Lecture 8: Fire Fighting and Protection

8.1 Introduction

Loss of life, Injuries and property damage in building fires in the past have been tragically large. In an effort to curtail these losses, building officials devote far more than half of the usual building codes to fire protection. As a result, owners must spend considerable sums of money to provide fire protection in buildings to meet code requirements. Designers therefore are professionally obligated not only to abide by the word of the law but also by its spirit.
In addition, obligated to the economic welfare of the owners, designers, in addition, should seek ways to provide life safety in buildings and to avoid or minimize property damage due to fires at least cost to the owners.

An owner pays for fire protection in several ways. Initially, he pays for installation of fire protection when a building is constructed.
Then, he pays for maintenance and operation of the fire-protection system. In addition, usually as long as he maintains ownership, he pays fire insurance premiums every year to cover possible fire losses. The last payments may amount to a considerable sum over a long period.

Because of insurance companies' concern with fire protection, they have promulgated many standards for the purpose that are widely used. Many have been adopted by reference in building codes and are specified by government agencies.

Standards, however, usually present minimum requirements. Often, public safety and the owners' special needs require more stringent fire protection and emergency measures than those specified in building codes and standards.

8.2 Fire Loads and Resistance Ratings

Fires occur in buildings because they contain combustibles, materials that burn when ignited. The potential severity of a fire depends on the amount and arrangement of these materials.

Combustibles may be present within a building or in the building structure. Contents of a building are related to the type of occupancy, whereas combustibility of structure is related to type of construction. Accordingly, building codes classify buildings by occupancy and construction.

Fire load, measured in pounds per square foot (pst) of floor area, is defined as the amount of combustibles present in a building. Heat content liberated in a fire may range from 7,000 to 8,000 Btu per lb for materials such as paper or wood to more than twice as much for materials such as petroleum products, fats, waxes and alcohol.

Fire load appears to be closely related to fire severity.

Fire resistance of building materials and assemblies of materials is determined in standardized fire tests. In these tests, temperature is made to vary with time in a controlled manner.

Height and Area Restrictions to limit the spread of fire and the length of travel of occupants to places of refuge, buildings may be compartmented horizontally and vertically. Fire-resistant floors and ceilings are used to prevent fire from spreading from story to story. Fire-resistant walls, called firewalls, are used to prevent fire from spreading horizontally. Openings in these fire barriers for passage of occupants in normal or emergency circumstances also must be fire protected.

Building codes may restrict building height and floor areas included between firewalls in accordance with potential fire hazards associated with type of occupancy and type of construction. Usually, the greater the fire resistance of the structure the greater the permissible height and floor area. Because of the excellent past record of sprinklers in early extinguishment or control of fires, greater heights and larger floor areas are often permitted when automatic sprinklers are installed.

8.3 Classes of Fires

Methods used for extinguishing some burning materials may not be suitable for others. Hence, for convenience in indicating the effectiveness of extinguishing media, such as water, powders, gases or foam, fires may be classified in accordance with the type of combustible material burning.

Class A fires. Ordinary combustibles. Extinguishable with water or by cooling or by coating with a suitable chemical powder.

Class B fires. Flammable liquids. Extinguishable by smothering or careful application of a cooling agent.

Class C fires. Live electrical equipment. Extinguishable with a no conducting medium. A

conducting agent can be used if the circuit is interrupted.

Class D fires. Metals, such as magnesium, powdered aluminum and sodium, that burn. Extinguishable by specially trained personnel applying special powders.

8.4 Fire Extinguishment

Ordinary means for extinguishing building fires.

Sprinklers

Automatic sprinklers have proven very effective in early extinguishment of fires. In fact, that is their main purpose; but they are also useful in curtailing the spread of fire and hot gases by cooling the environment around a fire.

Sprinklers are suitable for extinguishing Class A fires. Sprinklers also may be used for some Class B and Class C fires.

A sprinkler system consists of fire detectors, water for extinguishing fires, heads for discharging the water when actuated by the detectors, and piping for delivering the water to the heads. Heads should be located at ceiling and roof levels to completely cover the interior of the building. Intervals between heads on the piping should be small enough to provide desired concentration of water on every square foot of floor.

Requirements governing design and installation of sprinkler systems are given in building codes and in standards of the National Fire Protection Association. If such standards are ignored, the owner may have to pay higher than necessary fire-insurance premiums.

Standpipes

A standpipe is a water pipe within a building to which hoses may be attached for firefighting. Standpipes are required in buildings in which fires may occur too high to be reached by ground-based fire-department equipment.

These pipes also may be necessary in low buildings with large floor areas, the interiors of which may be difficult to reach with hose streams from the outside.

Chemical Extinguishing Systems

Small fires in buildings in ordinary materials, such as paper, wood and fabrics, when first starting, often may be rapidly extinguished with water, and propelled by compressed gases, from

hand-held extinguishers. Building codes may require such extinguishers to be located at convenient places in buildings. Occupants should be taught to operate the extinguishers. There is a risk in their use, however, in that the attempt to fight a fire with an extinguisher may delay notification of the fire department or other better-equipped fire fighters of the presence of the fire.

Instead of plain water for extinguishing fires, chemicals or water plus chemicals may be used. Applied by automatic sprinklers, hoses, handheld extinguishers, portable wheeled equipment or larger devices, chemicals may be desirable or necessary for fires in certain materials.

Foams. For flammable liquids, such as gasoline, a foamed chemical, mostly a conglomeration of air- or gas-filled bubbles, may be useful. Three types are suitable for fire extinguishment: chemical foam; air, or mechanical, foam; and high-expansion foam. Chemical foam is formed by the reaction of water with

powders. Usually, sodium bicarbonate and aluminum sulfate are used, forming carbon-dioxide bubbles. Air, or mechanical, foam is produced by mixing water with a protein-based chemical concentrate. High-expansion foam is generated by passage of air through a screen constantly wetted by a chemical solution, usually with a detergent base.

Carbon Dioxide. For flammable liquids or live electrical fires, carbon dioxide may be use-ful. It is also suitable for equipment fires, such as those in gasoline or diesel engines, because the gas requires no cleanup. Stored in containers under pressure, it is immediately ready for discharge when a valve is opened. Heavier than air, the gas tends to drop into the base of a fire and extinguish it by reducing the oxygen concentration.

Halon 1301. For use in the same circumstances as carbon dioxide, bromotrifluoromethane ($CBrF_3$), or Halon 1301, acts much faster. This gas also requires no cleanup. It extinguishes fires by interfering with the chain reaction necessary to maintain combustion.

Dry Chemicals. For Class Band C fires, dry chemicals, such as sodium bicarbonate, may be suitable. They tend to extinguish fires by breaking the chain reaction for combustion.

When dry chemicals are used, cleanup after a fire may be difficult.

Dry Powders. For combustible metals, dry powders, different from the dry chemicals previously mentioned, usually are the most suitable extinguishing agent. Specific metals require specific dry powders. Only properly trained personnel should fight fires in metals.

8.5 Emergency Egress

For life safety in buildings in event of fire or other emergencies, provisions must be made for safe, rapid egress of occupants, at least from the dangerous areas and preferably also from the buildings. The escape routes must be fire protected and smoke free to allow safe passage of occupants.
An exit is a means of egress from the interior of a building to an open exterior space beyond the reach of a building fire. The means of egress may be provided by exterior door openings and enclosed horizontal and vertical passageways.

In addition, structural members should have sufficiently high fire ratings to prevent collapse, for a few hours at least. The objectives of this are to allow all occupants to be evacuated and to give fire fighters time to extinguish the fire.
If structural members are inadequate for the purpose, they may be fire protected with other materials.

To permit prompt escape of occupants from danger, building codes specify the number, size, arrangement and marking of exit facilities, in addition to other life-safety measures. The requirements depend on the types of occupancy and construction.
Generally, building codes require a building to have at least two means of egress from every floor of a building. These exits should be remote from each other, to minimize any possibility that both may become blocked in an emergency.
Codes usually also specify that exits and other vertical openings between floors of a building be fire protected, to prevent spread of fire, smoke or fumes between stories.

8.6 Fire Protection

Systems Design for Fire Protection

1. Limitation of potential fire loads, with respect to both combustibility and ability to generate smoke and toxic gases.
2. Compartmentation of buildings by fire divisions to confine a fire to a limited space.
3. Provision of refuge areas and safe evacuation routes to outdoors.
4. Prompt detection of fires, with warning to occupants who may be affected and notification of presence of fire-to-fire fighters.

5. Communication of instructions to occupants as to procedures to adopt for safety, such as to stay in place, proceed to a designated refuge area or evacuate the building.
6. Early extinguishment of any fire that may occur, primarily by automatic sprinklers but also by trained fire fighters.
7. Provision, for firefighting, of adequate water supply, appropriate chemicals, adequate-sized piping, conveniently located valves, hoses, pumps and other equipment necessary.
8. Removal of heat and smoke from the building as rapidly as possible without exposing occupants to them, with the HVAC system, if one is present, assisting in venting the building and by pressurizing smoke proof towers, elevator shafts and other exits.

8.7 Emergency Power

In addition, not discussed before, a standby electric power and light system should be installed in large buildings. The system should be equipped with a generator that will start automatically on failure of normal electric service.

The emergency electric supply should be capable of operating all emergency electric equipment at full power within 60 seconds of failure of normal service. Emergency equipment to be operated includes lights for exits, elevators for fire fighters, escalators and moving walks designated as exits, exhaust fans and pressurizing blowers, communications systems, detectors, and controls needed for firefighting and life safety during evacuation of occupants.

8.8 Systems Design for Life Safety

For maximum protection of life and property in event of fire or other emergency at least cost, all the preceding elements should be integrated into a single life-safety system so that they work in unison to meet all objectives.

Some of the elements may be considered permanent. They require no supervision other than that necessary for ordinary maintenance.

These elements include the various fire divisions, structural members and exits. With the systems design approach, cost of the fire-resistance functions of these building components can be offset by assigning them additional functions, where feasible.

Other elements, such as detectors, automatic sprinklers and the emergency HVAC system, require at least frequent observation of their condition, if not constant supervision.

Personnel at a properly equipped control center, which may include an electronic computer,

supplemented by personnel performing scheduled maintenance, can efficiently provide supervision. The control center can continuously monitor alarms, gate valves, temperatures, and air and water pressures and perform other pertinent functions. In addition, in emergencies, the control center can hold two-way conversations with occupants throughout the building and notify the fire and police departments.