IFE Level 3 Certificate in Fire Engineering Science

Qualification Specification

Qualification Number: 603/6604/7

Date Issued: September 2020

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 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, 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 aims. 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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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 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 3 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 3 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
- Individuals working in general health and safety roles (eg building managers and 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 understanding of 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

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 (ie the Assessment Objectives) 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 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 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.

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 Please see the papers (and associated examiner reports) for March examinations for the L3D1 Fire Engineering Science unit (in the section for the Level 3 Diploma in Fire Science and Fire Safety).

Examinations are provided in English only.

Grading and 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 (ie 40% of the marks available) and 71 marks (59%).

Distinction - this is awarded where candidates achieve a mark of 72 or above (ie 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 (ie 20% of the marks available) or fewer, the result will show 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 results as described in the bands above. However, candidates who wish to know the specific mark awarded to them may email the IFE for this information.

Entry Requirements

There are no formal entry requirements. However, as mathematical skills are required to complete calculations, candidates are advised that a good standard of maths will be essential. Additionally, this qualification covers a wide range of topics and candidates will benefit from previous studies in one or more areas covered by the topics.

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 3. Other types of qualifications that are set at Level 3 include A 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

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

Total qualification time for most candidates will be around 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) ie 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 part 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 specialist qualification in Fire Engineering Science is available from the IFE. In addition, candidates may wish to progress to specialist degree programmes such as BEng or BSC in Fire Engineering Science.

Candidates who wish to broaden their knowledge and understanding at Level 3 could consider working towards other fire-specific qualifications such as the IFE Level 3 Certificate in Fire Safety or the IFE Level 3 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

This examination is available in March each year.

Individuals who wish to sit examinations may book examinations either through their examination centre (eg Fire and Rescue Service, IFE Branch) or they may book through the IFE. Where appropriate, the IFE will direct individuals to 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. Information on March 2021 examinations is available at: https://www.ife.org.uk/March-2021-Examinations

Detailed guidance for candidates on examination arrangements is provided in the Rules and Information for Candidates booklet. This booklet 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 centres – please email exams@ife.org.uk in the first instance.

Centres will need to comply with the Terms and Conditions for centres. Information for centres, including the Examination Centre Handbook which contains detailed guidance on running a centre, is available on the IFE website. Please see - https://www.ife.org.uk/Information-for-Examination-Centres. Centres are required to re-confirm their compliance with the Terms and Conditions prior to each examination session and to provide an Examination Centre Invigilation Report following the completion of examinations.

The IFE operates a centre inspection programme based on unannounced visits. All centres should anticipate visits from 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
- Fire Dynamics for Firefighters by Ben Walker, published by Pavilion

*Note: *PDF copies can be ordered through TSO https://www.tsoshop.co.uk/Safety/Fire-Service/*

Further Information

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

Candidates may also find the general guide for candidates which provides information on question terms and levels helpful - https://www.ife.org.uk/write/MediaUploads/Exams/Candidate_Guide.pdf

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

Content

1. Analysis and Interpretation of Data

Assessment Objective	Knowledge, Understanding and Skills
1.1 Extract and tabulate data	Expression of data in the form of: • Graphs including histograms, bar charts, pie charts • Tables
1.2 Obtain values from data	Identify/Calculate: • Median • Mean • Norm values
1.3 Extend graphs	• Project values from given data (extrapolate) • Deduce values from missing data (interpolate)

2. Mechanics

Assessment Objective	Knowledge, Understanding and Skills
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 Describe and carry out calculations involving equations of motion	• Describe and apply Newton's laws of motion
2.3 Understand and solve calculations involving vectors	• Use vector quantities to find resultant values • Apply vector methods to force and motion problems
2.4 Calculate moments around a fulcrum including the use of levers and parallel force	• Definition of "fulcrum" • Definition of "moment" • Methods of calculation
2.5 Carry out calculations involving centres of gravity and centres of buoyancy	• Definition of "centres of gravity" • Definition of "centres of buoyancy" • Methods of calculation
2.6 Carry out calculations involving stress and strain	• Definition of stress strain • Understand and apply Hooke's Law of elasticity
2.7 Carry out calculations involving work, power and efficiency	• Understand and apply the definitions of: o Work o Power o Efficiency o Force o Momentum o Mass o Weight
2.8 Describe and calculate friction force between two surfaces in contact	• Definition of "friction" • Methods of calculation

3. Hydraulics

Assessment Objective	Knowledge, Understanding and Skills
3.1 Define and solve problems involving density, specific gravity and pressures in fluids	• Define the terms density, specific gravity and pressures in fluids • Understand and apply the definitions of velocity, acceleration and energy • Demonstrate the relationship between the terms • Methods of calculation
3.2 Understand and apply the principle of atmospheric pressure in pumping systems	• As an aid to flow • As a means of measuring flow • Definition of “atmospheric pressure” and methods of measuring it
3.3 Understand and apply the laws of friction to calculate energy losses in piped water supplies	• Laws of friction • Methods of calculation • Operation of piped water supplies
3.4 Understand and explain the operation of pumps and carry out calculations	• Definition of water power • Definition of brake power • Definition of efficiency • Types of calculation required and methods of calculation
3.5 Explain the relationship between velocity and discharge of water through hose of differing diameters	• Methods of calculating velocity, flow and quantity of water in hose and pipelines of differing diameters
3.6 Explain the purpose and principles of design of siphons, branches and nozzles	• Purpose of nozzles and siphons • Design and operating principles of nozzles • Design and operating principles of siphons • Methods of calculating discharge from a nozzle
3.7 Calculate the theoretical and the effective height of a jet	• Methods of calculation • Significance of difference in specific gravities between different liquids

4. Electricity

Assessment Objective	Knowledge, Understanding and Skills
4.1 Understand the theory of electrical current flowing in a circuit and apply this	• Define the terms “electron” and “current” • Describe electric current as a flow of electrons • Describe how electrical energy is generated and distributed • Describe the characteristics of alternating and direct current • Define the following: Volts, Amperes, Ohms, Watts, Joules • Methods of calculating current, power, voltage, energy and resistance

4.2 Describe the operation and characteristics of a step-up and step-down transformer	• Principles of operation of a transformer • Methods of calculation
4.3 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
4.4 Explain the magnetic and chemical effects of electrical currents	• Show how these phenomena are applied in: a) Electric motors b) Primary and secondary electric cells
4.5 Describe the function and method of operation of circuit protective devices	Types to include: • Residual Current Device (RCD) • Miniature circuit breakers (MCB) • Fuses
4.6 Define and solve problems involving resistance variation	• Temperature • Resistivity • Methods of calculation
4.7 Apply the concept of power to electrical circuits	• Power formula • Methods of calculation

5. Heat and Energy

Assessment Objective	**Knowledge, Understanding and Skills**
5.1 Explain and apply the principles of heat transfer	• Methods of heat transfer • Definition of: ○ Absolute zero ○ Specific heat capacity ○ Latent heat ○ Thermal capacity of a body • Methods of calculation
5.2 Calculate linear, superficial and volumetric expansion using the relevant coefficients	• Definition of linear, superficial and volumetric expansion • Understand and use coefficients
5.3 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
5.4 Explain the principles of the electromagnetic spectrum	• Wavelength and intensity • Effect on materials • Effect on the human body

6. Radioactivity

Assessment Objective	Knowledge, Understanding and Skills

6.1 Describe the principle of radioactivity	• Explain the terms:
	  ○ Radioactivity
	  ○ Radiation
	• Define the terms “decay” and “half life”

6.2 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 • Effects on cells • Methods of contamination • Principles of protection from ionising radiation

7. Chemistry

Assessment Objective	Knowledge, Understanding and Skills
7.1 Describe the construction of an atom and show how the electron shell configuration has an effect on reactivity	• Definition of “reactivity” • Components of an atom – protons, neutrons, electrons, shell

7.2 Demonstrate an understanding of the classifications of the chemical elements and the main hazards associated with each grouping	• Structure of the Periodic Table of Elements
	• Classification of elements into Metals and Non-metals
	• Properties of elements:
	  ○ Reaction to heat
	  ○ Reaction to electricity
	  ○ Physical form in different situations
	  ○ Reaction with oxygen
	  ○ Reactivity
	• Explain the concept of valency and the relevance of the periodic classification of the elements

7.3 Understand and use chemical equations	• Balance simple chemical equations and define stoichiometric conditions • Calculate relative molecular masses and vapour densities from given relative atomic masses • Use “balanced” chemical reactions for the calculation of the masses and the volumes of reactants in chemical reactions
7.4 Explain the main properties, reactions and hazards of specified elements, compounds and groups	• Acids (inorganic and organic) • Bases and Alkalis • Ammonia • Calcium Oxide • Ammonium hydroxide • Carbon monoxide • Carbon dioxide • Chlorine

	• Hydrogen • Oxygen • Sodium • Sulphur • Phosgene

7.5 Explain the properties of hydrocarbons	• Composition of hydrocarbons - hydrogen and carbon
	• Structure and main properties of the first four members of the alkane family
	  ○ Methane, ethane, propane and butane
	  ○ Properties – density, boiling point and melting point
	• Structure of simple unsaturated hydrocarbons (alkenes and alkynes)
	• Structure and properties of aromatic compounds
	• Structure and properties of alcohols, aldehydes and ketones

7.6 Define the terms flashpoint, fire point and spontaneous ignition temperatures	• Definition of “flashpoint” • Definition of “fire point” • Definition of “spontaneous ignition temperatures”

7.7 Apply the principles of chemistry to the extinction of fire	• Principles involved in the extinction of fire by:
	  ○ Smothering
	  ○ Cooling
	  ○ Oxygen starvation
	• Understand that a combustion is a type of chemical reaction
	• The principle and components of the fire tetrahedron and the inhibition of combustion chains involving a free radical mechanism
	• Principle of free radicals

7.8 Explain the properties of oxidising agents	• Oxygen • Halogens • Inorganic and organic oxidising agents • Peroxide
7.9 Explain the properties of polymers	• Define “monomer” and “polymer” • Explain the polymerisation process • Thermosetting and thermoplastic materials • Fire hazards

8. Principles of Heat and Combustion Sensitive Detection Devices

Assessment Objective	Knowledge, Understanding and Skills

8.1 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 the detectors listed above according to the risk to be covered and their reliability

8.2 Explain and apply the principles of thermocouples and thermistors	• Explain the use of thermocouples • Explain the use of thermistors

Level 3 Fire Engineering Science Formula Sheet

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

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

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