Hydrogen Sulphide (H_2S) Awareness Training for Process 3 Services Solution Sdn Bhd

Abdul Aziz Mohd Azoddein[1], Mazrul Nizam Abu Seman[2], Wan Mohd Hafizuddin Wan Yussof[3], Mariah Che Mamat[4], Mohamad Drani[5]

[1,2,3,4,] *Faculty of Chemical & Natural Resources Engineering, Universiti Malaysia Pahang, 26300 Gambang, Pahang*

[5] *Process 3 Services Solution (P3SS) Sdn Bhd, Klang Selangor*

Corresponding author: *aaziz@ump.edu.my*

mariahchemamat78@yahoo.com

Abstract

Hydrogen Sulphide (H_2S) is one of the major polluting substances found in petroleum refinery wastewater as well as other industrial and domestic sludge. Sulfide build up may cause several side effects like corrosion of concrete sewer pipes, releasing unpleasant odors, toxicity due to sulfide gas and negative effect to subsequent wastewater. Early detection and accurate quantification of hydrogen sulphide is necessary to assure equipment integrity, to comply with regulations and to ensure safety of workers. Routine maintenance and inspection activities become non-routine when hydrogen sulphide present in the workplace is above the Permissible Exposure Limit (PEL) 10 mg/L and become problematic when hydrogen sulphide concentrations are above the PEL level. Occupational Safety and Health Administrations (OSHA) enforceable ceiling limit for workplace exposure is set at 20 parts per million (ppm). The National Institute of Occupational Safety & Health (NIOSH) Permissible Exposure Limit (PEL) for hydrogen sulphide is set at 15 mg/m^3 (10 ppm) averaged over a 10 minute period, and that work areas in which the concentration of hydrogen sulfide exceeds 70 mg/m^3 be evacuated . P3SS Sdn. Bhd. is one of the petrochemical based industries which facing direct hydrogen sulphide exposure in their jobs. The objective of this program is to conduct workshops as part of development process to generate a training methodology in hydrogen sulphide handling, hydrogen sulphide monitoring and hydrogen sulphide surveillance, to apply the knowledge of mercury awareness and proper personal protective equipment (PPE) used while handling hydrogen sulphide. This program also ensures a safe working environment to minimize any cross contamination when dealing with hydrogen sulphide or its complexes. About 50 of P3SS workers benefited from this knowledge transfer programs in the form of modules, PPE, evaluation and procedures which have been successfully transferred from the academicians to the graduate intern and P3SS workers.

Keywords: Hydrogen Sulphide (H_2S), Awareness, Petrochemical Industries

1. Introduction

Hydrogen sulfide either in liquid or gaseous forms, is an odorous substance with rotten egg smell produce naturally by reduction of either sulfate or sulfur containing inorganic material by a wide range of both aerobic and anaerobic microbes (Pokethitiyook, et al.2006; Vaiopoulou, et al. 2005;). Hydrogen sulfide generation by anaerobic microorganisms in sewer systems is generally associated with biogenic corrosion of concrete and release of odors to the urban atmosphere (L. Zhang et al., 2008).

Sulfide accumulation result in several negative health and side effects like corrosion of concrete sewer pipes (mainly, due to microbiologically-induced/influenced corrosion by sulfate reducing bacteria), releasing unpleasant malodors, toxicity due to sulfide gas, and negative effect to subsequent wastewater (Henri, Gilles, & Fernando, 2011). Depending on the exposed level, sulfide can cause several negative health effects such as coma, irritated eyes, and respiratory system irritation, impairment of the human physique, neural system and major organs like the liver and the kidney and even death. In addition, high levels of gaseous forms of sulfide are particularly dangerous in the presence of particulate matter, because it slowly adsorbs onto fine atmospheric particles and easily transported very deep into the lungs, where it remain for a long time (J. Zhang, Li, & Liu, 2015) (Nasir & Brahmaiah, 2015).

Wastewater containing sulfur compounds presents a serious discharge problem due to their poor biodegradability, high toxicity and ecological aspects (Hariz and Monser, 2014). The impacts caused by these industrial pollutants and growing concern for environmental issues have led to the search for new methods of treatment, and development of new materials that are able to reduce these environmental problems to a permissible level. Furthermore, it concerns to industry pollutant and safety worker, it led to conduct the hydrogen sulphide (H_2S) awareness training in Malaysia. It is because H_2S awareness is still low in Malaysia for petroleum industry worker.

2. Program Objectives

The objectives of this programme:

i. To conduct training and coaching hydrogen sulphide (H_2S) related waste handling, monitoring and surveillance.
ii. To apply the knowledge of hydrogen sulphide (H_2S) awareness and proper PPE used while handling hydrogen sulphide (H_2S) related waste
iii. To ensure a safe working environment and to minimize to as low as reasonably possible any cross contamination when dealing with hydrogen sulphide (H_2S) or its compounds.

3. Literature Review

3.1. Hydrogen Sulphide (H_2S) Properties

Hydrogen sulfide (H_2S) is a colourless gas, best known for its strong smell, much like the strong nauseating smell of rotten eggs. Hydrogen sulphide is a reducing agent and oxidizes easily when the conditions are right. It also corrodes metals and even concrete. Should a concrete sewer adsorb hydrogen sulfide for example, it will oxidize to elemental sulfur within the concrete and gradually oxidize to elemental sulfur and over time oxidize to sulfuric acid and eventually damage the sewer (Vollertsen, Nielsen, Jensen, Wium-Andersen, & Hvitved-Jacobsen, 2008). According to EPA (1991, 32), concrete wastewater pipe corrodes at a rate of 3.6 mm/year due to hydrogen sulfide. Under specific conditions such as at a low concentration (1.36 mg/L) pH between 3 to 5 and immersion time of more than two hours, hydrogen sulfide has been found to have an inhibiting effect on iron corrosion (Agrahari, Rawat, Verma, & Bhattacharya, 2013).

In a natural environment, acid rain is precipitated through the oxidation of hydrogen sulfide to sulfuric acid. Hydrogen sulfide dissolves easily in water (4-6 g/L) and it is poisonous to almost all types of life forms (Heinonen, 2012). The World Health Organization (WHO) does not specify the limits of hydrogen sulfide concentration for drinking water (WHO, 2008). Taste threshold of hydrogen sulfide would be noticeable to the sense of taste at between 0.05 and 0.1 mg/L, and concentration of hydrogen sulfide between 10 and 20 ppm causes discomfort to the eyes. It can cause irritation of the eyes (WHO, 2008). Other possible effects such as burning pain, blurred vision, tearing, and irritation to the nose and throat may occur at 50 to 100 ppm.

3.2 Toxicity and Regulations of H_2S

Hydrogen sulfide (H_2S) is also a harmful and putrid gaseous compound. The human nose can detect hydrogen sulfide at concentrations as low as 0.5 ppb (Skrtic, 2006). The H_2S is volatile in water and soluble in some polar organic solvents. Hydrogen sulfide can create health problems, like coma, irritated eyes, and respiratory system irritation. Exposure to hydrogen sulfide can bring about both chronic and acute ramifications (Lambert et al., 2006).

Hydrogen sulfide inhalation minimal risk level is determined at 0.02 ppm and 0.07 ppm respectively as recommended by the Agency for Toxic Substances and Disease Registry (ATSDR)(ATSDR, 2008). It is reported that a concentration equal to or greater than 500 to 1,000 ppm H_2S threatens human life and leads to imminent impairment of the human physique (EPA, 2003). Therefore, to safeguard employees, the Occupational Safety & Health Administration (OSHA) regulates the exposure limits for general industry at 20 ppm during an 8-hour workday. Moreover, hydrogen sulfide has been known to primarily target the neural system and major organs like the liver and the kidney (Guidotti, 1994).

Severe exposure to high levels of hydrogen sulfide can cause death (Hendrickson, Chang, & Hamilton, 2004). Therefore, due to the acute and chronic toxicity, an oral reference dose (RFD) of 0.003 mg/kg/day and an inhalation reference concentration (RFC) of 0.001 mg/m^3 has been derived by the EPA. In addition to this, in the workplace, an acceptable ceiling concentration of 20 ppm for hydrogen sulfide has been established by OSHA, with a maximum level of 50 ppm permissible for a10 minutes maximum duration. The sense of smell is impaired at 100 to 150 ppm of hydrogen sulfide concentration. At concentrations over 1000 ppm or 1400 ppm, it can be about immediate unconsciousness and eventually death as breathing stops (OSHA).

According to Lambert, eye irritation has been described as the first health effect to manifest at low concentrations of hydrogen sulfide (Lambert et al., 2006). Enzymes in the body have been identified to detoxify hydrogen sulfide through oxidation into the safe compound, sulfate. Therefore, the body is able to tolerate low levels of hydrogen sulfide (Ramasamy, Singh, Taniere, Langman, & Eggo, 2006). Hence, low levels of hydrogen sulfide may be tolerated indefinitely. Oxidative enzymes become overwhelmed at some threshold level, believed to average around 300–350 ppm.

Most personal safety gas detectors including utility, sewage and petrochemical employees, go off at a minimum of 5 ppm and a maximum of 15 ppm. In Talvivaara, Finland, hydrogen sulfide gas from mining activities has killed many miners in mining accidents (Tukes, 2012). Also, in Japan, hydrogen sulfide gas which originated from a wastewater treatment plant has been a cause of death of four workers (Kage, Ikeda, Ikeda, Tsujita, & Kudo, 2004).

4. Methodology

Hydrogen Sulphide (H_2S) awareness knowledge among workers who are exposed directly with hydrogen sulphide is important because of the toxicity of H_2S. Classroom training is conducted to build the capability within the company workers in hydrogen sulphide handling, hydrogen sulphide monitoring and hydrogen sulphide surveillance.

There has seven module applied in this programme which is introduction of hydrogen sulphide (H_2S), Awareness of hydrogen sulphide (H_2S), Management of hydrogen sulphide (H_2S), Hydrogen Sulphide (H_2S) lab testing, Personal Protective Equipment (PPE), Hydrogen Sulphide (H_2S) related waste handling and Hydrogen Sulphide (H_2S) related waste disposal.

First module is aimed to convey the information on hydrogen sulphide. It is important to understand the characteristics of hydrogen sulphide before handling with it. This module consists of physical and chemistry hydrogen sulphide, hazards, sources and safety data sheet (SDS) of hydrogen sulphide. It is important to know the characteristics of a substance in order to know the proper way to handle and prevent from harmful effect.

Second module which is awareness of hydrogen sulphide (H_2S) discussed about the H_2S toxicity and understands route entry of H_2S. It is important to develop H_2S awareness to each worker when handling with hydrogen sulphide. Besides that, this module introduced the health surveillance for workers who have the potential for exposure to H_2S. Participants should undergo this module as part of H_2S awareness training for legal requirement, responsibilities and safety and health.

Third module introduced the management of Hydrogen Sulphide (H_2S) which is consists elements of chemical management. Furthermore, this module important to understand H_2S safety policy which are include personal monitors, plant monitors, evacuation and emergency rescue first aid.

In fourth module entitled hydrogen sulphide (H_2S) lab testing. This module is to introduce lab safety which is consists general laboratory safety procedure, chemical labeling and chemical hazards. Besides that, method testing for H_2S in wastewater, type of site monitoring and H2S kit also discussed in this module.

Fifth module discussed about Personal Protective Equipment (PPE) training. PPE is safety equipment wear to prevent injury in the workplace when engineering and administrative controls fail to eliminate the hazard. This module is aim to all workers dealing with hydrogen sulphide that needed personal protective equipment (PPE) is correctly selected, maintained, provided and used to protect form H_2S exposure. Other than that, it involves practical training on wearing proper PPE. Figure 1 showed participant wear complete PPE when exposed to hydrogen sulphide (H_2S).

Figure 1. Complete PPE when exposed to hydrogen sulphide (H_2S).

Sixth module discussed how to handle hydrogen sulphide related waste. It is important to understand method to handle waste from stage packaging and storage waste container, labeling of waste container and last stage is transferring of waste container. The last module is hydrogen sulphide (H_2S) waste disposal which is concluded standard operating procedure (SOP) of disposal on hydrogen sulphide waste.

The practical training is a case study from real incident of hydrogen sulphide. Participants are divided into a group and need to discuss and present to solve the problem. Practical training is conducted indoor training place are showed in Figure 2. The participant's knowledge about mercury was evaluated by evaluation forms before and after the course session. The evaluation forms are divided into test 1, test 2 and final test. Test 1 is given before the course and test 2 is given after the course on first day. Total evaluation questions for both test 1 and test 2 are 20 questions where the same questions are repeated and rearranged differently. Meanwhile, final test is given after the second day session is ended. All of the evaluation forms will be marked and the result of all the evaluation will be analyzed in order to determine their achievement of knowledge regarding hydrogen sulphide through this hydrogen sulphide awareness training.

Figure 2. Group discussion to solve problem based on case studies.

6. Result & Discussion

In this training, participants were given several evaluation tests from the beginning of training until the end of training. The tests were classified as test 1, test 2 and final test. This approach was taken to identify their knowledge in understanding hydrogen sulphide awareness by theoretically and practically. This training was done for first batch which are consisting of 25 participants.

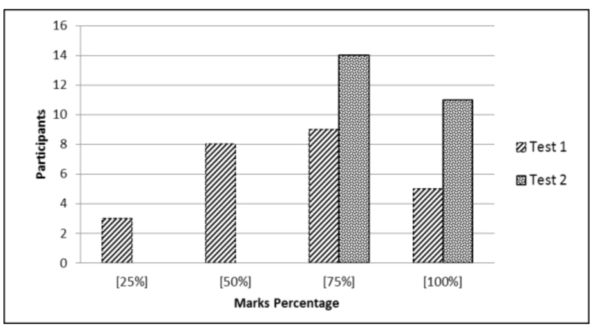

Figure 3. Graph of participants vs. marks range for test 1 and test 2.

Figure 3 showed the graph of participants vs. marks percentage for test 1 and test 2. Based on the graph, the marks are given into four percentage ranges, which are 25%, 50%, 75% and 100%. From Figure 3, it shows that when the mark percentage is keep highest, the number of participants is fluctuates for both tests. For test 1, the highest mark that participant obtained is 75%. From results, there are 3, 8, 9 and 5 of participants obtained marks percentage in range of 25%, 50%, 75% and 100% respectively.

For test 2, the highest mark that participant obtained is 75%. However, from Figure 3, its shows that 0, 0, 14 and 11 participants obtained marks percentage in range of 25%, 50%, 75% and 100% respectively. It showed a better performance from the participant if compared to the test 1.

From the comparisons that have been made for test 1 and test 2, there was some increment in term of marks that also represent participant's knowledge about hydrogen sulphide. Results percentage of 75% and 100% was increase about 20% and 24% respectively after the second test compared to test 1. Hence, it showed positive response after theoretical training hydrogen sulphide (H_2S) awareness session. For the first day, only theoretical training was done which involve the learning of topic in modules excluding personal protective equipment (PPE) and waste handling topic. Then, for the second day of training, participants was exposed on the appropriate way to use personal protective equipment (PPE), theoretical of waste handling and disposal.

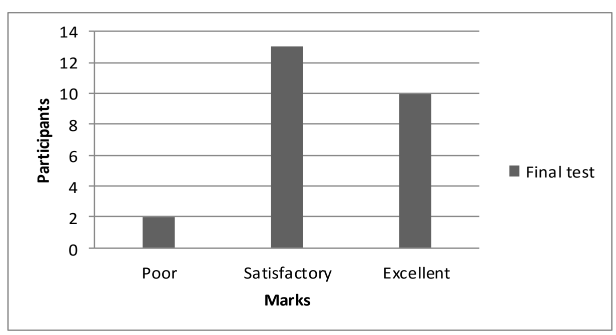

Figure 4. Graph of participant's final test marks.

Figure 4 above shows the graph of participant's final marks. For the final evaluation form, there were 30 questions provided to them. Based on Figure 4, the marks were given into three categories which are poor, satisfactory and excellent. Poor category is for mark from 0 to 10 marks. Meanwhile for marks from 11 to 20 and 21 to 30 are categorized as satisfactory and excellent respectively. From the data, it showed that the highest mark obtained is satisfactory mark in 13 out of 25 participants (52.0 %) attended the course. Next, it is followed by excellent marks obtained by 10 participants (40.0 %) and only 2 participants (8.0 %) obtained poor marks. It is can be seen that more than half are getting satisfactory marks and followed by excellent marks and lastly is poor marks. Based on the data obtained, it is proven that this training has given a positive impact on the knowledge transfer and sharing session.

7. Conclusion

As a conclusion, this knowledge transfer program is hopefully become an added value to participants for future career or personal knowledge improvement in petrochemical industry. This program enhanced their knowledge and understanding about hydrogen sulphide (H_2S) hazard, hydrogen sulphide (H_2S) monitoring and hydrogen sulphide (H_2S) surveillance.

From the observation, it can be concluded that the knowledge of participants about H_2S is still at low level before they joined this 'Hydrogen sulphide (H_2S) awareness training for process 3 services solution sdn bhd' training. However, from the evaluations performed was observed that, the results show that participants have clear understanding after two days training.

According to the measures of the tests done, all tests were given satisfactory improvement. It is also proven that their theoretical knowledge and case studies presentation were getting much better after joining this training. Based on their feedback, they are satisfied with the training program and to have more competency training will be conducted in the future. They suggested for extra facility and convenience in term of accommodation. However, their passion and enthusiasm does not become an obstacle for them to gain knowledge

8. Acknowledgement

This project was supported under Grant Knowledge Transfer Programme (KTP)-RDU161001. We are very grateful to P3SS Sdn. Bhd. as industrial partners who contributed to the training, particularly those who provided information and helped to running this project.

References

Potivichayanon, S., Pokethitiyook, P., & Kruatrachue, M. (2006). Hydrogen sulfide removal by a novel fixed-film bioscrubber system. Process Biochemistry, 41(3), 708–715. http://doi.org/10.1016/j.procbio.2005.09.006

Zhang, L., De Schryver, P., De Gusseme, B., De Muynck, W., Boon, N., & Verstraete, W. (2008). Chemical and biological technologies for hydrogen sulfide emission control in sewer systems: A review.

Water Research, 42(1-2), 1–12. http://doi.org/10.1016/j.watres.2007.07.013

Henri, G., Gilles, B., & Fernando, M. (2011). Microbial technologies for Hydrogen Sulphide removal from gas streams.

Zhang, J., Li, L., & Liu, J. (2015). Temporal variation of microbial population in a thermophilic biofilter for SO2 removal. JOURNAL OF ENVIRONMENTAL SCIENCES, 9(Lin Li), 4–12.

Nasir, U. P., & Brahmaiah, D. (2015). Impact of fireworks on ambient air quality: a case study. International Journal of Environmental Science and Technology, 12(4), 1379–1386. http://doi.org/10.1007/s13762-014-0518-y

Hariz, I.B. & Monser, L. (2014). "Sulfide Removal from Petroleum Refinery Wastewater by Adsorption on Chemically Modified Activated Carbon." 4(4): 264–87.

Vollertsen, J., Nielsen, A. H., Jensen, H. S., Wium-Andersen, T., & Hvitved-Jacobsen, T. (2008). Corrosion of concrete sewers—The kinetics of hydrogen sulfide oxidation. Science of the total environment, 394(1), 162-170.

Agrahari, G. K., Rawat, A., Verma, N., & Bhattacharya, P. K. (2013). Removal of dissolved H 2 S from wastewater using hollow fiber membrane contactor: Experimental and mathematical analysis. Desalination, 314, 34-42.

Lambert, T. W., Goodwin, V. M., Stefani, D., & Strosher, L. (2006). Hydrogen sulfide (H 2 S) and sour gas effects on the eye. A historical perspective. Science of the total environment, 367(1), 1-22.

Guidotti, T. L. (1994). Occupational exposure to hydrogen sulfide in the sour gas industry: some unresolved issues. International archives of occupational and environmental health, 66(3), 153-160.

Hendrickson, R. G., Chang, A., & Hamilton, R. J. (2004). Co-worker fatalities from hydrogen sulfide.

American journal of industrial medicine, 45(4), 346-350.

Ramasamy, S., Singh, S., Taniere, P., Langman, M., & Eggo, M. (2006). Sulfidedetoxifying enzymes in the human colon are decreased in cancer and upregulated in differentiation. American Journal of Physiology-Gastrointestinal and Liver Physiology, 291(2), G288-G296.

Kage, S., Ikeda, H., Ikeda, N., Tsujita, A., & Kudo, K. (2004). Fatal hydrogen sulfide poisoning at a dye works. Legal medicine, 6(3), 182-186.

Heinonen, A. (2012). Adsorption of hydrogen sulfide by modified cellulose nano/microcrystals.