IFE Level 4 Certificate in Fire Engineering Science

Qualification Specification

Qualification Number: 603/6612/6

About the Institution of Fire Engineers (IFE)

The IFE is the professional institution for those working in the fire sector. The IFE is a registered charity working for societal benefit. Founded in 1918, the IFE's mission is to promote, encourage and improve the science, practice and professionalism of fire engineering with the overall aim of protecting and saving lives.

Members of the IFE share a commitment to ensuring that the fire profession remains relevant and valued, protecting people, property and the environment from fire.

About the IFE Awarding Organisation

The IFE's awarding organisation is non-profitmaking.

The aim of the of the awarding organisation is to encourage those who work in the sector to engage with, and develop, the critical understanding needed to operate effectively and safely and to the best professional standards so that they can protect and save lives. In doing this, the awarding organisation contributes to three of the IFE's (six) over-arching strategic priorities ie:

- Facilitate awareness of fire issues and developments through the communication of ideas, knowledge and information.
- Foster professionalism by establishing and maintaining pathways and recognised standards of fire professionalism and competency.
- Increase knowledge in the science, practice and professionalism of fire engineering.

All of the IFE's qualifications are designed for those working in the fire sector and to meet the above priorities. The qualifications and the associated assessments (examinations and practical activities/assignments) provided by the IFE are designed, assessed and quality assured by experts with extensive experience of working within the fire sector.

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IFE Level 4 Certificate in Fire Engineering Science

Introduction

This qualification focuses on the understanding of fire engineering science and fire behaviour and the application of this understanding in a range of contexts. The content of the qualification 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 understanding will assist individuals in the sector in contributing to increased safety for members of the public as well as for those on fire incident grounds.

This qualification is derived from unit 1: Fire Engineering Science within the Level 4 Diploma in Fire Science and Fire Safety. It is directly equivalent to that unit in that the content and assessment remain exactly the same. Individuals who achieve this qualification may use it towards the achievement of the Level 4 Diploma in Fire Science and Fire Safety in the same way as unit 1 is/has been used. For information, please see - https://www.ife.org.uk/IFE-Qualifications-with-Syllabus-Links

Target Audience

This qualification will be appropriate for individuals working in all fire-related roles including:

- Fire Engineers and those who support fire engineers
- Individuals working in the construction industry who are involved in designing and implementing fire safety solutions
- Fire operations specialists and fire safety specialists working in fire and rescue services
- Fire Risk Assessors, Fire Inspectors and Fire Auditors

Learning Outcomes

Candidates who achieve this qualification 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 to explain issues and solve problems
- apply understanding of electricity to explain issues and solve problems
- apply scientific understanding of special hazards and hazardous materials to explain issues and solve problems
- understand and apply calculations and formulae

Membership of the IFE

Achievement of the Level 4 Certificate will enable successful candidates to meet the academic requirement for membership of the Institution at Technician Grade (TIFireE); achievement of this qualification along with one other IFE Level 4 Certificate, will enable the candidate to meet the academic requirement for membership of the Institution at Member Grade (MIFireE) and Associate Grade (AIFireE).

Please see Membership and Registration (ife.org.uk) for information on membership.

Qualification Content

The content of the qualification is set out in the section entitled 'Content' below. This provides information on the range of topics that must be studied including the way that candidates need to show their understanding (Assessment Criteria) and the scope/range/contexts in which they can be tested (Knowledge, Understanding and Skills).

The syllabus content is very broad and deep and therefore not all topics can be tested in all examinations. Candidates are advised to prepare for the examination by covering all topics so that they are able to provide comprehensive responses.

Fire Engineering Science Formulae

A list of relevant fire engineering science formulae is provided at the end of the syllabus content. The formulae have been taken from the *Fire Engineering Science Formulae* Booklet which is available on the *Preparing for Examinations* page of the IFE's website.

A copy of the formulae sheet will be provided for candidates taking the Level 4 Certificate in Fire Engineering Science examination along with the examination paper so candidates will have access to the list during the examination. Please note that candidates will not be able to take their own copy of the formulae sheet into the examination but will be able to use the sheet provided by the IFE.

Assessment

Assessment takes the form of one three-hour examination. The examination is closed book and provides a summative assessment of the full range of learning specified in the content below.

Examinations are provided in English only.

Candidates will be required to complete **six** questions from a choice of **eight** questions. There will be 20 marks available for each of the questions.

In order to achieve a pass, candidates will be required to attain at least 40% of the 120 marks available to them via the six questions (ie 48 marks).

Candidates who answer fewer than six questions will be able to achieve a pass as long as they achieve the minimum pass mark of 48. Where candidates answer more than six questions, candidates will not benefit as only the six best responses will be included in the final total mark.

Past papers for the last three years are available on the IFE website - https://www.ife.org.uk/Qualifications/Past-Papers-and-Exam-Reports

Certification

Results of examinations will be reported as follows:

Pass - this is awarded where candidates achieve a mark between the minimum pass mark of 48 marks (40% of the marks available) and 71 marks (59%).

Distinction - this is awarded where candidates achieve a mark of 72 or above (60% or more of the marks available).

Fail - candidates who achieve 47 marks or fewer will receive a result showing Fail. Where candidates receive 24 marks (20% of the marks available) or fewer, the result will show as Fail (X).

Candidates who are unsuccessful in the examination may re-sit the examination. There is no limit on the number of times that candidates may re-sit.

Note: The IFE reports achieved results as described in the bands above. However, candidates who wish to know the specific mark awarded to them may email the IFE to request this information.

Entry Requirements

There are no formal entry requirements.

However, as this qualification is set at Level 4, candidates are required to have a good understanding of the topics in the syllabus and will benefit from having completed a relevant qualification at level 3 such as the IFE Level 3 Certificate in Fire Engineering Science.

Additionally, as mathematical skills are required to complete calculations, candidates are advised that a good standard of maths will be essential.

As the paper is provided in English only, candidates will need to be able to read English fluently in order to access the examination questions and the relevant recommended reading material.

Qualification Level

This qualification has been designed to enable candidates to demonstrate that they have attained skills and knowledge at Level 4. Other types of qualifications that are set at Level 4 include Certificate of Higher Education (CertHE), Higher National Certificate (HNC) and Level 4 NVQs.

The qualifications regulator, Ofqual, has provided the following descriptors to illustrate the knowledge and understanding expected from those who hold qualifications at Level 4.

Level 4 Knowledge Descriptor

The candidate:

- Has practical, theoretical, or technical knowledge and understanding of a subject or field of work to address problems that are well defined but complex and non-routine.
- Can analyse, interpret, and evaluate relevant information and ideas.
- Is aware of the nature of approximate scope of the area of study or work.
- Has an informed awareness of different perspectives or approaches within the area of study or work.

Candidates are advised to bear these descriptors in mind when preparing for assessment and when presenting examination responses.

Qualification Learning Time

The length of time needed to prepare for this examination will vary depending upon the starting point for each candidate.

Total qualification time is 150 hours:

- 147 hours of learning study. Study may be self-study (please see the section on recommended reading material below) and may include relevant employer training programmes or other work-related training.
- 3 hours of assessment (directed time) i.e., one three-hour examination.

Most candidates prepare for IFE examinations via self-study or by drawing on training provided by their employer that covers aspects of the syllabus. Candidates are advised to cross-map their study/training against the content of the syllabus to ensure that all parts of the syllabus have been covered. Recommended reading materials are listed below.

Progression

Candidates who are successful in achieving this qualification may consider progression to specialist degree programmes such as BEng or BSc in Fire Engineering Science.

Candidates who wish to broaden their knowledge and understanding at Level 4 could consider working towards other fire-specific qualifications such as the IFE Level 4 Certificate in Fire Safety or the IFE Level 4 Certificate in Fire Investigation.

Reasonable Adjustments

The IFE permits reasonable adjustments to be made where candidates have disabilities (including medical conditions and learning disabilities such as Dyslexia). The IFE's policy on reasonable adjustments aims to enable candidates with disabilities and other difficulties to access the IFE qualifications without compromising the assessment process or the validity of the certificate.

The policy, which includes the types of arrangements that may be made (eg additional time, use of technology) and the procedure for applying for reasonable adjustments, is published on the IFE's website – https://www.ife.org.uk/Qualification-FAQs. The IFE will consider all requests for reasonable adjustments. All requests for reasonable adjustments must be submitted to the IFE as all decisions on reasonable adjustments rest with the IFE.

Booking Examinations and Additional Information on Examination Arrangements

Examinations are available in March each year.

Individuals who wish to sit examinations may book examinations through their employer, IFE branch or examination centre or they may book directly through the IFE using the booking form on the IFE's website. Where appropriate, the IFE will direct individuals to approach their employer or branch contact.

Information on the examination timetable and other relevant dates (such as the last date for booking examinations) for March examinations, together with the booking form, the list of venues available to candidates, the terms and conditions for candidates and additional information on examination arrangements is provided on the IFE website on 1 September each year. A separate page for each March examination session is provided on the IFE website.

Detailed guidance for candidates on examination arrangements is provided in the *Information and Rules for Candidates taking IFE Examinations* booklet. This booklet is updated prior to each examination session and sets out the rules to be followed by candidates and also the dates for publication of results and the timetable for candidates to query examination results.

Complaints and Appeals

Procedures for making a complaint or lodging an appeal are available on the IFE website - https://www.ife.org.uk/Qualification-FAQs

Information for Examination Centres

Organisations that would like to provide a venue for IFE examinations, should contact the IFE to discuss the requirements for IFE approved examination centres – please email exams@ife.org.uk in the first instance.

Examination centres will need to comply with the terms and conditions set by IFE. Information for examination centres, including the *Examination Centre Handbook* which contains detailed guidance on running an examination centre, is available on the IFE website. Please see - https://www.ife.org.uk/Information-for-Examination-Centres.

Examination centres are required to provide an Examination Centre Invigilation Report following the completion of examinations.

The IFE operates an examination centre inspection programme based on unannounced visits. All Examination centres should anticipate visits from IFE appointed Examination Centre inspectors.

Recommended Reading

This qualification covers an extensive range of specialist topics and candidates are advised to prepare for questions on all topics. Candidates should use the content listed below as the starting point for their study.

Candidates are also advised to review past examination papers. Past papers, together with the associated examiner reports on the papers, can be downloaded, free of charge, from the IFE website - https://www.ife.org.uk/Qualifications/Past-Papers-and-Exam-Reports.
The IFE has applied the following criteria in determining which resources should be included on this recommended reading list:

- the resource provides information which will be of benefit to the candidate in their professional life, providing depth and breadth of understanding;
- the resource contains some information that will be relevant to part of the syllabus;
- the resource is recognised by industry professionals as providing valuable information.

Candidates preparing for the examinations are advised to refer to the list below:

- The Foundation for Hazardous Materials (section 1) https://www.ukfrs.com/guidance/knowledge-base-
- Formula Booklet – by Richard Fowler - http://www.ife.org.uk/Preparing-for-Examinations
- The Chemistry of Combustion, J. Newton Friend, published by Bibliolife
- Fire Service Manual Volume 1: Fire Service Technology, Equipment & Media - Physics and Chemistry for Firefighters, TSO*

- Fire Service Manuals Volume 1: Fire Service Technology, Equipment and Media - Hydraulics, Pumps and Water Supplies, TSO*
- Introduction to Fire Dynamics by Drysdale, published by Wiley and Sons
- Sax's Handbook of Dangerous Substances. (Regularly updated: recommend the use of reference copies rather than purchase)
- Croner's Dangerous Substances. (Regularly updated: recommend the use of reference copies rather than purchase)
- Fundamentals of Physics by Halliday et al, published by Wiley and Sons
- Power Correction Factors – Article in Wiring Matters http://electrical.theiet.org/wiring-matters/2006.cfm, Wiring Matters Issue 18 Spring 2006, Institution of Engineering and Technology

Further Information

Further information on examination conditions is also available in the IFE booklet, *Information and Rules Candidates Taking IFE Examinations.* This booklet can be downloaded from the IFE's website.

Candidates may also find our general guide for candidates, *Preparing to Pass IFE Examinations - Guidance for Candidates* document which provides information on question types and levels helpful - https://www.ife.org.uk/write/MediaUploads/Exams/217_Candidate_Guide.pdf

Please address any queries to the IFE by emailing: exams@ife.org.uk

Content

1. Mathematics

Assessment Criteria	Knowledge, Understanding and Skills
1.1 Understand the underpinning mathematics required for fire engineering science *Note: Examination papers will not contain questions on pure mathematics, but this section indicates the mathematical techniques that candidates will require when dealing with the science.*	• Understand the order of operations of mathematical terms (e.g., BODMAS) • Transposition of formulae • Circles, Triangles and Angles • Sine, Cosine and Tangent • Graphs and data tables, interpolating, extrapolating data • Range, Mode, Median and Mean • Scalar and vector quantities and calculation methods • Recognise and use SI units for calculation and expressing values • Recognise and use scientific notation (standard form) with numbers

2. Hydraulics

Assessment Criteria	Knowledge, Understanding and Skills
2.1 Explain the principles of, and carry out, energy calculations	• Total Energy (Bernoulli) Equation • Continuity Equation
2.2 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
2.3 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
2.4 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

3. Combustion

Assessment Criteria	Knowledge, Understanding and Skills
3.1 Describe and explain a flame or combustion in terms of chemical reactions and analyse the factors which influence the speed of the reaction	• Understand and apply the definitions of: ♦ Limits of flammability ♦ Diffusion flames ♦ Premixed flames ♦ Cold flames ♦ Self-ignition temperature
3.2 Describe and explain combustion and the combustion reaction process	• Define terms: ♦ Spontaneous heating ♦ Spontaneous ignition ♦ Spontaneous combustion ♦ Chain mechanism ♦ Effects of temperature and pressure on rate of reaction ♦ Ignition processes ♦ Combustion of solids, liquids, gases, transient dust, and vapour phases ♦ Dust and spray explosions
3.3 Describe how the combustion process can be terminated	• Explain the principles involved in the extinction of fire by: ♦ Smothering ♦ Cooling ♦ Oxygen starvation
3.4 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
3.5 Explain the range and behaviours of explosives	• Differentiate between high and low explosives • Classifications of explosives: ♦ Detonators ♦ Propellants ♦ Initiators ♦ Deflagrators

4. Fire Dynamics

Assessment Criteria	Knowledge, Understanding and Skills
4.1 Understand the incubation and ignition stages of a fire	• Materials • Thermal inertia • Radiative heat transfer to fuel surfaces
4.2 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 • The effects of fire position (centre of room/near wall/in corner), ceiling height
4.3 Understand the impact of heat in a fire	• Release rate/square metre of material/item/whole fire • Fire calorimetry
4.4 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
4.5 Understand ventilation	• Bi-directional flow through an opening • Ventilation control of fires in compartments • Layer formation • Smoke outflow through an opening
4.6 Understand fire development in compartment fires	• Thermal properties of wall and ceiling materials • Flashover: ♦ Definition ♦ Heat release rates and conditions for flashover ♦ Time to flashover ♦ Growth prior to flashover ♦ Fully developed fire post-flashover • Backdraught (or smoke explosion): ♦ Definition ♦ Conditions for backdraught • Sketch a fire growth curve for a compartment fire showing incipient, developing, flashover, fully developed fire, and decay phases
4.7 Understand fire growth rates	• Time squared fires (slow/medium/fast/ultra-fast) • Factors affecting the growth of fire
4.8 Understand the steady state phase	• Duration of burning and fireload (Laws' Law)
4.9 Understand the decay phase	• Effect of fuel or air depletion • Automatic/manual extinction

5. Effects of Heat

Assessment Criteria	Knowledge, Understanding and Skills
5.1 Explain the production of heat by the following processes	• Friction • Combustion of gases • Passages of electric current • Chemical reactions
5.2 Explain the effects of fire and heat on structural materials	• Structure materials to include: ♦ Timber ♦ Brick ♦ Stone ♦ Reinforced concrete ♦ Cast iron ♦ Steel ♦ Aluminium ♦ Glass
5.3 Understand the principles of laboratory tests which may be used to assess materials and elements of structure	• Flammability • Fire resisting properties
5.4 Understand the factors which influence the severity of a fire within a room or building	• Fire Load • Fire Load Density • Calculations using calorific values
5.5 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

6. Electricity

Assessment Criteria	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 Explain and use Ohm's Law	• Principles of Ohm's Law • Use Ohm's Law to solve problems • Calculate the relationship between resistance, current and voltage in simple parallel and series circuits
6.4 Explain and use Kirchhoff's Law	• Principles of Kirchhoff's Current Law – the conservation of electric charge using node theory • Principles of Kirchhoff's voltage law – the sum of the voltages in a closed loop network equal zero
6.5 Carry out calculations involving electrical energy	• Power • Current • Voltage • Inductance • Capacitance • Impedance ♦ Resistance ♦ Inductive reactance ♦ Capacitive reactance ♦ Admittance ♦ Susceptance ♦ Conductance • Simple RLC series and parallel circuits involving resistors, capacitors, inductors, and AC/DC power supplies in combination • Power factor correction

7. Special Hazards

Assessment Criteria	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: ♦ Flammable ♦ Toxic ♦ Corrosive ♦ Radioactive ♦ 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

Level 4 Fire Engineering Science Formula Sheet

$v = u + at$	$s = \frac{(u+v)}{2}t$	$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$	$s = vt - \frac{1}{2}at^2$	$F = m \times a$
$P = \mu R$	$P - F_r = 0$	$R - F = 0$
$P = \frac{F \times d}{t}$	$W = Pt$	$W = Fd$
$KE = \frac{1}{2}mv^2$	$PE = mgH$	$P = \rho gH$
$v = \sqrt{2gH}$	$V_{rms} = I_{rms}Z$	$P_{Avg} = I_{rms}V_{rms}\cos\theta$
$P = I^2R$	$Q = I^2X$	$S = I^2Z$
$R_T = R_1 + R_2 \ldots R_n$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \ldots \frac{1}{R_n}$	$c = \frac{\Delta Q}{m \times \Delta t}$
$L_T = L_1 + L_2 \cdots L_n$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} \cdots \frac{1}{L_n}$	$X_L = 2\pi fL$
$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} \cdots \frac{1}{C_n}$	$C_T = C_1 + C_2 \cdots C_n$	$X_C = \frac{1}{2\pi fC}$
$V_s = \sqrt{V_R^2 + (V_L - V_C)^2}$	$I_s = \sqrt{I_R^2 + (I_L - I_C)^2}$	$Y = \frac{1}{Z}$ | $G = \frac{1}{R}$ | $B = \frac{1}{X}$
$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$Y = \sqrt{G^2 + (B_L - B_C)^2}$	$\frac{1}{Z} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$
$PF = \cos\theta$	$PF = \frac{R}{Z}$	$\theta = \cos^{-1}\left(\frac{R}{Z}\right)$
$L_{Exp} = l \times \propto \times \Delta T$	$A_{Exp} = A \times 2 \propto \times \Delta T$	$V_{Exp} = V \times 3 \propto \times \Delta T$

$P_1 \times V_1 = P_2 \times V_2$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	$PV = nRT$	$Q_1 = Q_2$
$P_1 + \rho g H_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g H_2 + \frac{1}{2}\rho v_2^2$		$A_1V_1 = A_2V_2$
$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$		$Q_1 = A_1V_1$
$m = \frac{A}{P}$	$H_f = \frac{2flv^2}{Dg}$	$P_f = \frac{20flv^2}{d}$
$F = \rho v^2 A$	$F = \rho v^2 A \cos\theta$	$Q = vA$
$v = C\sqrt{mi}$	$Q = \frac{2}{3}CL\sqrt{2g}\,H^{1.5}$	$Q = \frac{8}{15}Ctan\left(\frac{\theta}{2}\right)\sqrt{2g}H^{2.5}$
$\text{Sin}\,\theta = \frac{opp}{hyp}$	$\text{Cos}\,\theta = \frac{adj}{hyp}$	$\text{Tan}\,\theta = \frac{opp}{adj}$