Recommended Minimum Competencies for Fire Protection Engineering
2018

This document has been developed by the SFPE Standing Committee for Professional Qualification and specifically by the Subcommittee on Professional Competencies and Credentialing.

This is considered to be a minimum recommendation document. Future revisions will occur periodically to continually address any changes in the necessary skills to be a fire protection engineer.

Scope:

This document will define the "Recommended Minimum Competencies for Fire Protection Engineering." It should be noted that the term 'fire protection engineering' should be viewed as synonymous with the terms 'fire safety engineering' and 'fire engineering' in that they apply to the application of engineering principles to mitigate the unwanted impact of fire. For practical purposes, only the term 'fire protection engineering' is used in this document.

Application:

According to the United States Department of Labor, Employment and Training Administration (USDLETA), and the American Association of Engineering Societies (AAES), competency is defined as "a cluster of related knowledge, skills, and abilities that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measured against well accepted standards, and that can be improved through training, development, and experience." While different definitions exist in other countries, they largely embody the same principles. A comprehensive competency model for engineering can be found on the AAES or USDLETA websites, within this model, there is an undefined level, Tier 5, which is intended to be defined by specific industry sectors.

It is intended that a minimum level of competency is needed for professionals practicing fire protection engineering. It is the aim of this document to establish a common set of industry-specific criteria for the profession of fire protection engineering.

This document could serve as a basis for jurisdictions that are implementing credentialing programs for fire protection engineering that confirm professional competency. Practitioners can use this document to identify areas where they lack knowledge and need further development. Organizations, for example universities, can use this document for developing courses and programs that will help students when they become practitioners in the fire safety industry. These competencies define an adequate knowledge base for practice of fire protection

engineering. It could also be used within organizations to establish required or desired competencies for fire protection engineers.

It is expected that an engineering background including math, sciences, engineering basics and other general electives are part of one's education when pursuing a career in fire protection engineering. After obtaining an engineering degree from a university, which is intended to provide a minimum level of competency in the discipline, Continuing Professional Development (CPD) is the main vehicle with which practitioners will ensure that they maintain the minimum level of competency needed throughout their career. CPD is considered to be an ongoing process that continues throughout a person's career. In the end it is the sole responsibility of the practitioner to keep his/hers knowledge and skills up-to-date so that he/she can deliver the quality of service that meets the expectations of customers and the public along with the requirements of his profession. Education throughout one's career is needed to maintain the core competencies required of a practicing fire protection engineer.

The recommended minimum competencies for fire protection engineering can be achieved through different career paths. The most efficient route to gain the knowledge for a foundation in fire protection engineering is through university study specifically in a fire protection engineering program. These recommended minimum competencies for fire protection engineering are not intended to replace an in-depth university education in fire protection engineering. Rather, they can be used as guidance document by universities in establishing fire protection engineering curricula, and also to provide the basis for CPD education in support of core competencies areas of fire protection engineering. University courses traditionally offer a more in-depth look at a particular subject due to the length of instruction and activities, such as homework and projects, associated with the course. In additional to classroom education, becoming competent in many subject areas also involves practicing and applying the knowledge to the projects. This is done under an experienced fire protection engineer.

Some practitioners may have used different career paths, for example years of study in the field with knowledge learned from other professionals and continuing education courses. Whether the base knowledge is acquired in an education setting or practice, all those working in fire protection engineering need to maintain their skills with continuing education to support the knowledge in core competencies areas of fire protection engineering.

Definitions:

The following sections show short descriptions/definitions of key words used in this document. These are included to provide clarification of these words in the context of the objective of this document. These descriptions should not be considered to be official definitions but rather descriptions created to give a better understanding of this specific document.

Minimum competency: A minimum competency is the knowledge base that is needed to adequately perform a certain task, for example specific technical analysis.

Knowledge area: A knowledge area is an important subject that forms part of the overall knowledge base needed for a certain competency.

<u>Adequate knowledge base:</u> An adequate knowledge base is the summary of the information about a particular subject known by an individual; that information must be sufficient for an individual to be able to perform analysis tasks etc.

<u>Minimum knowledge:</u> Minimum knowledge is considered the knowledge base needed to gain a comprehensive understanding of a specific subject; to be able to understand how to use the knowledge of that specific subject in analysis etc.

Introduction:

The aim is that this document is utilized globally to ensure a level of quality is maintained within fire protection engineering and its related activities, this will help the fire protection engineering discipline to gain professional recognition world-wide for the industry. This recognition will be such that other professional engineers know there is an intricacy of knowledge needed to ensure appropriate fire protection. It is understood that although construction materials and methodologies, as well as customs and cultures, may vary around the world, the principles needed to evaluate and protect against fire are the same across these boundaries.

It is considered important to highlight the fact that the path to achieving minimum competency may look different for each professional. University programs are essential to provide a fundamental grounding in engineering knowledge, which every fire protection engineer should possess. Focused university programs in fire protection engineering provide one avenue to combine engineering fundamentals with topics and curricula specific to the discipline and practice of fire protection engineering. Another avenue may be continuing professional development (CPD), even more so for those practitioners lacking university education specific to fire safety, to gain knowledge in core competencies areas of fire protection engineering. In addition to education, experience is also a necessary component to ensure that the application of fire protection engineering encompasses the broad competencies expected of a professional.

Engineers within the fire safety industry must take the necessary steps to develop and maintain knowledge, skills, and expertise necessary to perform their roles successfully throughout their career. By participating in relevant training and professional development programs they can remain competent through education on new technologies, new methodologies and improved ways of implementing fire protection engineering.

The intent is to clearly identify the areas of knowledge, *the minimum competencies*, which are core to the fire protection engineering profession. These should be used as a base when evaluating the skill set of a fire protection engineer or when developing courses for continuing education and in this way help practitioners gain additional knowledge and skills in these base areas. In doing so, these competencies will provide a means through which the profession of fire protection engineering can be recognized across borders.

The Fire Protection Engineer:

For the purposes of this document, when referring to a “Fire Protection Engineer” it will include other similar titles such as Fire Safety Engineer and Fire Engineer as there are many titles used by this profession globally. A high-level description and general understanding of the type of work tasks that is expected to be performed by the “Fire Protection Engineer” has been

developed to assist in clarifying the individuals who should meet the minimum competencies laid out in this document.

The definition below refers to a practitioner that has an in-depth university education in fire protection engineering (e.g. a university degree from recognized university) and relevant experience from the industry. Individuals engaged in the fire protection engineering profession but are lacking this level of education and experience, should strive to reach the same knowledge base held by a Fire Protection Engineer referred to in this document.

A Fire Protection Engineer is an individual, who by formal training and professional experience, carries the necessary competency, and has the skills to provide guidance and direction to protect life, property and environment from threats posed by fire and its related mechanism.

It is considered very important to have a common understanding of the role of a Fire Protection Engineer and therefore the definition shown above has been further developed into the accompanying role description.

Fire protection engineers identify risks and design safeguards that aid in preventing, controlling, and mitigating the effects of fires. They have the ability to use and develop engineering methods and techniques related to fire safety design of buildings, industrial constructions, infrastructures, equipment and environment interfaces.

It is understood that the competence carried by the fire protection engineer is used within any sector of the fire safety industry, such as the building industry, the oil and gas industry, the nuclear industry, the forestry industry, etc.

A fire protection engineer is expected to identify and deal with complex issues autonomously and creatively. Through technical analysis the fire protection engineer is able to analyze, evaluate and develop various technical solutions to fire safety problems.

Fire protection engineers have an interdisciplinary role assisting project/design teams (which may include but are not limited to architects, building owners and developers) in reaching life safety, property protection and environmental protection goals.

The "Fire Protection Engineer" in addition to general engineering principles is expected to comprehensively understand:

- *Fire Safety Science: the underlying physical principles of fire and its related mechanisms,*
- *Active Fire Protection: the role of fire safety systems in fire safety design,*
- *Passive protection: the role of passive protection measures in fire safety design,*
- *Human Behavior & Evacuation: the behavior of persons during an emergency and the principles of evacuation design and escape facilities,*
- *Performance Based Design: the principles of using a PBD approach for fire safety design,*

- *Technical Fire Safety Analysis: the principles of technical analysis related to fire safety design,*
- *Computational Modeling: the use advanced modeling related to fire safety design,*
- *Fire Hazard and Risk Assessment: the basic principles of risk management and probabilistic analysis,*
- *General Building Design: how architectural, engineering and technical principles are incorporated into the design of buildings, industrial construction and other similar facilities,*
- *Code and Regulations: the role of regulations in relation to fire safety design.*

Recommended Minimum Competencies for Fire Protection Engineering:

The objective is for the individual to gain a comprehensive understanding of the competencies considered to be core to the profession. He/she must understand fire safety principles and the application of these principles in the engineering analysis and design of fire safety measures. Only by a comprehensive understanding of these core subjects will the professional achieve the minimum knowledge base considered needed for professionals practicing fire protection engineering.

The following four (4) competencies are considered to be core to the profession. These are the recommended minimum competencies for fire protection engineering.

A short description has been provided for each minimum competency:

- Fire Safety Science

A comprehensive understanding of the underlying physical principles of fire and its related mechanisms. This would include the principles of ignition, heat transfer, mass transfer, fire chemistry, and fire dynamics.

- Human Behavior and Evacuation

A comprehensive understanding of human behavior and the principles of evacuation design. This would include the behavior of persons during an emergency, different design approaches, tools and methods to perform evacuation assessments.

- Fire Protection Systems

A comprehensive understanding of fire mitigation, including water and non-water based suppression; detection systems; fire modeling; fire testing and code and standard concerns.

- Fire Safety Analysis

A comprehensive understanding of the principles of technical analysis related to fire safety design. This would include design approaches, concepts for evaluating design options, establishing boundary conditions and limits of analysis and design.

For each of one the above competencies, a number of core knowledge areas have been identified. The expectation is that the practitioner is proficient in these knowledge areas, i.e., in the application of science and engineering to protect the health, safety and welfare of the public from the impacts of fire. The knowledge areas presented in the following sections can be seen as

descriptions of the objectives of courses needed to be taken to achieve proficiency in each specific topic (subject).

The knowledge areas for *Fire Safety Science* are the following:

- Fire Dynamics

The objective of this topic would be to understand the various stages of fire, to provide a knowledge base concerning the different methods and techniques applied in the analysis of a fire sequence and develop ability to critically examine those methods in terms of practical application. This could include pool fires, point source models, pre-flashover compartment fire dynamics and assessment, and post-flashover fire dynamics and assessment.

- Heat transfer

The objective of this topic would be to provide a knowledge of the theory and application of steady state and transient heat conduction in solids, the concepts and applications of Biot and Fourier numbers, the principals of thermal radiation with application to heat exchange between black and non-black body surfaces, the use of radiation networks & surface radiation properties, principles of convection heat transfer.

- Fire Chemistry

The objective of this topic would be to give an understanding of fire chemistry. This would include basic chemical concepts that apply to combustion, specifically combustion reactions. It would also define physical and chemical properties of gases and liquids that are necessary for their ignition and combustion.

The knowledge areas for *Human Behavior and Evacuation* are the following:

- Human Behavior in Fire

The objective of this topic is to provide knowledge of human behavior in fire, including physiological and psychological response, decision-making and movement. This could include discussion on cues, recognition, decision making, response, social and cultural issues, crowd dynamics, etc.

- Egress and Life Safety

The objective of this topic is to provide knowledge of approaches, tools and methods to determine and evaluate egress and life safety issues in the event of fire. This could include characterization of population, toxicity, tenability, integrated assessment of overall response and movement times, and development and application of safety margins.

The knowledge areas for *Fire Protection Systems* are the following:

- Passive Systems

The objective of this topic would be to provide knowledge of the role of passive protection measures in fire safety design, fundamental principles, design criteria and installation requirements. This could include principles of fire resistance and testing, thermal response of structural elements, mitigation options, reliability and robustness.

- Active Systems

The objective of this topic would be to provide knowledge of the role of fire safety systems in fire safety design, fundamental principles, design criteria and installation requirements. This could include principles of engineering analysis, concepts of system design and components, design requirements for different hazards, response times and related issues, reliability and robustness.

- Fire Suppression

  The objective of this topic would be to provide knowledge of fundamental principles, design criteria and installation requirements for fire suppression systems (including water-based systems, clean agent, halon, carbon dioxide, inert gas, dry chemical and foam fire suppression agents). The design of systems for the specific construction features and occupancy involved, and the effects of various forms of heat transfer and oxygen displacement characteristics relating to the specific systems.

- Fire Detection and Alarm

  The objective is to provide knowledge of fundamental principles, design criteria and installation requirements for fire detection and occupant notification systems, including how to analyze, evaluate, and specify these systems.

The knowledge areas for ***Fire Safety Analysis*** are the following:

- Performance-Based Design

The objective of this topic would be to provide knowledge regarding development of fire safety engineering solutions from first principles to achieve fire performance objectives. This could include the concepts of goals, objectives and criteria, design fires, fire safety analysis, concepts for evaluating design options, concepts of uncertainty, sensitivity analysis and documentation.

- Smoke Management

The objective of this topic would be to provide knowledge of fundamental principles, design criteria and installation requirements for smoke control systems, including how to analyze, evaluate, and specify these systems. This could include principles of smoke production and spread, entrainment, axisymmetric and spill plumes, stratification, principles of natural and mechanical smoke exhaust system design, and reliability and robustness.

- Evacuation Analysis

The objective of this topic is to provide knowledge regarding approaches, tools and methods to evaluate evacuation in the event of fire or other similar events. Specifically orientated towards the use of a range of different calculation methods, from simple hand calculations to sophisticated computer simulations that may include behavioral rules of human interaction. This topic would also incorporate the design of egress systems, including special situations using performance-based designs.

- Structural Fire Safety

The objective of this topic is to provide knowledge regarding the impact of fire exposure on materials used in construction assemblies, the role various construction features play in the fire resistance of the assembly and the application of mechanics and heat transfer engineering principles. Thermal response of structural elements (timber, concrete, steel, composites).

- Risk Management

The objective of this topic is to provide knowledge in the areas of probability and statistics, of the concepts, tools and methods of hazard assessment and risk analysis, and of the use and application of these concepts, tools and methods to fire safety problems. A general understanding of how fire impacts people (including egress), property and society as a whole should be provided.

- Fire Modeling

The objective is to provide knowledge of zone and field models, including the technical basis for enclosure fire model elements, the limitations of computer-based fire models, validity and validation of fire models and the use of current computer-based fire models for practical FPE problems, including computer-based analysis of structures exposed to fire.

- Building and Fire Regulations & Standards

The objective of this topic is to provide knowledge of the use and application of building regulations (codes) and related reference standards, including for both active and passive fire protection.

The following table shows a summary of the recommended minimum competencies and the knowledge areas.

Minimum Competency	***Fire Safety Science***	***Human Behavior and Evacuation***	***Fire Protection Systems***	***Fire Safety Analysis***
Knowledge Areas	- Fire Dynamics - Heat transfer - Fire Chemistry	- Human Behavior In Fire - Egress and Life Safety	- Passive systems - Active systems Fire Detection and Alarm Fire Suppression	- Performance Based Design - Smoke Management - Evacuation Analysis - Structural Fire Safety - Risk Management - Fire Modeling - Fire Protection Related Codes & Standards

Recommended time needed to gain a comprehensive understanding of required knowledge areas:

The earlier section showed the four (4) competencies that are considered to be core to the profession, for each core competency several knowledge areas were also shown.

It is not the purpose of this document to give a detailed description of these knowledge areas nor is it the intention of this document to exactly show the necessary length needed for these topics if part of a course program or similar. However, it is considered to be of utmost importance to show a recommended range of hours that are considered to be needed to gain a comprehensive understanding of these knowledge areas, i.e. to gain a minimum knowledge level for each topic.

These recommended hours have been estimated based on the European Credit Transfer and Accumulation System (ECTS), where credits are a standard means for comparing the "volume of learning based on the defined learning outcomes and their associated workload." For simplicity the tables show a range of recommended hours, if needed these could be transformed to ECTS credits by assuming that one (1) ECTS credit can be estimated as 25 – 30 academic hours (or 1.5 ECTS credits is approximate one full-time academic week, 40h).

The following tables below show a recommended range of hours (academic hours) for each knowledge area.

Minimum Competency	***Fire Safety Science***	***Recommended Hours***	***Human Behavior and Evacuation***	***Recommended Hours***
Knowledge Areas	- Fire Dynamics	160 - 200	- Human Behavior In Fire	100 - 140
	- Heat transfer	120 - 160		
	- Fire Chemistry	80 - 120	- Egress and Life Safety	80 - 120

Minimum Competency	***Fire Protection Systems***	***Recommended Hours***	***Fire Safety Analysis***	***Recommended Hours***
Knowledge Areas	- Passive systems	60 - 90	- Performance Based Design	160 - 200
	- Active systems	60 - 90	- Smoke Management	100 - 140
	Fire Detection and Alarm	60 - 90	- Evacuation Analysis	100 - 140
	Fire Suppression	60 - 90	- Structural Fire Safety	100 - 140
			- Risk Management	140 – 180
			- Fire Modeling	160 - 200

			- Fire Protection Related Codes & Standards	60 – 90

It should also be mentioned that this document does not specify a certain way or method of how these knowledge areas should be taught. Nevertheless, it is considered that a suitable way of learning these is via a university course. In principle, any course must prepare the student to have proficiency in that specific subject.

It is also of absolute importance that the specific individual teaching the course has an acceptable knowledge level of the topic. It is understood that any person involved in teaching these knowledge areas must have the proper education and experience of the topic itself (and be able to show evidence of how this knowledge and experience was achieved) and he/she should also be recognized as an expert on the matter.

Ethics:

The professional conduct of engineers is of utmost importance. The role of ethics in engineering is imperative because our ethical values ensure honest and open transactions in the profession, it is only in this way that professionals are able to work without any type of partiality.

Ethics ensures that engineers are held accountable for their actions and by that keeping the interests of the public, clients, employers, colleagues, and the profession in mind.

The integrity of the profession depends on ethics, and therefore it has been considered very important to include a brief section about ethics in this document.

All fire protection engineers are expected to read, accept, and abide by the SFPE Canons of Ethics.

Professional Ethics:

Displaying strong engineering ethics by evaluating and applying the merits, risks, and social concerns of activities in engineering.

- *Practice in an ethical manner, with personal and professional integrity.*
- *Abide by one or more applicable (e.g., employer, professional society, client) strict code of ethics and behavior, even in the face of opposition.*
- *Encourage others to behave ethically.*
- *Understand that behaving ethically goes beyond what the law requires.*
- *Respect the need for confidentiality, when appropriate.*
- *Distinguish between a legal or management issue and an ethical matter.*

- *Select and take appropriate steps to record or to report to higher-level management or to public authorities in the event that an ethical matter is not adequately resolved in a manner consistent with the public health, safety, and welfare.*

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The document has also been subject to external reviews by persons within the international fire safety engineering community. The members of this Subcommittee would like to show their sincerest gratitude to these persons for their comments and help during the development of this document.

Currently the SFPE Subcommittee on Competencies and Credentialing are comprised of the following members.

Subcommittee role	Name	Organization
Chair	Jimmy Jönsson	JVVA Fire & Risk
SFPE liaison	Victoria Valentine	SFPE Headquarters
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Member	Justin Schmeer	Chevron

References:

The following documents are considered to be closely related to this specific document and it is recommended that readers of this document also takes a closer look at these references.

[1] SFPE Canons of Ethics, Link: http://www.sfpe.org/page/CodeofEthics

[2] Model Curriculum for a Bachelor's of Science (BS) Degree in Fire Protection Engineering (FPE), Link: https://c.ymcdn.com/sites/sfpe.site-ym.com/resource/collection/24609C80-7253-49A5-83AF-D0499353EAEA/SFPE_BS_Model_Curriculum.pdf

[3] Recommended Curriculum Content for an MS/ME in Fire Protection Engineering, Link: https://c.ymcdn.com/sites/sfpe.site-ym.com/resource/collection/24609C80-7253-49A5-83AF-D0499353EAEA/131027_MS_Program_in_FPE_-_Final.pdf

[4] ECTS Users' Guide, 2015, Link: https://ec.europa.eu/education/sites/education/files/ects-users-guide_en.pdf

[5] Competency model for engineering, Link: AAES or USDLETA websites (e.g., https://www.careeronestop.org/CompetencyModel/competency-models/engineering.aspx).