Development of Process Safety Management Expert System (PSMES) for UTP Mini Plant of High Gravitational Natural Gas Dehydration Unit

by

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CERTIFICATION OF APPROVAL

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Approved by,

(Assoc. Prof. Dr. Azmi Mohd Shariff)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

July 2009

CERTIFICATION OF ORIGINALITY

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

NOR HIDAYAH BINTI USOP

ABSTRACT

This report is prepared as the final documentation for the proposed final year project entitled 'Development of Process Safety Management Expert System (PSMES) for UTP Mini Plant of High Gravitational Natural Gas Dehydration Unit'. Process Safety Management (PSM) is a standard promulgated by the United States Occupational Safety and Health Administration (OSHA) in 2000 intended to prevent major accidents hazards from occurring. This standard comprises of fourteen (14) main elements to manage the hazards associated with highly hazardous chemical (HHC).

The main objective of this research is to develop an expert system named PSMES to be used in process plants and other companies which will ensure that they comply with OSHA regulations and requirements. For this project, PSM elements are divided into two (2) major categories; Process Flow Diagram (PFD) Elements and Block Diagram (BD) Elements. The author chose UTP mini plant of High Gravitational Natural Gas Dehydration Unit as the project case study. Furthermore, for this project, the author is developing only 7 (seven) out of 14 (fourteen) PSM elements. These elements are Process Safety Information, Training, Operating Procedures, Management of Change, Hot Work Permit, Incident Investigation, and also Compliance Audit.

The development PSMES utilizes tools such as Microsoft Visual Basic for programming purposes. The concept of the system is initially represented by the frameworks constructed in flow chart forms, designated for each element.

The results show how the expert system is executed using the approved frameworks constructed earlier. The development of this PSMES is expected to assist the company in managing its operation in an effective and convenient manner.

ACKNOWLEDGEMENT

In the name of Allah, The Most Gracious, The Most Merciful. Praise to Allah S.W.T by whose grace and blessing I receive guidance in completing this dissertation report. Thanks for His greatest love and blessings.

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A special thanks to my colleagues Mohammad Faizal Che Daud and Mohd Rafizie Roslan from Universiti Teknologi Petronas (UTP), who have given full commitment, share brilliant ideas as well as give unconditionally assistance to ensure this project is successful.

Lastly, thanks to my family members in helping me going through this one year duration. With the help and assistance all of these people mentioned above, I would say it's been a very valuable and unforgettable experience for me. Again, thank you very much.

A Special Dedication of This Grateful Feeling to My...

Beloved Mum and Dad;

Inspiring Supervisor;

AP Dr. Azmi Mohd Shariff

Enthusiastic and committed colleagues;

Mohammad Faizal Che Daud

and

Mohd Rafizie Roslan

My life aspiration;

Jeff

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LIST OF ABBREVIATION/NOMENCLATURE

- 1. PSMES Process Safety Management Expert System
- 2. PSM Process Safety Management
- 3. OSHA Occupational Safety and Health Administration
- 4. HHC Highly Hazardous Chemical
- 5. II Incident Investigation
- 6. HWP Hot Work Permit
- 7. CA Compliance Audit
- 8. TS Trade Secrets
- 9. PFD Process Flow Diagram
- 10. BD Block Diagram
- 11. P&ID Piping and Instrument Diagram

CHAPTER 1

INTRODUCTION

1.1 Background

In the past 20 years, there are numerous major disasters happened including the Bhopal incident in India which killed more than 2,000 human lives, followed by the Phillips Petroleum Company, Pasadena, Texas in October 1989 incident which caused in 23 deaths and 132 injuries. Although these major disasters involving highly hazardous chemicals (HHC) drew worldwide attention to the potential for major catastrophes, the public record is replete with information concerning many other less notable releases of highly hazardous chemicals (HHC). Hazardous chemical releases continue to pose a significant threat to employees and provide awareness drive, internationally and nationally, for authorities to develop or consider developing legislation and regulations to eliminate or minimize the potential for such events.

To prevent such unfortunate events from re-occurring, the U.S. Occupational Safety and Health Administration (OSHA) has taken an initiative to issue the Process Safety Management (PSM), a regulation which contains requirements for the management of hazards associated with processes using highly hazardous chemicals (HHC) to help assure safe and healthy workplaces.

PSM clarifies the responsibilities of employers and contractors involved in work that affects or takes place near covered processes to ensure that the safety of both plant and employees is considered. The standard also mandates written operating procedures; employee training; prestart up safety reviews; evaluation of mechanical integrity of critical equipment; and written procedures for managing changes. PSM specifies a permit system for hot work; investigation of incidents involving releases or near misses of covered chemicals; emergency, action plans; compliance audits at least every three years; and trade secret protection.

PETRONAS, the national oil and gas company is the pioneer in assuring the PSM implementation is being executed in Malaysia. PETRONAS recommends its HCU/OPUs to apply PSM in every oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities, or any other such facility, and thereby to achieve maximum technical and economic benefit from the standardization.

1.2 Problem Statement

Nowadays, there are several companies that already implement PSM at their work places. However, some issues arise pertaining on how to fully implement all the fourteen (14) elements of PSM in a process plant and how to relate them to each other. The current implementation of PSM is not feasible and user-friendly. This is because for instance, a company tends to keep their important documents such as PFD, P&ID, HAZOP report and training schedule in multiple locations and in multiple folders. Therefore, it is tedious for an employee to search for the documents everywhere in the plant if he or she were to use the P&ID and HAZOP report at the same time. In other words, the documents are not being grouped based on the PSM elements they belong to. By far, the current practice of PSM implementation does not fully involve all of its fourteen (14) elements and there are still no tools that can integrate all the PSM elements into one (1) practical and effective system where all the information of the company is available at one time. This is the main reason of introducing the PSM Expert System (PSMES) which will benefit not only the employees, but also the employees, contractors, vendors and clients.

1.3 Objectives and Scope of Study

The main objective of this project is to develop an expert system named PSMES to be applied in process plants and other companies which will ensure that they comply with OSHA regulations and requirements. However, the scope of the project is narrowed in terms of the application whereby in order to demonstrate the effeciencies of the system, the author selects UTP mini plant of High Gravitational Natural Gas Dehydration Unit as the project case study. Furthermore, for this project, the author is developing only 7 (seven) out of 14 (fourteen) PSM elements. These elements are Process Safety Information, Training, Operating Procedures, Management of Change, Hot Work Permit, Incident Investigation, and also Compliance Audit.

The work scopes of this project include constructing the concept of the expert system by developing the selected framework for each PSM elements extracted from OSHA regulation. Next is to develop the expert system by using the frameworks that have been approved by the supervisor. The expert system that has been developed is expected to demonstrate at least one working example for each category of PSM elements.

CHAPTER 2

LITERATURE REVIEW AND/OR THEORY

As stated in the Process Safety Management (PSM) publication by U.S Occupational Safety and Health Administration (OSHA) in 2000, PSM comprises of fourteen (14) main elements namely as follow^[1]:

- 1. Process Safety Information
- 2. Process Hazard Analysis
- 3. Operating Procedures
- 4. Employee Participation
- 5. Training
- 6. Contractors
- 7. Pre-Start-up Safety Review
- 8. Mechanical Integrity
- 9. Hot Work Permit
- 10. Management of Change
- 11. Incident Investigation
- 12. Emergency Planning and Response
- 13. Compliance Audit
- 14. Trade Secrets

The standard mainly applies to manufacturing industries—particularly, those pertaining to chemicals, transportation equipment, and fabricated metal products. Other affected sectors include natural gas liquids; farm product warehousing; electric, gas, and sanitary services; and wholesale trade. It also applies to pyrotechnics and explosives manufacturers covered under other OSHA rules and has special provisions for contractors working in covered facilities.^[2]

The following paragraphs are the citations obtained from various resources regarding the weakness of current PSM implementation.

^[3]Currently, the PSM standard is applied only to installations containing more than a threshold amount or either flammable or toxic chemicals; the threshold is typically 10,000 pounds of flammables, usually somewhat fewer pounds of toxic chemicals. Most of the time, installations used in process development activities fall below the thresholds outlined in the PSM standard, so legally, strict adherence is not required. Although the quantities of materials may be smaller than the OSHA thresholds, most process development activities have the potential for serious injury or fatality, even if the extreme numbers envisioned when the PSM standard was crafted are not possible.

^[4]There are insufficient data due to incomplete record keeping. Some companies began incorporating PSM as part of their culture many years ago. For some of these companies, much of the labor and other cost data were not being tracked until recently.

^[5]OSHA is experiencing similar "start-up" difficulties regarding enforcement of the standard. Some of the more difficult challenges facing OSHA are listed as follows:

- consistent interpretation of the standard
- a shortage of trained and qualified inspectors
- a shortage of sufficient resources to conduct inspections
- complexity due to other state and proposed federal process safety regulations

^[6]A number of recent devastating process safety failures have been ascribed to poor process safety management (PSM) systems, inadequate process safety culture, and weak

corporate oversight. This has been validated by both the BP North American Refineries Independent Safety Panel and the Hertfordshire Oil Storage Terminal Report.

^[7]Several problems commonly occur with companies attempting to meet the audit requirements of the standard:

- auditing the PSM system is often a new experience for managers
- little guidance is available on specifically how to evaluate compliance
- even less guidance is available on how to evaluate effectiveness
- no commonly accepted ranking system is available to rate performance
- since the standard is performance-based, it is difficult to conduct an audit unless specific goals have been set to measure performance against

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 The Development Process

In order to develop PSMES, the first task is to study and comprehend each PSM element and note the OSHA regulations they should comply with. It is observed that some of the PSM elements have connection with the other element. It is important to ensure that there will be no redundancy occurs once the expert system is developed. Next, the author proceeds with developing the concept of the expert system by constructing the framework for selected PSM elements. This is the most vital task as frameworks will be the back bone of the expert system. The frameworks are similar to flow charts constructed from OSHA regulations of each PSM elements. The purpose of constructing the frameworks is to demonstrate the engineering point of view on how the expert system should operates without violating any OSHA regulations. Then, the frameworks are to be reviewed and checked by the supervisor, AP Dr Azmi M Shariff in order to clarify that they are valid to be executed into an expert system. After making some adjustments and modifications, the frameworks are then approved by the supervisor. Once the frameworks are approved, the author starts to develop the expert system using computer programming aid. The following flow chart (Figure 1) simplifies the process of PSMES development.



Figure 1: The Process of PSMES Development

3.2 Separation of Elements

All PSM elements are divided into two (2) categories based on the characteristics of each element. The purposes of dividing the PSM elements into two (2) groups are to differentiate each element as well as to give convenience while developing the expert system. Process Flow Diagram (PFD) elements are referring to any PSM element that can be accessed via the PFD of the plant. On the other hand, the Block Diagram (BD) elements are referring to any elements that cannot be accessed via the PFD of the plant and they are separately placed on the Homepage of the expert system unlike the PFD elements.

TYPES OF ELEMENTS	LIST OF ELEMENTS
Process Flow Diagram (PFD) Element	 Process Safety Information Process Hazard Analysis Operating Procedures Pre-Start-up Safety Review Mechanical Integrity Management of Change
Block Diagram (BD) Element	Employee ParticipationTraining

Table 1: Categories of PSM Elements

Contractors
 Hot Work Permit
 Incident Investigation
• Emergency Planning and Response
Compliance Audit
• Trade Secrets

*The elements in bold are developed by the author.

The author develops only 7 (seven) out of 14 (fourteen) PSM elements. The elements constitute 3 (three) Process Flow Diagram (PFD) element and another 4 (four) Block Diagram (BD) elements.

3.3 Tools Required

In order to develop the PSMES, several tools are used to assist the author. Listed below are the tools required for developing the entire PSMES.

- 1. Microsoft Office Word To develop frameworks
- 2. Microsoft Visual Basic To develop system software

3.4 Project Activity and Schedule

Last semester, the project activities basically focus on finding the related journal/thesis regarding the flaws of current PSM implementation. These activities include books review and online journal research. The proofs of study are important to ensure the project of developing PSMES will be unique, cost-effective and beneficial in the future. Furthermore, literature reviews help in developing the understanding of PSM as well as give ideas to the author so that the system can be developed efficiently. Next, the author has started to construct the framework for PFD elements which are Process Safety Information, Operating Procedures and Management of Change. The frameworks will assist the system development in the future. For this semester, the project activity continues within the first 3 (three) months by constructing the frameworks for rest of the Block Diagram (BD) elements which include Training, Work Permit, Incident Investigation and Compliance Audit.

The author has already met one of the researchers of High Gravitational Natural Gas Dehydration Unit, Ms Nurhayati to get a clear explanation on the mini plant flow sheet. The flow sheet of the plant will be the main component mostly utilized in the development of the expert system. Furthermore, the author has also visited the mini plant and has better understanding on the equipment arrangement and the processes that take place. Then, the author has discussed with the mini plant contractor, ABA Gas Technologies Sdn. Bhd. and Ms Nurhayati to obtain more information for developing the expert system.

Once all the required information has been collected, the author starts to develop the expert system using Microsoft Visual Basic. The system is expected to show at least one element of each PSM category is successfully developed.

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No.	Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue															
2	Submission of Progress Report 1															
3	Project Work Continue															
4	Submission of Progress Report 2															
5	Seminar (compulsory)															
5	Project work continue															
6	Poster Exhibition															
7	Submission of Dissertation (soft bound)															
8	Oral Presentation															
9	Submission of Project Dissertation (Hard Bound)															

Table 2: Suggested Milestone for the Second Semester of Final Year Project

CHAPTER 4

RESULTS AND DISCUSSION

This section is divided into two (2) parts. The first part will discuss the results in terms of the frameworks that have been developed for the selected elements including the framework for Homepage while in the second part the results discuss the expert system execution. In the Homepage framework, there is no separation of elements being shown to avoid confusion among the readers. The frameworks are developed based on the requirements by OSHA ^[7].

4.1 Part I: Frameworks



4.1.1 PSMES Overall Framework





4.1.3 Block Diagram (BD) Frameworks

4.1.3.1 Audit Framework



4.1.3.2 Permit Framework







4.1.3.4 Training Framework



4.1.4 Process Flow Diagram Framework

4.1.4.1 Management of Change Framework



4.1.4.2 Operating Procedure Framework

4.2 Part II: PSMES Execution Example

This section shows a series of screen shots captured when the expert system is executed.

4.2.1 The Login Process

Process Safety N	lanagement (PSM) Expert System. Please	Logir
A	Employee ID : Password :	
S P	L can't access my account Help Sign In	
UNIVERSITI TEKNOLOGI	Login As Guest Guest)

Figure 2: The Login Page. Employee to enter ID and password or user can login as

guest

rimary form	
Login Successfull. Welcome to PSN	1 Expert Syster

Figure 3: Successful login notification

4.2.2 The General Interface of PSMES

Figure 4: PSMES Homepage shows the PFD of the mini plant which consist of 4 (four) main

systems

Equipment	List General Arrangement	High Gravitational NG Deny	aranon	Unit of Universm Te	
ase conth	e parts to view itd process safety				
PART NO.	PART'S NAME	PARTS DETAILS	QTY	REMARK	AIR
V100	Valve, Ball 2-way 0.5"	Swagelok SS-63TF8	5		
V110	Valve, Ball 2-way 0.5"	Parker HPBYB8FF	13		LINUVEDSITI
V120	Valve, Ball 2-way 0.5"	Swagelok SS-AFSS8	3		TEKNOLOGI
V130	Valve, Ball 2-way 0.375"	Swagelok	1		PETRONAS
V140	Valve, Ball 2-way 2.0"	Swagelok SS-68TSW32P	3		
V150	Valve, Ball 3-way 2.0"	Swagelok SS-68XTSW32P-F32	5		OUICK MENU
V155	Valve, Ball 2-way 0.5" w/act	Swagelok SS-AFSS8-A30C4	2		Audit
V160	Valve, Ball 2-way 2.0" w/act	Swagelok SS-68TSW32P-A150C5	16		Employee Participation
V170	Valve, Ball 3-way 2.0" w/act	Swagelok SS-63XTSW32P-F32-A100XD	1		T i i
V180	Valve, Check 0.5"	Swagelok SS-CHS8-1	13		Training
V190	Valve, Check 2.0"	VYC Model 179	6		Work Permit
V200	Valve, Regulator 0.5"	Swagelok KHF1GRB818A20000	2		Contractors
V210	Valve, Regulator 0.25"	Swagelok KPR1GRL412A20000	1		Incident Investigation
V220	Valve, Regulator BP 0.5"	Speck-Kolbenpumpenfabrik UL227/100	1		Emergency Planning
V230	Valve, Needle 0.25"	Swagelok SS-1KM4-S4	8		Trade Secret
V240	Valve, Purge 0.25"	Swagelok SS-4P-4M	2		
V250	Valve, Relief 0.5"	Flow Safe 01-2188M-102 set @1500psig	9		
V260	Valve, Relief 0.5"	Flow Safe 01-2188M-102 set @150psig	1		
V270	Gauge, Pressure	Wika 03000psig 4" dial LM 0.5"NPT	3		
V280	Gauge, Pressure	Wika 03500psig 4" dial LBM 0.5"NPT	2		
V290	Gauge, Pressure	Swagelok 06000psig 2.5"dial CBM 0.25"NPT	2	~	Help

Figure 5: The plant equipment list

Final Year Project (II)

Figure 6: The General Arrangement of the plant; from Angle 1

Figure 7: The General Arrangement of the plant; from Angle 2

4.2.3 Application Example 1 - To show one element from PFD category is successfully developed. The element selected is Process Safety Information (PSI).

Figure 8: From PFD, user to click on the desired equipment (compressor)

Figure 9: User to click on the PSI button on at the bottom right of the active window

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Final Year Project (II)

July 2009 Semester

Figure 10: MSDS of Natural Gas

Figure 11: Compressor detailed drawing

Final Report

Final Year Project (II)

July 2009 Semester

Figure 12: Safety system rules and instructions

Figure 13: Safety system operation and description

Final Year Project (II)

Final Report

📲 🔐 Natural Gas Compressor V470 🛛 🖳 Process Safety Information		
Englishment Overseiner Bud Guy MSDS Safety system Drawing MEB Ventilation system design Relief system design and design basis Elec	rical Classifications	
Adoba Reader . Linstallationpreservation pdf]		Basic Information
The Edit View Document Tools Window Help	_ 8 ×	System Operation
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INSTALLATION AND PRESERVATION		
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7 COMPRESSOR ENCLOSURE INSTALLATION 12		
7.1. Enclosure Concrete Foundation		
7.2. Enclosure boli down		
9. STORAGE CASCADE INSTALLATION 13		
10. GAS SUPPLY PIPING		
10.1. Cathodic Protection		
10.2. Frexulte Coupling		
10.4. Filter Meter Module		.:
11. PIELD STORED AND THE THREE THREE		Incident Investigation
a 112 FIGTRICAL INSTALLATION REQUIREMENTS		Emergency Planning
13.1. Area Electrical Classifications		Tech Court
13.2. Electrical Control Failer Instantiation		Thabe Secret
14. LONG TERM PRESERVATION PROCEDURE 14		
	1.00	
	~	Help
	_	Logout

Figure 15: Safety relief valve description

4.2.4 Application Example 2 - To show one element from BD category is successfully developed. The element selected is Compliance Audit.

Figure 16: At Homepage, user to click on the Audit button at the right hand side of the window

) by System	Audit Internal Audi	it Eutom	al Audit	Audit AA		at Equipmor	et Tost Dosu			
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	Stage 1 S	Stage 2	Stage 3							
	a Audit Man	agement								TEKNOLOGI
	Directory	Rew	(Q) Open	Duplicate	Archive	EB 🕼 Revert Remov	/e Email	Print H	ML Export	PETRONAS
	Filter	Start Date	End Date	Status	Audit ID	Area	Location	Title	Auditor	QUICK MENU
	IR	02/11/2001	02/11/2001	Pending	AU-000001	Quality, Sales	Service Centre	Example Audit 1	Auditor 1	 Audit
g.	Pending	02/11/2001	02/11/2001	Pending	AU-000012	Quality, Sales	Service Centre	Created From -	Auditor Name 1	Employee Participatio
	La la	03/01/2003	10/01/2003	Pending	AU-000008	Publishing	Lincoln	Example Audit	Jim Jones	Training
	In Progress	03/01/2003	10/01/2003	Pending	AU-000008	Publishing	Lincoln	Example Audit	Jim Jones	Work Permit
	Follow Up									Contractors Incident Investigatio
FEED S	B									Emergency Planning
	Complete									Trade Secret
	Archived									
	Versions									

Figure 17: Internal audit record

Final Year Project (II)

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Audit Tyne :	Start Date	: Finish Date :				
3rd Party (Independent Audit.)	▼ ▼ 01/01/2	2002	12 -			
			×			
Audit Certi	ication Audit Report	Form Audit Report Rec	ord Help	ļ		

Figure 18: Audit form

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	- Q						
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7 Complete EC		🗸 ок	7 Help				
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5 Receive stor	equest and test incoming goods from stock	Logistics Operato	r				
A Complete stor	pres release on ECS 5442 Raise Lah request o	Goods Receiving					
ECS 6390		Clerk					
	Audit Certification Audit	Report Form	Audit Report F	tecord Help			

Figure 19: Detailed audit form

Final Year Project (II)

Figure 20: Audit record

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Certificates	Page 1 📃 /	Appliance Details								
Show Items:	All Appliances	RESULTS	l Appliance 🏼 Edit 🛛 🗙	🕻 Delete 🛛 🗔 Find	() (1)	👍 Previous 🧯	👃 Next	Ch		
Appliance ID +	Test Date	Description	Location	Serial Number	Retest Period	Retest Date	Status	^		
AP0001	29/07/2008	IEC Lead	Office	N/A	6	29/01/2009	Pass			
AP0002	29/07/2008	240v Extension Lead	Board Room	N/A	6	29/01/2009	Fail			
AP0003	29/07/2008	110v Extension Lead	Warehouse	N/A	6	29/01/2009	Fail			
AP0004	29/07/2008	Monitor	Ground Floor Office	12345678	12	29/07/2009	Pass			
AP0019	29/07/2008	Convector heater	Office	N/A	12	29/07/2009	Pass	1000		
							1			
		Audit Certificat	on Audit Report	t Form Au	dit Repo	rt Record	Не	1p		
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Figure 21: Equipment test result

Form Peview					
Audit No.	Vendor-0004-Audits		Status	INWORKS	-
Audit Type	Vendor Audits		Phase	DISCOVERY	
Title	Supplier Quality Audit 001		Result		
Begin Date	4/23/2007		End Date	4/25/2007	
Audit					
		Audit I	nformation		
Requestor					
Administrator Role					
Document Owner					
Description				Vec	
Created Date			Work Group Access Only	Tes	
Program No.			Result Type	Standard Result	
Contact Role			Contact	SARA Sara Moon	
Duration					
Required Response Time			Follow-up To Audit No.		
Result Assigned By					
Result Assigned Date					
	Discussion				
		Auditee	Information		
Auditee Code	FACILITY 1				
Organization Unit	FAC 1 FACILITY 1		Product		
Process	All Processes All Operations		Location		
		Criteria	Information		
Criteria No.	0				

Figure 22: Audit report form

🖳 Audit	
Clents Clerk Assoc.	
	Image Attachments 1 of 1 CiProgram Files/Smeadink/Data/Attachments/Express/SL0/S0001SP.PVG Image Attachments / Express.mdb Manager v6.5.122 0(10)(2006 10:12 PM
📊 start 🔹 🕑 2 Flock 🔹 🔗 547. www.r 🕞 audik	🔐 2 Microsof 🔹 🕎 3 Window 🔹 😌 peja_etp 🛛 💽 Microsoft Ex 🎽 5 - Pant 🖉 2 Microsof 🍷 🤻 🔔 (2.53)

Figure 23: Audit report record

Discussion:

- 1. The frameworks are developed such that they comply with the regulatory requirements of Process Safety Management (PSM) publication by U.S Occupational Safety and Health Administration (OSHA) in 2000. This is to avoid any incompliance of regulations among the companies.
- Furthermore, this will assist in the audit process of the system and making it a smooth and easy process if the system follows all the regulatory requirements. If the system fails to comply with even one (1) requirement, then it cannot be established.
- 3. The fully developed expert system has high potential to be commercialized in the outside market since PSMES will be the ultimate tool that helps companies to comply with OSHA regulations and requirements.
- 4. The expert system will also helps in minimizing management and maintenance cost of a company as well as saving a lot of time.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

As the conclusion, PSMES is successfully developed by integrating all the selected PSM elements into one practical, efficient and user-friendly system. The author successfully demonstrates one working example from each category of PSM elements. The objective of the project is achieved. The strong frameworks developed for each PSM elements produce a reliable, convenient and user-friendly tool—the expert system. PSMES is an ultimate expert system that will assist the user in fulfilling the regulations of OSHA which is crucial for a company/plant to operate at all times. Developing PSMES is a sustainable achievement because it ensures profit in return as PSMES is the only tool of its kind which available in the market at present.

Recommendations:

- 1. The expert system must initially be tested by a number of respondents to identify any imperfections or weakness before being commercialized in the outside market.
- 2. The expert system should maintain a very high security to prevent any breakouts into the system by irresponsible individuals.

CHAPTER 6

REFERENCES

The format of references for the respective sources is as follows:

- 1. Website refer to <u>http://www.ehso.com/</u>
- 1. Website refer to http://www.osha.gov/Publications/osha3132.pdf
- 2. Article refer to W. Theodore and F. Richard (2005)
- 3. Journal refer to W. Bridges (1994)
- 4. Journal refer to N. Mulvey (1995)
- 5. Article refer to Chilworth Process Safety News (2008)
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- 7. Book refer to Chilworth Pvt. Ltd. (2009)

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