

JK Lakshmipat University Jaipur
INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination, December 2022
M. Tech. (HSEE), Semester III, 2022-23

Roll No.....

ME2201: Fire engineering and management

Time: 3 hours

Max. Marks: 60

Instructions to students:

1. Do not write anything other than your roll number on the question paper.
 2. Mention all the assumptions for your answers clearly.
 3. Choice for attempt Question-3 or Question-4.
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Case Study: Fire Incident Event

The Flixborough Works of Nypro Limited was designed to produce 70,000 tons per year of caprolactam, a basic raw material for the production of nylon. The process uses cyclohexane, which has properties similar to gasoline. Under the process conditions in use at Flixborough (155°C and 7.9 atm), the cyclohexane volatilizes immediately when depressurized to atmospheric conditions. The process where the accident occurred consisted of six reactors in series. In these reactors, cyclohexane was oxidized to cyclohexanone and then to cyclohexanol using injected air in the presence of a catalyst. The liquid reaction mass was gravity-fed through the series of reactors. Each reactor normally contained about 20 tons of cyclohexane.

Several months before the accident occurred, reactor 5 in the series was found to be leaking. Inspection showed a vertical crack in its stainless steel structure. The decision was made to remove the reactor for repairs. An additional decision was made to continue operating by connecting reactor 4 directly to reactor 6 in the series. The loss of the reactor would reduce the yield but would enable continued production because unreacted cyclohexane is separated and recycled at a later stage.

The feed pipes connecting the reactors were 28 inches in diameter. Because only 20-inch pipe stock was available at the plant, the connections to reactor 4 and reactor 6 were made using flexible bellows-type piping, as shown in Figure 1. It is hypothesized that the bypass pipe section ruptured because of inadequate support and over-flexing of the pipe section as a result of internal reactor pressures. Upon rupture of the bypass, an estimated 30 tons of cyclohexane volatilized and formed a large vapor cloud. The cloud was ignited by an unknown source an estimated 45 seconds after the release.

The resulting explosion leveled the entire plant facility, including the administrative offices. Twenty-eight people died, and 36 others were injured. Eighteen of these fatalities occurred in the

main control room when the ceiling collapsed. Loss of life would have been substantially greater had the accident occurred on a weekday when the administrative offices were filled with employees. Damage extended to 1821 nearby houses and 167 shops and factories. Fifty-three civilians were reported injured. The resulting fire in the plant burned for over 10 days.

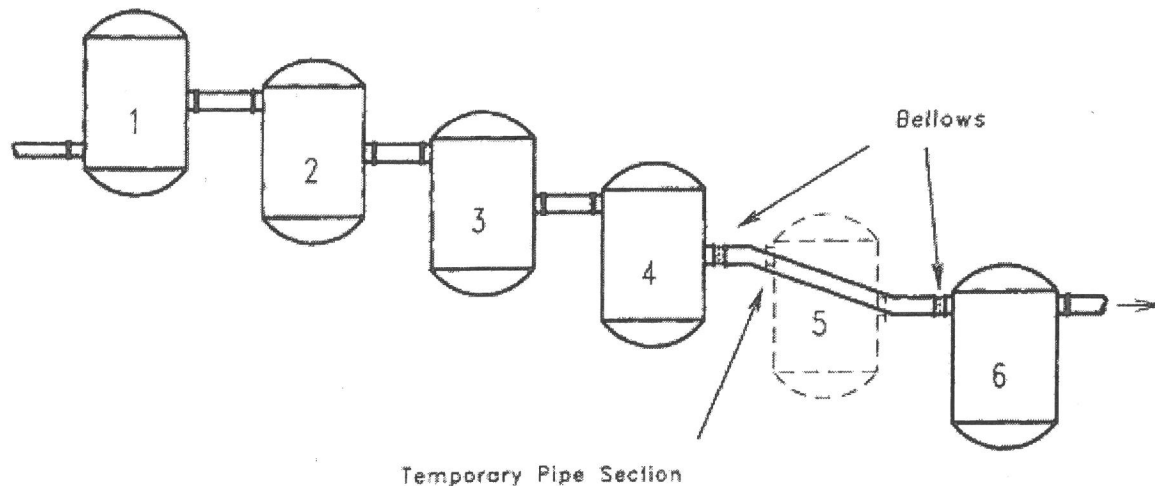


Figure 1: A failure of a temporary pipe section replacing reactor 5 caused the Flixborough accident

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|--------|---|----------------|
| Q. 1.1 | Select the most suitable portable and fixed fire extinguishing systems for the above fire accidents. | 6.0
(LO1) |
| Q. 1.2 | Determine factors necessary when selecting an appropriate fire detection system for controlling the fire for the above cases. | 6.0
(LO3) |
| Q. 1.3 | Prepare the safety procedure as per legislation to protect life, society, and property from the above fire accidents. | 8.0
(CO5,6) |

Case Study: Gas-cutting a Contaminated Drum

A production department supervisor of a chemical plant was in need of a medium-sized drum to use as a garbage can. He approached the stores' department in search of a suitable container. The stores in-charge informed him that there were empty drums, piled behind the stores shed and he could help himself to any. Accordingly, the supervisor proceeded to pick up a small ten-gallon drum and took it to a maintenance service welder and asked him if he could cut the top off. The welder, accepting his request, told him to come after an hour or so and pick it up.

Unfortunately, the drum had been used to transfer carbon disulphide (CS_2) under the coverage of water several times from one place to another and was ultimately discarded. It was not labelled properly and if it was, the marking had been destroyed.

The maintenance welder removed the top bung and was adjusting his torch to gas cut the top dish of the drum when the fumes ignited, causing an explosion and fire which blew the top off the drum.

It struck the welder first on his shoulder and then the side of his neck causing severe lacerations, which partially cut his jugular vein. Fortunately his windpipe did not get cut.

Another maintenance man who was working in the vicinity had the presence of mind to rush to the injured person's assistance and hold the injured person's jugular vein tightly with his thumb and finger until the first-aid man arrived on site and treated him. They were able to stop the bleeding. Three weeks of lost time resulted.

- Q. 2.1 Investigate the above accidents to find the root cause and the responsible person/department of the above accident and select suitable personal protective equipment to protect the worker from the above accident. 5.0 (LO1)
- Q. 2.2 Laid down the procedure for proper labeling of hazardous properties for the above accidents as per the NPFA-704. In addition, describe the number system used by the United Nations and Department of Transportation in classifying hazardous materials. 8.0 (LO2,5)
- Q. 2.3 Develop the key elements of an emergency response action program for the above accidents. 7.0 (LO6)
- Q. 3.1 Determine the voltage developed between a charging nozzle and a grounded tank, as shown in Figure 2. Also, compute the energy stored in the nozzle and the energy accumulated in the liquid. Explain the potential hazards in this process for a flow rate of 1 gpm. 5.0 (CO5,6)
- The data are Hose length: 20 ft. Hose diameter: 2 in, Liquid conductivity: mho/cm, Dielectric constant: 25.7, Density: 0.88 g/cm³

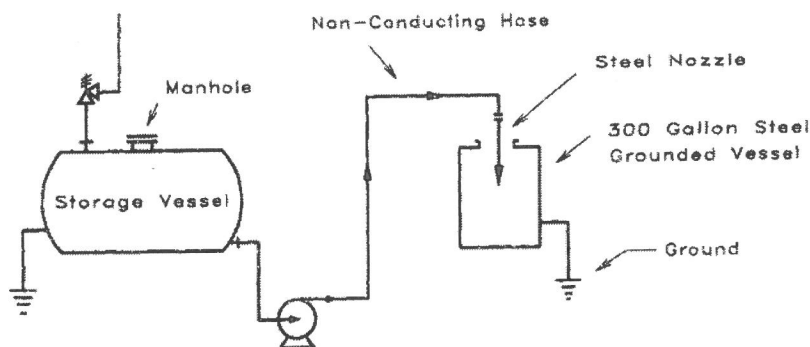


Figure 2 System for the above problem statement.

- Q. 3.2 Develop the policies, an organizational chart, training program, and Prepare standard operating procedures for Emergency Teams and Fire Brigades of petrochemical industries. 5.0 (CO6)
- Q. 3.3 Determine the factors necessary when selecting an appropriate fire detection and controlling system for any kind of building 5.0 (CO3)
- Q. 3.4 A storage vessel contains 100% air by volume and must be inerted with nitrogen until the oxygen concentration is below 1.25% by volume. The vessel volume is 1000 feet. How much nitrogen must be added, assuming the nitrogen contains 0.01% oxygen? 5.0 (CO5)

OR

- Q. 4.1 Use a vacuum purging technique to reduce the oxygen concentration within a 1000-gal vessel to 1 ppm. Determine the number of purges required and the total nitrogen used. The temperature is 75°F, and the vessel is originally charged with air under ambient conditions. A vacuum pump has used that reaches 20 mm Hg absolute, and the vacuum is subsequently relieved with pure nitrogen until the pressure returns to 1 atm absolute. 5.0 (LO1, 5)
- Q. 4.2 Describe the effective methods for proper care and maintenance of automatic sprinklers i.e., fixed fire protection systems. 5.0 (LO4)
- Q. 4.3 Estimate the capacitance of a person standing on a conductive floor. Assume that the person's shoe soles separate the person from the floor; that is, the shoe sole is the dielectric of the capacitor. 5.0 (LO6)
Given data: Shoe sole area (ft²) = 2 shoes (0.4 ft² each); Shoe sole thickness = 0.2 in, Dielectric constant of shoe soles = 3.5
- Q. 4.4 Explain the OSHA requirements, employees' training requirements, Personnel issues, Equipment needs, Management concerns, and Emergency operations for Emergency Teams and Fire Brigades members of higher education institutions. 5.0 (LO5,6)

All the best!