UNIVERSITI SAINS MALAYSIA

First Semester Examination
2011/2012 Academic Session

January 2012

EKC 512 – Safety Engineering and Environmental Management

Duration : 3 hours

Please check that this examination paper consists of FIVE pages of printed material and TWO pages of Appendix before you begin the examination.

Instruction: Answer **ALL** **(4)** questions.

Answer <u>ALL</u> questions.

1. [a] "Environmental management is not the conservation of the environment for the environment's sake, but rather the conservation of the environment for humankind's sake". Is the statement valid? Give reasons and examples for your answers.

[4 marks]

[b] What are the sustainability indicators? Why are they important?

[4 marks]

[c] Describe waste hierarchy by giving proper illustration and explanation.

[4 marks]

[d] What are the components in sustainable development? Elaborate.

[4 marks]

[e] Explain (with suitable diagram) and give example of the activity associated with each of the terms; *bearable, viable, equitable* and *sustainable*.

[4 marks]

[f] In what ways development from human activities can have impacts on the basic elements of the global biogeochemical cycles?

[5 marks]

2. [a] What are the differences between LCA and EIA?

[5 marks]

[b] Give examples of the differences in Q.2.[a] from the perspective of Perwaja EIA report that you discussed in class.

[5 marks]

[c] From the IAEA report for Lynas project and Perwaja EIA report, what are the information that are lacking in those reports, but very useful to the public and authority?

[5 marks]

[d] Ground level concentration of SO_2 emitted from a plant can be calculated using the Diffusion model. Determine the maximum ground level concentration of SO_2 (in g/m^3) at 1.5 km from the plant. Stack height = 2 m, stack tip radius = 3 m, exit velocity = 10 m/s, exit temperature = 100 ºC, wind speed = 1 m/s, horizontal dispersion = 75 m, vertical dispersion = 33 m, source strength = 55 Mg/s, ambient temperature = 30 ºC and pressure = 100 kPa.

[6 marks]

[e] Calculate the concentration of SO_2 from Q.2.[d]. using the Box model and give the reasons for the discrepancy from the Diffusion model. (Assume mixing height = Stack height, mixing length = distance from the plant)

[4 marks]

3. [a] Describe the difference between Solid Plume and Point Source radiation models. *[5 marks]*

[b] A pool fire incident occurred in Prai Industrial Zone due to the release of hydrocarbon A. The hydrocarbon liquid escaped from a leak at a volumetric rate of 0.3 m^3/s. A circular dike with a 25 m diameter contained the leak. The result of the analysis indicated that the radiation intensity of the pool fire was 13.0 kW/m^2 being experienced by a worker who stood 100 m away from the source. Estimate the heat of combustion of the liquid by using the Point Source model.

[20 marks]

Data:

Heat of vaporization of the liquid	400	kJ/kg
Boiling point of the liquid	370	K
Ambient temperature	298	K
Liquid density	750	kg/m^3
Heat capacity of liquid (constant)	3.0	kJ/kg-K

4. [a] One of the main criteria in safety engineering is to determine the tolerable risk value for both existing and new plants via Quantitative Risk Assessment. Outline the steps taken in conducting the Quantitative Risk Assessment.

[10 marks]

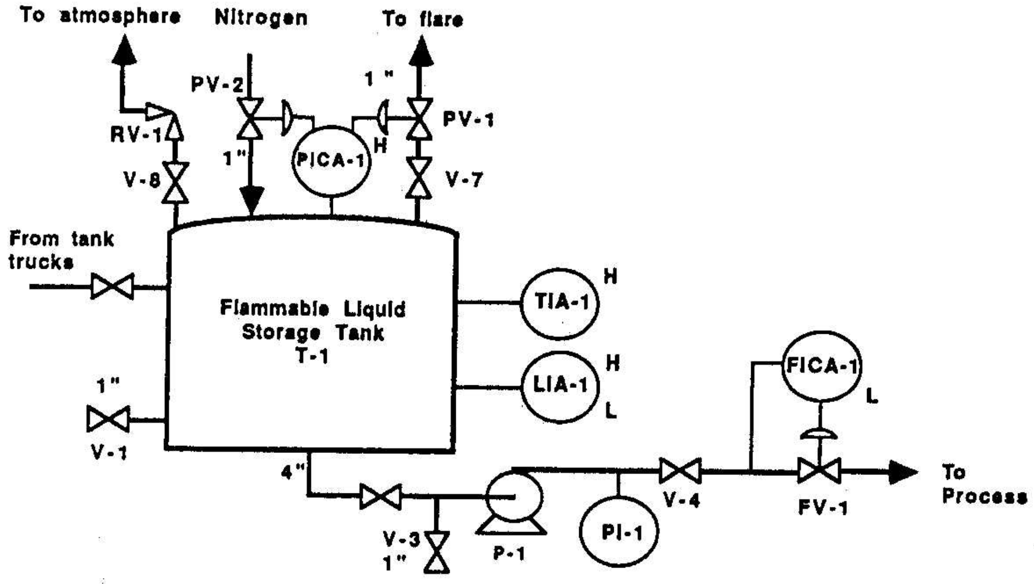
[b] Figure Q.4.[a] illustrates the Process and Instrumentation Diagram (P&ID) for a storage tank. The storage tank (T-1) is designed to hold a flammable liquid under a slight nitrogen positive pressure. A control system (PICA-1) is used to control the pressure in the tank. In addition, the tank is fitted with a relief valve to cope with emergencies. Liquid is fed to the tank from tank trucks. A pump (P-1) is used to supply flammable liquid to the process;

[i] Determine three (3) possible events that could lead to major flammable release other than the rupture of tank due to overpressure.

[ii] Based on Figure Q.4.[b], determine the combination of possible minimal cut set numbers for the occurrence of tank rupture due to overpressure.

[iii] Calculate the probability of the top event based on both minimal cut set and gate to gate technique.

[15 marks]



P & I D Legend

EQUIPMENT AND VALVES	INSTRUMENTS
FV - Flow Control Valve	P - Pressure
T - Tank	T - Temperature
P - Pump	L - Level
PV - Pressure Control Valve	F - Flow
RV - Relief Valve	I - Indicator
V - Valve	C - Controller
1" - 1 inch size	A - Alarm
	H - High,
	L - Low

Figure Q.4.[a]

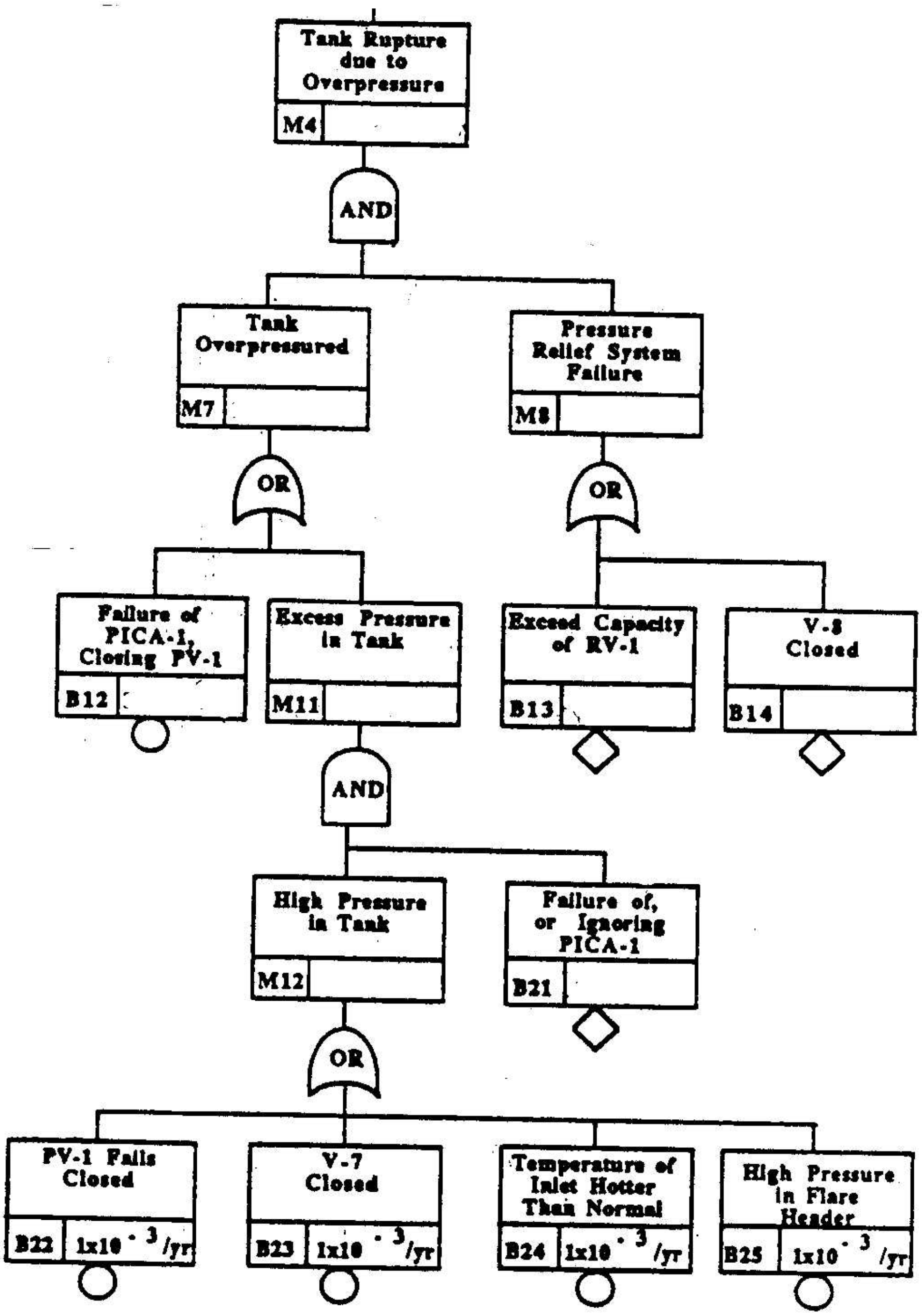


Figure Q.4.[b].

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Appendix

$$C(t) = \frac{qL}{vH}\left(1 - e^{(-vt/L)}\right)$$

$$C(x, y, z) = \frac{q}{2\pi\sigma_y\sigma_z v}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

$$\Delta H = \frac{2v_s r_s}{v}\left[1.5 + 2.68 \times 10^{-2} P\left(\frac{T_s - T_a}{T_s}\right)2r_s\right]$$

Volume Equivalents

in^3	ft^3	US gal	L	m^3
1	5.787×10^{-4}	4.329×10^{-3}	1.639×10^{-2}	1.639×10^{-5}
1728	1	7.481	28.32	2.832×10^{-2}
231	0.1337	1	3.785	3.785×10^{-3}
61.03	3.531×10^{-2}	0.2642	1	1.000×10^{-3}
6.102×10^4	35.31	264.2	1000	1

Ideal Gas Constant R_g

1.9872 cal/g-mol K
1.9872 Btu/lb-mol°R
10.731 psia ft^3/lb-mol°R
8.3143 kPa m^3/kg-mol K = 8.314 J/g-mol K
82.057 cm^3 atm/g-mol K = 8.2057×10^{-5} m^3 atm/mol K
0.082057 L atm/g-mol K = 0.082057 m^3 atm/kg-mol K
21.9 (in Hg) ft^3/lb-mol°R
0.7302 ft^3 atm/lb-mol°R
1,545.3 ft lb_f/lb-mol°R

Gravitational Constant, g_c

32.174 ft-lb_m/lb_f-s^2
1 (kg m/s^2)/N
1 (g cm/s^2)/dyne

Miscellaneous

1 Poise = 100 centipoise = 0.1 kg/m s = 0.1 Pa s = 0.1 N s/m^2
1 N = 1 kg m/s^2
1 J = 1 N m = 1 kg m^2/s^2
1 centipoise = 1×10^{-3} kg/m s = 2.4191 lb/ft-hr = 6.7197×10^{-4} lb/ft s

…2/-

Source Model

$$\frac{P_2 - P_1}{\rho} + \frac{g}{g_c}(z_2 - z_1) + \frac{1}{2g_c}(v_2^2 - v_1^2) + \sum e_f + \frac{W_s}{\dot{m}} = 0$$

$$e_f = K_f\left(\frac{v^2}{2g_c}\right)$$

$$K_f = \frac{K_1}{N_{RE}} + K_\infty\left(1 + \frac{1}{ID_{inches}}\right)$$

$$\dot{m} = AC_D\sqrt{2\rho g_c(P_1 - P_2)}$$

$$\dot{m} = \rho v A = \rho A C_D\sqrt{2\left(\frac{g_c P_g}{\rho} + g h_L\right)}$$

$$Q_m = C_o A P_o\sqrt{\left(\frac{2g_c M}{R_g T_o}\frac{\gamma}{\gamma - 1}\right)\left[\left(\frac{P}{P_o}\right)^{2/\gamma} - \left(\frac{P}{P_o}\right)^{(\gamma+1)/\gamma}\right]}$$

$$\frac{P_{choked}}{P_o} = \left(\frac{2}{\gamma - 1}\right)^{\gamma/(\gamma-1)}$$

$$(Q_m)_{choked} = C_o A P_o\sqrt{\left(\frac{g_c M}{R_g T_o}\right)\left[\left(\frac{2}{\gamma + 1}\right)^{(\gamma+1)/(\gamma-1)}\right]}$$

Dispersion Models

$$\langle C\rangle_{max} = \frac{\dot{m}}{\pi\sigma_y\sigma_z u}$$

$$\langle C\rangle_{ppm} = \frac{\dot{m}}{\pi\sigma_y\sigma_z u}\left[\frac{RT}{MP}\times 10^6\right]$$

$$\sigma_y = \exp\left[4.23 + 0.9222\ln\left(\frac{x}{1000}\right) - 0.0087\left[\ln\left(\frac{x}{1000}\right)\right]^2\right]$$

$$\sigma_x = \exp\left[3.414 + 0.7371\ln\left(\frac{x}{1000}\right) - 0.0316\left[\ln\left(\frac{x}{1000}\right)\right]^2\right]$$

Equations related to Fire Modeling

Pool Fires:

$$\dot{y}_{max} = 1.27\times 10^{-6}\frac{\Delta H_c}{\Delta H^*}$$

$$\Delta H^* = \Delta H_v + \int_{T_a}^{T_{BP}} C_p\,dT$$

$$m_B = 1\times 10^{-3}\frac{\Delta H_c}{\Delta H^*}$$

$$D_{max} = 2\sqrt{\frac{\dot{V}_L}{\pi\dot{y}}}$$

$$\frac{H}{D} = 42\left(\frac{m_B}{\rho_a\sqrt{gD}}\right)^{0.61}$$

$$E_{av} = E_m e^{-SD} + E_s\left(1 - e^{-SD}\right)$$

$$F_P = \frac{1}{4\pi x^2}$$

$$\tau_a = 2.02(P_W X_S)^{-0.09}$$

$$E_r = \tau_a Q_r F_P = \tau_a \eta m_B \Delta H_c A F_P$$

Jet Fires:

$$\frac{L}{d_j} = \frac{5.3}{C_T}\sqrt{\frac{T_f/T_j\left[C_T + (1 - C_T)\frac{M_a}{M_f}\right]}{\alpha_T}}$$

$$E_r = \tau_a Q_r F_p = \tau_a \eta\,\dot{m}\,\Delta H_c F_P$$

Equations related to Explosion Modeling

TNT Model

$$W = \frac{\eta M E_c}{E_{TNT}}$$

$$Z_e = \frac{R}{M_{TNT}}$$

$$P_S = \frac{P_o}{P_a}$$

TNO Model

$$\bar{R} = \frac{R}{(E/P_o)^{1/3}}$$

$$P_s = \Delta\bar{P}_s . P_o$$

$$t_+ = \bar{t}_+\left[\frac{(E/P_o)^{1/3}}{c_o}\right]$$