

N.B. 1. Question No.01 is compulsory

2. Attempt any Three questions from remaining Five questions

3. Assume suitable data wherever required

1. Answer the following (Any Four)

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- a. Explain in detail the need of safety instrumented system.
- b. What do you understand by operation phase of safety life cycle? Explain.
- c. Compare process control system and safety control system.
- d. A plant has identical solenoid valves, each of which is subjected to an annual function test. Over the course of 15 years, 75 dangerous failures have occurred. What is the failure rate and probability of failure on demand (maximum) for solenoid valves? (Assume there are enough failure for a simple failure rate calculation to be valid).
- e. What is consequence analysis? What are the factors to be considered for good impact consequence analysis?

2. a. Explain SIL determination using ALARP method.

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- b. A process incident may result in the breakage of a pipe elbow, which will then allow a mixture of ethane and propane to escape continuously at high velocity. If the release is ignited immediately (5% chance), the incident will result in a jet fire causing \$5 million worth of equipment damage. If the ignition is delayed, the release will result in either a flash fire or vapor cloud explosion. Delayed ignition has a probability of 25%. A flash fire would result in \$850000 of equipment damage, while a vapor cloud explosion would result in \$45 million in equipment damage. The calculations from a very detailed computational fluid dynamics model of the process area and release have yielded an estimate that 15% of the delayed ignition events will result in a vapor cloud explosion rather than a fire. What is the average consequence of this pipe elbow breakage incident? Also draw event tree for the same.

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3. a. Draw and explain the safety life cycle of IEC-61511.

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b. What is a protection layer? Explain in detail.

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4. a. Explain in detail fault propagation modelling for likelihood analysis.

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b. Write short note on safety instrumented function.

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TURN OVER

5. a. Compare SIS technology based on relay system and solid state device system. 10
- b. Discuss the following terms:- 10
- i. Complementary event
  - ii. Mutually exclusive event
  - iii. Non mutually exclusive event
6. a. Draw an event tree and quantify the outcome for overfilling a flammable materials tank. Define the initiating event as the delivery of the flammable material. Events that will determine the potential outcomes include:- 10
1. The tank may not have enough room to hold the delivery (10%)
  2. The operator may not detect that not enough room exists before starting the transfer (5%)
  3. The operator may not supervise the transfer and thus will not detect the high level in the tank (15%)
- (Assume an initiating event frequency of 52 times per year.)
- b. Explain in detail the SIL determination using risk graph method. 10
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