UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

M.Eng.

Chemical Eng E876: Advanced Safety and Loss Prevention

COURSE CODE	:	**CENGE876**
UNIT VALUE	:	**0.50**
DATE	:	**16-MAY-02**
TIME	:	**14.30**
TIME ALLOWED	:	**3 hours**

02-C0194-3-30

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UNIVERSITY OF LONDON

Chemical Engineering

E876

*Answer **FOUR QUESTIONS** only with **no more than TWO** questions from **each SECTION**.*
*ALL questions carry a total of **25 MARKS** each, distributed as shown* [ ].

SECTION A

1. a) Discuss the use of *event trees* as a method of safety analysis in the process industries. [5]

b) Figure 1 shows a pressure vessel V-101 handling flammable material operating at an elevated pressure of 16 barg. Liquid from the vessel is cooled and is discharged into a tank, which is not designed to withstand full vessel pressure. The liquid level in the vessel and the pressure let down across the liquid control valve LCV-002 are maintained. In the event of failure of the control valve, it is possible that high pressure gas breaks through into the low pressure system.

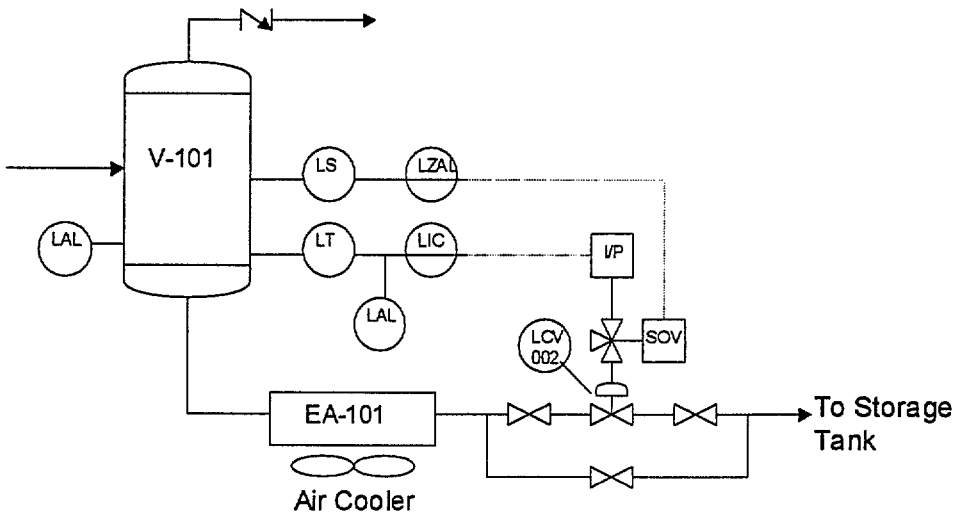

Figure 1. *Pressure vessel handling flammable material at high pressure*

Construct an event tree for the consequences of breakthrough and estimate the probability of fatal injury using the following probability data:

Cooling system fractures	0.02
Vapour cloud ignites	1.00
Operator present in vapour cloud area	0.80
Operator escapes before ignition	0.25
Operator burned but survives	0.5

[13]

c) The operating company has a target Fatal Accident Rate (FAR) of 0.4 for a single incident. (FAR is defined as the number of fatalities per 100 million exposure hours). Calculate the maximum frequency of liquid breakthrough to satisfy the operating company safety criteria given the plant is run continuously and is operated by a single operator working 250 eight hour shifts per year. [7]

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2. Figure 2 shows a flow diagram of a batch process vessel V-01 used for mixing two miscible liquids, *X* and *Y* and preheating them to 80°C before transferring the mixture to a reactor. The design pressure of the feed preparation vessel V-01 is 3.5 barg and full vacuum.

Initially, a specific volume of *X* is transferred into the empty vessel V-01 by centrifugal pump P-03, followed by a specific volume of liquid *Y* by pump P-04 and then mixed by starting the agitator. Low pressure steam (4.5 barg) is then applied to the heating coil E-01 until the temperature of the liquid mixture in the vessel reaches 80°C and the temperature is maintained using temperature controller TC-05. The agitator is then stopped, all valves to vessel V-01 are closed and the vessel is pressurised to 1.5 barg with nitrogen through pressure control valve PCV-03. The nitrogen source pressure available upstream PCV-03 is 6 barg. The discharge valve is then opened and the liquid mixture is transferred to the reactor under pressure by the nitrogen. A pressure relief valve PSV-09 is fitted on vessel V-01 to protect it from overpressure.

For the relief valve PSV-09 on the vessel determine the relief cases to be considered, and the basis for calculating the relief loads. [25]

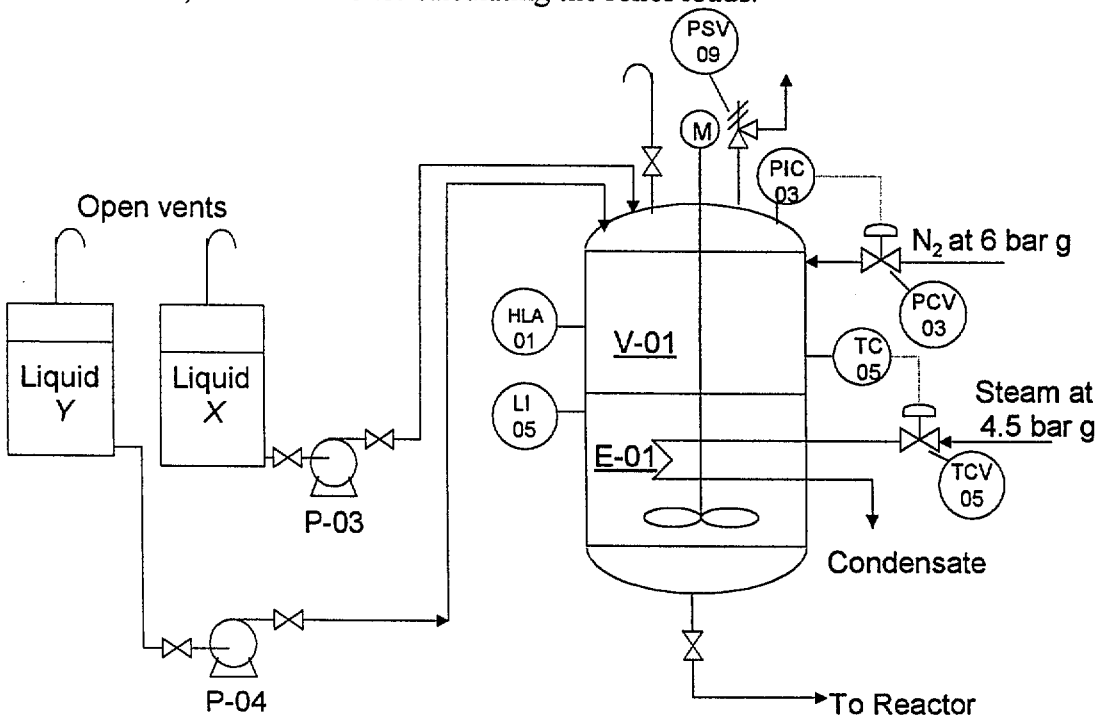

Figure 2. *Process flow diagram of batch process preheating vessel, and includes normal operating conditions.*

3. A plant has been shut down for a two weeks annual maintenance and inspection of equipment. One of the jobs to be done was to clear accumulated dust from the fins of a finned fan cooler and this was to be done by a man entering the base and using a high pressure air jet. A scaffolder had to enter the plenum chamber and make working conditions safe prior starting the work. A second scaffolder was to standby outside the chamber during entry. Design your own certificate(s) required for the scaffolder to carry out this work. [25]

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SECTION B

4. a) In 1974 the most important and far-reaching changes to industrial safety were enacted when the British Parliament promulgated the Health & Safety at Work Act. Compare and contrast the safety regimes before and after 1974 highlighting seven important aspects. [12]

b) An explosion assessment is required for a partially enclosed but congested process area and separate but nearby control room. Indicate how you would undertake the assessment. State what practical measures you would recommend to reduce explosion hazards should that appear to be necessary. [13]

5. The offshore Safety Case Regulations require hazards and risk to personnel to be systematically and logically evaluated.

a) Two main categories of hazard are recognised: major hazards and occupational hazards; catalogue the major hazards and give examples of occupational hazards. [6]

b) Provide examples of standard techniques used in hazard evaluation, and assessment. [4]

c) State what technique you would use to estimate risk levels. [3]

Explain how that technique is applied. [12]

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6. a) With aid of a simple block diagram, show the basic philosophy of Safety and Risk Assessment in the context of the operation of process plant. [5]

b) Describe five important environmental, social and economic benefits of loss prevention. [5]

c) Explain what you understand by the term, inherent safety and describe five important elements associated with its implementation. What are the economic advantages, if any, in adopting inherent safety during the design and operation of process plant. [6]

d) Figure 1 shows a process and instrumentation flow diagram for a distillation column protected by two pressure switches (PS_1 and PS_2) operating on an emergency shutdown valve (ESDV). Using the data below, calculate the total availability for the system assuming that the pressure switches respond on a 2002 voting system. [9]

	PS1	PS2	ESDV
Availability	0.9951	0.9961	0.9831

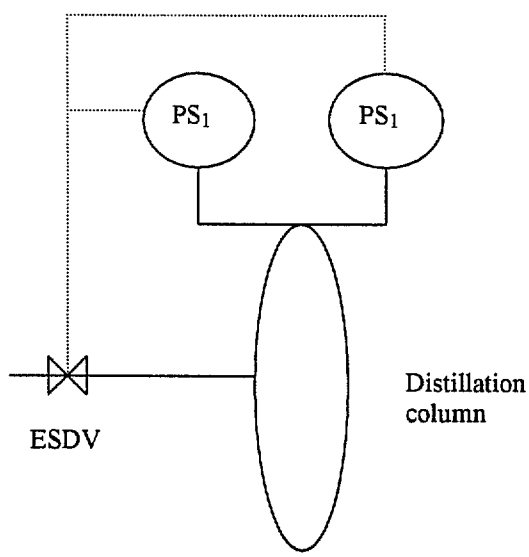

Figure 1. *Schematic representation of a distillation column protected by two pressure switches.*

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