Process Hazard Management System (PROHAMS) based on PSM

A. M. Shariff, H. A. Aziz and K. H. Yew
Process Safety Research Group, Department of Chemical Engineering
Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia
azmish@petronas.com.my, Tel: 605-3687570, Fax: 605-3656176

***Abstract*—** The key contributing factors that could prevent major accidents, injuries and fatalities in the process industries are by controlling the process hazards within the process plant. However, accidents can still happen if the process hazards are inadequately managed. One of the established standards to manage process hazards is Process Hazard Analysis (PHA) of Process Safety Management (PSM) 29 CFR 1910.119(e). This paper presents a PHA management and implementation technique that could fulfil the 29 CFR 1910.119(e) requirements. The technique provides organized strategies to manage and track information, documents, and resolution of recommendations related to the process hazards. Piping and Instrumentation Diagram (P&ID) is used as a foundation for the PHA data management. The data is efficiently managed using a computer database prototype known as Process Hazards Management System (PROHAMS). Implementation of this technique could help the employers to manage process hazards successfully and compliance with PSM regulation.

***Keywords*—** Managing Hazards, Process Hazard, Process Hazard Analysis, PSM

I. Introduction

Numerous major accidents in process industries such as at Bhopal (1984), BP Texas Refinery Plant (2005) and BP Deepwater Horizon Mexico (2010) caused high fatalities and damages to properties and environment due to failure of managing process hazards properly. In order to prevent such accidents, rigorous hazard identification techniques and preventive safety procedures are implemented. Some of the well-known techniques are Hazard and Operability Studies (HAZOP), Fault Tree Analysis (FTA) and What-if analysis. Despite all the prevention efforts, accidents are still occurring worldwide. Investigations on these accidents have revealed that inadequate hazards review and improper hazards managements were the main factors that contribute to the accidents [1, 2].

To prevent major accidents from occurring, regulatory bodies worldwide posted certain industrial process safety standards that come in many forms, including mandatory standards, voluntary standards and consensus codes. One of the established mandatory standards that addressed the above issues is Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) of Highly Hazardous Chemicals (HHC), 29 CFR 1910.119 [3]. The industries and regulatory bodies worldwide agreed that the implementation of PSM could prevent accidents if process plants follow the regulation as intended [4, 5].

Currently, the practical implementations of PSM are varied from plant to plant due to lacking of established technique for industries to comply with PSM requirements and maintaining the effective process safety programs [6, 7]. PSM auditing costs are high, and people are doubtful about its effectiveness [8]. PSM documentation is a very tedious process and requires strict management. Furthermore, good documentation is just a beginning and proper utilization is again difficult without a systematic filing system [9]. In general, the PSM implementation requires a lot of effort and time but pays off well if implemented fully [10].

The PSM standard contains 14 elements, including Process Hazard Analysis (PHA) 29 CFR 1910.119(e). The PHA is the heart of PSM standard that aims for systematically identifies, evaluates, and mitigates potential hazards in process plant [11]. This article proposes a structured technique using Piping and Instrumentation Diagram (P&ID) as a platform to manage PHA implementation that complies with OSHA PSM.

II. Methodology

A. Compliance with PHA of PSM Requirements

OSHA does not provide any specific methodology to be used for the implementation of PHA in order to comply with PSM regulation. However, there are numbers of general guidelines provided such as from CCPS [12-13]. Since particular methodology is not publicly available, therefore many companies developed the system based on their own interpretation and understanding from PSM guidelines. This paper introduces a technique to establish a PHA system that can comply with PSM regulation.

A framework in Fig. 1 summarizes vital information and strategy to manage and implement PHA as required by 29 CFR 1910.119(e). The detail explanation on the technique is given in the case study at section IV.

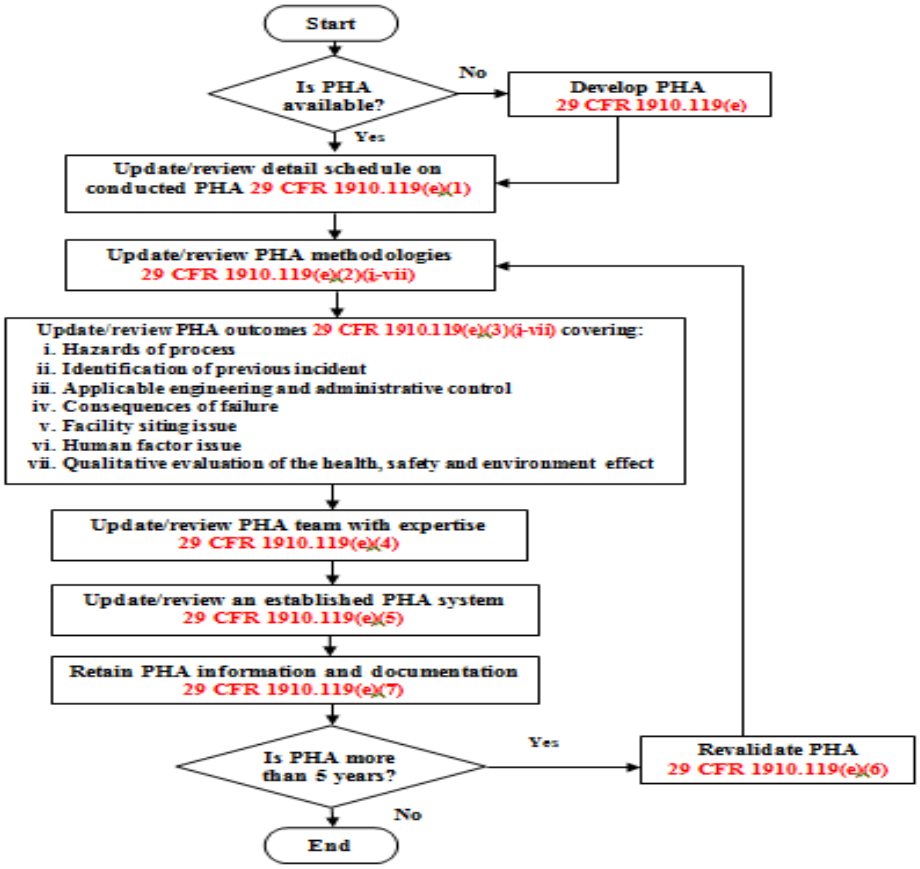


Fig. 1 Framework of PHA based on 29 CFR 1910.119(e)

B. Using P&ID as a Foundation for Data Management

A node system based on P&ID is used for managing and tracking written information of PHA. The P&ID is divided into several nodes. The number of nodes selected depends on the design intent and the number of equipment within the process plant which is considered manageable by the end users. The PHA implementation for each node is carried out according to 29 CFR 1910.119(e) standards as shown in Fig. 1. After all the information has been updated, the end users can select the next node to review or update the data. The updating information process will continue until all nodes in the P&ID are completed. For some cases, the node size may be quite large depending on the scope of the process. One P&ID may not capture the whole process well. Regardless of the numbers of P&IDs involved; similar steps should be adopted until the entire process plant is covered.

III. Process Hazard Analysis Management System (PROHAMS)

Even though the provision contained in OSHA PHA can be done manually, the best results can be obtained through a computer database system for efficient management of data and time. A prototype database management system known as PROHAMS was developed to demonstrate the concept using Microsoft Office Access 2010.

PROHAMS interfaces contain details of the mandatory requirements for employers to comply with PHA element of PSM. The information to be compiled may be found in hardcopy and softcopy forms, such as log book, report and plant layout. The system allows for capturing information at any specific location. It also provides an effective communication process to all relevant personnel by allowing access to the information and acknowledged them for any process changes. Any database can be used to adopt the technique introduced to suit with the plant's requirements and size of the data to be managed.

IV. Case Study

A case study was conducted using real data from LPG treating unit (LPGU) of typical oil and gas refinery in Malaysia using PROHAMS. The LPGU is used to remove hydrogen sulphide (H2S) content in various LPG blend stock. The P&ID was divided into several nodes according to its design intention. Fig. 2 shows the selected node that consists of a phase separator (V-201) with inlet and outlet streams.

A. PHA Schedule 29 CFR 1910.119(e)(1)

Priority order for conducting initial PHA was based on the extent of process hazards, number of potentially affected employees, age of process and operating history [14]. Fig. 3 shows PROHAMS interface for PHA schedule. The system assists authorized personnel to plan, record, monitor, and update the information related to PHA development activities. In this case, the schedule for all the activities has been recorded and ready to be accessed by relevant personnel.

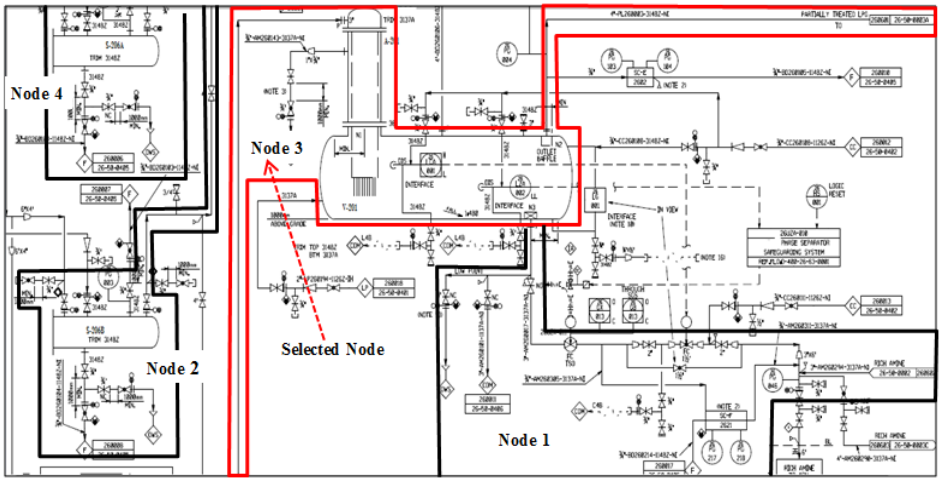


Fig. 2 Part of LPGU P&ID showing Phase Separator (V-201)

B. PHA Methodology 29 CFR 1910.119(e)(2)

Fig. 4 shows PROHAMS interface for PHA methodology. Any appropriate PHA methodology can be used to perform hazard identification and assessment, including HAZOP, FTA or any other established methodology. In this case, HAZOP was used to analyse process hazards on the selected node. PROHAMS captured the HAZOP report at C:\Amin_Treater-V-201\PHA\HAZOP_Report-2012.pdf. The document can be tracked by referring to the date of document as given in the 'Revision date' column.

C. PHA Outcomes 29 CFR 1910.119(e)(3)

PHA outcomes are important to ensure that employer and employees are alerted of process hazards so that the appropriate control measures can be implemented. Fig. 5 shows the interface for PHA outcomes. The interface prompts the authorized personnel to describe the availability of information as covered in the "Description" column. The evidence of the documented information can be referred to in the "Evidence location" column.

Once the information of the PHA outcomes completed, the authorized personnel can tick the "Complete" check box. The incomplete information can be tracked for the necessary actions. Any suitable personnel can be assigned by a superior in the "Action By" column with the due date at "Reply date" column. Therefore, the appropriate action can be taken, monitored and resolved effectively.

In this case, PROHAMS successfully captures information pertaining process hazards, previous accidents, engineering and administrative control of hazards, consequences due to the failure of control system, qualitative evaluation of safety and health effect of V-201. All the above information was recorded in HAZOP worksheet at C:\Amin_Treater-V-201\PHA\HAZOP_Worksheet-2012-013AI.pdf. Information of the previous accidents was recorded in the accident log book of LPGU and also at C:\Amin_Treater-V-201\PHA\Recent_Incident-2012-013AE.pdf. For incomplete information, "Norsyida" and "Ng Siew" have been assigned to compile and provide the information within the specified time frame.

D. PHA Team Members 29 CFR 1910.119(e)(4)

In this case, a PHA study for V-201 has been done by PHA team led by safety expert who is also knowledgeable of the HAZOP procedures. Other team members are involved directly with the identified unit operation within the node, hence capable to contribute in the PHA development.

E. PHA Recommendations and Required Actions 29 CFR 1910.119(e)(5)

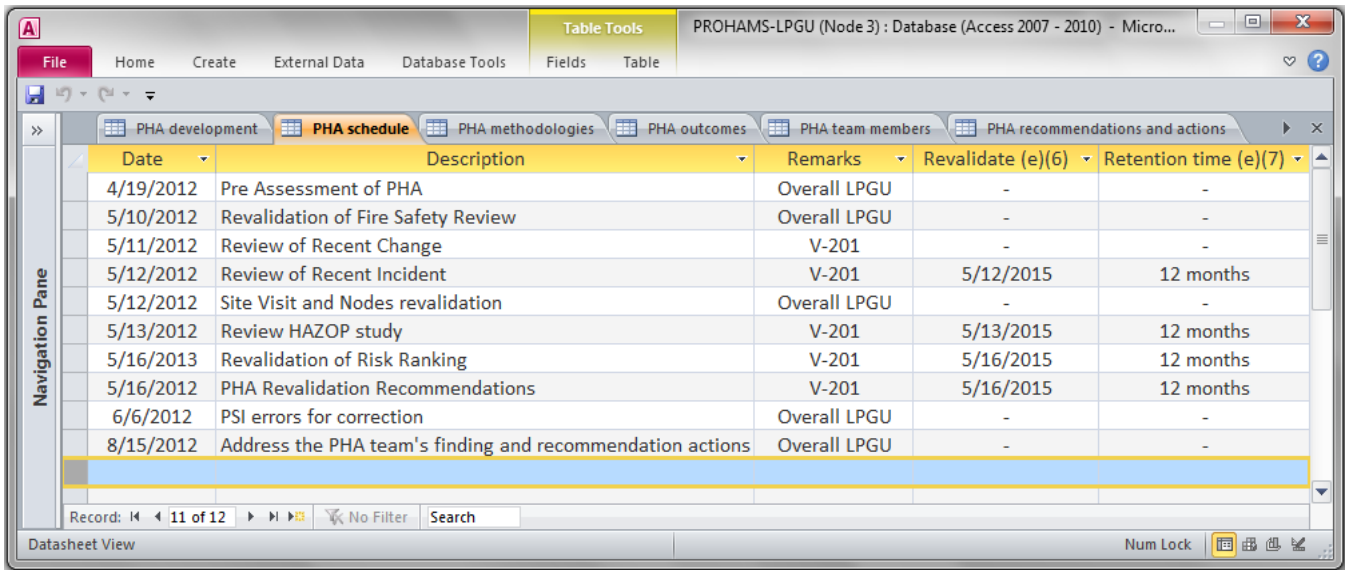
PHA requires the measured excessive risk to be managed. Therefore, a tracking system is in place to ensure that necessary action will be taken timely based on the findings and recommendations by PHA team. PROHAMS can check the accessibility of the PHA information by the relevant personnel. The tracking was conducted by checking the last login date in PROHAMS. Hence, PHA outcomes, recommendations and required actions could be communicated effectively within the process plant. In this case, it was found that not all of them have completely accessed the PHA outcomes.

F. Validation of PHA Data 29 CFR 1910.119(e)(6)

PSM is primarily a performance-based regulation, thus an employer should determine appropriate frequency at least every five years for updating and revalidating PHA information. The 'Revalidate' column in PHA schedule of PROHAMS (Fig. 3) makes the planning process easier by providing the latest update of PHA information. The revalidation allows the employer to have an updated PHA, which is consistent with the current plant operation.

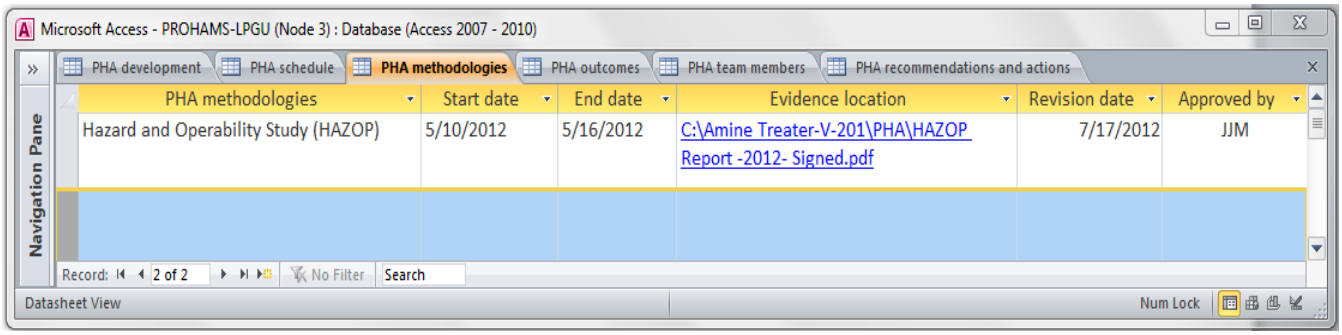
G. Retention Life of PHA Data 29 CFR 1910.119(e)(7)

Once PHA process is completed, the employer is required to retain all the PHA information. This includes the updated and revalidated data, as well as the records related to the resolution of recommendations as described in 29 CFR 1910.119(e)(5) for the life of the process plant. PROHAMS is designed to manage the above information in the database for easy retrieval. This system also assists the authorized personnel to assess the PHA data retention life based on the date of PHA process at 'Retention Date' column in the PHA schedule of Fig. 3.



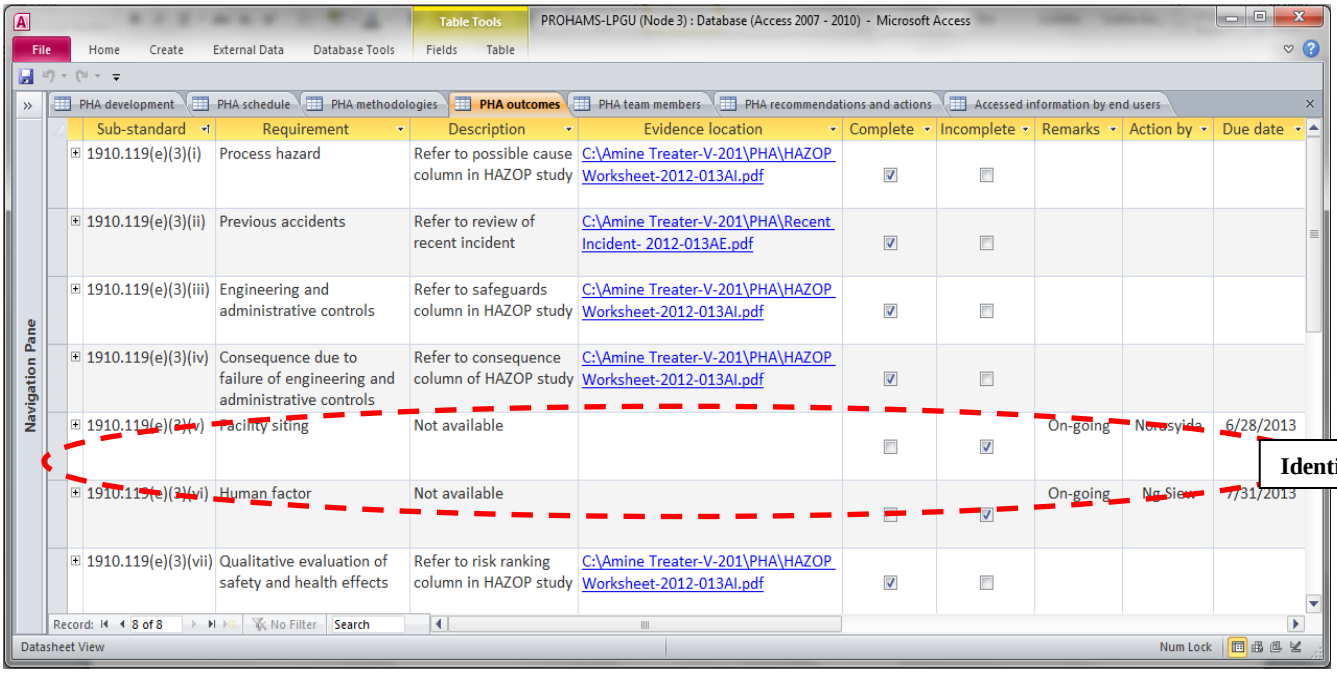
Date	Description	Remarks	Revalidate (e)(6)	Retention time (e)(7)
4/19/2012	Pre Assessment of PHA	Overall LPGU	-	-
5/10/2012	Revalidation of Fire Safety Review	Overall LPGU	-	-
5/11/2012	Review of Recent Change	V-201	-	-
5/12/2012	Review of Recent Incident	V-201	5/12/2015	12 months
5/12/2012	Site Visit and Nodes revalidation	Overall LPGU	-	-
5/13/2012	Review HAZOP study	V-201	5/13/2015	12 months
5/16/2013	Revalidation of Risk Ranking	V-201	5/16/2015	12 months
5/16/2012	PHA Revalidation Recommendations	V-201	5/16/2015	12 months
6/6/2012	PSI errors for correction	Overall LPGU	-	-
8/15/2012	Address the PHA team's finding and recommendation actions	Overall LPGU	-	-

Fig. 3 PHA Schedule



PHA methodologies	Start date	End date	Evidence location	Revision date	Approved by
Hazard and Operability Study (HAZOP)	5/10/2012	5/16/2012	C:\Amine Treater-V-201\PHA\HAZOP Report -2012- Signed.pdf	7/17/2012	JJM

Fig. 4 PHA Methodology



Sub-standard	Requirement	Description	Evidence location	Complete	Incomplete	Remarks	Action by	Due date
1910.119(e)(3)(i)	Process hazard	Refer to possible cause column in HAZOP study	C:\Amine Treater-V-201\PHA\HAZOP Worksheet-2012-013AI.pdf	☑	☐			
1910.119(e)(3)(ii)	Previous accidents	Refer to review of recent incident	C:\Amine Treater-V-201\PHA\Recent Incident- 2012-013AE.pdf	☑	☐			
1910.119(e)(3)(iii)	Engineering and administrative controls	Refer to safeguards column in HAZOP study	C:\Amine Treater-V-201\PHA\HAZOP Worksheet-2012-013AI.pdf	☑	☐			
1910.119(e)(3)(iv)	Consequence due to failure of engineering and administrative controls	Refer to consequence column of HAZOP study	C:\Amine Treater-V-201\PHA\HAZOP Worksheet-2012-013AI.pdf	☑	☐			
1910.119(e)(3)(v)	Facility siting	Not available		☐	☑	On-going	No Sieva	6/28/2013
1910.119(e)(3)(vi)	Human factor	Not available		☐	☑	On-going	No Sieva	7/31/2013
1910.119(e)(3)(vii)	Qualitative evaluation of safety and health effects	Refer to risk ranking column in HAZOP study	C:\Amine Treater-V-201\PHA\HAZOP Worksheet-2012-013AI.pdf	☑	☐			

Identified gaps

Fig. 5 PHA Outcomes

V. Conclusion

A systematic technique towards PHA implementation in process plant based on PSM requirements is presented in this study. The technique for implementation and process data management is clearly tabulated through established PHA framework and P&ID study node Implementation of this technique could manage process hazards successfully that is in compliance with PSM regulation.

Acknowledgment

The researches would like to acknowledge University Teknologi PETRONAS for the support in terms of financial and research materials.

References

[1] P.P. Howell, "Plant Explosion Emphasizes Importance of Implementing PSM," *Process Saf. Prog.* vol. 29, no.2, pp. 144-149, 2010.

[2] M. Kaszniak, "Oversights and Omissions in Process Hazard Analyses: Lessons Learned from CSB Investigations," *Process Saf. Prog.* Vol. 29, no. 3, pp. 264-269, 2010.

[3] L.A. Long, "History of Process Safety at OSHA," *Process Saf. Prog.* vol. 28, no. 2, pp. 128-130, 2009.

[4] J.F. Louvar, "Improving the Effectiveness of Process Safety Management in Small Companies," *Process Saf. Prog*. vol.27, no. 4, pp. 280-283, 2008.

[5] H. A. Aziz, A. M. Shariff and R. Rusli, "Managing Process Safety Information Based on Process Safety Management Requirements," *Process Saf. Prog*. vol. 00, no. 00, pp. 1-8, 2013.

[6] M. Kho, "Strengthening Process Safety Requirements in Hse Management System an Noc's Experience" AIChE PPSS Conference, Ernest N. Morial Convention Center, 2008.

[7] W.F. Early, "Database Management Systems for Process Safety," *J. Hazard. Mater*. vol. 130, no. 1-2, pp. 53-57, 2006).

[8] S. Arendt, "Continuously Improving Psm Effectiveness—a Practical Roadmap," *Process Saf. Prog.* vol. 25, no. 2, pp. 86-93, 2006.

[9] P.R. Amyotte, A.U. Goraya, D.C. Hendershot, and F.I. Khan, "Incorporation of Inherent Safety Principles in Process Safety Management," *Process Saf. Prog*. vol. 26, no. 4, pp. 333-346, 2007.

[10] M.I. Rashid, N. Ramzan, T. Iqbal, S. Yasin, and S. Yousaf, "Implementation Issues of Psm in a Fertilizer Plant: An Operations Engineer's Point of View," *Process Saf. Prog*. vol. 32, no. 1, pp. 59-65, 2013).

[11] S.G. Kariuki and K. Löwe, "Integrating Human Factors into Process Hazard Analysis," *Reliab. Eng. Syst. Safe.* vol. 92, no. 12, pp. 1764-1773, 2007.

[12] CCPS, "Guidelines for Implementing Process Safety Management Systems," American Institute of Chemical Engineers, New York, 1994.

[13] CCPS, "Guidelines for Risk Based Process Safety," John Wiley & Sons, Inc. New Jersey, 2007.

[14] D. Einolf and L. Menghini, "PSM/RMP Auditing Handbook: A Checklist Approach," Government Institutes, United States of America, 1999.

Prof. Dr. Azmi Mohd Shariff is a Professor in Chemical Engineering Department at Universiti Teknologi PETRONAS (UTP), Perak, Malaysia. He was conferred a PhD in Chemical Engineering from University of Leeds, United Kingdom (1996). He was with Universiti Kebangsaan Malaysia in 1989 as a tutor and was appointed as a lecturer in 1996 upon his return from University of Leeds. He joined Universiti Teknologi PETRONAS in 1997. He was appointed as the Head of Industrial Internship in 1998 and later he was appointed as Head of Chemical Engineering Department from 1999 until 2003. His current research works are in the area of process safety and CO2-NG separation. In the area of Process Safety, his research works are in the area of QRA, PSM, BBS and Inherent Safety. In the area of CO2-NG separation, his research works are in the area of CO2 Capture Technology, specifically on Absorption, Adsorption and Membrane. He can be reached at azmish@petronas.com.my.

Hanida Abdul Aziz is a PhD candidate in Process Safety at Universiti Teknologi PETRONAS, Malaysia. She received a MSc of Chemical Engineering from Universiti Sains Malaysia. Before joining UTP, She worked for Institut Teknologi PETRONAS as a lecturer. She is also has experienced as team member in conducting QRA for oil and gas related companies. She can be reached at hanidaaziz@gmail.com.

Kwang Hooi Yew is a lecturer in Computer and Information Sciences Department at Universiti Teknologi PETRONAS (UTP), Perak, Malaysia. Currently, he is doing PhD at Universiti Teknologi PETRONAS, Malaysia. He received a MSc of Engineering in Computer science, from Cornell University, New York, United States (2006). His current research works are in the area of Sentiment Analysis, Semantic Analysis, Natural Language Processing, Artificial Intelligence, Algorithm and data structure.