IFE Level 4 Certificate in Fire Science and Fire Safety (HL)

Unit 1: Fire Engineering Science

Unit Reference Number: Y/505/5931

Introduction

This unit focuses on fire engineering science and fire behaviour. The content of the unit has been designed to reflect the critical technical knowledge that fire professionals need in order to understand the behaviour of fire and the behaviour of materials and substances. This knowledge and skill will contribute to increased safety on the incident ground.

Learning Outcomes

Candidates who achieve this unit should be able to:

- Understand and apply the scientific principles that underpin fire behaviour and the management of fires
- Apply understanding of combustion, fire dynamics and the effects of heat
- Apply scientific understanding of special hazards and hazardous materials

Unit Status

This is a Mandatory Unit for candidates who wish to achieve the Level 4 Certificate in Fire Science and Fire Safety.

Content

1. Hydraulics

Assessment Objective	Knowledge, Understanding and Skills
1.1 Explain the principles of, and carry out energy calculations	• Total Energy (Bernoulli) Equation • Continuity Equation
1.2 Describe, and carry out calculations in relation to, flow of water in pipes and open channels	• Turbulent flow • Laminar flow • The Venturi effect • Operating principles of siphons • Operating principles of weirs
1.3 Explain how Venturi meters, Pitot tubes and weirs are used to evaluate flow rates, pressure and pressure drops	• Carry out calculations for flow rate using the Venturi meter • Calculate the flow of water through open channels, rectangular weirs and vee notch weirs

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1.4 Calculate forces exerted by a jet hitting a flat or inclined surface	• Jet hitting a flat surface • Jet hitting inclined surface • Formula for calculating jet reaction

2. Combustion

Assessment Objective	Knowledge, Understanding and Skills
2.1 Describe a flame or combustion in terms of chemical reactions and analyse the factors which influence the speed of the reaction	Definition of: • Limits of flammability • Diffusion flames • Premixed flames • Cold flames • Self ignition temperature • Flashover • Flashback • Backdraught
2.2 Describe and explain the combustion reaction process	• Chain mechanism • Effects of temperature and pressure on rate of reaction • Ignition processes • Combustion of solids, liquids, gases, transient dust and vapour phases • Diffusion flames • Pre-mixed flames • Dust and spray explosions
2.3 Describe how the combustion process can be terminated	• Principles involved in the extinction of fire by: o Smothering o Cooling o Oxygen starvation
2.4 Explain combustion processes	Define terms: • Spontaneous heating • Spontaneous ignition • Spontaneous combustion
2.5 Explain the process and effects of oxidation	• Define the term oxidation • Identify examples of high temperature oxidation processes • Hazards of flammable materials that contain their own means of oxidation
2.6 Explain the range and behaviours of explosives	• Differentiate between high and low explosives • Classifications of explosives: o Detonators o Propellants o Initiators o Deflagrators

3. Fire Dynamics

Assessment Objective	Knowledge, Understanding and Skills
3.1 Understand the incubation and ignition stages of a fire	• Materials • Thermal inertia • Radiative heat transfer to fuel surfaces
3.2 Understand the early growth stage of a fire	• Surface spread of flame (wind aided/wind opposed) • Floors/walls/stairs/trench effect • Fuel array geometry • Radiative spread
3.3 Understand the impact of heat in a fire	• Release rate/ square metre of material/item/whole fire • Fire calorimetry
3.4 Understand flame and smoke plumes	• Flame height versus heat release • Plume height • Cold air entrainment • Basic smoke movement • Ceiling layer formation • Layer temperature versus radiant
3.5 Understand ventilation	• Bi-directional flow through an opening • Ventilation control of fires in compartments • Layer formation • Smoke outflow through an opening
3.6 Understand flashover	• The effects of fire position (centre of room/near wall/in corner) ceiling height • Thermal properties of wall and ceiling materials • Heat release rates for flashover, time to flashover
3.7 Understand fire growth rates	• Time squared fires (slow/medium/fast/ultra fast) • Factors affecting the growth of fire
3.8 Understand the steady state phase	• Duration of burning and fire load (Laws' Law)
3.9 Understand the decay phase	• Effect of fuel or air depletion • Automatic/manual extinction
3.10 Understand how to prepare a quantitative fire growth curve	• Fire growth • Steady state • Decay

4. Effects of Heat

Assessment Objective	Knowledge, Understanding and Skills
4.1 Explain the production of heat by the following processes	• Friction • Combustion of gases • Passages of electric current • Chemical reactions
4.2 Explain the effects of fire and heat on structural materials	Structure materials to include: • Timber • Brick

	• Stone • Reinforced concrete • Cast iron • Steel • Aluminium • Glass
4.3 Understand the principles of laboratory tests which may be used to assess materials and elements of structure	• Flammability • Fire resisting properties
4.4 Understand the factors which influence the severity of a fire within a room or building	• Fire Load • Fire Load Density • Calculations using calorific values
4.5 Apply the Gas Laws to calculations involving changing conditions of heat	Define and use Gas Laws: • Boyle's Law • Charles's Law • Law of Pressures (also known as Gay-Lusacc's Law) • Combined Gas Law

5. Principles of Heat and Combustion Sensitive Detection Devices

Assessment Objective	Knowledge, Understanding and Skills

5.1 Explain the operating principles of heat and combustion sensitive detection devices	• Types of device
	  ○ Ionisation detectors
	  ○ Optical detectors
	  ○ Heat detectors
	  ○ Combustion detectors
	  ○ Radiation detectors
	  ○ Flame detectors
	• Use and effectiveness of detectors according to the risk to be covered and their reliability
	• Operating principles of thermocouples and thermistors

6. Electricity

Assessment Objective	Knowledge, Understanding and Skills
6.1 Explain in detail the principles of electrical energy	• Generation • Transmission • Distribution • Utilisation • Generation, storage and discharge of static electricity
6.2 Explain the principle of protective measures utilised to safeguard individuals and equipment in conjunction with electrical energy	• Earthing • Bonding • Earth fault loop • Earth fault loop impedance • Protective arrangements for the use of electricity

	in atmospheres that are flammable or contain explosive dusts • Precautions necessary to minimise the generation, accumulation and discharge of static electricity particularly in flammable atmospheres
6.3 Carry out calculations involving electrical energy	• Power • Current • Voltage • Resistance • Complex series and parallel circuits in combination

7. Special Hazards

Assessment Objective	Knowledge, Understanding and Skills
7.1 Explain the methods of storage of hazardous substances and assess safety implications	• Internal and external storage • Hazardous materials which are: o Flammable o Toxic o Corrosive o Radioactive o Combination of hazards
7.2 Understand the effects of hazardous substances	• Physiological effects of hazardous substances • Effects of toxicity • Means by which toxic material can enter the body
7.3 Describe the nature, properties, industrial processes, the precautions to be taken in handling and storage, the signs and symptoms of poisoning, the flammability of the substances used in the process, the correct medical treatment to be applied, their reaction to firefighting media and to other substances and hazards of substances	• Fats and waxes • Paints and varnishes • Coal and coke • Petroleum spirit and fuel oils • Liquefied petroleum gases • Cellulose materials • Plastics • Metals • Animal and vegetable oils • Radioactive materials • Cryogenic substances • Explosives • Organic Solvents
7.4 Explain the hazards associated with energy materials	• Coal gas and natural gas installations • Petroleum and oil installations • Chemical plants • Liquefied petroleum gas installations • Pipelines convey flammable gas or liquids