



**Chapter 2:
Fire Behavior, Systems and
Devices, and Fire Prevention
Pages 34 - 64**



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Objectives (1 of 3)

- Describe the stages of fire, types of heat transfer, and the fire triangle and tetrahedron (NFPA 4.1.1). (pp. 36–37)
- Demonstrate an understanding of the history of fire prevention and the resulting agencies and codes. (pp. 39–42)
- Identify organizations and sources of codes for reference. (pp. 42–44)

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Objectives (2 of 3)

- Discuss the behavioral and physical arrangements and changes businesses, schools, and other public facilities can make to comply with codes that will result in safer conditions for occupants. (pp. 45–48)
- Differentiate among basic fire detection and suppression devices and explain their benefits when installed correctly (NFPA 4.1.1). (pp. 50–58)

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Objectives (3 of 3)

- Dispel misconceptions regarding the operation and cost of commercial and residential sprinkler systems (NFPA 4.1.1). (pp. 57–60)
- Discuss the need to investigate new fire safety and injury prevention technology as it relates to the work of fire and life safety educators. (p. 60)

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Introduction

- Safety educators should understand the basic principles of fire science and fire prevention.
 - It is essential in providing the public with understandable explanations.
 - Care should be taken to keep explanations simple.

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Introduction

- Fire and life safety educators
 - Interact with the public
 - Schools, churches, etc.
 - Well-planned presentation
 - Roadmap for messages to be taught
 - Will not always cover questions that arise
 - Must understand basic principles
 - Answer questions
 - Provide explanations

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Fire Behavior

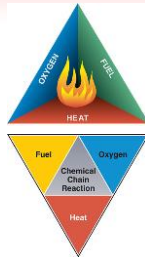
- What is fire?
 - Burning or combustion
 - Chemical chain reaction
 - Rapid oxidation of a fuel
 - Release of heat and light
 - Explained by the fire triangle
 - _____, _____, _____
 - Fire tetrahedron
 - Includes _____, _____, _____, _____

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Fire Behavior

- What is fire?
 - A chemical chain reaction that includes a self-sustaining rapid oxidation of a fuel accompanied by the release of heat and light



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Fire Growth

- Exothermic reaction
- Forms of heat transfer
 - Conduction
 - Convection
 - Radiation

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Fire Growth

- Exothermic reaction: transfer of heat
- Forms of heat transfer
 - **Conduction**
 - Heat transfer through a _____
 - **Convection**
 - Heat transfer through _____
 - **Radiation**
 - Heat transfer through _____

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Fire Stages (1 of 5)

- The four stages of fire
 - Incipient
 - Growth
 - Fully developed
 - Decay



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Fire Stages (2 of 5)

- Incipient or the ignition stage
 - When the materials reach their ignition temperature, a fire is started.
 - Spontaneous combustion or spontaneous heating occurs if a material is able to heat to the point of ignition because of an internal heat source.
 - Ignition point is the temperature at which an object begins to burn.

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Fire Stages (3 of 5)

- Growth stage
 - The speed of the growth of the fire depends on several factors:
 - Oxygen supply
 - The amount and type of available fuel
 - The size of the room or structure
 - The amount of insulation containing the heat transfer
 - Flashover
 - The transition between the growth stage and the fully developed stage

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Fire Stages (4 of 5)

- Fully developed stage
 - Air supply impacts the speed and extent of the fire.
 - Oxygen is consumed rapidly during this stage.
 - Products of combustion are given off.
 - When winds fan the flames and quicken the spread, the fire is known as a conflagration.

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Fire Stages (5 of 5)

- Decay stage
 - All fuel has been consumed.
 - The fire begins to weaken and extinguishes itself.
- Backdraft
 - A sudden and explosive ignition of pressurized, superheated, and oxygen-deprived gases
 - Happens within an enclosed space when oxygen is reintroduced

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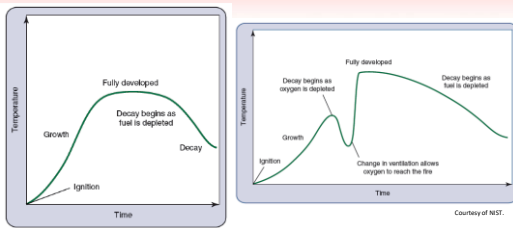
Emerging Studies in Fire Growth Stages (1 of 2)

- Many factors that contribute to fire growth have changed in recent years.
 - Energy-efficient features also create a ventilation-limited environment.
 - As a result, fires release energy faster and reach their flashover potential sooner.
- Educators must be aware of new advances in these areas.
 - It affects the messages to be delivered to the public regarding protection and evacuation.

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Emerging Studies in Fire Growth Stages (2 of 2)



A traditional fire growth curve with a fuel-limited fire.

Illustration of a ventilation-limited fire.

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Fire Classification (1 of 4)

- Based on the type of fuel that is burning
- Determines the type of extinguishment to be used
- Class A fire
 - Involves ordinary combustibles
 - Extinguished with water, water-based agents or foam, and multipurpose dry chemicals

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Fire Classification (2 of 4)

- Class B fire
 - Involves flammable and combustible liquids, gases, and greases
 - Extinguished with multipurpose dry chemical extinguishers, carbon dioxide (CO₂) extinguishers, and foam
 - Attempting to extinguish with water can actually make the fire worse by spreading the burning liquid.

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Fire Classification (3 of 4)

- Class C fire
 - Involves energized electrical equipment
 - Key to extinguishing is disconnecting the source of electricity.
- Class D fire
 - Involves metals and alloys
 - Best extinguished with Class D dry powder extinguishers

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Fire Classification (4 of 4)

- Class K fire
 - Involves high-temperature combustible cooking fuels
 - Extinguished with Class K agents, considered wet chemicals

TABLE 2-1 Classification of Fires and Extinguishing Agents

Fire Class	Description	Examples	Extinguishing Agent
A	Common combustibles	Wood, paper, cloth, plastic, rubber	Water, dry chemical, foam, some halon
B	Flammable or combustible liquids	Gasoline, oil, grease, LPG, alcohol, petroleum-based paints and stains	CO ₂ , dry chemical, halon, foam
C	Energized electrical equipment	Energized class A materials such as household appliances or class B materials heated by electricity	CO ₂ , dry chemical, halon Remove source of electricity
D	Combustible metals	Magnesium, sodium, potassium, titanium	Dry powder
K	Cooking appliances with combustible media	Deep fat fryers using vegetable and animal fats and oils	Wet chemical

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The History of Fire Prevention and Code Development

- The first known fire prevention code, the Code of Hammurabi, dates to about 1772 BC.
- English cities continued their work to prevent fires by passing ordinances.

TABLE 2-2 Early Fire Prevention Regulations: A Brief History	
England	1066: All home fires are to be extinguished at the ringing of a bell. 1189: Stone, slate, and tile houses are recognized as safer from fires. 1500s: Businesses of candle makers and bakers regulated—no wooden chimneys and thatched roofs; brick or stone firewalls mandated. 1668: Building height limited to five stories. 1763: Piercing of fire walls prohibited.
Salem, Massachusetts	1663: Annual chimney cleaning required.
Boston, Massachusetts	1700s: Boston General Court orders all buildings to be constructed of brick or stone with slate or tile roofs. This order was never enforced.
Reading, New York	1897: No fireworks for children.
New York, New York	1860: Fire stairs and fire escapes required.
Columbus, Ohio	1897: Fire companies start performing fire inspections.

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The Nation Looks at Fire Prevention (1 of 2)

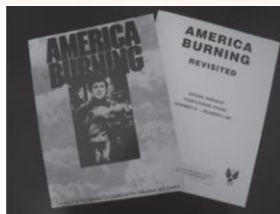
- Timeline:
 - 1911: The first Fire Prevention Day was observed.
 - 1913: The First American National Fire Prevention Convention was held.
 - 1940: Insurance Committee for the Protection of American Industrial Plants was organized.
 - 1947: The Presidential Conference on Fire Prevention was announced.
 - 1968: The National Commission on Fire Prevention and Control was established.

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The Nation Looks at Fire Prevention (2 of 2)

- Timeline (cont'd)
 - 1973: The report “America Burning” was presented.
 - 1987: The report “America Burning Revisited” was submitted.
 - 1999: The study and report “America at Risk” was submitted.



Courtesy of Marsha Geisler.

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The Beginnings of Organizing for Code Compliance

- In 1866, the National Board of Fire Underwriters was formed.
 - It has served as the foundation for many of today's fire service and construction codes, municipal water supply and alarm systems, fire apparatus, and fire insurance rating systems.
- The *Wildland-Urban Interface Code*
 - To protect communities living in residential areas near natural areas

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Codes, Ordinances, and the Process

(1 of 4)

- 1892: The National Board Electrical Code, known today as the *National Electrical Code®* (NFPA 70), was formed.
- 1930: The first model fire prevention code, was developed.
- A number of regional codes were also set up.



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Codes, Ordinances, and the Process

(2 of 4)

- 1994: The International Code Council (ICC), consisting of representatives of the BOCA, OCBO, and SBCCI, was established.
 - The ICC developed the International Fire Code (IFC), which references several codes and standards.
- Adoption
 - The process of formally accepting the code and setting it into action

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Codes, Ordinances, and the Process

(3 of 4)

- Basic code types:
 - Specification code
 - Performance code
 - Technical code
- Authority having jurisdiction (AHJ)
 - An organization, office, or individual responsible for enforcing the requirements

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Codes, Ordinances, and the Process

- Important terms

– Standards	– Adoption by reference
– Codes	– Adoption by transcription
– Codified	– Mini-maxi codes
– Model codes	– Specification code
– Adoption	– Performance code
– Ordinances	– Technical code

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Model Code

- Systems of rules, guidelines, methods and regulations developed and accepted through consensus by private not-for-profit organizations with an interest and expertise in that area and made available to governments to formally accept and put into use within their jurisdiction
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Adoption

- By reference
- By transcription

- Examples:

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Mini-Maxi Code

- Codes adopted as a state minimum code and cannot be amended locally
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Specification Code

- A code that specifies a type of construction or materials to be used
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Performance Code

- A code that assigns an objective to be met and establishes criteria for determining compliance
- Examples:

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Technical Code

- A code designed to regulate technical processes such as construction installation of electrical, mechanical, and plumbing systems; regulation of hazardous industrial processes; and building electrical, mechanical, plumbing, and property maintenance code
- Example:

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Codes, Ordinances, and the Process

(4 of 4)

- NFPA 101®, the *Life Safety Code*®:
 - Code addresses occupant safety in buildings with regard to the establishment and maintenance of exits.
- Code compliance through changing human behavior
 - Behavior changes are desirable as they can keep occupants safer.
 - Furthermore, behavior changes are required by code.

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NFPA 101®, the *Life Safety Code*®

- Addresses occupant safety in buildings
 - Exit facility establishment and maintenance
- Result of Triangle Shirtwaist fire
 - 1911: New York garment factory
- Categorizes buildings into occupancy types based on:
 - Use and occupant characteristics
 - Processes taking place within

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Occupancy

- Model building and fire codes and NFPA 101 classify buildings into 10 general classifications.
- Two high-risk occupancy groups:
 - Group A: Assembly occupancies
 - Group E: Education occupancies



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Storage

- Accumulation of “stuff” constitutes additional fire load, blocks exits and pathways, and presents tripping hazards.
- Poor storage habits also compromise the effectiveness of a sprinkler head.



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Means of Egress

- Exit access
- Exit
- Exit discharge

Exit Access →
Exit - - - - ->
Exit Discharge →

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Holidays and Provisions for People with Disabilities

- Holidays
 - Present the potential for many fire hazards
- Provisions for People with Disabilities
 - Americans with Disabilities Act (ADA) of 1990 prohibits discrimination based on disability.
 - Defend-in-place strategy allows occupants to remain in the structure in a protected area until the fire department can assist them in evacuating.

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Types of Hazards and Home Inspections

- Types of Hazards
 - Fire hazard
 - Common fire hazard
 - Personal fire hazard
 - Target fire hazard
 - Special fire hazard
- Home Inspections
 - Inspectors need to be invited to inspect private areas.

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Fire Hazards

- **Common Fire Hazards** – those prevalent in almost all occupancies – **can be poor housekeeping**
- **Personal Fire Hazards** – common hazards caused by the unsafe acts of individuals. The result of attitudes and behaviors the FLSE I must try to change – **example is use of candles**
- **Target Hazards** – properties where there is a great potential for loss of life or property loss if fire (**hospitals, schools, shopping centers, nursing homes**)

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92% of Fire Deaths happen in Residential Occupancies

Least Inspectable
 Most Susceptible
 Must Educate

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Fire Hazards (Cont'd.)

- **Special Fire Hazards** – arise from or related to the particular process or operation in an occupancy. Commercial and manufacturing occupancies present these situations depending on the contents, use of high-piled storage, and processing. Overcrowding in public assemblies (blocked exits, interior furnishings, storage in means of egress)

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Fire Protection Systems

- Fire Alarm and Detection Systems
 - An initiation device is connected to a fire alarm system. When triggered, it sends a signal to the control panel.
 - The signal then passes through the alarm system to a fire alarm control panel (FACP), where it is then directed to the notification device.

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Fire Alarm and Detection Systems

- Emergency voice/alarm communications system (EVACS)
- Voice override system
- Pull stations
- Heat detectors
- Smoke detectors and smoke alarms
- Gas detectors and flame detectors
- Carbon monoxide detectors

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Automatic Sprinkler Systems (1 of 2)

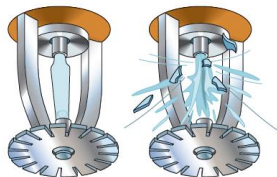
- Properly maintained automatic fire sprinkler systems have proven to be extremely effective in suppressing fires as early as the incipient stages.
 - The system operates by a network of underground and overhead pipes with sprinkler heads connected to the overhead piping at specified intervals.

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Automatic Sprinkler Systems (2 of 2)

- Types:
 - Wet pipe sprinkler system
 - Early suppression fast response (ESFR) sprinkler
 - Dry pipe sprinkler system
 - Preaction sprinkler system
 - Deluge sprinkler system



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Residential Sprinkler Systems

- Type of automatic fire sprinkler system equipped with fast response automatic sprinkler heads specifically designed for low heat release and low water pressures
 - Goals are to prevent flashover in the room of origin and to improve the occupants' chances for escape.
- Different from commercial installations in that residential systems are not required in every room of the home

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Other Fire Suppression Systems and Agents

- Range from simple hood and duct systems in commercial kitchens to sophisticated technologies designed to suppress an explosion
- Employees need to be trained on how to activate the system when necessary, and protective measures to be taken after the system is activated.

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Portable Fire Extinguishers






- Multipurpose A-B-C extinguisher: most commonly required, installed, and used extinguisher today
- PASS method of operation:
 - *P: Pull the pin.*
 - *A: Aim the nozzle.*
 - *S: Squeeze the handle.*
 - *S: Sweep the base of the fire.*



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Fire extinguishers are rated by their intended use

A		Common Combustibles	Wood, paper, cloth etc.
B		Flammable liquids and gases	Gasoline, propane and solvents
C		Live electrical equipment	Computers, fax machines
D		Combustible metals	Magnesium, lithium, titanium
K		Cooking media	Cooking oils and fats

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New Technology – Why Did we Spend Time on This?

Because.....Fire and life safety educators...

- Must stay current with new technologies
 - More effective in answering questions
- Public will ask questions about reliability
 - Research credibility
 - Ask trusted sources before promoting or condemning
 - Always changing!

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New Technology Awareness

- The public looks to the fire service as experts in answering their questions about new products' reliability.
- Questions must be asked to verify the credibility of the new products:
 - Do they meet national standards?
 - Have they been approved and endorsed by national fire safety and protection organizations?

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Summary (1 of 3)

- Fire and life safety educators need a foundation of information about fire science and fire prevention codes to be able to answer questions from the public.
- Even the best efforts to protect citizens from serious fires have been compromised by the improper acts of human beings.
 - This is where educators can be valuable assets to the local fire department.

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Summary (2 of 3)

- It is important to work with the department's fire prevention inspectors.
 - Savvy educators can gain compliance by making real connections to the reasons for the codes in the first place and the advantages they have for the occupants.
- Educators should be aware of new construction, new residential developments, and new businesses moving to their jurisdiction.

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Summary (3 of 3)

- Sometimes the most effective results are gained by teaming up with fire department inspectors and playing the supporting fifth leg of the Five Es of the prevention triangle—engineering, enforcement, and *education*.
- Educators who pay attention to emerging fire safety technology will be more effective in answering questions for the general public.

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Tomorrow's Assignment

- Your Learning Style Profile
- Chapters 4 and 5
- Chapter 14, pages 251-261
- Questions?

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What's Your Learning Style?

- <http://www.educationplanner.org/students/self-assessments/learning-styles.shtml>

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