# IFE Level 3 Certificate in Fire Engineering Science

## Qualification Specification

Qualification Number: 603/6604/7

# 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.

**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 i.e.:

- 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 their 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 3 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. This knowledge and understanding will assist individuals working in the sector in contributing to increased safety for members of the public as well as for those on fire incident grounds.

Individuals who achieve this qualification may use it towards the achievement of the Level 3 Diploma in Fire Science and Fire Safety. For information, please see: https://ife.org.uk/Home/Education/IFE-qualifications.

**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
- individuals working in general health and safety roles (e.g.: building managers or health and safety officers) where individuals wish to extend their specialist understanding of fire science and fire safety

**Learning Outcomes**
Candidates who achieve this qualification should be able to:

- solve problems in fire-related contexts by applying mathematics, mechanics, hydraulics, chemistry and electricity
- use understanding of science to explain hazards and their potential effects
- understand and apply principles of heat and combustion sensitive detection devices
- interpret data and carry out relevant calculations

**Membership of the IFE**
Achievement of this qualification enables candidates to meet the academic requirement for membership at **Technician (TIFireE) Grade**.

Completion of **three Level 3 Certificates** will meet the academic requirement and minimum credit criteria necessary for **Graduate (GIFireE) Grade** membership.

To achieve the full **Level 3 Diploma**, candidates must complete this mandatory qualification **in addition to** the following:

- The mandatory Level 3 Certificate in Fire Safety
- Two additional **IFE Level 3 Certificates**

All four qualifications must be achieved **within a five-year period.**

**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 and Understanding).

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 Formula Booklet which is available on the *Preparing for Examinations* page of the IFE's website.

A copy of the formulae list will be provided for candidates taking the Level 3 Certificate in Fire Engineering Science examination along with the examination 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**
The assessment takes the form of one three-hour examination 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 48 of the 120 marks available to them via the six questions.

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. Should candidates answer more than six questions, they will not benefit as only the six best responses will be included in the final mark.

**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 and 71 marks.
Distinction - this is awarded where candidates achieve a mark of 72 or above.
Fail - candidates who achieve 47 marks or fewer will receive a result showing Fail. Where candidates receive 24 marks 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.

Candidates will be issued with the mark achieved out of a total of 120.

**Entry Requirements**
There are no formal entry requirements.
As the examination is provided in English only, candidates will need to have a comprehensive understanding of the English language in order to access the examination questions.

**Qualification Level**
This qualification has been designed to enable candidates to demonstrate that they have attained knowledge and understanding at Level 3. Other types of qualifications that are set at Level 3 include GCE A/As levels, Level 3 NVQs and Level 3 Diplomas such as the IFE Level 3 Diploma in Fire Science and Fire Safety.

The qualifications regulator for England, Ofqual, has provided the following descriptors to illustrate the knowledge and understanding expected from those who hold qualifications at Level 3.

Level 3 Knowledge Descriptor

The candidate:

- has factual, procedural and theoretical knowledge and understanding of a subject or field of work to complete tasks and address problems that, while well-defined, may be complex and non-routine.
- can interpret and evaluate relevant information and ideas.
- is aware of the nature of the area of study or work.
- is aware 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 composing responses to examination questions.

**Qualification Learning Time**

Total qualification is 140 hours:

- 137 hours of learning /study. Study may be self-study (please see the section on recommended reading 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.

However, the length of time needed to prepare for this examination is not a mandatory timeframe and will vary depending upon the starting point for each candidate.

Most candidates prepare for IFE examinations via self-study or by drawing on training provided by their employer that covers aspects of the content set out below. 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 provided below.

**Progression**
Candidates who are successful in achieving this qualification may consider progression to Level 4. A Level 4 qualification in Fire Engineering Science is available from the IFE.

**Further Information**
Further information on examination conditions is available on the IFE website.

**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 examinations. Past papers, together with the associated examiner reports on the papers, can be downloaded, free of charge, from the IFE website - Past papers and exam reports (ife.org.uk).

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:

- IFE Fire Engineering Science Study Guide
- Hazardous Materials Health Hazards – National Operational Guidance
- IFE Fire Engineering Science Resources
- 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
- Fundamentals of Physics by Halliday et al, published by Wiley and Sons

# Content

### 1. Analysis and Interpretation of Data

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 1. 1 Extract and tabulate data | Expression of data in the form of:<br>♦ Graphs including histograms, bar charts, pie charts<br>♦ Tables |
| 1.2 Obtain values from data | Define, identify and calculate:<br>♦ median<br>♦ mean<br>♦ mode |
| 1.3 Extend graphs | • Project values from given data (extrapolate)<br>• Deduce values from missing data (interpolate) |

### 2. Mechanics

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 2.1 Define and apply the SI system of units in terms of basic and derived units | • Recognise and use SI units for calculation and expressing values |
| 2.2 Explain and carry out calculations involving equations of motion | • Describe and apply Newton's laws of motion<br>• Acceleration<br>• Velocity |
| 2.3 Explain and solve calculations involving vectors | • Use vector quantities to find resultant values<br>• Apply vector methods to force and motion problems |
| 2.4 Define terms and calculate moments around a fulcrum including the use of levers and parallel force | • Definition of "fulcrum"<br>• Definition of "moment"<br>• Calculate the moments around a fulcrum<br>• Determine the effects of levers and pulleys |
| 2.5 Define and carry out calculations involving centres of gravity and centres of buoyancy | • Definition of "centres of gravity"<br>• Definition of "centres of buoyancy" |
| 2.6 Define and carry out calculations involving stress and strain | • Define the terms "stress" and "strain"<br>• Understand and apply Hooke's Law of elasticity |
| 2.7 Define terms and carry out calculations in different contexts | • Work<br>• Power<br>• Efficiency<br>• Force<br>• Momentum<br>• Mass<br>• Weight |
| 2.8 Describe and calculate friction force between two surfaces in contact | • Define the term "friction"<br>• Describe the effects of friction |

## 3. Hydraulics

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 3.1 Define and carry out calculations involving density, specific gravity and pressures in fluids | • Define the terms:<br>♦ density<br>♦ specific gravity<br>♦ pressures in fluids<br>• Explain and apply the definitions of:<br>♦ Velocity<br>♦ acceleration<br>♦ energy<br>• Demonstrate the relationship between the terms |
| 3.2 Explain and apply the principle of atmospheric pressure in pumping systems | • As an aid to flow<br>• As a means of measuring flow<br>• Definition of “Atmospheric pressure” and methods of measuring it |
| 3.3 Explain and apply the laws of friction to calculate energy losses in piped water supplies | • Laws of friction<br>• Operation of piped water supplies |
| 3.4 Explain the operation of pumps and carry out calculations | Define and calculate:<br>♦ Water power<br>♦ Brake power<br>♦ Efficiency |
| 3.5 Explain the relationship between velocity and discharge of water through hose of differing diameters and carry out calculations | • Velocity<br>• Flow<br>• Quantity of water in hose and pipelines of differing diameters<br>• Theoretical and the effective height of a jet |
| 3.6 Explain the purpose and principles of design of siphons, branches and nozzles and carry out calculations | • Purpose of nozzles and siphons<br>• Design and operating principles of nozzles and siphons<br>• Discharge from a nozzle |

## 4. Electricity

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 4.1 Explain the theory of electrical current flowing in AC and DC circuits and carry out calculations | • Define the terms:<br>♦ Electron<br>♦ Current<br>• Describe electric current as a flow of electrons<br>• Describe the characteristics of direct current<br>• Define the following:<br>♦ Volts<br>♦ Amperes<br>♦ Ohms<br>♦ Watts<br>♦ Joules<br>♦ Current<br>♦ Power<br>♦ Voltage |

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|---|---|
| | ♦ Energy<br>♦ Resistance |
| 4.2 Describe the operation and characteristics of a step-up and step-down transformer and carry out calculations | Principles of operation of step-up and step-down transformers |
| 4.3 Explain and use Ohm's Law and carry out calculations | • Principles of Ohm's Law<br>• Parallel and series circuits |
| 4.4 Explain the magnetic and chemical effects of electrical currents | • Show how these phenomena are applied in:<br>♦ Electric motors<br>♦ Primary and secondary electric cells<br>• Fleming's left and right hand rules |
| 4.5 Describe the function and method of operation of circuit protective devices | Types to include:<br>♦ Residual current device (RCD)<br>♦ Residual current circuit breakers (RCCB)<br>♦ Residual Current Breaker with over current (RCBO)<br>♦ Miniature circuit breakers (MCB)<br>♦ Surge protection device<br>♦ Fuses |
| 4.6 Define and solve problems involving resistance variation | • Temperature<br>• Resistivity |

**5. Heat and Energy**

| **Assessment Criteria** | **Knowledge and Understanding** |
|---|---|
| 5.1 Explain and apply the principles of heat transfer and carry out calculations | • Methods of heat transfer<br>• Define:<br>♦ Absolute zero<br>♦ Specific heat capacity<br>♦ Latent heat<br>♦ Thermal capacity of a body<br>• Exothermic and endothermic reactions |
| 5.2 Explain linear, superficial, and volumetric expansion using the relevant coefficients and carry out calculations | • Define:<br>♦ Linear<br>♦ Superficial<br>♦ Volumetric expansion |
| 5.3 Apply the Gas laws to calculations involving changing conditions of heat | • Define and use Gas laws:<br>♦ Boyle's Law<br>♦ Charles's Law<br>♦ Law of Pressures (also known as Gay Lusac's Law)<br>♦ Combined Gas Law<br>♦ Ideal Gas Law |
| 5.4 Explain the principles of the electromagnetic spectrum | • Wavelength and intensity<br>• Effect on materials<br>• Effect on the human body |

## 6. Radioactivity

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 6.1 Describe the principle of radioactivity | • Explain the terms:<br>♦ radioactivity<br>♦ radiation<br>• Define the terms “decay” and “half-life”<br>• Radioisotopes<br>♦ ionising radiation<br>♦ non-ionising radiation |
| 6.2 Explain the units of measurement used for radiation | • Radiation<br>• Absorbed dose<br>• Equivalent or effective dose |
| 6.3 Describe the biological effects of radiation and precautions to be adopted for safety from the effects of radiation | • Explain the construction and properties of alpha and beta particles and gamma radiation and compare their penetrating powers<br>• Effects on cells<br>• Methods of contamination<br>• Principles of protection from ionising radiation |

## 7. Chemistry

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 7.1 Explain the construction of an atom and show how the electron shell configuration has an effect on reactivity | • Definition of “reactivity”<br>• Components of an atom – protons, neutrons, electrons<br>• Electron shell |
| 7.2 Explain of the classifications of the chemical elements and the main hazards associated with each grouping | • Structure of the Periodic Table of Elements<br>• Classification of elements into metals and non-metals<br>• Properties of elements:<br>♦ Reaction to heat<br>♦ Reaction to electricity<br>♦ Physical form in different situations<br>♦ Reaction with oxygen<br>♦ Reactivity<br>• Concept of valency and the relevance of the periodic classification of the elements |
| 7.3 Explain and use chemical equations | • Balance simple chemical equations and define stoichiometric conditions<br>• Calculate relative molecular masses and vapour densities from given relative atomic masses<br>• Balanced chemical reactions and the calculation of the masses and the volumes of reactants in chemical reactions |

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| 7.4 Explain the main properties, reactions and hazards of specified elements, compounds and groups | • Acids (inorganic and organic)<br>• Bases and Alkalis<br>• Ammonia<br>• Calcium Oxide<br>• Ammonium hydroxide<br>• Carbon monoxide<br>• Carbon dioxide<br>• Chlorine<br>• Hydrogen<br>• Oxygen<br>• Sodium<br>• Sulphur<br>• Phosgene |
| 7.5 Explain the properties of hydrocarbons | • Composition of hydrocarbons – hydrogen and carbon<br>• Structure and main properties of the first four members of the alkane family; methane, ethane, propane, and butane<br>• Properties – density, boiling point, and melting point<br>• Structure of simple unsaturated hydrocarbons (alkenes and alkynes)<br>• Structure and properties of aromatic compounds |
| 7.6 Define and explain ignition processes | • Flashpoint<br>• Fire point<br>• Spontaneous ignition |
| 7.7 Apply the principles of chemistry to the extinction of fire | • Smothering<br>• Cooling<br>• Oxygen starvation<br>• Combustion as a type of chemical reaction<br>• The fire tetrahedron and the inhibition of combustion chains involving a free radical mechanism |
| 7.8 Explain the properties of oxidising agents | • Oxygen<br>• Halogens<br>• Inorganic and organic oxidising agents<br>• Peroxide |
| 7.9 Explain the properties and fire hazards of polymers | • Define “monomer” and “polymer”<br>• Explain the polymerisation process<br>• Thermosetting and thermoplastic materials |

## 8. Principles of Heat and Combustion Sensitive Detection Devices

| Assessment Criteria | Knowledge and Understanding |
|---|---|
| 8.1 Explain the operating principles, use and effectiveness of heat and combustion sensitive detection devices | • Ionisation detectors<br>• Optical detectors<br>• Heat detectors<br>• Combustion detectors<br>• Radiation detectors<br>• Flame detectors<br>• Thermocouples<br>• Thermistors |

## Level 3 Certificate in Fire Engineering Science Formula Sheet

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|---|---|---|
| $v = u + at$ | $s = \frac{(u+v)}{2}t$ | $s = ut + \frac{1}{2}at^2$ |
| $v^2 = u^2 + 2as$ | $s = vt - \frac{1}{2}at^2$ | $F = m \times a$ |
| $P = \mu R$ | $P - F_r = 0$ | $R - F = 0$ |
| $\sigma = \frac{F}{A}$ | $\varepsilon = \frac{e}{l}$ | $E = \frac{\sigma}{\varepsilon}$ |
| $\mathrm{F}x = \mathrm{F}\cos\theta$ | $\mathrm{F}y = \mathrm{F}\sin\theta$ | $P = \frac{F \times d}{t}$ |
| $F = ke$ | $X \propto \frac{1}{d^2}$ | $KE = \frac{1}{2}mv^2$ |
| $W = Pt$ | $W = Fd$ | $P = \rho gH$ |
| $PE = mgH$ | $v = \sqrt{2gH}$ | $P = \frac{H}{10}$ |
| $P_f = \frac{9000flL^2}{d^5}$ | $WP = \frac{100LP}{60}$ | $E = \frac{WP}{BP} \times 100$ |
| $L = \frac{2}{3}d^2\sqrt{P}$ | $R = 0.157Pd^2$ | $F = BIL$ |
| $V = IR$ | $P = IV$ | $R = \frac{\rho l}{a}$ |
| $R_T = R_1 + R_2 + R_3$ | $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ | $R_t = R_0(1 + \alpha t)$ |
| $c = \frac{\Delta Q}{m \times \Delta t}$ | $\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$ | $\frac{R_0}{R_t} = \frac{1 + \alpha_0 t_{ref}}{1 + \alpha_0 t_{final}}$ |
| $L_{Exp} = l \times \propto \times \Delta T$ | $A_{Exp} = A \times 2 \propto \times \Delta T$ | $V_{Exp} = V \times 3 \propto \times \Delta T$ |

| | | |
|---|---|---|
| $P_1 \times V_1 = P_2 \times V_2$ | $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ | $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ |
| $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ | $PV = nRT$ | $H_e = \frac{2}{3}\left(H - 0.113\frac{H^2}{d}\right)$ |
| $A = \pi r^2$ or $A = \frac{\pi d^2}{4}$ | $V = Ah$ | $A = \frac{1}{2}(a+b)h$ |
| $V = \frac{\pi d^3}{6}$ or $V = \frac{4\pi r^3}{3}$ | $V = \frac{Ah}{3}$ | $a^2 + b^2 = c^2$ |
| $K = °C + 273$ | $°C = K - 273$ | $C = \frac{2}{3}A \times D \times 1000$ |

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|---|---|
| $adj = hyp \times \cos\theta$ or $\sin\theta = \frac{opp}{hyp}$<br>$opp = hyp \times \sin\theta$ or $\cos\theta = \frac{adj}{hyp}$<br>$opp = adj \times \tan\theta$ or $\tan\theta = \frac{opp}{adj}$ | $A = \frac{1}{2}ab\sin C$ |
| | $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ |
| | $a^2 = b^2 + c^2 - 2bc\cos A$ |