UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE : **CEB4533 - TECHNICAL MANAGEMENT FOR PROCESS SAFETY**

DATE : **17 APRIL 2025 (THURSDAY)**

TIME : **9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **SIX (6)** pages in this Question Booklet including the cover page .

ii. **DOUBLE-SIDED** Question Booklet.

1. a. An employee in a chemical plant makes the following statement:

"I came to work here almost 15 years ago. I've seen a lot of change, some for the better, some worse. Some new equipment has been bought to replace the older one. I just heard a supervisor talking about new challenges for our plant from OSHA enforcement of the Process Safety Management (PSM) standards. He said there is really no need for more government regulation or enforcement, that this will just hurt our industry. I think the PSM Standard was a good change for our industry, but I'd like some facts to back that up."

By elaborating the definition of the term 'process', 'safety' and 'management', convince the employee that the Process Safety Management (PSM) is important and required for the industry to minimise the risk of catastrophic incidents.

[12 marks]

b. CFR1910.119 Process Safety Management of Highly Hazardous Chemicals is a set of regulations enacted in 1992 which contains requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. Elaborate on how regulatory standards prevent catastrophic incidents in workplaces where highly hazardous chemicals are used, handled, or processed. In addition, suggest whether industries would continue to manage process safety if the relevant regulatory standards were repealed or removed.

[12 marks]

2. On August 14, 2002, approximately 182 m^3 of chlorine was released from a railroad tank car at a company near Festus, Missouri during a repackaging operation. The company received bulk liquid chlorine in 82000 kg tank cars and repackaged it into 68 kg cylinders and 907 kg containers for commercial and municipal use. 63 people from the surrounding community sought medical attention for symptoms related to the release, and three workers received minor skin exposure. Hundreds of residents in the community were required to shelter-in-place for 4 hours. It was found that the release was the result of a hose that had ruptured; and the poor-quality assurance practices and ineffective testing and inspection procedures led to the hose failure. The hose that failed was made of materials inappropriate for the chlorine unloading operation, and therefore it corroded and eventually failed. The report stated that this hose was similar in appearance to one that should have been used, but there was no mechanism at the company to identify and differentiate similar looking hoses.

a. Identify and describe the specific element of the Process Safety Management (PSM) system that could have prevented this incident based on the description. Additionally, explain how this element helps minimize the likelihood of such an incident occurring.

[10 marks]

b. If, after implementing the PSM element identified in **part (a)**, a similar incident still occurs, deduce the probable reasons for its occurrence.

[8 marks]

c. Explain the importance of adequate quality assurance in this situation.

[8 marks]

3. The following statements are the descriptions of accidents that occurred after the implementation of the CFR1910.119 PSM Standard. Select and indicate relevant elements of the Standard which might have prevented the accident. Justify your answer.

   a. On October 2, 2007, five workers were killed, and three others were injured in a chemical fire at the Cabin Creek Hydroelectric Plant near Georgetown, Colorado. Contractors were working in a confined space, recoating the penstock tunnel with an epoxy coating material, when the fire occurred. The accident report stated that the flammable solvent used to clean the epoxy likely ignited, and the fire grew as additional buckets of epoxy material and solvent also ignited. It was also stated that the company and its contractor failed to plan and coordinate the recoating project, and therefore did not analyse or prepare for the confined space hazards. The report also stated that, "the serious safety hazards of using a flammable solvent inside the confined space were not identified or addressed." Consequently, appropriate controls such as substituting a non-flammable solvent, providing adequate ventilation, eliminating ignition sources, and providing confined space rescue teams were not considered. According to the report, "The majority of the contractor employees working at Cabin Creek had not received comprehensive formal safety training; or site-specific instruction addressing confined space safety, the safe handling of flammable liquids, the hazard of static discharge, emergency response and rescue, and fire prevention." The report also stated that, although the work created the potential for life threatening exposure to a flammable atmosphere with a need for immediate emergency response, the only emergency plan was to call emergency dispatch. No emergency responders were on site on the day of the accident, and the response time for trained personnel was over an hour. The workers died before trained emergency response crews could arrive.

   [12 marks]

b. On June 22, 1997, an explosion occurred at a chemical plant in Deer Park, Texas. The facility produced several petroleum intermediates by processing crude petroleum feed stocks. Although no one was killed in the explosion, 9 workers received minor injuries, and the facility and nearby residences were extensively damaged. The accident was jointly investigated by the Environmental Protection Agency (EPA) and OSHA. The EPA/OSHA team found that the cause of the accident was the failure of a check valve located on a high- pressure light hydrocarbon gas line. The check valve failure started a large flammable gas leak; the escaping gas then formed a vapor cloud which ignited. The report stated that the check valves had not been properly designed and manufactured for heavy duty service and were susceptible to failure during normal use. There were check valve failures prior to this accident, but the EPA/OSHA report stated that lessons from the prior failures had not been properly shared and implemented. These prior incidents were treated as maintenance actions and therefore no formal investigations were conducted to determine root cause. A processes hazard analysis had been performed, but this analysis did not include failure of a check valve, and therefore mitigations were not implemented for such failures. Procedures were also found to be inadequate, and did not instruct operators to verify the valve positions prior to restarting the process.

[12 marks]

4. a. Two types of safety indicators are often used to track safety performance in process safety management. Explain the main reason for measuring the safety performance of a facility. Identify and differentiate between the two types of process safety indicators, providing suitable examples for both. Suggest how a facility could measure the effectiveness of these indicators.

[12 marks]

b. The Process Safety Management standard, promulgated in 1992, is widely credited for reducing major accident risks and improving chemical industry performance. However, major fire and explosion accidents, such as those at the BP Texas City Refinery and the Buncefield Oil Storage Depot in 2005, still occurred. Deduce the probable causes of such disastrous accidents even though the PSM standards has been enacted. Suggest appropriate strategies to improve the situation.

[14 marks]

-END OF PAPER-