SECTION 5 - BUILDINGS & FIRE
UNIT 1 - FIRE SAFETY & BUILDING DESIGN

UNIT GOAL
To introduce the student to the fundamentals of fire safety in relation to building design and its im pact on life safety.

UNIT OBJECTIVES
The student by the end of the semester shall:
- List three [3] objectives of fire safe design
- List at least three [3] elements of building fire safety
- List the three [3] considerations regarding site planning as it applies to fire safety

KEY TERMS
Life Safety
Property Conservation
Continuity of Building Operations

INTRODUCTION
Building construction and design practices have changed greatly over the past century. These changes have brought structural steel, reinforced concrete, and the development of the "high-rise" building. Fire protection has also made considerable strides in the building industry. In the early part of the century it was not uncommon to see many buildings destroyed by conflagrations. In later years a better understanding of fire behavior in buildings has allowed us to construct buildings in such a manner to confine the fire to the building of origin and not allow it to spread to other buildings or blocks of buildings. This progress has continued to the point where we are able to design buildings do the fire will not extend outside the room of origin and possibly even smaller divisions within the structure.

OBJECTIVES OF FIRE SAFE DESIGN
A conscious and integrated process of design must be used for fire safety in buildings. If fire safety is to be effective and economical it must be integrated into the architectural process. A first step is to develop objectives that a fire safe design must meet. These objectives must meet an acceptable level of risk for the building and the occupants. The three objective concentrations are: *Life safety, Property conservation, Continuity of building operations.*

Life Safety
Adequate life safety must go beyond the local building codes. The first step is to identify who the occupants of the building are. What are their physical and mental capabilities? What is the range of activity over a seven day, 24 hour period? Are any special considerations needed for certain times of the day or week, or other special times? In short the building designer must consider special life safety needs for the occupants during the entire period of operation of the building.

Property Conservation
It must be determined if property in the building has a special value, monetary, or other value. In some cases a specially protected room or area must be designed to protect certain property or records necessary to the occupants operation. The fire safety objectives must determine if the owner of the building has special property considerations that need to be met.

Continuity of Building Operations
The continuity of the building's operations is the third important concern in a fire safe design. What is the greatest amount of "downtime" that can be tolerated is a factor in designing the building. Area that are sensitive to the operation should be given particular attention. In some modern buildings certain rooms may contain or store sensitive or vital information. It is necessary that extra protection be considered in the design process to protect these areas from the products of a fire.

ELEMENTS OF BUILDING FIRE SAFETY

Some of the basic elements that should be considered in building design are *fire prevention, preventing rapid initial growth of spread, designing counter measures to fire growth, detection and alarm, automatic suppression, compartmentation, design for evacuation and occupant movement, and design to help the fire department.*

Fire Prevention
The first opportunity to achieve fire safety is to stop ignition from happening. This involves separating the fuel form any potential heat sources. Since most building fires are started by heat sources and ignitable materials that are brought into the building, and not what is built into the building, it is logical that preventing these potential fire starters from entering the building is a primary goal. From this aspect the preventing of fires from the architect and builder is limited, but from the building owner, manager, and occupants view they have numerous ways of preventing fires from starting.

For design purposes, the adherence to codes and standards will help enhance fire prevention efforts. The proper design and installation of electrical and lighting systems, heating systems, cooking, refrigeration, air conditioning, and ventilation systems can help in preventing fires from occurring. Regular maintenance of these systems as well as routine housekeeping can also aid in prevention of fires. The external design of the building also has an effect on fire prevention. The protection of the exterior from lightning and exposure fires from other structure aids in the prevention part of the design.

Preventing Rapid Initial Growth or Spread
The concern here is to slow the progress of the fire once it has started. This also includes any of the combustion by-products (smoke, heat, flame, fire or toxic gases). The design of the building should provide countermeasures to these potential problem areas. Concern in the area of life safety must be to smoke and toxic gases, since these are the biggest killers in most building fires. Next is heat, this causes less deaths but does have a direct affect on injuries that occur. Next is thermal and smoke damage to the structure and to the property inside the building.

The areas to concentrate are limiting flame spread by using materials that have finish that does not propagate flame. The limiting of vertical and horizontal spread through channels in the buildings structure and interior finish is also important.

Designing Countermeasures to Fire Growth

The building fire safety system can be organized around the fire growth and its resulting products of combustion. How easy these products are generated and moved are in direct relation to the countermeasures designed in the building. The speed of fire growth and development in rooms can vary greatly. If the contents and interior finish are safe, the likelihood for a fire spreading once it is ignited is small.

The traditional method of describing the fire growth hazard has been to determine the fire load (fuel load) of the building. This is based on the combustible materials in the structure. Once this is determined the building is classified by a type of hazard. The greater the combustible fire load (flammable liquids, large quantities of Class A fire materials) the higher the hazard class. That is why storage, industrial, and mercantile occupancies have a greater hazard class than educational or residential occupancies. This has been the basis for determining occupancy types in most of the building codes throughout the country.

When looking at the fire safe design of the building there are other factors to consider besides fuel or fire load. The fire growth hazard should be looked at also. This identifies the speed and the likelihood of the fire reaching full development. The main factors to consider are the fuel load (type of material and its distribution); interior finish of the room; air supply; and size, shape and construction of the room. Based on this the proper type of suppression system can be determined to best control the fires growth and spread.

Detection and Alarm

In the fire safe design there needs to be provisions for detection of the fire. This detection can allow manual or automatic fire suppression equipment to be activated, activation of systems to limit fire spread (fire doors, dampers) and allow for compartmentation, and provide ample time for the occupants to go to a safe area, preferably outside the building. It is important that detection be provided to shrink the rapid initial fire growth, which will have a direct impact on saving life and property.

Automatic Suppression

For more than 100 years automatic sprinkler systems have been the most important system for control of unfriendly fires. Some of the advantages of automatic sprinkler systems are they operate directly over the fire, they are unaffected by the products of combustion, they provide extinguishment of the fire with a minimum of water so water damage is lessened. There are other suppression systems, theses are usually used for specific hazards. Some of these are Carbon Dioxide systems, Foam systems, Halon systems, and Dry-Chemical systems.

Automatic sprinklers have had a remarkable success rate in controlling and extinguishing fires, but it is possible for sprinkler systems to fail. Most of the reasons for failure are either they were under designed for the hazard use, failure to perform needed maintenance, lack of inspection of system. During the design process the automatic suppression system should be designed to meet the type of hazard that will be in the building.

Compartmentation

Barriers, such as, walls, partitions ,and floors can delay the spread of fire from one room to another, or one floor to another. The effectiveness of these barriers are the fire resistance of the material, details of construction, and penetrations, such as, doors, windows, ducts, pipe chases, and electrical raceways. Most barriers are fire rated, but this rating is no guarantee that the barrier will hold for that specific amount of time. If the barrier is penetrated and not protected the fire may extend past the barrier and into another

room or area. This may be caused by unprotected pipe chases, duct work, or the leaving open of a window or door that is part of the fire resistance of that barrier. These fire barriers also help to maintain the structural integrity of the structure and of the escape routes.

Design of Evacuation and Occupant Movement
The design for life safety may involve one or a combination of alternatives. Some of these are: *evacuation, defending in place, refuge.*

In designing a building with evacuation in mind involves

- the availability of an acceptable path or paths for escape
- the effective alerting of the occupants in sufficient time to allow egress before segments of the path become untenable.

The second life safety design alternative is to defend the individual in place. This can be appropriate for hospitals, nursing homes, or prisons. These types of occupancies can be difficult to evacuate because of the type of occupants it houses. Many of these occupants have limited mobility because of physical or mental limitations. Defend in place uses a performance criteria of time and tenability levels.

Helping Fire Departments
A building is usually designed so that a if a fire occurs it can either be extinguished by a suppression system, limited in spread by compartmentation, or limited in rate of growth by interior finish. Each of these should allow a small fire that has not spread quickly to be encountered by the fire department on arrival. The aspects of the building design that can assist the fire department are: *fire department notification, agent application, manual extinguishment, ventilation, water supply and use, and water removal.*

The chain of events that notifies the fire department, detection, decision to inform fire department, sending the message, correct receipt of message, should be part of any fire safe building design. The time delay of notification can have a dramatic affect on the extinguishment of the fire. Many buildings have been lost due to a delay in notification.

The next critical event is the application of extinguishment agent by the fire department. There are three distinct events that occur, these are: *arrival at site, nozzle entrance into room, water discharge from nozzle*. Each of these events can be affected by access considerations of the design. The ideal access is that all sides of the building are accessible, which is not always the norm. The ability to advance the nozzle into the fire room or area is important, but can be time consuming depending on the configuration of the structure and the ease at which the fire department can access it. If the design of the building is one that does not allow adequate ventilation this can have an effect on the application of water on to the fire.

Once the notification and agent application events have transpired, which can be time consuming, the extinguishment of the fire takes place. There are three categories that manual extinguishment can take:

- small fires can be extinguished with a direct application of water
- larger fires must first ventilated (removal of products of combustion from building)
- large fires must be surrounded to prevent extension to other buildings or structures

Ventilation involves the removal of products of combustion from the building. Ventilation provides the following benefits.

- Protection of life by diverting toxic smoke, heat, and gases form occupants.
- Improve the environment to allow for more effective attack on the fire.
- Controls the spread of the fire by keeping it from unaffected areas.
- Limits the possibility of a backdraft or smoke explosion.

It is important that the building designer be aware of the functions of fire ventilation and provide means for making this task easier for the firefighter. This can be removable access panels, windows, and skylights. Emergency controls for the buildings mechanical ventilation system.

Since water is the principle agent for extinguishment it is important that provisions in the building design be made to provide and adequate water supply to control the fire. This includes the water distribution system and system pressure. The water system must be designed to provide adequate pressure and flow for the automatic sprinkler system and for manual fire control by the fire department. This includes spacing of fire hydrants, effective standpipe systems for the building, backup water supply for the in-house suppression system.

Because water weighs about 8.5 pound per gallon, it can have a serious effect on the structural integrity of the building if the means are not provided to effectively remove it.

SITE PLANNING

How an architect designs the site for the building can have a direct impact on fire department operations. Three major considerations are: *traffic and transportation, fire department access, and location of hydrants*.

Traffic and Transportation

The response time of a fire department is major factor in fire control. Since fire apparatus must respond during any part of the day to fires the traffic patterns and conditions can have a major impact on fire department operations. While certain types of roadways may attract motorists to a particular area, they may not be helpful to fire departments trying to reach the scene. Limited-access highways can have a direct effect on the fire departments ability to get to a fire scene in a short period of time if there are no access routes near to where the fire is. Limited-access highways can also divide a town or city in to areas that are not readily accessible to fire apparatus.

Fire Department Access

Ideally, access form all sides would help fire department operations during a fire. This is not always the case, sometimes the access to buildings can be limited. This can be as a result of the distance from the roadway and water source, or by the layout and topography of the land around the building. Limited access can delay setting up of ground ladders, hose lines, positioning of apparatus to perform their functions. All of this will severely limit the fire department. If the designers does not take into account the need for fire department access in the development stages, then a more extensive in-house automatic suppression system must be installed to counteract the delay that will occur in setting up operations by the fire department.

Location of Hydrants

Many times inadequate attention is given to the location of fire hydrants. Poorly spaced hydrants on a limited water supply system can be dire results for the fire department in setting up an adequate water supply to combat the fire.