Professional Engineering Exam
Fire Protection Engineering
Study Guide

Saudi Council of Engineers (SCE)
Education and Training Evaluation Commission (ETEC)
National Center for Assessment (NCA)

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1. Aim:

The objective of this Instruction Manual is to provide guidelines for the NCA proposed Professional Engineers Exam. These guidelines cover the eligibility conditions, the grading and passing conditions, the structure of the exam and the distribution of exam questions among various areas. In essence, this Instruction Manual represents a "bridge" between the developed exam standards and the actual phrased questions. It is designed to help item writers prepare questions for the Fire Protection Engineering Discipline paper as well as a study guide for the examinees.

2. Exam Structure:

2.1 Exam Type

The exam is initially paper-based with questions being a combination of multiple-choice questions (MCQ) and essays.

2.2 Exam Organization

The exam is conducted in two sessions during one day. The duration of the first session is 2.5 hours while the second session is 4 hours long. There is one-hour break between the two sessions.

2.2.1. Session #1

The first session is the common part to be taken by all the examinees from all disciplines. This part includes seven topics: (Ethics – Professionalism - Laws for Professional Practice, Professional Laws and Regulation - Environment and Natural Resources - Engineering Management - Engineering Economics - Health, Safety and Security (HSS)).

The total duration of this session is 2.5 hours and the total number of questions is 30 MCQ and 2 essays.

2.2.2. Session #2

The second session is the Discipline Part. The following engineering disciplines are considered:

Code	Discipline
STE	Structural Engineering
GTE	Geotechnical Engineering
TRE	Transportation Engineering
WREE	Water Resources and Environmental Engineering
PE	Power Engineering
HVAC	Heating, Ventilation, and Air Conditioning (HVAC) and Refrigeration Engineering
TFSE	Thermal and Fluids Systems Engineering
CHE	Chemical Engineering
FPE	Fire Protection Engineering
ARCH	Architecture

The total duration of this session is 4 hours and the total number of questions is 30 MCQs and 4 essays. The examinee must answer all the MCQs and two essays (two essays to be chosen out of four).

2.3 Eligibility for the Exam

As per Saudi Council of Engineers Requirements.

2.4 Grades

Each part (common part and discipline part) carries a total grade of 100. The MCQs carry a grade of 60% while the essays carry a grade of 40%. Each MCQ has 4 choices for the answer. There is no negative marking for wrong answers.

2.5 Passing Rules

- The eligible candidate must take in his/her first sitting the two exam parts (common part and discipline part).
- In order to pass the exam, the candidate must obtain a grade of 60% or above in each part of the exam.
- If the candidate fails both parts of the exam (by receiving in each part a grade less than 60%), he/she can take the two parts of the exam but only when one full year has passed.
- If the candidate fails only one part of the exam (common part or discipline part), he/she must repeat only the part he/she failed, but he/she must pass this part within one year.
- If a year passed and the candidate did not succeed in passing the part he/she failed, then he/she has to take both parts of the exam.

2.6 Exam Rules

- No printed or electronic material is allowed during the exam. All necessary reference materials will be provided by NCA
- Calculators approved by NCA are allowed.
- Comprehensive exam rules will be provided by the examination authority, NCA, in a separate manual.

3. Table of Specifications for NCA Professional Engineers Exam: Fire Protection Engineering:

<table>
<tr><th rowspan="2">Major Area</th><th colspan="2">Multiple Choice Questions (MCQs)</th><th rowspan="2">Number of Essay Questions</th><th rowspan="2">Engineering Standard</th></tr>
<tr><th>%</th><th>Number of Questions</th></tr>
<tr><td>Principles of fire</td><td>13</td><td>4</td><td rowspan="9">The examinee will choose two essay questions out of four</td><td>FPE-T1</td></tr>
<tr><td>Information and Analysis for Fire Protection</td><td>7</td><td>2</td><td>FPE-T2</td></tr>
<tr><td>Fire Prevention</td><td>10</td><td>3</td><td>FPE-T3</td></tr>
<tr><td>Fire Detection</td><td>10</td><td>3</td><td>FPE-T4</td></tr>
<tr><td>Human Behavior in Fire and Means of Egress</td><td>10</td><td>3</td><td>FPE-T5</td></tr>
<tr><td>Passive Fire Protection Systems</td><td>13</td><td>4</td><td>FPE-T6</td></tr>
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<tr><td>Explosion Principles and Protection</td><td>7</td><td>2</td><td>FPE-T9</td></tr>
<tr><td>Total</td><td>100%</td><td>30</td><td>Two Essays</td><td></td></tr>
</table>

4. Standards for Fire Protection Engineering Exam:

FPE-T1: Principles of fire

FPE-T1-1	Understand fire properties of combustible gases, liquids and solids.
FPE-T1-2	Understand the thermodynamics and kinetics of combustion reaction, the adiabatic flame temperature and properties of diffusion flames.
FPE-T1-3	Explain the process of fire development, growth, spread, development, peak, and decay in closed and open environments.
FPE-T1-4	Evaluate the burn characteristics of flammable materials based upon live burns and computer modeling.
FPE-T1-5	Describe the differences between piloted ignition, non-piloted ignition and spontaneous combustion.
FPE-T1-6	Evaluate fire plume and the effect of setting such as walls, ceilings, wind, and air supply.
FPE-T1-7	Evaluate quantitatively the toxic impact of fire effluents on occupants, firefighters and the environment.
FPE-T1-8	Evaluate quantitatively the impact of exposure to heat and smoke on occupants, firefighters and structures.
FPE-T1-9	Identify tenability limits in fires so that occupants and firefighters are not exposed to untenable conditions.
FPE-T1-10	Describe the effects of fire protection systems and building design on fire progression.
FPE-T1-11	Understand heat transfer, ignition, smoke and smoldering combustion.

FPE-T2: Information and Analysis for Fire Protection

FPE-T2-1	Identify potential fire hazards at a specific occupancy.
FPE-T2-2	Explain specific principles of controlling the risks of fire.
FPE-T2-3	Estimate the potential impact of fire using risk based analysis and hazard based analysis methods on given occupancies.
FPE-T2-4	Carry out a fire risk assessment of specific occupancies.
FPE-T2-5	Identify and describe the structural and other potential damages to be evaluated after a fire.
FPE-T2-6	Describe the methods of collection of physical evidence and analysis of fire scene data.
FPE-T2-7	Examine the fire scene in accordance with best practice.
FPE-T2-8	Explain the legal requirements of evidence collection and maintenance of the chain of evidence in fire scenes.

FPE-T3: Fire Prevention

FPE-T3-1	Describe basic fire prevention housekeeping procedures.
FPE-T3-2	Explain hazard classification systems for gases, liquids and solids.
FPE-T3-3	Assess fire risk by considering fire hazards or ignition sources (e.g. pyrophoric substances, water-reactive metals, operations using flammable sources, heat utilizing equipment, industrial furnaces or ovens, electrical and semiconductors systems, etc.)
FPE-T3-4	Assess the risks posed by fire hazards or ignition sources using a variety of tools (qualitative, deterministic assessment, probabilistic risk assessment).
FPE-T3-5	Implement measures to control risks associated with the fire hazards or ignition sources.
FPE-T3-6	Implement plan to monitor fire hazards or ignition sources and review the controls.
FPE-T3-7	Develop policies, procedures, and training programs to educate public in fire prevention.
FPE-T3-8	Conduct inspection of buildings and facilities to evaluate their construction and fire protection types and components.
FPE-T3-9	Evaluate buildings and industrial facility's compliance with regulation pertinent to fire protection.
FPE-T3-10	Determine operations of fire departments and how a building should be designed to accommodate and enhance fire department operations during an emergency.
FPE-T3-11	Identify methods to control flammable atmospheres, ignition sources, and static electricity to reduce fire and eliminate hazards.

FPE-T4: Fire Prevention

FPE-T4-1	Describe components of automatic fire detection systems.
FPE-T4-2	Classify automatic fire detection systems (e.g. alarms, heat detection, smoke detection, hypoxic).
FPE-T4-3	Identify the operational properties, design criteria, application and limitations of automatic fire detectors systems.
FPE-T4-4	Describe installation, maintenance and testing requirements of automatic fire alarm systems.
FPE-T4-5	Describe how automatic fire alarm systems interface with other systems.
FPE-T4-6	Understand governing equations of first sprinkler activation code like DETACT.

FPE-T5: Human behavior in fire and means of egress

FPE-T5-1	Identify features (social, physical, operational) that influence occupant reaction and movement during normal conditions and fire emergency situations.
FPE-T5-2	Identify factors that delay occupant response to verbal and device warning during fire emergency situations.
FPE-T5-3	Explain human fire behavior as it pertains to occupant movement, both, as an individual and in a crowd during fire emergency.
FPE-T5-4	Describe the physiological effect of fire combustion products that may incapacitate people during fire emergency situations.
FPE-T5-5	Identify means to disseminate information to occupants during fire emergencies.
FPE-T5-6	Identify methods of managing the movement (evacuation, relocation, protect-in-place) of building occupants during fire emergencies.
FPE-T5-7	Identify the components of means of egress.
FPE-T5-8	Determine the design elements of means of egress (number of exits, capacity, arrangement of egress means facilities, door hardware, locations, lighting and signage, fire-resistance rated construction for egress elements), and ergonomic aspects of firefighting equipment design.

FPE-T6: Passive fire protection systems

FPE-T6-1	Describe passive fire protection design systems in buildings and their relations to the requirements of the Saudi Building Code (fire protection requirements).
FPE-T6-2	Identify key factors in the selection of passive fire protection systems in relation to their ability to affect fire resistance of a building and its components.
FPE-T6-3	Identify and design passive fire protection in building (e.g. structural fire protection, compartmentation, opening protection, fire stopping materials).
FPE-T6-4	Describe key testing requirements for fire resistance of different building elements.
FPE-T6-5	Identify the passive fire protection systems used in process industries.
FPE-T6-6	Describe fire resistant materials that can be used with structural designs.
FPE-T6-7	Understand the response to heat of different structural materials (steel, concrete, and wood).
FPE-T6-8	Understand one dimensional heat flow into elements of building structures.
FPE-T6-9	Understand the spread of fire vertically and horizontally.

FPE-T6-10 Estimate fire loading in a building.

FPE-T6-11 Evaluate methods of fire resistance of concrete, steel and timber structures.

FPE-T6-12 Understand concept of safe separation distances based on radiation heat transfer calculations.

FPE-T6-13 Understand the mechanism of control of the flow of smoke and gases by both natural and mechanical means.

FPE-T6-14 Understand the design and effect of roof and wall vents.

FPE-T6-15 Understand the pressurization.

FPE-T7: Active fire protection: Water-based suppression

FPE-T7-1 Identify key considerations when selecting active water based fire suppression systems.

FPE-T7-2 Evaluate the existing water supply to determine the need for additional or enhanced water distribution systems.

FPE-T7-3 Identify local requirements pertinent to water supply for active water based fire suppression systems.

FPE-T7-4 Identify design criteria for hydraulics for water based fire protection systems.

FPE-T7-5 Describe the operational components of stationary fire pumps.

FPE-T7-6 Identify the operational components, design criteria, applications and limitations of automatic water sprinkler systems and water spray systems.

FPE-T7-7 Understand fluid dynamics of jets and sprays.

FPE-T7-8 Understand hydraulics of water supply systems in cities and major risks.

FPE-T8: Active fire protection: non-water based suppression

FPE-T8-1 Identify the operational components, design criteria, applications and limitations of dry and wet chemical extinguishing systems.

FPE-T8-2 Identify the operational components, design criteria, applications and limitations of foam systems.

FPE-T8-3 Identify the operational properties, design criteria, applications and limitations and hazards of gaseous extinguishing systems (carbon dioxide, inert gas, halon systems, halocarbon systems).

FPE-T8-4 Explain installation, maintenance and testing requirements of non- water-based fire suppressing systems.

FPE-T8-5	Understand fluid dynamics of vaporizing liquids.
FPE-T8-6	Understand fluid dynamics of two phase flow with foam.
FPE-T8-7	Understand fluid dynamics of two phase flow with dry powder.
FPE-T8-8	Describe tests used for testing suppression agents (e.g. Cup Burner Test).
FPE-T8-9	Understand non dimensional numbers involved in flame extinction (e.g. Damkohler number).
FPE-T8-10	Understand flame stretch.

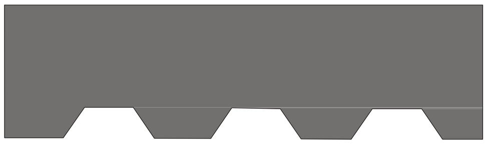
FPE-T9: Explosion principles and protection

FPE-T9-1	Demonstrate the differences between deflagration and detonation.
FPE-T9-2	Explain the similarities and differences between combustion, fire, and explosion characteristics.
FPE-T9-3	Identify types of explosive substances, safety parameters, and methods of measurement of performance of explosive substances.
FPE-T9-4	Explain explosions: requirements, types, categories, phases, and effects.
FPE-T9-5	Describe explosion prevention methods (removal of free space, storage of flammable liquids, floating lid, layer of microspheres, layer of stable foam, inertization).
FPE-T9-6	Explain explosion design protection (explosion proof construction. relief openings, relieving diaphragm, relief valves).
FPE-T9-7	Understand the detonation in free space and the impact of pressure waves (blast waves).
FPE-T9-8	Understand basic TNT scaling analysis for blast waves.
FPE-T9-9	Understand safe separation distance based on blast loading.
FPE-T9-10	Understand BLEVE theory and prevention.
FPE-T9-11	Understand the deflagration in closed spaces and explosion relief for buildings.
FPE-T9-12	Understand explosion in pipes.
FPE-T9-13	Understand flame quenching and flame arrestor operating principle and designs.

Selected References:

- Saudi Building Code (SBC).
- National Fire Protection Association, NFPA.
- Morgan J. Hurley, “SFPE Handbook of Fire Protection Engineering”.

5. Samples of Questions

Q. No.	Major Area	Indicator Code	Question Statement (Answer's Choices)	Key Answer	Expected Time (min)	Supplied Reference
1	**Passive fire protection systems**	FPE-T6-11	The figure below represents a siliceous concrete panel. The panel has a minimum thickness of 150 mm, a width of 3.5 m and a net cross-sectional area of 370,000 mm^2. The spacing between the ribs is 400 mm. What is the fire resistance rating (hr) of the panel?  A) 1 B) 2 C) 3 D) 4	(B)	3.0 - 4.0	See Reference
2	**Principles of Fire**	FPE-T1-6	A 50 cm diameter pan fire of heptane is burning with a heat intensity of 2500 kW/m^2. Assuming a convective heat release fraction of 0.8, normal atmospheric conditions of 760 mm Hg and 15°C, and density of air of 1.225 kg/m^3, what is the volumetric exhaust rate (m^3/s) required to keep smoke at a height of 3 m? A) 1.21 B) 3.23 C) 5.12 D) 7.54	(B)	3.0 - 5.0	See Reference
3	**Human behavior in fire and means of egress**	FPE-T5-8	The occupant load factor for a mall is designed to be 2.8 square meters per person. What is approximatively the minimum gross leasable area (m^2) of the covered mall building (excluding anchor buildings)? A) 6821 B) 9285 C) 10345 D) 12003	(A)	2.0 - 3.0	See Reference

Q. No.	Major Area	Indicator Code	Question Statement (Answer's Choices)	Key Answer	Expected Time (min)	Supplied Reference
4	**Active fire protection: Water-based suppression**	FPE-T7-6	After a fire broke out in a hotel kitchen, forensic investigators were sent to try to determine the timing of events. The kitchen is equipped with a sprinkler (RTI of 33 $m^{1/2}$ $s^{1/2}$, ordinary temperature, 75°C). The initial temperature of the kitchen ceiling (3.3 m) was around 20°C which was exposed to a plume of approximately 80°C traveling at a speed around 1.3 m/s. What should have been the response time (s) of the sprinkler? A) 43 B) 58 C) 67 D) 72	(D)	3.0 – 4.0	See Reference
5	**Principles of fire**	FPE-T1-2	An open tank containing 130 kg of butter (gross heat of combustion is 38.5 MJ/kg) was accidently set on fire of power 1.4 MW as a result of tank rupture. About how long will it take before two thirds of the tank content are burned? A) 10 s B) 30 s C) 40 min D) 2 h	(C)	2.0 – 3.0	None
6	**Active fire protection: non-water based suppression**	FPE-T8-3	HFC-125 agent is to be used to protect in full flood application a space (10 m long by 5 m wide by 2 m tall with a fixed structure of 10 m3) at 25oC containing sensitive electronic materials. Assuming a design concentration of 7.0%, what is the minimum required quantity (kg) of the agent? A) 36.1 B) 24.2 C) 15.1 D) 7.2	(A)	3.0 – 4.0	See Reference

Q. No.	Major Area	Indicator Code	Question Statement (Answer's Choices)	Key Answer	Expected Time (min)	Supplied Reference
7	**Explosion principles and protection**	FPE-T9-12	A plastic material of thermal conductivity of k=0.12 W/m K is used as an electric insulator of an electric cable. The cable diameter is 8 mm. The convection heat transfer coefficient from cable surface is h=20 W/m^2 K. Estimate the insulator thickness δ required to dissipate the maximum heat from the cable. A) 12.5 B) 9.3 C) 7.1 D) 3.2	(B)	1.0 – 3.0	See Reference
8	**Active fire protection: Water-based suppression**	FPE-T7-6	An automatic sprinkler system is to be designed for an ordinary hazard group 1 in a certain room, where the application density is assumed to be 6.11 Lpm/m^2. The system is composed of 6 nozzles with 3 m spacing. The total floor area is 55 m^2. The sprinkler has a temperature rating of 68°C and a K value of 8.073 Lpm/kPa$^{0.5}$. The required pressure (kPa) at the sprinkler head is: A) 23 B) 37 C) 48 D) 56	(C)	2.0 – 3.0	See Reference
9	**Explosion principles and protection**	FPE-T9-3	Class II organic peroxide describes formulations that: A) are capable of deflagration but not detonation.54.5% B) burn in the same way as ordinary combustibles and pose a minimal reactivity hazard C) burn rapidly and pose a moderate reactivity hazard. D) burn very rapidly and pose a moderate reactivity hazard.	(D)	1.0 – 2.0	None

<table>
<tr><th>Q. No.</th><th>Major Area</th><th>Indicator Code</th><th>Question Statement (Answer's Choices)</th><th>Key Answer</th><th>Expected Time (min)</th><th>Supplied Reference</th></tr>
<tr><td>10</td><td>Passive fire protection systems</td><td>FPE-T6-5</td><td>According to Saudi Fire Code (SBC 801), the width of sumps or other basins for the retention of oil or petroleum products should not exceed ------ (m).

A) 0.5
B) 1.7
C) 2.5
D) 3.6</td><td>(D)</td><td>1.0 – 2.0</td><td>Saudi Fire Code (SBC 801)</td></tr>
<tr><td>Essay</td><td>Active fire protection: Water-based suppression</td><td>FPE-T7-3</td><td>Consider the piping system shown in the following figure which is used to distribute water. Table 1 shows the pipe data. Determine the length of a single equivalent pipe that has a 242.8 mm diameter. Assume a C-factor of 100 for all pipes and a flow of 4542 LPM

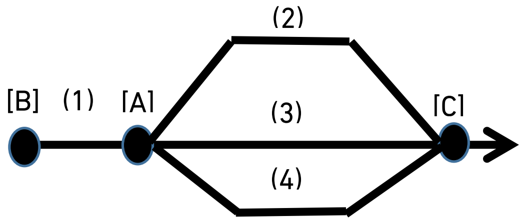


Table: Pipes characteristics
<table>
<tr><th></th><th>Pipe (1)</th><th>Pipe (2)</th><th>Pipe (3)</th><th>Pipe (4)</th></tr>
<tr><td>Length (m)</td><td>274</td><td>335</td><td>243</td><td>304</td></tr>
<tr><td>Inside diameter (mm)</td><td>363.5</td><td>228.9</td><td>193.7</td><td>228.9</td></tr>
</table></td><td>----</td><td>30 - 40</td><td>See Reference</td></tr>
</table>

References

1) Equivalent thickness for ribbed or undulating surfaces.

The equivalent thickness of panels with ribbed or undulating surfaces (T_e) is determined by one of the following expressions:

- For s > 4t, the thickness to be used shall be: t
- For s ≤ 2t, the thickness to be used shall be: t_e
- For 4t > s > 2t, the thickness to be used shall be: $t + (\frac{4t}{s} - 1)(t_e - t)$

where:

s	=	Spacing of ribs or undulations, m.
t	=	Minimum thickness, m.
t_e	=	Defined as the net cross sectional area of the panel divided by the width, m.

TABLE: MINIMUM SLAB THICKNESS (inches)

CONCRETE TYPE	FIRE-RESISTANCE RATING (hours)				
	1	11/2	2	3	4
Siliceous	3.5	4.3	5	6.2	7
Carbonate	3.2	4	4.6	5.7	6.6
Sand-lightweight	2.7	3.3	3.8	4.6	5.4
Lightweight	2.5	3.1	3.6	4.4	5.1

1 inch = 25.4 mm

2) Axisymmetric plumes.

The plume mass flow rate (m_p), (kg/s), is determined by placing the design fire center on the axis of the space being analyzed.

The limiting flame height shall be determined by:

$z_l = 0.166\ Q_c^{2/5}$

for $z > z_l$

$m_p = 0.071 Q_c^{1/3} z^{5/3} + 0.0018 Q_c$

for $z = z_l$

$m_p = 0.035 Q_c$

for $z < z_l$

$m_p = 0.032\ Q_c^{3/5} z$

$V = m_p / \rho$

where:

z_l: Limiting flame height (m).

z: Height from top of fuel surface to bottom of smoke layer, (m).

Q_c: Convective heat output, (kW).

V: Volumetric flow rate, (m^3 /s).

ρ: Density of air at the temperature of the smoke layer, (kg/m^3)

m_p: Plume mass flow rate (kg/s)

3) Occupant formula.

In determining required means of egress of the mall, the number of occupants for whom means of egress are to be provided shall be based on gross leasable area of the covered mall building (excluding anchor buildings) and the occupant load factor as determined by the following equation:

OLF = (0.00007) (GLA) + 2.3225

Where:

OLF = The occupant load factor (square meters per person).

GLA = The gross leasable area (square meters).

4) Automatic Sprinklers.

$RTI = t_r u_0^{1/2} / \ln((T_g - T_a)/(T_g - T_r))$

where:

RTI: Response time index ($m^{1/2}\ s^{1/2}$)

T_g: Temperature of fire gas (ºC)

T_a: Ambient temperature (ºC)

T_r: Rating temperature (ºC)

t_r: Response time (s)

u_0: Velocity of fire gas (m/s):

5) Agent Quantity.

$$W = \frac{V}{S}\left(\frac{C}{100 - C}\right)$$

where:

V: Net volume of protected space (m^3)

C: Design concentration (%)

W: Weight of agent required (kg)

S: Specific volume (m^3/kg) and is determined by

$S = k_1 + k_2 .T$

Where:

T is the minimum ambient temperature (ºC)

k1 and k2 are contestants.

Specific volume constants

Agent	k_1	k_2
FC-3-1-10	0.0941	0.0003
HFC-124	0.1578	0.0006
HFC-125	0.1701	0.0007
HFC-23	0.2954	0.0012
IG-541	0.649	0.00237
IG-01	0.5685	0.00208

6) Sustained detonation.

Sustained detonation can only occur if the characteristic length scale of the gas-air mixture is greater than some multiple of the detonation cell width (S_c). The value of the multiplication factor depends on the geometry.

- In the case of a pipe, the detonation will not propagate down the pipe if the pipe diameter is less than about $S_c/3$.
- The detonation will not propagate from open end of the pipe into the surrounding gas mixture if the pipe diameter is less than $13S_c$.

7) Discharge from a sprinkler head.

$$Q = K\,P^{0.5}$$

where:

Q: Flow rate (liter per minute)

P: Pressure (bar per meter)

K: Sprinkler constant

8) Hazen–Williams equation.

$$H=10.67Q^{1.85}L/(C^{1.85}\,D^{4.87})$$

where:

H: head loss in meters (water) over the length of pipe

L: length of pipe, m

Q: volumetric flow rate, m3/s

C: pipe roughness coefficient

D: inside pipe diameter, m

6. Solutions of Sample Questions

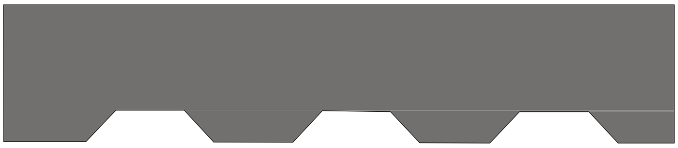
Multiple Choice Questions (MCQs)

Question # 1

Indicator FPE-T6-11: Evaluate methods of fire resistance of concrete, steel and timber structures

Example FPE-T6-11:

The figure below represents a siliceous concrete panel. The panel has a minimum thickness of 150 mm, a maximum thickness of 150, a width of 3.5 m and a net cross-sectional area of 370,000 mm^2. The spacing between the ribs is 400 mm. What is the fire resistance rating (hr) of the panel?



A) 1

B) 2

C) 3

D) 4

Solution FPE-T6-11:

t=150 mm

s=400 mm

Using the relations given in the appendix we have:

We have the situation where 4t > s > 2t (since 4x150 >400>2x150)

Therefore the thickness to be used is : $t+(4t/s-1)(t_e-t)$

Where $t_e=A/w$=(net cross sectional area)/width

The equivalent thickness is therefore: 150+(4*150/400-1)(370000/3500-150)=127.9 mm =5.03 in

The table provided in reference for siliceous material yields a resistance rating of 2 h

Answer FPE-T6-11: (B)

Question # 2

Indicator FP-T1-6: Evaluate fire plume and the effect of setting such as walls, ceilings, wind, and air supply.

Example FPE-T1-6:

A 50 cm diameter pan fire of heptane is burning with a heat intensity of 2500 kW/m2. Assuming a convective heat release fraction of 0.8, normal atmospheric conditions of 760 mm Hg and 15oC, and density of air of 1.225 kg/m3, what is the volumetric exhaust rate (m3/s) required to keep smoke at a height of 3 m?

A) 1.21

B) 3.23

C) 5.12

D) 7.54

Solution FPE-T1-6

The total heat release rate

is Q =2500*π *0.52/4=490.87 kW

Convective heat is Qc=0.8*Q= 392.7 kW

Using the relations given in the reference, we have:

Zi = 0.166Qc2/5=1.81 m

Z=3 m is larger than Zi therefore:

mp = 0.071 Qc1/3 z5/3 + 0.0018Qc

mp=3.95 kg/s

The volume is given by

V=mp/ρ=3.95/1.225= 3.23 m3/s

Answer FPE-T1-6: (B)

Question # 3

Indicator FPE-T5-8:

Determine the design elements of means of egress (number of exits, capacity, arrangement of egress means facilities, door hardware, locations, lighting and signage, fire-resistance rated construction for egress elements), and ergonomic aspects of firefighting equipment design.

Example FPE-T5-8:

The occupant load factor for a mall is designed to be 2.8 square meters per person. What is approximatively the minimum gross leasable area (m2) of the covered mall building (excluding anchor buildings)?

A) 6821

B) 9285

C) 10345

D) 12003

Solution FPE-T5-8

Using the relation given in the reference, we have:

GLA=(OLF-2.3225)/0.00007=6821 m2

Answer FPE-T5-8: (A)

Question # 4

Indicator FPE-T7-6: Identify the operational components, design criteria, applications and limitations of automatic water sprinkler systems and water spray systems.

Example FPE-T7-6

After a fire broke out in a hotel kitchen, forensic investigators were sent to try to determine the timing of events. The kitchen is equipped with a sprinkler (RTI of 33 m1/2 s1/2, ordinary temperature, 75oC). The initial temperature of the kitchen ceiling (3.3 m) was around 20oC which was exposed to a plume of approximately 80oC traveling at a speed around 1.3 m/s. What should have been the response time (s) of the sprinkler?

A) 43

B) 58

C) 67

D) 72

Solution FPE-T7-6

RTI=tru01/2 /ln ((Tg-Ta)/(Tg-Tr))

tr=RTI* ln ((Tg-Ta)/(Tg-Tr))/ u01/2

tr=33*ln ((80-20)/ (80-75))/1.3(1/2) =71.9 s

Answer FPE-T7-6: (D)

Question # 5

Indicator FPE-T1-2: Understand the thermodynamics and kinetics of combustion reaction, the adiabatic flame temperature and properties of diffusion flames.

Example FPE-T1-2:

An open tank containing 130 kg of butter (gross heat of combustion is 38.5 MJ/kg) was accidently set on fire of power 1.4 MW as result of tank rupture. About how long will it take before two thirds of the tank content are burned?

A) 10 s

B) 30 s

C) 40 min

D) 2 hr

Solution FPE-T1-2

Time of burning: $t = M\,\Delta H/Q_{max}$

M=130*2/3 kg

ΔH= heat of combustion=38.5 MJ/kg

t= (130*2/3) *38.5/ (1.4) = 2383 s= 39.7 min

Answer FPE-T1-2: (C)

Question # 6

Indicator FPE-T8-3:

Identify the operational properties, design criteria, applications and limitations and hazards of gaseous extinguishing systems (carbon dioxide, inert gas, halon systems, halocarbon systems).

Example FPE-T8-3

HFC-125 agent is to be used to protect in full flood application a space (10 m long by 5 m wide by 2 m tall with a fixed structure of 10 m3) at 25oC containing sensitive electronic materials. Assuming a design concentration of 7.0%, what is the minimum required quantity (kg) of the agent?

A) 36.1

B) 24.2

C) 15.1

D) 7.2

Solution FPE-T8-3:

Using the relations given in the appendix, we have:

W=(V/S) (C/(100-C))

S=k1+k2xT

For HFC-125, and from Table

k1=0.1701 and k2= 0.0007

S=0.1701 + 0.0007x25=0.1876

V=10*5*2-10=90 m3

W=36.1 kg

Answer FPE-T8-3: (A)

Question # 7

Indicator FPE-T9-12: Understand explosion in pipes.

Example FPE-T9-12

A fuel pipe containing a stoichiometric methane-air mixture (detonation cell width of 28 cm) is used to feed a burner to provide heat to a chemical reactor. What is the critical diameter (cm) of the fuel pipe to prevent a detonation in the fuel line if the ignition has been accidently delayed after filling the fuel-air mixture?

A) 12.5

B) 9.3

C) 7.1

D) 3.2

Solution FPE-T9-12

Using the relations given in the appendix, we have:

Critical diameter=Sc/3=28/3=9.3 cm

Answer FPE-T9-12: (B)

Question # 8

Indicator FPE-T7-6:

Identify the operational components, design criteria, applications and limitations of automatic water sprinkler systems and water spray systems.

Example FPE-T7-6:

An automatic sprinkler system is to be designed for an ordinary hazard group 1 in a certain room, where the application density is assumed to be 6.11 Lpm/m2. The system is composed of 6 nozzles with 3 m spacing. The total floor area is 55 m2. The sprinkler has temperature rating of 68oC and a K value of 8.073 Lpm/kPa0.5. The required pressure (kPa) at the sprinkler head is:

A) 23

B) 37

C) 48

D) 56

Solution FPE-T7-6

Using the relation given in the appendix, we have:

Flow rate for each of the six nozzles= Area*application density/6=55*6.11/6=56 Lpm

P=(Q/K)^2= (56/8.073)^2=48 kPa

Answer FPE-T7-6: (C)

Question # 9

Indicator FPE-T9-3:

Identify types of explosive substances, safety parameters, and methods of measurement of performance of explosive substances.

Example FPE-T9-3

Class II organic peroxide describes formulations that:

A) are capable of deflagration but not detonation.

B) burn in the same way as ordinary combustibles and pose a minimal reactivity hazard.

C) burn rapidly and pose a moderate reactivity hazard.

D) burn very rapidly and pose a moderate reactivity hazard.

Answer FPE-T9-3: (D)

Question # 10

Indicator FPE-T6-5:

Identify the passive fire protection systems used in process industries.

Example FPE-T6-5

According to Saudi Fire Code (SBC 801), the width of sumps or other basins for the retention of oil or petroleum products should not exceed --- (m).

A) 0.5

B) 1.7

C) 2.5

D) 3.6

Solution FPE-T6-5

From Saudi Fire Code (SBC 801), page 578

5706.3.3 Sumps. Sumps associated with wells shall comply with Sections 5706.3.3.1 through 5706.3.3.3.

5706.3.3.1 Maximum width. Sumps or other basins for the retention of oil or petroleum products shall not exceed 3.6 m in width.

Answer FPE-T6-5: (D)

Essay Question

Indicator FPE-T7-3 Identify local requirements pertinent to water supply for active water based fire suppression systems.

Consider the piping system shown in the following figure which is used to distribute water. Table 1 shows the pipe data. Determine the length of a single equivalent pipe that has a 242.8 mm diameter. Assume a C-factor of 100 for all pipes and a flow of 4542 LPM in pipe #2.

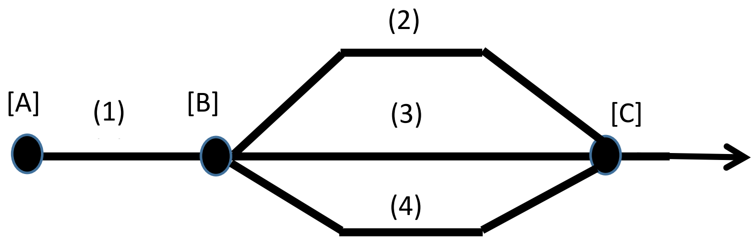


Table: Pipes characteristics

	Pipe (1)	Pipe (2)	Pipe (3)	Pipe (4)
Length (m)	274	335	243	304
Inside diameter (mm)	363.5	228.9	193.7	228.9

Answer to Essay Question

Convert all D to (m) and Q to (m3/s)

H=10.67Q1.85L/ (C1.85 D4.87)

Step 1: Evaluate head loss in pipe (2):

H=10.67Q1.85L/ (C1.85 D4.87) =7.91 m

Step 2: Evaluate flow for pipe (3) and (4)

For pipe (3), Solving for Q yields

Q=(H*C1.85*D4.87/(10.67L)) (1/1.85) = 0.058 m3/s

For pipe (4)

Q=(H*C1.85*D4.87/(10.67L)) (1/1.85) =0.080 m3/s

Evaluate the total flow from node B to C

Q = 0.0757 + 0.058 + 0.080 = 0.214 m3/s

Calculate head loss in pipe (1)

H=10.67Q1.85L/ (C1.85 D4.87) = 4.63 m

Evaluate the overall head loss

hL = 7.91+4.63 = 12.54 m

Determine a 242.8 mm equivalent pipe length

L=hLC1.85D4.87/(10.67Q1.85) =104 m

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