Fire Protection Fundamentals

An Online Continuing Education Course for Engineers

Course Number: M-5004

Credit: 5 Hours / 5 PDH / 5 CPD

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Fire Protection Fundamentals

INTRODUCTION

The objective of this course is to familiarize engineers with basic principles related to fire protection and the safeguarding of life and property against fire loss. It describes the fundamental principles of fire science and of the dynamics of fire growth in buildings and demonstrates how a sound understanding of these is necessary before viable fire protection measures can be implemented. The course develops an engineering appreciation of standard practices and regulations related to the prevention, detection, and suppression of fires.

The primary thrust of the course is to describe current fire safety practices and regulations; however, a brief account is given of the emerging discipline of fire protection engineering. This relatively new field is fostering engineered design solutions to fire safety problems which are sometimes more cost-effective and flexible than standardized solutions.

The course is divided into seven sections. The first section provides a general background and overview. It presents U.S. fire loss statistics—particularly as they relate to the workplace. Most important, it provides an overview of the sometimes-daunting regulatory framework intended to ensure fire safety.

The second section provides an introduction to fire protection engineering issues. It stresses the need for an understanding of the relationship between the scientific principles underlying fire science and effective fire protection measures. It also emphasizes that a clear statement of the objectives of a fire safety analysis is necessary before effective solutions can be sought.

The third section describes the fundamental principles of fire science. The fourth section introduces the study of room fire dynamics to stress the interrelationship between fire growth and the enclosure where the fire burns. Section five describes the practice of fire protection, including the role of codes and standards. It also offers guidelines for the selection of effective solutions to reduce fire hazards and to achieve pertinent fire safety objectives.

Sections six and seven provide overviews of two central components of fire safety design: fire detection and fire suppression.

BACKGROUND AND OVERVIEW

Fire Loss Statistics

Fires extract a high toll in injuries and in loss of human life. In the United States, deaths related to fires and explosions accounted for approximately 4% of all occupational fatalities in 2010.[1] According to the U.S. Department of Labor, the number of fatal work injuries resulting from fires and explosions rose from 113 in 2009 to 187 in 2010, an increase of 65 percent.[2]

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Statistics generated by the National Fire Protection Association show that during the period 2003-2006 industrial and manufacturing fires accounted for annual property losses of about $509 million.[3] More recently, 2010 direct property losses due to all fires in the United States have been estimated to be more than $11 billion.[4] Although residential fires accounted for approximately 60% of these losses, industrial property damage was also high and estimated to be $2.6 billion.

Although the causes of industrial and manufacturing fires are often difficult to determine, the major sources of ignition appear to be manufacturing, electrical or heating equipment; open flames and incendiary sources. Because of the diverse nature of the causes of industrial fires, protective measures must be carefully engineered for specific industrial processes and their hazards.

Regulatory Framework

Although these fire statistics are significant, they represent an improvement in fire safety compared with past experience. Much of this improvement results from the regulatory framework that has been established to ensure that fire safety objectives are met throughout the United States. Although this regulatory framework is multi-layered and complex, the simplified picture that follows shows how it is structured and how it works.

Building Codes

Three private organizations have developed and maintain three model-building codes in the United States: the International Conference of Building Officials (ICBO), the Southern Building Code Congress International (SBCCI), and the Building Officials and Code Administrators (BOCA). Among other functions, these codes provide a set of fire safety provisions intended to ensure that an acceptable level of life safety is incorporated into buildings at the time of their construction. The codes use fire safety standards developed by the National Fire Protection Association (NFPA) and the American Society for Testing and Materials (ASTM).

States and municipalities adopt one of these model codes to form the basis of local building regulations. Enforcement of these regulations is the responsibility of local (and sometimes State) building inspectors. Consequently, both the letter of the law and its enforcement may vary somewhat from place to place.

Fire Prevention Codes

The NFPA has developed and maintains *NFPA 1*®, a model fire prevention code.[4] The code Offers provisions intended to ensure that, following construction, buildings are equipped, operated, and maintained to provide an acceptable level of life safety and property protection from potential hazards created by fires or explosions. *NFPA 1*® makes reference to 130 other codes and standards developed by the NFPA to address various specific fire safety concerns. State and local jurisdictions have adopted *NFPA 1*® as the basis of their fire prevention regulations. Again, enforcement of these regulations is the responsibility of local and state officials including fire service personnel.

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National Fire Protection Association
The National Fire Protection Association (NFPA) is a nonprofit organization that develops and publishes codes and standards intended to minimize the occurrence and effects of fire in all aspects of contemporary activity. The more than 300 codes and standards of the NFPA are developed by committees comprised of expert volunteers from various backgrounds. Some of these codes and standards delineate standard practices for designing facilities, installing equipment or undertaking inspections. Others describe standardized methods for conducting fire tests on personal protective equipment, building products and fire protection equipment. These codes and standards are widely used as the basis of legislation and regulation at all levels of government, from local to federal. Many are referenced by agencies of the federal government, such as the Occupational Safety and Health Administration (OSHA). NFPA codes and standards are also used by insurance authorities for risk evaluation and premium rating.

Occupational Safety and Health Administration
The provision of workplace safety is the purview of the Occupational Safety and Health Administration (OSHA), an agency of the U.S. Department of Labor. OSHA has a mandate to provide workplace fire protection and explosion prevention standards and regulations to ensure safe working conditions. To achieve its mandate, OSHA generates its own standards and also often adopts standards developed by the NFPA.

Testing Laboratories
The provision of fire safety relies heavily on NFPA standard fire tests. Several accredited testing laboratories are available to undertake such testing and, hence, to document the fire performance of personal protective equipment, building products, and fire protection equipment.

Consumer Protection
Consumer protection departments of Federal and State governments are concerned with the fire performance of commercial products such as furnishings, which may not be regulated by building codes or fire prevention codes. These departments have implemented programs that limit the consumer's choice to products with acceptable fire performance.

Insurance Carriers
Although not strictly part of the regulatory framework, insurance carriers play an important role in fire safety provision. Insurance carriers are concerned with the potential for loss of life and property damage resulting from fires. Insurance companies have developed methods for assessing the fire risk in a facility to levy appropriate premiums. For large facilities, such as in industry, assessment methods can involve advanced engineering analysis. The Factory Mutual System and Underwriters Laboratories Inc. provide engineering services to support insurance carriers. These include development of insurance-industry fire standards, testing of the fire performance of products and inspection of industrial facilities.

The multi-layered structure of the regulatory framework provides checks and balances to ensure an acceptable level of fire safety in a facility. At the same time, the various layers of codes and standards and the large number of participants in the policing of regulations make the framework appear complex. As a result, it is common practice to engage a fire protection engineer with wide

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ranging expertise in fire-related codes and standards to formulate designs or strategies that ensure compliance with regulations in an economical and efficient manner.

Fire Protection Engineering

Traditionally, fire safety regulations have been prescriptive; that is, detailed and often rigid solutions are mandated in codes and standards as the means to ensure fire safety. Such regulations are based on collective experience of what works and what does not, along with technological analysis and professional judgment. Statistics reveal that these regulations work well for conventional buildings. Nonetheless, prescriptive fire safety solutions are often cumbersome and expensive when applied to the design of modern buildings.

A better understanding of the behavior of building fires is evolving through research. Computer software is available to model the spread and severity of a fire in a building as well as the response of building occupants, building components, and fire protection systems. Codes and standards are being revised to encourage performance-based design whereby the solution is tailored to address the hazard. These developments are opening the door for engineered fire safety solutions as an alternative to prescriptive regulations. Clearly, such design can only be undertaken by a well-trained fire protection engineer.

Fire protection engineering is not yet a mature discipline. Few textbooks are devoted to the subject. Likewise, limited opportunities exist for studying the discipline.

Nonetheless, it is an emerging discipline. It requires practical and fundamental training in the behavior of fires, fire protection systems, human behavior and risk assessment, as well as in basic engineering subjects such as thermodynamics, fluid mechanics and heat transfer. The fire protection engineer must also be aware of pertinent codes and standards, and the legal implications of the work. Mastery of the discipline requires a considerable commitment of time and effort.

Fire protection engineers interact with a wide variety of professionals in their daily activities including architects, structural engineers, building service engineers, construction personnel and regulatory authorities. Additionally, a client's or insurer's concerns may determine how the fire protection engineer provides solutions. Training presents a challenging task,[5] but employment opportunities abound with consulting groups, government agencies, industry, insurance companies, and fire protection equipment manufacturers.

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INTRO NEERING

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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Fire Safety Objectives

In general terms, the pu "Background and Overview" section is to res to achieve particular fire safety obje ensure:

1. life safety,
2. property protectio
3. minimal disruptio

When undertaking a fire s ated at the outset. The objectives should be e ough it is common practice, simply stating tha It would be more helpful to state that if fire c protection measures to ensure that occupants have outdoors (or at least to an area of refuge) before they are ove ardous conditions. An objective stated in this fashion makes recommending various acceptable solutions possible. A choice among those solutions that meet the objective could then be made on the basis of other considerations such as aesthetics, economics or constraints related to other building services.

Given the complexity of the regulatory framework, a given requirement cannot always be directly linked with a single objective. Strategies that appear directed to life safety often serve the interest of property protection. For example, fire alarm systems, which are intended to provide early warning to occupants, may also alert the fire services to the presence of fire. Suppression activities may then begin early enough that property damage is reduced. On the other hand, the provision of sprinklers for property protection in a warehouse may mean that fire spread is held in check and hazards to employees are greatly reduced.

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