

SECTION 1 - FIRE & PEOPLE

UNIT 4 - HUMAN BEHAVIOR AND FIRE

UNIT GOAL

To introduce the student to factors that affect people's behavior during emergency situations

UNIT OBJECTIVES

The student by the end of the semester shall:

- identify the following concepts as they apply to life safety
 - time
 - fire hazard
 - interval for action
- describe the decision process for individuals as they relate to a fire threat
- identify at least three [3] behavioral actions of occupants
- define panic behavior
- identify four [4] characteristics of occupants as they relate to people at risk in a fire situation
- identify three [3] life safety strategies

KEY TERMS

Decision Process of Individuals

Panic Behavior

Characteristics of Occupants

Life Safety Strategies

INTRODUCTION

Only in the past 40 years has any serious study been done to how people act in emergency situations. This is a critical area of study that determines what is the best method of fire protection we can use in structures. This knowledge also impacts how we educate people about the dangers of fire. Over the centuries tens of thousands of people have died in fires. A study of human behavior can provide us with information to better develop strategies of limiting the number of deaths that occur at fires. In this lesson the student will be introduced to some basic principles of human behavior and how they relate to and are affected by emergency situations.

BASIC CONCEPTS

- Life safety involves avoiding exposure to harmful products of combustion. There are three directions that can be taken. The first is to prevent ignition, the second is to control the fire process, the third is to separate the individuals from the harmful effects of the products of combustion by *time, distance, or shielding*.
- **Time**
 - As the fire develops over time, smoke and heat will buildup to create a hazardous environment. The rate at which this occurs is difficult to predict because the number of

variables. Most fire will develop slowly and are small, as time goes on they will build in size and intensity, creating a much more hazardous environment. At some time the fire will be detected by either automatic or personnel detection. It is at what time the fire is discovered in relation to its ignition and development that will have a major impact on life safety.

■ **Fire Hazard**

- The critical time will be affected by three sets of conditions that interact. These are *elevated environmental temperatures, toxic conditions, and the pre-existing or current psycho-physiological attributes of the occupants*. Elevated temperatures can cause burns or heat stress that can be minimal or lethal. Toxic conditions can occur from the by-products that are created during the combustion process. The pre-existing or current psycho-physiological attributes of the occupants will be affected by the conditions created by the elevated temperatures or the toxic by-products. Examples of a pre-existing heart condition or the age of the occupant.

■ **Interval for Action**

- The interval between fire discovery and its criticality is the time that is available to undertake action to prevent occupants from being exposed to the fire hazards. This action may be the activation automatic equipment for extinguishment or confinement of the fire, evacuation of occupants, or both. The sooner the fire is discovered the more time there is for action. The hazard does not always grow at the same rate as the fire. The effect of an automatic suppression system or a detection system may slow the rate of the hazard.

THE HUMAN FACTOR

Two different people can react differently to the same situation when it occurs. One of these people can also act one way today and totally different a week from now. There are certain factors that will determine how we will act under fire situations. How we react to heat, smoke and flame is based on the following

- **Age** - the very young and the elderly are less able to withstand the effects of fire. Statistics show that these two age groups have the highest fatality rate during fires
- **Size** - larger people can tolerate higher doses of toxic materials that are generated during a fire. But size can also be a negative factor when considered with a lack of physical conditioning
- **Pre-existing physical condition** - the overall condition of an individual will have an effect on their survivability in a fire. This includes
 - cardiac stability
 - aerobic condition
 - mobility [weight, flexibility, muscular/skeletal diseases]
- **Respiratory capacity** - the majority of fire deaths are a result of smoke inhalation. Because of this a person's respiratory capacity is critical to their survival. Any chronic diseases such as emphysema or asthma will lower this capacity. Acute conditions such as flu, pneumonia will also have an effect on capacity. Cigarette smoking will also raise the body's level of carbon monoxide which will reduce the body's ability to take in oxygen.
- **Medication, drugs, alcohol** - over the counter and prescribed drugs, as well as alcohol can reduce a person's ability to recognize a dangerous situation and react to it. Recent estimates say that at least 10% of the residential fatalities were impaired by alcohol or drugs. The age group of 20 to 64 years old were twice as impaired as the general population. Estimates also show that men are more prone to be affected by drugs or alcohol than women.

HAZARDS FROM FIRE

How people react to fire is impacted by the hazards produced by a fire situation. The conditions to be aware of are Temperature, Heat, Smoke, Oxygen Depletion.

- **Temperature** - The effects vary with the length of exposure. Humidity and breathability also have an effect. Severe discomfort can occur with temperatures as low as 122°F and temperatures above 150°F are considered as incapacitating. Temperatures above 212°F will cause death. The following table shows the physiological effects of heat.

TABLE 1 - PHYSIOLOGICAL EFFECTS OF HEAT	
PHYSIOLOGICAL EFFECTS	TEMPERATURE in °F
Possible heatstroke	140
Able to tolerate temperature for 49 minutes	180
Very rapid skin burns in humid air	212
20 minute tolerance	240
Difficulty breathing through nose	260
Difficulty breathing through mouth	300
Temperature limit for escape	300
Rapid, unbearable pain to dry skin	320
Ability to tolerate temperature drops to less than 4 minutes	390
Respiratory system threshold	390

- **Heat flux and burn injuries** - This is the measurement of how much heat is available for transfer to a human skin [or other surface]. The upper limit is 2.5 kW/m² for 3 minutes without severe pain. This is equivalent to holding your hand a few inches above a 100 watt light bulb for 3 minutes. **The higher the temperature the more quickly the burn injury will occur.**

TABLE 2 - TEMPERATURE AND TIME TO SECOND DEGREE BURNS	
Skin Surface Temperature in Degrees F.	Time[in Seconds]
160	60
180	30
212	15

- **Smoke Obscuration** - Smoke has several negative effects - reduced visibility; irritation and toxicity caused by inhalation; causes fear. This reduces a person ability to escape
- **Oxygen Depletion** - Normal oxygen in the atmosphere is 21%. When this percentage drops it causes physiological effects.

TABLE 3 - PHYSIOLOGICAL EFFECTS OF REDUCED OXYGEN	
Oxygen in Air [%]	Symptoms
21	None - normal conditions
17	Some impairment of muscular coordination; increase in respiratory rate
12	Dizziness, headache, rapid fatigue
9	Unconsciousness
6	Death within minutes

- **Exposure to fire gases** - There are many fire gases present in a fire situation, the biggest problem is with Carbon Monoxide [CO]. CO accounts for more than half of all fire-related deaths. CO attaches itself easily to the red blood cells [the oxygen carrying cells] in the human body. This decreases the bodies ability to carry oxygen throughout the body. Even in small amounts it can be dangerous. CO is also accumulative. This means that several exposures over a period of time can allow enough CO to buildup in the body to be fatal

TABLE 4 - TOXIC EFFECTS OF CARBON MONOXIDE	
CO in Air [%]	Symptoms
0.01	No symptoms - no damage
0.02	Mild headache; few other symptoms
0.04	Headache after 1 to 2 hours
0.08	Headache after 45 minutes; nausea, collapse; unconsciousness after 1 hour
0.10	Dangerous - unconsciousness after 1 hour
0.16	Headache, dizziness, nausea after 20 minutes
0.32	Headache, dizziness, nausea after 5 to 10 minutes; unconsciousness after 30 minutes
0.64	Headache, dizziness, nausea after 1 to 2 minutes; unconsciousness after 10 to 15 minutes
1.26	Immediate unconsciousness, danger of death in 1 to 3 minutes

HUMAN BEHAVIOR DURING FIRES

■ **What Happens During a Fire**

- How people react during a fire is impacted by the items previously mentioned
- How someone becomes aware of the fire is going to have a direct impact on their actions.
- It is obvious that the way an individual is alerted to the fire will have an affect on the way the threat is perceived. There are several ways that individuals can be made aware of the fire threat. Some of the are the following. Through vocal alerting systems in the buildings, the voice quality, pitch, volume and content of the message will have a direct effect on how they perceive the threat. The odor of smoke is another way of being notified of the threat of fire. Personal notification is another means of notification that combines being notified by “family members” or by “others”. Noise is another method of notification. This includes persons moving up and down stairs, in corridor, and the sound of the fire department arriving and working. **(See Table 5)**

TABLE 5 - MEANS OF AWARENESS OF THE FIRE INCIDENT	
MEANS OF AWARENESS	PARTICIPANTS
Smelled Smoke	148
Notified by Others	121
Noise	106
Notified by Family	076
Saw Smoke	052
Saw Fire	046
Explosion	006
Felt Heat	004
Saw/Heard Fire Department	004
Electricity went off	004
Pet	002
TOTAL	569

- In studies done in England and the United States it was found that among the participants in both studies that the most frequent items done were *evacuation of the building, fight or control the fire, alert other individuals, and alert the fire department*. The studies showed that the behavior of individuals varied by sex, with female and male behavior divided along culturally determined primary group roles. The male were predominate in the firefighting aspects of the study and females were predominately concerned with alerting others and helping them leave the building. (See Table 6 & 7)

TABLE 6 - COMPARISON OF THE BEHAVIOR OF BRITISH AND U. S. POPULATIONS		
BEHAVIOR	BRITISH [%]	U. S. [%]
Evacuation	54.5	80.0
Re-entry	43.0	27.9
Firefighting	14.7	22.9
Moved Through Smoke	60.0	62.7
Turned Back	26.0	18.3
British Total	2193	
U. S. Total		584

TABLE 7 - FIRST ACTIONS OF OCCUPANTS RELATIVE TO SEX OF OCCUPANT		
FIRST ACTION	MALE [%]	FEMALE [%]
Notified others	16.3	13.8
Searched for Fire	14.9	06.3
Called Fire Department	06.1	11.4
Got Dressed	05.8	10.1
Left Building	04.2	10.4
Got Family	03.4	11.0
Fought Fire	05.8	03.8
Got Extinguishers	06.9	02.8
Left Area	04.6	04.1
Woke Up	03.8	02.5
Nothing	02.7	02.8
Had Others Call Fire Department	03.4	01.3
Got Personal Property	01.5	02.5

Went to Fire Area	01.9	02.2
Removed Fuel	01.1	02.2
Entered Building	02.3	0.09
Tried to Exit	01.5	01.6
Went to Fire Alarm	01.1	0.19
Telephoned Others	00.8	01.6
Tried to Extinguish	01.9	00.6
Closed Door to Fire Area	00.8	01.3
Pulled Fire Alarm	01.1	00.6
Turned Off Appliances	00.8	00.9
Checked on Pets	00.8	00.9
Other	06.5	02.5
Total Respondents	262	318

■ **Panic Behavior**

- The media tends to show that fire and panic are closely linked
- Over the past 30 years more and more studies have been done regarding panic. What this has shown is that in most cases panic did not occur. An early definition of panic was - **A sudden and excessive feeling of alarm or fear usually affecting a body of persons, originating in some real or supposed danger, vaguely apprehended, and leading to extravagant and injudicious efforts to secure safety.**
- In 1982 Dr. John Keating wrote an article for the NFPA magazine - Fire Journal, entitled - "The Myth of Panic". In this article he identified certain elements that were essential to panic behavior. He also developed an new definition for panic - **A fear-induced flight behavior which is non-rational, nonadaptive, and nonsocial, which serves to reduce the escape possibilities of the group as a whole.**
- The four elements of panic are:
 - A hope for escape, even with closing escape routes
 - Contagious behavior, especially if keyed by leaders of the group affected by the fire.
 - "Aggressive concern" by the individual for his or her own safety, as opposed to concern for others in the same fire
 - Irrational, illogical response to the fire situation
- He also wrote that one or more of these elements were missing in most fire evacuations

- There is usually no evidence of panic when there is no hope of escape
- Contagious behavior is very common in emergencies or ambiguous situations simply because people tend to “follow the leader” in times of stress or when they need reassurance about the right thing to do. Panic occurs in those instances where an individual does not follow the actions of the group
- People often help others - even at great personal risk.
- Escape strategies that are unsuccessful are not necessarily irrational or illogical
- As few as one third of the victims in the **Coconut Grove** panicked. There was no panic behavior among the 164 victims of the **Beverly Hills Supper Club** fire.

MAKING SENSE OF HUMAN BEHAVIOR DURING FIRES

- How people react during a fire is based on a complex pattern of human behavior. This can be grouped together in a process called **Decision Process of the Individuals**.
- People use six basic techniques to decide what to do in an emergency situation. These are recognition, validation, definition, evaluation, commitment, and reassessment
- **Recognition** - The recognition process happens when the individual perceives cues that indicate a threat of fire. These cue may be ambiguous and not always indicative of a severe fire. This is where something “does not feel right” to the person. The threat is unrecognized until flame, heat, or smoke are seen
- **Validation** - The validation process consists of attempts by the individual to determine the seriousness of the threat cues. Question such as “Do we evacuate the building?” or “Do you smell smoke?”
- **Definition** -.The definition process basically consists of an attempt by the individual to relate information concerning the threat to some certain variable, such as the qualitative nature of the threat, the magnitude of deprivation of the threat, and the time context. In this part the person will determine a course of action on “How much smoke do we see” or “How much heat do we feel”
- **Evaluation** - The evaluation process can be described as the cognitive and psychological activities required for the individual to respond to the threat. The individuals ability to reduce their stress and anxiety levels became an essential psychological factor. In this process the threat created by the fire will determine the decision of whether to fight the fire or take flight. Because of the speed at which the fire grows and intensifies, the time frame for this evaluation is usually completed in a few seconds.
- **Commitment** - This part of the process consists of mechanisms the individual will use to initiate the behavioral activity required to fulfill the defense plan that was developed in the evaluation process.
- **Reassessment** - This is the most stressful of the processes for the individual because the last process has failed. As successive failures are encountered the individual will become more frustrated. At this point the possibility of injury and risk increase with a greater activity level and with less probability of success. At htis point decisions become less rational

OTHER ACTIONS AFFECTING PEOPLES REACTION TO FIRE

- AVOIDANCE** A person can feel that they protect themselves, from a psychological standpoint, denying unpleasant situations. This is a form of denial that is common in early stages of a fire. Avoidance is one of the reasons that many people delay their reaction to a fire, by treating the alarm as a “false alarm”
- COMMITMENT** Most persons are committed to what they are doing at the time, work projects, leisure activities, personal projects, etc. When a person picks up cues of a fire they will continue working despite the danger warnings. People will finish up what they are doing and then evacuate the danger area, even though the alarm has sounded. At other times a person may see the warning signal that a fire alarm is occurring, but still enter the building as if nothing is wrong.
- AFFILIATION** People are social animals, and tend to act as a group, whether they know the people or not. Most people leave together in a danger situation, and the speed of the evacuation is usually based on the speed of the slowest member. This affiliation explains why parents will not leave without their children, and why people will wait for co-workers and even strangers.
- ROLE** The role or status of someone will determine how they will react in a fire situation. Someone unfamiliar with a building or facility, i.e., a visitor, may take more time to react to a fire threat than someone who works or lives there. People will tend to turn to someone “in the know”, such as a supervisor, security personnel, or firefighter for information on what to do next in the emergency.

LIFE SAFETY STRATEGIES

- Ideally, building design considers the risk factors that are associated with occupants and fires, and includes the safety features that might mitigate the risks. Some of the strategies that are used to limit these risks are *fire prevention, fire management, occupant management*.
- **FIRE PREVENTION**
 - If there is no fire than there is no harm from it. Fire prevention methods have the potential to eliminate fire safety measures. But, since fire prevention is not totally effective it can not be relied on as the sole answer to fire control. Fire prevention relates to the control of heat sources and their coming in contact with burnable fuels. Fire prevention also deals with the major cause fires - humans.
- **FIRE MANAGEMENT**
 - Since we cannot control all ignitions, we must consider the management of the fires. This strategy attempts to control the rate of production of smoke and heat by controlling the combustion process by manual or automatic suppression, and to control the products of combustion through ventilation and/or containment. The objective of fire management is to reduce the risks associated with fire growth, and to reduce fire and smoke spread.
- **OCCUPANT MANAGEMENT**
 - This is the most complex of the strategies, because we are dealing with people. Occupant management involves undertaking emergency action appropriate to the expected fire development and to the characteristics of the occupants. To initiate occupant management there must first be detection and alerting activities. The functions performed by this equipment involves evacuation, refuge or rescue. Evacuation is the most common approach for occupants that are alert and mobile. Areas of refuge from fire and smoke

- are employed to move occupants in the building to safe areas to await emergency personnel.
- Emergency egress systems should be assessed in terms of their adequacy and reliability. Adequacy refers to the structural components that determine the capacity to evacuate part or all of a building in a safe time span. Reliability considers how efficient the egress capacity will be used. Some factors of reliability include alerting messages and instructions, signage and emergency lighting, protection of egress routes from the products of combustion.

RECOMMENDED REFERENCES

- NFPA Fire Protection Handbook, 18th Edition, 1997, NFPA
- Principles of Fire Protection, by Cote & Bugbee, 1976, NFPA
- Fire & Life Safety Educator, 2nd Edition, 1997, IFSTA
- <http://www.nfpa.org>
- <http://www.ifsta.org>