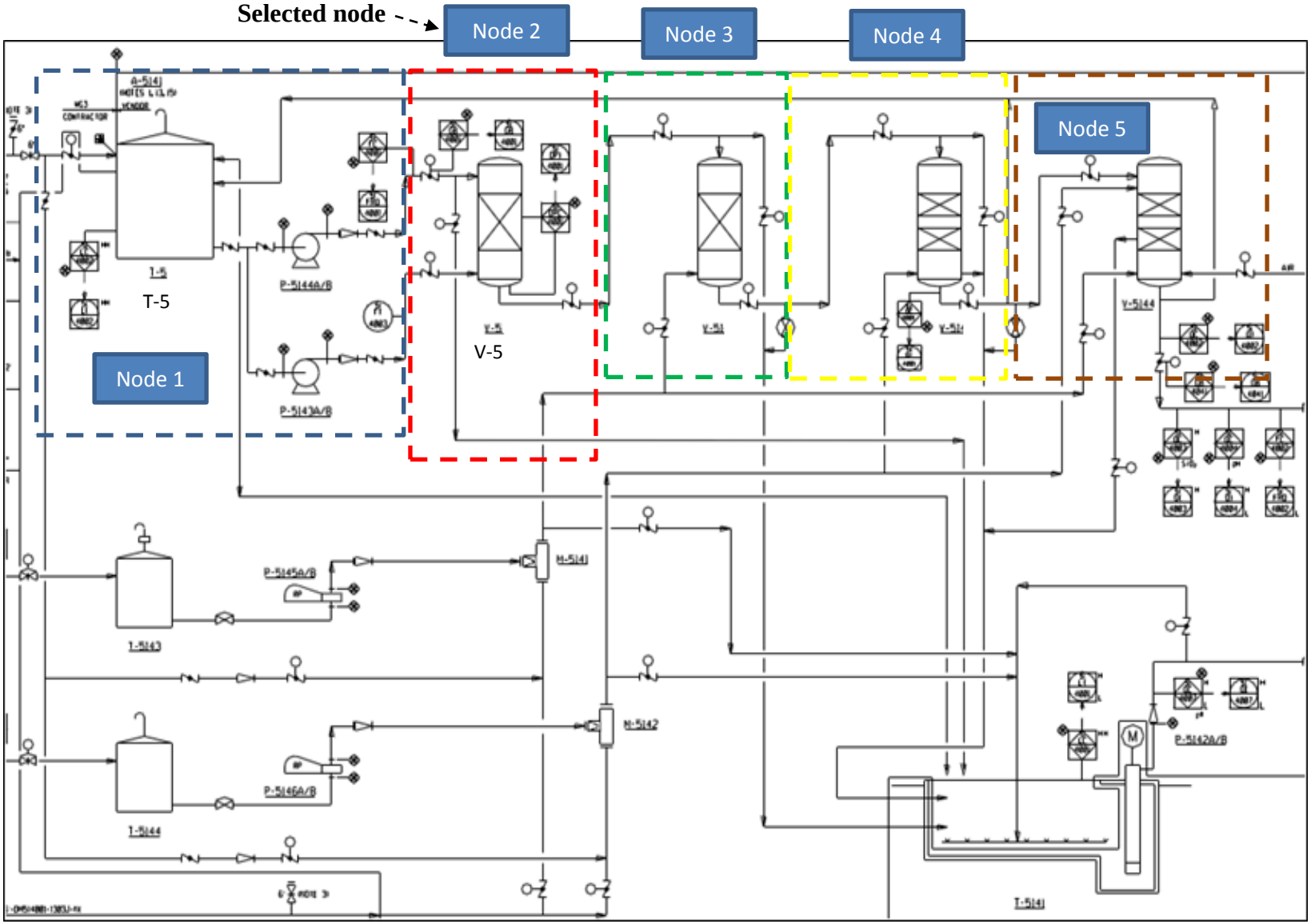


Figure 5: Part of overall P&ID diagram showing the Activated Carbon Filter (V-5)

4.3.1.1 MI application 29 CFR 1910.119(j)(1)(i-vi)

Under 29 CFR 1910.119(j)(1) provision, MI element is applicable to 6 process equipment including pressure vessel and storage tanks, piping systems, relief and vent systems and devices, emergency shutdown systems, controls, and pumps. However, when the standard mentions pressure vessels and storage tank, it no doubt that it included much more. Surely the standard means to include reactor, filters, furnaces, boilers, other heat exchangers, knock-out pots, and other smaller miscellaneous containers common within the industry though they were below 15 psig (104 KPa gauge) or not a storage tank [15]. Hence, the prototype has included the name of equipment as well as the equipment code as there would be different equipment under the designated sub-standard. Figure 6 shows the MI Application interface for MIMS which includes 'Sub-standard', 'Application', 'Equipment name' and 'Equipment code' columns.

MI application is the main interface for the MIMS since it is the first requirement that needs to be checked regarding MI of the PSM. In this case, Activated Carbon Filter with tag no.V-5 is categorized under Pressure vessel and storage tank, thus it is obliged to comply with 29 CFR 1910.119(j)(1)(i).

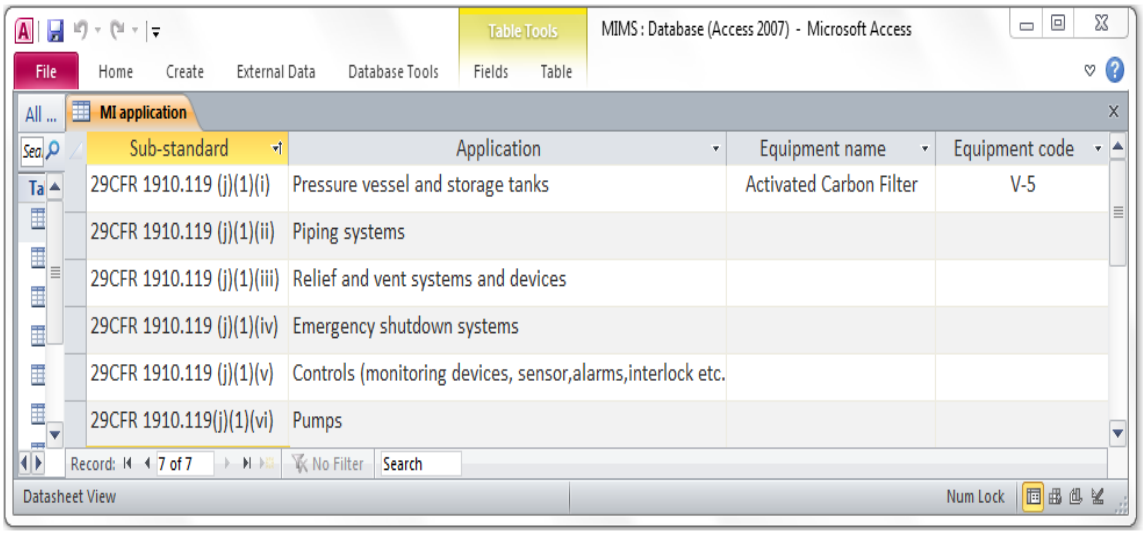


Figure 6: MI Application in MIMS for V-5

In MIMS, MI data management is comes afterward once MI application is determined. This is to make sure that the process equipment satisfies the entire requirement of the PSM standard. Based on the framework of structured technique in Figure 3, it is possible that all the sub-standards of MI can be assessed and monitored easily using data captured through computerized system that can be stored in a centralized database. MI Data management interface shows the overall status of the compiled data of selected node. Figure 7 illustrates the MI data management interface which consists of 'Sub-standard', 'Description', 'Complete', 'Incomplete' and 'Remarks' column.

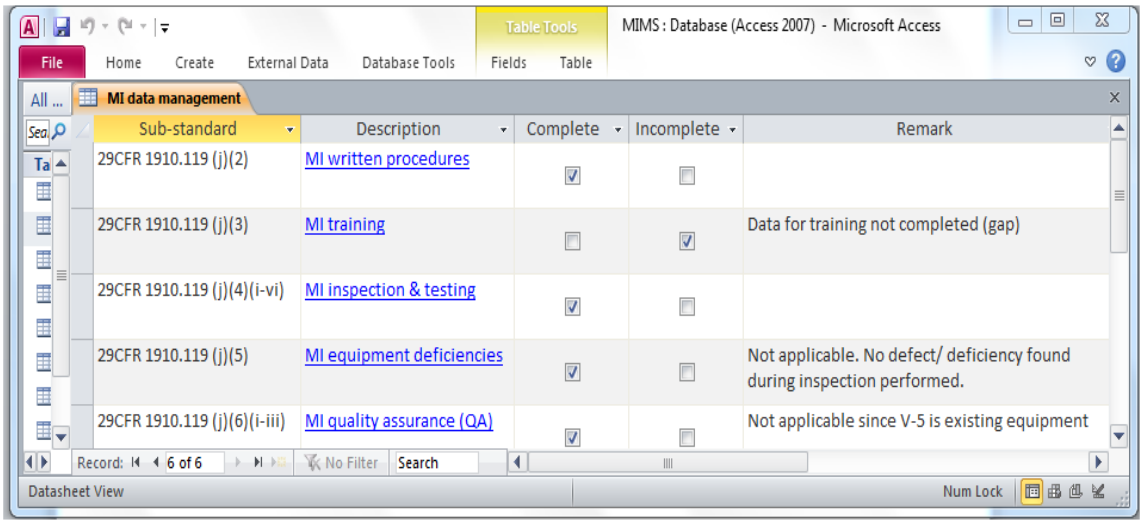


Figure 7: MI data management in MIMS for V-5

In this case, only one out of six sub-standards of MI is not complying due to data for training is not completed. If the sub-standards are complying as outlined by PSM, end users can hit the 'Complete' column and otherwise they can tick in 'Incomplete' column with the issue as refer to 'Remark' column. From here, the gap that hinders the compliance to the standard is identified and further action can be initiated in order to comply with all the MI requirements. It shows that this systematic checklist system capable in identifying the gap and the end users would always be alerted of insufficient MI information that need to be compiled to ensure the accomplishment of hazards control and risk reduction program.

4.3.1.2 MI Written Procedures 29 CFR 1910.119(j)(2)

MI procedures should be written in adequately detail in order to maintain the on-going integrity of process equipment throughout its life span. Procedures must be there to control overwhelming safety critical systems. Before the system can be taken out of service for any length of time, there must be appropriate authority, communication and detailed contingency planning to avoid any unwanted accident happen [15]. MI written procedures can be managed by allocating respective personnel to provide the procedures document sheet for easy reference to employee in handling any MI activity in the process plant. Figure 8 shows the MI written procedures in MIMS consists of 'Document name', 'Document no.', 'Review date', 'Verified by, 'Evidence location', 'Complete ', 'Incomplete', 'Remarks', 'Action by' and ' Due date' columns.

'Document Name', Document no.' and 'Review Date' in conjunction with 'Verified by' information are needed to ensure the accuracy of the documented procedures. 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. The end users ensure completeness of written procedure through 'Complete' and 'Incomplete' checkboxes. These columns are important as they specify which task is yet to be completed and therefore requires further action to be taken. For any incomplete tasks, the solution is to assign the qualified person to provide the required data through the 'Action by' and 'Due date' columns. Therefore the tasks is properly monitored and completed within the given time.

In this case, MI written procedure for vessel is located at *C:\MIMS\Database\V-5\20511_Guideline_Pressure_Vessel.doc.* Basically this document explained the need for the inspection, testing, and maintenance of pressure vessels as established by recognized and generally accepted good engineering practices (RAGAGEPs).

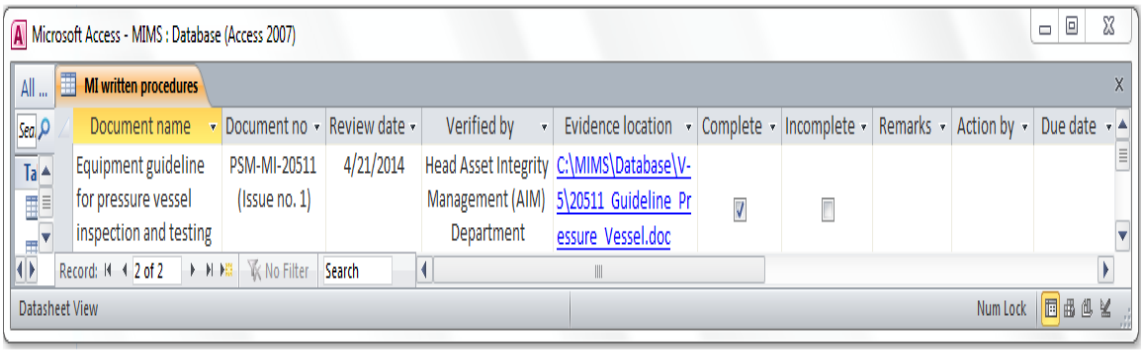


Figure 8: MI written procedure in MIMS for V-5.

4.3.1.3 MI Training 29 CFR 1910.119(j)(3)

Training is said to be an important ingredient of an effective MI program. By having a proper and adequate training program, it ensures that only qualified personnel perform MI tasks. Consistent training that assigned to the personnel is capable in reducing the human errors that lead to catastrophic accidents. Each existing and new hired employees should attend the training program to ensure the task is done in a correct and safe manner. Once the MI training is conducted to the employees, evaluation for the training should be performed to evaluate the skills/ knowledge gain by the employees in handling any required task in the process plant. Training can be a successful platform in determining the skill and knowledge areas required for improvement.

By having this system, the end users can monitor the training required for process maintenance for all the employees involved. It can be monitored by listing out all the required trainings depend on the focus groups and trace all the attended and yet to attend training for each employee. The interface of MI training is displayed in the Figure 9. The first layer of the training interface consist of ‘Staff no’, ‘Name’, ‘Required training by’, ‘Complete’, ‘Incomplete’, ‘Remarks’ and ‘Schedule’ column. ‘Required training by’ column is filled with the position of the trainee and it is hyperlink to the list of required training to that particular position.

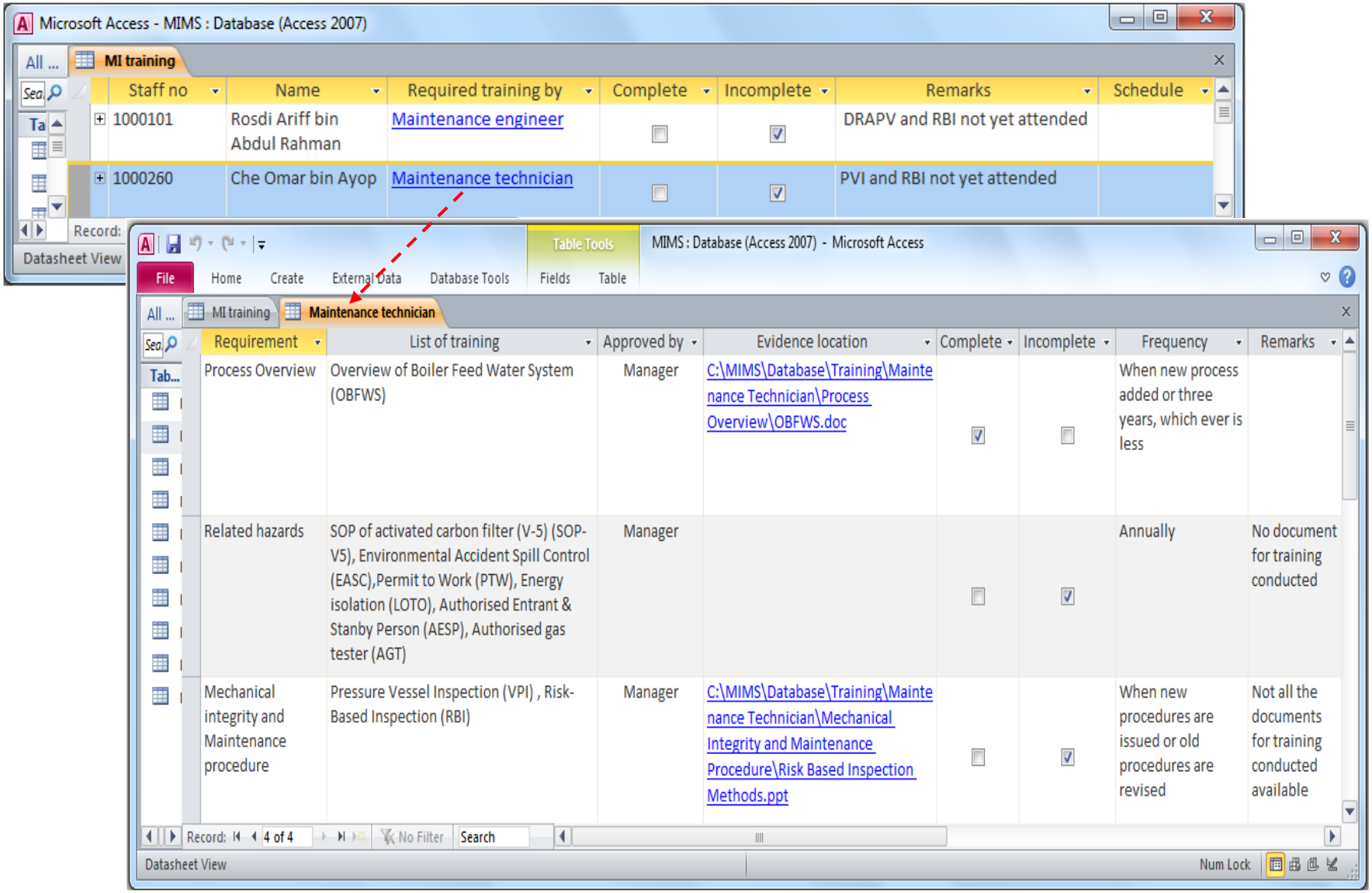


Figure 9: MI Training in MIMS for V-5

Based on Figure 9, list of training tab consists of ‘Requirement’, ‘List of training’, ‘Approved by’, ‘Evidence location’, ‘Complete’, ‘Incomplete’, ‘Frequency’ and ‘Remarks’ column. This tab is to manage what kinds of training needs to be attended by affected employees and the materials of the trainings have to be available in ‘Evidence location’ for the ease of managing the training process. PSM has outlined 3 category of MI training to maintain the mechanical integrity of the equipment. The category of the training is listed in the ‘Requirement’ column. The trainings are divided into Process Overview, Related Hazards and Mechanical integrity and Maintenance procedure. Since there are several trainings organized for each category, the function of ‘List of training’ column is to identify the related training to that specific category.

For demonstration, list of training for maintenance technician is tabulated in Figure 9 as referred to Maintenance technician tab. Generally, training related to Process Overview involved plant process and chemistry. The training need to be refreshed when the new process is added or every three years, whichever is less. For Related Hazards, the scope of the training covers hazard exposure and control measure, personnel protective equipment, emergency response and basically related to Health, Safety & Environment Management System (HSEMS) training. Some of the training needs to be revised on annual basis according to the plant practices. For Mechanical integrity and Maintenance procedure, it covers overview of MI program, detail MI procedures and specific procedures for the performance of MI. For this plant, all these trainings are refreshed when new procedures are issued or existing procedures are revised.

In this case study, some of the documents for the training organized to the maintenance technicians are not available. This system helps to discover the identified gaps for training element using the checklist method. Once the gaps are identified, the end users can overcome the gaps by providing all the documents so that the training program are effectively conducted and easily meet its objectives. Besides, availability of all this documents in the system helps to ease the MI auditing process.

According to 29 CFR 1910.119(j)(3), the employer should train each employee involved in maintaining the on-going integrity of the equipment. Hence, MIMS is designed to trace all the training needed for every each employee as shown in Figure 10. MI documentation interface consists of ‘Attended training’, ‘From date’, ‘To date, ‘Evaluation description’ ‘Evidence location’ ‘Remarks’ and ‘Refresh date’.

For this case, the compiled MI training information is assessed to one of the maintenance technician. Overall status of attended the required training is directly identified from checkbox system and lacking of accomplishment is noted at ‘Remarks’ columns. He has another two mandatory training need to be completed including Pressure Vessel Inspection (PVI) and Risk- Based Inspection (RBI) trainings. For any incomplete training, the employee should be prohibited to attend any equipment by himself to avoid any unwanted accident happen. The ‘Schedule’ column in Figure 9 functioned to inform the affected personnel on the date of training to be attended. By having the schedule embedded within the MIMS, problem of absenteeism due to overlook of the date of training can be prevented.

The proof of the attended training is compiled and tracked as refer to ‘evidence location’ column either in softcopy or hardcopy version. The training documentation for staff no. 1000260 is referred to Figure 10. Out of 7 attended trainings, only 3 documentations are available. Figure 11 shows Standard Operating procedure (SOP) evaluation and certification for Authorised Entrant & Stanby Person (AESP) and Authorised gas tester (AGT) is shown in Figure 12. The 'Refresh date' column in the training documentation of MIMS in Figure 10 makes the planning process easier by providing the latest update on attended trainings. Then, the training scheduler can automatically refer to the refresher date to plan and create training schedules for each employee.

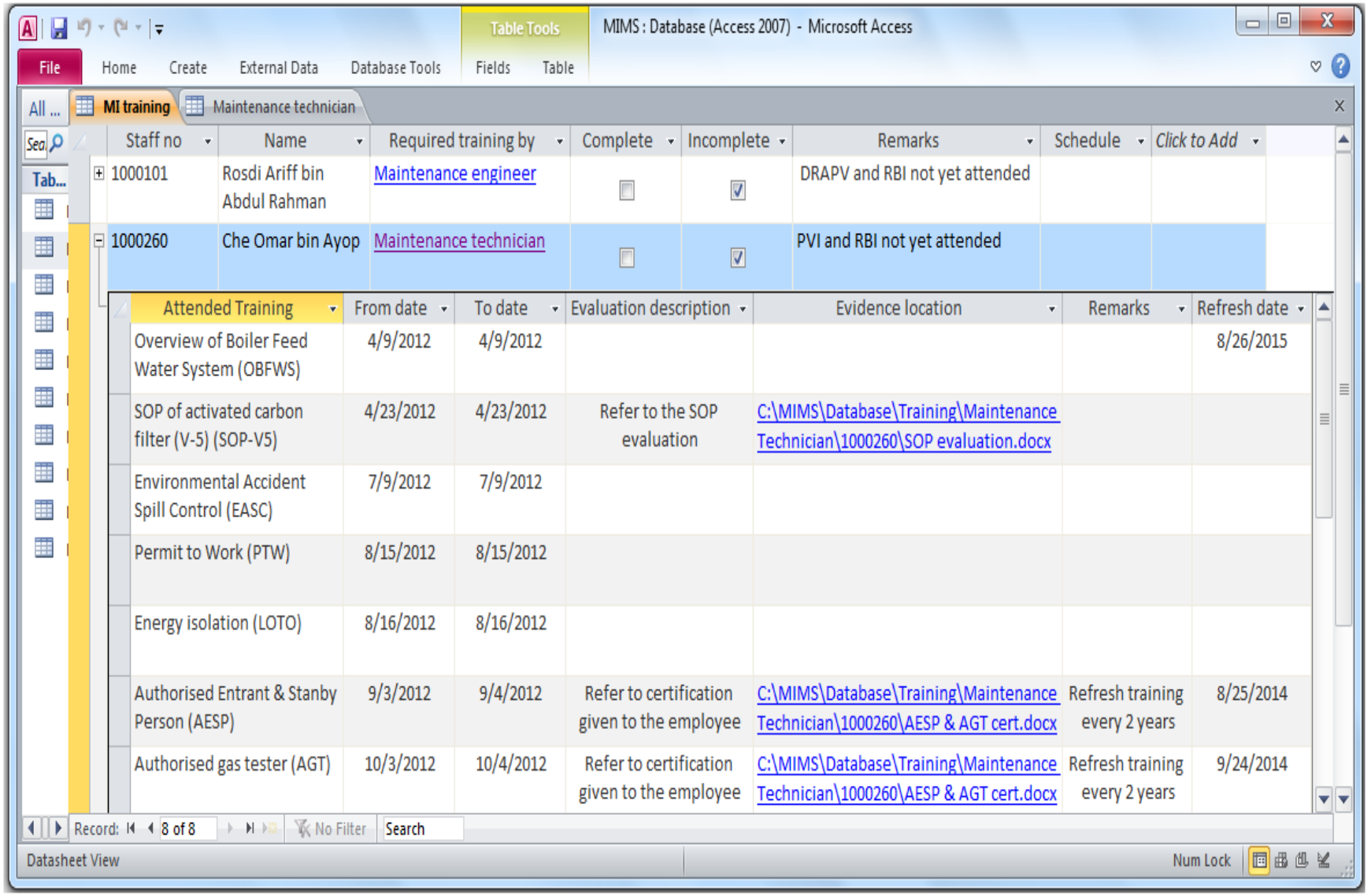
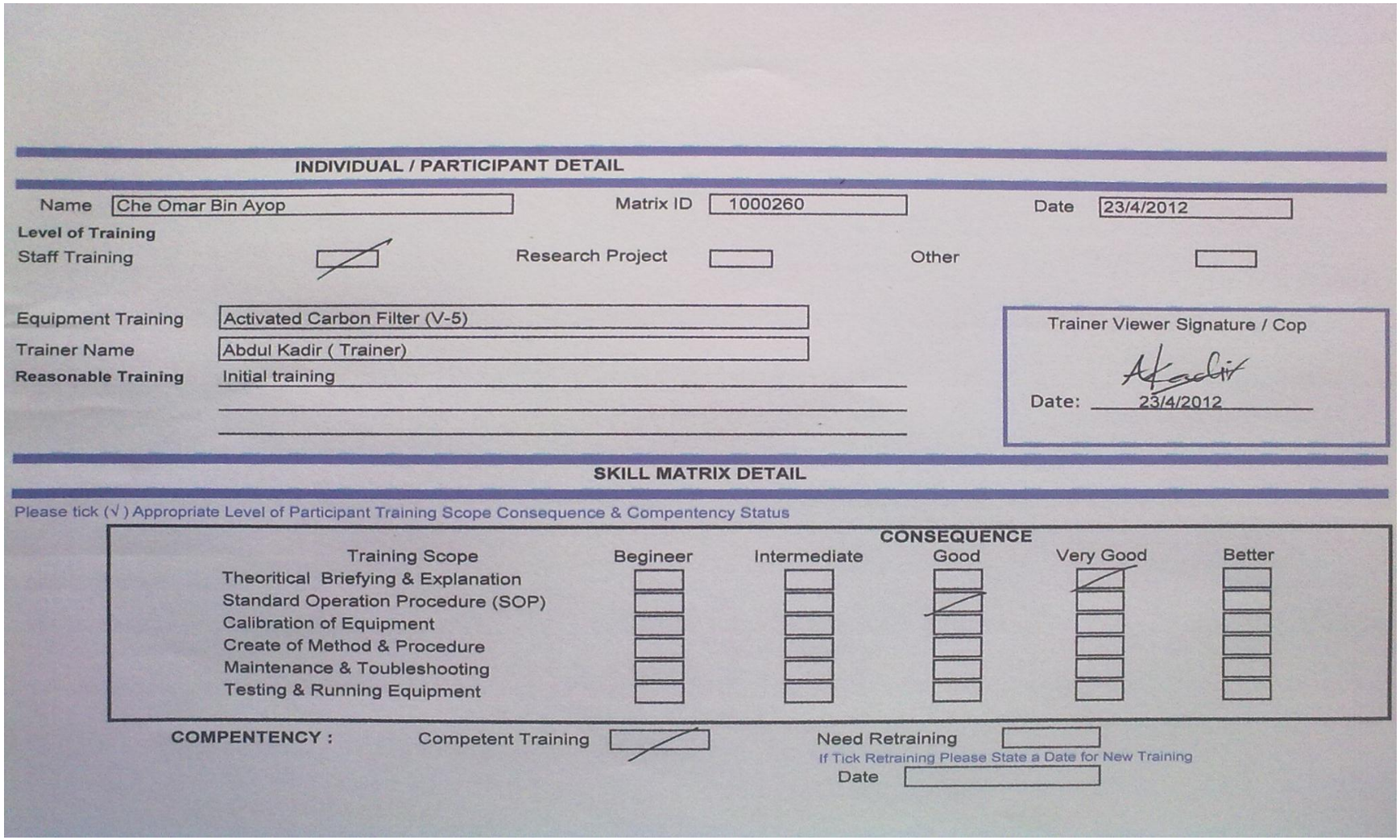


Figure 10: MI Training documentation in MIMS for V-5



INDIVIDUAL / PARTICIPANT DETAIL

Name: Che Omar Bin Ayop | Matrix ID: 1000260 | Date: 23/4/2012

Level of Training

Staff Training: ☑ | Research Project: ☐ | Other: ☐

Equipment Training: Activated Carbon Filter (V-5)

Trainer Name: Abdul Kadir (Trainer)

Reasonable Training: Initial training

Trainer Viewer Signature / Cop

Date: 23/4/2012

SKILL MATRIX DETAIL

Please tick (√) Appropriate Level of Participant Training Scope Consequence & Compentency Status

Training Scope	CONSEQUENCE: Begineer	Intermediate	Good	Very Good	Better
Theoritical Briefying & Explanation	☐	☐	☐	☑	☐
Standard Operation Procedure (SOP)	☐	☐	☑	☐	☐
Calibration of Equipment	☐	☐	☐	☐	☐
Create of Method & Procedure	☐	☐	☐	☐	☐
Maintenance & Toubleshooting	☐	☐	☐	☐	☐
Testing & Running Equipment	☐	☐	☐	☐	☐

COMPENTENCY : Competent Training ☑ | Need Retraining ☐

If Tick Retraining Please State a Date for New Training

Date: ☐

Figure 11: Evaluation on Standard Operating Procedure (SOP) Training


AGT 0906

MALAYSIA

AKTA KESELAMATAN DAN KESIHATAN PEKERJAAN 1994
TATAAMALAN INDUSTRI BEKERJA SELAMAT DI DALAM RUANG TERKURUNG 2010

Adalah disahkan bahawa
CHE OMAR BIN AYOB
(K.P. :861224-02-5691)

telah didaftarkan dengan Ketua Pengarah
Jabatan Keselamatan dan Kesihatan Pekerjaan Malaysia

sebagai

PENGUJI GAS BERTAULIAH
No. Rujukan Pendaftaran : JKKP HIE 127/171-5 (766)

&

PENYELIA KEMASUKAN
No. Rujukan Pendaftaran : JKKP HIE 127/171-6 (700)

Pendaftaran ini sah bagi kerja-kerja di Syarikat :

dari
15 OKTOBER 2012 **sehingga 6 JULAI 2013***

(Dato' Ir. Dr. Johari Basri)
Ketua Pengarah
Jabatan Keselamatan dan Kesihatan Pekerjaan Malaysia

Tarikh: 29.10.12

*(sila lihat muka sebelah untuk tarikh pembaharuan sijil)

Figure 12: Sample of 'Certification for Authorised Entrant & Stanby Person (AESP) and Authorised gas tester (AGT)'

4.3.1.4 MI Inspection & Testing 29 CFR 1910.119(j)(4)(i-iv)

Referring to the framework in Figure 3, there are several sub-standards of MI inspection and testing that need to be fulfilled in order to comply with the PSM standard. Figure 13 shows the interface of MIMS for inspection & testing with 'Sub-standard', 'Requirement', 'Description, 'Evidence location', 'Complete', 'Incomplete', 'Remarks', 'Action by' and 'Due date' columns. The listed sub-standards CFR 1910.119 (j) (4)(i-iv) in this interface provide guideline to end users about important information that need to be compiled. MIMS gives flexibility to the end user on how they would carry out the inspection and testing to the equipment as long as they comply with the standard by performing the inspection on process equipment, procedures of the inspection followed RAGAGEPs, frequency of the inspection and test consistent with manufacturer recommendations and RAGAGEPs and last but not least each of performed inspection is documented as described in the 'Description' column.

In this case, all four sub-standards of MI inspection and testing for V-5 complies with the PSM requirement as indicate by the 'Complete' checkbox. 'Action by' and 'Due date' columns work similarly like in other interfaces as to convey solution for any incomplete tasks. Inspection Reference Plan document is located at *C:\MIMS\Database\V-5\Inspection reference plan.pdf* stated that the inspection and testing is carried out to the filter which categorized under pressure vessel and storage tank process equipment. The Reference Plan for V-5 is illustrated in Figure 14. The procedure for the inspection follows the established Internal Technical Standard (ITS) of plant X which is one of the RAGAGEPs.

The frequency of the inspection is following API 510 for internal and external inspection. According to API 510, the period between internal inspections shall not exceed one half of the remaining life of the vessel or 10 years, whichever is less meanwhile the interval for external inspection does not exceed the lesser of 5 years or the required internal inspection. The frequency is believed to be consistence with the RAGAGEPs as the previous inspection is done for about 2 ½ years beforehand which

means that it is still not exceeded the recommended interval. On the other hand, the inspection and testing is documented in title 'Inspection Report Summary' which available at *C:\MIMS\Database\V-5\Inspection report summary.pdf* as shown in Figure 15 and Figure 16 respectively.

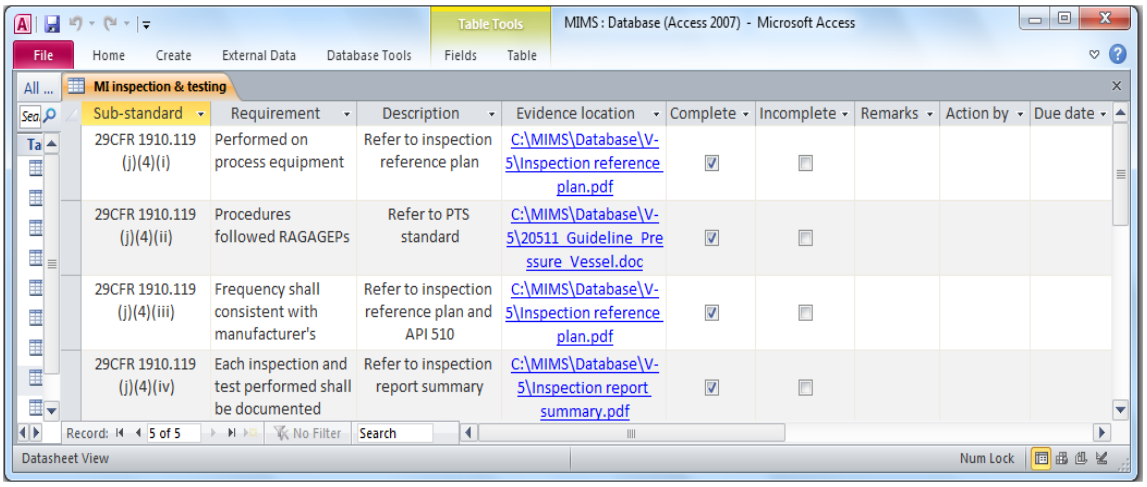


Figure 13: MI inspection & testing in MIMS for V-5

INSPECTION REFERENCE PLAN

Asset Integrity Management Department

Equipment No	V-5	**Description**	Activated Carbon Filter			**Rev**	**Description**	**By/Date**	**Verified**	**Appr**	**Date**
PMT No	MK PMT 1482					0	Draft	AM/Aug.11			
Manuf. Serial No	VESB-U-406	**CF Expiry**				1	Rev-1	AM/Sept.11	AAR		
Manufacturer	VESSELTECH ENGINEERING SDN. BHD.			**Insulation :**		2					
Fluid	Water			**Full**		3					
Unit	51-BFU, Steam & Condensate System			**Partial**		4					
Area	5			**Heat Tracing**		5					
Plant	PSR 1			**None**	X	6					
Safety Valve	1. None	2.		**Above ground**		7					30/9/11
Spring Set Pressure (SSP)				**Under ground**		8					

Materials	Shell : SA 516 Gr. 70 (15.88t) Head : SA 516 Gr. 70 (15.88t, After forming - 12.0t) Nozzle Plate : SA 516 Gr. 70 (22.2t)			**SHELL / PIPE**	**TUBE**
Corrosion allowance (mm)	3.0	**Remaining Life, (years)**	20.00	**Design Pressure (kg/cm²G)**	11.25	-
Design Specification	ASME Section VIII Div. 1, 2004 ED + 2005 ADD. Internal Coating : 1st - Ammine Adduct Epoxy (125 micron), 2nd - Ammine Adduct Epoxy (125 micron)			**Operating Pressure (kg/cm²G)**	9.14	-
				Design Temperature (°C)	50.00	-
Thickness Minimum Based on Design Calculation (mm)	Shell : 9.03. Head : 9.0			**Operating Temperature (°C)**	38.00	-
				Corrosion Loop	**Location**	**Criticality (N, L, M, MH, H, E)**
Potential Hazard	Refer to HEMP report			CL 5101	Shell	MH

Legend : N = Negligible, L = Low, M = Medium, MH = Medium High, H = High and E = Extreme

Probable Mode / Location Of Deterioration	**Damage Mechanism**		**Strategy Table**	**Focus Area**
	CL 5101	General Corrosion	T1,T2	Shell

NDT INSPECTION REQUIREMENT (Tick if required)

		Interval	Last Inspc. Date	METHOD (Tick if required)		LOCATION	Interval (Year)	Last Inspc. Date	METHOD (Tick if required)		LOCATION
ONSTREAM	EXTERNAL	6.25	01/05/2009	VISUAL	X	100% Visual inspection as per MI checklist (PSM-MI-30512)			REPLICA TEST		
		6.25	01/05/2009	UTTM	X	As per TML's (Attachment 1)			MPI /DPI		
				UTFD					DCVG		
				IR					UCS		
				RT					OTHERS		
				PMI							
SHUTDOWN	EXTERNAL	TA		VISUAL	X	100% Visual inspection as per MI checklist (PSM-MI-30512)			REPLICA TEST		
				UTTM	X	As per TML's (Attachment 1)			UCS		
				UTFD					PEC		
				TOFD					RT		
				MPT					HARDNESS		
				DPT					OTHERS		
				IR							
				PMI							
	INTERNAL			VISUAL	X	100% Visual inspection as per MI checklist (PSM-MI-30515)			DFT	X	Dry film thickness as per attachment 2
				UTTM	X	As per TML's (Attachment 1)			BOROSCOPE		
				UTFD					VIDEOSCOPE (CCTV)		
				DPT					REPLICA TEST		
				MPT					ID/OD Bore Gauge		
				RT					FTIS (Int. Tube)		
				RFET					VACUM BOX TEST		
				IRIS					OTHERS		
				ECT					**HYDRO TEST (kg/cm2G)**		**PNEUMATIC TEST (kg/cm2G)**
				MFL					SHELL / PIPE		SHELL / PIPE
				HARDNESS					TUBE		TUBE
				HOLIDAY TEST	X	Holiday test as per attachment 2			NOTE		

REMOVED / DISMANTLING / UNLOADING REQUIREMENT (Tick if required)

EXTERNAL	Open / Refit Insp. Windows			New Inspection Window		
	Remove / Refit Insulation			Others	X	N3, vent
	Open Manhole	X	MH1 and MH2			
	AFC Plugs					
INTERNAL	Open Trays			Demister		
	Packing/Catalyst	X	To unload / reload activited carbon resin	Others		
	Pull Tube Bundle					

CLEANING REQUIREMENT (Tick if required)

EXTERNAL	Weldment		
	Non Weldment		
	Others		
INTERNAL	Weldment		
	Non Weldment	X	Remove all loose scales
	Tube Internal		
	Tube external		
	Others		

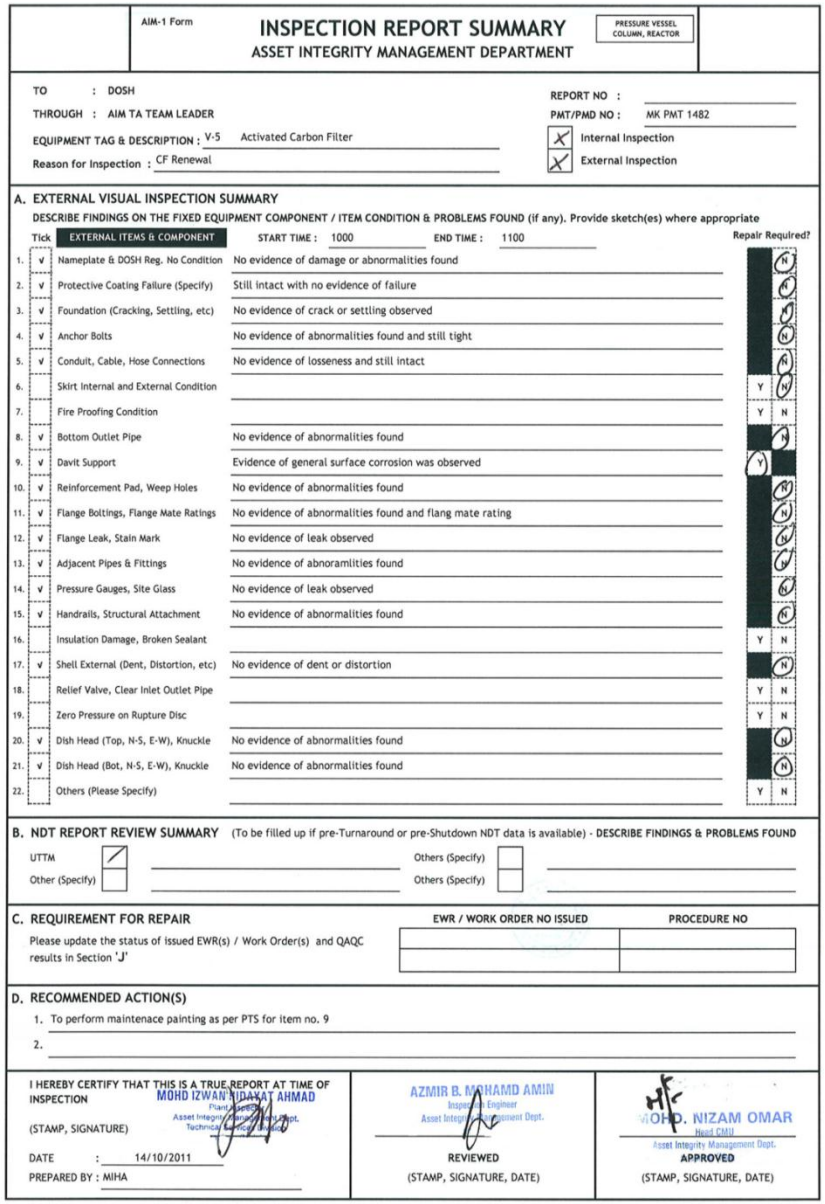
ACCESSIBILITY REQUIREMENT (Tick if required)

EXTERNAL	Scaffolding		
	Ladder		
	Others		
INTERNAL	Scaffolding		
	Ladder	X	To access internal thru manhole MH1
	Others		

OTHER REQUIREMENT (Tick if required)

EXTERNAL	Touch up Painting					
	Power Supply					
	Others					
INTERNAL	Passivation			Others		
	Power Supply	X				
	Ventilation	X				
	Lighting	X				
PREVIOUS INSPECTION FINDINGS HIGHLIGHT	May 2009 - External inspection : Generally still in good condition. UTTM - Still within corrosion allowance.					

Figure 14: Inspection Reference Plan for V-5



AIM-1 Form

INSPECTION REPORT SUMMARY
ASSET INTEGRITY MANAGEMENT DEPARTMENT

PRESSURE VESSEL
COLUMN, REACTOR

TO : DOSH
THROUGH : AIM TA TEAM LEADER
EQUIPMENT TAG & DESCRIPTION : V-5 Activated Carbon Filter
Reason for Inspection : CF Renewal

REPORT NO :
PMT/PMD NO : MK PMT 1482
[X] Internal Inspection
[X] External Inspection

A. EXTERNAL VISUAL INSPECTION SUMMARY
DESCRIBE FINDINGS ON THE FIXED EQUIPMENT COMPONENT / ITEM CONDITION & PROBLEMS FOUND (if any). Provide sketch(es) where appropriate

START TIME : 1000 END TIME : 1100

	Tick	EXTERNAL ITEMS & COMPONENT		Repair Required?
1.	√	Nameplate & DOSH Reg. No Condition	No evidence of damage or abnormalities found	N
2.	√	Protective Coating Failure (Specify)	Still intact with no evidence of failure	N
3.	√	Foundation (Cracking, Settling, etc)	No evidence of crack or settling observed	N
4.	√	Anchor Bolts	No evidence of abnormalities found and still tight	N
5.	√	Conduit, Cable, Hose Connections	No evidence of losseness and still intact	N
6.		Skirt Internal and External Condition		Y N
7.		Fire Proofing Condition		Y N
8.	√	Bottom Outlet Pipe	No evidence of abnormalities found	N
9.	√	Davit Support	Evidence of general surface corrosion was observed	Y
10.	√	Reinforcement Pad, Weep Holes	No evidence of abnormalities found	N
11.	√	Flange Boltings, Flange Mate Ratings	No evidence of abnormalities found and flang mate rating	N
12.	√	Flange Leak, Stain Mark	No evidence of leak observed	N
13.	√	Adjacent Pipes & Fittings	No evidence of abnoramlities found	N
14.	√	Pressure Gauges, Site Glass	No evidence of leak observed	N
15.	√	Handrails, Structural Attachment	No evidence of abnormalities found	N
16.		Insulation Damage, Broken Sealant		Y N
17.	√	Shell External (Dent, Distortion, etc)	No evidence of dent or distortion	N
18.		Relief Valve, Clear Inlet Outlet Pipe		Y N
19.		Zero Pressure on Rupture Disc		Y N
20.	√	Dish Head (Top, N-S, E-W), Knuckle	No evidence of abnormalities found	N
21.	√	Dish Head (Bot, N-S, E-W), Knuckle	No evidence of abnormalities found	N
22.		Others (Please Specify)		Y N

B. NDT REPORT REVIEW SUMMARY (To be filled up if pre-Turnaround or pre-Shutdown NDT data is available) - DESCRIBE FINDINGS & PROBLEMS FOUND

UTTM [√] —
Other (Specify) [ ] —
Others (Specify) [ ] —
Others (Specify) [ ] —

C. REQUIREMENT FOR REPAIR
Please update the status of issued EWR(s) / Work Order(s) and QAQC results in Section 'J'

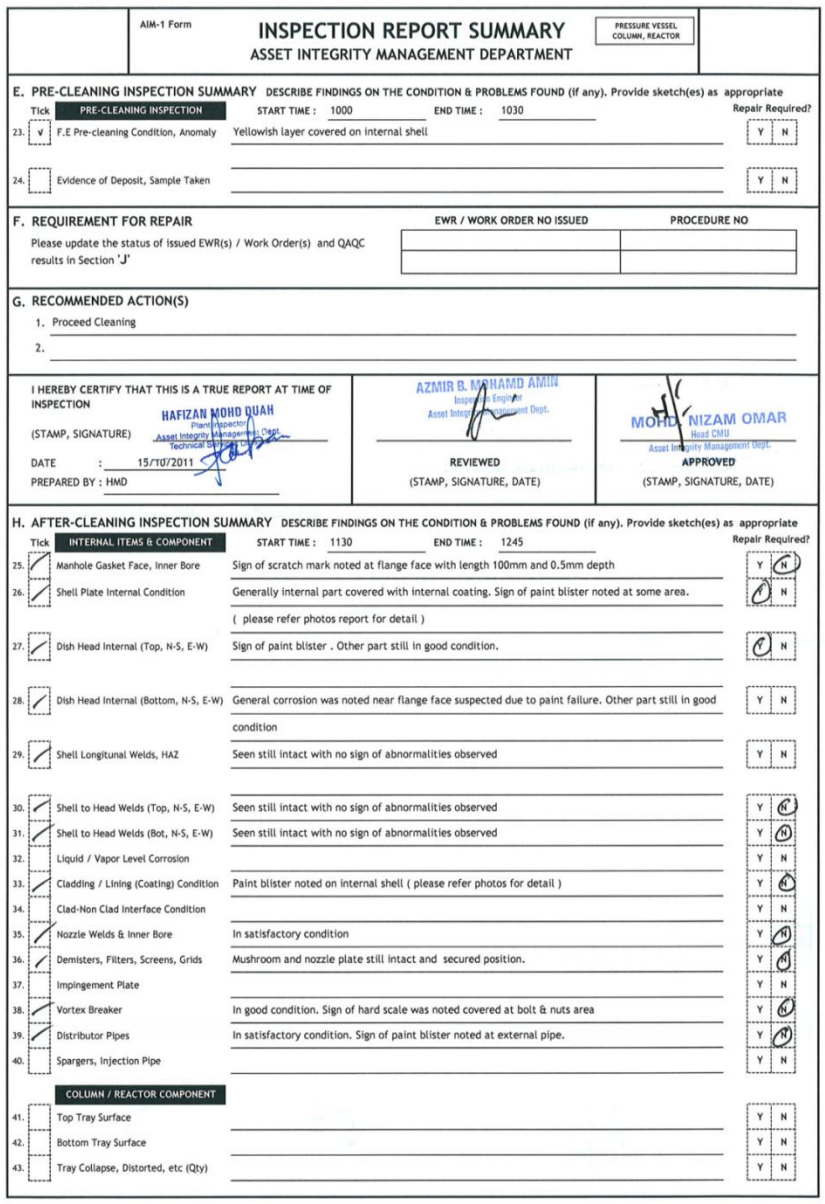
EWR / WORK ORDER NO ISSUED	PROCEDURE NO

D. RECOMMENDED ACTION(S)
1. To perform maintenace painting as per PTS for item no. 9
2.

I HEREBY CERTIFY THAT THIS IS A TRUE REPORT AT TIME OF INSPECTION
(STAMP, SIGNATURE) MOHD IZWAN NIDAKAT AHMAD Plant Inspector Asset Integrity Management Dept. Technical Section
DATE : 14/10/2011
PREPARED BY : MIHA

AZMIR B. MOHAMD AMIN Inspection Engineer Asset Integrity Management Dept.
REVIEWED
(STAMP, SIGNATURE, DATE)

MOHD. NIZAM OMAR Head CMU Asset Integrity Management Dept.
APPROVED
(STAMP, SIGNATURE, DATE)



AIM-1 Form

INSPECTION REPORT SUMMARY
ASSET INTEGRITY MANAGEMENT DEPARTMENT

PRESSURE VESSEL
COLUMN, REACTOR

E. PRE-CLEANING INSPECTION SUMMARY DESCRIBE FINDINGS ON THE CONDITION & PROBLEMS FOUND (if any). Provide sketch(es) as appropriate

START TIME : 1000 END TIME : 1030

	Tick	PRE-CLEANING INSPECTION		Repair Required?
23.	√	F.E Pre-cleaning Condition, Anomaly	Yellowish layer covered on internal shell	Y N
24.		Evidence of Deposit, Sample Taken		Y N

F. REQUIREMENT FOR REPAIR
Please update the status of issued EWR(s) / Work Order(s) and QAQC results in Section 'J'

EWR / WORK ORDER NO ISSUED	PROCEDURE NO

G. RECOMMENDED ACTION(S)
1. Proceed Cleaning
2.

I HEREBY CERTIFY THAT THIS IS A TRUE REPORT AT TIME OF INSPECTION
(STAMP, SIGNATURE) HAFIZAN MOHD QUAH Plant Inspector Asset Integrity Management Dept. Technical Section
DATE : 15/10/2011
PREPARED BY : HMD

AZMIR B. MOHAMD AMIN Inspection Engineer Asset Integrity Management Dept.
REVIEWED
(STAMP, SIGNATURE, DATE)

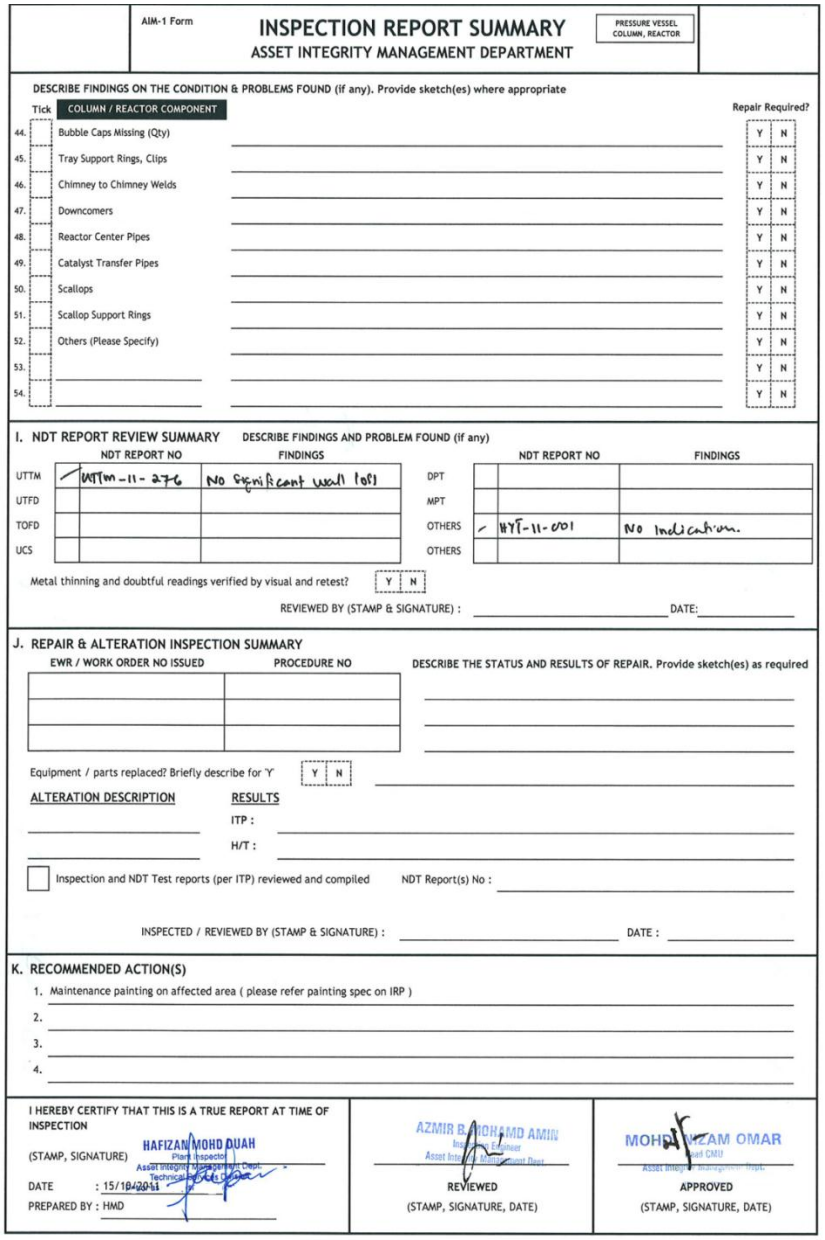
MOHD. NIZAM OMAR Head CMU Asset Integrity Management Dept.
APPROVED
(STAMP, SIGNATURE, DATE)

H. AFTER-CLEANING INSPECTION SUMMARY DESCRIBE FINDINGS ON THE CONDITION & PROBLEMS FOUND (if any). Provide sketch(es) as appropriate

START TIME : 1130 END TIME : 1245

	Tick	INTERNAL ITEMS & COMPONENT		Repair Required?
25.	/	Manhole Gasket Face, Inner Bore	Sign of scratch mark noted at flange face with length 100mm and 0.5mm depth	Y N
26.	/	Shell Plate Internal Condition	Generally internal part covered with internal coating. Sign of paint blister noted at some area. (please refer photos report for detail)	Y N
27.	/	Dish Head Internal (Top, N-S, E-W)	Sign of paint blister . Other part still in good condition.	Y N
28.	/	Dish Head Internal (Bottom, N-S, E-W)	General corrosion was noted near flange face suspected due to paint failure. Other part still in good condition	Y N
29.	/	Shell Longitunal Welds, HAZ	Seen still intact with no sign of abnormalities observed	Y N
30.	/	Shell to Head Welds (Top, N-S, E-W)	Seen still intact with no sign of abnormalities observed	Y N
31.	/	Shell to Head Welds (Bot, N-S, E-W)	Seen still intact with no sign of abnormalities observed	Y N
32.		Liquid / Vapor Level Corrosion		Y N
33.	/	Cladding / Lining (Coating) Condition	Paint blister noted on internal shell (please refer photos for detail)	Y N
34.		Clad-Non Clad Interface Condition		Y N
35.	/	Nozzle Welds & Inner Bore	In satisfactory condition	Y N
36.	/	Demisters, Filters, Screens, Grids	Mushroom and nozzle plate still intact and secured position.	Y N
37.		Impingement Plate		Y N
38.	/	Vortex Breaker	In good condition. Sign of hard scale was noted covered at bolt & nuts area	Y N
39.	/	Distributor Pipes	In satisfactory condition. Sign of paint blister noted at external pipe.	Y N
40.		Spargers, Injection Pipe		Y N
		COLUMN / REACTOR COMPONENT		
41.		Top Tray Surface		Y N
42.		Bottom Tray Surface		Y N
43.		Tray Collapse, Distorted, etc (Qty)		Y N

Figure 15: Parts of Inspection Report Summary (a) for V-5



AIM-1 Form

INSPECTION REPORT SUMMARY

ASSET INTEGRITY MANAGEMENT DEPARTMENT

PRESSURE VESSEL
COLUMN, REACTOR

DESCRIBE FINDINGS ON THE CONDITION & PROBLEMS FOUND (if any). Provide sketch(es) where appropriate

	Tick	COLUMN / REACTOR COMPONENT		Repair Required?
44.		Bubble Caps Missing (Qty)		Y N
45.		Tray Support Rings, Clips		Y N
46.		Chimney to Chimney Welds		Y N
47.		Downcomers		Y N
48.		Reactor Center Pipes		Y N
49.		Catalyst Transfer Pipes		Y N
50.		Scallops		Y N
51.		Scallop Support Rings		Y N
52.		Others (Please Specify)		Y N
53.				Y N
54.				Y N

I. NDT REPORT REVIEW SUMMARY — DESCRIBE FINDINGS AND PROBLEM FOUND (if any)

	NDT REPORT NO	FINDINGS		NDT REPORT NO	FINDINGS
UTTM	UTTM-11-276	No significant wall loss	DPT		
UTFD			MPT		
TOFD			OTHERS	HYT-11-001	No indication.
UCS			OTHERS		

Metal thinning and doubtful readings verified by visual and retest? Y N

REVIEWED BY (STAMP & SIGNATURE) : _____ DATE: _____

J. REPAIR & ALTERATION INSPECTION SUMMARY

EWR / WORK ORDER NO ISSUED	PROCEDURE NO	DESCRIBE THE STATUS AND RESULTS OF REPAIR. Provide sketch(es) as required

Equipment / parts replaced? Briefly describe for 'Y' Y N

ALTERATION DESCRIPTION

RESULTS

ITP :

H/T :

☐ Inspection and NDT Test reports (per ITP) reviewed and compiled NDT Report(s) No :

INSPECTED / REVIEWED BY (STAMP & SIGNATURE) : _____ DATE : _____

K. RECOMMENDED ACTION(S)

1. Maintenance painting on affected area (please refer painting spec on IRP)
2.
3.
4.

I HEREBY CERTIFY THAT THIS IS A TRUE REPORT AT TIME OF INSPECTION

(STAMP, SIGNATURE) HAFIZAN MOHD DUAH Plant Inspector Asset Integrity Management Dept. Technical Support Division

DATE : 15/10/2011

PREPARED BY : HMD

AZMIR B. MOHAMMAD AMIN Inspection Engineer Asset Integrity Management Dept.

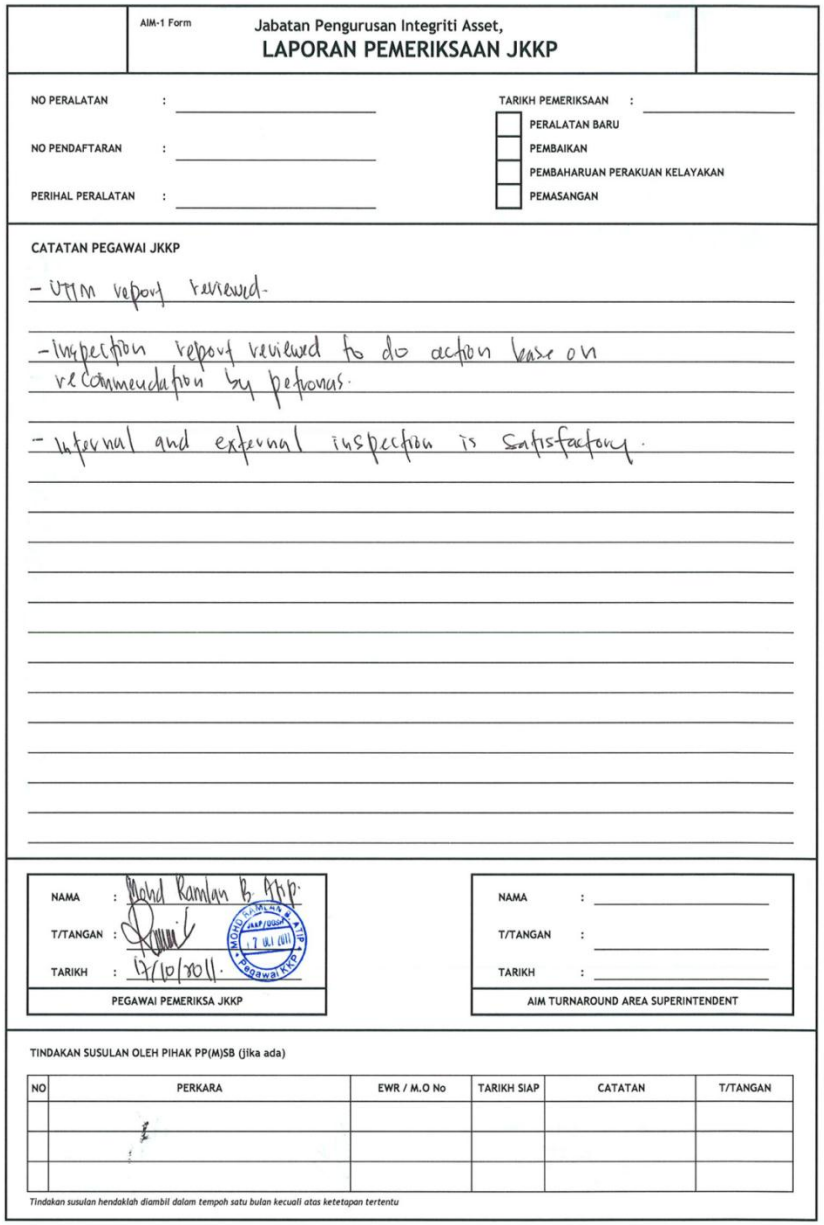
REVIEWED

(STAMP, SIGNATURE, DATE)

MOHD AZAM OMAR Head GMU Asset Integrity Management Dept.

APPROVED

(STAMP, SIGNATURE, DATE)



AIM-1 Form

Jabatan Pengurusan Integriti Asset,

LAPORAN PEMERIKSAAN JKKP

NO PERALATAN :

NO PENDAFTARAN :

PERIHAL PERALATAN :

TARIKH PEMERIKSAAN :

☐ PERALATAN BARU
☐ PEMBAIKAN
☐ PEMBAHARUAN PERAKUAN KELAYAKAN
☐ PEMASANGAN

CATATAN PEGAWAI JKKP

- UTTM report reviewed.
- Inspection report reviewed to do action base on recommendation by petronas.
- Internal and external inspection is satisfactory.

NAMA : Mohd Ramlan B. Alip.

T/TANGAN :

TARIKH : 17/10/2011.

PEGAWAI PEMERIKSA JKKP

NAMA :

T/TANGAN :

TARIKH :

AIM TURNAROUND AREA SUPERINTENDENT

TINDAKAN SUSULAN OLEH PIHAK PP(M)SB (jika ada)

NO	PERKARA	EWR / M.O No	TARIKH SIAP	CATATAN	T/TANGAN

Tindakan susulan hendaklah diambil dalam tempoh satu bulan kecuali atas ketetapan tertentu

Figure 16: Parts of Inspection Report Summary (b) for V-5

4.3.1.5 MI Equipment Deficiencies 29 CFR 1910.119(j)(5)

A deficiency is noted when an observed condition is outside the established limits (acceptance criteria) that define equipment integrity. According CCPS, 2006 [9], deficient equipment condition can be discovered; (1) during acceptance testing for new equipment fabrication or installation, (2) during performing inspection, testing and preventive maintenance activities, or (3) while measurements are taken when the equipment is accessible during a repair. The equipment deficiency can be managed effectively by allowing the following action to occur [16]:

i. Identify deficient conditions
ii. Ensuring proper responses to deficient
iii. Communicating the equipment deficiencies to affected personal
iv. Ensuring timely correction of deficient conditions

To illustrate the requirements, Figure 17 shows the equipment deficiencies interface in MIMS for 29 CFR1910.119(j)(5) consists of 'Status', 'Deficiency', 'Required Action', 'Action by', 'Verified by', 'Date assess', 'Date return to service', 'Complete', 'Incomplete' and 'Remarks' columns.

'Status' column is created in the MIMS to distinguish in what mode the equipment is whether in online or offline (shutdown) mode before proceeding with any action. The MI equipment deficiency is also monitored by figuring out the deficiency of the equipment during inspections performed and assigning the respective personnel to correct the deficiency. Any action assigned to the employee should be verified by qualified authorities in most of the cases is Engineer Manager. 'Date access' and 'Date return to service' columns can notify the responsible personnel to ensure the equipment is corrected and it is available to handover to the operation side or its normal service within the specified time.

Based on the inspection report there is no abnormalities of V-5 that identified as outside acceptable limit. According to this kind of situation, the end users can tick in 'Complete' column with remark as not applicable as shown in Figure 17.

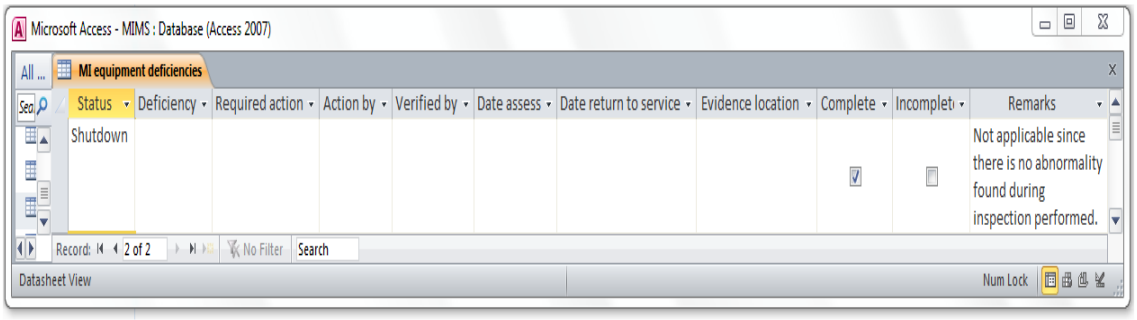


Figure 17: MI equipment deficiencies in MIMS for V-5

4.3.1.6 MI Quality Assurance (QA) 29 CFR 1910.119(j)(6)(i-iii)

Quality Assurance (QA) considers the quality of equipment from the time it is designed until the time it is taken out of service; for retirement or reuse [9]. QA specifically refers to new equipment [17]. The QA can be addressed at various stages in process life which means that it can be classified into three principals area; i) fabrication, ii) installation and iii) maintenance materials, spare parts and equipment [18]. Figure 18 shows the interface of MI Quality Assurance (QA) of MIMS with 'Sub-standard', 'Requirements', 'Description', 'Evidence location' and 'Remarks' columns. The 29 CFR 1910.119(j)(6)(i-iii) sub-standard in the interface act as guideline to end users about vital action and documentation that need be done.

There are 3 sub-standards that needed to be fulfilled in managing the MI quality assurance of new equipment. The listed sub-standards determined the requirement that needed to be access to the new equipment so that they are suitable or acceptable to be used for process application. In this case, V-5 is determined as existing equipment, therefore there is no requirement to check for the QA as stated in framework in Figure 3. Once the equipment is defined as existing equipment; means it is already in service for any years, it does not has to go through QA but it needs to fulfill the other outlined MI sub-standards by PSM. QA is applicable only for new equipment that wishes to be installed or introduced in the process industries. For this case, the end users will notified the affected plant personnel by fill in the 'Description' column as not applicable with remark V-5 is an existing equipment as demonstrated in Figure 18.

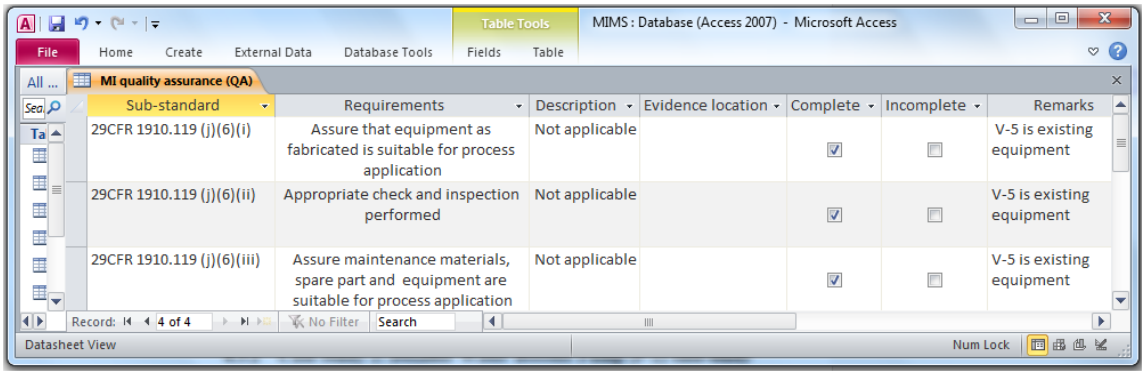


Figure 18: MI Quality Assurance (QA) in MIMS for V-5

4.3.2 Case Study 2: Desalter Water Booster Pump (P-2)

Another case study was conducted involving Desalter Water Booster Pump with tag no. P-2. P-2 is a centrifugal pump and it was designated to transfer liquid, inversely with compressor as the medium is normally in the form of vapor or gas. In this plant, the crude oil will undergo a refine process to remove salt from the crude oil through one of the process unit called as desalter. In removing the salt, it needs to be dissolved in the water in the crude oil. For the 2nd stage of desalting, the water used is stripped sour water from Sour Water Treatment Unit (SWTU), which is pumped by P-2 under flow control in the Desalter Water Surge Drum, V-2. The discharged from the Pump P-2 will undergo heat exchange before entering 2nd Stage Desalter, V-2-1. The study node in P&ID is shown in Figure 19.

This case is the example of process application that fall under new equipment category. Since it is categorized as the new equipment, it must covered 2 sub-standards which is CFR 1910.119(j)(1) and CFR 1910.119(j)(6) (i-iii) highlighting process application and QA respectively. However, for the next cycle of inspection, it has to undergo the same process with the existing equipment and complete all the requirements of MI element.

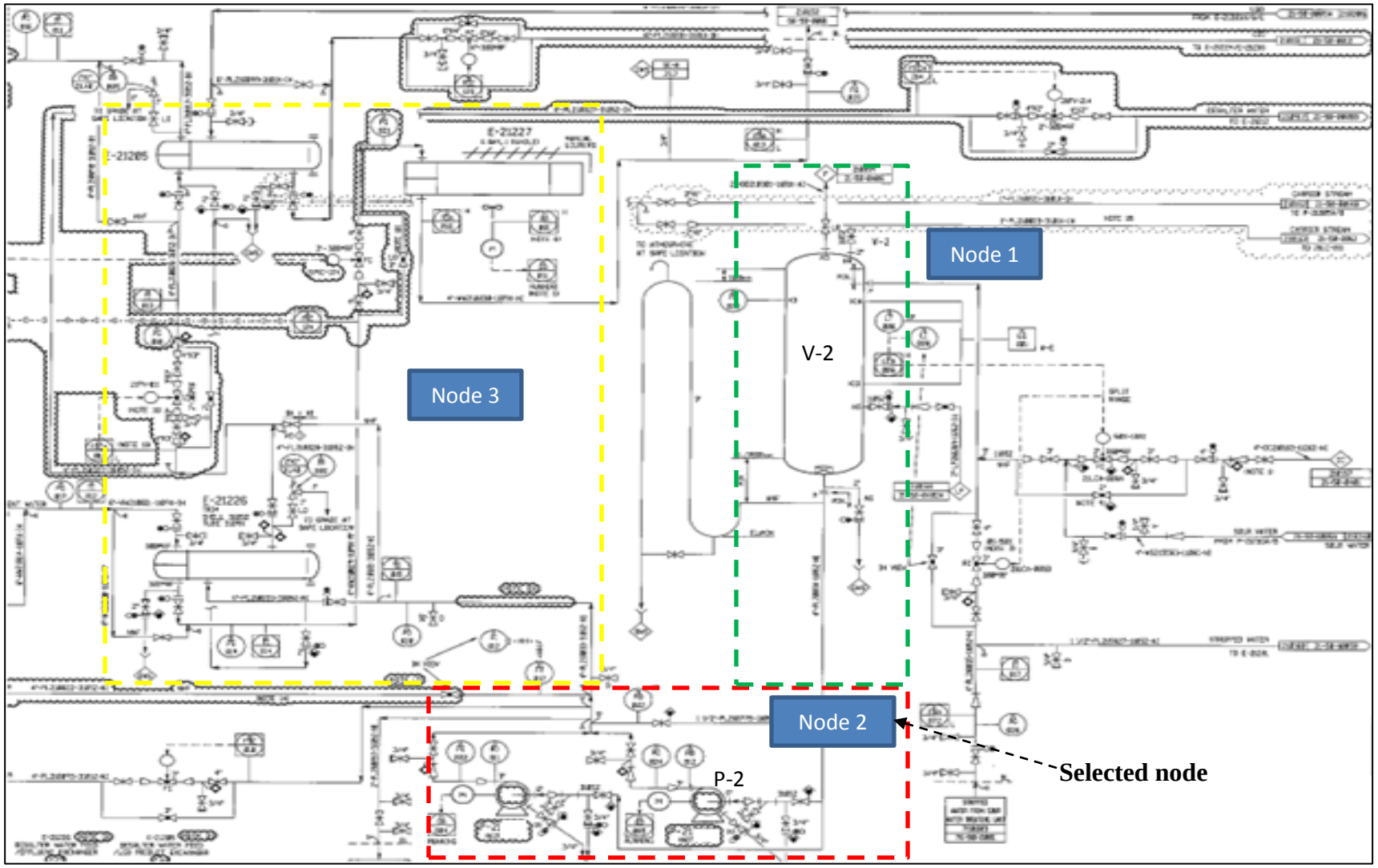


Figure 19: Part of overall P&ID diagram showing Desalter Water Booster Pump P-2

4.3.2.1 MI Application 29 CFR 1910.119 (j) (1)

'Pumps' is included in the PSM-covered process application of 29 CFR 1910.119(j)(1)(vi) sub-standard. However 'Pumps' absolutely do not focus on the pumps only. It includes all rotating machinery like compressors, fans, blowers as well as agitators. Basically, the function of MI application interface is similar to the previous case study (section 4.3.1.1) except the P-2 is grouped under 'Pumps' process application. The interface for MI application of the pump P-2 is shown in Figure 20.

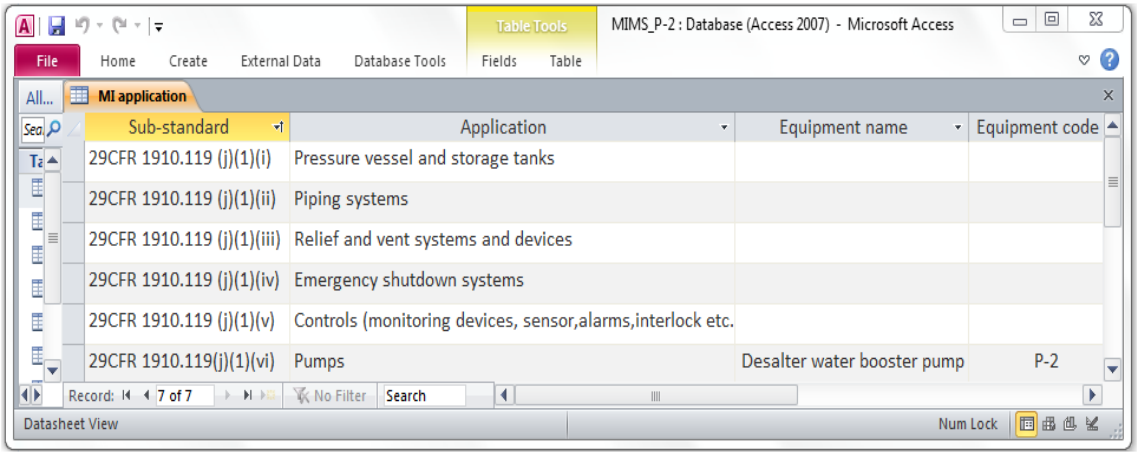


Figure 20: MI application in MIMS for P-2

4.3.2.2 MI Quality Assurance (QA) 29 CFR 1910.119(j)(6)(i-iii)

The framework of MI management to fulfill 29 CFR 1910.119(j) in Figure 3 is applicable for any equipment under specified process application. According to framework, once the identified equipment is covered in one of the process application, the next step is to justify whether it existing or new equipment. For this case, the pump is categorized as new equipment. For any new equipment, it has to undergo QA check before it can be installed in the process plant. Ultimately, this case study is to emphasize more on QA as it is applicable for new equipment only and to show how interface for QA works since it does not applicable in the previous case study. Figure 21 shows QA interface of MIMS.

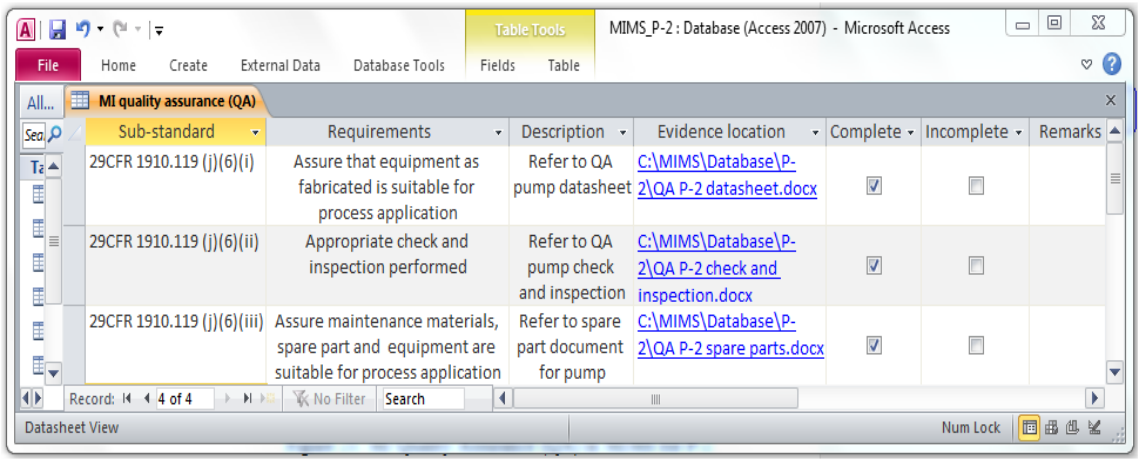


Figure 21: MI Quality Assurance (QA) in MIMS for P-2

In this case study, all the QA requirements of the P-2 are comply with the PSM requirements. The employers have the responsibility to ensure that the PSM-covered equipment is designed, purchased, fabricated and commissioned properly and these processes are controlled and documented for good. Generally, QA documents can be obtained from the suppliers or manufacturers once the new equipment is bought. The first QA requirement which is to assure equipment as fabricated is suitable for process application was identified in P-2 datasheet. The documentation is located at *C:\MIMS\Database\P-2\QA P-2 datasheet.docx.* Part of the document is disclosed in Figure 22. According to the document, it stated that the P-2 is fabricated almost completely same with the order specification and indicate that the pump is suitable for process application for which it may be used.

In addition, appropriate QA check and inspection shall be performed as required in CFR 1910.119 (j) (6) (ii). MIMS captured written information of check and inspection, and spare part record for P-2. The information is stored at *C:\MIMS\Database\P-2\QA P-2 check and inspection.docx*, and *C:\MIMS\Database\P-2\QA P-2 spare part.docx.* as shown in Figure 23 and Figure 24 respectively. From the data assessment it is found that the requirement is adhere to the PSM standard.

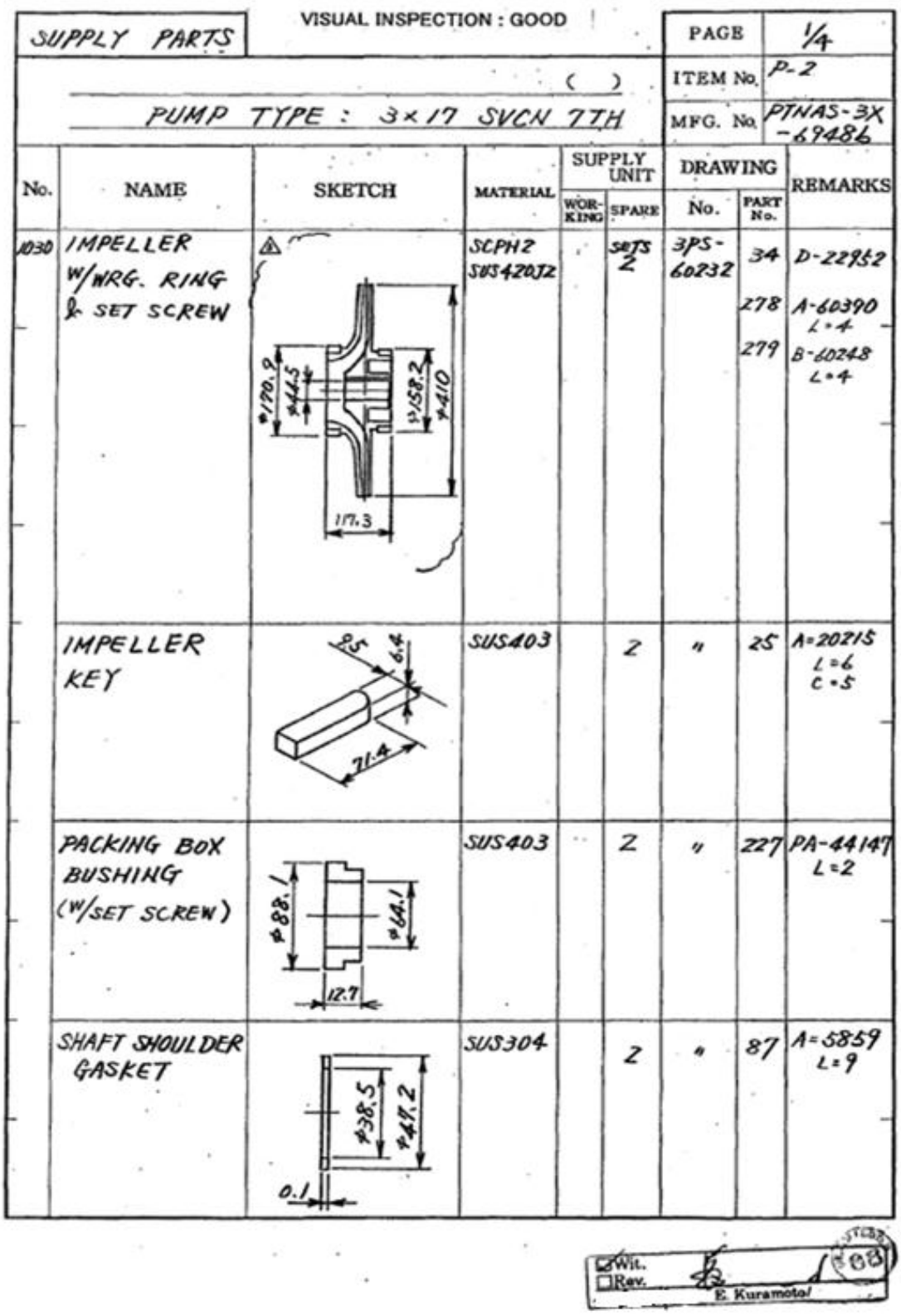
CENTRIFUGAL PUMP NUMBER(S) P-2		Issued for Firm Proposals 3080-8410-21-DS-0011			Revision
Customer's ref :					
Manufacturer's ref. : PTNAS - 3X - 69486					
GENERAL INFORMATION		**REQUISITION**	**FIRM SPEC**	**ORDER SPEC.**	
Compliance with Procurement Initiative Manual		Engineered Solution		Engineered Solution	F1
Specification dated					F1
DESIGN OPERATING CONDITIONS		**REQUISITION**	**FIRM SPEC**	**ORDER SPEC.**	
Pump speed (single/double suction impeller)	rpm	2980 /	/	2980 / ---	F1
Min. continuous flow (stable / thermal)	m^3/h	25		25	F1
Rated Capacity	m^3/h	55.0		55	F1
Differential head at rated capacity	m liq.	209.9		210	F1
Efficiency at rated capacity	%	30.0		30	F1
Power absorbed at rated capacity	kW	104		103.5 Note 6)	F1
Capacity at BEP (actual impeller size)	m^3/h	By SNM		71	F1
Power absorbed at 120 % BEP	kW	By SNM		124 Note 6)	F1
Recommended driver power	kW	110		110 Note 6)	F1
Viscous correction factors CQ/CH/CE		1.00 / 1.00 / 1.00	/ /	1.00 / 1.00 / 1.00	F1
NPSH required from Minimum to Rated capacity	m liq.			3.3	F1
NPSH required from Rated to 120% Rated capacit	m liq.			3.4	F1
PUMP DESIGN		**REQUISITION**	**FIRM SPEC**	**ORDER SPEC.**	
Pump model / frame / size : Note 4)		3 x 17 SVCN 7TH		3 x 17 SVCN 7TH	F1
= Basic Type (Rotor)		Overhung		Overhung	F1
= ISO 13709 configuration code		OH2		OH2	F1
= Single / Double volute / Diffuser		Single Volute		Single volute	F1
= Single / Double suction (first stage)		Single Suction		Single suction	F1
Number of stages		1		1	F1
Max. / Actual / Min. impeller diameter	mm	425.5 / 381 / 355.6	/ /	425.5 / 410 / 355.6	F1
Max. allowable casing working pressure	kg/cm^2g			29	F1
Max. allowable jacket / C.W. piping pressure	kg/cm^2g			--	F1
Suction specific speed with max. impeller diameter at BEP (m^3/h - m - rpm)		Less than 12800		9107	F1
MECHANICAL SEAL & SEALING SYSTEM		Note 3)			
MATERIALS OF CONSTRUCTION		**REQUISITION**	**FIRM SPEC**	**ORDER SPEC.**	
Service Group / Material Group: Note 4)		S-3	/	S-3	F1
Casing		SCPH2		SCPH2	F1
Inner casing or volutes		N/A		N/A	F1
Casing studs		SNB7		SNB7	F1
Min. wall thickness	mm	14.4		14.4	F1
Cover		SF440A		SF440A	F1
Casing gaskets		V#6590V		V#6590V	F1
Wet bolting		SUS304		SUS304	F1
Bearing bracket		SM400B		SM400B	F1
Impeller		Ni Resist		(SCPH2)	F1
Impeller wear ring hardness	HB	325 ~ 375		325 ~ 375	F1
Casing wear ring hardness	HB	225 ~ 275		225 ~ 275	F1
Wear ring coating		NO		NO	F1
Diffuser		N/A		N/A	F1
Shaft		SCM440		SCM440	F1
Interstage shaft sleeve		N/A		N/A	F1
Interstage bushing		N/A		N/A	F1
Balance drum		N/A		N/A	F1
Balance ring		N/A		N/A	F1
Throat bushing		Ni Resist		(SUS403)	F1
PRESSURE CONTAINING PARTS		**REQUISITION**	**FIRM SPEC**	**ORDER SPEC.**	
Pump casing manufacturer					
Pump covers manufacturer					
NOTES ON PROCUREMENT INITIATIVE COMPLIANCE (N/A)					
			Sheet No. 3		
Engineering by :	FOSTER WHEELER E & C (M) SDN BHD		Equipment No.	P-2	
Principal :			Requisition No.	3080 - 1311A - 017	

OLD SNM JOB NO.:PTNAS-5P-60232

Figure 22: Part of the QA datasheet document for Booster Pump (P-2)

									REV. 0	SHEET 1 OF 1	
COMPANY				EQUIPMENT	CENTRIFUGAL PUMP				VENDOR	SHIN NIPPON MACHINERY CO.,LTD	
CONTRACT	FOSTER WHEELER E&C (M) SDN BHD			ITEM NO.	P-2				SNM JOB NO.	PTNAS-3X-69486	
P.O. NO.	533027/003080			PUMP TYPE	3X17SVCN7TH					Inspection Class II	
APPLICABLE CODES AND STANDARDS	REQUISITION NO. :3080-1311A-017 JIS B 8301, 8302, 8310, 0905 API 610 10th Edition ASME Section VIII, DIVISION 1 ASME Section V PTS 31.29.02.30-Gen, MAY 2004 MSS SP-55 (Note) The other applicable specifications shall be refered to Requisition.										
ABBREVIATIONS	H : Hold Point W : Witness I : Random Inspection R : Document Review and Acceptance M : Vendor Inspection										
REFERENCE DWG.	4TP-69484 : INSPECTION AND TEST PROCEDURE 4WP-69484 : WPS&PQR										
NO.	INSPECTION			ITEM NAME	ACCEPTANCE VERIFYING STANDARD	INSPECTION/TEST MARK-UP/SIGN OFF				REMARKS	
						PUMP VENDOR		△ FW/MRC			
1	MATERIAL INSPECTION	MATERIAL CERTIFICATE		Impeller Wearing Bushing	JIS	M	M.S	R		3.1B except for cast iron	
2	MAJOR REPAIR	PT & RT		Impeller	4TP-69484 4WP-69484	M	—	R		When repair occurs submit maps for review prior to repair	
	MINOR REPAIR	PT		Impeller	4TP-69484 4WP-69484	M	—	R	△	When repair occurs	
3	NDE	VISUAL INSPECTION		Impeller	4TP-69484	M	M.S	R			
		PT or MT		Impeller	4TP-69484	M	M.S	R		On Mill Sheet	
4	DYNAMIC BALANCING TEST			Impeller	4TP-69484	M	M.S	R			
5	VISUAL INSPECTION			PUMP PARTS	4TP-69484	M	M.S	R	△		
6	FINAL INSPECTION	Dispatch Verification		PUMP PARTS	4TP-69484 4SPL-69486	M	M.S	W	△		
COMPLETED BY (SNM) M. Shinkai				APPROVED BY (SNM) H. Uetsuki						ENDORSMENT BY	

Figure 23: Part of the QA Check and Inspection Report for Centrifugal Pump (P-2)



SUPPLY PARTS

VISUAL INSPECTION : GOOD

PAGE 1/4

( )

ITEM No. P-2

PUMP TYPE : 3×17 SVCH 7TH

MFG. No. PTNAS-3X-69486

No.	NAME	SKETCH	MATERIAL	SUPPLY UNIT WORKING	SUPPLY UNIT SPARE	DRAWING No.	DRAWING PART No.	REMARKS
1030	IMPELLER W/WRG. RING & SET SCREW	⚠ φ170.9 φ144.5 φ158.2 φ410 171.3	SCPH2 SUS420J2		2 SETS	3PS-60232	34	D-22952
							278	A-60390 L=4
							279	B-60248 L=4
	IMPELLER KEY	8.5 6.4 71.4	SUS403		2	"	25	A=20215 L=6 C=5
	PACKING BOX BUSHING (W/SET SCREW)	φ88.1 φ64.1 12.7	SUS403		2	"	227	PA-44147 L=2
	SHAFT SHOULDER GASKET	φ38.5 φ47.2 0.1	SUS304		2	"	87	A=5859 L=9

Wit.
Rev.
E. Kuramoto

Figure 24: Parts of QA spare parts document for Booster Pump (P-2)

4.3.3 Overall findings of case studies

Table 5 shows the overall findings of the case studies conducted at Refinery X based on the MI requirements. It represents the identified gaps and actions to be taken by the end users for every each of MI sub-standards starting from CFR 1910.119 (j) (1) until CFR 1910.119(j) (6). From the table, it shows that only one of the MI sub-standards of the company which is MI training CFR 1910.119 (j) (3) did not comply with PSM standard. Details of the findings are presented in the Table 5.

Table 5: Overall findings of case studies

Sub-standard	Reference CFR	Gaps	Action to be taken
MI process application	CFR 1910.119 (j) (1)(i-iv)	None (comply)	- Maintain to access MI program to PSM-related equipment
MI written procedures	CFR 1910.119 (j) (2)	None (comply)	- Maintain as per practices
MI training	CFR 1910.119 (j) (3)	- Some documents are not available - Incomplete training the employees	- Provide documents of the training conducted - Provide schedule to every employee so that they are aware about the training.
MI inspection & testing	CFR 1910.119 (j) (4)(i-iv)	None (comply)	- Maintain the inspection & testing conducted as per practices
MI equipment deficiency	CFR 1910.119 (j) (5)	None (comply)	- None
MI Quality Assurance (QA)	CFR 1910.119(j) (6)(i-iii)	None (comply)	- Maintain as per practices

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 CONCLUSION

This present study introduced a structured technique for easy implementation and management of mechanical integrity at a process plant in order to comply with MI 29 CFR 1910.119(j) requirements. The framework was developed as a guide for the employer to manage the MI and determine the gaps and solutions in a systematic ways. The technique uses P&ID as a foundation in tracking and managing the data as it prevents missing of MI program perform to the related equipment since the P&ID contain details of any equipment involved in the process plant.

MIMS is a developed prototype database management system based on the proposed concept for easy implementation and explanation. Following all the systematic approach as described in the system, the end users are capable to determine the gaps for improvement in term of safety as well as for smooth plant operation. By knowing where the weakness exists allows a facility to develop or address the greatest MI needs. Implementation of this technique will help industries to ensure the equipment integrity and control process hazards that could prevent major accidents such as fire, explosion and toxic releases and compliance with PSM regulation. Besides, a well implemented MI system ensures that the people, assets and surrounding environment are not adversely affected by inadequate evaluation of hazards, threats and other potential undesired events related to failure of facilities.

5.2 RECOMMENDATIONS

For future recommendation, in upgrading the system, continuous research of MI program should be done within a longer time frame so that it provides more impactful result to the system and discover full ability or strength of the system. Once the database system is proven to be manageable by the end users, it can be implemented in process industries as the best way to manage the MI of the company in order to assure high level of safety is practiced as intended and lead to no accidents.

Besides, other elements of PSM are encouraged to follow the introduced technique used by MIMS in order to comply with overall PSM requirements. Last but not least, to integrate the other 13 PSM elements into a centralized database system to obtain complete integration of PSM program and completely prevent any hazards related to the accidents in process industries.

REFERENCES

[1] CCPS. Center for Chemical Process Safety. (1999). *Guidelines for Consequence Analysis of Chemical Releases*. AIChe. New York.

[2] U.S. Department of Labor. (1996). *Process safety management of highly hazardous chemicals.* Retrieved June 22, 2012, from http://www.osha.gov/doc/outreachtraining/htmlfiles/psm.html.

[3] Khan, F. I., & Abbasi, S. A. (1999). Major accidents in process industries and an analysis of causes and consequences. *Journal of Loss Prevention in the Process Industries, 12*(5), 361-378.

[4] Prem, K. P., Ng, D., & Mannan, M. S. (2010). Harnessing database resources for understanding the profile of chemical process industry incidents. *Journal of Loss Prevention in the Process Industries, 23*(4), 549-560.

[5] Konstandinidou, M., Nivolianitou, Z., Markatos, N., & Kiranoudis, C. (2006). Statistical analysis of incidents reported in the Greek petrochemical industry for the period 1997–2003. *Journal of Hazardous Materials, 135*(1–3), 1-9.

[6] Nivolianitou, Z., Konstandinidou, M., & Michalis, C. (2006). Statistical analysis of major accidents in petrochemical industry notified to the major accident reporting system (MARS). *Journal of Hazardous Materials, 137*(1), 1-7.

[7] Bridges,W. & Tew, R. (n.d.). *Human Factors Elements Missing from Process Safety Management (PSM).* Paper presented at American Institute of Chemical Engineers 2010 Spring Meeting 6th Global Congress on Process Safety and the 44th Annual Loss Prevention Symposium San Antonio. Retrieved June 22, 2012 from http://www.piii.com/_downloads/Human_Factors_Elements_Missing_from_PSM.pdf

[8] Planas, E. & Casal, J. (n.d.)*Fire accidents in process plants: Mathematical modelling, uncertainties and research needs.* Retrieved June, 23, 2012, from http://areeweb.polito.it/ricerca/safer/page10/files/Casal/M.%20M.%20Fires%20-2.pdf.

[9] CCPS. Centre for Chemical Process Safety. (2006). *Guidelines for Mechanical Integrity Systems.* New Jersey: John Wiley & Sons.

[10] Hazzan, M.J. (n.d.). *Repair your mechanical integrity program.* Retrieved June, 22, 2012, from http://www.chemicalprocessing.com/articles/2005/588.html

[11] Long, L. A., Marshall, M. L., & Lay, J. (2011). Update on OSHA's PSM national emphasis programs. *Process Safety Progress, 30*(4), 303-306.

[12] CCPS. Centre for Chemical Process Safety. (2011). *Guidelines for Auditing Process Safety Management System,*2nd ed., New York: John Wiley & Sons.

[13] Rivero, W. (2011). *Mechanical integrity best practices case study.* Retrieved June 25, 2012, from http://www.apmadvisor.com/archivearticle.asp?id=265&is=52&ord=1

[14] Bragatto, P. A., Pittiglio, P., & Ansaldi, S. (2009). The management of mechanical integrity inspections at small-sized "Seveso" facilities. *Reliability Engineering & System Safety, 94*(2), 412-417.

[15] Sanders, R.E. (2005). *Chemical Process Safety: Learning from Case Histories,* 3rd ed.,Oxford, U.K.: Elsevier Butterworth- Heinemann.

[16] Montgomery, R., Patschke, C., & Thompson, G. (2009). *Equipment deficiencies: How well are they being managed?* Retrieved August 12, 2012 from http://www.absconsulting.com/resources/articles/054_BICDecJan09.pdf

[17] Sanders, R.E. (1999). *Chemical Process Safety: Learning from Case Histories,* Oxford, U.K.: Butterworth- Heinemann.

[18] Sasser K. N., M.S., EIT and Ford R.T. (1999).*A Three-Phase Approach to Mechanical Integrity.* Paper presented at ASSE Professional Development Conference and Exhibition, June 13 - 16, 1999, Baltimore, Maryland. Retrieved August 22, 2012 from http://www.onepetro.org/mslib/servlet/onepetropreview?id=ASSE-99-060#