

Chapter 1

Orientation and Fire Service History



Lesson Goal

After completing this lesson, the student shall be able to describe how the history and culture of the fire service influence its basic mission, the roles within it, and the skills needed to operate as a part of the fire service.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Summarize the history of the fire service.
2. Explain the organizational characteristics, cultural challenges, and cultural strengths that influence the fire service.
3. Describe the mission of the fire service. *[NFPA® 1001, 5.1.1]*
4. Describe the organization of fire departments. *[NFPA® 1001, 5.1.1]*
5. Distinguish among functions of fire companies. *[NFPA® 1001, 5.1.1]*
6. Summarize primary knowledge and skills the firefighter must have to function effectively. *[NFPA® 1001, 5.1.1, 6.1.1]*
7. Distinguish among the primary roles of fire service personnel. *[NFPA® 1001, 5.1.1, 6.1.1]*
8. Describe fire department organizational principles. *[NFPA® 1001, 5.1.1]*
9. Locate information in departmental documents and standard or code materials. *[NFPA® 1001, 5.1.2]*
10. Distinguish between fire department SOPs and rules and regulations. *[NFPA® 1001, 5.1.1]*
11. Explain the ways the fire service may interact with other organizations. *[NFPA® 1001, 5.1.1]*



Instructor Information

This is the lesson covering the basic historical background and development of the fire service. This lesson describes both the culture and organizational structures of the fire service. The lesson also covers basic information on department regulations and policies.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture and discussion. The level of learning is comprehension.

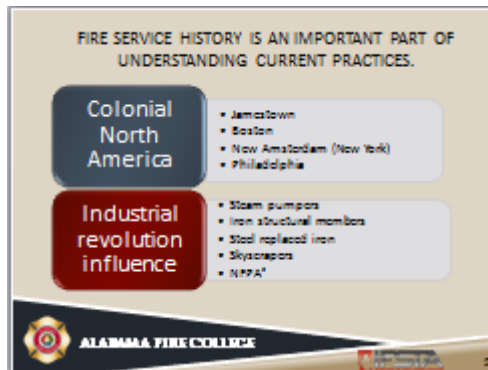
I. FIRE SERVICE HISTORY AND CULTURE

pp. 10-17

Objective 1 — Summarize the history of the fire service.

A. Fire Service History

1. Fire is an important element in all cultures
 - a. Properly used – Provides warmth, security, and light; cooks food; manufactures tools and implements
 - b. Uncontrolled – Destroys lives and property
2. Colonial North America
 - a. 1608 Jamestown – First major recorded fire in New World; burned down many structures in settlement
 - b. Boston
 - i. As early as 1631 – Banned thatched roofs and wood chimneys to prevent fires
 - ii. 1653 – First fire engine purchased
 - iii. 1678 – First paid fire company formed
 - c. New Amsterdam (later New York)
 - i. 1647 – Governor Peter Stuyvesant formed first fire organization in America – Surveyors of Buildings
 - ii. 1658 – New Amsterdam Fire Company formed with eight members
 - d. Philadelphia
 - i. 1735 – Fire society formed by citizens
 - ii. Volunteer fire departments
 - (a) 1736 – *Union Volunteer Fire Company formed; guided by Benjamin Franklin*
 - (b) 1737 – *Also formed in New York City*
 - iii. Hand-carried buckets of water were replaced by hand-operated pumps and nozzle-equipped hoses
3. Industrial Revolution
 - a. Steam pumpers developed by mid-1800s
 - b. Iron structural members replaced wood beams

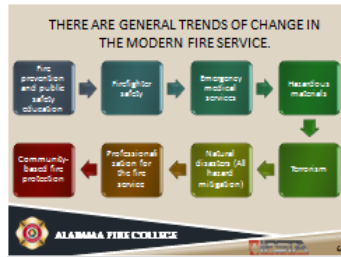


- c. Stronger and lighter steel replaced iron in buildings in urban areas
- d. Steel frame buildings – Skyscrapers, could reach 10 – 20 stories
- e. Use of steel increased fire risk in some ways
 - i. Large numbers of people in tall buildings with combustible interior finishes/contents and limited means of escape
 - ii. Ignition sources in structures – Natural gas lighting and development of electric lighting
 - iii. Need for regulation became evident
- f. 1896 – National Fire Protection Association[®] (NFPA[®]) formed
 - i. Develops consensus-based codes and standards to ensure fire and life safety for public
 - ii. First standard – NFPA[®] 13 regulated design and installation of fire protection sprinkler systems in structures
 - iii. National Electric Code[®] published in 1897

4. General trends of change

a. Fire prevention and public safety education

- i. 1968 – National Commission on Fire Prevention and Control (NCFPC) established to determine how to reduce fire loss
- ii. Published *America Burning* 1973 – Emphasized the need to increase public fire and life safety education and prevention programs
- iii. Published *American Burning Revisited* in 1987 – Described evolution of fire safety and recounted need for public fire and life safety education



b. Firefighter safety

- i. Averaging 100 firefighter line-of-duty-deaths (LODD) per year; 80,000 injuries in both emergency and nonemergency duties
- ii. 2004 National Fallen Firefighters Foundation issued *Everyone Goes Home*® listing 16 Firefighter Life Safety Initiatives – Program intended to educate firefighters in ways to reduce LODDs and injuries

c. Emergency medical services

- i. All departments provide some type of First Responder Care, may provide Basic Life Support (BLS) and Advanced Life Support (ALS)
- ii. Delivery occurs in various ways

Instructor Note: Explain to students the three basic ways of EMS delivery:

- 1) Cross-trained/multi-role firefighters,
- 2) Single role EMS-trained responders, and
- 3) Combined system with fire department for emergency response and “third service” as transportation support

See Appendix B on pp. 1273 for further information.

d. Hazardous materials

- i. Increased use led to development of new fire suppression agents and haz mat control procedures using trained personnel, special apparatus, foam nozzles, and special equipment

- ii. OSHA 1910.120 and Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) passed – Regulates transportation, design of transportation vehicles, and training of emergency responders
- e. Terrorism
 - i. Increased training for response and mitigation of terrorist attacks and incidents with weapons of mass destruction (WMD) post 9/11
 - ii. Government funding for specialized equipment, apparatus, and training; emphasis on greater coordination and training between agencies
- f. Natural disasters (all hazard mitigation)
 - i. Firefighters are usually the first called and the first on scene to provide all-risk mitigation
 - ii. Additional training, equipment, and established procedures help departments prepare
- g. Professionalization of the fire service
 - i. Increased need for education and specialized training
 - ii. National Fire Academy provides Executive Fire Officer Program for chief officers
 - iii. Mid-level administration need college degrees in management as well as proficiency in public speaking and human relations
- h. Community-based fire protection
 - i. Attempt to integrate fire department into community
 - ii. Approach developed in Los Angeles in 1990s to address lack of minorities in ranks
 - iii. Involves three stages
 - (a) *Research – Information on community demographics gathered*
 - (b) *Education – Personnel learn about community and specific challenges*
 - (c) *Implementation – Project designed to meet specific needs of community*

pp. 17-20

Objective 2 — Explain the organizational characteristics, cultural challenges, and cultural strengths that influence the fire service.

B. Fire Service Culture



1. Culture – Shared assumptions, beliefs, and values of group or organization
 - a. Based on history and traditions of fire service
 - b. Education – Begins with learning history and symbols of fire service; continues with learning jargon, attitudes, and stories of department
2. Organizational characteristics
 - a. Command structure – Including chain of command
 - b. Using ranks to define positions
 - c. Wearing uniforms, badges, and symbols of rank
 - d. Emphasis on teamwork, discipline, and following orders
3. Cultural challenges
 - a. Diversity – Membership within fire service has been changing since early 1950s
 - b. Resistance to change – Firefighters may resist change; important to remain flexible
 - c. Differences of personal characteristics
 - i. Worldview core values, generational difference, and peer pressure
 - ii. May lead to resistance of allowing people we think are different to join group
 - d. Accepting personal responsibility
 - i. Accountability is basis for successful and safe career
 - ii. Make your department better through your actions, and the image you project
4. Cultural strengths
 - a. Integrity – Doing the right thing simply because it is right – not required
 - b. Moral character – Involves right or just behavior, with an emphasis on trust
 - c. Work ethic – Valuing the virtues of hard work and thoroughness
 - d. Pride – Feeling of self-respect and personal worth



- e. Courage – Ability to confront fear, pain, danger, or uncertainty in controlled and rational way
- f. Loyalty – Attitude displayed by risking lives to save trapped or missing firefighters; taking care of injured or family of fallen firefighter; defending department and service if others try to tarnish image
- g. Respect – Attitude of admiration or esteem shown toward peers and superiors
- h. Compassion – Caring shown toward citizens, fellow firefighters, and their families

II. FIRE SERVICE MISSION AND ORGANIZATION

pp. 20-21

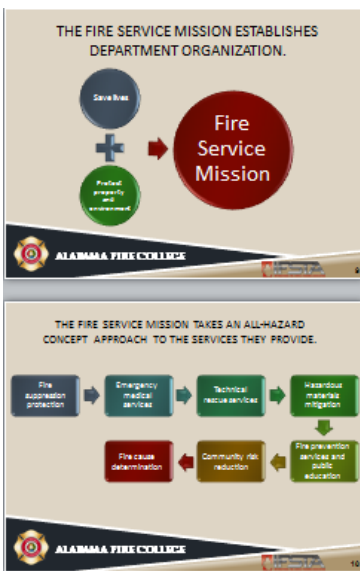
Objective 3 — Describe the mission of the fire service.

A. Authority Having Jurisdiction (AHJ)

1. Enacts mandated mission of the fire service
2. Establishes organization of fire department

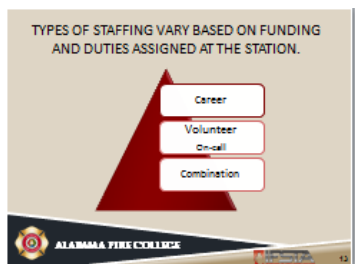
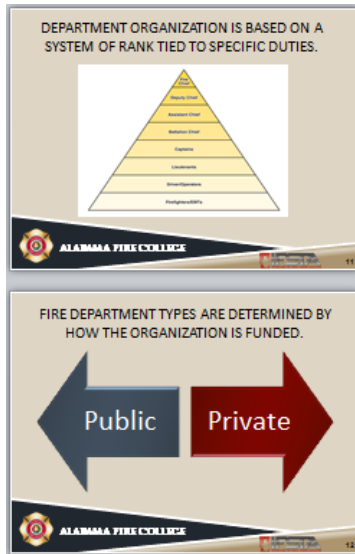
B. Fire Service Mission

1. Mission – To save lives and protect property and environment from fires and other hazardous situations
2. Many departments use an all hazards approach – Provide a variety of services
 - a. Fire suppression protection
 - b. Emergency medical services
 - c. Technical rescue services
 - d. Hazardous materials mitigation
 - e. Airport and/or seaport protection
 - f. Emergency management services
 - g. Fire prevention services and public education (engineering, education, and enforcement)
 - h. Community risk reduction
 - i. Fire cause determination
3. Local mission will depend on legal mandates
 - a. Firefighter's mission – Fulfill stated goals and objectives of department mission statement
 - b. Statements usually posted in facility and available to department members and public



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Objective 4 — Describe the organization of fire departments.



A. Fire Department Organization

1. Organizational structure

- a. Pyramid/hierarchy with chief at tip and firefighters forming base; layers in between are personnel assigned by rank and duty
- b. Moving up pyramid increases level of authority and responsibility

2. Types of fire departments – Determined by how organization is funded

- a. Public
 - i. Funded through taxes, fees, grants, fundraisers, donations, and contracts
 - ii. Community may be municipality, county, district, or other area defined by AHJ
- b. Private
 - i. Funded through contracts, billing for services, revenue provided by parent organization
 - ii. Services provided to single firm, facility, or municipality

3. Staffing

- a. Career – Work a required schedule, receive pay and benefits for work
 - i. Facilities and equipment maintained by municipality, county, or industry
 - ii. Provide services through full-time career firefighters and other personnel needed
 - iii. Also include departments serving military installations and private industrial sites
 - iv. Continually staffed – Personnel live in station when on duty with administrative offices on conventional business hours
- b. Volunteer – Personnel receive minimal or no pay for work
 - i. May be overseen by local government; may be independent, governed by elected board of directors
 - ii. Funding

(a) *Publicly funded – Town or county provides facility, purchases equipment, pays for maintenance*

- (b) *Other funding sources – May include donations, subscription fees, billing, and fundraising events*
 - iii. Station not usually continually staffed – Designated personnel respond to station to drive apparatus, and others report to the scene
 - iv. On-call – Responder is summoned to station or scene by telephone call, pager, or community signal
 - (a) *Personnel paid for responding – Hourly wage or set fee per response*
 - (b) *May be used to pay part-time personnel in full-time organizations*
 - c. Combination – Some personnel receive pay while others serve voluntarily
- 4. Separation of departmental duties
 - a. Line personnel – Deliver emergency services directly to external customers
 - b. Staff personnel – Provide advice, services, and support to line personnel

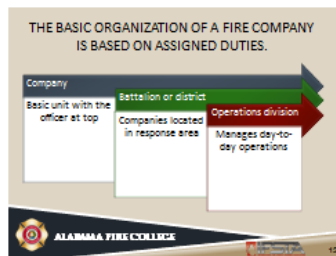


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Objective 5 — Distinguish among functions of fire companies.

B. Basic Company Organization

1. Company – Basic unit with company officer at top; driver/operator or engineer, firefighter, and/or emergency medical technician or paramedic at base
2. Battalion or district – Composed of variety of companies located in response area
3. Operations division – Manages day-to-day operations of battalions/divisions, both emergency and non-emergency



C. Fire Companies

1. Engine Company
 - a. Performs fire suppression duties at structure, vehicle, wildland, and other types of fires



including providing water supply and advancing attack hoselines

- b. Additional duties may include search and rescue, extrication, ventilation, emergency medical care
2. Truck (Ladder) company
 - a. Performs forcible entry, search and rescue, ventilation, salvage and overhaul, utilities control, and provides access to upper levels of a structure
 - b. Additional duties may include providing elevated water stream, extrication, emergency medical care
 3. Rescue squad/company
 - a. Searches for and removes victims from areas of danger or entrapment
 - b. May perform technical rescues
 4. Brush Company – Extinguishes ground cover, grass fires and protects structures in the wildland/urban interface
 5. Hazardous materials company – Mitigates hazardous materials incidents
 6. Emergency medical/ambulance company
 - a. Provides emergency medical care to patients
 - b. May provide transport to a medical facility
 7. Special rescue company – Performs technical rescues including rapid intervention for rescue of firefighters
 8. Aircraft rescue and fire fighting company – Performs rescue and fire suppression activities involving aircraft accidents



pp. 26-34



Objective 6 — Summarize primary knowledge and skills the firefighter must have to function effectively.

Objective 7 — Distinguish among the primary roles of fire service personnel.

A. Fire Department Personnel

1. Professional Qualifications

- a. Based on NFPA[®] Standard, 1001
 - b. Establishes two levels of competency/professionalism – FFI and FFII
2. Candidates must meet several requirements
 - a. Minimum educational requirements set by AHJ
 - b. Age requirements set by AHJ
 - c. Medical requirements set by NFPA[®] 1582
 - d. Job-related physical fitness requirements set by AHJ
3. Candidates must possess or be trained in the skills to deliver basic medical care

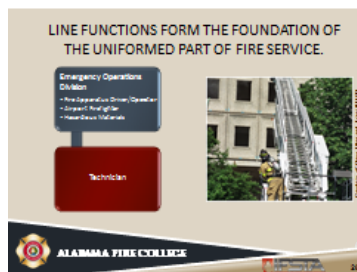
B. Line Functions – Foundation for uniformed part of fire service

1. Emergency operations division

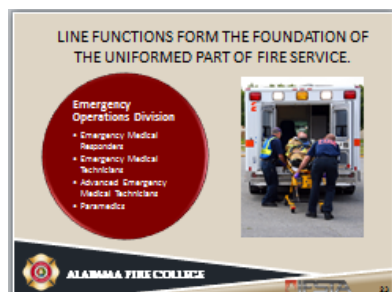
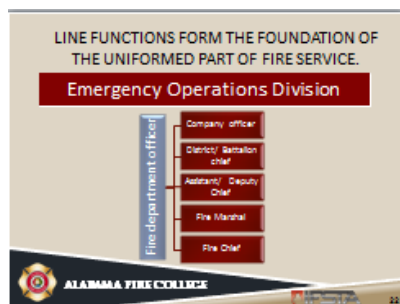
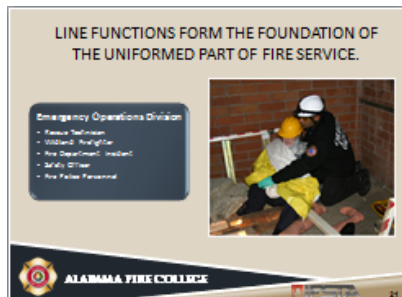
- a. Firefighter, NFPA[®] 1001, establishes two levels
 - i. Firefighter I (FFI) – Works under supervision of FFII or company officer (CO)
 - ii. FFI duties – Trained in fire suppression, search and rescue, extrication, ventilation, salvage, overhaul, EMS, and hazardous material emergencies
 - iii. Firefighter II (FFII) – Trained to coordinate FFI and FFII under direction of CO
 - iv. FFII duties – Performs more complex fire fighting tasks, coordinate the activities of Firefighter I and II personnel, assume and transfer command within an incident command system (ICS)



Instructor Note: Discuss complete list of duties for FFI found on pp. 27-28 and for FFII found on p. 28.



- b. Fire apparatus driver/operator – Trained to drive fire apparatus to and from incidents, operate pumps, aerial devices or other mechanical equipment, responsible for servicing and maintaining apparatus; meet requirements of NFPA[®] 1002
 - c. Airport firefighter – Trained in airport operations and aircraft safety; certified to NFPA[®] 1003; if operating aircraft fire fighting vehicles certified to NFPA[®] 1002

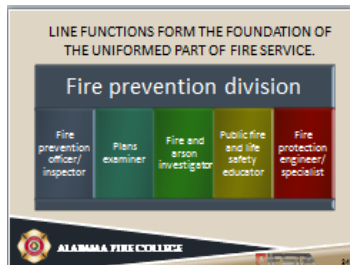


- d. Hazardous materials technician –Certified to handle hazardous materials and chemical, biological, radiological, nuclear, or explosive (CBRNE) emergencies; certified based on NFPA® 472
- e. Rescue technician – Certified to handle technical rescue; meet requirements of NFPA® 1006
- f. Wildland firefighter – Trained to extinguish fires in outdoor vegetation, including wildland/urban interface; certification based on NFPA® 1051
- g. Fire department incident safety officer – Monitors operational safety at incidents; may be assigned to any qualified fire officer; duties defined in NFPA® 1521
- h. Fire police personnel – Assist law enforcement officers with traffic control, crowd control, scene security; no NFPA® standard
- i. Fire department officer – Meet requirements of NFPA® 1021
 - i. Company officers – Supervises fire company at station and incidents
 - ii. District/Battalion chiefs – Supervise group of fire companies and stations in response area
 - iii. Assistant/Deputy Chiefs – Manage various upper level functions
 - iv. Fire Marshals – Manage fire prevention, plan review, investigation division; meet requirements of NFPA® 1021 and 1037
 - v. Fire Chief – Head of department
- j. Emergency medical responders (EMRs) – Provide immediate lifesaving care to critical patients while awaiting additional EMS response
- k. Emergency medical technicians (EMTs) – Provide basic emergency medical care and transportation for critical and emergent patients
- l. Advanced emergency medical technicians (AEMTs) – Provide basic and limited advanced emergency medical care and transportation for critical and emergent patients
- m. Paramedics – Provide advanced emergency medical care for critical and emergent patients

Review Question: What is the primary difference between Firefighter I and Firefighter II duties?
See pages 27-28 of the textbook for answers.

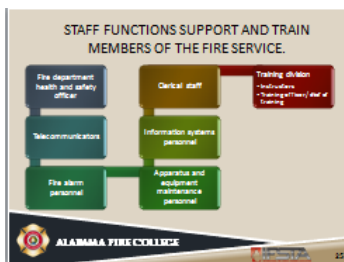
2. Fire prevention division

- a. Fire prevention officers/inspectors – Uniformed or non-uniformed personnel that perform periodic inspections of various occupancies, enforce building and fire codes, and interact with public; meet requirements of NFPA[®] 1031
- b. Plans examiners – Uniformed or non-uniformed personnel that ensure code compliance by reviewing architectural and fire protection systems plans; meet requirements of NFPA[®] 1031
- c. Fire and arson investigators – Uniformed personnel that investigate fire and explosions to determine origin and cause of incident; certified to minimum requirements of NFPA[®] 1033
- d. Public fire and life safety educator – Uniformed or non-uniformed personnel that informs public about fire and life safety hazards, fire causes, and precautions or actions to take during fire; meet requirements of NFPA[®] 1035
- e. Fire protection engineer/specialist – Uniformed or non-uniformed personnel that checks architectural and fire protection systems to ensure compliance with local fire and life safety codes and ordinances



C. Staff Functions

1. Fire department health and safety officer – Uniformed or non-uniformed officer oversees departmental occupational safety and health program described in both NFPA[®] 1500 and NFPA[®] 1521
2. Telecommunicators – Establish and maintain communications with in-service companies, complete incident reports; meet minimum requirements of NFPA[®] 1061
3. Fire alarm maintenance personnel – Technicians that maintain municipal fire alarm systems; based on requirements of NFPA[®] 72



4. Apparatus and equipment maintenance personnel – Mechanics and technicians who maintain department apparatus, vehicles, equipment; minimum training provided in NFPA[®] 1071
5. Information systems personnel – Manage collection, entry, storage, retrieval, and dissemination of electronic databases
6. Clerical staff – Provide secretarial, administrative, and record-keeping support for department
7. Training division
 - a. Instructors – Uniformed personnel that deliver training to department or other students; certified to Level I of NFPA[®] 1041
 - b. Training officer/chief of training – Oversees all training activities and supervises personnel assigned to training division; certified to Level II or higher based on NFPA[®] 1041

p. 33-35

Objective 8 — Describe fire department organizational principles.

A. Organizational Principles

1. Chain of command – Formal line of authority, responsibility, and communication; use ensures unity of command
2. Unity of command – Every employee reports directly to just one supervisor
3. Span of control – Establishes maximum number of subordinates or functions one supervisor can effectively control; ranges from 3 to 7, 5 is optimum
4. Division of labor – Process of dividing large jobs into smaller jobs; need to assign responsibility, prevent duplication of effort, assign specific and clear-cut tasks
5. Discipline – Administered through clearly communicated rules in organization
 - a. Organization's responsibility to provide leadership



- b. Individual's responsibility to follow orders

III. FIRE DEPARTMENT REGULATIONS

pp. 35-36

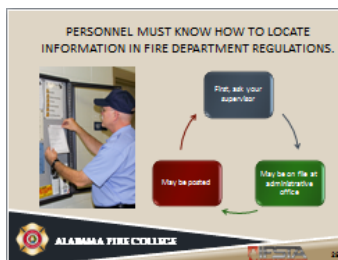
Objective 9 — Locate information in departmental documents and standard or code materials.

Objective 10 — Distinguish between fire department SOPs and rules and regulations.

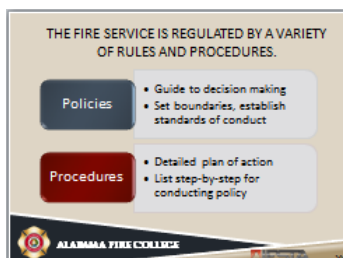
A. Fire Department Regulations



1. Written regulations – Clarify expectations and delegate authority based on structure and mission
 - a. Consist of policies and procedures, municipal ordinances, state/provincial and federal laws, codes and standards mandated by AHJ
 - b. May include labor/management agreements with union or bargaining agent
2. Your responsibility to learn and adhere to
3. Methods of distribution
 - a. Distribute in written or electronic format
 - b. Communicate verbally
 - c. Post in a conspicuous place in the facilities
4. To locate information
 - a. Ask supervisor first – May answer directly or direct you toward location of needed documents
 - b. Regulations – On file at administrative office; usually at every station and division office
 - c. Recent policies or amendments – Posted on bulletin board



B. Policies



1. Are a guide to decision making in an organization
2. Determined by top management then distributed to lower ranks for implementation
3. Function – Set boundaries and establish standards of conduct for members

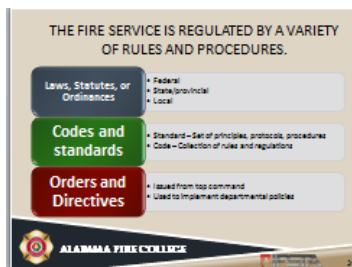
4. Created in response to government mandates or changes in operation needs
5. Can be traditional or unwritten
 - a. Called organizational norms or past practices
 - b. Implied in routine activities
 - c. Develop where no clear policy exists
 - d. Can create potentially dangerous or legally liable situations; should be corrected

C. Procedures

1. Are a detailed plan of action that resemble policy
2. List step-by-step for conducting policy
3. Standard operating procedures (SOPs) – Enable all members to perform specific tasks to required standard
4. Standard operating guidelines (SOGs) – Similar to SOPs or may allow leeway in particular situations

D. Laws, Statutes, or Ordinances

1. Federal mandates, state/provincial regulations, local laws or ordinances result in policies
2. Federal laws
 - a. Fair Labor Standards Act (FLSA) – Sets criteria for pay
 - b. Americans with Disabilities Act (ADA) – Affects hiring practices and building accessibility
 - c. *Code of Federal Regulations (CFR)* – U.S. Federal laws that pertain to firefighters; include requirements administered by Occupational Safety and Health Administration (OSHA)
3. Occupational Health and Safety (OH&S) – Canadian agency responsible for federal firefighters; each province has agency for provincial and local firefighters



E. Codes and Standards**1. Standard**

- a. Set of principles, protocols, or procedures developed by committees through consensus
- b. Explain how to do something or provide minimum standards to be followed

2. Code

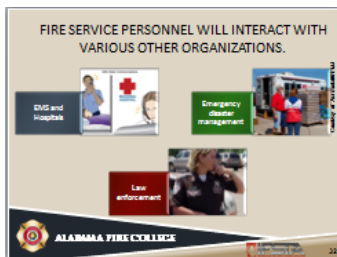
- a. Collection of rules and regulations enacted by law in particular jurisdiction
- b. A law that may be based on one or incorporate an entire standard
- c. Must be up-to-date, written, applied in consistent manner

F. Orders and Directives

1. Issued from top of chain of command; used to implement departmental policies and procedures
2. May be written or verbal
3. May be based on policy or procedure
4. Definition varies by department
- 5.

IV. INTERACTING WITH OTHER ORGANIZATIONS

pp. 37-40

Objective 11 — Explain the ways the fire service may interact with other organizations.**A. Emergency Medical Services (EMS)**

1. Provide prehospital patient care and/or transportation to a medical facility
2. May be privately owned or agency of AHJ
3. May provide
 - a. Complete medical services
 - b. Supplemental services to those provided by fire department
 - c. Standby units during training

B. Hospitals

1. Regulated by state medical authorities
 - a. Joint commission (JC) – Establishes standards of care
 - b. State Department of Health – Issues license to operate
 - c. Occupational Safety and Health Administration (OSHA) – Establishes levels of accreditation
2. May provide direct assistance via radio or by dispatching medical professional to scene

C. Emergency Disaster Management

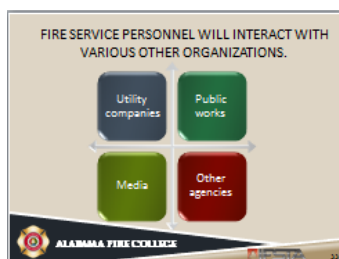
1. Administered by city, county, and tribal levels of government
2. Manage emergency and disaster response by coordinating multiagency activities
3. Fire department may be designated emergency disaster management authority

D. Law Enforcement

1. Interaction with various agencies is possible
 - a. Local police department
 - b. County sheriff's office
 - c. State/provincial police or highway patrol
 - d. Federal agencies
2. Agencies can provide
 - a. Incident scene security
 - b. Traffic and crowd control
 - c. Protection to firefighters
 - d. Handle fire cause determination and investigation
 - e. Explosives disposal
 - f. Intelligence gathering

E. Utility Companies

May be privately owned or a department of local government



1. Personnel assist at incidents by shutting off natural gas lines, electricity, or public water mains
2. May provide training for handling same tasks
3. May maintain fire hydrant flow tests and maintenance

F. Public Works

1. Typically oversee construction and maintenance of public roads, buildings, and sewers
2. Administered at municipal, county, and state/provincial levels
3. May oversee water distribution system
4. Assists the fire department by providing
 - a. Heavy equipment for confined-space rescue
 - b. Earth-moving equipment
 - c. Flood-control equipment and materials
 - d. Sand for containing spills
 - e. Barriers and signs to divert traffic
 - f. Facility maintenance and repair
 - g. Civil/structural engineers

G. Media

1. Consists of journalists from print (newspapers and magazines), broadcast (radio and television), and Internet sites
2. Delivery of news can
 - a. Divert traffic from incident scene
 - b. Alert when large-scale evacuations necessary
 - c. Inform public of fire and life safety information, fire department activities and events, and important changes to department policies

3. When approached by media
 - a. Do not answer questions or offer opinion unless authorized
 - b. Direct to appropriate person – Incident commander, ranking officer, or Public Information Officer (PIO)

H. Other Agencies That May Assist

1. Public health departments
2. Coroner/medical examiner's offices
3. National or state/provincial environmental protection agencies
4. National or state/provincial forestry departments
5. Coast Guard
6. National Guard and military reserve units
7. District attorney's offices
8. Occupational Safety and Health Administration (OSHA)
9. Federal Aviation Administration (FAA)
10. Water resources boards
11. Community Organizations
12. Local Emergency Planning Committee/Office of Emergency Management (LEPC/OEM)
13. Red Cross
14. Salvation Army
15. University and federal laboratories

V. SUMMARY AND REVIEW

A. Chapter Summary

1. Firefighting is a profession with a long and proud tradition of service to the community.
2. To perform as a firefighter, you need physical skills, knowledge of the regulations that govern your organization, the laws that regulate fire service, and the incident command system, as well as, an understanding of agencies that interact with the fire department.



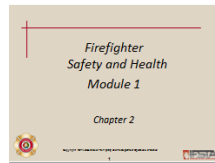
B. Review Questions

1. How was early fire organizations started? (*pp. 11-12*)
2. What are some of the areas that have changed significantly in the 20th Century for fire service in North America? (*pp. 15-17*)
3. How do organizational characteristics, cultural challenges, and cultural strengths influence the fire service? (*pp. 17-20*)
4. What is the mission of the fire service? (*p. 21*)
5. What are the three main types of staffing found in the fire service? (*p. 23*)
6. How are the duties of an engine company different from a rescue squad/company? (*p. 26*)
7. What is the central difference between line functions and staff functions? (*p. 24*)
8. What is the primary difference between Firefighter I and Firefighter II duties? (*pp. 27-28*)
9. How are qualifications for different line positions regulated? (*p. 27*)
10. What types of staff functions support and supplement line functions? (*pp. 32-33*)
11. What are the organizational principles of the fire service? (*pp. 33-35*)

12. What steps can be taken to locate information in department policies? (*p. 35*)
13. How are policies and procedures different from one another? (*pp. 35-36*)
14. What other organizations may provide services to the public along with firefighters? (*pp. 37-39*)
15. What should a firefighter do when approached by members of the media? (*p. 39*)

Chapter 2

Firefighter Safety and Health



Lesson Goal

After completing this lesson, the student shall be able to discuss how firefighter health, safety prevention, and situational awareness are interrelated parts of preventing on-the-job injuries.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. List the main types of job-related firefighter fatalities, injuries, and illnesses. *[NFPA[®] 1001, 5.1.1]*
2. Describe the National Fire Protection Association[®] standards related to firefighter safety and health. *[NFPA[®] 1001, 5.1.1]*
3. Identify Occupational Safety and Health Administration (OSHA) regulations and how they relate to firefighters. *[NFPA[®] 1001, 5.1.1]*
4. Summarize the model that supports the concept of risk management. *[NFPA[®] 1001, 5.1.1]*
5. Describe fire department safety and health programs. *[NFPA[®] 1001, 5.1.1]*
6. Summarize firefighter health awareness issues. *[NFPA[®] 1001, 5.1.1]*
7. Summarize safe vehicle operations. *[NFPA[®] 1001, 5.3.2]*
8. Summarize guidelines for riding safely on the apparatus. *[NFPA[®] 1001, 5.3.2]*
9. Describe ways to help prevent accidents and injuries in fire stations and facilities. *[NFPA[®] 1001, 5.1.1]*
10. Explain general guidelines for tool and equipment safety. *[NFPA[®] 1001, 5.1.1]*
11. Describe ways to maintain safety in training. *[NFPA[®] 1001, 5.1.1]*
12. State the practices a Firefighter I uses for emergency scene preparedness and safety. *[NFPA[®] 1001, 5.1.1, 5.3.3]*
13. Summarize general guidelines for scene management including highway incidents, crowd control, and cordoning off emergency scenes. *[NFPA[®] 1001, 5.1.1, 5.3.3]*
14. Explain the importance of personnel accountability. *[NFPA[®] 1001, 5.3.5]*
15. Respond to an incident, correctly mounting and dismounting an apparatus. *[NFPA[®] 1001, 5.3.2]*
16. Wearing appropriate PPE, including reflective vest, demonstrate scene management at roadway incidents using traffic and scene control devices. *[NFPA[®] 1001, 5.3.3]*



Instructor Information

This is the lesson covering firefighter safety and health. This lesson describes requirements from various organizations regarding protection and preventative measures. The lesson also covers specific skills to practice for safety during an incident response.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

I. FIREFIGHTER FATALITIES, INJURIES, AND ILLNESSES

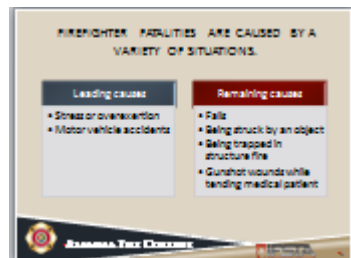
pp. 46-54

Objective 1 — List the main types of job-related firefighter fatalities, injuries, and illnesses.



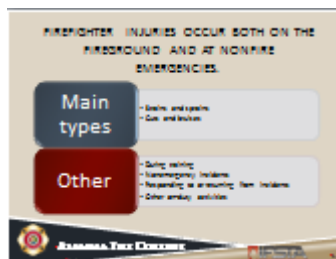
A. Fatalities – 2010 NFPA® report

1. 72 on-duty – Lowest annual figure since data collection began in 1977
2. Leading causes
 - a. Stress or overexertion
 - i. Heart attacks
 - ii. Strokes
 - b. Motor vehicle accidents
3. Remaining causes
 - a. Falls
 - b. Being struck by an object
 - c. Being trapped in structure fire
 - d. Gunshot wounds while tending medical patient



B. Injuries – 2010 NFPA® report

1. Estimated slightly less than 72,000 injured
 - a. 32,000 were injured on fireground
 - b. 14,200 were nonfire emergency incidents
 - c. Main types
 - i. Strains and sprains
 - ii. Cuts and bruises
 - d. Other occurrences – During training, during nonemergency incidents, while responding to or returning from incidents, in other on-duty activities
2. Costs to both individual and department
 - a. Individual – Physical pain, emotional stress
 - b. Career department – Lost duty time, worker's compensation payments, need to replace personnel when off duty





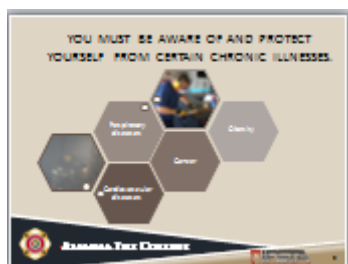
- c. Volunteer department – Possible worker's compensation by department, no wages for firefighter when missing full-time job

3. Can be prevented by specific action

- a. Providing effective training
- b. Maintaining company discipline and accountability
- c. Following established safety-related standard operating procedures
- d. Using personal protective clothing and equipment properly
- e. Maintaining high levels of physical fitness
- f. Following risk management guidelines
- g. Using rehabilitation facilities at emergency incidents

C. Illnesses

1. Defined as acute or chronic
 - a. Acute – Short term, may only last a few days
 - b. Chronic – Long lasting, can be fatal
2. Can be hereditary, also result of lifestyle choices and exposure to toxic atmospheres or infected persons
3. Be aware of and protect yourself from certain chronic illnesses
4. Cardiovascular diseases
 - a. Leading cause of firefighter fatalities
 - b. Work-related causes
 - i. Exposure to smoke and chemicals
 - ii. Heat stress from fires and ambient temperatures
 - iii. Psychological stressors
 - iv. Long, irregular work hours
 - c. Job-related prevention – Mitigated by policies, procedures, and equipment provided by department
 - d. Nonjob-related causes
 - i. Obesity



- ii. Tobacco use
- iii. Lack of physical fitness
- e. Nonjob-related prevention – Mitigated by eating healthy diet, discontinuing tobacco use, exercising regularly

5. Respiratory diseases

- a. Most common types
 - i. Asthma
 - ii. Lung cancer
 - iii. Chronic obstructive pulmonary disease (COPD)
- b. Can be caused by exposure to smoke, fire gases, chemicals
- c. Prevention – Individual responsibilities
 - i. Always follow departmental regulations for wearing respiratory equipment
 - ii. Always wear respiratory protection in immediately dangerous to life and health (IDLH) situations
 - iii. Wear appropriate level of respiratory protection for medical responses, when working with paints, thinners, cleaners, around dust or particulates
 - iv. Do not smoke or expose yourself to secondhand smoke unnecessarily

6. Cancer

- a. Firefighters at increased risk
 - i. Testicular
 - ii. Non-Hodgkin's lymphoma
 - iii. Prostate
 - iv. Multiple myeloma – Bone cancer
- b. Risk can be increased by exposure to carcinogens present in fires and apparatus exhaust fumes
- c. Prevention measures
 - i. Follow departmental safety policies
 - ii. Wear correct level of respiratory protection
 - iii. Thoroughly clean PPE when contaminated by smoke

7. Obesity



- a. Avoid by exercising and following a healthy diet
- b. Increases risk of chronic diseases
 - i. Type 2 diabetes
 - ii. Coronary heart disease
 - iii. Stroke
 - iv. Hypertension
 - v. Some forms of cancer

8. Diabetes

- a. Marked by high levels of sugar in blood – Type 1 controlled by insulin, Type 2 controlled through exercise, diet, and oral medication
- b. NFPA[®] 1582 changed in 2007 to allow persons under physician's care and that have control to be hired by departments
- c. Steps toward prevention
 - i. Exercise, eat properly, and annual medical exam
 - ii. Be aware of symptoms and family medical history

9. Drug and alcohol abuse

- a. Impairs ability to function and slows reaction times
- b. Most departments prohibit responding to emergency operations if consumed within specific period of time before incident or duty shift
- c. Prescription drugs can also impair ability to safely operate equipment
- d. Individual responsibility to prevent impairment
 - i. Control use of alcohol when on-call or prior to reporting for duty
 - ii. Do not respond to call or report to station if you have been drinking
 - iii. Same rule of thumb for medications that may impair your ability

10. Stress-induced hypertension

- a. Physical and emotional stress build while responding to emergency incidents over time
- b. Stress can cause
 - i. Headaches

- ii. Nausea
- iii. Weakness in legs

Instructor Note: Discuss Table 2.2 on p. 48 of the textbook. Ask students to consider how these symptoms might be masked by daily life. Ask students to discuss how they can keep a watch for these types of symptoms in their own lives.

- c. Stress can be mitigated
 - i. Stay in good physical condition
 - ii. Have positive mental attitude
 - iii. Relax when possible
 - iv. Use personal stress management program

(a) Seek assistance from employee assistance program (EAP) if needed

(b) Seek physician if not EAP in organization

11. Tobacco use/dependence

- a. Use is linked to chronic diseases – Cancer, cardiac arrest, COPD; makes other diseases last longer
- b. Preventative actions taken by several agencies
 - i. Prohibit smoking in department facilities
 - ii. Require that probationary firefighters do not smoke
 - iii. Provide cessation programs for current members who do
- c. Prevention – Do not start; if you do, take advantage of programs to stop

12. Exposure-related diseases

- a. Contracted by exposure to victims during medical responses
 - i. Blood- and fluid-borne pathogens
 - ii. Airborne pathogens
 - iii. Viruses
 - iv. Other easily transmitted diseases
- b. Can also be caused by exposure to antibiotic resistant bacteria
- c. Prevention

- i. Use proper level of medical protection when treating patients – Correct protective clothing, respiratory protection
- ii. Use body substance isolation methods to treat patients

Review Question: What types of job-related injuries and illnesses can a firefighter expect to encounter?
See pages 46-54 of the textbook for answers.

II. FIRE SERVICE SAFETY STANDARDS, REGULATIONS, AND INITIATIVES

pp. 55-59

Objective 2 — Describe the National Fire Protection Association® standards related to firefighter safety and health.

A. Fire Service Safety Standards, Regulations, and Initiatives

1. Prominent regulations and standards

- a. NFPA® consensus standards
- b. U.S. Occupational Safety and Health Administration (OSHA) regulations
- c. Canada's National Occupational Safety and Health (CanOSH) regulations

2. Other safety-related programs

- a. Everyone Goes Home® - Developed by The National Fallen Firefighters Foundation, based on 16 Firefighter Life Safety Initiatives
- b. Annual safety stand-down – Sponsored by International Association of Fire Chiefs



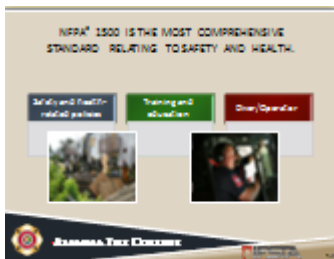
B. NFPA® Standards

1. Establish design criteria for protective clothing and equipment

- a. NFPA® 1971
- b. NFPA® 1975
- c. NFPA® 1977

2. Define safe training practices and programs
 - a. NFPA[®] 1403
 - b. NFPA[®] 1404
 - c. NFPA[®] 1407
 - d. NFPA[®] 1410
 - e. NFPA[®] 1451
3. Set requirements for care and maintenance of personal and respiratory protection equipment
 - a. NFPA[®] 1851
 - b. NFPA[®] 1981
4. Establish safety programs departments must adopt
 - a. NFPA[®] 1581
 - b. NFPA[®] 1582
 - c. NFPA[®] 1854

C. NFPA[®] 1500, Standard on Fire Department Occupational Safety and Health Program



1. Most comprehensive standard relating to firefighter safety and health
2. Specifies minimum requirements for department safety and health program
3. Minimum standard – Departments may choose to exceed requirements
4. Safety and health-related policies and procedures
 - a. Program must address all anticipated hazards to which members might be exposed
 - i. Obvious fire fighting hazards
 - ii. Hazardous materials releases
 - iii. Communicable disease
 - iv. Energized electrical equipment
 - v. Hazards of driving apparatus during emergency responses

- b. Program must include provisions for dealing with nonemergency issues
 - i. Alcohol abuse
 - ii. Drug abuse
- 5. Training and education
 - a. Outlines requirements of fire department training program
 - i. Initial training for new recruits
 - ii. Methods for becoming proficient in duties
 - iii. Process for evaluating skills and knowledge
 - b. States all training must meet requirements of NFPA[®] 1000 series of professional qualification (ProQual) standards
 - c. Requires annual proficiency training and evaluations
 - d. Requires training whenever policies, procedures, or guidelines are altered or updated
- 6. Fire apparatus, equipment, and driver/operators
 - a. Establishes safety requirements for all uses of fire department apparatus
 - b. Establishes minimum requirements for apparatus and vehicle driver/operators
- 7. Protective clothing and protective equipment
 - a. Requires all personnel operating in IDLH to be fully equipped with personal protective equipment, including SCBA
 - b. Protective equipment
 - i. Must be appropriate for hazards to which personnel will be exposed
 - ii. Must meet current edition of NFPA[®] design standard
 - iii. Refers to self-contained breathing apparatus (SCBA), supplied-air respirators (SARs), other respiratory protection
 - iv. May also refer to body armor; protective barrier to blood and airborne pathogens



8. Emergency operations

- a. Required to be managed through incident management system (IMS) during all emergency operations; also known as Incident Command System (ICS)
- b. System must include risk management plan, personnel accountability system
- c. Limits emergency operations to those that can be safely conducted by personnel on scene
- d. Requires personnel trained to perform rapid intervention crews for rescue of firefighters in distress, rehabilitation for firefighters during operations, and postincident analysis

9. Facility safety

- a. Sets minimum design requirements for facilities that meet NFPA[®] 101
- b. Requires facilities
 - i. To have space and means for cleaning, disinfecting, storing infection control devices
 - ii. Be designated as smoke-free
- c. Requires inspection, maintenance, and prompt repair of facilities

10. Medical and physical requirements

- a. Requires candidates to be medically evaluated
- b. Prohibits participating in fire department operations while under the influence of alcohol or drugs
- c. Requires departments to develop physical performance standards for those participating in emergency operations; must include annual medical verification of duty fitness
- d. Requires establishment of job-related fitness standards and program
- e. Requires departments to maintain confidential health database on each member
- f. Requires departments to operate an infection control program



- g. Requires that departments designate physician to advise on work-related health issues
- h. Requires departments must report all on-the-job exposures and injuries

11. Member assistance and wellness programs

- a. Requires departments to have the program to assist firefighters and families with substance abuse, stress, and personal problems that adversely affect job performance
- b. Requires wellness program to assist with health-related issues

12. Critical incident stress management

- a. Requires departments to establish the program to provide critical incident stress management (CISM)
- b. Program goal – Assist members who have been involved in highly stressful events

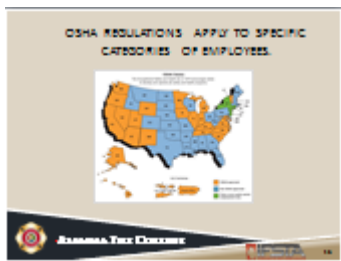
Review Question: What topics does NFPA® 1500 cover regarding firefighter safety and health?
See pages 55-59 of the textbook for answers.

pp. 60-62

Objective 3 — Identify Occupational Safety and Health Administration (OSHA) regulations that relate to firefighters.

D. OSHA Regulations

1. OSHA – Division of U.S. Department of Labor
 - a. Regulations contained in Code of Federal Regulations (CFR)
 - b. Regulations designed to ensure workplaces are free from hazards that can cause death or serious injury
2. Only apply to federal and private-sector employees who fight fires
3. Apply to state employees in states and territories operating OSHA-approved plans
4. States may follow OSHA regulations even if federal mandate does not apply
5. Canadian requirements



- a. Know provincial safety and health requirements
- b. Canadian Centre for Occupational Health and Safety (CCOHS) requirements may apply



E. Everyone Goes Home

1. National Fallen Firefighters Foundation, non-profit created by U.S. Congress in 1992
2. Foundation works to achieve U.S. Fire Administration goal of reducing fatalities 25 percent within first 5 years of program and 50 percent within 10 years of program start
3. 16 Firefighter Life Safety Initiatives are blueprint for changes needed; also known as *Everyone Goes Home*®

Instructor Note: Discuss 16 Firefighter Life Safety Initiatives on p. 61 of the textbook.

F. International Association of Fire Chiefs Safety Stand-Down

1. International Association of Fire Chiefs (IAFC) annual day-long stand-down held to focus on firefighter safety
2. Nonemergency work ceases and safety training sessions held

Review Question: Federal OSHA regulations apply to what specific groups of firefighters?
See page 60 of the textbook for answers.

III. RISK MANAGEMENT

pp. 62-63

Objective 4 — Summarize the model that supports the concept of risk management.



A. Risk Management

1. Required by NFPA® 1500
2. Established set of decision-making criteria based on an assessment of benefits and risk

3. Decision-making model developed by Phoenix (AZ) Fire Department (PFD) – Plan intended to help officers make reliable decisions during emergency response
 - a. Emergency response assumption – Responders can protect lives and property
 - b. Responders will risk their lives a lot, to save savable lives
 - c. Responders will risk their lives a little, to save savable property
 - d. Responders will **NOT** risk their lives to save lives and property already lost
4. PFD model supported by behaviors that support safety-first mindset

Instructor Note: Discuss key behaviors that support a safety-first mindset on p. 63 of the textbook.

Review Question: How do the key behaviors of driving defensively, keeping the crew intact, and following standard fireground procedures support the concept of risk management?
See pages 62-63 of the textbook for answers.

IV. FIRE DEPARTMENT SAFETY AND HEALTH PROGRAMS

pp. 63-66

Objective 5 — Describe fire department safety and health programs.

Objective 6 – Summarize firefighter health awareness issues.

A. Fire Department Safety and Health Program Goals

1. Prevent human suffering, fatalities, injuries, illnesses, exposures to hazardous atmospheres and contagious diseases
2. Prevent damage to or loss of equipment
3. Reduce occurrences and severity of accidents and hazardous exposure





4. Effective programs must be promoted and practiced at all levels

B. Safety and Health Program Components

1. Departmental safety and health policies
2. Safety and health training for all personnel
3. Accident prevention program
4. Safety and health committee established – Headed by Health and Safety Officer (HSO)

C. Firefighter Health Considerations

1. Adopt a healthy lifestyle
 - a. Participation in physical fitness program
 - i. Career – May be mandatory participation
 - ii. Volunteer – Establish own regimen to stay in shape
 - b. Adhere to good nutritional program
2. Keys to maintaining personal health
 - a. Stay informed about job-related health issues
 - b. Wear incident-appropriate personal protective clothing and respiratory protection
 - c. Clean all PPE at least twice annually, remove heavy contamination after each use
 - d. Follow recommendations for hepatitis B vaccination
 - e. Use precautions to avoid exposure to airborne and bloodborne pathogens
 - f. Use proper lifting techniques to avoid muscle strains and other related injuries
 - g. Use lifting tools or help to assist lifting heavy objects
 - h. Clean, disinfect, and properly store tools and equipment used in patient care
 - i. Maintain a regular exercise program
 - j. Maintain a diet low in cholesterol, fat, and sodium



- k. Reduce heart attack and stroke risk – Maintain acceptable blood pressure and cholesterol levels
- l. Reduce cancer risk – Eliminate use of all tobacco products
- m. Have regular physicals and medical checkups

Review Question: What are the main goals of a safety and health program?

See page 63 of the textbook for answers.



D. Employee Assistance and Wellness Programs

1. Employee Assistance Program (EAP)
 - a. Provides services to firefighters and families
 - b. Offers easily accessible, confidential assistance with problems that could adversely affect job performance
 - c. Areas of assistance – Alcohol abuse, drug abuse, personal/interpersonal problems, stress, depression, anxiety, marriage counseling, and financial problems
2. Wellness program
 - a. Assists with health-related problems
 - b. Areas of assistance – Nutrition, hypertension, cessation of tobacco use, weight control, and physical conditioning

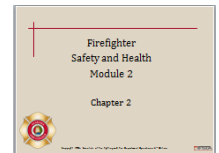
Review Question: What areas can an Employee Assistance and Wellness program assist with?

See pages 65-66 of the textbook for answers.



Chapter 2

Firefighter Safety and Health



Lesson Goal

After completing this lesson, the student shall be able to discuss how firefighter health, safety prevention, and situational awareness are interrelated parts of preventing on-the-job injuries.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. List the main types of job-related firefighter fatalities, injuries, and illnesses. *[NFPA[®] 1001, 5.1.1]*
2. Describe the National Fire Protection Association[®] standards related to firefighter safety and health. *[NFPA[®] 1001, 5.1.1]*
3. Identify Occupational Safety and Health Administration (OSHA) regulations and how they relate to firefighters. *[NFPA[®] 1001, 5.1.1]*
4. Summarize the model that supports the concept of risk management. *[NFPA[®] 1001, 5.1.1]*
5. Describe fire department safety and health programs. *[NFPA[®] 1001, 5.1.1]*
6. Summarize firefighter health awareness issues. *[NFPA[®] 1001, 5.1.1]*
7. Summarize safe vehicle operations. *[NFPA[®] 1001, 5.3.2]*
8. Summarize guidelines for riding safely on the apparatus. *[NFPA[®] 1001, 5.3.2]*
9. Describe ways to help prevent accidents and injuries in fire stations and facilities. *[NFPA[®] 1001, 5.1.1]*
10. Explain general guidelines for tool and equipment safety. *[NFPA[®] 1001, 5.1.1]*
11. Describe ways to maintain safety in training. *[NFPA[®] 1001, 5.1.1]*
12. State the practices a Firefighter I uses for emergency scene preparedness and safety. *[NFPA[®] 1001, 5.1.1, 5.3.3]*
13. Summarize general guidelines for scene management including highway incidents, crowd control, and cordoning off emergency scenes. *[NFPA[®] 1001, 5.1.1, 5.3.3]*
14. Explain the importance of personnel accountability. *[NFPA[®] 1001, 5.3.5]*
15. Respond to an incident, correctly mounting and dismounting an apparatus. *[NFPA[®] 1001, 5.3.2]*
16. Wearing appropriate PPE, including reflective vest, demonstrate scene management at roadway incidents using traffic and scene control devices. *[NFPA[®] 1001, 5.3.3]*



Instructor Information

This is the lesson covering firefighter safety and health. This lesson describes requirements from various organizations regarding protection and preventative measures. The lesson also covers specific skills to practice for safety during an incident response.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

I. APPARATUS AND VEHICLE SAFETY

pp. 66-71

Objective 7 — Summarize safe vehicle operations.

Instructor Note: Although NFPA® 1001 does not contain job performance requirements for personal or emergency vehicle operation during emergency responses, IFSTA believes that it is important to include this information. It is strongly recommended that the instructor develop appropriate skills for safe and defensive driving en route to and from emergency incidents.



A. Apparatus and Vehicle Safety

1. Basic causes of apparatus collisions
 - a. Improper backing of apparatus
 - b. Excessive speed by driver/operator
 - c. Lack of driving skill and experience by driver/operator
 - d. Reckless driving by public
 - e. Poor apparatus design or maintenance
2. Driver/operator responsibilities
 - a. Follow posted speed limits, practice proper driving techniques
 - b. Use proper backing techniques
 - c. Be aware of other drivers, be prepared to take evasive action
 - d. Inspect and report maintenance needs of apparatus
 - e. Wear seat belts all times when apparatus is in motion
 - f. Restrict use of cell phone – Pull to side of road or wait until reaching destination
3. Never operate vehicle you are not certified for – Check local licensing requirements

Review Question: What key defensive driving skills can help promote safe vehicle operations?

See page 67 of the textbook for answers.

B. Safe Vehicle Operation

1. Requires situational awareness – Be aware of surroundings, anticipate potential hazards
2. Be aware of your physical, mental, and emotional condition
3. Driving defensively – Anticipate potential hazards, and develop strategies to deal with them



6



7



8

Instructor Note: Refer students to key defensive driving skills on p. 67 of textbook. Discuss how these should be applied while driving both emergency vehicles and private vehicles.

4. Responding in private vehicles – Laws vary depending on state/province, be familiar and adhere to
5. Fire apparatus and department vehicles
 - a. Unique characteristics make more difficult to handle

Instructor Note: Refer students to safe driving techniques on pp. 68-69 of textbook. Discuss how these should be applied while driving both emergency vehicles and private vehicles.

- b. Be aware of maximum allowed weights for bridges in response area
 - c. Be aware of overhead clearance limitations
6. Emergency responses
 - a. Before leaving station
 - i. Seatbelt must be securely in place
 - ii. Hearing protection must be worn
 - b. While en route to incident scene
 - i. Make sure that all visible warning devices are on and functioning
 - ii. Leave station slowly

- iii. Approach intersections cautiously
- iv. Always come to complete stop at red light or stop sign
- v. Cautiously move into opposing lane of traffic at intersection if all traffic is stopped
- vi. Use extreme caution at railroad crossings
- vii. Aim high when steering
- viii. Use headlights during daytime responses
- ix. Use mixture of audible warning sounds
- x. Multiple emergency vehicles should travel at least 300 – 500 feet (91 to 150 m) apart
- xi. Do not blind oncoming drivers with your lights
- xii. Turn off wig-wag lights at night
- xiii. Always use turn signals

c. Principles of braking and stopping

- i. Faster movement means longer time to stop
- ii. Driver-reaction distance – Distance apparatus travels from when driver/operator realizes the need to stop and until driver/operator's foot touches brake pedal
- iii. Braking distance – Distance apparatus travels from when driver/operator touches brake pedal until vehicle is completely stopped, distance increased on wet or slick roadways
- iv. Total braking distance – Sum of driver-reaction distance and braking distance
- v. Slow down on wet or icy roadways – Braking distance is always greater

d. Water tender considerations

- i. Vehicle is much heavier and more difficult to control
- ii. Do not exceed speed limit or existing conditions
- iii. Slow when entering curves or turns – Posted speed limit may be too fast to negotiate safely
- iv. If wheels leave pavement – slow down before pulling back on roadway

7. Nonemergency operations

- a. Includes returning from incidents, going to training or maintenance



- b. Use defensive driving skills
- c. Never allow anyone to ride on exterior of apparatus – Exception is slow-speed (less than 5 mph [8 km/h]) hose loading operations
- d. Should always use spotters when backing the apparatus
 - i. Spotter safety guidelines
 - (a) *Wear PPE or reflective vests*
 - (b) *Always remain visible to the driver/operator*
 - (c) *Never shine a handlight into the mirror*
 - (d) *Use your department's hand signals for communicating with the driver*
- e. To avoid and combat skids
 - i. Do not drive too fast for conditions
 - ii. Anticipate weight shifts and possible obstacles
 - iii. Pump brakes on old apparatus; let up and pump again if skid begins
 - iv. Newer apparatus equipped with antilock braking systems (ABS) maintain constant pressure on the brake; be prepared to let up if skidding does occur
 - v. Do not release the clutch on a standard transmission until the vehicle is under control
 - vi. On slick roads, test brakes at low speed to see if vehicle is likely to skid

pp. 72

Objective 8 — Summarize guidelines for riding safely on the apparatus.

C. Safety on the Apparatus

1. Follow SOPs and requirements of NFPA[®] 1500 when riding
2. Guidelines for safety
 - a. Never stand on or in moving apparatus – Exception loading hose and apparatus is moving forward at 5 mph [8 km/h] or less
 - b. Always be seated and securely belted in before apparatus moves



10

- c. Always wear hearing protection or radio headsets
- d. Secure all loose tools and equipment
- e. Close cab doors securely
- f. On unenclosed apparatus, close safety gates or bars securely
- g. Use steps and handrails when mounting and dismounting

Review Question: What are the guidelines for safely riding on, mounting, and dismounting an apparatus?
See page 72 of the textbook for answers.

II. SAFETY WITH TOOLS AND EQUIPMENT

pp. 75-76

Objective 10 — Explain general guidelines for tool and equipment safety.

A. Safety with Tools and Equipment

1. Use PPE to reinforce fundamental safe work practices
2. Follow safety procedures when using hand and power tools – wear appropriate PPE

B. Unpowered Tools

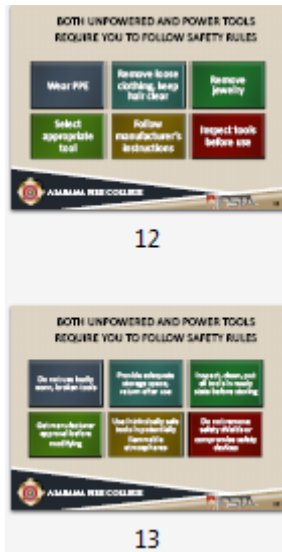
1. Most common tool type
2. Designed to be carried and used by one person; may require two people
3. Examples
 - a. Pike poles
 - b. Sledge hammers
 - c. Flat-head, pick-head axes
 - d. Claw hammers, roofing hammers
 - e. Picks
 - f. Shovels
 - g. Bolt, wire cutters



- h. Pry bars
- i. Halligans
- j. Battering rams

C. Power Tools

1. Can cause life-threatening injury if used improperly
2. Do not operate unless you have read and fully understood manufacturer's instructions
3. Repairs
 - a. Only trained, authorized personnel should repair
 - b. Repair log – Must document all repairs and name of person performing repair
4. Any not marked "double insulated" should have three-prong plug
 - a. Third prong must be connected to electrical ground while in use
 - b. Never bypass or remove third prong



D. Safety Rules for Both Unpowered and Power Tools

1. Wear appropriate PPE
2. Remove loose clothing, keep long hair clear of operating tool heads
3. Remove jewelry, including rings and watches
4. Select appropriate tool for job
5. Follow manufacturer's instructions
6. Inspect tools before use to determine condition
7. Do not use badly worn or broken tools
8. Provide adequate storage space for tools and always return promptly after use
9. Inspect, clean, and put all tools in a ready state before storing
10. Get approval of manufacturer before modifying any tool

11. Use intrinsically safe tools when working in potentially flammable atmospheres, such as around a vehicle's fuel system
12. Do not remove safety shields or compromise built-in safety devices



E. Power Saws – Safety Rules to Prevent Accidents

1. Choose right type of saw for task
2. Never force beyond its design limitations
3. Wear proper protective equipment, including gloves and vision and hearing protection
4. Remove loose clothing and contain long hair that could become entangled in the saw
5. Have hoselines in place when cutting materials that generate sparks
6. Never use a power saw in a potentially flammable atmosphere
7. Keep bystanders out of work area
8. Follow manufacturer's procedures for proper saw operation
9. Allow gasoline-powered saws to cool before refueling
10. Keep blades and cutting chains well sharpened
11. Use extreme caution when operating any saw above eye level

Review Question: What are two general guidelines to follow that can improve tool and equipment safety?
See page 76 of the textbook for answers.

III. SAFETY IN TRAINING

pp. 76-78

Objective 11 — Describe ways to maintain safety in training.

A. Maintaining Personnel Safety



1. Use appropriate PPE – Must be fully clothed for any activity that simulates emergency scene conditions
2. Be in good physical condition – Severe physical discomfort or illness can reduce ability to perform
3. Exhibit safe behavior – Horseplay or unprofessional conduct is not allowed, remain focused on training exercise at all times

B. Live Fire Training

1. Realistic training
 - a. Important – Determines field performance
 - b. Conducted according to NFPA® 1403 requirements
2. During training
 - a. Maintain situational awareness
 - b. Apply knowledge of fire behavior
 - c. Listen to instructors
 - d. Remain with team or partner
 - e. Remain calm, taking slow regular breaths
 - f. Be aware of your physical condition
 - g. Take advantage of rehab breaks
 - h. Stay hydrated



C. Maintaining and Servicing Equipment

1. Equipment used for training may wear out sooner than that used for emergency calls
2. Inspect and clean – Tools, equipment, and PPE assigned for training
3. Report items that need repaired or replaced to supervisor
4. Clean PPE thoroughly
5. Disinfect – SCBA face piece, CPR manikins, and medical equipment after each session

Review Question: What three steps can you take to maintain personnel safety during training?
See page 77 of the textbook for answers.

IV. EMERGENCY OPERATIONS SAFETY

pp. 78-80

Objective 12 — State the practices a Firefighter I uses for emergency scene preparedness and safety.

A. National Incident Management System (NIMS)

1. Incident Command System (ICS) – Organizational model designed to be applicable to all size, types of incidents
2. NIMS- ICS
 - a. Developed by federal government
 - b. Provides consistent framework for agencies from multiple jurisdictions to operate together at large-scale disasters
3. ICS operates under command and control of one Incident Commander (IC)
4. Your responsibilities as part of ICS
 - a. Report to only one supervisor
 - b. Operate as part of a team
 - c. Carry out your orders
 - d. Remain constantly aware of your situation
 - e. Advise your supervisor of any changes in the situation
 - f. Manage your air supply
 - g. Enter and withdraw from hazardous area as a team



B. Preparedness - Important Aspect of Firefighter Safety

1. Volunteer – Perform regular inspections to make sure equipment is ready for use
2. Career
 - a. Report for duty in uniform, well-rested, and mentally alert



- b. Make sure tools, equipment, and PPE are in proper location, and ready for use
- c. Check SCBA to make sure fully functional and air cylinder is full

- 3. EMS equipment – Restock supplies, replace out-of-date materials, update accountability equipment

C. Emergency Scene Safety

- 1. Help minimize risks by following fundamental rules
 - a. Follow your supervisor's orders
 - b. Wear appropriate PPE
 - c. Work as a team
 - d. Follow departmental SOPs
 - e. Maintain communications with team members and Command
 - f. Do a risk/benefit analysis for every action
 - g. Employ safe and effective tactics
 - h. Never operate alone or without supervision
 - i. Perform an initial assessment and maintain situational awareness
- 2. Your safety depends on situational awareness
 - a. Knowledge of situation or environment around you
 - b. Train yourself to be aware of environment and potential threats
- 3. In addition, apply basic techniques during structural fire fighting
 - a. Scan the outside of the building before entry to locate windows and doors that could be used as escape routes
 - b. Wear full PPE, including SCBA
 - c. Manage your air supply
 - d. Bring appropriate tools and equipment
 - e. Stay in physical, vocal, or visual contact with other members of your team
 - f. Maintain radio contact with Command, or with others outside the building

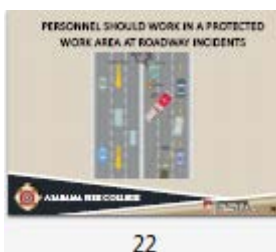
Review Question: What fundamental rules can help minimize risks at an emergency scene?

See page 79 of the textbook for answers.



D. Safety at Roadway Incidents

1. Creates danger of being struck by moving traffic
2. Visibility – PPE and vests
 - a. Wear high-visibility vests at all times
 - b. Reflective trim must meet applicable safety standards – Trim on structural PPE does not meet standard
 - c. Wear PPE without vest only when directly involved with fire fighting or hazardous materials tactical activities – Don again when completed
3. Visibility – Apparatus and scene lighting
 - a. Use emergency vehicle warning lights – Especially during initial stages of incident
 - b. SOPs may require reduced use of warning lights during night time operations
 - c. Exercise caution in use of floodlights – Ensure they are raised and deployed to direct light down onto scene without blinding motorists passing by
4. Establish protected work area
 - a. Emergency vehicles form protective barrier between oncoming traffic and working personnel
 - i. Park apparatus at angle with front wheels turned away from scene – If struck from behind it will not strike working personnel
 - ii. Position apparatus with pump panel on protected side to protect operator
 - iii. Additional apparatus can form second barrier 150 to 200 feet (45 to 60 meters) behind first
 - iv. Any apparatus not used must be moved to shoulder of roadway
 - v. Use multiple apparatus to protect all sides of work area in intersection
 - b. Signs and traffic cones
 - i. Used to detour traffic



- ii. Close off one lane of traffic next to scene
 - iii. Request traffic control assistance
- 5. Guidelines for situational awareness
 - a. Turn off all forward facing lights, including headlights
 - b. Minimize flashing lights on vehicle's sides and rear
 - c. Turn off lights that face approaching traffic, to avoid blinding or distracting drivers
 - d. Turn off all headlights, unless they are being used to illuminate the work area or warn motorists that the vehicle is in an unexpected location
- 6. Use extreme caution when exiting
 - a. Dismount on side not exposed to oncoming traffic when possible
 - b. When on exposed side – Watch for vehicles before opening door, wait for break in traffic

Review Question: What protective equipment is available to increase your safety at emergency scenes?
See page 80 of the textbook for answers.

pp. 80-85

Objective 13 — Summarize general guidelines for scene management including highway incidents, crowd control, and cordoning off emergency scenes.

E. Scene Management

- 1. Crowd control – Usually responsibility of law enforcement, may be performed by firefighters or other emergency responders
 - a. Spectators may wander through scene and interfere with working personnel; may injure themselves
 - b. Relatives and friends of victims
 - i. Treat with sensitivity and understanding
 - ii. Gently but firmly restrain from getting too close
 - iii. Responsible person should stay with them
- 2. Control zones



- a. Cordoning area off with rope, fireline, caution tape – Tied to any stationary object except vehicle
- b. Cold zone – Most distant from the incident, not specific distance away but far enough to ensure bystanders are not in danger
- c. Warm and hot zone – Take into account how much room personnel need to work, degree of hazard, and weather conditions
- d. Collapse zone – Area that must be kept clear in case wall or other piece of structure collapses into
 - i. Established when – Prolonged heat or fire have weakened structure; defensive strategy has been adopted; interior operations cannot be justified
 - ii. Size takes into consideration type of construction, other exposures, safest location for apparatus and personnel
 - iii. May be calculated by estimating height of structure and multiplying by factor of $1\frac{1}{2}$ – Rule may not be practical for taller structures

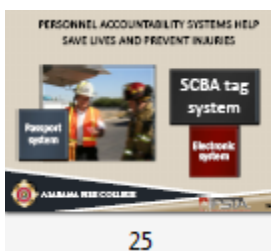
Review Question: What types of control zones may be used to establish scene security?
See pages 83-85 of the textbook for answers.

pp. 85-86

Objective 14 — Explain the importance of personnel accountability.

F. Personnel Accountability

1. Vital in the event of sudden change in fire behavior or structural collapse
2. Systems assist in keeping track of firefighters to save lives and prevent injuries
3. Variety of systems used
 - a. Passport system – Also called tag system
 - i. Crew members give passport (tag) to a designated Accountability Officer (AO) or supervisor before entering hot zone
 - ii. Passports are attached to control board or identification chart
 - iii. Personnel collect passports when leaving hot zone



b. SCBA tag system

- i. Provides more accountability data on personnel in hot zone
- ii. Firefighters give tag to AO who records time of entry and expected time of exit based on pressure in lowest-reading SCBA on team
- iii. AO also performs brief check of protective equipment
- iv. Firefighters take tags back when leaving hot zone

c. Computer-based electronic accountability systems

- i. Use bar code technology with scanners/readers and GPS or radar-based transmitters placed on PPE or radio-based tracking
- ii. Offer rapid deployment and sensors that detect and notify immobile crew members
- iii. Capable of remotely sounding *MAYDAY* or evacuation alarm; can verify receipt by IC or other firefighters
- iv. Should only supplement, not replace manual accountability methods

Review Question: Why is proper use of your personnel accountability system so important?
See pages 85-86 of the textbook for answers.

pp. 88-89

Objective 15 — Respond to an incident, correctly mounting and dismounting an apparatus.

pp. 90-91

Objective 16 — Wearing appropriate PPE, including reflective vest, demonstrate scene management at roadway incidents using traffic and scene control devices.

V. SUMMARY AND REVIEW

A. Chapter Summary

1. Safety is essential to your mission of protecting the public.



2. Protect yourself by relying on situational awareness, wearing required PPE, following orders, and following departmental safety policies and procedures.
3. Take responsibility for your own safety – You cannot protect the community unless you first protect yourself.

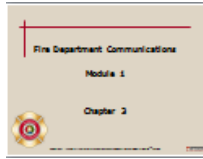
B. Review Questions

1. What types of job-related injuries and illnesses can a firefighter expect to encounter? (*pp. 46-54*)
2. What topics does NFPA[®] 1500 cover regarding firefighter safety and health? (*pp. 55-59*)
3. Federal OSHA regulations apply to what specific groups of firefighters? (*p. 60*)
4. How do the key behaviors of driving defensively, keeping the crew intact, and following standard fireground procedures support the concept of risk management? (*pp. 62-63*)
5. What are the main goals of a safety and health program? (*p. 63*)
6. What areas can an Employee Assistance and Wellness program assist with? (*pp. 65-66*)
7. What key defensive driving skills can help promote safe vehicle operations? (*p. 67*)
8. What are the guidelines for safely riding on, mounting, and dismounting an apparatus? (*p. 72*)
9. How can firefighters prevent most back and leg strains related to injuries at fire stations and facilities? (*p. 74*)
10. What are two general guidelines to follow that can improve tool and equipment safety? (*p. 76*)
11. What three steps can you take to maintain personnel safety during training? (*p. 77*)
12. What fundamental rules can help minimize risks at an emergency scene? (*p. 79*)

13. What protective equipment is available to increase your safety at emergency scenes? (*p. 80*)
14. What types of control zones may be used to establish scene security? (*pp. 83-85*)
15. Why is proper use of your personnel accountability system so important? (*pp. 85-86*)

Chapter 3

Fire Department Communications



Lesson Goal

After completing this lesson, the student shall be able to discuss external and internal communications in the fire service. Students shall also display the correct communication skills during emergency and nonemergency calls.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain the procedures for receiving emergency and nonemergency external communications. *[NFPA® 1001, 5.2.1, 5.2.2]*
2. Describe the information required to dispatch emergency services. *[NFPA® 1001, 5.2.1, 5.2.2, 5.2.3]*
3. Describe the systems used for internal communications. *[NFPA® 1001, 5.2.1, 5.2.2]*
4. Explain radio limitations that may impact internal communications. *[NFPA® 1001, 5.2.3]*
5. Describe radio procedures used for internal communications. *[NFPA® 1001, 5.2.1, 5.2.3]*
6. Handle emergency and nonemergency calls. *[NFPA® 1001, 5.2.1, 5.2.2]*
7. Use a portable radio for routine and emergency traffic. *[NFPA® 1001, 5.2.1, 5.2.3]*



Instructor Information

This is the lesson covering fire department communication. This lesson describes external and internal communications for a Firefighter I.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

I. EXTERNAL COMMUNICATIONS

pp. 96-103

Objective 1 — Explain the procedures for receiving emergency and nonemergency external communications.

Objective 2 — Describe the information required to dispatch emergency services.

A. Receiving Emergency Calls

1. Categories of telecommunications systems
 - a. Emergency Service Specific Telecommunications Center — Separate telecommunications or dispatch centers that fire department, emergency medical service, or law enforcement agency operates
 - b. Public Safety Answering Point (PSAP) — Central location that takes all emergency calls and routes call to fire, emergency medical, or law enforcement dispatcher
2. Communications center equipment
 - a. Two-way radio system for communicating with mobile and portable radios at emergency scene as well as base station (fixed locations) radios in fire stations or other department facilities
 - b. Telecommunications Device for the Deaf (TDD), Teletype (TTY), and Text phone for receiving calls from hearing-impaired individuals
 - c. Tone-generating equipment for dispatching resources
 - d. Telephones for receiving both emergency and nonemergency calls
 - e. Direct-line telephones for communications with fire department facilities, hospitals, utilities, and other response agencies
 - f. Computers for dispatch information and communications
 - g. Recording systems or devices to record telephone calls and radio transmissions



- h. Alarm-receiving equipment for municipal alarm box systems and private fire alarm reporting systems

3. Processing emergency calls

- a. Minimum requirements for receiving, processing, and dispatching emergency responders are included in NFPA[®] 1221
- b. Telecommunicators (dispatchers) — Trained to obtain correct information quickly and accurately
- c. If public contacts fire station directly — Firefighters must obtain same information caller provides
- d. Based on local protocol, information that should be gathered



- i. Type of emergency
 - ii. Location of emergency
 - iii. Number and location of people involved
 - iv. Name and location of caller
 - v. Caller's callback number
 - vi. Cross street, building name, neighborhood, area of city/county, or any nearby landmarks
- e. Enhanced 9-1-1 (E-9-1-1) — 96 percent of U.S. has access through landlines telephone connections
 - i. Combine telephone, computer equipment, computer-aided dispatch (CAD) to provide dispatcher with instant information
 - (a) *Caller's location*
 - (b) *Phone number*
 - (c) *Directions to location*
 - (d) *Other information about address*

4. Computers display street addresses associated with number call is made from

5. Public alerting systems — Anyone can use to report an emergency

- a. Uses Automatic Location Identification (ALI)
- b. ALI relies on Global Positioning System (GPS)

- c. Radio
 - i. Most likely to come from fire department personnel or other government workers
 - ii. Firefighter or dispatcher monitoring radio gathers same information that would be taken from telephone caller
- d. Wired telegraph circuit box
 - i. Pressing lever on door of box transmits unique telegraph code that identifies location of activated box
 - ii. Very reliable, but only transmits locations, not emergency
 - iii. Need has greatly diminished
- e. Telephone fire alarm box
 - i. Equipped with telephone for direct voice contact with telecommunications center
 - ii. Pull-down hook is used to send coded signal and telephone is included to allow caller to provide additional information to telecommunications center
- f. Radio fire alarm box
 - i. Contains independent radio transmitter with battery power supply
 - ii. Some have small solar panels for recharging battery
 - iii. Others have spring-wound alternator to provide power when operating handle is pulled

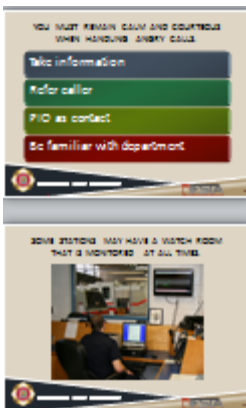
Review Question: What is the procedure for receiving an emergency external communication?
See page 98 of the textbook for answers.

B. Receiving Nonemergency Calls

1. Range from inquiries and requests for assistance to personal calls from family members or friends
2. Know and follow departmental procedures for answering nonemergency calls
3. Always be professional and courteous when answering telephone
 - a. Answer calls promptly



- b. Be pleasant and identify department, station or facility, unit, and yourself
 - c. Be prepared to record messages accurately by including date, time, name of caller, caller's telephone number, message, and your name
 - d. Never leave telephone line open or caller on hold for extended period of time
 - e. Post message or deliver it promptly to person to whom it is directed
 - f. If you cannot answer caller's question
 - i. Refer them to someone who can
 - ii. Say: "I will get that information for you and call you back shortly"
 - iii. Then follow up on request
 - g. End calls courteously; disconnect according to local protocol
4. When handling angry calls
- a. Remain calm and courteous
 - b. Take necessary information
 - c. Refer caller to appropriate officer or division that can assist
 - d. Public Information Officer (PIO) is contact person for nonemergency or complaint calls
 - e. Become familiar with functions and personnel in each division of your department
5. Some fire stations have a watch room or booth
- a. Contains
 - i. Radio communications equipment for receiving alarms from telecommunications center
 - ii. Telephones
 - iii. TDD/TTY devices
 - iv. Station intercommunications (intercom) equipment
 - b. Local protocol usually requires one member of crew to remain in room at all times
 - c. Responsibilities for monitoring
 - i. Listening to all radio communications
 - ii. Answering telephone



- iii. Acknowledging receipt of alarms
- iv. Notifying crew members of telephone calls and messages

C. Dispatching Emergency Services

Instructor Note: Direct students to Figure 3.1 on page 97 of the textbook to see the components of public safety answering point. Ask students why timely dispatch is important and can save lives.



1. Begins with some form of alert to stations, apparatus, or individuals
2. Alarm notifications
 - a. Visual
 - b. Audible
 - c. Electronic
3. Volunteer fire departments may use pagers to alert an emergency
4. Sirens, whistles, and air horns most commonly employed in small communities
 - a. Devices produce signal that everyone in community can hear
 - b. Information regarding emergency must be broadcast to department members
 - c. Broadcast should include information received from caller and information from preincident plan developed for specific address or a similar facility
 - d. Preincident surveys and fire prevention inspections may be located in a preplan book
 - e. Basic information broadcast
 - i. Units assigned
 - ii. Type of emergency
 - iii. Address or location
 - iv. Dispatch time
 - v. Current conditions, such as wind direction/speed and road closures
 - vi. Units substituted into normal assignment, if any

- f. Assigned units confirm receipt of information according to local protocol after transmission
- g. Confirmation may include
 - i. Pressing button on alarm panel in station
 - ii. Keying radio microphone
 - iii. Vocally acknowledging
- h. Telecommunications center will confirm that all units have been notified

Review Question: What is the procedure for receiving a nonemergency external communication?

II. INTERNAL COMMUNICATIONS

pp. 103-109

Objective 3 — Describe the systems used for internal communications.

A. Internal Communications

1. Messages transmitted within fire department and between department and other agencies during emergencies
 - a. Dispatch transmissions
 - b. Transmissions between telecommunications center and units at emergency scene
 - c. Transmissions between Incident Commander, Command staff, and units at scene
 - d. Transmissions between Incident Commander, Command staff, and other agencies
 - e. Transmissions between units and between members of units at scene
2. Most are radio communications
 - a. Safe and efficient emergency scene operations
 - b. Used to alert units of an emergency
 - c. Coordinate tactics at emergency
 - d. Request additional resources
 - e. Monitor activities of units and individuals



3. Most facilities, apparatus, official vehicles, and personnel assigned radios during emergencies or on daily basis
4. General knowledge required
 - a. Radio systems, how they work
 - b. Limitations of radio communications
 - c. Fixed, mobile, and portable radios assigned to you

B. Radio Systems

1. Location and size

- a. Radios used in fixed locations are referred to as base station radios



- i. Have stable, powerful transmitters and interference-resistant receivers that provide better performance than mobile and portable radios

- ii. Parts

- (a) Receiver
 - (b) Transmitter
 - (c) Antenna
 - (d) Microphone
 - (e) Speakers

- iii. Power source is electrical system for building
 - iv. May also be connected to alarm notification system

- b. Mobile radios are mounted in fire apparatus, ambulances, and staff vehicles and are powered by vehicle's electrical system

- i. Receiver and transmitter are usually located in cab within reach of officer and driver/operator
 - ii. Headset connections are usually provided
 - iii. Pumping apparatus have additional connections at pump panel while aerial devices have connections on turntable and in elevating platform

- c. Portable radios are handheld devices

- i. Designed to withstand heat, moisture, and physical impact
 - ii. Powered by rechargeable or replaceable battery packs

- iii. Controls on radio include
 - (a) *Knobs for changing channels*
 - (b) *Adjusting volume*
 - (c) *A push-to-talk switch for transmitting*
- iv. Have an orange or red EMERGENCY button
- v. If used in hazardous atmospheres must be intrinsically safe for that environment
- vi. Distribution depends on local protocol

2. Signal type

- a. Radio signals travel between transmitter and receiver in either analog or digital format
- b. Transmits over amplitude modulation (AM) or frequency modulation (FM) carrier waves
 - i. AM waves vary strength of signal to reflect speaker's voice and sometimes referred to as medium wave signals
 - ii. FM waves allow for signal to change based upon microphone audio
 - iii. FM waves do a better job of cancelling naturally-occurring noise
- c. Digital radios
 - i. Improved audio quality
 - ii. Make better use of assigned frequency or band



3. Signal transmission

- a. Direct communication — Straight line travel of radio signals between an antenna connected to a transmitter and an antenna connected to a receiver
 - i. Terrain and buildings may block radio signals
 - ii. Allows same radio channel to be used by other groups when located at greater distance from first group
- b. Simplex system — When one radio transmits and another receives
 - i. Two-party system operating on one radio can transmit at a time
 - ii. When first speaker is finished, second can press talk button and respond
 - iii. Portable radios include talk-around mode — Permits units to communicate directly





c. Repeaters

- i. Usually located on high points within broadcast area
- ii. Used to increase range of radio system and to send signals over tall barriers
- iii. Half-duplex communication — A repeater system that uses two radio frequencies
- iv. Full-duplex system
 - (a) *Allows radio communication in both directions simultaneously*
 - (b) *Can become garbled because multiple microphones broadcast at same time*

4. Fireground channels

- a. Modern radio systems designed to operate on multiple channels
- b. Most departments have channel assigned for dispatching only
- c. Command channel assigned to Incident Commander at incident
- d. Second channel usually simplex channel for communication between units and personnel
- e. Nonemergency channels exist in some departments for use by training center

5. Trunked radio systems



- a. Radio systems may either be conventional or trunked
 - i. Conventional system — Frequency is dedicated to a single function
 - ii. Trunked system — Depends on repeaters to route calls assigning transmissions to available frequencies
- b. Notifying controller
 - i. Conventional system – Term talk group distinguishes among physical frequencies or channels
 - ii. Trunked system
 - (a) *Turning a radio on notifies a trunking system controller*
 - (b) *Controller assigns a channel to that radio*

- (c) *Activating press-to-talk button sends a request to controller*
- (d) *Controller sends a message that emits a three-beep tone sequence telling firefighter to continue with transmission*
- (e) *Failure tone sounds when talk group not available – Described as bonk*

c. Other features

- i. Multigroup Call — Used to transmit calls to two or more talk groups; once connection established, talk groups can communicate
- ii. Private Call — Permits one radio to call another; conversation is private, will not be heard by others on channel or talk group
- iii. Dynamic regrouping — Emergency alert feature that sends signal to agency's dispatch center

Review Question: What types of systems are used for internal communication?

C. Radio Communications



1. Federal Communications Commission (FCC) regulates all radio communication in U.S.
 - a. Issues licenses to fire departments that operate radio equipment
 - b. One license may cover several departments that operate joint system
2. Federal offense to send personal or other unauthorized messages over designated fire department radio channel

Instructor Note: In Canada, the Canadian Radio-Television and Telecommunications Commission regulates radio communications.

3. Radio terminology

- a. Fire departments have eliminated use of ten-codes and other local terminology historically used for radio transmissions due to National Incident Management System (NIMS)
- b. Clear text — A standardized set of emergency-specific words and phrases used by fire departments

- c. Canada does not have national requirement for clear text transmissions, they use ten-codes or clear text

pp. 109-112

Objective 4 — Explain radio limitations that may impact internal communications.

A. Radio Limitations

1. Distance

- a. Signals travel in straight line
- b. Depends on power of transmitter and receiver and height of broadcast and receiving antennas
- c. Some jurisdictions use repeaters to increase area of coverage
- d. Static and broken messages mean receiver is near limit of transmission range

2. Physical barriers

- a. Signal may be totally blocked, partially blocked, or reflected by anything in between
- b. Be aware and consider repositioning to see if your signal can be sent
- c. To overcome
 - i. You may need to turn your body 90 degrees
 - ii. Lift portable radio higher
 - iii. Raise antenna up straight
- d. Dead zones occur with portable radios
 - i. May not be possible to overcome dead zones in rural areas
 - ii. Inside structures, moving to an outside wall, roof, window, or doorway can improve reception

3. Interference

- a. Originate from
 - i. Another powerful radio signal
 - ii. Vehicle ignitions
 - iii. Electric motors
 - iv. High-voltage transmission lines
 - v. Computers
 - vi. Equipment that contain microprocessors

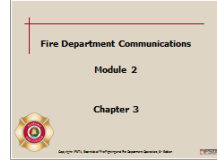
- vii. Cellular telephone towers or transmitters
 - viii. High-power radio sites such as television and radio stations
 - b. Manufacturers design high-quality transmitters, receivers, and repeater systems to filter out
 - c. Department administration or AHJ should specify and purchase best quality radio systems that are available
 - d. Watch for external causes of interference
- 4. Ambient noise
 - a. Emergency scene noise that can make radio communication difficult
 - b. Noise-canceling microphones may help
 - c. Overcoming is responsibility of each person operating a mobile or portable radio
 - i. Turn off apparatus audible warning devices when they are no longer needed
 - ii. Move away from noise-emitting equipment when transmitting
 - iii. Follow radio procedures at all times
 - iv. Move to a location that blocks wind noise
 - v. Use your body or PPE to create a wind barrier when transmitting

Review Question: What radio limitations can impact internal communication?



Chapter 3

Fire Department Communications



Lesson Goal

After completing this lesson, the student shall be able to discuss external and internal communications in the fire service. Students shall also display the correct communication skills during emergency and nonemergency calls.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain the procedures for receiving emergency and nonemergency external communications. *[NFPA® 1001, 5.2.1, 5.2.2]*
2. Describe the information required to dispatch emergency services. *[NFPA® 1001, 5.2.1, 5.2.2, 5.2.3]*
3. Describe the systems used for internal communications. *[NFPA® 1001, 5.2.1, 5.2.2]*
4. Explain radio limitations that may impact internal communications. *[NFPA® 1001, 5.2.3]*
5. Describe radio procedures used for internal communications. *[NFPA® 1001, 5.2.1, 5.2.3]*
6. Handle emergency and nonemergency calls. *[NFPA® 1001, 5.2.1, 5.2.2]*
7. Use a portable radio for routine and emergency traffic. *[NFPA® 1001, 5.2.1, 5.2.3]*



Instructor Information

This is the lesson covering fire department communication. This lesson describes external and internal communications for a Firefighter I.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

pp. 112-115

Objective 5 — Describe radio procedures used for internal communications.**A. Radio Procedures**

1. Important to follow local protocol for sending message
2. All recorded transmissions become part of official record on incident



Instructor Note: Direct students to the Communication Model information box on p. 112 of the textbook. Briefly discuss the six basic elements.

3. Rules to control communications
 - a. Units or individuals must identify in every transmission as outlined in local radio protocols

Instructor Note: Briefly discuss with students the example on p. 112 for proper protocol communication.

- b. Receiver must acknowledge every message by repeating essence of message to sender – Ensures message received, understood
 - c. Key microphone and wait second or two for signal to capture antenna before starting message

Instructor Note: Direct students to the information box on p. 114 titled “ABCs of Good Communications.” Briefly discuss the differences between the two example communications provided.

4. Guidelines

- a. Know what you are going to say before you open microphone
 - b. Use moderate rate of speaking focused on clear understanding; do not use pauses or verbal fillers such as “ah” or “um”
 - c. Use moderate amount of expression in speech — not monotone, not overemphasized — with carefully placed emphasis
 - d. Use vocal quality that is not too strong or weak
 - e. Do not chew gum or eat food while transmitting

- f. Be concise, to the point; do not talk around issue
- g. Do not transmit until radio frequency is clear
- h. Remember that emergency transmissions have priority over routine transmission
- i. Do not use profane or obscene language on air
- j. Hold radio/microphone 1 to 2 inches (25 mm to 50 mm) from mouth or self-contained breathing apparatus (SCBA) voice port when transmitting
- k. Speak directly into microphone, not across it
- l. Hold microphone according to manufacturer's recommendations
- m. Repeat message back to sender to ensure that they know you received and understood it
- n. Place microphone against your throat if you cannot be understood through SCBA facepiece
- o. Practice communicating with portable radio while wearing SCBA before you have to use it



WARNING: DO NOT REMOVE YOUR FACEPIECE TO TALK INTO THE MIC.

5. Radio communications best practices

- a. Speak with loud, controlled, and clear voice
- b. Shield microphone from noise, water, and debris; cup hand over or use helmet brim to protect
- c. Locate microphone or radio as far away from personal alert safety system (PASS) device, low-pressure alarm, or other noise-generating equipment
- d. Avoid laying microphone on seat of vehicle because transmission button may be pressed inadvertently
- e. Position antennae vertically for best transmission results
- f. Do not shout

Review Question: What radio procedures must be followed for internal communications? *P. 112 for answers.*

Firefighter II Content

Lesson Goal

After completing this lesson, the student shall be able to discuss on-scene communications and postincident reports.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Describe the aspects that make up on-scene communications. *[NFPA® 6.2.2]*
2. Explain the information gathered by postincident reports. *[NFPA® 6.2.1]*
3. Create an incident report. *[NFPA® 6.2.1]*

Instructor Information

This is the lesson covering fire department communications. This lesson describes on-scene communications for a Firefighter II.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

I. ON-SCENE COMMUNICATIONS

pp. 116-121

Objective 1 — Describe the aspects that make up on-scene communications.

A. Arrival Report

1. If first on-scene, provide initial radio report – Provide other units, telecommunications center with description of conditions as they appear
2. Referred to as
 - a. Arrival report
 - b. Report on conditions
 - c. Brief initial report
 - d. On-scene report
 - e. Situation report
 - f. Size-up report
 - g. CAN (condition, actions, needs) report
3. Initial report
 - a. Establishes initial arrival time
 - b. Informs other responding units of current conditions
 - c. Describes actions that are being taken
 - d. Describes actions that need to be taken by other responding units
4. Two basic arrival situations
 - a. No visual evidence of emergency, requires more investigation
 - b. Obvious signs of emergency requires immediate action
5. Arrival report should contain
 - a. Unit (or individual) arriving on-scene
 - b. Correct address of incident if different from dispatch address
 - c. Description of conditions found



- d. If structure fire or collapse, description of structure
 - i. Number of floors
 - ii. Type of construction
 - iii. Type of occupancy
- e. Operational strategy
- f. Intended initial actions
- g. Water supply need or availability
- h. Establishment of Command
 - i. Specify who is Incident Commander
 - ii. State name of incident (may be address or name of occupancy)
 - iii. State location of Command Post when applicable
 - iv. State location(s) of staging areas for arriving units
- i. Calls for additional resources
- j. Routing instructions to arriving units
- k. Assignments to arriving units
- l. Tactical radio channel for use if required by local protocols

Instructor Note: In some jurisdictions, the telecommunications center will provide the radio channel to responding units.

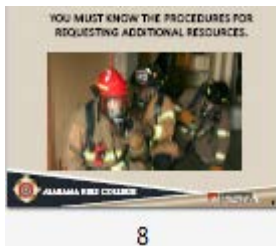
B. Progress Report

1. Provides telecommunications center with continuous record of actions at scene
2. Contain
 - a. Transfer of Command
 - b. Change in Command Post location
 - c. Progress (or lack of) toward incident stabilization
 - d. Direction of fire spread
 - e. Exposures by direction, height, occupancy, and distance
 - f. Any problems



- g. Anticipated actions
- h. Need for additional resources
- 3. Telecommunications center may be assigned task of providing periodic time transmissions at designated intervals
 - a. Used to assist in air management – Remind interior units to read air capacity gauges
 - b. Used to assist IC, Command Staff to gauge effectiveness of strategies and tactics being used
- 4. Tactical progress report
 - a. Provides opportunity to check individual air supplies
 - b. When giving include air consumption
 - c. Keep track of crew's air management – Be outside structure before low air alarm activates
 - d. Provided to IC
 - e. Must be accurate, brief, concise

Instructor Note: Direct students to the information box on page 119 of the textbook entitled Tactical Progress Report Example. Discuss with students the acronyms CARA and CAN.



C. Requesting Additional Resources

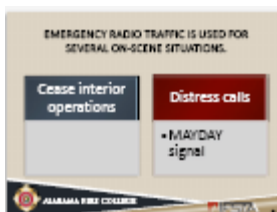
- 1. Know local procedure for requesting additional resources
- 2. Be familiar with procedures for requesting multiple or special alarm signals
- 3. Know what resources each additional alarm assignment will include – Number and types of units that respond

Ask Students: What are the resources each additional alarm assignment could include?
Briefly discuss answers with students. Possible answers are the number and types of units that respond to each additional alarm

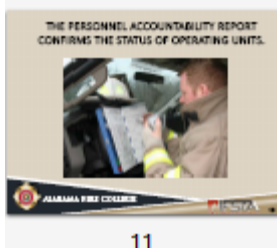
- 4. Radio-equipped, mobile communications vehicle can be used at large incidents to maintain communication



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D. Emergency Radio Traffic

1. Intended to warn personnel at scene of impending hazard
2. Broadcast process
 - a. Begins with clear statement to alert all listeners – “Dispatch, Engine One, Emergency Traffic!”
 - b. Dispatch or IC acknowledge statement with vocal response or use of alert tone
 - c. Unit originating states type of hazard, action required – “Engine One, west wall showing signs of collapse, cease interior operations and evacuate the structure.”
3. To cease interior operations
 - a. Broadcast radio message on incident’s tactical channel ordering evacuation
 - b. Sound audible warning devices on apparatus at scene
4. Can include distress calls from firefighters
5. May require use of MAYDAY signal

E. Personnel Accountability Report (PAR)

1. Systematic method of confirming status of units operating at incident
2. When requested, every supervisor must verify status of those under command and report it
3. Limitation — Uses a considerable amount of radio time
4. Reasons for request
 - a. Incident declared under control
 - b. Change from offensive to defensive strategy
 - c. Sudden catastrophic event such as flashover, backdraft, or collapse
 - d. Emergency evacuation
 - e. Firefighter reported missing or in distress
 - f. Primary search completed
 - g. Safety Officer requests it

Review Question: What are the basic aspects of on-scene communications?

See page 116 of the textbook for answers.

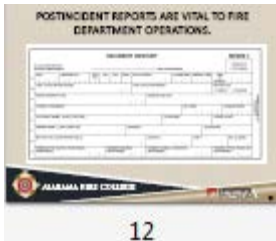
II. POSTINCIDENT REPORTS

pp. 121-123

Objective 2 — Explain the information gathered by postincident reports.

A. Postincident Reports

1. Vital to fire department operations from legal, statistical, and record-keeping standpoints
2. Must be complete and written in terminology that general public can understand
3. Can be handwritten or entered into computer
4. Information gathered for
 - a. Assessing departmental needs
 - b. Budgeting
 - c. Determining trends in types of responses
 - d. Determining trends in firefighter injuries
 - e. Providing information for national fire safety databases
 - f. Determining trends in fire causes
 - g. Determining requirements for fire and life safety education programs
 - h. Providing information to insurance rating agencies
5. Based on form or checklist that is easy to complete and thorough
6. National Fire Incident Reporting System (NFIRS)
 - a. Developed by United States Fire Administration (USFA)
 - b. Outlines necessary information needed to complete incident reports
 - c. Computer-based system that transfers data from each state to federal database



- d. Developed to create data for analyses and to assist in combatting nation's fire problem

7. General list of information

- a. Fire department name, incident number, district name/number, shift number, and number of alarms
- b. Names and addresses of occupant(s) and/or owner(s)
- c. Type of structure, primary use, construction type, and number of stories
- d. How emergency was reported
- e. Type of call
- f. Action that was taken
- g. Property use information
- h. Number of injuries and/or fatalities
- i. Number of personnel and type of apparatus that responded
- j. How and where fire started
- k. Method used to extinguish fire
- l. Estimated cost of damage
- m. Remarks/comments

Instructor Note: Postincident reports must be accurate, complete, and correctly compiled. Because incident reports are legal documents, there are possible legal consequences if the reports are inaccurate or incomplete.

Review Questions: What are postincident reports used for?
See page 121 of the textbook for answers.

What information is gathered when creating a postincident report?
See page 122 of the textbook for answers.

III. SUMMARY AND REVIEW

A. Chapter Summary

1. Fire department communications include the methods used to exchange information between individuals and units at the emergency scene.
2. As a firefighter, you must know the importance of initial and progress reports from the incident, and how to prepare postincident reports.

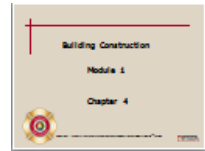


B. Review Questions

1. What are the basic aspects of on-scene communications? (*p. 116*)
2. What are postincident reports used for? (*p. 121*)
3. What information is gathered when creating a postincident report? (*p. 122*)
4. internal communications? (*p. 112*)

Chapter 4

Building Construction



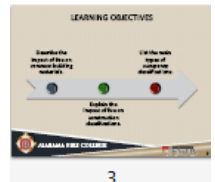
Lesson Goal

After completing this lesson, the student shall be able to explain how common building materials and construction methods are impacted by fire. The student shall also be able to explain how construction methods of basic building materials can either contribute to, or help control, fire spread.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Describe the impact of fire on common building materials. *[NFPA[®] 1001, 5.3.4, 5.3.10, 5.3.12]*
2. Explain the impact of fire on construction classifications. *[NFPA[®] 1001, 5.3.4, 5.3.10, 5.3.12]*
3. List the main types of occupancy classifications.
4. Describe the basic construction of building components. *[NFPA[®] 1001, 5.3.4, 5.3.10, 5.3.12]*



Instructor Information

This is the lesson covering building construction for Firefighter I. This lesson describes basic building materials, construction classifications, occupancy classifications and building components.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

I. BUILDING MATERIALS

pp. 134-142

Objective 1 — Describe the impact of fire on common building materials.

A. Building Materials

1. Variety used in construction
2. All react differently when exposed to heat of fire
3. Knowledge of reaction will give an idea of what to expect from a fire in that type of construction

B. Wood

1. Most common material used in North America
2. Main component in variety of structural assemblies
3. Size and moisture content affect how reacts to fire
 - a. Smaller dimensions
 - i. Easier to ignite
 - ii. Lose structural integrity faster
 - iii. Protected by gypsum drywall or other insulation
 - b. Large beams
 - i. Difficult to ignite
 - ii. Retain structural integrity even after prolonged exposure to direct flame
4. Moisture content affects burn rate
 - a. High moisture content – Can be known as green wood
 - i. Does not ignite readily
 - ii. Does not burn as fast as kiln dried or dehydrated by exposure to air over long periods of time
 - b. May be pressure treated with fire-retardant chemicals to reduce ignition and burn speed
 - i. Not always totally effective in reducing fire spread
 - ii. Weakens load-carrying ability by as much as twenty-five percent



5. Newer construction contains composite building components and materials
 - a. Made of wood fibers, plastics, other substances; joined by glue or resin binders
 - b. Include plywood, particleboard, fiberboard, oriented strand board (OSB)
 - c. Under fire conditions
 - i. May be highly combustible
 - ii. Can produce significant toxic gases
 - iii. Can rapidly deteriorate

C. Masonry

1. Includes bricks, stones, concrete blocks
2. Brick, stone used to create veneer walls – Decorative covers for wood, metal, concrete block load-bearing walls
3. Minimally affected by fire, exposure to high temperatures
4. Signs of deterioration
 - a. Bricks – Rarely show any signs of loss of integrity, serious deterioration
 - b. Stone, concrete – May lose small portions of surface when heated, called spalling
 - c. Concrete blocks – May crack, usually retain strength and structural stability
 - d. Mortar between bricks, blocks, stone – May degrade by heat, display signs of weakening



D. Metal

1. Used to provide structural support, decorative covering on exterior walls, stairs, door and window frames, ductwork, pipes, and fasteners
2. Effect of heat will depend on type of metal and if it is exposed or covered

3. Iron

a. Cast iron

- i. Commonly used in 19th Century for structural support beams and columns, stairs, balconies, railings, elevators, facades of buildings
- ii. Stands up well to fire, intense heat
- iii. May crack or shatter when rapidly cooled with water
- iv. During fire, bolts or other connections holding cast iron components can fail – Causing them to fall
- v. Failure can also result from bolts rusting through, mortar becoming loose around bolt

b. Wrought iron

- i. Used in buildings of early 1800s for nails, straps, tie rods, railings, balconies
- ii. Used after 1850 for rail and I-beams, channels, support columns
- iii. Used today for decorations in construction of gates, fences, balcony railings

c. Construction

- i. Cast iron – Bolted or screwed
- ii. Wrought iron – Usually riveted or welded together

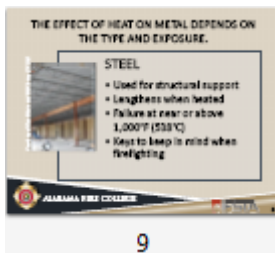
4. Steel

a. Uses

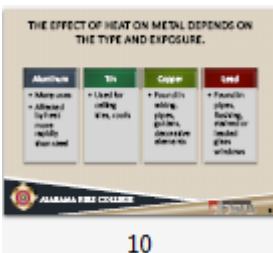
- i. Primary material used for structural support of large modern buildings
- ii. Stairs, wall studs, window and door frames, balconies, railings
- iii. Reinforce concrete floors, roofs, walls

b. Structural members lengthen (elongate) when heated

- i. A 50 foot (15 m) beams may elongate as much as 4 inches (100 mm) when heated to about 1,000°F (538°C)
- ii. If restrained from movement at ends, buckles and fails somewhere in middle



- iii. Failure anticipated at temperatures near or above 1,000°F (538°C) – Exact temperature varies based on variables
 - (a) *Size of member*
 - (b) *Load it is under*
 - (c) *Composition of steel*
 - (d) *Geometry of member*
- c. Effect of heat reduced when fireproofing materials used – Such as sprayed-on concrete or sprayed-on insulation
- d. When fire fighting
 - i. Be aware of type of members used in particular structure
 - ii. Determine how long members have been exposed to heat – Gives indication when failure may occur
 - iii. Remember critical temperature can be easily reached at ceiling level from rising heat, smoke
 - iv. Always consider effect of heat on members even if you cannot see
- e. Elongating steel can push out load-bearing walls, cause collapse
 - i. If walls withstand elongation, steel will fail and sag somewhere in middle causing collapse of upper floors, roof
 - ii. Water can cool structural members and stop elongation – Reducing risk of collapse



5. Aluminum

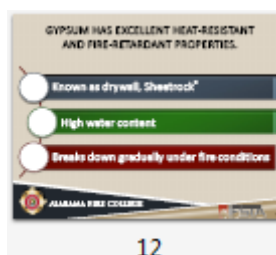
- a. Uses
 - i. Decorative features – Tower portion of Empire State Building in New York City, NY
 - ii. Decorative/functional – Roofing, flashing, gutters, downspouts, window and door frames, exterior curtain wall panels
 - iii. Residential uses – Sun rooms, screened porches, car ports, awnings
 - iv. Aluminum studs replaced wood in commercial and residential buildings

- v. Aluminum framing and support wires support acoustical tile ceilings – Can create entanglement hazard
- b. Will be affected by heat more rapidly than steel
- 6. Other metals – Fail when exposed to excessive amounts of heat
 - a. Tin – Used to produce metal ceiling tiles, also as roof covering
 - b. Copper – Found in wiring, pipes, gutters, decorative elements
 - c. Lead – Found in pipes, flashing, as component of stained or leaded glass windows

E. Reinforced Concrete



1. Can be poured in place at construction site or formed into precast sections and transported to site
2. Internally fortified with steel reinforcement bars (rebar) or wire mesh
 - a. Gives material compressive strength – Ability to withstand pressure on surface
 - b. Gives tensile strength – Ability to withstand being pulled apart or stretched
3. Under fire conditions
 - a. Performs well but can lose strength through spalling
 - b. Cracks and spalling indicate damage has occurred, strength may be reduced
4. Prolonged exposure to chemicals before exposure to fire can cause rebar to corrode and concrete bond to weaken – Reduces time to failure, very important to know occupancy history



F. Gypsum

1. Also known as drywall or Sheetrock® – Inorganic product from which plaster and wallboards are constructed
2. Unique high water content

- a. Absorbs great deal of heat as moisture evaporates
 - b. Gives excellent heat-resistant and fire-retardant properties
3. Breaks down gradually under fire conditions – Commonly used to insulate steel and structural members
 4. Where failed – Structural members behind will be subjected to higher temperatures, could fail

G. Lath and Plaster

1. Process rather than single material
 - a. Horizontal wood strips (lath) nailed to wall studs
 - b. Covered with mixture of plaster to form interior wall finish
2. Generally found in buildings constructed prior to 1950s
3. Wire mesh may be used to replace lath in some houses
4. Can be very difficult to penetrate with axes or hand tools
5. Can also conceal fire within cavity between surfaces
6. May add fuel to fire in form of studs, lath



H. Glass/Fiberglass

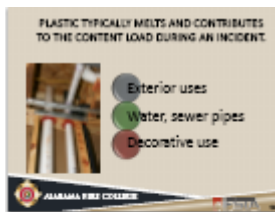
1. Glass – Not typically used for structural support
 - a. Sheet form used for doors and windows
 - b. Block form used for non-load-bearing walls
 - c. Wire-reinforced may provide some thermal protection as a separation
 - d. Conventional not effective barrier to fire extension
 - e. Heated may crack and shatter when struck by cold fire stream
2. Fiberglass – Typically used for insulation
 - a. Located between interior/exterior walls and between ceilings and roofs

- b. Glass component not significant fuel
- c. Materials used to bind may be combustible, difficult to extinguish

Instructor Note: Discuss the Information Box on pages 140-141 of the textbook. Highlight the types of insulation commonly found in your jurisdiction. Ask students why it is important to know what types of insulation are present during fire suppression. In your discussion focus on possible health risks that may be present.

I. Plastic

1. Used in many forms
 - a. Exterior – Vinyl siding over older siding, foam insulation panels, other materials
 - b. Water and sewer pipes – Made from various sizes of plastic pipe and fittings, used to replace lead pipes
 - c. Decorative uses – Moldings, wall coverings, mantel pieces
2. Most will melt, can contribute to fuel load



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J. Composite Materials

1. Used more frequently than in the past
2. Manufactured by combining two or more distinctly different materials
3. Results in lightweight materials with high structural strength, resistance to chemical wear, corrosion resistant, heat resistant
4. Materials are cost effective, easy to manufacture
5. Examples
 - a. Finger-jointed timber — Small pieces of wood joined into longer boards using epoxy resins, glues
 - b. Laminated timber — Known as plywood or glulam (glue-laminated) wood; sheets of wood used for roof and floor decking, walls, stair treads
 - c. Medium density fiberboard (MDF) — Another type of laminated wood product, closer in appearance and strength to hardwood; used for doors and door-surrounds, decorative moldings, rails, skirtings, and cornices



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- d. Particle board
 - i. Made from small particles and flakes generated in the manufacture of lumber; used for exterior and interior wall panels and furniture
 - ii. Urea formaldehyde is one of the glues used to manufacture particle board – Can pose health hazard due to outgassing when heated
- e. Synthetic wood
 - i. Produced in sheets and boards
 - ii. Manufactured from recycled plastic from liquid containers – Primarily milk bottles
 - iii. Primarily used for exterior rails, stairs, decks

Review Question: What impact can fire have on common building materials?

See pages 134-142 of the textbook for answers.

II. CONSTRUCTION CLASSIFICATIONS

pp. 142-151

Objective 2 — Explain the impact of fire on construction classifications.

A. Construction Classifications

1. Type is determined by
 - a. Architect, structural engineer, contractor
 - b. Local building codes regulate based on
 - i. Intended use – Known as occupancy classification
 - ii. Structure size
 - iii. Presence or lack of automatic fire suppression system
 - c. Materials used in construction, how well materials resist exposure to fire
2. Building codes
 - a. Adopted by authority having jurisdiction (AHJ), amended to meet local requirements
 - b. May be locally developed or based on nationally accepted codes



- c. Two major models in United States
 - i. NFPA[®] 5000, Building Construction and Safety Code[®]
 - ii. International Code Council's (ICC) *International Building Code*[®] (IBC[®])
- d. One code in Canada – May be adopted by provincial or local government
- e. Buildings may be exempt from local codes
 - i. Factory-built homes, also known as mobile or manufactured – Regulated by Department of Housing and Urban Development
 - ii. Federal- or State-owned buildings – Such as offices, courthouses, university buildings, postal facilities, other government facilities
 - iii. Manufactured housing in Canada regulated by Canadian Standards Associations (CSA) and Standards Council of Canada (SCC)

3. Be aware that local AHJs can amend model codes to meet needs

4. Renovations can change structures

- a. Can create structures containing more than one construction method – Structure may appear fire-resistant but be vulnerable to rapid fire development
- b. May improve fire and life safety through addition of fire alarm systems or sprinkler systems
- c. Modifications can create potential hazards for occupants and firefighters



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B. United States Construction

- 1. IBC[®] and NFPA[®] classify five types of construction
 - a. Further divided depending on code, construction type
 - b. Defined by construction materials, performance when exposed to fire
 - c. Every building composed of
 - i. Structural frame
 - ii. Floor construction
 - iii. Roof construction

2. Type I (Fire-Resistive)

- a. Provides highest level of protection from fire development, spread, and collapse
- b. Structural members composed of noncombustible or limited-combustible materials with high fire-resistive rating
- c. Walls, floors, ceilings must be able to resist fire for 3 to 4 hours depending on component
- d. Can be expected to remain structurally stable during fire – Considered to be most collapse resistant
- e. Reinforced concrete, precast concrete, protected steel frame construction – Meet criteria for Type I
- f. Fire walls used to limit fire spread through structures
 - i. Can be reduced or eliminated when owners, and contractors make unprotected penetrations through walls for pipes, wires, and ducts
 - ii. Heat, smoke, flames quickly progress through openings – Spreading fire where otherwise might have been protected
- g. Incorrectly referred to as fireproof
 - i. Structure will not burn – May degrade from effects of fire
 - ii. Provides structural stability – Combustible materials present may generate sufficient heat over time to compromise structural integrity
- h. Conditions that may be present during fire
 - i. Compartments can retain heat contributing to potential for rapid fire development
 - ii. Roofs extremely difficult to penetrate for purpose of ventilation due to construction material and design
 - iii. Windows may be nonoperating, very difficult to open for ventilation

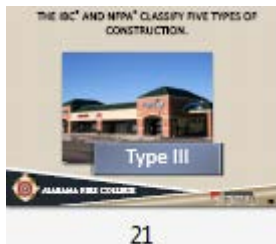
3. Type II (Noncombustible or Limited-Combustible)

- a. Composed of materials that will not contribute to fire development or spread

- b. Materials do not meet stricter requirements used in Type I – Steel components do not need to be protected for same lengths of time or have same fire-resistance
- c. Most common form – Structures with metal framing members, metal cladding, or concrete-block construction of walls with metal deck roofs supported by unprotected open-web joists
- d. Fire-resistance rating half that of Type I – 1 or 2 hours depending on component
- e. More prone to collapse
- f. Normally used when
 - i. Fire risk expected to be low
 - ii. Fire suppression and detection systems designed to meet fuel load of contents
- g. Noncombustible does not reflect true nature of structure
 - i. Lower fire-resistive ratings permitted for roof systems and flooring
 - ii. Fire-resistant metal roof decking may be covered with combustible layers – Can melt and ignite causing second fire
 - iii. Combustible features included on exterior – Balconies and facades

4. Type III (Ordinary Construction)

- a. Commonly found in older schools, mercantile, business, and residential structures
- b. Requires
 - i. Exterior walls, structural members be constructed of noncombustible materials
 - ii. Interior walls, columns, beams, floors, and roofs are completely or partially constructed of wood
- c. Conditions that can affect behavior during fire
 - i. Voids exist inside wooden channels created by roof and truss systems, between wall studs – Allow for spread of fire unless fire stops installed in void
 - ii. May have undergone renovations that contributed to greater fire risk due to creation of



large hidden voids above ceilings and below floors

- iii. Structural components may have been removed to change configuration open up floor space during renovations – May reduce load-carrying capacity of supporting structural member
- iv. Change in building use or occupancy may result in additional loads that building was not designed to carry
- v. Prefabricated wood truss systems may be found in new Type III structures – May fail quickly when exposed to fire

Instructor Note: Discuss the Safety Alert Box on page 146 of the textbook. Highlight the types of renovations that may be found in your jurisdiction. Ask students how fire fighters can monitor these types of changes. In your discussion focus on local renovation projects that recruits may not know about.

5. Type IV (Heavy Timber/Mill Construction)

- a. Characterized by use of large-dimension lumber
 - i. Dimensions vary depending on building code at time of construction
 - ii. Generally structural members greater than 8 inches (203.2 mm) in dimension, fire rating of 2 hours
 - iii. All structural element dimensions adhere to minimum dimension sizing – Other materials not wood must have rating of at least 1 hour
- b. Extremely stable, resistant to collapse – Due to sheer mass of structural members
- c. When in fire heavy members form insulating effect – Derived from timbers' char, reduces heat penetration to inside of beam
- d. Exterior walls – Constructed of noncombustible materials
- e. Interior elements
 - i. Constructed of solid or laminated wood with no concealed spaces
 - ii. Lack of voids or concealed spaces helps prevent fire travel



- f. May include small-dimension lumber glued together to form laminated structural element – Sometimes called glulam
 - i. Elements extremely strong, commonly found in churches, barns, auditoriums, and other large facilities with vaulted or curved ceilings
 - ii. Beams may fail when exposed to fire – Glue holding together may be affected by heat
 - g. Conditions that can affect behavior during fire
 - i. High concentration of wood can contribute to intensity of fire once it starts
 - ii. Collapse of masonry walls can be caused by loss of structural integrity of timbers
6. Type V (Wood or Stick Frame)
- a. Exterior load-bearing walls composed entirely of wood
 - b. Veneer of stucco, brick, and stone may be constructed over wood frame
 - i. Offers appearance of Type III construction
 - ii. Provides little additional fire protection or structural support
 - c. Most common example single-family dwelling, residence – May be multistory apartment building
 - d. Consists of framing materials that include wood 2 x 4 or 2 x 6 inch (50 mm by 100 mm or 50 mm by 152 mm) studs
 - i. Northern climates may mandate 6 inch (152 mm) exterior wall cavities for increased insulation
 - ii. Outside of members covered with variety of materials

Instructor Note: Discuss the list of types of materials that may cover Type V construction on pages 148-149 of the textbook. Highlight the types of coverings commonly found in your jurisdiction.

- iii. Exterior siding attached by nails, screws, glue – For stucco, spread over lattice attached to framing studs

- e. Includes the use of prefabricated wood truss systems in place of solid floor joists – Creates large, open void between floors rather than closed channel system
- f. Wood I-beams
 - i. When used constructed of thin plywood, wood composite glued to 2 x 4 inch (50 mm by 100mm) forming bottom and top truss
 - ii. May have numerous holes cut to in them to allow for electric, communication, utility lines to be extended through
 - iii. Under fire conditions fail and burn more rapidly than solid lumber

C. Manufactured Structures

1. Structure built in factory, shipped to location to be installed
2. Mobile homes have axle assembly under frame
3. Make up twenty-five percent of all housing sales in U.S.
4. Not required to conform to model building codes – Must conform to U.S. HUD standard similar to Type V construction
5. Fire-resistance will vary depending on age – Those built before 1976 have less fire-resistance than current construction
6. Lightweight building materials
 - a. Susceptible to early failure in fire
 - i. Heat produced by contents can cause to ignite or melt rapidly
 - ii. Contents have same fuel load as in conventional structures
 - b. Make forced entry easier because walls can be quickly breached
7. May be anchored directly to concrete slab, have open crawl spaces beneath – Crawl spaces provide additional source of oxygen during fire



8. NFPA[®] analysis shows steady decline of fires in manufactured homes since 1980 – Compares pre 1976 construction (prestandard) to post 1976 (poststandard)
9. Reductions attributed to construction requirements of HUD standard
 - a. Factory-installed smoke alarms
 - b. Use of flame-retardant materials in interior finishes
 - c. Use of flame-retardant materials around heating and cooking equipment
 - d. Installation of safer heating and cooking equipment
 - e. Installation of gypsum board rather than wood paneling in interior finishes
 - f. Factory-installed fire suppression systems (sprinklers)

Instructor Note: Discuss the Information Box on pages 150-151 of the textbook. Highlight the types of factory-built homes commonly found in your jurisdiction. In your discussion focus on the specific ways each type of home behaves during a fire.

III. OCCUPANCY CLASSIFICATIONS

pp. 151-157

Objective 3 — List the main types of occupancy classifications.

A. Occupancy Classifications

1. Defined by building code and life safety code adopted by AHJ
2. Three primary models in North America
 - a. NFPA[®] 5000
 - b. IBC[®]
 - c. National Building Code of Canada (NBC[®])



Instructor Note: Discuss the Table 4.1 “Comparative Overview of Occupancy Categories” on pages 153-156 of the textbook. In your discussion focus on the similarities and differences students can find between the three codes.

B. Single-Use

1. Must meet building code for intended use
2. Examples
 - a. Office building must meet requirements in Business Occupancy Classification
 - b. Elementary school must meet requirements of Educational Occupancy
3. Requirements may include exit access, emergency lighting, fire protection systems, construction type, fire separation barriers
4. Generally classified by primary function when structure contains multiple types of uses
 - a. Furniture manufacturing plant classified as Manufacturing Occupancy – Contains storage of raw materials, finished products, offices, and manufacturing
 - b. May require fire separation walls and fire protection systems to protect one area from other

C. Separated Use

1. Structures that contain multiple occupancies or use groups
2. Must meet requirements for each individual occupancy classification
3. Example – Strip mall
 - a. Retail outlets – Mercantile Occupancy
 - b. Offices – Business Occupancy
 - c. Restaurants – Assembly Occupancy
4. Occupancies may change over time without updating proper fire separations

- a. Unauthorized, non-code- compliant penetrations may be made in fire walls – Permit spread of fire and smoke
- b. Periodic preincident surveys are important to prevent these conditions

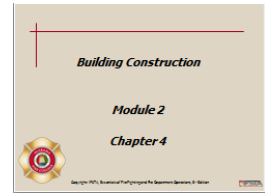


Review Question: What are the main types of occupancy classifications?

See pages 151-157 of the textbook for answers.

Chapter 4

Building Construction



Lesson Goal

After completing this lesson, the student shall be able to explain how common building materials and construction methods are impacted by fire. The student shall also be able to explain how construction methods of basic building materials can either contribute to, or help control, fire spread.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Describe the impact of fire on common building materials. *[NFPA[®] 1001, 5.3.4, 5.3.10, 5.3.12]*
2. Explain the impact of fire on construction classifications. *[NFPA[®] 1001, 5.3.4, 5.3.10, 5.3.12]*
3. List the main types of occupancy classifications.
4. Describe the basic construction of building components. *[NFPA[®] 1001, 5.3.4, 5.3.10, 5.3.12]*



Instructor Information

This is the lesson covering building construction for Firefighter I. This lesson describes basic building materials, construction classifications, occupancy classifications and building components.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

I. BUILDING COMPONENTS

pp. 157-189

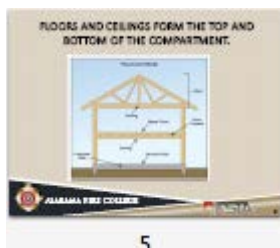
Objective 4 — Describe the basic construction of building components.

A. Building Components

1. Buildings composed of same components
2. Each component has function, can prevent or contribute to growth of fire

B. Foundations

1. Designed to support weight of building and all contents
2. May be shallow or deep
3. Shallow – Extends few feet (meters) into earth around perimeter of structure
 - a. Sits on footing made from poured, reinforced concrete or concrete blocks
 - b. First floor constructed on foundation – Takes one of two forms
 - i. Solid concrete slab
 - ii. Stem wall with wood or metal joist floor – Creates crawl space between floor, soil below
 - c. Single-story basements also constructed
4. Deep – Used to support mass of large area or tall building
 - a. Include piers or pilings driven into soil, drilled shafts, caissons, helical piles, earth stabilized columns
 - b. Multiple basement levels may rest on piers
 - c. Specialized systems may be used in earthquake-prone regions



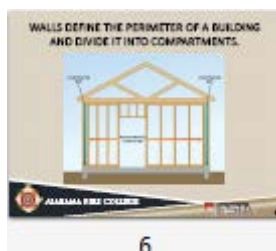
C. Floors/Ceilings

1. Form the top and bottom of compartment with walls forming sides
2. Construction varies depending on level

- a. At ground level – May consist of concrete slab or floor assembly made up of joists and decking over crawl space or basement
 - b. Upper floors of multistory building – Consists of joists and decking with ceiling attached to bottom
 - c. Top level – Consists of ceiling, joists or rafters, roof above
3. Space formed by floor/ceiling or ceiling/roof may contain
- a. Duct work or open return air plenum
 - b. Electrical or communication wiring
 - c. Water or natural gas pipes
 - d. Pipes for fire suppression system
 - e. Recessed lighting, speakers for audio system may be located above ceiling
 - f. Fiberglass, cellulose, or foam insulation may be located in space beneath roof or under floors as soundproofing

Instructor Note: Remind students of the information in the NOTE on page 159 of the textbook. Discuss if your jurisdiction has this requirement and how it will impact fire suppression activities.

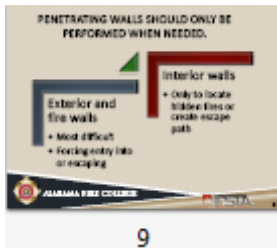
4. May be constructed of combination of materials
- a. Floors may be poured reinforced concrete; cellular concrete over metal decking; finished wood, tile, carpet surface over wood subfloor attached to metal or wood joists
 - b. Ceilings generally gypsum board, tin tiles, or lath and plaster attached to joists, roof trusses, beams
5. In corridors designated as exit or egress pathways
- a. Ceilings have same fire-resistance rating as walls in corridor
 - b. Material used to cover floors also rated to limit flammability in corridor
 - c. Rating indicated in hours



D. Walls

1. Define perimeter of building, divide it into compartments or rooms
2. Exterior walls may be
 - a. Wood or metal siding attached to studs, single layer of concrete, concrete blocks, and logs
 - b. Assembly of studs with exterior material on outside and interior coving on inside
3. Wall assemblies
 - a. Consist of bottom plate, top plate, vertical studs, horizontal braces sandwiched between two surfaces of gypsum or lath and plaster
 - b. Cavity formed by two surfaces may be dead air space or void; contain some form of insulation
4. Types
 - a. Load-bearing – Interior and exterior walls that support weight of structure or structural components
 - b. Non-load-bearing
 - i. Walls that only support their own weight
 - ii. May act as partition wall – Dividing two areas within structure
5. Rating
 - a. Interior assemblies may be rated for specified fire-resistance time depending on local building code
 - b. Rated assemblies may be continuous from floor to bottom of next floor
 - c. Unrated walls may only extend to room ceiling creating open space over multiple rooms
6. Fire walls
 - a. Constructed of variety of masonry materials – These materials do not burn
 - b. Intended to provide separation that meets requirements of specified fire-resistance rating
 - c. Assemblies include wall structure, doors, windows, any other protected openings meeting required protection-rating criteria





- d. May be used as party walls to separate two adjoining structures or two occupancy classifications within same structure to prevent fire spread
- e. Assemblies can divide large structures into smaller portions; contain fire to particular portion of structure

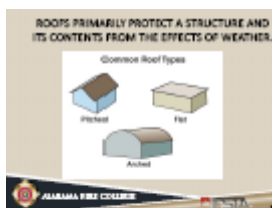
7. Penetrating walls

- a. Exterior and fire walls are most difficult when forcing entry into or escaping area
- b. Some interior walls can be, but only to locate hidden fires or create escape path

E. Roofs

1. Primary function – Protect structure and contents from effects of weather

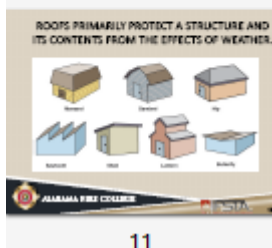
- a. Shape and construction intended to
 - i. Provide drainage
 - ii. Support weight of accumulations of snow
 - iii. Resist effects of wind
 - iv. Insulate interior from external temperature changes
- b. Geographic location of structure will influence type and construction
- c. Penetrations openings indications of general arrangement of rooms within – Can assist in vertical ventilation during fire



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2. Roof types

- a. Three prevalent types – Flat, pitched, arched
- b. Building may have combination of designs
 - i. Common styles – Gable, hip, gambrel, shed, mansard, and lantern
 - ii. Less common styles – Sawtooth, butterfly
 - iii. Can contribute to voids underneath, limit ability of firefighters to access areas under roof
- c. Flat roofs
 - i. Common on commercial, industrial, multifamily residential structures; some single-family



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- ii. Generally has slight slope toward outer edge to facilitate drainage
 - iii. Frequently penetrated by chimneys, vent pipes, shafts, scuttles, and skylights
 - iv. May be surrounded by parapet walls or divided by fire separation walls that extend from foundation to above roof
 - v. Water tanks, HVAC equipment, antennas, solar panels, signs, and other obstructions may be present
- d. Pitched roofs – A number of styles
- i. Most common – Elevated in center along ridge line with roof deck that slopes down to eaves along edges
 - ii. Shed roofs – Pitched along one edge and deck slopes to eaves at opposite end
 - iii. Construction
 - (a) *Most involves rafters or trusses that run from ridge line to top of outer wall at eaves level – Made of wood or metal*
 - (b) *Decking or sheathing applied at right angles over rafters – May be applied solidly or with boards, and planks with space between them (called skip sheathing)*
 - iv. Usually have covering of roofing paper before finish surface laid
 - v. Finish – May consist of shingles, asphalt roll roofing, metal panels, slate, and tile
- e. Arched roofs
- i. Ideal for some occupancies because can span large open areas unsupported by columns, pillars, and posts
 - ii. Primarily used from late 1800s to mid-1900s
 - iii. Design depends on exterior walls to support weight of roof
 - iv. Types – Bowstring, ribbed, diagonal grid (Lamella), and pleated barrel

Instructor Note: Remind students of the information in the Safety Alert Box on page 163 of the textbook. Discuss the

importance of knowing how arched roofs contribute to firefighter casualties.

3. Roof construction

a. Roof supports

- i. Beams – Sections of lumber located directly under roof decking

- (a) *Extend from ridge line or pole at peak to each side wall on pitched roof*
- (b) *Extend from wall to wall on flat roof*
- (c) *May be exposed or concealed behind ceiling*
- (d) *Generally made of solid timbers 4 x 4 inch (100 mm by 100 mm) and larger*

- ii. Truss assemblies

- (a) *May be constructed on site or premanufactured and shipped to site*
- (b) *Those constructed on site consist of top and bottom chords and webbing that extend from peak to walls*
- (c) *Ends connected by horizontal joist that has supports between joist and rafters*
- (d) *Assembled using metal gusset plates (gang nails) that penetrate about 3/8 inch (9.5 mm) into the wood*
- (e) *Types – Parallel chords, pitched chord, arched truss, and bowstring truss*
- (f) *Parallel chord used to support flat roofs and floor assemblies – May be constructed of wood or metal*

- iii. Behavior in fire conditions

- (a) *Solid wood joists tend to lose strength gradually when exposed to fire – Roofs become soft or "spongy" before failure*
- (b) *Soft roof not the only sign of collapse – Plywood or OSB used for sheathing can fail quickly without prior warning*



- iv. Box beams and I-beams (also known as wide flange beams) used to support flat roofs, floors

- (a) *Made from plywood and wood truss joints*
- (b) *Provide strength, but thin web portion of I-beam and members used to manufacture truss renders susceptible to early failure in fire*
- (c) *Open web design of truss joists permits rapid spread of fire in directions perpendicular to truss joint*

- v. Increased use of engineered or lightweight construction and trussed support systems

- (a) *Engineered construction – Manufactured from smaller pieces of wood or light gauge steel to form trusses that weigh less than traditional systems*
- (b) *Lightweight construction – More common in Type I, Type IV construction; also homes, apartments, small commercial buildings, and warehouses*
- (c) *Lightweight steel trusses – Made from long steel chords that are straight or bent by as much as 90 degrees with flat or tubular members in web space*
- (d) *Light weight wooden trusses – Constructed of 2 x 3-, 2 x 4-, or 2 x 6- inch (50 mm by 75 mm, 50 mm by 100 mm, or 50 mm by 150 mm) lumber connected by gusset plates made of wood or metal*

- vi. Flat roofs supported by open-web steel joists and steel beams – Depending on fuel load unprotected web joists can be expected to fail quickly in fire

- b. Roof decks – Portion of roof between roof supports and roof covering

- i. Types in North America

- (a) *Plywood sheathing*
- (b) *Oriented Strand Board (OSB)*
- (c) *Wood tongue and groove*



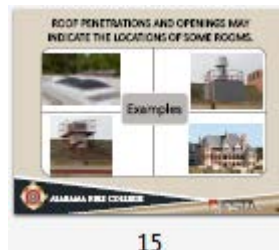
- (d) *Corrugated metal*
 - (e) *Sprayable concrete encapsulated polystyrene*
 - (f) *Reinforced concrete*
 - (g) *Double tee preformed concrete*
 - ii. Components
 - (a) *Sheathing*
 - (b) *Roof planks or slabs*
 - (c) *Purlins*
 - iii. Can act as roof support – Example, concrete deck roofs
 - iv. Roof covering and deck may be the same – Example, corrugated steel decking
 - v. Same structural system for floor and roof usually used in multistory building with flat roof
 - vi. Concrete roofs in North America – Precast and poured-in-place
 - (a) *Precast – Fabricated off-site, hauled to construction site ready for use; widespread in use*
 - (b) *Precast can be lightweight material made of gypsum plaster, Portland cement mixed with aggregates – May be referred to as lightweight concrete*
 - (c) *Precast planks made from lightweight concrete, reinforced with steel mesh or rods*
 - (d) *Usually finished with roofing felt, mopping of tar – Make it extremely difficult to penetrate, ventilate as last resort*

c. Roof coverings

- i. Part of roof exposed to weather
- ii. Materials include
 - (a) *Wooden shingles or shakes (rough cut wood)*



- (b) *Molded metal or rubber imitation shingles or tiles*
- (c) *Asphalt shingles*
- (d) *Asphalt sheets*
- (e) *Terracotta or concrete tile, slate, synthetic membrane*
- (f) *Blown-on foam*
- (g) *Built-up tar and gravel surface*
- (h) *Metal roof systems or sheets*
- (i) *Composite materials*



4. Roof penetrations and openings

- a. Variety of items that provide light, ventilation, access, and vapor exhausts are part of plumbing of HVAC systems
- b. May be locked or secured in some manner
- c. Types
 - i. Scuttle hatches
 - ii. Skylights
 - iii. Monitors
 - iv. Automatic smoke vents
 - v. Ventilation shafts
 - vi. Ventilation fans
 - vii. Penthouse or bulkhead doors
 - viii. Chimneys
 - ix. HVAC exhausts
 - x. Bathroom vent pipes
 - xi. Attic vents
 - xii. Dormers
- d. Penetrations can indicate location of some types of rooms – Bathrooms, mechanical spaces
- e. Possible to gain access to attics through monitors, smoke and attic vents, scuttle hatches, and skylights



- f. Cockloft possible to use as exit point for some types of ventilation

5. Roof obstructions – Observing presence can help when structure needs to be ventilated

a. Green roofs – Using roof surface for rooftop garden

- i. Take several forms – From potted plants and flower boxes to layer of earth with growing plants covering large area of roof
- ii. Constitutes dead load on roof structural system

- (a) *Layer of earth can vary from few inches (millimeters) to 1 or 2 feet (0.3 m to 0.6 m)*
- (b) *Dead load can vary from 20 pounds per square foot to 150 pounds per square foot (100 kg/sqm to 750 kg/sqm)*
- (c) *Load will be planned for in new construction – Must be analyzed when planned for existing construction*

iii. Under fire conditions

- (a) *Load can accelerate structural failure*
- (b) *Can interfere with ventilation practices, and fire location indicators*

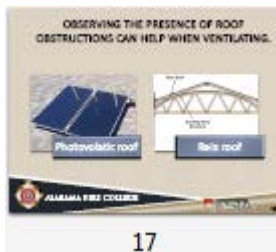
iv. Other concerns

- (a) *Effects of high-velocity winds and uplift wind pressures*
- (b) *Roof drainage which can add weight to roof creating a collapse hazard*
- (c) *Exposure hazard that may be created by dry vegetation on roof*
- (d) *Need for clear space between vegetation and fire walls that penetrate roof*

b. Cold roofs

- i. Found in cold, snowy climates to prevent ice damming and icicle formation at eaves
- ii. Designed to prevent interior heat from escaping into attic space

- (a) *Requires sheathing layer, and membrane to prevent buildup*
- (b) *Above membrane two layers of 1 x 4 inch (25 mm by 100 mm) parallel spacers are installed to create a 3-inch (75 mm) void air space*
- (c) *Second layer of sheathing installed above spacers, followed by roof covering*
- iii. Can create significant difficulty during vertical ventilation
- iv. Structures in cold climates without cold roofs
 - (a) *More likely to have trusses lined with vapor barrier, covered with at least 12 to 16 inches (300 mm to 400 mm) of insulation*
 - (b) *Roof, soffit would have multiple vents*
 - (c) *Membrane over roof sheathing provides some insulation – Primary purpose to protect plywood sheathing from moisture*



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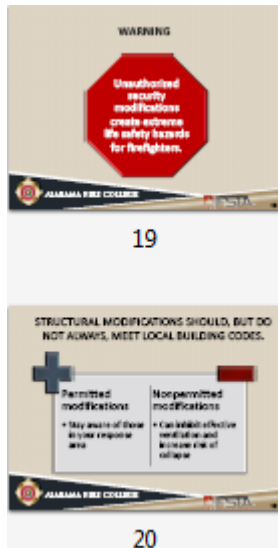
- c. Photovoltaic roofs – Solar energy system
 - i. Cells in panels can be laid on top of or embedded in roof
 - ii. Represents significant hazard for firefighters
 - (a) *Even when off, panels retain significant amount of electricity*
 - (b) *Panels continue to produce power if sunlight available – Even if fire damaged*
 - (c) *Not safe to break cells or skylights that are solar powered*
 - (d) *Panels present tripping, falling hazard*
 - iii. Safety considerations during emergency conditions
 - (a) *Electrical shock*
 - (b) *Inhalation exposure*
 - (c) *Falls from roofs*
 - (d) *Roof collapse*

- iv. Crucial to identify during preincident planning
 - v. Panels may not be visible from ground if building has flat roof
- d. Rain roofs
- i. Found on commercial buildings, schools, and residential structures
 - ii. Pitched roof placed over older flat roofs – May exist over mobile homes
 - iii. May be constructed from lightweight metal panels, trusses to form peak or simply a second flat roof surface made from wood and roofing materials
 - iv. Void created can conceal fire and allow to burn undetected
 - (a) *Trusses exposed to fire weaken increasing potential collapse for both rain and original roof*
 - (b) *HVAC units may be hidden adding to collapse potential*
 - v. Ventilating rain roof will not remove smoke until original roof is penetrated
 - vi. Do not enter void area to cut hole in original roof
 - (a) *You can become trapped in void*
 - (b) *You can be overcome by heat and smoke trapped in void*
 - (c) *You can fall through weakened original roof*
 - (d) *You can be caught in extreme fire condition as heated gases mix with fresh air*



- e. Security
- i. Metal security bars or grilles may be mounted over doors and windows to prevent illegal entry
 - ii. Will slow entry, create emergency exit hazards, and reduce effectiveness of ventilation tactics
 - iii. Wired glass may be encountered on skylights – Difficult to penetrate, takes time to remove
 - iv. Other security may be encountered - Example

- (a) *Shop owner installed iron plates on roof of grocery store*
- (b) *Weight of plates caused roof collapse during fire*
- (c) *Can prevent timely tactical vertical ventilation*
- (d) *Only discovered through preincident surveys*



WARNING!: Unauthorized security modifications create extreme life safety hazards for firefighters.

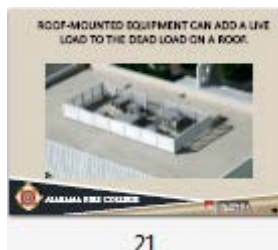
- f. Permitted structural modifications
 - i. Building code requirements are intended to provide occupants with highest level of fire and life safety possible
 - ii. Permits ensure compliance with building code
 - iii. Modifications over the life of a structure must meet local building codes and be approved by local official
 - iv. May include
 - (a) *Additions to structure*
 - (b) *Removal of non-load-bearing walls or partitions*
 - (c) *Replacement of fire escapes with enclosed stairways*
 - (d) *Sealing windows or doors that are not required for emergency exits*
 - v. Can affect fire fighting operations – Essential to remain aware of all modifications to structures in response area
- g. Nonpermitted structural modifications
 - i. Owners/occupants may make unapproved or nonpermitted modification – Can inhibit effective ventilation, increase risk of fire extension and structural collapse
 - ii. May include
 - (a) *Removal of load-bearing interior walls*

- (b) *Removal of load-bearing pillars or columns*
- (c) *Removal of roof supports*
- (d) *Increasing dead load by installing HVAC or mechanical equipment on or under roofs or in attic spaces*
- (e) *Storing heavy contents on roof support beams or in attic spaces*
- (f) *Removing or modifying automatic ventilation systems or components*
- (g) *Removing or modifying code-required fire detection and suppression systems*
- (h) *Altering attic spaces into living spaces*
- (i) *Removing fire stops from wall cavities*
- (j) *Installing or altering interior wall arrangements that effect air flow patterns*
- (k) *Removing interior doors or sealing exterior openings*
- (l) *Sealing basement ventilation openings*
- (m) *Penetrating fire walls*
- (n) *Installing unapproved rain roofs over flat roofs*

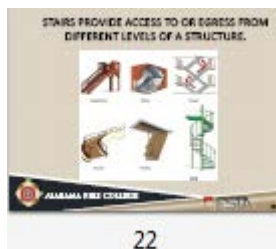
- iii. Can only be uncovered through effective and periodic inspection of commercial and industrial occupancies in community
- iv. Impossible to monitor or be aware of modification made to single-family residential structures

h. Roof-mounted equipment

- i. Present on most commercial, industrial, institutional, educational, and some residential structures
- ii. Found in particular on structures with flat roofs
- iii. Add live load to dead load distributed on roof, increase collapse hazards, and add to obstructions that affect ventilation



- iv. May also be found on flat roofs under rain roofs
- v. Can include
 - (a) HVAC units
 - (b) Water towers
 - (c) Telecommunications equipment
 - (i) Telephone towers
 - (ii) Radio transmission equipment
 - (iii) Television antennas and satellite dishes
 - (d) Advertising signs or billboards
 - (e) Recreation areas
 - (f) Wind generators
 - (g) Electrical transformers
 - (h) Derricks, hoists, and cranes
 - (i) Winches
 - (j) Steeples, minarets, spires, and crosses
 - (k) Electrical lines and weather heads
- vi. Can injure or kill firefighters by causing collapse of fire-weakened roof
- vii. Must be aware of
 - (a) Fire behavior, how it affects building
 - (b) General design and construction of building



F. Stairs

1. Provide access to or egress from different levels of structure
2. If part of required means of egress must provide protection for occupants as they travel to safety
 - a. Called protected or enclosed
 - b. Built to resist spread of fire, smoke

3. If not required as part of means of egress typically connect no more than two levels – Called access or convenience stairs
4. Can be classified as interior or exterior, depending on location
5. Design or layout may take several forms
6. No longer allowed as required means of egress – Exterior fire escapes, escalators, and fixed ladders
7. Protected stairs
 - a. Interior protected stairs critical components of building life safety system
 - i. Enclosed with fire-rated construction – Usually either 1- or 2-hour rating
 - ii. Generally serve two stories or more
 - iii. Part of required means of egress
 - b. Primary egress paths from floors above or below ground level
 - c. Can adversely affect safety of occupants if do not maintain breathable atmosphere
8. Exterior stairs – Either open air or enclosed
 - a. Enclosed must comply with requirements similar to interior protected stairs
 - b. Open are naturally ventilated by may be partially enclosed from weather - Typically have at least two adjacent sides open to natural ventilation
9. Fire escapes
 - a. Open metal stairs and landings attached to outside of building
 - b. Lowest flight may consist of swinging stair section to limit unwanted access
 - c. If in place for many years may not be able to support live load during emergency evacuations or fire suppression
 - d. Usually anchored to building, not supported at ground level
 - i. Anchor points subject to freeze-thaw cycle, corrosion from pollution and weather, temperature changes

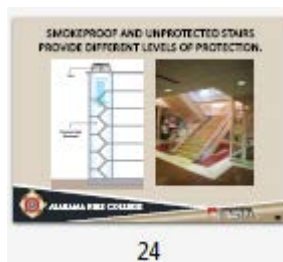


- ii. Mortar for anchors may suffer from deterioration or may be originally inadequate for expected load

Instructor Note: Discuss with students the Safety Alert Box on page 176 of the textbook. Share alternative measures they may need to take to enter a structure without using a fire escape.

10. Smokeproof stair enclosures

- a. May be required by building codes under certain circumstances – Stairs serving high-rise building
 - i. Must use either active or passive smoke control
 - ii. Mechanical ventilation system actively keeps enclosure free of smoke – Even when door open to fire floor
 - iii. Activated by automatic fire/smoke detection equipment – Keeps smoke out by pressurizing shaft
 - iv. System should be specially designed for particular installation
- b. If properly designed, installed, and maintained, it should allow firefighters to begin suppression operations in one stairwell while occupants use second for escape



11. Unprotected stairs

- a. Not protected from fire and smoke
- b. Not enclosed with fire-rated construction
- c. May serve as path for spread of fire and smoke
- d. Will not protect anyone from products of combustion
- e. Building codes typically allow use in buildings when connect only two adjacent floors above basement level
- f. Sometimes referred to as access or convenience
- g. Can be used as part of exit system in two-story building



G. Doors

- 1. Vary widely in operation, style, design, and construction
- 2. Classified by the way they operate

3. Swinging doors

- a. Rotate around vertical axis by means of hinges secured to side jambs of doorway framing
- b. May operate on pivot posts supported at top and bottom
- c. Can be either single or double leaf
- d. May be single acting (swinging in one direction) or double acting (swinging in two directions)
- e. Generally required as exit doors in means of egress

4. Sliding doors

- a. Suspended from overhead track, may use steel or nylon rollers
- b. Floor guides or tracks usually provided to prevent from swinging laterally
- c. Can be designed as surface sliding, pocket sliding, bypass sliding
- d. Main advantage – Eliminates door swing that might interfere with use of interior space
- e. Pocket sliding door slides into wall assembly – Frequently used in residential units
- f. May be used for elevators, power-operated doors in storefront entrances, fire doors used to protect openings not part of means of egress
- g. Never allowed as part of means of egress – Slow travel of people through door opening

5. Folding doors

- a. Hung from overhead track with rollers or guides similar to sliding door
- b. Can be bifolding or multifolding
- c. May be found in residential occupancies, places of assembly to divide large conference areas into smaller rooms, as horizontal fire doors
- d. Horizontal fire-door assemblies must meet very specific requirements, be tested, and listed for use in means of egress



6. Vertical doors

- a. If opens in vertical plane known as overhead door – Often found in industrial occupancies
 - i. Can be simple single leaf that is raised in vertical guides along edge of doorway – Can consist of two or more horizontal panels
 - ii. May consist of interlocking metal slats – Commonly used in factories and warehouses
- b. Usually provided with some type of counterbalance to help overcome weight of door – May be weights or springs
- c. Can be raised manually, mechanically via chain hoist, and power operated

7. Revolving doors

- a. Constructed with three or four sections or wings that rotate in circular frame
 - i. Designed to minimize flow of air through door opening to reduce heating/cooling costs
 - ii. Prevents movement of hose or equipment into building – Presents problem for firefighters
 - iii. Crowd of people attempting to flee cannot move through as quickly
- b. Wings designed to collapse under pressure and provide unobstructed opening in emergency conditions
 - i. Old models hold wings in place with chain keepers or stretcher bars between wings
 - ii. New models use spring-loaded, cam-in-groove hardware
 - iii. Most employ collapsing mechanism that allows wings to open in book-fold position when pushed in opposite directions
- c. Can be classified by style, construction material
 - i. Material influences effectiveness as fire barrier, degree to which door can be pushed in emergency
 - ii. Wood – May be panel or flush designs, may contain glass components
 - iii. Metal – Most used aluminum or carbon steel; may also be stainless steel, bronze, copper
 - iv. Other – May be manufactured with veneer of hardboard, fiberglass, or plastic

8. Wood panel and flush doors

a. Panel door

- i. Consists of vertical and horizontal members that frame rectangular area
- ii. Thin panels of wood, glass, or louvers placed in framed rectangular area

b. Flush door – Also known as slab door

- i. Consists of flat face panels that are full height and width of door
- ii. Panels attached to solid or hollow core
- iii. Can be designed with openings to accommodate glass vision panels or ventilation louvers
- iv. In past, constructed of one solid piece or slab of wood
- v. Modern construction is wood components finished to present smooth, unbroken surface on both sides

c. Solid-core doors – Formed with interior core of laminated blocks of wood, particleboard, or mineral composition

- i. Core covered with two or three layers of surface material, usually plywood
- ii. If intended for exterior application where security is concern – Layer of sheet metal may be attached to exterior surface to increase resistance

d. Hollow-core door – Constructed with spacers between face panels to provide lateral support

- i. Spacers consist of grid or honeycomb of wood, plastic, or fiberboard
- ii. Less expensive, lighter than solid-core
- iii. Have minimal thermal or sound-insulating value
- iv. Usually used for interior applications

e. Fire barriers

- i. Solid-core better than either panel or hollow-core
- ii. Can act as significant barrier to fire if closed at time if fire even if not specifically designed as fire door

9. Glass doors

a. Used for both exterior and interior applications



- b. Found in almost all occupancies
- c. Can be either framed or frameless
 - i. Frameless – Consists of single sheet of glass to which door hardware is attached
 - ii. Framed – Glass is placed within, surrounded by metal or wood frame with require hardware attached to frame
- d. Building codes require to be made of tempered glass that resists breakage
- e. May be made of plastics such as Lexan[®] or Plexiglas[®]

10. Metal doors

- a. Hollow metal can be either panel or flush, normally 1¾ inches (45 mm) thick
- b. Flush consists of smooth metal face panels 1/20 inch (1 mm) thick
 - i. Vertical sheet metal ribs within door spaced 6 to 8 inches (150 mm to 200 mm) apart separate face panels
 - ii. Sound-deadening material can be placed between ribs
 - iii. Aluminum flush door usually has core of hardboard and honeycomb-patterned paper
- c. Can be constructed of heavy corrugated steel
 - i. Steel frame supports one or two corrugated sheets
 - ii. Has interior core material such as Styrofoam[®]

11. Fire doors

- a. Protect openings in fire-rated walls
- b. When properly maintained and operated, very effective at limiting spread of fire and total fire damage
- c. Differ from ordinary doors in construction, hardware, extent to which they may close automatically
- d. To qualify as rated fire door
 - i. Entire assembly must pass test by third-party testing agency – Includes door, hardware (hinges, latches, locks, etc), door seal, frame



- ii. Assembly certified as single unit for specified time
- iii. Identified by label
 - (a) *Includes door type, hourly rating, identifying logo of testing laboratory*
 - (b) *May be painted over in course of building maintenance*
- e. Construction and operation depends on type of occupancy, amount of space around door opening, required fire-protection rating for door
 - i. Most constructed of metal, may roll, slide, and swing into place when released
 - ii. Special types available for freight and passenger elevators, service counter openings, security, dumbwaiters, and chute openings
- f. Rolling steel fire doors
 - i. Overhead rolling door commonly used to protect opening in fire wall at industrial occupancy or wall separating buildings into fire areas
 - ii. May be used on one or both sides of opening
 - iii. Cannot be used on any opening required to be part of means of egress
 - iv. Constructed of interlocking steel slats with other components – Releasing devices, governors, counterbalance mechanism, and wall guides
 - v. Ordinarily closes under force of gravity when fusible link melts – Motor driven available
- g. Horizontal sliding fire doors
 - i. Often found in old industrial buildings
 - ii. Usually held open by fusible link – Slide into position along track by gravity or force of counterweight
 - iii. Constructed with several different materials
 - iv. Cannot be used to protect openings in walls required as parts of means of egress
 - v. Common type is metal-covered, wood-core
 - (a) *Core provides thermal insulation, sheet metal protects wood from fire*
 - (b) *Vent hole usually provided in sheet metal to vent gases of wood decomposition*

(c) *Metals used – Steel, galvanized sheet metal, and terneplate (metal composed of tin and lead)*

(d) *Terneplate doors may be called tin-clad doors – Metal used is not pure tin*

h. Swinging fire doors

- i. Commonly used in stairwell enclosures or corridors that require fire door
- ii. Disadvantage of requiring clear space around door to ensure closure
- iii. Must remain closed when fire occurs to perform function
- iv. Can be either automatic or self-closing

(a) *Automatic – Normally held open, closes automatically when operating device activated*

(b) *Self-closing – Normally closed, will return to closed position if opened and released*

- v. To close detection device must first sense fire or smoke from fire

(a) *Simplest device is fusible link that melts from heat of fire*

- (i) Advantages – Inexpensive, relatively rugged, easy to maintain
- (ii) Disadvantages – Depends on heat from fire to operate, slower to operate than devices that react to smoke

(b) *Smoke detector device*

- (i) Advantages - Door closes more quickly, permits easy testing of fire door
- (ii) Disadvantages – Costs more, requires periodic cleaning, must be properly positioned



H. Windows

1. Construction

- a. Frame – Members that form perimeter of window, fixed to surrounding wall or other supports

- b. Sash – Framed unit that may be included within window frame, may be fixed or movable
- c. Frame – Composed of sill, side jamb, and head jamb
- d. Sill – Lowest horizontal member of window frame, supports weight of hardware and sash
- e. Glass – Known as glazing
 - i. May be single-, double-, or triple-glazed – One thickness of glass, two thicknesses separated by inert gas, or three thicknesses separated by voids filled with gas
 - ii. May have retracting shades located in void

2. Fixed windows – Nonoperable

- a. Consists of frame, glazed stationary sash
- b. Used alone or in combination with movable
- c. May be called display windows, picture windows, and deadlights
- d. May be found in many applications – Over and around doors, in skylights, residential applications, and fronts of retail shops

3. Movable windows – Operable

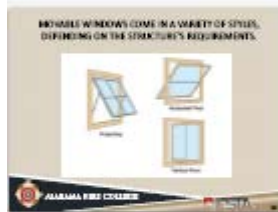
- a. Double-hung
 - i. Has two sashes that can move past each other in a vertical plane
 - ii. Commonly used in residential occupancies
 - iii. Balancing devices consisting of counterweights, springs, or a spring-loaded coiled tap hold movable sashes at desired position
- b. Single-hung
 - i. Has only one sash operable
 - ii. Balancing devices consisting of counterweights, springs, or spring-loaded coiled tap hold movable sash at desired position
- c. Casement
 - i. Has side-hinged sash that is usually installed to swing outward
 - ii. May contain one or two operating sashes



- iii. Can be opened fully by unlatching and pushing or using mechanical window crank for ventilation
- d. Horizontal sliding
 - i. Has two or more sashes of which at least one moves horizontally within window frame
 - ii. In three-sash design, middle sash is usually fixed; in two-sash unit, one or both sashes may be movable



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- e. Awning
 - i. Has one or more top-hinged, outward-swinging sashes that are opened by unlatching and pushing or using mechanical window crank
 - ii. Permits the window to be open during rain
 - iii. Hopper windows similar in design to awning windows except are hinged at bottom.
- f. Jalousie
 - i. Includes large number of narrow overlapping glass sections swinging outward
 - ii. Individual pieces of glass are about 4 inches (100 mm) in width – Glass sections are supported at ends by an operating mechanism
 - iii. Popular architecturally because amount of opening can be varied for ventilation without admitting rain
- g. Projecting
 - i. Swings outward at top or bottom and slides upward or downward in grooves
 - ii. Usually is operated by push bar that is notched to hold window in place
- h. Pivoting
 - i. Has sash that pivots horizontally or vertically about a central axis
 - ii. Part swings inward and part swings outward when it is opened
 - iii. Provides full area of the window opening for ventilation

4. Security

- a. May provide access point to intruders – Means may be provided to increase security

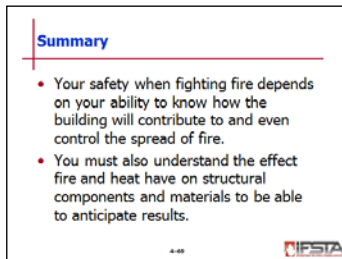
- i. Metal bars or screens may be fastened to exterior of window frame or building itself
 - ii. Metal bars may be fastened to building, embedded in masonry, mounted on hinges and locked with padlocks or other locking devices
- b. Security windows available with movable sashes and fixed bars so windows can be open for ventilation while maintaining security
- c. In emergency situation
 - i. Bars or grilles can prevent escaped of trapped occupants or firefighters, can slow access time
 - ii. Remove or disable to ensure firefighter safety in case of rapid egress



Review Question: In what ways can building components impact fire suppression efforts?

See pages 158-189 of the textbook for answers.

II. SUMMARY AND REVIEW



A. Chapter Summary

1. Your safety when fighting fire depends on your ability to know how the building will contribute to and even control the spread of fire.
2. You must also understand the effect fire and heat have on structural components and materials to be able to anticipate results.

B. Review Questions

1. What impact can fire have on common building materials? (*pp. 134-142*)
2. How are different construction classifications affected by fire suppression? (*pp. 144-151*)
3. What are the main types of occupancy classifications? (*pp. 151-157*)
4. In what ways can building components impact fire suppression efforts? (*pp. 158-189*)

Chapter 4

Building Construction

Firefighter II Content



Lesson Goal

After completing this lesson, the student shall be able to identify hazards related to building construction, as well as factors that indicate possible structural collapse.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain the hazards related to building construction. *[NFPA[®] 1001, 6.3.2]*
2. Recognize the factors that influence structural collapse potential. *[NFPA[®] 1001, 6.3.2]*



Instructor Information

This is the lesson covering building construction for Fire Fighter II. This lesson describes hazards associated with building construction and indicators for structural collapse.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture and discussion. The level of learning is comprehension.

I. HAZARDS RELATED TO BUILDING CONSTRUCTION

pp. 190-195

Objective 1 — Explain the hazards related to building construction.

A. Hazards Related to Building Construction

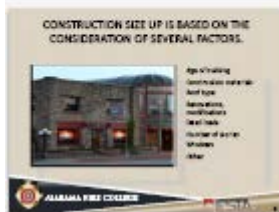
1. To locate and extinguish building fire – Must know types of building construction, materials, and components
2. Knowledge of construction types
 - a. Can help predict fire development, spread, and effects of fire, and fire suppression on building
 - b. Makes aware of conditions that lead to structural failure, and indicators of structural instability
 - c. Can select correct type of forcible entry tool needed to gain access when you recognize types of doors and door hardware
 - d. Judge safety of roof by knowing types, roof supports, and coverings
 - e. Makes you able to select right type of vertical tactical ventilation
 - f. Helps apply emergency escape techniques
 - g. Adds to situational awareness



4



5



6

B. Sizing up Existing Construction

1. Outward appearance may be deceiving – Exterior finishes make buildings appear more substantial than they are
2. Look for when sizing up
 - a. Age of building – Are there obvious signs of deterioration?
 - b. Construction materials – Is it wood-frame, unreinforced masonry, all-metal, or concrete building?
 - c. Roof type – Is roof flat, pitched, or arched; What type of roof covering is visible?
 - d. Renovations or modifications – Have additions been made that may create internal hazards?

- e. Dead loads – Are there HVAC units, water tanks, or other heavy objects visible on roof?
 - f. Number of stories – How many stories, above and below ground, are visible; Are there stories below ground on one side of building that are at ground level on another side?
 - g. Windows – Can windows be opened from inside; Are there security grilles that should be removed from outside of building?
3. Other items – Note though not directly related to building construction hazards
- a. Occupancy type
 - b. Adjacent exposures
 - c. Presence or lack of operational fire suppression systems
 - d. Fire conditions

C. Dangerous Building Conditions

1. Firefighters must be aware
 - a. Conditions created by fire
 - b. Conditions created while trying to extinguish fire
2. Primary types of dangerous conditions – Related to one another
 - a. Conditions that contribute to spread, intensity of fire
 - b. Conditions that make building susceptible to collapse
3. Fuel loading
 - a. Fuel load
 - i. Maximum heat that can be produced if all combustible material in given area burn
 - ii. Includes contents, building materials
 - b. Heavy fuel loading – Presence of large amounts of combustible materials in area
 - c. Arrangement of materials in building directly affects fire development and severity – Considered during preincident surveys
 - d. Heavy content fuel loading



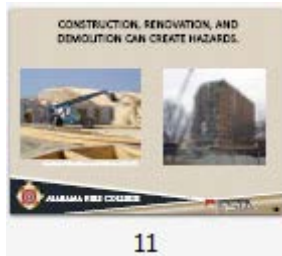
- i. One of most critical hazards in commercial, industrial, and storage facilities
 - ii. Fire can overwhelm capabilities of fire suppression system, make it difficult to gain access
 - iii. Most effective defense is proper inspection, code enforcement
 - e. Combustible structural components also contribute
 - i. Wood framing, floors, and ceilings
 - ii. May weaken with prolonged exposure, increase chances of collapse
- 4. Furnishings and finishes
 - a. Can contribute to fire spread and smoke production
 - b. Furnishings – Generally found in all types of occupancies
 - c. Interior finishes – Window, wall, and floor coverings
 - d. Combustibility identified as major factor in loss of lives in fires
- 5. Roof coverings
 - a. Basic concern to fire safety of entire community
 - b. Earliest fire regulations related combustible roof coverings – Flaming embers can fly from roof to roof
 - c. Wood shakes, even when treated with fire retardant, contribute to fire spread
 - i. Particular problem in wildland/urban interface fires
 - ii. Use exposure protection tactics to protect adjacent structures
- 6. Large, open spaces
 - a. Found in warehouses, churches, large atriums, and large-area mercantile buildings, theaters
 - b. Proper vertical tactical ventilation essential for slowing spread of fire – Channeling smoke from building at highest point
 - c. May be concealed from view between roofs and ceilings; under rain roofs
 - i. Fire can travel undetected
 - ii. Exact point of origin deceiving when smoke appears through openings in roof or around eaves

D. Engineered and Truss Construction Hazards

1. Unprotected engineered steel and wooden trusses – Can fail
 - a. After five to ten minutes of exposure to fire
 - b. From exposure to heat alone without flames
2. Steel trusses – 1,000°F (538°C) is critical temperature
3. Unless corner-nailed, metal gusset plates in wooden trusses can warp, fail quickly when exposed to heat
4. Both may be protected with fire-retardant treatments – Most lack this protection
5. Bowstring truss roofs
 - a. Identified by arched or curved outline
 - b. Commonly used wherever large open floor spaces with limited interior supports needed
 - c. Construction
 - i. Curved top chord members made by sawing straight lumber into curved shapes or laminating multiple smaller pieces bent over jig to desired shape
 - ii. Bottom chord members typically constructed with large, straight lumber members joined by either wood or metal bolted splice plates, located near mid-span, to achieve the required length
 - iii. Top and bottom chord members fastened at truss ends with U-shaped steel heels (end shoes) bolted to both chord members
 - iv. Web members used to form series of triangles that transfer tension from bottom chord and compression from top chord onto load-bearing walls
 - v. Difference from other types of truss construction
 - (a) *Compressional forces within top chord force load-bearing walls outward as well as downward*
 - (b) *Space between trusses is greater than found in other types*



- d. Suffer from problems
 - i. Related to design inaccuracies
 - ii. Bottom chord members may have inadequate tensile strength to support roof loads



E. Construction, Renovation, Demolition Hazards

1. Contributing factors to risk of fire rise sharply due to
 - a. Additional fuel loads, ignition sources brought by building contractors, and associated equipment
 - b. Standpipes and sprinkler systems may be inoperative in violation of fire codes
2. When under construction
 - a. Subject to rapid fire spread when partially completed – Protective features not in place
 - b. Can be equivalent of vertical lumberyard
 - c. Lack of doors, other barriers contribute to rapid fire growth
3. When renovated, demolished, and abandoned
 - a. Subject to faster than normal fire growth
 - b. Potential contributors
 - i. Breached walls
 - ii. Open stairwells
 - iii. Missing doors
 - iv. Deactivated fire suppression systems
 - c. Potential for sudden collapse serious consideration
 - d. Arson may also be factor
4. Renovation hazards
 - a. Danger increased because occupants and belongings remain in one part of building while work goes on in another
 - b. Fire detection or alarm systems may be taken out of service or damaged
 - c. Accumulations of debris, construction materials can block exits
 - d. Contractors, owner/occupants do not always follow local building codes

Review Question: What are the main hazards related to building construction during fire suppression?
See pages 193-195 of the textbook for answers.

II. STRUCTURAL COLLAPSE

pp. 195-202

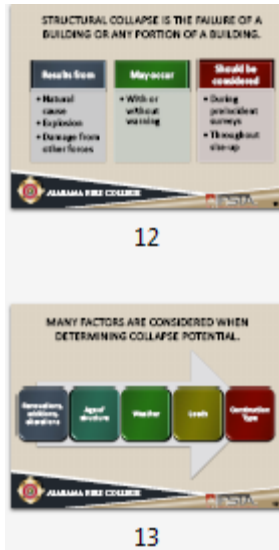
Objective 2 — Recognize the factors that influence structural collapse potential.

A. Structural Collapse

1. Failure of building or any portion resulting from
 - a. Natural – Fire, snow, wind, water, earthquake, and flood
 - b. Explosion
 - c. Damage from other forces
2. Can occur with or without warning
3. Understanding collapse potential extremely important for firefighters – Should be considered
 - a. During preincident surveys
 - b. Throughout size-up process until situation mitigated

B. Structural Collapse Factors

1. Many factors considered
 - a. Renovations, additions, and alterations
 - b. Age of structure
 - c. Weather
 - d. Loads
2. Construction type
 - a. Collapse of Type I construction limited in North America
 - i. Strict building codes ensure structural members remain sound
 - ii. Collapse due to earthquakes usually involve smaller buildings



- b. Consider potential collapse hazards even if structure is not
 - i. Church steeples
 - ii. Water tanks
 - iii. Chimneys and
 - iv. False facades that extend above top of structure
- c. Collapse not limited to actual emergency
 - i. Can occur well after fire extinguished
 - ii. Ensure structural stability before entering
- d. Documented evidence for how long structural members remain intact when exposed to fire only recent
 - i. Testing began in 2000 – Analysis ongoing

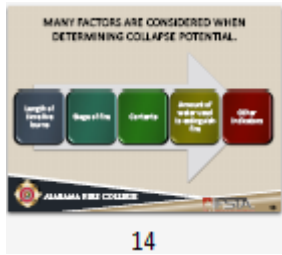
Instructor Note: The report on this testing can be found online at www.ul.com/fireservice under the title **Structural Stability of Engineered Lumber in Fire Conditions**. The grant report (NC9140-20090512-Report-independent.pdf) summarizes the test conditions and findings on pages 4-8.

- ii. Both residential and commercial structures – little difference between collapse times for steel bar joist-supported roofs and wood-truss supported roofs

(a) Both prone to very rapid collapse

(b) Collapse of lightweight construction may occur earlier in incident, not provide indicators

Instructor Note: Discuss the Safety Box, "Hazards of Truss Systems," on pages 196-197 of the textbook. Go over the steps to minimize risk of injury or death during structural fire fighting operations with your students and clarify any steps that seem unclear to them.



3. Length of time fire burns – Temperature increases in upper levels longer fire burns
 - a. Standard time-temperature curve used to illustrate temperature increase
 - b. Apply estimate of length of time fire has been burning to type of construction gives general idea of heat
4. Stage of fire – Indicates quantity of heat structure exposed to, potential for collapse
 - a. Incipient stage not generated enough heat or flame to cause collapse
 - b. Potential increases in growth stage as upper levels spread, consume structural members
 - c. Collapse very likely in decay stage, during post-suppression activities due to weakened state of structural members, buildup of water
5. Contents
 - a. Visible contents can contribute by
 - i. Generating higher temperatures, rapid combustion will weaken structure due to higher fuel load
 - ii. Causing collapse more rapidly due to added weight
 - iii. Increasing stress on structural members due to increased weight from water retention
 - iv. Knowledge gained through preincident surveys, inspections
 - b. Storage increases potential for ceiling joists to fail
 - i. May not be visible during preincident surveys
 - ii. Often heavier than joists designed to carry
6. Amount of water used to extinguish fire – Can have direct effect on unstable structure
 - a. Every US gallon (SI liter) of water used to suppress fire adds 8.33 pounds (3.96 kilograms) (Imperial gallon = 10 pounds) of weight to floors
 - b. Added weight may cause floors to pancake down or push walls out – Can result in complete failure

7. Other indicators of potential, imminent collapse
 - a. Roof sagging, pulling away from parapet walls, or feeling spongy (soft) under foot
 - b. Fire involvement of trusses and other engineered structural components
 - c. Floors sagging or feeling spongy (soft) under foot
 - d. Chunks of ceiling tiles or plaster falling from above
 - e. Movement in roof, walls, or floors
 - f. Noises caused by structural movement
 - g. Little or no water runoff from interior of structure
 - h. Cracks appearing in exterior walls with smoke or water appearing through cracks
 - i. Evidence of existing structural instability – Presence of tie rods and stars that hold walls together
 - j. Loose bricks, blocks, or stones falling from buildings
 - k. Deteriorated mortar between masonry
 - l. Walls that appear to be leaning
 - m. Structural members that appear to be distorted
 - n. Fires beneath floors that support heavy machinery or other extreme weight loads
 - o. Prolonged fire exposure to the structural members (especially trusses)
 - p. Structural members pulling away from walls
 - q. Excessive weight of building contents

WARNING!: Structural collapse can occur with little warning. If indicators start to appear, collapse is imminent and personnel must withdraw from the structure and the collapse zone.



C. Actions Taken When Collapse Is Imminent

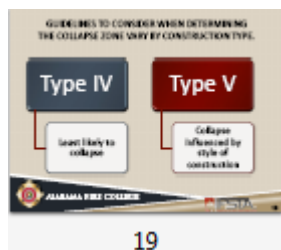
1. Take action if firefighter suspects collapse imminent or likely
2. First – Inform Command and all others in building of situation

3. Second – Establish clear collapse zone as soon as possible
 - a. No personnel should be allowed to operate
 - b. May cautiously place unstaffed master stream, immediately withdraw once in operation
4. Third – Roll call or personnel accountability report (PAR)

D. Determining Collapse Zone

1. Establish adjacent to any exposed exterior walls
2. Do not position apparatus, personnel operation master stream in
3. Estimated by taking height of structure, multiplying by factor of $1\frac{1}{2}$
4. Guidelines to consider when determining collapse zone
 - a. Type I construction high-rise buildings – Not as likely to collapse
 - i. Primary concern hazard of flying glass from windows or curtain walls
 - ii. Zones must be determined considering direction and velocity of wind currents that can carry the glass shards
 - iii. Structural collapse, if it does occur, will be localized and not structure wide
 - b. Type II construction – Unprotected steel or noncombustible supports, such as I-beams.
 - i. When exposed to temperatures above 1,000° F (537.78° C) – Will expand and twist, pushing out walls; when cooled will slightly constrict
 - ii. Movements will cause floors and walls to collapse
 - iii. Construction that includes brick and block walls supporting unprotected steel bar joists and I-beams is involved in large number of collapses
 - c. Type III construction multistory buildings should have collapse zone of $1\frac{1}{2}$ times height of structure
 - i. Exterior load-bearing walls made of concrete, brick, or masonry while interior loads are carried by wood, masonry, or unprotected steel





- ii. Masonry construction walls can collapse in one piece or crumble in many parts
- iii. Debris can travel distance; even cause collapse of other structures or objects
- d. Type IV heavy-timber or mill construction – Least likely to collapse
 - i. Weight-bearing capacity of large-dimension wood members will resist collapse unless affected by large volume of fire
 - ii. Collapse zone should be established if fire is intense or structure has been weakened by repeated fires over time
- e. Type V construction collapses influenced by style of construction
 - i. Multistory platform frame construction structure will generally burn through, collapse inward
 - ii. Balloon frame construction structure can have full walls fall outward in single piece
 - iii. Exterior masonry and veneer walls that are not load-bearing placed over load-bearing wood walls
 - iv. Brick veneer attached to frame can fall straight down (curtain collapse) into pile, or fall straight out as unit as ties and supports fail
 - v. Rare for Type V to collapse outward – Great danger due to interior collapses
 - vi. Lightweight trusses fail within five minutes when exposed to direct heat

Instructor Note: Discuss the Information Box, “Balloon and Platform Frame Construction” on page 201 and Figure 4.81 on page 202 of the textbook. Ask students to give examples of types of construction that shows they understand the difference between balloon frame and platform frame construction.



- 5. Establish when
 - a. Indication that structure has been weakened by prolonged exposure to fire or heat
 - b. Defensive strategy has been adopted
 - c. Interior operations cannot be justified
- 6. Size must consider
 - a. Type of building construction

- b. Other exposures
- c. Safest location for apparatus and personnel
- 7. Safest location for personnel
 - a. Defensive operations – Corner of building
 - b. Master streams, apparatus
 - i. Area formed by 90-degree arc from wall intersection
 - ii. Must be far enough away that flying debris will not strike

Review Question: What indicators of building collapse or structural instability may occur during fire suppression?
See pages 198-199 of the textbook for answers.

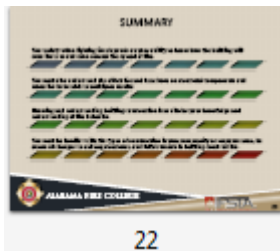
III. SUMMARY AND REVIEW

A. Chapter Summary

1. Knowing and understanding building construction is as vital as your knowledge and understanding of fire behavior.
2. You must be familiar with the types of construction in your community or response area, be aware of changes to existing structures, and follow trends in building construction.

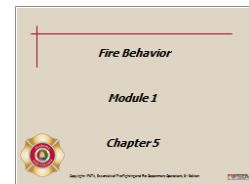
B. Review Questions

1. What are the main hazards related to building construction during fire suppression? (*pp. 194-195*)
2. What indicators of building collapse or structural instability may occur during fire suppression? (*pp. 198-199*)
3. What factors influence structural collapse potential? (*pp. 195-199*)
4. How is a collapse zone typically measured? (*p. 199*)



Chapter 5

Fire Behavior



Lesson Goal

After completing this lesson, the student shall be able to explain the science of fire behavior as it relates to recognizing stages of fire development, rapid fire behavior, and fire fighting operational safety.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain the science of fire as it relates to energy, forms of ignition, and modes of combustion. *[NFPA® 1001, 5.3.11]*
2. Describe the impact of thermal energy on heat, temperature, and heat transfer. *[NFPA® 1001, 5.3.12]*
3. Recognize the physical states of fuel. *[NFPA® 1001, 5.3.10]*
4. Explain the relationship between oxygen and life safety. *[NFPA® 1001, 5.3.11]*
5. Identify the products of self-sustained chemical reactions. *[NFPA® 1001, 5.3.11]*
6. Explain the factors that affect fire development. *[NFPA® 1001, 5.3.11]*
7. Describe the stages of fire development. *[NFPA® 1001, 5.3.11]*
8. Recognize signs, causes, and effects of rapid fire development. *[NFPA® 1001, 5.3.11]*
9. Describe the methods through which fire fighting operations can influence fire behavior. *[NFPA® 1001, 5.3.11, 5.3.12]*



Instructor Information

This is the lesson covering fire behavior. This lesson describes the science of fire, various physical states fuel can be found in, classification of fires, and the stages of fire development. The relationship between fire behavior and fire fighting operations is also discussed.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture and discussion. The level of learning is comprehension.

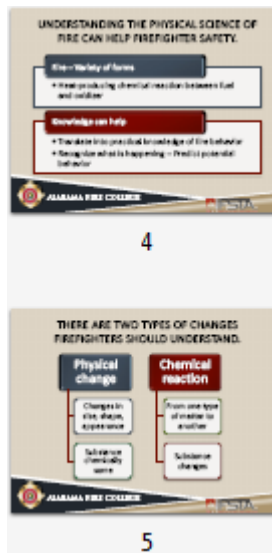
I. SCIENCE OF FIRE

pp. 208-216

Objective 1 — Explain the science of fire as it relates to energy, forms of ignition, and modes of combustion.

A. Science of Fire

1. Fire takes variety of forms – All involve heat-producing chemical reaction between fuel and oxidizer (most common is oxygen in air)
2. Understanding physical science of fire can help firefighter safety
 - a. Translates into practical knowledge of fire behavior
 - b. Be able to “read” the fire – Recognize what is happening, predict potential behavior
3. Physical change
 - a. Substance remains chemically the same, changes in size, shape, or appearance
 - b. Examples
 - i. Water freezing – Liquid to solid
 - ii. Boiling – Liquid to gas
4. Chemical reaction
 - a. Substance changes from one type of matter into another
 - b. Examples
 - i. Two or more substances combining to form compounds
 - ii. Oxidation – Combination of oxidizer with other materials; can be slow or rapid



B. Energy

1. Defined as capacity to perform work
2. In case of heat – Defined as increasing temperature of substance
3. Work occurs when
 - a. Force is applied to object over distance

- b. Substance undergoes chemical, biological, or physical change

4. Forms of

a. Potential

- i. Represents amount of kinetic energy that an object can release at some point in the future
- ii. Fuels have certain amount of chemical potential energy before ignited
- iii. Different fuels release different amounts of energy over different amounts of time

b. Kinetic

- i. Energy possessed by moving object
- ii. "Moving" may be on molecular level – Molecules vibrate when heat increases

5. Many types

- a. Chemical
- b. Thermal
- c. Mechanical
- d. Electrical
- e. Light
- f. Nuclear
- g. Sound

6. All energy can change from one type to another

7. In fire behavior – Potential chemical energy of fuel is

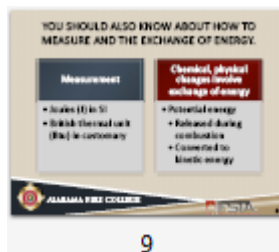
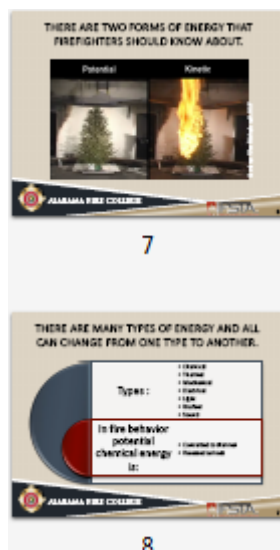
- a. Converted to thermal energy
- b. Released as heat

8. Measurement

- a. Joules (J) in International System of Units (SI)
- b. British thermal unit (Btu) in customary system – Frequently used in fire service
- c. $1055 \text{ J} = 1 \text{ Btu}$

9. Chemical, physical changes always involve exchange of energy – Fuel's potential energy

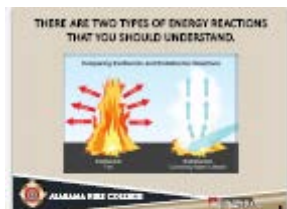
- a. Released during combustion



- b. Converted to kinetic energy

10. Reactions

- a. Exothermic
 - i. Emit energy as they occur
 - ii. Fire is combustion that releases energy in form of heat, and sometimes visible light
- b. Endothermic
 - i. Absorb energy as it occurs
 - ii. Converting water from liquid to gas requires input of energy – Important part of controlling, extinguishing some types of fires



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C. Forms of Ignition

1. Process of ignition

- a. Fuel is heated – Temperature increases
- b. Sufficient heat transfer
 - i. Causes pyrolysis in solid fuels, vaporization in liquid fuels
 - ii. Releases ignitable vapors or gases
- c. Energy necessary for ignition
 - i. Provided by external source
 - ii. Fuel can be heated until ignites without spark or other source
- d. Continues production, ignition of fuel vapors or gases so combustion reaction is sustained

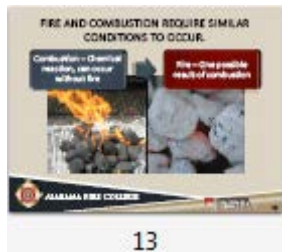
2. Forms of ignition

- a. Piloted
 - i. Most common
 - ii. Occurs when mixture of fuel, oxygen encounter external heat source with sufficient heat or thermal energy to start combustion process
- b. Autoignition (nonpiloted)
 - i. Occurs without any external flame or spark to ignite fuel gases or vapors
 - ii. Fuel surface is chemically heated to point at which combustion reaction occurs
 - iii. Autoignition temperature (AIT) – Minimum temperature to which fuel in air must be heated to

start self-sustained combustion; always higher than piloted ignition temperature

D. Modes of Combustion

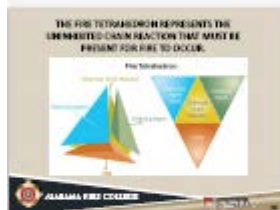
1. Fire, combustion similar conditions
 - a. Combustion is chemical reaction – Can occur without fire
 - b. Fire is one possible result of combustion
2. Two modes
 - a. Nonflaming – Occurs more slowly at lower temperature producing smoldering glow in material's surface
 - b. Flaming – Produces visible flame above material's surface; commonly referred to as fire
3. Fire Models – Explain elements of fire, how fires can be extinguished



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Instructor Note: The IFSTA validation committee recommends emphasizing to students that both the fire triangle and fire tetrahedron are important fire behavior models to understand. In their opinion, the fire triangle works as an excellent introduction to the idea of the relationship between the elements needed for a fire and how removing one element can work toward extinguishing the fire. The fire tetrahedron should be explained as the industry standard for examining the chemical reaction that fire creates.

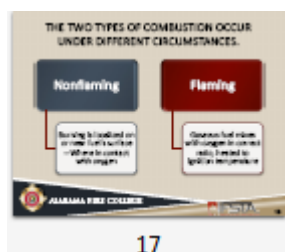
- a. Fire triangle
 - i. Oldest and simplest model
 - ii. Three elements necessary – Fuel, oxygen, and heat
 - iii. Remove any elements, fire extinguished
- b. Fire tetrahedron
 - i. Uninhibited chemical chain reaction must be present for fire to occur
 - ii. Created to explain fires involving certain types of substances, types of agents necessary to extinguish
- c. Materials that have effect on both ignition, fire development
 - i. Fuel

- ii. Heat
- iii. Oxygen
- iv. Passive agents – Materials that absorb heat but do not participate actively in combustion reaction

(a) *Drywall*

(b) *Content of vegetation*

(c) *Relative humidity in air outside of structures*



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4. Nonflaming combustion

- a. Occurs when burning is localized on or near fuel's surface, where in contact with oxygen
- b. Examples – Burning charcoal, smoldering wood or fabric
- c. Fire triangle used to illustrate

5. Flaming combustion

- a. Occurs when gaseous fuel mixes with oxygen in correct ratio, is heated to ignition temperature
- b. Requires liquid or solid fuels to be vaporized or converted to gas phase through addition of heat
- c. Fire tetrahedron reflect conditions required
 - i. Removing any element interrupts chemical chain reaction, stops flaming combustion
 - ii. Even with elements removed – May continue to smolder

6. Products of combustion

- a. Produced as fuel burns, changes chemical composition
- b. Often described as
 - i. Heat (energy release, thermal energy)
 - ii. Smoke (new substances)
- c. Thermal energy
 - i. Heats adjacent fuels, and make them more susceptible to ignition
 - ii. Causes fire spread



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- iii. Without adequate protection persons may suffer from burns, damage to respiratory tract, dehydration, and heat exhaustion
- d. Toxic smoke – Causes most fire deaths
- e. Smoke
 - i. Aerosol comprised of gases, vapor, solid particulates
 - ii. Product of incomplete combustion
 - iii. In structure fires multiple fuels are involved, there is limited air supply
 - iv. Produces wide range of products – Toxic, flammable gases; vapors; particulates
 - (a) *Fire gases – Generally colorless*
 - (b) *Vapor, particulates give smoke color*
 - v. Most components toxic, present significant threat to human life – Effects result of interrelated products present

Instructor Note: Discuss the table on page 215 of the textbook. Discuss the types of common products of combustion and their toxic effects with students. In the discussion be sure to review with students the SOPs departments may use to shield them from these effects.

- f. Carbon monoxide (CO)
 - i. Toxic, flammable product of incomplete combustion of organic (carbon-containing) materials
 - ii. Most common product encountered in structure fires
 - iii. Exposure frequently identified as cause of death for both civilians, firefighters
 - iv. Acts as chemical asphyxiant – Binds with hemoglobin in blood preventing cells from distributing oxygen to body
- g. Hydrogen cyanide (HCN)
 - i. Toxic, flammable substance produced by materials containing nitrogen
 - ii. Acts as chemical asphyxiant – Prevents body from using oxygen on cellular level

- iii. Significant by-product of polyurethane foam – Commonly used in furniture, bedding
- h. Carbon dioxide (CO₂)
 - i. Product of complete combustion of organic materials
 - ii. Acts as simply asphyxiant by displacing oxygen
 - iii. Acts as respiratory stimulant – Increasing respiratory rate
- i. Irritants in smoke
 - i. Cause breathing discomfort, inflammation of eyes, respiratory tract, and skin
 - ii. Depends on fuels involved
- j. Smoke may contain unburned fuel in form of solid, liquid particulates and gases
- k. Smoke must be treated with same respect as any other flammable gas – It may burn or explode
- l. Firefighters must use SCBA when operating in toxic atmospheres
 - i. Volume and density reduced during overhaul – But hazard not eliminated
 - ii. Hazardous concentrations above published short-term exposure limits likely to be present during overhaul
 - iii. Hazardous concentrations may be present in areas outside structure



WARNING: Smoke is fuel and is always potentially flammable. Wear full PPE and SCBA anytime you work in smoke.

- m. Flame
 - i. Visible and luminous body of burning gas
 - ii. When mixed with proper amounts of oxygen, flame becomes hotter and less luminous
 - iii. Loss of luminosity caused by more complete combustion

Review Question: How does the science of fire relate to energy, forms of ignition, and modes of combustion?
See pages 208-216 of the textbook for answers.

II. THERMAL ENERGY (HEAT)

pp. 216-223

Objective 2 — Describe the impact of thermal energy on heat, temperature, and heat transfer.

A. Thermal Energy (Heat)

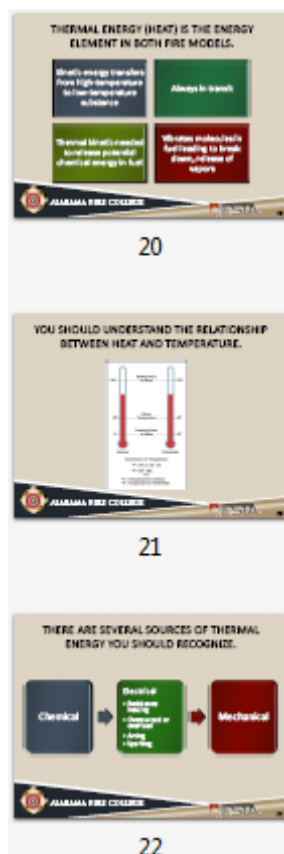
1. Is energy element of both fire triangle and tetrahedron
2. Kinetic energy transferred from high-temperature substance to low-temperature substance
3. Always in transit from one location to another
4. Thermal kinetic energy needed to release potential chemical energy in fuel
5. Vibrates molecules in fuel leading to their breakdown and release of vapors – Vapors can ignite, release thermal energy

B. Heat and Temperature

1. Temperature is measurement of heat – Average kinetic energy in particles of sample of matter
2. Scales used
 - a. Celsius – Used in metric system
 - b. Fahrenheit – Used in customary system

C. Sources of Thermal Energy

1. Chemical energy
 - a. Most common source of heat in combustion reactions
 - b. Potential for oxidation exists when any combustible fuel is in contact with oxygen – Process almost always results in thermal energy
 - c. Self-heating – Form of oxidation
 - i. Chemical reaction that increases temperature of material without addition of external heat
 - ii. When produced slowly, energy is lost almost as fast as it is generated
 - iii. May be initiated or accelerated by external heat source



- d. Spontaneous ignition – To occur material must be heated to autoignition temperature
 - i. Insulation properties of material immediately surrounding fuel must be such that heat cannot dissipate as fast as being generated
 - ii. Rate of heat production must be great enough to raise temperature of material to autoignition temperature
 - iii. Available air supply in, around material being heated must be adequate to support combustion
 - e. Rate of oxidation reaction (heat production) increases as more heat is generated, trapped by insulating materials
 - f. When heat generated exceeds heat being lost, material may reach autoignition temperature
2. Electrical energy – Occurs in several ways
- a. Resistance heating
 - i. When electric current flows through conductor, heat is produced
 - ii. Some electrical appliances, designed to make use of resistance heating
 - iii. Other electrical equipment designed to limit resistance heating under normal operating conditions
 - b. Overcurrent or overload
 - i. When current flowing through conductor exceeds design limits, may overheat and present ignition hazard
 - ii. Overcurrent or overload is unintended resistance heating
 - c. Arcing
 - i. Is high-temperature luminous electric discharge across gap or through medium such as charred insulation
 - ii. May be generated when conductor is separated (such as in electric motor or switch) or by high voltage, static electricity, and lightning
 - d. Sparking
 - i. When electric arc occurs, luminous (glowing) particles can be formed, spatter away from point of arcing

- ii. Sparking refers to this spatter, while arc is luminous electric discharge

3. Mechanical energy

- a. Generated by friction or compression
- b. Movement of two surfaces against each other creates heat of friction – Results in heat and/or sparks
- c. Heat of compression generated when gas is compressed

D. Heat Transfer

1. Understanding concept helps firefighters

- a. Understand the transfer of heat from initial fuel package to other fuels in, beyond the area of origin affects growth of any fire
- b. Use knowledge of heat transfer to estimate size of fire before attacking, to evaluate effectiveness of attack
- c. Know that transfer occurs from warmer to cooler objects – Objects at same temperature cannot transfer heat



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2. Transfer rate

- a. Related to temperature differential of bodies, thermal conductivity of solid material involved
- b. Greater the temperature differences between bodies, greater transfer rate
- c. Heat flux
 - i. Energy transfer over time per unit of surface area
 - ii. Measured in kilowatts per meter squared (kW/m²)

Instructor Note: Point out the Safety Alert on page 220 of the textbook. Discuss what these studies can mean to firefighters wearing PPE. Emphasize that being aware of the condition of your PPE is an important part of situational awareness.

3. Conduction

- a. Transfer of heat through and between solids
- b. Occurs when material is heated as result of direct contact with heat source

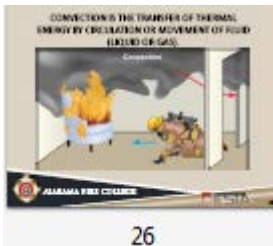
- c. Results from increased molecular motion; collisions between molecules of substance resulting in transfer of energy through substance
- d. More tightly packed molecules are, more readily substance will conduct heat
- e. Dependent on
 - i. Area being heated
 - ii. Temperature difference between heat source and material being heated
 - iii. Thermal conductivity of heated material

Instructor Note: Point out Table 5.3 on page 221 of the textbook. Discuss any materials commonly seen in your local jurisdiction. Emphasize how knowing about conductivity can help firefighters during emergency scene operations.

- f. Insulating materials slow conduction of heat
 - i. Disrupt point-to-point transfer of heat or thermal energy
 - ii. Best used in building construction are made of fine particles, fibers with void spaces filled with gas – Gases do not conduct heat well

4. Convection

- a. Transfer of thermal energy by circulation or movement of fluid (liquid or gas)
- b. Usually through movement of hot smoke, fire gases in fire environment
- c. May occur in any direction – Generally upward because smoke, fire gases are buoyant
- d. Can move laterally
 - i. Result of differences in pressure
 - ii. Move from areas of high pressure to low pressure
 - iii. Can be from fire area or openings on windward side (higher pressure) to leeward side
- e. Will feel increase in temperature when working in flow path – Energy is transferred from gas to skin



Instructor Note: One way to illustrate the concept of convection is to hold your finger in front of a blow dryer on a high heat but low blow setting. The transfer of the heat from the blow dryer to

your skin illustrates how working in a flow path will increase temperatures on the fire ground.



5. Radiation

- a. Transmission of energy as electromagnetic wave, without intervening medium
- b. Can become dominant mode of heat transfer when fire grows in size; may affect objects located some distance from fire
- c. Influenced by wide range of factors
 - i. Nature of exposed surfaces
 - (a) *Dark materials emit, absorb heat more effectively than lighter color materials*
 - (b) *Smooth, highly polished surfaces reflect more radiant heat than rough surfaces*
 - ii. Distance between heat source and exposed surfaces – Increasing distance reduces effect of radiant heat
 - iii. Temperature difference between heat source and exposed surfaces
 - (a) *Temperature difference has major effect on heat transfer through radiation*
 - (b) *As temperature of heat source increases, radiant energy increases by factor to fourth power*
- d. Travels in straight line at speed of light
- e. Common cause of exposure fires – Fires ignited remote from initial origin
- f. Travels through vacuums, air spaces where conduction, convection normally disrupted – Also disrupted by materials that reflect radiated energy
- g. Radiant energy sources in fire
 - i. Flames have high temperature
 - ii. Hot smoke in upper layer

Review Question: What impact does thermal energy have on heat, temperature, and heat transfer?
See pages 216-223 of the textbook for answers.

III. FUEL

pp. 223-231

Objective 3 — Recognize the physical states of fuel.

A. Fuel

1. Material or substance oxidized or burned in combustion process
2. Scientifically known as reducing agent
3. Types
 - a. Inorganic – Do not contain carbon
 - i. Hydrogen
 - ii. Magnesium
 - b. Organic – Containing carbon, other elements
 - i. Hydrocarbon-based – Gasoline, fuel, oil, and plastics
 - ii. Cellulose-based – Wood, paper
4. Chemical content influences
 - a. Heat of combustion
 - i. Total amount of thermal energy released when specific amount of fuel is oxidized (burned)
 - ii. Usually expressed in kilojoules/gram (kJ/g)
 - iii. Plastics, flammable liquids, and flammable gases contain more than wood – Will be encountered in modern construction
 - b. Heat release rate (HRR)
 - i. Energy released per unit of time as fuel burns
 - ii. Usually expressed in kilowatts (kW) or megawatts (MW)
 - iii. Dependent on type, quantity, and orientation of fuel
 - iv. Directly related to oxygen consumption – Combustion process requires continuous supply to continue



(a) Higher HRR with more available oxygen

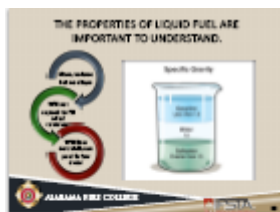
(b) Decreased HRR when ventilation limited

B. Gaseous Fuel

1. Can be most dangerous of all fuel types – Are already in physical state required for ignition
2. Vapor density
 - a. Describes density of gases in relation to air
 - b. Air assigned vapor density of 1
 - i. If gas is less than 1, will rise
 - ii. If gas is greater than 1, will sink

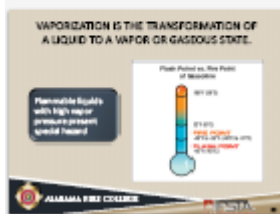
C. Liquid Fuel

1. Properties
 - a. Have mass, volume but no definite shape – Except flat surface or shape of container
 - b. Will not expand to fill all of container
 - c. When released on ground, will flow downhill, can pool in low areas



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2. Density compared to water
 - a. Specific gravity – Ratio of mass of given volume of liquid compared with mass of equal volume of water at same temperature
 - b. Water assigned specific gravity of 1
 - i. Liquids with less than 1, will float on surface
 - ii. Liquids with greater than 1, will sink



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3. Must be vaporized to burn
 - a. Vaporization – Transformation of liquid to vapor or gaseous state
 - b. Escaping vapors must be at higher pressure than atmospheric pressure to occur
 - c. Vapor pressure – Pressure vapors escaping from liquid exert; indicates how easily substance will evaporate or go into air
4. Flammable liquids with high vapor pressure present special hazard for firefighters
 - a. As liquid heats, vapor pressure increases with rate of vaporization
 - b. Volatility (ease) with which liquid gives off vapor influences how easily it can be ignited

- c. Flash point – Minimum temperature at which liquid gives off sufficient vapors to ignite, but not sustain combustion
- d. Fire point
 - i. Temperature at which sufficient vapors are being generated to sustain combustion reaction
 - ii. Commonly used to indicate flammability hazard of liquid fuels
- e. Extent to which liquid gives off vapor also influenced by how much surface area is exposed to atmosphere

5. Solubility

- a. Extent to which substance will mix with water
- b. Expressed in qualitative terms or as percentage
- c. Miscible materials – Mix in any proportion
- d. Hydrocarbon fuels – Do not mix
- e. Polar solvents – Readily mix

6. Liquids less dense than water difficult to extinguish using water as only extinguishing agent

- a. Fuel will not mix with water, adding water may disperse burning liquid instead of extinguishing; potentially spreading fire
- b. Should be extinguished with appropriate foam, chemical agent

7. Water-soluble liquids will mix with agent, become less effective at extinguishing fire – To avoid use foams specifically designed for polar solvents

D. Solid Fuel

1. Properties

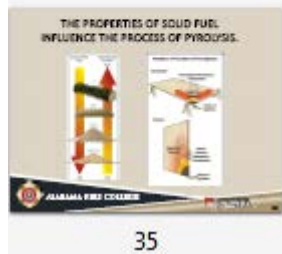
- a. Have definite size and shape
- b. May react differently when exposed to heat; some readily melt and others do not
- c. When heated – Decompose, release fuel gases, and vapors



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2. Pyrolysis – Chemical decomposition of substance through action of heat
 - a. Can generate sufficient quantities of burnable vapors to ignite in presence of sufficient oxidizer
 - b. Must occur to generate flammable vapors required for combustion
 - i. Begins in wood at temperatures below 400°F (204°C)
 - ii. Occurs much sooner in plastics – No moisture to slow process

Instructor Note: Discuss the table on page 229 of the textbook. Discuss the effects of pyrolysis within the temperature zone of your jurisdiction. Emphasize with students how to remain aware of the impact of seasonal changes on these effects.

3. Primary consideration for ignition is surface area of fuel in proportion to mass – Called surface-to-mass ratio
 - a. Example

Instructor Note: Discuss the example of surface-to-mass ratio changes in a large tree provided on page 230 of the textbook. Emphasize with students how this concept impacts combustion rates.

- b. As surface-to-mass ratio increases – Fuel particles become smaller
 - c. As surface area increases, more material is exposed to heat, and generates combustible pyrolysis products more quickly
4. Proximity, orientation of solid fuel relative to source of heat also affects way it burns

Review Question: What are the physical states that fuel can be found in?
See pages 223-231 of the textbook for answers.

IV. OXYGEN

pp. 231-233

Objective 4 — Explain the relationship between oxygen and life safety.

A. Oxygen

1. Primary oxidizing agent in most fires – Consists of about 21 percent oxygen
2. At normal ambient temperatures (68°F/20°C) – Materials can ignite, burn at oxygen concentrations as low as 14 percent
3. When oxygen is limited flaming combustion will diminish – Causing nonflaming combustion
4. Impact of ambient temperature
 - a. Nonflaming can continue at extremely low concentrations when surrounding temperature is relatively low
 - b. Flaming may continue at lower oxygen concentrations when temperature is high



Instructor Note: Discuss the Safety Alert on page 231 of the textbook. Emphasize with students how oxygen concentration impacts both fire behavior and survival.

5. When oxygen concentration is higher than normal
 - a. Materials will burn more intensely, may ignite more readily
 - b. Some petroleum-based materials will autoignite
 - c. Materials that do not burn at normal levels will burn
 - d. Fires may be more difficult to extinguish, present safety hazard to firefighters
6. Combustion occurs after fuel has been converted to gaseous state when mixed with oxidizer in proper ratio
 - a. Range of concentrations called flammable (explosive) range

- b. Reported using percent by volume of gas or vapor in air for
 - i. Lower flammable limit (LFL) – Minimum concentration of fuel vapor, and air that supports combustion
 - ii. Upper flammable limit (UFL) – Concentration above which combustion cannot take place
- c. Ideal concentration for combustion is within flammable range

Review Question: How do oxygen and life safety relate to one another?

See pages 231-233 of the textbook for answers.

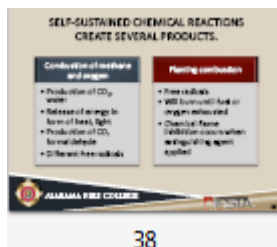
V. SELF-SUSTAINED CHEMICAL REACTION

pp. 233-234

Objective 5 — Identify the products of self-sustained chemical reactions.

A. Self-Sustained Chemical Reaction

1. Example of complex reaction – Combustion of methane, oxygen
 - a. Complete oxidation of methane results in
 - i. Production of CO₂, water
 - ii. Release of energy in form of heat, light
 - b. Molecules break apart as flaming combustion occurs – Form free radicals
 - c. Free radicals combine with oxygen or elements that form fuel material – Produce new substance; leads to more free radical production
 - d. Production of CO and formaldehyde occurs at various points in process – Both are flammable and toxic
 - e. Different free radicals, intermediate combustion products created based on type of chemically complex fuels that burn
2. Another example – Flaming combustion
 - a. Sufficient heat causes fuel, oxygen to form free radicals, and initiate reaction



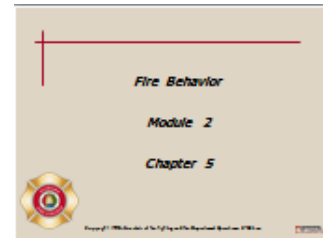
- b. Fire will burn until fuel or oxygen exhausted or extinguishing agent applied in sufficient quantity to interfere with reaction
- c. Chemical flame inhibition occurs when extinguishing agent
 - i. Interferes with chemical reaction
 - ii. Forms stable product
 - iii. Terminates combustion reaction



Review Question: What products of self-sustained chemical reactions combine to make flammable and toxic substances?
See pages 233-234 of the textbook for answers.

Chapter 5

Fire Behavior



Lesson Goal

After completing this lesson, the student shall be able to explain the science of fire behavior as it relates to recognizing stages of fire development, rapid fire behavior, and fire fighting operational safety.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain the science of fire as it relates to energy, forms of ignition, and modes of combustion. *[NFPA® 1001, 5.3.11]*
2. Describe the impact of thermal energy on heat, temperature, and heat transfer. *[NFPA® 1001, 5.3.12]*
3. Recognize the physical states of fuel. *[NFPA® 1001, 5.3.10]*
4. Explain the relationship between oxygen and life safety. *[NFPA® 1001, 5.3.11]*
5. Identify the products of self-sustained chemical reactions. *[NFPA® 1001, 5.3.11]*
6. Explain the factors that affect fire development. *[NFPA® 1001, 5.3.11]*
7. Describe the stages of fire development. *[NFPA® 1001, 5.3.11]*
8. Recognize signs, causes, and effects of rapid fire development. *[NFPA® 1001, 5.3.11]*
9. Describe the methods through which fire fighting operations can influence fire behavior. *[NFPA® 1001, 5.3.11, 5.3.12]*



Instructor Information

This is the lesson covering fire behavior. This lesson describes the science of fire, various physical states fuel can be found in, classification of fires, and the stages of fire development. The relationship between fire behavior and fire fighting operations is also discussed.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture and discussion. The level of learning is comprehension.

I. STAGES OF FIRE DEVELOPMENT

pp. 234-250

Objective 6 — Explain the factors that affect fire development.

Objective 7 — Describe the stages of fire development.

A. Stages of Fire Development

1. Occur in both unconfined, confined fires
2. Distinct in laboratory simulations, not in exact sequence outside of laboratory
3. Single compartment used to illustrate fire progression – Actual conditions in multiple compartments vary widely
4. Used at fire scene as guide for what could occur, not a pattern of what will occur every time
5. Assess changing hazards, conditions at incident – Do not assume fire will follow laboratory pattern



B. Factors that Affect Fire Development

1. Fuel type
 - a. Affects heat release rate (HRR)
 - b. Class A fires – High surface-to-mass ratio materials more easily ignited, will burn more quickly
 - c. Class B fires – Influenced by surface area, type of fuel involved
 - d. Fires involving single type of fuel rare
 - i. Modern contents are largely petroleum-based materials – Have higher heat of combustion, produce higher HRRs than wood alone
 - ii. Burning synthetic fuels – Products of combustion contain solid, liquid particulates and unburned gases
 - e. Compartment fire as result of flammable/combustible gas leak
 - i. May begin with rapid ignition of gas and explosion
 - ii. If fuel source not controlled may burn at point of release, continue to adjacent combustibles

- iii. Shutting off fuel source or controlling leak may reduce, eliminate Class B fire – Resulting Class A fire will continue to burn
2. Availability and location of additional fuel
- a. Building configuration (layout of structure) – Elements can contribute to fire spread or containment
 - i. Number of stories above or below grade
 - ii. Compartmentation
 - iii. Floor plan
 - iv. Openings between floors
 - v. Continuous voids or concealed spaces
 - vi. Barriers to fire spread
 - b. Construction materials – Can add to fuel load
 - i. Orientation and surface-to-mass ratio of structural materials influence rate, intensity of fire spread
 - ii. Interior finishes can influence fire spread
 - c. Contents
 - i. Most readily available fuel source
 - ii. When releasing large amount of heat rapidly – Increases intensity of fire, speed of development
 - d. Proximity of initial fire to exposed fuel sources
 - i. Fuels in upper level of adjacent compartments pyrolyze more quickly
 - ii. Continuous fuels rapidly spread fire from compartment to compartment
 - iii. Location of fire within building will influence development



3. Compartment volume and ceiling height
- a. All other factors being equal – Fire in large compartment will develop more slowly than in small compartment
 - i. Due to greater volume of air, increased distance radiated heat must travel from fire to contents
 - ii. Large volume of air will support development of larger fire

- b. High ceiling can make determining extent of fire development difficult
 - i. Large volume of hot smoke, fire gases can accumulate at ceiling level, while conditions at floor level remain unchanged
 - ii. Do not mistake floor level conditions for actual state of fire development

4. Ventilation

- a. All buildings exchange air from inside to outside
 - i. Constructed openings – Windows, doors, and passive ventilation devices
 - ii. Leakage through cracks, other gaps in construction
 - iii. Heating, ventilating, and air conditioning (HVAC) system
- b. Influenced by size, number, locations of openings, and velocity of air being exchanged
- c. Can be increased by natural conditions (wind direction, velocity) or assisted by HVAC system

Instructor Note: Discuss the Information Box “Ventilation vs. Tactical Ventilation” on page 239 of the textbook. Be sure students understand the distinction between the exchange of air and tactical ventilation practices.

- d. Two forms of compartment fires
 - i. Fuel controlled – Sufficient oxygen available; characteristics, configuration of fuel control development
 - ii. Ventilation controlled
 - (a) *Available air supply begins to limit fire development in compartment fire*
 - (b) *Fire has tendency to grow in direction of ventilation openings*
- e. Ventilation changes can
 - i. Alter flow path
 - ii. Create rapid fire development
 - iii. Place firefighters in extreme danger
- f. When ventilation controlled – HRR decreases



- g. Sudden introduction of air creates rapid increase in HRR
- 5. Thermal properties of the compartment – Can contribute to rapid fire development; make extinguishment difficult, reignition possible
 - a. Insulation – Contains heat within compartment causing localized increase in temperature and fire growth
 - b. Heat reflectivity – Increases fire spread through transfer of radiant heat from wall surfaces to adjacent fuel sources
 - c. Retention – Maintains temperature by absorbing and releasing large amounts of heat slowly

6. Ambient conditions

- a. High humidity, cold temperatures – Can slow natural movement of smoke
- b. Strong winds – Place additional pressure on side of structure, force both smoke, and fire out opposite side
- c. If window fails or door opens on windward side – Intensity, spread can increase significantly
- d. Wind direction, velocity can prevent or assist in ventilation activities
- e. Cold temperatures can cause smoke to appear white, and give false impression of interior conditions
- f. Atmospheric air pressure can cause smoke to remain close to ground obscuring visibility

7. Fuel load – Total quantity of combustible contents of building, space, and fire area

- a. On scene you will only be able to estimate based on knowledge, experience
- b. Knowledge of building construction, and occupancy types will be essential to determining



Review Question: What different factors can impact fire development?

See pages 234-241 of the textbook for answers.

C. Incipient Stage

1. Starts ignition when three elements of fire triangle come together, and combustion process begins
2. Fire is small and confined to material first ignited
3. Development
 - a. Largely dependent on characteristics, and configuration of fuel involved
 - b. Air provides oxygen to continue
 - c. Radiant heat warms adjacent fuel, and continues process of pyrolysis
 - d. Plume of hot gases, and flame rises from fire and mixes with cooler air
 - e. As plume reaches ceiling, begins to spread horizontally across, forming ceiling jet
 - f. Process of heat transfer begins to increase overall temperature in room
4. Characteristics
 - a. Fire has not yet influenced environment to significant extent
 - b. Temperature only slightly above ambient
 - c. Concentration of combustion products low
 - d. Occupants can safely escape from compartment
 - e. Fire could be safely extinguished with portable extinguisher, small hoseline
5. Essential to recognize that transition from incipient to growth can occur quickly (even in seconds) depending on type, and configuration of fuel



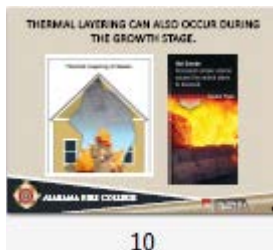
D. Growth Stage

1. As fire transitions
 - a. Begins to influence environment within compartment
 - b. Grown large enough for compartment configuration, and amount of ventilation to influence it



2. Amount of air entrained in plume

- a. Affected by location of fuel package in relation to compartment walls – Also impacts amount of cooling taking place
- b. Unconfined fires draw from all sides, cools plume of hot gases, reducing flame length, and vertical extension
 - i. Fuel packages in middle of room can entrain air from all sides
 - ii. Fuel packages near walls can only entrain air from three sides
 - iii. Fuel packages in corners can only entrain air from two sides
- c. When fuel package not in middle of room – Combustion zone expands vertically, higher plume results
 - i. Higher plume increases temperature in developing hot-gas layer at ceiling level, and increases speed of development
 - ii. Heated surfaces around fire radiate heat back toward burning fuel, and increases speed of development



3. Thermal layering – Also referred to as heat stratification and thermal balance

- a. Tendency of gases to form into layers according to temperature
 - i. Hottest gases tend to be in upper layer
 - ii. Cooler gases tend to be in lower layer
 - iii. Effects of heat transfer through radiation, convection
 - iv. Radiation from hot gas layer heats interior surfaces of compartment, and contents
 - v. Can be altered by change in ventilation and flow path
- b. Pressure increases as volume, temperature do
 - i. Causes hot gas layer to spread downward within compartment, and laterally through openings
 - ii. Cool gas layer pressure lower – Results in inward movement of air from outside at bottom as hot gases exit top

- c. Interface of hot, cooler gas layers at opening – Neutral plane
 - i. Pressure is neutral where layers meet
 - ii. Only exists at openings where hot gases exiting, cooler air entering
- d. When possible – Maintain or raise level of hot gas layer above floor
 - i. Provide more tenable environment for firefighters and trapped occupants
 - ii. Use effective fire control, and ventilation to raise position

4. Isolated flames

- a. May be observed moving through hot gas layer
- b. Indicates that portions of layer are within flammable range, there is sufficient temperature to result in ignition
- c. Frequently observed prior to more substantial involvement of flammable products of combustion in layer

5. Rapid transition

- a. Flashover – From growth to fully developed stage
- b. Occurs during growth stage in laboratory; may occur at any time conditions are right in uncontrolled situation
- c. Does not occur at every fire
 - i. Development may take alternate path when ventilation limited
 - ii. Ventilation control limits HRR, causing fire to enter decay stage
- d. Most fires that develop beyond incipient stage become ventilation controlled



E. Fully Developed Stage

- 1. Occurs when all combustible materials in compartment are burning
- 2. Burning fuels in compartment are releasing maximum amount of heat possible for available fuel, oxygen; producing large volumes of fire gases

3. Is ventilation controlled because heat release is dependent on compartment openings
 - a. Provide oxygen, supports ongoing combustion, and releases products of combustion
 - b. Increases in available air supply will result in higher heat release
4. Flammable products of combustion
 - a. Likely to flow from compartment of origin into adjacent compartments or out through openings to exterior of the building
 - b. Flames will extend out of compartment openings because insufficient oxygen for complete combustion in compartment

Note: If there are limited or no openings in the compartment, it is unlikely that the fire will reach a fully developed stage due to limited ventilation.



F. Decay Stage

1. Occurs
 - a. As fuel is consumed
 - b. If oxygen concentration falls to point that flaming combustion is diminished
2. Brings combustion reaction to stop
3. Consumption of fuel
 - a. As fuel is consumed, HRR begins to decline
 - b. With adequate ventilation, fire becomes fuel controlled
 - c. Temperature in compartment may remain high even after HRR drops
 - d. Flammable products of combustion can accumulate within compartment and adjacent spaces
4. Limited ventilation
 - a. HRR declines due to lack of oxygen
 - b. May maintain extremely high temperature within compartment

- c. Pyrolysis can continue
- d. Large volume of flammable products of combustion can accumulate

Review Question: What are the stages of fire development?
See pages 241-247 of the textbook for answers.

pp. 247-250

Objective 8 — Recognize signs, causes, and effects of rapid fire development.

A. Rapid Fire Development

1. Responsible for numerous firefighter deaths, injuries
2. Protect yourself, crew
 - a. Recognize indicators
 - b. Know conditions created by situations
 - c. Determine best action to take before occurrence



B. Flashover

1. Combustible materials in compartment, gases produced by pyrolysis ignite almost simultaneously – Full-room involvement
2. Typically occurs during growth stage – May occur during fully developed stage
3. Environment of room changes from two-layer condition to single well mixed, untenable hot gas condition
4. Transition between pre-flashover to post-flashover can occur rapidly
5. Conditions during
 - a. Volume of fire can increase from $\frac{1}{4}$ to $\frac{1}{2}$ room's upper volume to fill entire room – Potentially expanding out of any openings
 - b. Burning gases push out of openings at substantial velocity
6. Common elements





- a. Transition in fire development – Represents transition from growth stage to fully developed stage
 - b. Rapidity – Not an instantaneous event, but happens rapidly (often in seconds) to spread complete fire involvement within compartment
 - c. Compartment – Must be enclosed space such as single room or enclosure
 - d. Ignition of all exposed surfaces – Virtually all combustible surfaces in enclosed space become ignited
7. Factors that determine if fire will progress to flashover
 - a. Sufficient fuel, heat release rate
 - b. Ventilation – Must have sufficient oxygen
 8. Survival rates extremely low – Typically occurs at 1,100°F (600°C) ceiling temperature
 9. Be aware of indicators
 - a. Building indicators
 - i. Can occur in any building
 - ii. Interior configuration, fuel load, thermal properties, and ventilation will determine how rapidly
 - b. Smoke indicators – Rapidly increasing volume, turbulence, darkening color, optical density, and lowering of hot gas level
 - c. Airflow indicators
 - i. High velocity, turbulence
 - ii. Bi-directional movement with smoke exiting at top of doorway, fresh air moving in at bottom
 - iii. Pulsing air movement
 - d. Heat indicators
 - i. Rapidly increasing temperature in compartment
 - ii. Pyrolysis of contents or fuel packages located away from fire
 - iii. Darkened windows
 - iv. Hot surfaces

- e. Flame indicators – Isolated flames in hot gas layers or near ceiling

10. Rollover also indicator

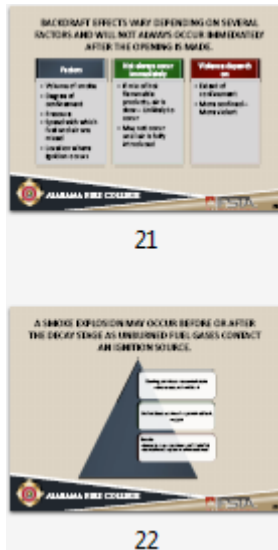
- a. Condition where unburned fire gases at top of compartment ignite, and flames propagate through hot gas layer or across ceiling
- b. May occur during growth stage
- c. Flames may be observed in layer while gases reach combustible temperature
- d. Will generally precede, but will not always result in flashover

C. Backdraft

1. Increase in low-level ventilation prior to upper level ventilation results in explosively rapid combustion of flammable gases
2. Occurs in decay stage – In a space containing high concentration of heated flammable gases that lacks sufficient oxygen for flaming combustion
3. When potential conditions exist introduction of new source of oxygen will return fire to fully involved state – Can occur with creation of horizontal or vertical opening
4. Consider potential for before creating any openings into compartment
5. Be aware of indicators



- a. Building indicators
 - i. Fire confined to single compartment or void space
 - ii. Building contents have high heat release rate
- b. Smoke indicators
 - i. Optically dense smoke, light colored or black becoming dense gray-yellow – Color alone is not reliable indicator
 - ii. Neutral plane rising, lowering similar to pulsing or breathing movement
- c. Airflow indicators – High velocity, turbulent smoke discharge, and sometimes appearing to pulse or breath



- d. Heat indicators – High heat, smoke stained windows
- e. Flame indicators – Little or no visible flame
- 6. Effects vary depending on factors
 - a. Volume of smoke
 - b. Degree of confinement
 - c. Pressure
 - d. Speed with which fuel and air are mixed
 - e. Location where ignition occurs
- 7. Will not always occur immediately after opening made
 - a. If mix of hot flammable products, air is slow – Unlikely to occur
 - b. May not occur until air is fully introduced
- 8. Violence depends on extent of confinement – More confined, more violent backdraft will be

D. Smoke Explosion

- 1. May occur before or after decay stage
- 2. Occurs as unburned fuel gases contact ignition source
- 3. Cooling smoke can accumulate in other areas, mix with air – If contact ignition source while in flammable range, can result in explosively rapid combustion
- 4. Violent because involve premixed fuel and oxygen
- 5. Smoke generally cool, less than 1,112° F (600° C), located in void spaces connected to fire or in uninvolved areas remote

Review Question: What are the signs and causes of a backdraft?

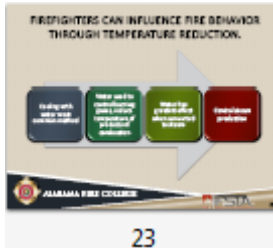
See pages 248-250 of the textbook for answers.

II. FIRE BEHAVIOR AND FIRE FIGHTING OPERATIONS

pp. 250-253

Objective 9 — Describe the methods through which fire fighting operations can influence fire behavior.

A. Temperature Reduction



1. Most common method – Cooling with water
 - a. Enough must be applied to burning fuel to absorb heat generated by combustion
 - b. Reduces temperature of fuel to point where does not produce sufficient vapor to burn
 - c. Can extinguish solid, liquid fuels with high flash points
 - d. Cannot sufficiently reduce vapor production when low flash point flammable liquids, gases involved
 - e. Most effective method for extinguishment of smoldering fires
2. Water can also be used to control burning gases, reduce temperature of hot products of combustion in upper layer
 - a. Slows pyrolysis process
 - b. Reduces radiant heat flux from upper layer
 - c. Reduces potential for flashover
3. Water has greatest effect when vaporized into steam
 - a. Converted to steam at 212°F (100°C)
 - b. Expands 1,700 times – Avoid creating too much
 - c. Excess steam
 - i. Reduces visibility
 - ii. Increase chances for steam burns
 - iii. Disrupts thermal balance
4. Control steam production by
 - a. Using good nozzle technique
 - b. Applying appropriate amount of water
 - c. Applying water using most effective form of stream based on conditions



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B. Fuel Removal

1. Simplest method – Allow fire to burn until all fuel consumed; not always desirable
2. Best solution may be to allow fire to burn, minimizing groundwater pollution
3. Other methods
 - a. Stop flow of liquid fuel
 - b. Close valves to stop emission of gaseous fuels
 - c. Move solid fuels out of path of fire

C. Oxygen Exclusion

1. Reduces fire's growth, may totally extinguish over time
2. Methods – Do not work if fuel self-oxidizing
 - a. Flood area with inert gas to displace oxygen
 - b. Separate oxygen by blanketing fuel with foam
3. Closing doors before leaving building can limit air supply, and help prevent flashover

D. Chemical Flame Inhibition

1. Extinguishing agents interrupt combustion reaction, and stop flame production
2. Effective on gas and liquid fuels
3. Do not easily extinguish nonflaming fires – No chemical chain reaction to inhibit
4. Not practical for smoldering fires

E. Ventilation and Fire Behavior

1. Unplanned ventilation – May occur before or after suppression operations start
 - a. Can result from wind outside structure – Impact
 - i. Increase pressure inside structure
 - ii. Drive smoke and flames into unburned portions of structure, onto advancing firefighters
 - iii. Upset tactical ventilation efforts



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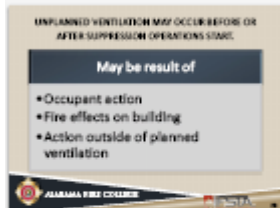


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WARNING: Wind driven conditions can occur in any type of structure. Wind speeds as low as 10 mph (16 kph) can create wind-driven conditions.



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- b. Can also be result of
 - i. Occupant action
 - ii. Fire effects on building
 - iii. Action outside of planned, systematic, and coordinated tactical ventilation

2. Ventilation strategies – Tactical ventilation

- a. Planned, systematic, and coordinated introduction of air; removal of hot gases, and smoke from building
- b. Must be coordinated with fire suppression operations to prevent unwanted consequences for hoseline crews
- c. Influence on fire behavior based on variety of factors
 - i. HRR increased in ventilation-controlled fire when ventilation increased
 - ii. Can be as simple as keeping exterior door closed or as complex as performing vertical ventilation
- d. Increase in combustion rate when fire is ventilation controlled

WARNING: Even coordinated tactical ventilation increases the combustion rate in ventilation controlled fires.

Review Question: How can fire fighting operations impact fire behavior?

See pages 250-253 of the textbook for answers.

III. SUMMARY AND REVIEW



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A. Chapter Summary

1. You need to understand the combustion process, how fire behaves, and how to select appropriate extinguishing agents.

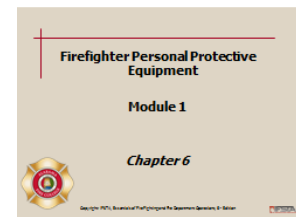
2. Understanding fire behavior can help you recognize developing fire conditions and respond safely to mitigate hazards present in the fire environment.

B. Review Questions

1. How does the science of fire relate to energy, forms of ignition, and modes of combustion? (*pp. 208-216*)
2. What impact does thermal energy have on heat, temperature, and heat transfer? (*pp. 216-223*)
3. What are the physical states that fuel can be found in? (*pp. 223-231*)
4. How do oxygen and life safety relate to one another? (*pp. 231-233*)
5. What products of self-sustained chemical reactions combine to make flammable and toxic substances? (*pp. 233-234*)
6. What different factors can impact fire development? (*pp. 234-241*)
7. What are the stages of fire development? (*pp. 241-247*)
8. What are the signs and causes of a backdraft? (*pp. 248-250*)
9. How can fire fighting operations impact fire behavior? (*pp. 250-253*)

Chapter 6

Firefighter Personal Protective Equipment



Lesson Goal

After completing this lesson, the student shall be able to properly use and care for personal protective equipment (PPE) as well as describe how it can protect firefighters. Students will understand how the limitations of PPE impact the need to select equipment appropriate for the incident in order to take advantage of this protection.

Objectives

Upon successful completion of this lesson, the student shall be able to:



1. Describe the purpose of personal protective equipment. *[NFPA[®] 1001, 5.1.1, 5.3.3]*
2. Describe characteristics of each type of personal protective equipment. *[NFPA[®] 1001, 5.3.2]*
3. Summarize guidelines for the care of personal protective clothing. *[NFPA[®] 1001, 5.1.1, 5.3.3, 5.5.1]*
4. Explain safety considerations for personal protective equipment. *[NFPA[®] 1001, 5.3.1]*
5. Identify respiratory hazards. *[NFPA[®] 1001, 5.3.1]*
6. Identify types of respiratory protection equipment. *[NFPA[®] 1001, 5.3.1]*
7. Describe the limitations of respiratory protection equipment. *[NFPA[®] 1001, 5.3.1]*
8. Explain methods for storing respiratory protection equipment. *[NFPA[®] 1001, 5.5.1]*
9. Describe general donning and doffing considerations for protective breathing apparatus. *[NFPA[®] 1001, 5.3.1, 5.3.2]*
10. Summarize general considerations for protective breathing apparatus inspections and care. *[NFPA[®] 1001 5.1.1, 5.5.1]*
11. Summarize safety precautions for refilling SCBA cylinders. *[NFPA[®] 5.5.1]*
12. Explain procedures for replacing SCBA cylinders. *[NFPA[®] 1001 5.3.1]*
13. Explain safety precautions for SCBA use. *[NFPA[®] 1001 5.3.1]*
14. Describe nonemergency and emergency exit indicators. *[NFPA[®] 5.3.1]*
15. Describe nonemergency exit techniques. *[NFPA[®] 1001 5.3.1]*
16. Demonstrate the method for donning structural personal protective clothing for use at an emergency. *[NFPA[®] 1001, 5.1.2, 5.3.1, 5.3.2, 5.3.3]*

17. With structural personal protective clothing in place, demonstrate the over-the-head method of donning an SCBA. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
18. With structural personal protective clothing in place, demonstrate the coat method of donning an SCBA. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
19. With structural personal protective clothing in place, demonstrate the method for donning an SCBA while seated. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
20. Doff personal protective equipment, including respiratory protection, and prepare for reuse. *[NFPA[®] 1001 5.1.2, 5.3.2, 5.3.3]*
21. Demonstrate the steps for inspecting an SCBA. *[NFPA[®] 1001 5.3.2, 5.5.1]*
22. Demonstrate the steps for cleaning and sanitizing an SCBA. *[NFPA[®] 1001 5.3.2, 5.5.1]*
23. Demonstrate the method for filling an SCBA cylinder from a cascade system, wearing appropriate PPE, including eye and ear protection. *[NFPA[®] 1001 5.3.1]*
24. Demonstrate the method for filling an SCBA cylinder from a compressor/purifier system wearing appropriate PPE, including eye and ear protection. *[NFPA[®] 1001 5.3.1]*
25. Demonstrate the one-person method for replacing an SCBA cylinder. *[NFPA[®] 1001 5.3.1]*
26. Demonstrate the two-person method for replacing an SCBA cylinder. *[NFPA[®] 1001 5.3.1]*

Instructor Information

This is the lesson covering personal protective equipment. This lesson describes basic information about the various types of equipment and how it can protect firefighters. The lesson also covers PPE limitations, selection of PPE based on proposed use, as well as care and maintenance.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

I. PERSONAL PROTECTIVE EQUIPMENT

pp. 259-276

Objective 1 — Describe the purpose of personal protective equipment.

Objective 2 – Describe characteristics of each type of personal protective equipment.



A. Personal Protective Equipment

1. Includes
 - a. Personal protective clothing (PPC)
 - b. Respiratory protection equipment
 - c. Personal alert safety system (PASS)
2. Worn during emergency responses
3. Designed to protect from hazards; minimize risk of injury or fatality
4. PPC
 - a. Includes
 - i. Helmets
 - ii. Coats
 - iii. Trousers
 - iv. Boots
 - v. Protection – Eye and hearing
 - vi. Protective gloves, hoods
 - b. Use mandated by NFPA[®] 1500
 - c. Equipment must be designed, constructed based on NFPA[®] standards
 - i. SCBA design, construction – NFPA[®] 1981
 - ii. PASS design, construction – NFPA[®] 1982



B. Structural Fire Fighting Protective Clothing

1. Clothing designed for structural and proximity fire fighting must meet NFPA[®] 1971
 - a. Includes –
 - i. Helmets
 - ii. Coats

- iii. Trousers
 - iv. Boots
 - v. Eye protection
 - vi. Protective gloves, hoods
 - b. Requires all components include permanent label that shows compliance
2. Compliance label information
- a. Manufacturer's name, identification, or designation
 - b. Manufacturer's address
 - c. Country of manufacture
 - d. Manufacturer's identification, lot, or serial number
 - e. Month and year of manufacture
 - f. Model name, number, or design
 - g. Size or size range
 - h. Principal materials of construction
 - i. Footwear size and width (where applicable)
 - j. Cleaning precautions
3. Components must be compatible; only intended to protect from specific hazards
4. Never alter protective clothing
- a. May void manufacturer's warranty, affect worker's compensation benefits, and endanger lives
 - b. Do **NOT**
 - i. Remove moisture barrier or liner of coats and trousers
 - ii. Sew hooks, loops, or clasps to outer shell
 - iii. Add combustible decals to helmet



Ask Students: Why is it important to NEVER alter PPC components?

Discuss why doing so could unknowingly create a dangerous situation during an incident. For example, adding combustible decals to the helmet can endanger both the firefighter wearing the helmet and others who may have to come rescue the firefighter as a result of that danger.



5. Design benefits

- a. Covers all portions of skin when reaching, bending, and moving
- b. Prevents heat transfer from fire to body

6. Design limitations – Prevents heat transfer away from body

- a. temperature, core temperature, and physiological stress
- b. If conditions allow, open PPC to permit air flow during authorized breaks

7. Helmets

- a. Provide multiple benefits during structural fire fighting
 - i. Prevent heated or scalding water and embers from reaching ears and neck
 - ii. Protect head from impact injuries caused by objects or falls
 - iii. Provide protection from heat and cold
- b. Help identify personnel based on local SOPs
 - i. Shell color – Rank
 - ii. Markings – Unit
 - iii. Removable identification labels – Accountability
- c. Must be worn correctly for proper protection
 - i. Place helmet on head, secure chin strap under chin and tighten
 - ii. Fold ear flaps down to cover ears and neck – Must fold down even if wearing protective hood
 - iii. May have ratchet at back of headband to adjust fit



8. Eye protection devices

- a. Includes – SCBA facepieces, helmet-mounted faceshields, goggles, safety glasses
- b. Helmets must be equipped with faceshields or goggles
- c. Faceshields are intended for use in combination with primary form of eye protection

- d. NFPA® 1500 requires goggles or other primary eye protection be worn in operations where protection from flying particles or chemical splashes is necessary
 - e. Primary protection during fire fighting – Use SCBA facepiece
 - f. Eye protection may be required without respiratory protection – Use safety glasses or goggles
 - i. Emergency medical responses where exposure to body fluids is possible
 - ii. Vehicle extrications
 - iii. Wildland and ground cover fires
 - iv. Industrial occupancy inspections
 - v. Station maintenance
 - g. Safety glasses or goggles
 - i. Protect against approximately 85 percent of eye hazards
 - ii. Prescription safety glass frames and lenses must meet American National Standards Institute (ANSI) Standard Z87.1
 - h. Be aware of signs posted near power equipment – Always follow department's safety policies
9. Protective hoods
- a. Fabric coverings that protect ears, neck, and face from exposure to heat, embers, and debris
 - b. Cover areas not protected by SCBA facepiece, helmet, ear flaps, and coat collar
 - c. Face opening has elastic edge that fits tightly to SCBA facepiece, forming seal
 - d. Typically made of fire-resistant material
 - e. Available with long or short skirts – Designed to fit inside protective coat; forms continuous layer of protection
 - f. To wear
 - i. Pull on before protective coat to keep skirt under coat
 - ii. Ensure secure seal between hood and SCBA facepiece; secure facepiece first



Review Question: What is the purpose of personal protective equipment?

See pages 259-261 of the textbook for answers.



12

10. Protective coats

- a. Three components required by NFPA[®] 1971
 - i. Outer shell
 - ii. Moisture barrier
 - iii. Thermal barrier
- b. Barriers trap insulating air to prevent heat transfer from fire to body
- c. Provide limited protection from direct flame contact, hot water, steam, and cold temperatures, other environmental hazards
- d. Never remove liner or wear only shell – Compromises design; increases likelihood of injuries, and voids manufacturer warranty

WARNING!: All layers of the protective coat must be in place during any fire fighting operation. Failure to wear the entire coat and liner system during a fire may expose you to severe heat resulting in serious injury or death.



13



14

- e. Design features required by NFPA[®] 1971
 - i. Retroreflective trim — Strips of trim on torso and sleeves make it more visible
 - ii. Wristlets — Fabric interface between end of sleeve and palm protects wrist from water, embers, other debris; keeps coat sleeves from riding up when reaching
 - iii. Collars — Protects neck from water, embers, other debris; must be turned up under helmet ear flap
 - iv. Closure system — Snaps, clips, zippers, or Velcro[®] fasteners that secure front
 - v. Drag Rescue Device (DRD) — Harness and hand loop at back of neck that enables a rescuer to grab and drag a downed firefighter
- f. Typically reinforced in high compression areas – Shoulders, areas prone to wear



g. Optional features

- i. Cargo, radio, or SCBA facepiece pockets
- ii. Must meet NFPA[®] standard

11. Protective trousers

- a. Constructed from same fabric, moisture barrier, and thermal layering used in protective coats
- b. Reinforced in high compression areas and areas prone to wear
- c. May have cargo or patch pockets for gloves, and small tools
- d. Heavy-duty suspenders used to hold up
- e. Same closure system as on protective coat

12. Protective gloves

- a. Protect hands, wrists from heat, steam, cold penetration; resist cuts, punctures, and liquid absorption
- b. Must allow dexterity and tactile feel to perform job effectively
- c. Should cover wristlet of protective coat to form complete seal
- d. Structural fire fighting gloves must be NFPA[®] compliant for activity

13. Protective footwear

- a. Protect foot, ankle, and lower leg
 - i. Puncture wounds to sole caused by nails, broken glass, and other sharp objects
 - ii. Crushing wounds to toes and instep
 - iii. Scalding water or contaminated liquids
 - iv. Burns from embers and debris
- b. Have steel inner sole; steel or reinforced toe cap
- c. Must be high enough to protect lower leg
- d. Outer shell – May be rubber, leather, and other weather resistant material
- e. Thermal, physical, and moisture barriers are required inside shell



- f. Tops fit inside trouser legs, provide barrier even when kneeling

14. Hearing protection devices

- a. Guard against temporary and permanent hearing loss
- b. Required by NFPA[®] 1500, but not NFPA[®] 1971
 - i. States departments must protect from effects of harmful noise
 - ii. Best solution – Eliminating or reducing noise, not always possible
- c. Most commonly worn when riding apparatus
 - i. Noise exceeds maximum noise exposure levels (90 decibels in US; 85 decibels in Canada)
 - ii. Intercom/ear protection systems most effective – Allow for crew communication; monitor radio
- d. Required during operation of power tools, generators, apparatus pump, when testing PASS device
- e. May be impractical, dangerous during structural fire fighting – May prevent communication between firefighters, hearing radio transmissions, changes in fire behavior, and calls from trapped victim

15. Personal alert safety systems (PASS)

- a. Emit loud alarm to alert personnel to firefighter in danger
 - i. Activated when firefighter is motionless for more than 30 seconds, when firefighter presses emergency button; may be activated when temperature exceeds preset limit
 - ii. Must be at least 95 decibels; go off continuously for an hour
- b. Assist rescuers attempting to locate trapped, unconscious, and incapacitated firefighters
- c. Useful in total darkness, dense smoke, and confined spaces
- d. Design varies
 - i. Stand-alone units manually activated



- ii. Integrated units, connected to SCBA regulator, activated when main air supply valve opened – May be manually activated
- e. Settings
 - i. Off
 - ii. Alarm
 - iii. Sensing
 - iv. Pre-alarm – Activates when motionless for 30 seconds, different tone than full alarm
- f. Firefighters must
 - i. Learn how to turn unit from off to sensing (on); to manually activate alarm
 - ii. Test, maintain, and activate according to department SOP, manufacturer's instructions, NFPA[®] 1500, and NFPA[®] 1982

C. Wildland Personal Protective Clothing

1. Specifications found in NFPA[®] 1977

2. Includes

a. Gloves

- i. Made of leather or inherently flame-resistant materials
- ii. Protect from sharp or hot objects, temperature extremes, and scalding water

b. Goggles

- i. Protect eyes from ash, embers, dust, and other particulates
- ii. Must meet ANSI Z87.1

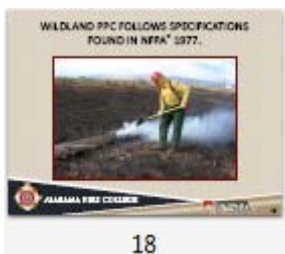
c. Jackets

- i. Made of high-strength, flame-resistant fabric
- ii. May have thermal liner for use in cold climates
- iii. Cuffs close snugly around the wrists, front of jacket must close completely from hem to neck

d. Trousers

- i. Made of same material and design as jackets
- ii. Leg cuffs must close securely around boot tops

e. One-piece jumpsuits — Similar in design to two-piece jacket and trousers



- f. Long-sleeve shirts — Protective shirts worn under jackets, are of similar design
- g. Helmet
 - i. Lightweight with chin straps
 - ii. Provides impact, penetration, and electrical insulation protection
- h. Face/neck shrouds
 - i. Flame resistant fabric, attaches to helmet
 - ii. Protects face and neck
- i. Footwear
 - i. Typically lace-up safety boots with lug or grip-tread soles
 - ii. Must be high enough to protect lower leg
 - iii. Steel toes in ordinary safety boots absorb and retain heat, not recommended
- j. Fire shelter
 - i. Fire resistant aluminized fabric covers; protect the firefighter from convected and radiant heat
 - ii. Use required by NFPA[®] 1500
 - iii. Design must meet United States Department of Agriculture (USDA) Forest Service Specification 5100-606
- k. Load-carrying or load-bearing equipment — Belt and suspender systems that distribute weight of firefighter's equipment; including tools, water bottles, and protective fire shelters
- l. Respiratory protection
 - i. Accepted form of respiratory protection has been cotton bandana or dust mask worn over nose and mouth – Not adequate protection
 - ii. National Institute for Occupational Safety and Health (NIOSH) certified and NFPA[®] approved air-purifying respirators (APR) and powered air-purifying respirators (PAPR) will be available 2011
- m. Chain saw protection – Chaps, leggings, or protective trousers made of ballistic nylon fibers that protect legs



19



20



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3. Will not protect from extreme heat – Do not wear underclothing made of synthetic materials (nylon, polyester); can result in materials melting to skin

Review Question: Why are there differences in the characteristics of structural firefighter protective clothing and wildland personal protective clothing?

See pages 261-273 of the textbook for answers.

WARNING!: Wildland personal protective clothing is not designed, certified, or intended for interior structural fire fighting.

D. Roadway Operations Clothing

1. Roadway operations are extremely dangerous
2. Best protection is to be visible to other motorists, work behind barrier formed by apparatus
3. Wear traffic vests with retroreflective trim to increase visibility
 - a. Trim reflects headlight beams, providing visibility
 - b. Required at incidents on federally-funded highways
 - c. Should be worn over PPE, or as soon as situation stabilized
 - d. Not commonly worn during fire suppression or hazardous materials activities

E. Emergency Medical Protective Clothing

1. Must wear to protect against exposure to infectious bodily fluids and airborne pathogens
2. May be either single- or multiple-use garments
3. Must meet NFPA[®] 1999
4. Includes
 - a. Utility gloves
 - i. Not used for patient care
 - ii. Provide barrier against bodily fluids, disinfectants, and cleaning solutions
 - b. Medical examination gloves—Certified for patient care; provide barrier up to wrist



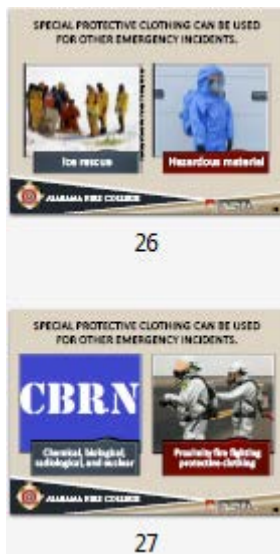
- c. Eye/face protection device —Faceshield, goggles, safety glasses, or hooded visor; provides limited protection for eyes and face
- d. Facemask — Full face device that protects eyes, face, nose, and mouth
- e. Footwear — Safety shoes or boots that protect feet and ankles; may be dual certified station/work shoes
- f. Footwear cover — Single-use item worn over footwear to provide limited barrier against bodily fluids
- g. Medical garment
 - i. Single- or multiple-use clothing that provides barrier against bodily fluids
 - ii. May be sleeves, jackets, trousers, gowns, or coveralls that can be worn over a uniform
- h. Medical helmet
 - i. Head protection designed to provide impact, penetration, and electrical insulation protection while working with patient in a hazardous area
 - ii. Must meet ANSI design requirements for Type 1 hardhats
- i. Respiratory protection device — Filter mask that protects from airborne pathogens

F. Special Protective Clothing

- 1. Technical rescue
 - a. Must protect wearer from physical, thermal, liquid hazards, and infectious diseases
 - b. Design criteria specified in NFPA[®] 1951
 - c. May be dual certified for emergency medical use as defined by NFPA[®] 1951 and NFPA[®] 1999
 - d. May be chemical, biological, radiological, or nuclear (CBRN) certified
 - e. Structural personal protective clothing usually too bulky and heavy
 - f. Respiratory protection – Consists of air-purifying respirators (APR), SCBAs, or supplied air respirators (SAR)



2. Standing/swift water rescue
 - a. Full-body dry suit – Buoyant, thermally-insulated, and abrasion/puncture-resistant
 - b. Rescue helmet required
 - c. U.S. Coast Guard (USCG) approved personal floatation device (PFD) must be worn in rivers, streams, lakes, along shorelines and coastlines
3. Ice rescue
 - a. Similar to full-body suit used in water rescue, more thermal insulation
 - b. USCG PFDs are mandatory
 - c. Some models have water tight hoods, integrated gloves, and attachable boots
4. Hazardous materials — Varying types include high-temperature protective clothing and chemical-protective clothing (CPC) that protects against splashes and vapor
5. Chemical, biological, radiological, and nuclear (CBRN)
 - a. Protect against hazard types during accidents and terrorist incidents
 - b. Must adhere to NFPA[®] 1994
 - c. NFPA[®] 1971 establishes optional design requirements for structural and proximity ensembles certified for CBRN incidents
 - d. Must carry the appropriate CBRN label
6. Proximity fire fighting protective clothing
 - a. Similar to structural protective clothing but with aluminized outer shell on coat, trousers, gloves, and helmet shroud
 - b. Outer shell designed to reflect high levels of radiant heat and protect against direct flame contact
 - c. Must be resistant to water, impact from sharp objects, and electrical shock
 - d. Proximity PPE may be used in some hazardous materials operations



G. Station/Work Uniforms

1. Performs two functions
 - a. Identify wearer as member of organization
 - b. Provide layer of protection against direct flame contact
 - c. Should not wear non-fire resistant synthetic materials under
2. Must meet requirements of NFPA® 1975
 - a. Minimum requirements for functional work wear
 - i. Will not contribute to injury
 - ii. Will not reduce effectiveness of outer PPC
 - b. Garments addressed – Trousers, shirts, jackets, and coveralls
 - i. Underwear not addressed
 - ii. 100 percent cotton underwear is recommended to prevent burns
3. Must have permanently attached label stating certification
4. Designed to be fire resistant but not to be worn for fire fighting operations
 - a. Structural fire fighting protective clothing always worn over
 - b. Wildland protective clothing may be worn – Depending on design and local protocols
 - c. May be dual certified as work uniform and wildland protective clothing – Must carry appropriate label
5. Safety shoes or boots may be part
 - a. Required while conducting inspections; doing work around station
 - b. Usually have steel toes, puncture-resistant soles; special inserts
 - c. Should not be worn for station duties if worn during emergency operations – Can cause contamination
6. May be contaminated during emergency response
 - a. Should not be washed in personal washing machines or at public laundromats



- b. Must be laundered at fire station or by contractor

pp. 277-280

Objective 3 — Summarize guidelines for the care of personal protective clothing.

A. Care of Personal Protective Clothing

1. PPE must be properly maintained
 - a. Hydrocarbon contamination reduces fire resistance
 - b. Chemicals, oils, and petroleum products in/on outer shell can ignite when exposed to fire
 - c. Some contaminants reduce effectiveness of retroreflective trim; soot obscures visibility
 - d. Hydrocarbons, body fluids, and toxins can be inhaled, ingested, and absorbed – Causing serious or fatal injury
2. Firefighter responsible for inspection, cleaning, and condition of assigned PPE
3. Procedures for care
 - a. Department SOPs
 - b. Manufacturer's instructions
 - c. NFPA® 1851



B. Inspecting

1. Frequency
 - a. Beginning of shift
 - b. After every use
 - c. After washing, repair, and decontamination
 - d. Periodic basis – Weekly or monthly
 - e. Annual inspection – Made by member of department trained in advanced inspection requirements
2. Conditions to look for in routine inspection
 - a. Soiling
 - b. Contamination
 - c. Missing or damaged hardware and closure systems

- d. Physical damage including rips, tears, and damaged stitching on seams
 - e. Wear due to friction under arms, in crotch, at knee and elbow joints
 - f. Thermal damage – Including charring, melting, discoloration, and burn holes
 - g. Shrinkage
 - h. Damaged or missing retroreflective trim or reinforcing trim
 - i. Loss of reflectivity of shell on proximity equipment
 - j. Cracks, melting, abrasions, or dents in helmet shell
 - k. Missing or damaged faceshield or hardware
 - l. Missing or damaged earflaps or neck shroud
 - m. Loss of water-tight integrity in footwear
 - n. Damage to or faulty installation of drag rescue device (DRD)
3. Findings from inspection
- a. Routine cleaning does not require removal from service – Perform yourself
 - b. Advanced cleaning, decontamination, repairs, and replacements must be reported to supervisor

C. Cleaning

1. Four types defined by NFPA[®] 1851
- a. Determined by amount and type of contamination, if equipment must be removed from service
 - b. Departments may provide spare sets of PPE to replace removed units
2. Routine cleaning – Does not require removal from service
- a. At incident – Brush off loose debris with broom or soft bristle brush; rinse off debris and soil with gentle spray of water
 - b. Remove heavy soil by hand in utility sink in designated area at station
 - c. Always follow manufacturer's recommendations



- d. Wear appropriate gloves and eye protection
- 3. Advanced cleaning
 - a. Requires trained personnel
 - b. Use washing machine designed to handle heavy loads – Should be dedicated to cleaning PPC
- 4. Specialized cleaning
 - a. Required when hazardous materials or body fluids that cannot be removed by routine or advanced cleaning present
 - b. Performed by trained department member or outside contractor
 - c. Clothing too contaminated to be cleaned must be removed from service and destroyed
- 5. Contract cleaning
 - a. Specialized cleaning performed by manufacturer, their representative, and a certified vendor
 - b. Removes accumulated grime or contaminants
 - c. Contractors may provide replacement PPE while cleaning



WARNING! Do not wash contaminated protective clothing in washing machines used for other garments or items. Do not take contaminated protective clothing into the living or sleeping quarters of the fire station or your residence. PPE should not be stored where it can come in contact with vehicle exhausts. PPE that is carried in personal vehicles should be placed in closable garment bags intended for that purpose.

D. Repairing

- 1. Damage must be repaired immediately by manufacturer, approved repair facility, or trained department member
- 2. Damage beyond repair must be removed from service and destroyed
- 3. May be marked for training only – Used in non-live fire training

Review Question: What are some basic guidelines for the care of personal protective clothing?
See pages 277-280 of the textbook for answers.

p. 280

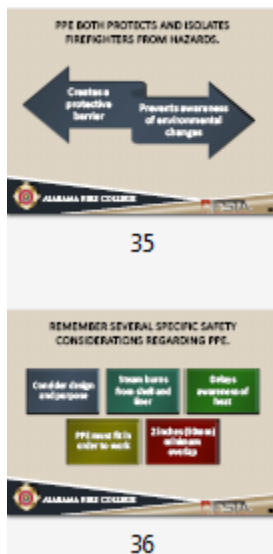
Objective 4 — Explain the safety considerations for personal protective equipment.

A. Safety Considerations for Personal Protective Equipment

1. PPE designed as barrier between firefighter and work environment
2. Can isolate – Prevent firefighter from being aware of important environmental changes; may make overconfident of safety

B. Specific Safety Considerations

1. Always consider design and purpose of protective clothing; be especially aware of garment limitations
2. Moisture in shell and liner material will conduct heat rapidly, resulting in serious steam burns – Ensure garment is dry before wearing into fire
3. PPE insulates from heat of a fire – Will protect, but will also delay awareness of temperature increases
4. Never wear protective clothing that does not fit, provides reduced protection
 - a. Tight clothing will not close properly, leaving a gap
 - b. Loose clothing can hinder mobility and dexterity by bunching up at shoulders, elbows, and knees – Can also snag on debris, create tripping hazard, absorb contaminants, reduce thermal protection
5. Make sure that overlap between coat and trousers is a minimum of 2 inches (50 mm) at the waist when you bend over to a 90° angle
6. Thermal burns may occur at compression points where garment layers are pressed together – Under SCBA shoulder harness, along sleeves in contact with hoselines, on knees when kneeling on hot debris, and embers



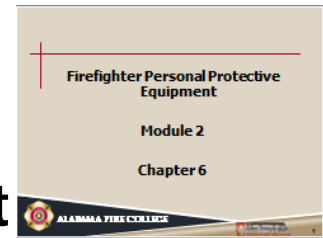
7. Radiant heat can rapidly penetrate protective clothing, causing serious burns – If you feel thermal radiant burns developing, withdraw from area immediately
8. Prolonged exposure to hot environments will cause body to sweat
 - a. Protective clothing liner will retain moisture produced by sweating, which may cause heat stress or burns
 - b. Move to a cool, safe area, remove your PPE, and follow established rehabilitation procedures when symptoms of heat exhaustion appear – Weakness, dizziness, rapid pulse, or headache
9. PPE is designed to protect, but it is not designed to protect against extreme fire conditions such as backdraft, flashover, or other extreme fire behavior



Review Question: What safety considerations do firefighters need to keep in mind when using personal protective equipment? See page 280 of the textbook for answers.

Chapter 6

Firefighter Personal Protective Equipment



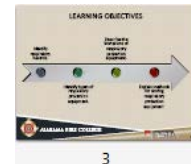
Lesson Goal

After completing this lesson, the student shall be able to properly use and care for personal protective equipment (PPE) as well as describe how it can protect firefighters. Students will understand how the limitations of PPE impact the need to select equipment appropriate for the incident in order to take advantage of this protection.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Describe the purpose of personal protective equipment. *[NFPA[®] 1001, 5.1.1, 5.3.3]*
2. Describe characteristics of each type of personal protective equipment. *[NFPA[®] 1001, 5.3.2]*
3. Summarize guidelines for the care of personal protective clothing. *[NFPA[®] 1001, 5.1.1, 5.3.3, 5.5.1]*
4. Explain safety considerations for personal protective equipment. *[NFPA[®] 1001, 5.3.1]*
5. Identify respiratory hazards. *[NFPA[®] 1001, 5.3.1]*
6. Identify types of respiratory protection equipment. *[NFPA[®] 1001, 5.3.1]*
7. Describe the limitations of respiratory protection equipment. *[NFPA[®] 1001, 5.3.1]*
8. Explain methods for storing respiratory protection equipment. *[NFPA[®] 1001, 5.5.1]*
9. Describe general donning and doffing considerations for protective breathing apparatus. *[NFPA[®] 1001, 5.3.1, 5.3.2]*
10. Summarize general considerations for protective breathing apparatus inspections and care. *[NFPA[®] 1001 5.1.1, 5.5.1]*
11. Summarize safety precautions for refilling SCBA cylinders. *[NFPA[®] 5.5.1]*
12. Explain procedures for replacing SCBA cylinders. *[NFPA[®] 1001 5.3.1]*
13. Explain safety precautions for SCBA use. *[NFPA[®] 1001 5.3.1]*
14. Describe nonemergency and emergency exit indicators. *[NFPA[®] 5.3.1]*
15. Describe nonemergency exit techniques. *[NFPA[®] 1001 5.3.1]*
16. Demonstrate the method for donning structural personal protective clothing for use at an emergency. *[NFPA[®] 1001, 5.1.2, 5.3.1, 5.3.2, 5.3.3]*



17. With structural personal protective clothing in place, demonstrate the over-the-head method of donning an SCBA. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
18. With structural personal protective clothing in place, demonstrate the coat method of donning an SCBA. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
19. With structural personal protective clothing in place, demonstrate the method for donning an SCBA while seated. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
20. Doff personal protective equipment, including respiratory protection, and prepare for reuse. *[NFPA[®] 1001 5.1.2, 5.3.2, 5.3.3]*
21. Demonstrate the steps for inspecting an SCBA. *[NFPA[®] 1001 5.3.2, 5.5.1]*
22. Demonstrate the steps for cleaning and sanitizing an SCBA. *[NFPA[®] 1001 5.3.2, 5.5.1]*
23. Demonstrate the method for filling an SCBA cylinder from a cascade system, wearing appropriate PPE, including eye and ear protection. *[NFPA[®] 1001 5.3.1]*
24. Demonstrate the method for filling an SCBA cylinder from a compressor/purifier system wearing appropriate PPE, including eye and ear protection. *[NFPA[®] 1001 5.3.1]*
25. Demonstrate the one-person method for replacing an SCBA cylinder. *[NFPA[®] 1001 5.3.1]*
26. Demonstrate the two-person method for replacing an SCBA cylinder. *[NFPA[®] 1001 5.3.1]*

Instructor Information

This is the lesson covering personal protective equipment. This lesson describes basic information about the various types of equipment and how it can protect firefighters. The lesson also covers PPE limitations, selection of PPE based on proposed use, as well as care and maintenance.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

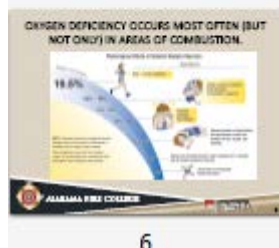
I. RESPIRATORY PROTECTION

pp. 281-287

Objective 5 — Identify respiratory hazards.

A. Respiratory Protection

1. Wearing appropriate protection is most effective way to protect health
2. Operations that require protection
 - a. Structural and wildland fires – Produce smoke and other products of combustion
 - b. Medical responses – May expose you to airborne pathogens
 - c. Confined space search, rescue, and recovery – May take place in toxic or low oxygen atmospheres
 - d. Repair work that generates fine particulates – Such as dust, paint, or metal shavings
3. Always wear equipment appropriate for type of hazard – Use equipment properly



B. Respiratory Hazards

1. Found in situations that produce immediate, irreversible, debilitating effects on health, may result in death
 - a. Defined by NFPA[®] 1500 and OSHA as immediately dangerous to life and health (IDLH)
 - b. Must don correct level of protective clothing and respiratory protection before entering IDLH area
2. Oxygen deficiency
 - a. Oxygen levels
 - i. Less than 19.5 percent defined by NFPA[®] and OSHA as oxygen-deficient
 - ii. Below 18 percent causes human body to increase respiratory rate
 - iii. Hypoxia caused by less oxygen reaching body tissues
 - b. Most commonly caused by combustion
 - i. Consumes oxygen

- ii. Produces toxic gases – Physically displace oxygen or dilute concentration
- c. Can occur in confined spaces – Sewers, chemical storage tanks, grain bins, or underground caverns
- d. Also found in rooms, compartments where carbon dioxide total-flooding extinguishing systems discharged

3. Elevated temperatures

- a. Superheated air can damage respiratory tract – Worse when air is moist
- b. Excessive heat inhaled quickly can cause serious decrease in blood pressure, failure of circulatory system
- c. Inhaling can cause pulmonary edema which can lead to death from asphyxiation
- d. Damage is not immediately reversible – Prompt treatment required



4. Particulate contaminants

- a. Small particles may be suspended in air
- b. Sources – Vehicle exhaust emissions, chemical reactions, heated metals or metal compounds, and combustion
- c. Exposure causes asthma, lung cancer, cardiovascular disease, and premature death
- d. Encountered during
 - i. Wildland fires
 - ii. Welding and metal cutting operations
 - iii. Operation of fire apparatus and small engines
 - iv. Operations following explosion or building collapse
 - v. Structural fires
- e. Protection provided by air-purifying respirators and powered air-purifying respirators
 - i. Cartridge type have half or full facepiece units with replaceable filter elements that capture particulates

- ii. Approved for wildland fire fighting but do not protect against toxic gases, or in heated or oxygen deficient atmospheres

5. Gases and vapors

- a. Gases exist at standard temperature and pressure
- b. Vapors result from temperature or pressure changes that affect solid or liquid
- c. Both may be inhaled, ingested, or absorbed into body – Resulting in illnesses and death
- d. Exposure may cause – Cancer, cardiovascular disease, thyroid damage, respiratory problems, and eye irritation
- e. Fire gases and vapors created by combustion
 - i. Carbon monoxide
 - ii. Carbon dioxide
 - iii. Hydrogen cyanide
 - iv. Hydrogen chloride
 - v. Hydrogen sulfide
 - vi. Nitrous gases
 - vii. Phosgene
 - viii. Sulfur dioxide
 - ix. Ammonia
 - x. Formaldehyde
- f. Carbon monoxide (CO) and hydrogen cyanide (HCN) responsible for majority of fire-related fatalities
- g. Carbon monoxide
 - i. Colorless, odorless gas present in every fire, and released when organic material burns
 - ii. CO poisoning – Sometimes lethal condition when CO molecules attach to hemoglobin, and decreasing blood's ability to carry oxygen
- h. Hydrogen cyanide
 - i. Produced by incomplete combustion of nitrogen and carbon containing substances
 - ii. Released during off-gassing as object heated
 - iii. Can be inhaled, ingested, and absorbed in to body – Targets heart and brain



i. Nonfire gases and vapors

- i. Can be produced during incidents involving – Industrial, commercial, or warehouse occupancies, spills resulting from transportation accidents, leaks from storage containers or pipelines
- ii. Always remain at safe distance until risk analysis completed – SCBAs must be worn until atmosphere determined safe
- iii. Also possible at transportation incidents; in storage and manufacturing facilities
- iv. Common types produced – Carbon dioxide, ammonia, sulfur dioxide, chlorine, and pesticides
- v. May also be found in sewers, storm drains, caves, trenches, storage tanks, tank cars, bins, and other confined spaces – Search, rescue, and recovery in these areas require SCBAs and SARs



6. Airborne pathogens

- a. Disease-causing microorganisms suspended in air
- b. Encountered when assisting during medical responses, vehicle extrications, rescue and recovery operations, and terrorist attacks
- c. Cause infection after being inhaled or directly contacted
- d. Can result in – Meningitis, influenza, methicillin-resistant *Staphylococcus aureus* (MRSA), pneumonia, tuberculosis (TB), severe acute respiratory syndrome (SARS), measles, chickenpox, and smallpox
- e. Protection provided by high-efficiency particulate air (HEPA) filters, APR/PAPRs, and SCBA/SAR
 - i. HEPA – Single use masks are certified by NIOSH; designated N95, N99, and N100
 - ii. Designations indicate percentage of particles that the masks remove
- f. Surgical masks not approved – May be used on patients to prevent spread of disease by exhaling, sneezing, and coughing

Review Question: What common respiratory hazards do firefighters face?

See page 281 of the textbook for answers.

pp. 287-295

Objective 6 — Identify types of respiratory protection equipment.**A. Types of Respiratory Protection Equipment**

1. Two main categories
 - a. Atmosphere-supplying respirators – Provide breathable air when working in oxygen deficient, toxic, or gas-filled atmospheres
 - b. Air-purifying respirators – Only filter particulates out of ambient air
2. ASR is primary type used in fire service

B. Atmosphere-Supplying Respirators (ASRs)

1. Consist of either SCBA or supplied air respirators (SARs)
 - a. SCBA carry air in cylinder
 - b. SARs connected to breathing-air compressor or portable air supply
2. SARs used when firefighter must be in hazardous area for long period of time and there is no danger that fire may damage hose
 - a. Hazardous materials incidents, confined space rescues, and other technical rescue incidents
 - b. Not used for fire fighting; only used by personnel certified in technical rescue functions
3. Closed-circuit SCBAs – Use compressed oxygen
 - a. Exhaled air stays in system; is reused
 - b. Less common, mainly used in shipboard operations, extended hazardous materials incidents, and some rescue operations
4. Open-circuit SCBAs – Use compressed air
 - a. Exhaled air vented to outside atmosphere
 - b. Backplate and harness assembly
 - i. Rigid frame with adjustable straps holds breathing air cylinder on backplate
 - ii. Straps designed to stabilize unit, carry part of weight, provide secure and comfortable fit



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c. Air cylinder assembly

- i. Cylinder contains breathing air under pressure
- ii. May be constructed of steel, aluminum, aluminum wrapped in fiberglass, or KevlarTM/carbon composite
- iii. Weight depends on size and construction materials – Significantly increases physical stress during operations
- iv. Control valve – threaded stem and/or quick connect fitting – and pressure gauge attached to one end; opened fully when in use
- v. High pressure hose attaches to stem, and connects cylinder to regulator assembly
- vi. Pressure gauge displays estimate of amount of air in cylinder in pounds per square inch (psi)

d. Regulator assembly

- i. Reduces high pressure of cylinder air to slightly above atmospheric pressure; controls air flow to wearer
- ii. Wearer inhales, creating pressure differential; diaphragm moves inward, low-pressure air flows into facepiece
- iii. Exhalation moves diaphragm back to closed position
- iv. Located on facepiece, shoulder harness, or waist belt harness
- v. Control valves – Mainline and bypass
- vi. With both valves equipped – Mainline valve locked open during normal operations; bypass closed
- vii. Once set in normal operating position valves should not be changed unless emergency bypass function needed

e. Facepiece assembly – Provides fresh breathing air while protecting eyes and face from injury

- i. Must fit tightly to face
- ii. Facepiece frame and lens — Made of clear safety plastic and mounted in flexible rubber facepiece frame; NFPA[®] 1981 requires all new SCBA facepieces be equipped with heads-up display (HUD)

- iii. Head harness and straps — Holds facepiece snugly against face with adjustable straps, net, or other arrangement
- iv. Exhalation valve — One-way valve that releases exhaled air without admitting any of contaminated outside atmosphere
- v. Nose cup — Deflects exhalations away from lens, reducing fogging or condensation
- vi. Speaking diaphragm — Mechanical diaphragm permits limited communication by wearer; may be replaced by an electronic speaking diaphragm connected to portable radio
- vii. Regulator fitting or hose connection — Permits regulator or hose to attach to facepiece frame

f. Fit testing

- i. Required to ensure perfect seal
- ii. Must use same make, model, style, and size of facepiece worn during operations
- iii. OSHA accepts two types of tests – Qualitative or quantitative

g. Other regulations

- i. NFPA[®] 1500 – Prohibits beards or facial hair that prevent complete seal
- ii. Wearing eyeglasses prohibited if side frames pass through seal area – Kits provided with all full facepiece masks
- iii. Soft contact lenses allowed by NFPA[®] 1500 and Code of Federal Regulations if previous long-term use (6 months) is successful

h. Additional components

- i. Remote pressure gauge displays pressure within cylinder – Must be mounted in visible position
- ii. Pressure readings most accurate at or near upper range of gauge – Always assume lowest reading is correct
- iii. End-of-service-time indicators (ESTI) – Warns user when system is reaching end of air-supply; typically 20-25% of cylinder capacity
- iv. ESTI has both audible alarm and flashing light or physical vibration – Cannot be turned off until air-cylinder valve closed and system bled of pressure



- v. New SCBA equipped with rapid intervention crew universal air coupling (RIC UAC) – Located within 4 inches (101 mm) of outlet
- vi. RIC UAC allows cylinder to be transfilled from another cylinder – Air supply equalizes between two cylinders when connected

C. Air-Purifying Respirators (APRs)

1. Removes contaminants by passing ambient air through filter, canister, and cartridge
2. May have full facepieces that provide complete seal to face, protect eyes, nose, and mouth; half facepieces provide complete seal to lower part of face, protect nose, and mouth
3. Particulate filters
 - a. Single use items that protect respiratory system from large airborne particulates
 - b. May be used with half or full facepiece masks, mounted on one or both sides of facepiece – Eye protection required when used with half facepiece
 - c. Regulated by *Code of Federal Regulations*, divided into nine classes
 - i. Three levels of filtration – 95, 99, 99.97 percent
 - ii. Three categories of filter degradation – N: not resistant to oil, R: resistant to oil, P: Used when oil or non-oil lubricants present
 - d. Used primarily at emergency medical incidents; appropriate for investigations or inspections involving body recovery, when excrement is present, agricultural and industrial accidents, when working with particulate-producing tools
4. Limitations
 - a. Limited life of filters, canisters, and cartridges
 - b. Need for constant monitoring of contaminated atmosphere
 - c. Need for normal oxygen content of atmosphere before use
5. Usage should be restricted to hazards for which APR is certified



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6. Should be inspected regularly, and cleaned following each use
7. Filters, canisters, and cartridges should be discarded following use; when have passed end of service life date
8. Have visual ESTIs only – Show when air cleanser is totally saturated, and no longer providing breathable air
9. Check indicators visually before entering contaminated atmospheres; periodically while wearing – If reaching saturation level, exit area, replace canister or cartridge
10. Clues or symptoms of losing effectiveness
 - a. Time – Estimate amount of time work will take, compare to manufacturer's estimated life expectancy; when time approaches exit area
 - b. Taste and smell – No longer protected if you can smell or taste contaminate
 - c. Resistance-to-breathing-indicators – When breathing is labored, and filter has reached saturation level

Review Question: How do atmosphere-supplying respirators differ from air-purifying respirators?
See page 287 of the textbook for answers.

pp. 295-296

Objective 7 — Describe the limitations of respiratory protection equipment.

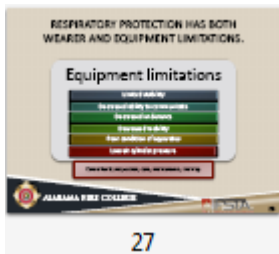
Objective 8 — Explain methods for storing respiratory protection equipment.

A. Respiratory Protection Limitations

1. Wearer limitations

- a. Lack of physical condition — If not in good physical condition or if overweight, you may deplete your air supply rapidly
- b. Lack of agility — If not sufficiently agile to begin with, weight and restriction of equipment will make you even less so, making it difficult to accomplish your assigned tasks





- c. Inadequate pulmonary capacity – Must have sufficient lung capacity to inhale and exhale sufficient air while wearing respiratory protection equipment
- d. Weakened cardiovascular ability – Must have strong enough heart to prevent heart attacks, strokes, or other related problems while performing strenuous activity
- e. Psychological limitations – Must be able to overcome stress, fear, and feelings of claustrophobia while wearing respiratory protection equipment
- f. Unique facial features – Shape and contour of face can affect ability to get a complete facepiece-to-face seal; weight loss or gain can alter seal
- g. Can be offset through constant training, periodic medical evaluations, and proper fit testing of facepieces

2. Equipment limitations

- a. Limited visibility – Full facepiece can reduce peripheral vision, and facepiece fogging can reduce overall vision
- b. Decreased ability to communicate – Facepiece can seriously hinder voice communication unless it has built-in voice amplification or a microphone connection
- c. Decreased endurance – Weight of SCBA units, averaging between 25 and 35 pounds (11 kg and 16 kg), makes you tire more quickly
- d. Decreased mobility – Increase in weight and restrictions caused by the harness straps can reduce mobility
- e. Poor condition of apparatus – Minor leaks and poor valve and regulator adjustments can result in excess air loss



Instructor Note: Discuss with students the Safety box "NFPA® Safety Alert Issued for SCBA Facepiece Lenses" on p. 335 of the textbook.

Emphasize the information in the NFPA® alert and ask students to

consider how this information should be used to increase fire operations safety. While student answers will vary, the discussion should emphasize that students need to be aware of changes in their equipment as conditions change during operations.

- f. Low air cylinder pressure – If not filled to capacity, amount of working time reduced proportionately
- g. Controlled through frequent and proper inspections, care, maintenance, and training

Review Question: What are some of the limitations of respiratory protection equipment?
See pages 295-296 of the textbook for answers.

B. Storing Respiratory Protection Equipment

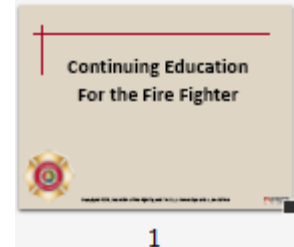
- 1. Should store so can be quickly and easily donned
- 2. Be protected from contamination, temperature changes, and ultraviolet light
- 3. May depend on size, available storage compartments on apparatus, and manufacturer's instructions
- 4. SCBA – Can be mounted in various ways; if in seat mounts should be arranged to allow donning without removing seatbelt

Review Question: What should respiratory equipment be protected from during storage?
See page 296 of the textbook for answers.



Chapter 6

Firefighter Personal Protective Equipment



Lesson Goal

After completing this lesson, the student shall be able to properly use and care for personal protective equipment (PPE) as well as describe how it can protect firefighters. Students will understand how the limitations of PPE impact the need to select equipment appropriate for the incident in order to take advantage of this protection.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Describe the purpose of personal protective equipment. *[NFPA® 1001, 5.1.1, 5.3.3]*
2. Describe characteristics of each type of personal protective equipment. *[NFPA® 1001, 5.3.2]*
3. Summarize guidelines for the care of personal protective clothing. *[NFPA® 1001, 5.1.1, 5.3.3, 5.5.1]*
4. Explain safety considerations for personal protective equipment. *[NFPA® 1001, 5.3.1]*
5. Identify respiratory hazards. *[NFPA® 1001, 5.3.1]*
6. Identify types of respiratory protection equipment. *[NFPA® 1001, 5.3.1]*
7. Describe the limitations of respiratory protection equipment. *[NFPA® 1001, 5.3.1]*
8. Explain methods for storing respiratory protection equipment. *[NFPA® 1001, 5.5.1]*
9. Describe general donning and doffing considerations for protective breathing apparatus. *[NFPA® 1001, 5.3.1, 5.3.2]*
10. Summarize general considerations for protective breathing apparatus inspections and care. *[NFPA® 1001 5.1.1, 5.5.1]*
11. Summarize safety precautions for refilling SCBA cylinders. *[NFPA® 5.5.1]*
12. Explain procedures for replacing SCBA cylinders. *[NFPA® 1001 5.3.1]*
13. Explain safety precautions for SCBA use. *[NFPA® 1001 5.3.1]*
14. Describe nonemergency and emergency exit indicators. *[NFPA® 5.3.1]*
15. Describe nonemergency exit techniques. *[NFPA® 1001 5.3.1]*
16. Demonstrate the method for donning structural personal protective clothing for use at an emergency. *[NFPA® 1001, 5.1.2, 5.3.1, 5.3.2, 5.3.3]*



17. With structural personal protective clothing in place, demonstrate the over-the-head method of donning an SCBA. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
18. With structural personal protective clothing in place, demonstrate the coat method of donning an SCBA. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
19. With structural personal protective clothing in place, demonstrate the method for donning an SCBA while seated. *[NFPA[®] 1001 5.3.1, 5.3.2, 5.3.3]*
20. Doff personal protective equipment, including respiratory protection, and prepare for reuse. *[NFPA[®] 1001 5.1.2, 5.3.2, 5.3.3]*
21. Demonstrate the steps for inspecting an SCBA. *[NFPA[®] 1001 5.3.2, 5.5.1]*
22. Demonstrate the steps for cleaning and sanitizing an SCBA. *[NFPA[®] 1001 5.3.2, 5.5.1]*
23. Demonstrate the method for filling an SCBA cylinder from a cascade system, wearing appropriate PPE, including eye and ear protection. *[NFPA[®] 1001 5.3.1]*
24. Demonstrate the method for filling an SCBA cylinder from a compressor/purifier system wearing appropriate PPE, including eye and ear protection. *[NFPA[®] 1001 5.3.1]*
25. Demonstrate the one-person method for replacing an SCBA cylinder. *[NFPA[®] 1001 5.3.1]*
26. Demonstrate the two-person method for replacing an SCBA cylinder. *[NFPA[®] 1001 5.3.1]*

Instructor Information

This is the lesson covering personal protective equipment. This lesson describes basic information about the various types of equipment and how it can protect firefighters. The lesson also covers PPE limitations, selection of PPE based on proposed use, as well as care and maintenance.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

I. DONNING AND DOFFING PROTECTIVE BREATHING APPARATUS

pp. 297-302

Objective 9 — Describe general donning and doffing considerations for protective breathing apparatus.

A. General Donning Considerations

1. Checks should be performed at beginning of shifts
– If unable to perform daily checks, should perform prior to donning
2. Check air cylinder gauge to make sure full – NFPA[®] 1852 recommends no less than 90 percent of cylinder capacity
3. Check remote gauge and cylinder gauge to ensure they read within manufacturer's recommended limits
4. Check harness assembly and facepiece to ensure all straps are fully extended
5. Operate all valves to ensure they function properly and are left in correct position
6. Test low-pressure alarm
7. Test PASS device to ensure it is working
8. Check all battery-powered functions



B. Donning an Unmounted SCBA

1. SCBA stored in cases can be donned using over-the-coat or coat method
2. SCBA must be positioned on ground in front of firefighter with all straps extended



C. Donning from a Seat Mount

1. Should only be used if firefighter can don without removing apparatus seat belt
2. NFPA[®] 1901 requires SCBA be held in place by mechanical latching device
3. Facepiece should be stored in drawstring, quick-opening bag, or pouch in protective coat

Caution: Never connect the regulator and breathe cylinder air when seated in the apparatus. This activity will deplete your air supply before you arrive at the incident.



4. Air cylinder's position in seat back should match proper wearing position for firefighter
5. Exit apparatus carefully – Extra weight of SCBA makes slips, falls more likely

D. Donning From a Side or Rear External Mount

1. Does not permit donning en route, requires more time for donning, and reduces chances of slips and falls
2. Faster than donning SCBA stored in carrying case
3. Potential disadvantage – SCBA exposed to weather, physical hazards; can be minimized with waterproof covers
4. When mounted at correct height, can be donned with little effort
5. Running boards or tailboards near mount allows donning while sitting
6. Donning steps similar to seat-mounted SCBA

E. Donning From a Backup Mount

1. When located inside compartment protected from weather; provide same advantages as side- or rear-mounted
2. Compartment doors may interfere with donning – Others may be located too high on apparatus
3. Provides quick access to SCBA
4. Donning procedure similar to seat-mounted method

F. Donning the Facepiece

1. Differences
 - a. Some use rubber harness, others mesh skullcap – Both have adjustable straps





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- b. Location of regulator – May attach to facepiece or mount on waist belt or shoulder harness; shape and size of lenses may differ

2. General considerations

- a. All straps fully extended
- b. No hair between skin and facepiece sealing surface
- c. Chin should be centered in chin cup and harness centered at rear of head
- d. Facepiece straps should be tightened by pulling opposing straps evenly and simultaneously to rear
 - i. Pulling straps outward, to sides, may damage and prevent proper engagement with adjusting buckles
 - ii. Tighten lower straps first, then temple straps, and finally top strap
- e. Always check that facepiece is completely sealed to face, exhalation valve is functioning, and all connections are secure – Check that donning mode switch is in proper position if present
- f. Protective hood must be worn over facepiece harness or straps
 - i. All exposed skin must be covered and vision must not be obscured
 - ii. No portion of hood should be located between facepiece and face
- g. Helmet should be worn with chin strap secured – If equipped with a ratchet adjustment should be adjusted so helmet fits properly



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G. Doffing Protective Breathing Apparatus

1. Make sure you are out of the contaminated area and SCBA is no longer required
2. Discontinue flow of air from regulator to facepiece
3. Disconnect regulator from facepiece
4. Remove protective hood, or pull down around neck
5. Remove facepiece by loosening straps and lifting from chin



6. Remove backpack assembly while protecting regulator
7. Close cylinder valve
8. Relieve pressure from regulator according to manufacturer's instructions
9. Turn off PASS device
10. Extend all facepiece and harness straps
11. Check air pressure to determine if air cylinder needs refilled or replaced
12. Clean and disinfect facepiece
13. Clean SCBA backplate and harness if necessary
14. Secure complete unit in case, seat bracket, or storage bracket

Review Question: What general considerations need to be taken when donning and doffing protective breathing apparatus? See pages 297-302 of the textbook for answers.

II. INSPECTION AND MAINTENANCE OF PROTECTIVE BREATHING APPARATUS

pp. 303-307

Objective 10 — Summarize general considerations for protective breathing apparatus inspections and care.



A. Inspection and Maintenance of Protective Breathing Apparatus

1. Inspection frequency established by NFPA[®] 1852
2. Schedule determined by department – Based on NFPA[®], OSHA, manufacturer's requirements
3. Typically performed daily, weekly, or whenever reporting for duty
4. Period between inspections must not exceed one week
5. Qualified SCBA technicians must inspect units annually, and after any repairs

B. Protective Breathing Apparatus Inspections and Care

1. Must clean, inspect after each use, at beginning of every duty shift, and every week
2. Report repairs needed immediately – May require unit be taken out of service
3. Care – Daily/weekly inspection

a. Facepiece

- i. Inspect frame for deterioration, dirt, cracks, tears, and holes
- ii. Inspect head-harness buckles, straps, and webbing for wear, breaks, or loss of elasticity
- iii. Inspect lens for scratches, abrasions, holes, cracks, or heat damage
- iv. Inspect heads-up display for proper operation
- v. Inspect lens for proper seal with facepiece frame
- vi. Inspect valve seat of exhalation valve
- vii. Inspect springs and covers to ensure cleanliness and ease of operation
- viii. Inspect regulator and hose connection points for cleanliness, damage, and proper operation
- ix. Inspect speaking diaphragm for cleanliness and damage

b. Backplate and harness assembly

- i. Inspect harness straps and backplate for abrasions, cuts, tears, or heat or chemical-induced damage
- ii. Ensure all buckles, fasteners, and adjustments operate properly
- iii. Ensure harness straps are fully extended
- iv. Inspect cylinder retention system for proper operation and damage
- v. Ensure cylinder is securely attached to backplate

c. Breathing air cylinder assembly

- i. Ensure cylinder hydrostatic test date is current
- ii. Inspect cylinder gauge for cleanliness and damage
- iii. Inspect cylinder body for cracks, dents, weakened areas, and heat or chemical-induced damage
- iv. Inspect composite cylinders for cuts, gouges, loose fibers, and missing resin material





- v. Inspect cylinder valve outlet sealing surface and threads for damage
- vi. Check valve hand wheel for damage, proper alignment, serviceability, and secure attachment
- vii. Check burst disc outlet area for debris
- viii. Check cylinder to ensure that it is full

d. Hoses

- i. Inspect high and low pressure hoses for abrasions, bubbling, cuts, cracks, and heat and chemical-induced damage
- ii. Inspect hose fittings for cleanliness and damage
- iii. Visually check high pressure hose to cylinder "O" ring
- iv. Test hose connections for tightness

e. Low-pressure alarm

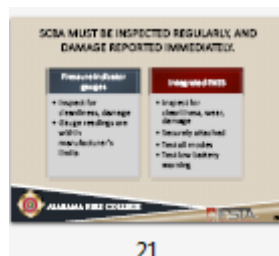
- i. Inspect low-pressure alarm and mounting hardware for cleanliness, proper attachment, and damage
- ii. Test alarm for proper activation and operation

f. Regulator

- i. Inspect regulator controls and pressure relief devices for cleanliness, proper operation, and damage
- ii. Inspect housing and components for cleanliness and damage
- iii. Check regulator for any unusual sounds during operation, such as whistling, chattering, clicking, or rattling
- iv. Check mainline and bypass valve for proper function

g. Pressure indicator gauges

- i. Inspect remote pressure indicator gauge for cleanliness and damage
- ii. Ensure pressure readings on cylinder pressure gauge and remote gauge are within manufacturer's recommended limits



h. Integrated PASS

- i. Inspect PASS device for cleanliness, wear, and damage

- ii. Ensure all parts are securely attached to PASS device
- iii. Test all operating modes for proper operation
- iv. Test low battery warning signal for proper operation

4. Care

- a. Clean and sanitize after each use – Prevents debris from collecting in exhalation valve and regulator fitting

- b. Dirt and debris can cause malfunctions

- i. Exhalation valve can malfunction allowing air from tank to escape
- ii. Can prevent regulator from fitting securely to facepiece
- iii. Soot on facepiece can reduce visibility

- c. Wash facepiece thoroughly with warm water containing mild commercial disinfectant – Rinse with clear, warm water

- d. Dry facepiece with lint-free cloth or air dry – Do not dry with paper towels

- e. Do not submerge regulators and low-pressure hoses

- f. Sanitize facepiece seal, interior of facepiece

- g. May prevent fogging through use of antifogging chemicals applied following cleaning

- h. Individual facepieces should be cleaned after each use – Prevents hydrocarbons from contaminating skin

- i. When clean, dry store in case, bag, coat pocket – Straps should be fully extended



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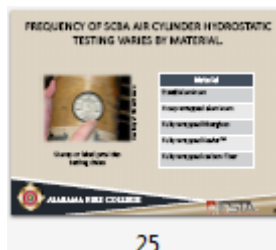
Review Question: What are the general inspection and care considerations for protective breathing apparatus?
See pages 303-307 of the textbook for answers.



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C. Annual Inspection and Maintenance

1. Must be performed by specially trained, factory qualified technicians
2. Technicians may be members of department or employees of certified maintenance contractor



D. SCBA Air Cylinder Hydrostatic Testing

1. Must be stamped or labeled with date or manufacture and date of last hydrostatic test
2. Type of material used to construct cylinder determines frequency of hydrostatic testing
 - a. Steel and aluminum cylinders tested every five years, have indefinite service life until fail hydrostatic test
 - b. Hoop-wrapped aluminum cylinders tested every three years, have 15-year service life
 - c. Fully wrapped fiberglass cylinders tested every three years, have 15-year service life
 - d. Fully wrapped Kevlar™ cylinders tested every three years, have 15-year service life
 - e. Fully wrapped carbon fiber cylinders tested every five years, have 15-year service life

pp. 307-311

Objective 11 — Summarize safety precautions for refilling SCBA cylinders.

Objective 12 — Explain procedures for replacing SCBA cylinders.

E. Refilling SCBA Cylinders

1. Three sources used to refill
 - a. Stationary fill systems
 - b. Mobile fill systems
 - c. Firefighter Breathing Air Replenishment Systems (FBARS)
2. Each source must provide Type 1 Grade D quality air
3. Safety precautions
 - a. Check hydrostatic test date of cylinder
 - b. Visually inspect cylinder for damage
 - c. Don eye and hearing protection
 - d. Place cylinder in a shielded fill station
 - e. Fill cylinder slowly to prevent it from overheating





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- f. Ensure that cylinder is completely full but not over pressurized
4. Filling unshielded cylinders while firefighter is wearing cylinders is prohibited
5. Rapid intervention crew or team (RIC/RIT) rescuing trapped or incapacitated firefighter may be granted exception – Three criteria must be met
 - a. NIOSH-approved RIC Universal Air Connection (UAC) fill options are used
 - b. Risk assessment has been conducted to limit safety hazards and ensure necessary equipment is fully operational
 - c. There is an imminent threat to safety of downed firefighter, and immediate action is required to prevent loss of life or serious injury
6. Stationary fill stations
 - a. Filled from either cascade system or directly from compressor air purification system
 - i. Must be connected to fill station that holds SCBA cylinders in rupture-proof sleeves during filling process
 - ii. Filling may be performed by trained members of department or contractors
 - iii. Filling procedures should be posted on fill station; follow station manufacturer's recommendations to avoid excessive overheating
 - b. Safety precautions
 - i. Only trained personnel should operate fill equipment
 - ii. Cylinders must be inspected before filling
 - iii. Hearing and eye protection must be worn during fill operations
 - iv. Cylinders must be placed in shielded fill station
 - v. Cylinders must be filled slowly to prevent overheating
 - vi. Cylinders must be filled to capacity
 - vii. Cylinders must not be overfilled
 - c. Breathing air quality must be tested regularly by third-party testing facility, results documented



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7. Mobile fill systems
 - a. Designed to refill at emergency incidents
 - b. Consist of fill station equipped with breathing-air compressor or cascade fill station; mounted on trailer or apparatus chassis
 - c. Operation similar to station system
 - d. May support SAR system or firefighting breathing air replenishment system (FBARS)
8. Firefighting breathing air replenishment system (FBARS)
 - a. Carrying replacement SCBA cylinders to top floors of highrise building is highly inefficient, cause severe strain on personnel
 - b. Provide endless source of breathing air to any floor within structure from ground level connection
 - c. Components of system
 - i. Fire department air connection panel, containing connection fittings, control valves, and gauges, located on exterior of structure
 - ii. Emergency Air Storage (EAS) system that provides breathing air if mobile system is not available to supply external connection
 - iii. Remote air fill panels, containing a certified rupture-proof containment fill station, connection and control valves, and gauges, located in protected stairwells on designated floors
 - iv. Interconnected piping certified to carry breathing air under pressure throughout system
 - v. Low air pressure monitoring switches and alarms, used to maintain minimum air pressure and warn of pressure loss or system failure

Review Question: What kinds of safety precautions should be taken when refilling SCBA cylinders?
See page 307 of the textbook for answers.



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F. Replacing SCBA Cylinders

1. Replace under specific circumstances
 - a. During daily/weekly inspection, if cylinder contains less than 90 percent of its capacity

- b. During training exercises
 - c. During long-duration emergency operations
 - d. After any emergency operations
- 2. Can be a one- or two-person task
 - 3. Empty cylinders should be kept separate from full cylinders that have been serviced, ready for use
 - 4. Damaged cylinders clearly marked and kept separate

Review Question: What methods can you use to replace an SCBA cylinder?
See page 311 of the textbook for answers.

III. USING RESPIRATORY PROTECTION EQUIPMENT

pp. 312-315

Objective 13 — Explain safety precautions for SCBA use.

Objective 14 — Describe nonemergency and emergency exit indicators.

Objective 15 — Describe nonemergency exit techniques.



A. Safety Precautions for SCBA Use

- 1. Only enter IDLH atmosphere if certified to wear and properly fit-tested for facepiece
- 2. Closely monitor how you feel while wearing – If fatigued, notify supervisor and take rest before returning to work
- 3. Remember that air supply duration can vary – Depends on
 - a. Air cylinder size and beginning pressure
 - b. Physical conditioning
 - c. Task being performed
 - d. Level of training
 - e. Operational environment
 - f. Level of stress



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4. After entering IDLH atmosphere, keep SCBA on and activated until leaving contaminated area
5. Before removing SCBA, atmosphere must be tested with properly calibrated instruments and found to be safe
6. In IDLH atmosphere, work in teams of two or more – Remain in physical, voice, or visual contact with each other while in hazardous area
7. While in IDLH atmosphere, check air supply status frequently
8. Exit IDLH atmosphere before low air alarm activates to avoid using reserve air supply

Review Question: What are the safety precautions taken when using an SCBA?

See pages 312-313 of the textbook for answers.



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B. Exit Indicators and Techniques

1. Nonemergency exit procedures – Commonly used at majority of incidents
2. Emergency exit procedures – Used in life threatening situations
3. Exit indicators – Situations or events that signal need for exit

a. Nonemergency

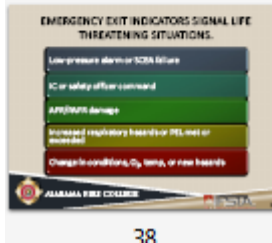
- i. Situation is stabilized
- ii. Shift in operational strategy
- iii. Necessary to replace air cylinder
- iv. Incident Commander (IC) orders a nonemergency withdrawal
- v. Assignment is completed

b. Emergency

- i. Activation of SCBA low-pressure alarm
- ii. SCBA failure
- iii. Withdrawal orders issued by IC or safety officer
- iv. Presence of APR/PAPR breakthrough symptoms



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- v. Activation of APR/PAPR end-of-service-life indicators
- vi. Change in concentration of respiratory hazards
- vii. Attaining or exceeding permissible exposure limit (PEL) for hazardous material
- viii. Changes in environmental conditions within or around site of incident
- ix. Changes in oxygen level
- x. Changes in temperature
- xi. Indications of new hazards

Review Question: What are common emergency and nonemergency exit indicators a firefighter may encounter during an incident?

See pages 313-314 of the textbook for answers.



- 4. IC responsible for constantly monitoring environment – Orders change in level of protection when potential hazard revealed
- 5. Self-monitor oxygen level
 - a. Oxygen deficiency –
 - i. Light-headedness
 - ii. Disorientation
 - iii. Loss of coordination
 - iv. Increased breathing rates
 - v. Rapid fatigue
 - b. Report symptoms by radio, evacuate area immediately
- 6. Nonemergency exit techniques
 - a. Based on Incident Command System (ICS) and NFPA® 1500
 - b. Buddy system
 - i. Work in teams of at least two in hazardous situations
 - ii. At first sign of exit indicator leave as group or in pairs
 - iii. Never leave individual in IDLH



- iv. If working in confined space – Second team member remains outside area monitoring search line ready to enter if needed
- c. Controlled breathing
 - i. Allows for efficient air use in IDLH
 - ii. Inhale naturally, forcefully exhale through mouth
 - iii. Use primarily with SCBA
 - iv. Practice in training until becomes second nature
- d. Egress paths
 - i. Use same path to exit IDLH as used to enter
 - ii. Reduces possibility of becoming lost and disoriented
 - iii. May need to follow hoselines or search lines out of area if original route blocked
 - iv. Apply situational awareness, and look for possible exit points before entering IDLH
- e. Accountability systems
 - i. Required by NFPA® 1500
 - ii. Check in with accountability officer before entering IDLH – Check out when leaving

Review Question: What are some nonemergency exit techniques firefighters can use?
See pages 314-315 of the textbook for answers.

IV. SKILLS

- | | |
|--------------------|---|
| p. 317 | Objective 16 — Demonstrate the method for donning structural personal protective clothing for use at an emergency. |
| pp. 318-319 | Objective 17 — With structural personal protective clothing in place, demonstrate the over-the-head method of donning an SCBA. |
| pp. 320-321 | Objective 18 — With structural personal protective clothing in place, demonstrate the coat method of donning an SCBA. |

pp. 322-323	Objective 19 — With structural personal protective clothing in place, demonstrate the method for donning an SCBA while seated.
pp. 324-325	Objective 20 — Doff personal protective equipment, including respiratory protection, and prepare for reuse.
p. 326	Objective 21 — Demonstrate the steps for inspecting an SCBA.
p. 327	Objective 22 — Demonstrate the steps for cleaning an SCBA.
pp. 328-329	Objective 23 — Demonstrate the method for filling an SCBA cylinder from a cascade system.
pp. 330-331	Objective 24 — Demonstrate the method for filling an SCBA cylinder from a compressor/purifier system.
pp. 332-333	Objective 25 — Demonstrate the one-person method for replacing an SCBA cylinder.
p. 334	Objective 26 — Demonstrate the two-person method for replacing an SCBA cylinder.

V. SUMMARY AND REVIEW

A. Chapter Summary

1. Your PPE will protect you from hazards and minimize the risk of injury or fatality if properly worn, cleaned, and maintained.
2. Respiratory equipment can protect you from toxic gases and vapors, particulates, and disease, but only if properly used, inspected, cleaned, and maintained.
3. Knowing how to select the type of respiratory equipment that is appropriate, as well as manage your air supply, are also important.

B. Review Questions

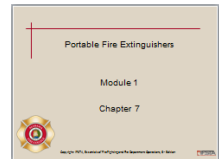
1. What is the purpose of personal protective equipment? (pp. 259-261)



2. Why are there differences in the characteristics of structural fire fighting protective clothing and wildland personal protective clothing? (pp. 261-273)
3. What are some basic guidelines for the care of personal protective clothing? (pp. 277-280)
4. What safety considerations do firefighters need to keep in mind when using personal protective equipment? (p. 280)
5. What common respiratory hazards do firefighters face? (p. 281)
6. How do atmosphere-supplying respirators differ from air-purifying respirators? (p. 287)
7. What are some of the limitations of respiratory protection equipment? (pp. 295-296)
8. What should respiratory equipment be protected from during storage? (p. 296)
9. What general considerations need to be taken when donning and doffing protective breathing apparatus? (p. 297-302)
10. What are the general inspection and care considerations for protective breathing apparatus? (pp. 303-307)
11. What kinds of safety precautions should be taken when refilling SCBA cylinders? (p. 307)
12. What methods can you use to replace an SCBA cylinder? (p. 311)
13. What are the safety precautions taken when using an SCBA? (p. 312-313)
14. What are common emergency and nonemergency exit indicators a firefighter may encounter during an incident? (pp. 313-314)
15. What are some nonemergency exit techniques firefighters can use? (pp. 314-315)

Chapter 7

Portable Fire Extinguishers



Lesson Goal

After completing this lesson, the student shall be able to select, use, and correctly maintain portable fire extinguishers.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain portable fire extinguisher classifications. *[NFPA® 1001, 5.3.16]*
2. Describe types of portable fire extinguishers. *[NFPA® 1001, 5.3.16]*
3. Define the ratings in a portable fire extinguisher rating system. *[NFPA® 1001, 5.3.16]*
4. Explain the considerations taken when selecting and using portable fire extinguishers. *[NFPA® 1001, 5.3.16]*
5. Identify procedures used for the inspection, care, and maintenance of portable fire extinguishers. *[NFPA® 1001, 5.3.16, 5.5.1]*
6. Operate a stored pressure water extinguisher. *[NFPA® 1001, 5.3.16]*
7. Operate a dry chemical (ABC) extinguisher. *[NFPA® 1001, 5.3.16]*
8. Operate a carbon dioxide (CO₂) extinguisher. *[NFPA® 1001, 5.3.16]*



Instructor Information

This is the lesson covering portable fire extinguishers. This lesson describes how these are classified, rated, and the various ways to select the correct extinguisher for a fire. The lesson also covers care and maintenance.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

I. CLASSIFICATIONS OF PORTABLE FIRE EXTINGUISHERS

pp. 340-342

Objective 1 — Explain portable fire extinguisher classifications.

A. Classifications of Portable Fire Extinguishers

1. Classified by type of fire designed to effectively extinguish
2. Five classes match classes of fire
 - a. Class A
 - b. Class B
 - c. Class C
 - d. Class D
 - e. Class K
3. Choose which to use based on the fuel that is burning



B. Class A

1. Fires involve ordinary combustibles
 - a. Textiles
 - b. Paper
 - c. Plastics
 - d. Rubber
 - e. Wood
2. Extinguished with
 - a. Water
 - b. Water-based agents (Class A foam)
 - c. Dry chemicals

C. Class B

1. Fires involve flammable, combustible liquids and gases
 - a. Alcohol
 - b. Gasoline
 - c. Lubricating oils



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d. Liquefied petroleum gas (LPG)

2. Extinguished with

- Carbon dioxide (CO₂)
- Dry chemical
- Class B foam

D. Class C

- Fires involve energized electrical equipment
- Cannot use water and water-based agents until current eliminated – These conduct electrical current
- These extinguishing agents will not conduct electricity
- Once power supply is turned off or disconnected – Fire can be treated as Class A or B

E. Class D

- Fires involve combustible metals, alloys – Can be identified by bright white emissions during combustion process
 - Lithium
 - Magnesium
 - Commonly used in wheels, transmission components in autos
 - May be in metal box springs in beds
 - Potassium
 - Sodium

Caution: The use of water or water-based agents on Class D fires will cause the fire to react violently, emit bits of molten metal, and possibly injure firefighters close by.

2. Dry powder extinguishers work best

- NOT** the same as dry chemical units used on Class A, B, C fires
- Remember dry chemical agents react violently with burning metal if applied to Class D fire



Caution: Do not use a dry chemical extinguisher on Class D fire. The dry chemical often reacts violently with burning metals.

F. Class K

1. Fires involve combustible cooking oils
 - a. Vegetable or animal fats
 - b. Oils that burn at extremely high temperatures
 - c. Found in commercial, institutional kitchens; industrial cooking facilities; private homes
2. Controlled by use of wet chemical systems, portable fire extinguishers

Review Question: How are the classifications for portable fire extinguishers divided?
See pp. 340-342 of the textbook for answers.

II. TYPES OF PORTABLE FIRE EXTINGUISHERS

pp. 342-351

Objective 2 — Describe types of portable fire extinguishers.

A. Types of Portable Fire Extinguishers

1. Extinguishing agents – Organized by
 - a. Type of agent
 - b. Method used to expel contents
2. Extinguishing agents use at least one method
 - a. Smothering – Excluding oxygen from burning process
 - b. Cooling – Reducing burning material below ignition temperature
 - c. Chain breaking – Interrupting chemical chain reaction in burning process
 - d. Saponification – Forming oxygen- excluding soapy foam surface



Instructor Note: Point out tables 7.1 and 7.2 on pp. 342-343 of the textbook. Explain how these tables may benefit students in remembering the extinguishing methods, agents and operational characteristics of portable fire extinguishers.

3. Agents that work by smothering are ineffective on materials that contain own oxidizing agent

Instructor Note: Discuss the Safety Alert Box “Privately Owned Extinguishers Can Be Dangerous” on p. 342 of the textbook. Point out why firefighters need to be aware of this important information.

NOTE: Water-type extinguishers should be protected against freezing if they are going to be exposed to temperatures lower than 40°F (4°C). Freeze protection may be provided by adding antifreeze to the water or by storing in warm areas.



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4. Use various mechanisms to expel contents

- a. Manual pump

- i. Operator physically applies pressure to pump that increases pressure within container
- ii. Forces agent out nozzle at end of hose

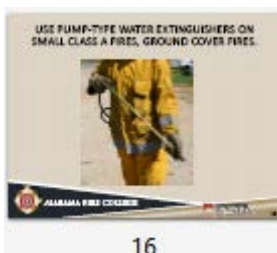
- b. Stored pressure – Compressed air or inert gas within container forces the agent out nozzle at end of hose when operator presses handle

- c. Pressure cartridge

- i. Compressed inert gas is contained in separate cartridge on side of container
- ii. When operator punctures cartridge – Expellant enters container forcing agent out nozzle on end of hose

B. Pump-Type Water Extinguishers

1. Intended primarily for use on ground cover fires – May be used for small Class A fires
2. Designed to be worn on back with manually operated trombone-style slide pump
3. Nozzle produces straight stream, fog, or water-mist pattern



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C. Stored-Pressure Water Extinguishers

1. Also called – Air-pressurized water (APW) or pressurized water
2. Useful for all types of small Class A fires
3. Often used for extinguishing confined hot spots during overhaul
4. Operation
 - a. Water stored in tank along with either compressed air or nitrogen
 - b. Gauge located on side of valve assembly shows when properly pressurized
 - c. When operating valve activated – Store pressure forces water up siphon tube, out through hose
5. Class A foam concentrate is sometimes added to increase effectiveness
 - a. Serves as wetting agent – Aids in extinguishing deep-seated fires
 - b. Enhances effectiveness by reducing surface tension of water – Allows to quickly penetrate surface



D. Wet Chemical Stored-Pressure Extinguishers

1. Similar in appearance to stored-pressure water extinguishers
2. Intended for use on Class K fires
3. Contain special potassium-based, low-pH agent
 - a. Formulated to operate on principle of saponification
 - b. Agent combines with oils to create soapy foam surface over cooking appliance
4. Some departments may carry on apparatus

E. Aqueous Film Forming Foam (AFFF) Extinguishers

1. Intended for Class B fires
2. Useful in combating fire in or suppressing vapors from small liquid fuel spills

NOTE: Some manufacturers market AFFF foam concentrates that can be used on Class A fires.

3. Different from store-pressure water extinguishers
 - a. Tank contains specified amount of AFFF concentrate mixed with water to produce foam solution
 - b. Has air-aspirating foam nozzle that aerates foam solution – Produces better-quality foam than standard extinguisher nozzle
4. Water/AFFF solution expelled using compressed air or nitrogen stored in tank with solution
 - a. Resulting foam floats on surface of fuels lighter than air
 - b. Vapor seal created by film extinguishes flame, and prevents reignition
5. To prevent disturbance
 - a. Do not apply directly onto fuel
 - b. Allow to either gently rain down onto fuel surface or deflect off nearby object, surface
6. Most effective on static pools of flammable liquids
7. Not suitable for
 - a. Class C, Class D, or Class K fuels
 - b. Fuel flowing down from elevated point
 - c. Fuel under pressure spraying from leaking flange

NOTE: AFFF is corrosive and can remove paint from tools and apparatus.



F. Clean Agent Extinguishers

1. Developed to replace halogenated extinguishing agents
 - a. Most common – Halon 1211, 1301
 - b. Were extremely effective for extinguishing fires in computer rooms, aircraft engines, areas that

contained materials easily damaged by water or dry chemical agents

- c. Have very damaging effect on ozone layer

2. Use

- a. Discharged as rapidly evaporating liquid – Leaves no residue
- b. Effectively cool, smother fires in Class A and Class B fuels
- c. Nonconductive – Can be used on energized electrical equipment (Class C) fires

Review Question: What are the differences between wet chemical stored-pressure, aqueous film forming foam (AFFF), and clean agent extinguishers?

See pp. 346-347 of the textbook for answers.

3. Operation

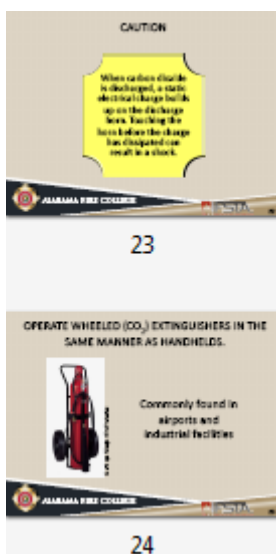
- a. CO₂ stored under own pressure as liquefied gas ready for release
- b. Discharged through plastic or rubber horn on end of either short hose, tube
- c. Discharge usually accompanied by dry ice crystals or CO₂ snow
- d. CO₂ gas displaces oxygen, and smothers fire
- e. Has little cooling effect on fires
- f. Produces no vapor-suppressing film; reignition always danger



Caution: When carbon dioxide is discharged, a static electrical charge builds up on the discharge horn. Touching the horn before the charge has dissipated can result in a shock.

4. Wheeled units similar to handheld

- a. Larger – 50 to 100 pound (23 kg to 45 kg)
- b. Most commonly used in airports, and industrial facilities
- c. Hose must be deployed or unwound from unit before use
- d. Operate the same as handheld



G. Dry Chemical Extinguishers

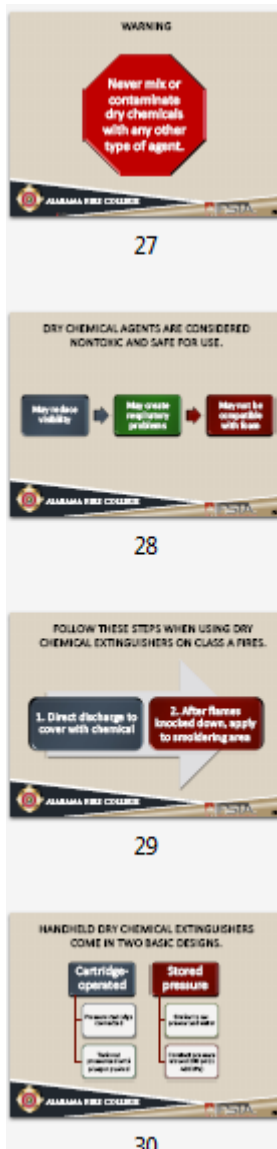


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1. For use on Class A-B-C fires and/or Class B-C fires
2. Types
 - a. Regular B:C-rated
 - b. Multipurpose, A:B:C-rated
3. Agents mixed with small amounts of additives during manufacture
 - a. Prevent from caking
 - b. Keeps agents ready for use even after long storage periods, makes free flowing
4. Never mix or contaminate with other type of agent – May chemically react, and cause dangerous rise in pressure inside extinguisher

WARNING: Never mix or contaminate dry chemicals with any other type of agent.



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5. Agents nontoxic – Generally considered safe for use
 - a. Clouds may reduce visibility, and create respiratory problems
 - b. May not be compatible with foam
6. On Class A fires
 - a. Direct discharge at whatever is burning to cover with chemical
 - b. When flames knocked down – Apply agent as needed on smoldering areas
7. May be mildly corrosive to all surfaces
8. Handheld units – Two basic designs
 - a. Cartridge-operated
 - i. Employ pressure cartridge connected to agent tank
 - ii. Tank not pressurized until plunger pushed to release gas
 - b. Stored pressure
 - i. Similar to air-pressurized water extinguisher
 - ii. Constant pressure of about 200 psi (1 400 kPa) in storage tank



Caution: When pressurizing a cartridge-type extinguisher, do not place your head or any other part of your body above the top of the extinguisher. If the fill cap was not properly screwed back on, the cap and/or a cloud of agent can be forcibly discharged.

9. Wheeled units

- a. Similar to handheld units – Larger
- b. Rated for Class A-B-C fires based on chemical in unit
- c. Operates similar to handheld, cartridge-type
 - i. Agent kept in one tank, and pressurizing gas in separate cylinder
 - ii. When in position at fire – Stretch out hose completely
 - iii. Once charged removing hose more difficult, powder can sometimes clog in bends
 - iv. Introduce pressurizing gas, allow few seconds to fully pressurize before nozzle opened
 - v. Be prepared for significant nozzle reaction when opened
 - vi. Apply agent in similar manner as handheld cartridge-type



Caution: The top of the extinguisher should be pointed away from the operator and any other nearby personnel when pressurizing the unit.

H. Dry Powder Extinguishers

1. Developed to control, and extinguish fires involving Class D combustible metals
2. No single method will control all combustible metals
3. Appropriate application techniques given in manufacturer's guide – Be familiar with information that applies to agent carried on your apparatus
4. Use
 - a. Come in both handheld and wheeled models



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- b. Must be applied in sufficient depth to completely cover burning area in order to create smothering blanket
- c. May be applied with extinguisher or scoop
- d. Should be applied gently to avoid breaking crust that may form over burning metal – If broken, fire may flare, and expose more material to combustion
- e. Avoid scattering metal – Apply over hot spots as necessary

Caution: Water applied to a combustible metal fire results in a violent reaction that intensifies the combustion and causes bits of molten material to spatter in every direction.

- f. If small amount of burning metal is on combustible surface
 - i. First cover with powder
 - ii. Layer powder (1 to 2 inches [25 mm to 50 mm] deep) spread nearby – Add more as needed
 - iii. After extinguishment – Leave material undisturbed until mass cooled completely before attempting disposal

Review Question: How do carbon dioxide (CO₂), dry chemical, and dry powder extinguishers differ?
See pp. 348-351 of the textbook for answers.

III. PORTABLE FIRE EXTINGUISHER RATING SYSTEM

pp. 351-353

Objective 3 — Define the ratings in a portable fire extinguisher rating system.

A. Portable Fire Extinguisher Rating System

1. Rated according to performance capability
2. Based on tests conducted by Underwriters Laboratories Inc. (UL) and Underwriters Laboratories of Canada (ULC)



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Instructor Note: Table 7.3 on pp. 351 of the textbook has incorrect information. Please refer to the information in the paragraph of the textbook or this teaching outline.



B. Class A Ratings

1. Rated from 1-A through 40-A
2. Primarily based on amount of extinguishing agent, duration and range of discharge
3. 1-A requires 1¼ gallons (5 L) of water; 2-A requires 2½ gallons (10 L)

C. Class B Ratings

1. Range from 1-B through 640-B
2. Based on approximate square foot (square meter) area of flammable liquid that non-expert operator can extinguish using one, full extinguisher
3. Expected to extinguish 1 square foot (0.09 m²) for each rating

D. Class C Ratings

1. No capability test specifically for Class C
2. These fires are essentially Class A or Class B with energized equipment
3. Tests conducted to test agent for electrical non-conductivity – Rating confirms agent nonconductive
4. Assigned in addition to Class A or Class B rating

E. Class D Ratings

1. Tests vary based on type of combustible metal being tested
2. Consider several factors
 - a. Reactions between metal and agent
 - b. Toxicity of agent
 - c. Toxicity of fumes produced and products of combustion
 - d. Time to allow metal to burn completely without fire suppression compared to time to extinguish fire using extinguisher
3. Application instructions included on faceplate of extinguisher – No numerical rating given
4. Cannot be used on other classes of fire

F. Class K Ratings

1. Must be capable of saponifying
 - a. Vegetable oil
 - b. Peanut oil

- c. Canola oil
- d. Other oils with little or no fatty acids
- 2. Contain alkaline mixture – Work by suppressing vapors, smothering fire
 - a. Potassium acetate
 - b. Potassium carbonate
 - c. Potassium citrate
- 3. Minimum criteria – Capable of extinguishing fire from deep fryer using light oils with surface area of 2.25 square feet (0.2 m²)

G. Multiple Markings

- 1. Identified by combinations of letters – Most common
 - a. Class A-B-C
 - b. Class A-B
 - c. Class B-C
- 2. Any not marked as multipurpose should not be used for fire other than intended
- 3. Ratings for each class are separate, and do not affect each other
- 4. Portable extinguishers identified in two ways
 - a. Geometric shapes of specific colors with class letter shown within shape
 - b. Pictographs
 - i. Recommended in NFPA[®] 10
 - ii. Shows types of fires **NOT** to use on also



Instructor Note: Table 7.4 on p. 353 of the textbook compares these two identification systems.

Review Question: How are the ratings used for portable fire extinguishers determined?

See pp. 351-353 of the textbook for answers.

IV. SELECTING AND USING PORTABLE FIRE EXTINGUISHERS

pp. 354-356

Objective 4 — Explain the considerations taken when selecting and using portable fire extinguishers.

A. Selecting the Proper Fire Extinguisher

1. Selection factors – Choose so that it
 - a. Minimizes risk to life and property
 - b. Is effective in extinguishing fire
2. Factors to consider
 - a. Classification of burning fuel
 - b. Rating of extinguisher
 - c. Hazards to be protected
 - d. Size, intensity of fire
 - e. Atmospheric conditions
 - f. Availability of trained personnel
 - g. Ease of handling extinguisher
 - h. Any life hazard or operational concerns
3. In areas where highly sensitive computer equipment is located
 - a. Do not select dry chemical – Residue could do more damage than fire
 - b. Use clean agent or CO₂

B. Using Portable Fire Extinguishers

1. Operating procedures similar – But be familiar with detailed instructions found on labels as well

Note: Wear full structural or wildland fire fighting personal protective equipment including appropriate respiratory protection when operating any portable fire extinguisher. Even small incipient fires will produce toxic gases that can injure you.



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2. After selecting correct size, and type make a quick visual inspection
 - a. Necessary to ensure extinguisher is charged, operable
 - b. May protect from injury caused by defective or depleted
3. Conditions to check
 - a. External condition – No apparent damage
 - b. Hose/nozzle – In place
 - c. Weight – Feels as though it contains agent
 - d. Pressure gauge (if available) – In operable range
4. General steps for use
 - a. Approach fire from windward side – With wind at your back
 - b. Pick up by handles – Carry to point of application
 - c. Use PASS application method
 - i. P – Pull pin breaking thin wire or plastic seal
 - ii. A – Aim nozzle at base of fire
 - iii. S – Squeeze handles together to release agent
 - iv. S – Sweep nozzle back and forth to cover burning material
 - d. Be sure agent reaches fire
 - i. Smaller extinguishers may require closer approach than larger units
 - ii. Adverse winds can limit reach of agent
 - e. Operating close to fire can scatter lightweight solid fuels or penetrate surface of liquid fuels
 - i. Apply from point where reaches but does not disturb fuel surface
 - ii. Releasing handles will stop flow of agent
5. After fire is reduced in size
 - a. If not achieved after entire extinguisher discharged – Withdraw and reassess situation



- b. If solid fuel has been reduced to smolder phase – May be overhauled using appropriate tool
- c. If liquid fuel – May be necessary to apply appropriate type of foam
- 6. Portable extinguisher is first-aid appliance – Does not take place of appropriate-sized hose
- 7. If using more than one simultaneously – Work in unison
- 8. Lay empty extinguishers on side after use – Signals to others they are empty

Review Question: When using a portable fire extinguisher, how can you determine the best way to use it?
See pp. 354-356 of the textbook for answers.

V. INSPECTION, CARE, AND MAINTENANCE OF PORTABLE FIRE EXTINGUISHERS

pp. 357-358

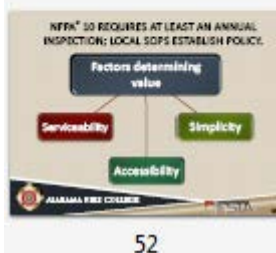
Objective 5 — Identify procedures used for the inspection, care, and maintenance of portable fire extinguishers.

A. Inspection, Care, and Maintenance of Portable Fire Extinguishers

- 1. For fire department portable fire extinguishers
 - a. Specified by department's standard operating procedures (SOPs)
 - b. Based on NFPA® 10 requirements
- 2. For extinguishers privately owned – Regulated by locally adopted codes, standards

B. Inspection

- 1. NFPA® 10 requires inspection at least once a year – Department will establish SOPs
- 2. Factors that determine value of extinguisher
 - a. Serviceability
 - b. Accessibility



- c. Simplicity of operation

3. Procedures for inspection

- a. Check to ensure that extinguisher is in proper location, and that it is accessible
- b. Inspect discharge nozzle or horn for obstructions
- c. Check hose for cracks and dirt or grease accumulations
- d. Inspect extinguisher container shell for any physical damage
- e. Check to see if operating instructions on nameplate are legible
- f. Check locking pin and tamper seal to ensure that extinguisher has not been discharged or tampered with
- g. Determine if extinguisher is full of agent and fully pressurized
 - i. Check pressure gauge, weigh extinguisher, or inspect agent level
 - ii. If found to be deficient in weight by 10 percent, should be removed from service and replaced
- h. Check inspection tag for date of previous inspection, maintenance, or recharging
- i. If any are deficient
 - i. Remove from service
 - ii. Replace with operational extinguisher
 - iii. Report need for service

4. Only trained personnel should repair or refill

C. Care

1. Guidelines

- a. Never drop or throw
- b. Depending on size and weight – Carry diagonally across body with one hand on handle, and other on bottom edge
- c. Do not remove safety pin until ready to use
- d. Store securely in its apparatus or facility mounting bracket



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- e. Lay empty on their side to indicate out of service
 - f. Do not store or stack items in front of wall-mounted extinguishers
 - g. Shake dry chemical extinguishers monthly to loosen agent to prevent from settling
2. Clean – After use or periodically
 - a. Use warm water, soap – Remove dirt, grease, and other foreign material
 - b. Avoid solvents that might damage plastic parts
 - c. Remove corrosion with steel wool or sand paper
 3. Recharge or refill – Must be performed by trained personnel

D. Maintenance

1. Should be removed from service annually
2. Includes thorough inspection, and disassembly of unit
3. Pressurized must be hydrostatically tested
 - a. Described in NFPA® 10
 - b. Required by both U.S. Department of Transportation, and Transport Canada
 - c. Test results affixed to shell
4. Empty dry chemical every six years, refill – Must be done in controlled atmosphere

Caution: Never attempt to repair the shell or cylinder of a defective fire extinguisher. Contact the manufacturer for instructions on where to have it repaired or replaced.

Review Question: What are the basic procedures for the care and maintenance of portable fire extinguishers?
See pp. 358 of the textbook for answers.

VI. SKILLS

pp. 360-361	Objective 6 — Operate a stored pressure water extinguisher.
pp. 362-363	Objective 7 — Operate a dry chemical (ABC) extinguisher.
pp. 364-365	Objective 8 — Operate a carbon dioxide (CO₂) extinguisher.

VII. SUMMARY AND REVIEW

A. Chapter Summary

1. Portable fire extinguishers can control or extinguish small incipient or early growth stage fires quickly in the hands of trained personnel; so you must be familiar with their characteristics and be able to select and use them properly.
2. Not only should you be familiar with their characteristics and be able to select and use them properly, you must also be able to educate the public.
3. Inspecting, caring for, maintaining extinguishers assigned to your apparatus and facilities are also important skills for you to have.

B. Review Questions

1. How are the classifications for portable fire extinguishers divided? (*pp. 340-342*)
2. What are the differences between wet chemical stored-pressure, aqueous film forming foam (AFFF), and clean agent extinguishers? (*pp. 346-347*)
3. How do carbon dioxide (CO₂), dry chemical, and dry powder extinguishers differ? (*pp. 348-351*)
4. How are the ratings used for portable fire extinguishers determined? (*pp. 351-353*)



5. How should you choose a portable fire extinguisher? (*p. 354*)
6. When using a portable fire extinguisher, how can you determine the best way to use it? (*pp. 354-356*)
7. What types of procedures are used to inspect portable fire extinguishers? (*p. 357*)
8. What are the basic procedures for the care and maintenance of portable fire extinguishers? (*p. 358*)

Chapter 8

Ropes, Webbing, and Knots

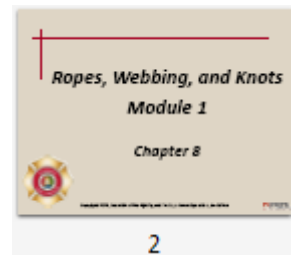
Lesson Goal

After completing this lesson, the student shall be able to appropriately select rope and webbing based on proposed use. The student shall also be able to select and tie the appropriate knot for the task presented.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Compare and contrast the characteristics of life safety rope and utility rope. *[NFPA[®] 1001, 5.3.2]*
2. Summarize basic guidelines for rope maintenance. *[NFPA[®] 1001, 5.5.1]*
3. Explain reasons for placing rope out of service. *[NFPA[®] 1001, 5.3.20]*
4. Describe webbing and webbing construction. *[NFPA[®] 1001, 5.3.20]*
5. Describe parts of a rope and considerations in tying a knot. *[NFPA[®] 1001, 5.1.2, 5.3.20]*
6. Describe knot characteristics and knot elements. *[NFPA[®] 1001, 5.1.2, 5.3.20]*
7. Describe characteristics of knots commonly used in the fire service. *[NFPA[®] 1001, 5.1.2, 5.3.20]*
8. Select commonly used rope hardware for specific applications. *[NFPA[®] 1001, 5.1.2, 5.3.20]*
9. Summarize hoisting safety considerations. *[NFPA[®] 1001, 5.1.2, 5.3.20]*
10. Inspect, clean, and store rope. *[NFPA[®] 1001 5.5.1]*
11. Tie an overhand knot. *[NFPA[®] 1001 5.3.20]*
12. Tie a bowline knot. *[NFPA[®] 1001 5.3.20]*
13. Tie a clove hitch. *[NFPA[®] 1001 5.3.20]*
14. Tie a clove hitch around an object. *[NFPA[®] 1001 5.3.20]*
15. Tie a handcuff (rescue) knot. *[NFPA[®] 1001 5.3.20]*
16. Tie a figure-eight knot. *[NFPA[®] 1001 5.3.20]*
17. Tie a figure-eight bend. *[NFPA[®] 1001 5.3.20]*
18. Tie a figure-eight on a bight. *[NFPA[®] 1001 5.3.20]*
19. Tie a figure-eight follow through. *[NFPA[®] 1001 5.3.20]*
20. Tie a Becket bend. *[NFPA[®] 1001 5.3.20]*



21. Tie a water knot. *[NFPA[®] 1001 5.3.20]*
22. Hoist an axe. *[NFPA[®] 1001 5.1.2, 5.3.20]*
23. Hoist a pike pole. *[NFPA[®] 1001 5.1.2, 5.3.20]*
24. Hoist a roof ladder. *[NFPA[®] 1001 5.1.2, 5.3.20]*
25. Hoist a dry hoseline. *[NFPA[®] 1001 5.1.2, 5.3.20]*
26. Hoist a charged hoseline. *[NFPA[®] 1001 5.1.2, 5.3.20]*
27. Hoist a power saw. *[NFPA[®] 1001 5.1.2, 5.3.20]*

Instructor Information

This is the lesson covering ropes, webbing, and knots. This lesson describes basic information for use and care of ropes and webbing. The lesson also covers rope types, selection of ropes and knots based on proposed use, as well as care and maintenance.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson lecture, discussion, and skills practice. The level of learning is application.

I. ROPE

pp. 370-376

Objective 1 — Compare and contrast the characteristics of life safety rope and utility rope.

A. Rope Types

1. Two general classifications

a. Life safety rope

- i. Used to support rescuers or victims during incidents or training
- ii. Must meet requirements of NFPA® 1983

b. Utility rope

- i. Used in any situation not involving life safety
- ii. No standard for requirements; follow manufacturers recommendations

2. Two specific classifications defined by NFPA® 1983 – Intended for rescues, similar construction to life safety rope

a. Escape rope

- i. Single-use, intended for emergency self-rescue situations
- ii. Designed to carry weight of only one person
- iii. Must be destroyed after use

b. Water rescue throw line

- i. Floating rope used during water and ice rescues
- ii. Can be tied around rescuer or thrown to victim

3. NFPA® 1983 regulations for life safety rope

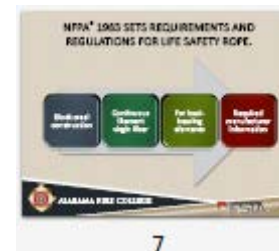
- a. State only block creel construction using continuous filament virgin fiber for load-bearing elements is suitable
- b. Require manufacturers provide information
 - i. Proper use
 - ii. Inspection and maintenance procedures



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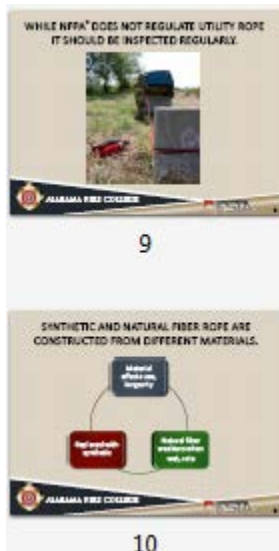
- iii. Criteria for retiring rope from service
- c. Establish criteria for re-use of life safety rope
 - i. No abrasions or visible damage
 - ii. Not been exposed to heat or direct flame
 - iii. Not been subjected to any impact load
 - iv. Not been exposed to liquids, solids, gases, mists, or vapors of any chemical or other material that can deteriorate rope
 - v. Has passed inspection conducted by qualified personnel
- d. Require rope log includes
 - i. Product label
 - ii. Manufacturer's instructions
 - iii. Purchase date
 - iv. Use, maintenance, and inspections
 - v. Impact loading incidents – Must be recorded because cannot be detected by inspections
- e. Designate options for life safety rope subjected to impact load or failed inspection
 - i. Destroyed immediately – Altered so cannot be mistaken for life safety
 - ii. May be discarded, have manufacturer's label removed, cut into smaller lengths and marked as utility

4. Utility rope considerations

- a. Uses – Hoist equipment, secure unstable objects, and cordon off area
- b. Standards addressing properties, care, and use not regulated by NFPA®
- c. Should be inspected regularly

B. Rope Materials

- 1. Two types of fibers used – Synthetic and natural
 - a. Rope material affects use and longevity
 - b. Natural fiber loses strength when wet, rots rapidly – Being replaced with synthetic



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2. Synthetic fibers

- a. Include – Polypropylene, polyester, nylon, Polysteel®, Kevlar™, and Spectra®
- b. Resistance to water, mildew, mold, rotting, shrinkage, and effects of ultraviolet (UV) light
- c. Advantages
 - i. Longer life span than natural
 - ii. Very strong yet lightweight
 - iii. Easy to maintain
- d. Disadvantage – Melt when exposed to heat

3. Natural fibers

- a. Include – Manila, sisal, and cotton
- b. Advantages
 - i. Resistant to sunlight
 - ii. Does not melt when exposed to heat
 - iii. Holds a knot firmly
- c. Disadvantages
 - i. Prone to mildew and mold
 - ii. Deteriorates when exposed to chemicals
 - iii. Burns when in contact with embers and open flame

Review Question: What are the differences in the characteristics of life safety and utility rope?
See pages 370-372 of the textbook for answers.



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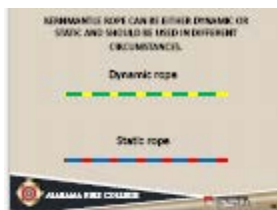
C. Rope Construction

1. Common types of construction

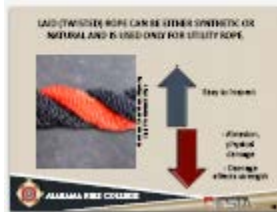
- a. Used for life safety – Kernmantle
- b. Used for utility – Laid, braided, and braid-on-braid

2. Kernmantle rope

- a. Constructed of jacketed synthetic rope, composed of braided covering or sheath



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(mantle) over core (kern) of main load-bearing strands

b. Core

- i. Runs parallel with length
- ii. Works in conjunction with covering to increase stretch resistance and load characteristics
- iii. Made of high-strength fibers

c. Sheath – Provides remainder of strength; protects core from abrasion, and contamination

d. Dynamic (high-stretch) type

- i. Used when long falls possible
- ii. Designed to stretch without breaking
- iii. NOT used for rescue or hoisting

e. Static (low-stretch) type

- i. Designed for low stretch without breaking
- ii. NFPA[®] 1983 requirement – Must not elongate more than 10 percent under load equal to 10 percent of breaking strength
- iii. Used for rescue, rappelling, hoisting, when falls not likely, only short falls possible

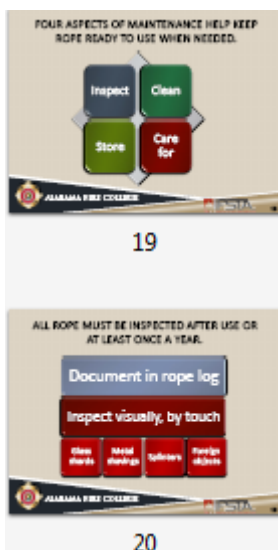
3. Laid (twisted) rope

- a. Constructed by twisting fibers together to form strands, then twisting strands together to make final
- b. Most natural fiber and synthetic ropes are this type
- c. Used exclusively as utility
- d. Disadvantages
 - i. Susceptible to abrasion, physical damage
 - ii. Damage immediately affects rope strength due to large proportion of load-bearing strand exposure
- e. Advantage – Strand exposure makes easy to inspect



4. Braided rope
 - a. Constructed by uniformly intertwining strands for rope together in diagonally overlapping pattern
 - b. Less likely to twist during use than laid rope
 - c. Load-bearing fibers still vulnerable to direct abrasion and damage
 - d. Used most commonly as utility
 - e. Most are synthetic, some use natural fiber
5. Braid-on-braid rope
 - a. Constructed of braided core enclosed in braided, herringbone-patterned sheath
 - b. Also known as double-braided rope; may be confused with kernmantle
 - c. Very strong – Half strength in sheath; other half in core
 - d. Disadvantages – Does not resist abrasion as well as kernmantle; sheath may slide along inner core
 - e. Used most often as utility

pp. 376-381

Objective 2 — Summarize basic guidelines for rope maintenance.**Objective 3 — Explain reasons for placing rope out of service.****D. Rope Maintenance**

1. Rope must be properly maintained so it is ready for use when need
2. Aspects of maintenance - Inspect, clean, store, and care for

E. Inspecting Rope

1. All types must be inspected after each use; unused rope should be inspected at least once a year
2. Inspections must be documented in rope log

3. Inspect both visually and by touch – Check for following
 - a. Imbedded shards of glass
 - b. Metal shavings
 - c. Wood splinters
 - d. Foreign objects than can damage fibers
4. Kernmantle rope



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- a. Performed by putting slight tension on rope while feeling for lumps, depressions, and soft spots
- b. Soft spots – May or may not be signs of damage to core
 - i. Inspect outer sheath if found
 - ii. If sheath is damaged, core is likely as well
- c. If any doubt remove from service, downgrade to utility use, or destroy
- d. Also inspect for irregularities in shape or weave, foul smells, discoloration from chemical contamination, roughness, abrasions, and fuzziness
- e. Some fuzziness is normal – If excessively fuzzy remove from service; no specific guideline, use judgment



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5. Laid rope – Synthetic
 - a. Untwist so all sides of each strand inspected
 - b. Remove all mildew, clean rope, and reinspect
 - c. Look for soft, crusty, brittle spots; excessive stretching; cuts, nicks, abrasions; chemical damage; dirt, grease; other obvious flaws



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6. Laid rope – Natural fiber
 - a. Remove from service when at end of service period as determined by manufacturer
 - b. Determine rope age from log
 - c. Inspect for signs of damage
 - i. Ruptured fibers, powdering between strands; indicate the rope has been overloaded



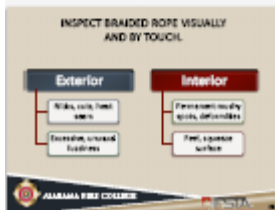
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- ii. Dark red, brown, or black spots between strands, along with sour, musty, or acidic odor; indicate rot, mildew
 - iii. Powdering between strands; indicates internal wear
 - iv. Brittle or ruptured fibers, dark red or brown spots, salt incrustation, or swollen areas; indicate chemical damage
 - v. Rust spots, occur on ropes used with pulleys or other metal devices
 - vi. Accumulations of heavy, greasy materials; may adversely affect rope strength, reduce holding power
- d. Rot will spread to new rope quickly
- i. When discovered – Remove rotten and surrounding rope from service, clean, reinspect
 - ii. Dry, ventilate storage area before putting rope back in storage

7. Braided rope

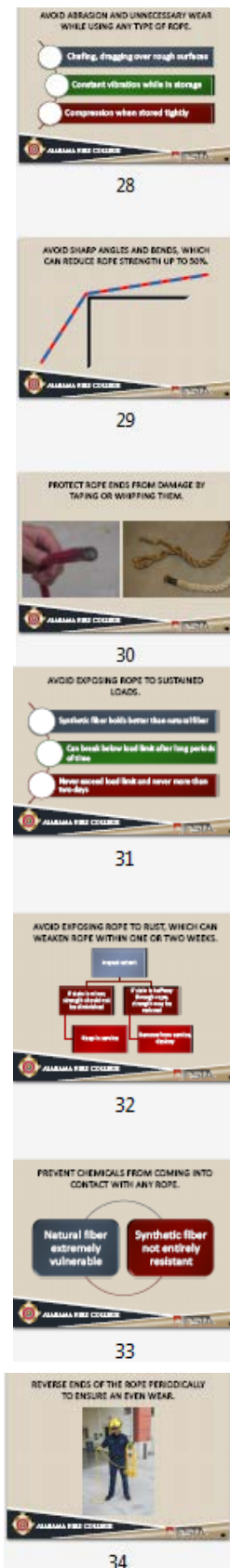
- a. Inspect visually for exterior damage – Nicks, cuts, heat sears, excessive or unusual fuzziness
- b. Inspect for permanent mushy spots or deformities – Feel, squeeze surface of rope

8. Braid-on-braid rope

- a. Inspect visually – Heat sears, nicks, and cuts
- b. Feel for lumps – Indicate core damage
- c. Shrinking rope diameter may indicate break in core
- d. Examine sheath if any damage or questionable wear
- e. If sheath slides on core – Cut off end, pull off excess material, and seal end

Review Question: What are the basic guidelines for rope maintenance?

See pages 376-378 of the textbook for answers.



F. Caring for Rope

1. Avoid abrasion, unnecessary wear
 - a. Rope can be weakened from surface damage caused by chafing or dragging over splintered, rough, or gritty surfaces
 - b. Constant vibration against apparatus compartment surfaces
 - c. Compression when stored in tight spaces
2. Avoid sharp angles and bends – Sharp angles, bends, and knots can reduce strength as much as 50 percent
3. Protect ends from damage – Prevent unraveling by properly whipping or taping cut ends
4. Avoid sustained loads
 - a. Natural fiber ropes have less ability to bear sustained loads than synthetic fiber ropes; break if subjected to heavy loads for long periods of time
 - b. Never exceed load limit of any rope or subject it to sustained loads for more than two days
5. Avoid rust – Can weaken rope in as little as one to two weeks.
 - a. If rust stained, inspect extent of the stain
 - b. If halfway through the rope, then rope strength may be reduced by as much as 50 percent, remove from service and destroy
6. Prevent contact with chemicals
 - a. Natural fiber rope extremely vulnerable to chemicals and solvents
 - b. Synthetic rope not entirely resistant to damage from oils, gasoline, paint, and chemicals
7. Reverse ends of the rope periodically – Uncoil rope and recoil with location of ends changed; ensures even wear along all portions of rope



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8. Do not walk on rope – Grinds dirt and debris into the strands; will bruise strands by compressing

G. Cleaning rope

1. Visually inspect for contamination, soil; use stiff bristled brush to remove
2. Synthetic fiber cleaning – Washed in lukewarm to warm water with mild detergent or fabric softener to loosen imbedded particles; DO NOT use bleaches or strong cleaners
 - a. Washing by hand – Place rope in sink filled with water, detergent; scrub with bristle brush; can also soak in mesh bag then agitate by hand to remove grit; rinse thoroughly in clean water
 - b. Rope washing device – Manually feed rope through device; removes mud, surface debris; cannot be used with detergent
 - c. Washing machine – Use front- or top-loading without center agitators; place in bag; set washer on coolest temperature; use small amount of detergent; may be used to rinse rope cleaned with high-pressure washer
3. Dry immediately after wash, rinse – Spread out on hose drying rack, suspended in hose tower, loosely coiled in hose dryer; never place near heat source; do not dry in direct sunlight
4. Natural fiber cleaning – Wipe or gently brush; do not use water; dry using same methods as synthetic

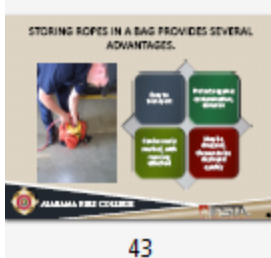
H. Maintaining a Rope Log



1. Life safety rope must be permanently identified when purchased
 - a. Done by marking ends with unit number and begin service date
 - b. Information printed on label, sealed to ends with liquid compound
2. Log must be kept throughout working life
3. Dates recorded – All uses, maintenance, and inspections
4. Information helps determine when rope should be removed from service
5. Log should be kept in waterproof envelope in pocket usually sewn to side of rope storage bag
6. Not required for utility rope

Instructor Note: Discuss with students a local example of a rope log. Point out how this information is crucial to knowing when a rope should be placed out of service. Reinforce why keeping ropes well maintained is a critical part of safety during emergency incidents.

I. Rope Storage



1. Should be in clean, dry, unheated area with freely circulating air currents
2. Must protect rope from weather, direct sunlight, chemicals, fumes, and vapors
3. Should not be in same compartments with gasoline-powered tools or fuel containers
4. Storing in a bag makes easy to transport and protects from abrasion, contamination
5. Bag can be marked with type, size of rope, unit assigned; rope log may also be attached
6. Bag may be dropped or thrown to quickly deploy rope

Review Question: Why would a rope need to be placed out of service?

See pages 376-381 of the textbook for answers.

II. WEBBING

pp. 381-384

Objective 4 — Describe webbing and webbing construction.

A. Webbing Material and Construction

1. Made from same materials as used to make synthetic rope
2. Two types – Flat or tubular in either spiral weave or chain weave
3. Webbing used for life safety applications must be NFPA® compliant
4. Flat webbing
 - a. Constructed of single layer of material, resembles seat belt
 - b. Less expensive than tubular
 - c. Stiffer and more difficult to tie in knots
 - d. Mainly used for straps and harness
5. Tubular webbing
 - a. More supple and easier to tie
 - b. Use for rescue applications
 - c. Two types
 - i. Edge-stitched – Formed by folding piece of flat webbing lengthwise and sewing edges together; becomes unstitched through wear, abrasion; prevent with lock-stitching
 - ii. Spiral weave – Also known as shuttle-loom construction; constructed by weaving tube as unit; threads spiral around tube as woven



B. Webbing Uses



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1. Life safety webbing uses
 - a. To support firefighters during technical rescue operations
 - b. To construct technical rescue anchor systems
 - c. To package and secure victims to litters
 - d. To fasten rescue components together
2. Life safety webbing must be certified to NFPA[®] 1983 standard – Three classes described
 - a. Class I: Known as seat harness; fastens around waist, under thighs, or under buttocks; intended for emergency escape with load of up to 300 pounds (1.33 k/N)
 - b. Class II: Fastens in same manner as Class I; rated for load up to 600 pounds (2.67 k/N)
 - c. Class III: Known as full body harness; fastens around waist, thighs or under buttocks, over shoulders; rated for loads up to 600 pounds (2.67 k/N)
3. Utility webbing not regulated by standard – Must support load limit plus safety factor
4. Utility webbing uses
 - a. Securing hose rolls and bundles together
 - b. Raising and lowering tools, equipment
 - c. As part of search line system
 - d. Securing doors and hatches in open position
 - e. Carrying hose, SCBA cylinders, and equipment
 - f. Controlling inward swinging door when being forced open
 - g. Pulling unconscious or incapacitated person out of hazardous area
 - h. Securing vehicle roof when folded back during extrication

- i. Holding door in place while being opened with spreaders during vehicle extrication

Review Question: What are the two main uses for webbing?
See page 382 of the textbook for answers.

C. Webbing Care and Maintenance

1. Follow same guidelines as synthetic rope for care, cleaning, maintenance
2. Always follow manufacturer's instructions

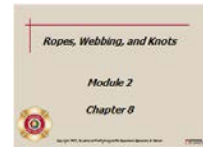
D. Webbing Storage

1. Firefighters may carry 20 to 30 foot (6.10 to 9.14 m) length of utility webbing in protective coat pocket – Used as loop to tie to hardware or wrap around object
2. Long lengths of webbing may be rolled or daisy-chained
3. Life safety harnesses carried in bags to protect in apparatus compartments
4. Ladder belts carried in apparatus to prevent UV ray and moisture damage



Chapter 8

Ropes, Webbing, and Knots



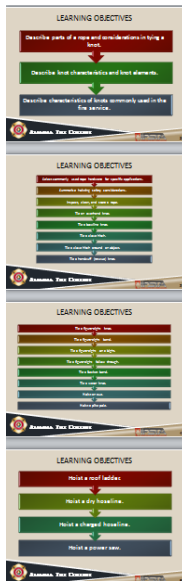
Lesson Goal

After completing this lesson, the student shall be able to appropriately select rope and webbing based on proposed use. The student shall also be able to select and tie the appropriate knot for the task presented.

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Instructor Information

This is the lesson covering ropes, webbing, and knots. This lesson describes basic information for use and care of ropes and webbing. The lesson also covers rope types, selection of ropes and knots based on proposed use, as well as care and maintenance.

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Methodology

This lesson lecture, discussion, and skills practice. The level of learning is application.

I. KNOTS

pp. 384-385

Objective 5 — Describe parts of a rope and considerations in tying a knot.

Objective 6 — Describe knot characteristics and knot elements.

A. Knots

1. Used to join ropes and webbing together
2. Critical part of fire fighting and rescue operations
3. Three parts
 - a. Working end – Used to tie knot or hitch
 - b. Running part – Free end used for hoisting or pulling
 - c. Standing part – Section between working end and running part
4. Should always be tightened until snug – Remove all slack after tying, known as dressing
5. Knots used to prevent knot failure
 - a. Overhand safety knot tied in tail of working end
 - b. Hitch, temporary knot undone by pulling against the strain that holds it



B. Elements of a Knot

1. Knot must be easy to tie, be secure under load, and reduce rope strength as little as possible – Tighter bend leads to more strength lost
2. Three bends created when tying knot or hitch
 - a. Bight – Formed by bending rope back on itself while keeping sides parallel
 - b. Loop – Crossing side of bight over standing part
 - c. Round turn – Further bending one side of a loop



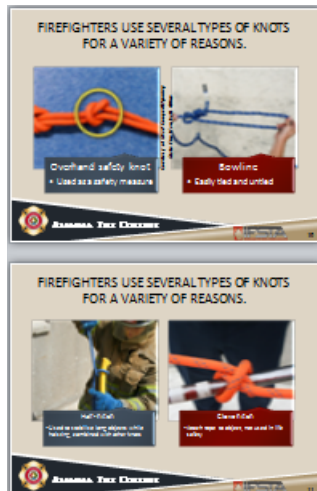
Review Question: What are the three parts of a knot?
See page 384 of the textbook for answers.

pp. 386-389

Objective 7 — Describe characteristics of knots commonly used in the fire service.

C. Overhand Safety Knots

1. Used as safety measure when tying other knot
2. Eliminates danger of running end slipping back through knot, and causing knot failure



D. Bowline

1. One of most important knots in fire service
2. Easily tied, untied; good for forming single loop that will not constrict

E. Half-hitch

1. Useful for stabilizing long objects being hoisted
2. Always combined with other knot or hitch
3. Formed by making round turn around object; standing part passed under round turn on side opposite intended direction of pull

F. Clove Hitch

1. Essentially two half-hitches
2. Principle use – Attach rope to object
3. NOT appropriate for life safety
4. May be formed anywhere in rope

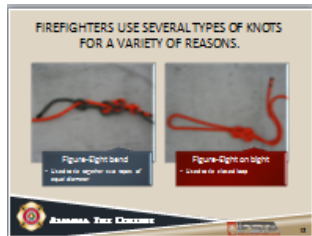
G. Handcuff (Rescue)

1. Two adjustable loops formed from a bight
2. Used to secure victim's hands or feet to raise or drag to safety
3. Loops adjustable until half-hitches are tightened



H. Figure-Eight

1. Foundation knot for entire family of figure-eight knots
2. Can be used as stopper knot so rope will not pass through rescue pulley or grommet of rope bag



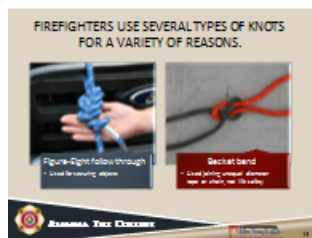
I. Figure-Eight Bend

1. Also known as Flemish Bend
2. Used primarily on life safety rope to tie ropes of equal diameters together

INSTRUCTOR NOTE: The knot shown on the skill example on pg. 405 in the textbook is incorrect. The figure-eight bend knot on the PowerPoint slide is the correct example.

J. Figure-Eight on Bight

1. Good way to tie closed loop
2. Tied by forming bight on rope, then tying simple figure eight with bight in double part of rope



K. Figure-Eight Follow Through

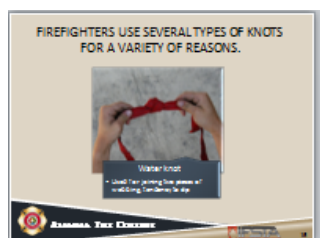
1. Used for securing objects
2. Basically figure-eight on a bight that is around object

L. Becket Bend

1. Used for joining two ropes of unequal diameters or joining rope and chain
2. Unlikely to slip when rope is wet
3. Not suitable for life safety

M. Water Knot

1. Preferred knot for joining two pieces of webbing, or end of same piece when loop needed



2. Has tendency to slip – Important to dress properly, and have webbing as flat as possible when forming
3. Allow at least 3 inches (76.2 mm) for tail

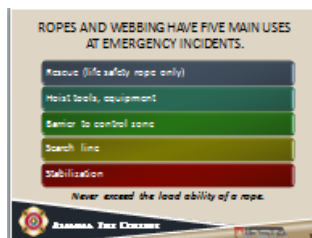
Review Question: What are the three main elements of a knot that can be combined to create knots and hitches?
See page 385 of the textbook for answers.

II. ROPE AND WEBBING USES

pp. 389-396

Objective 8 — Select commonly used rope hardware for specific applications.

Objective 9 — Summarize hoisting safety considerations.

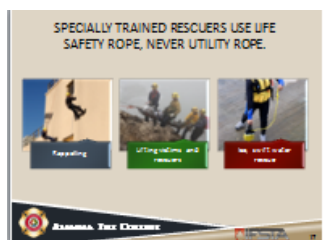


A. Rope and Webbing Uses

1. Uses at emergency incident
 - a. Rescue operations
 - b. Hoist tools and equipment
 - c. As barrier to indicate control zone
 - d. As search line during search operations
 - e. Stabilize objects
2. Utility rope used in all applications except rescue
3. Load ability of rope or webbing must exceed weight of object hoisted or stabilized

B. Rescue Uses

1. Utility never used
2. Life safety uses
 - a. Rappelling
 - b. Lifting victims and rescuers
 - c. Removing victims from ice and swift water situations



3. Specialized training required for these uses –
Be able to recognize ropes, hardware, and equipment used in order to assist if needed

C. Hoisting Tools and Equipment

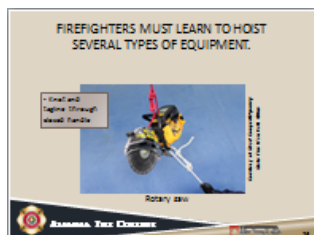
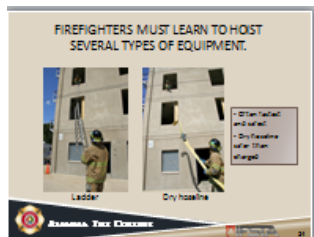
1. Hoisting pressurized cylinders, such as SCBA, prohibited by OSHA
2. Prevent equipment damage by using proper knots, securing procedures
3. Control or tag line may be used as well –
Hoisting line may serve as tag line
4. Keep safety first when selecting method
5. Rope hardware
 - a. Carabiner – Snap link made from aluminum, titanium, or steel, with sprung or screwed gate that connects ropes to other mechanical gear
 - b. Pulley – Used to create mechanical advantage; consists of grooved wheel through which rope can run to change direction or point of application of force applied to rope



Review Question: What kinds of rope hardware may be encountered when hoisting using rope?
See page 390 of the textbook for answers.

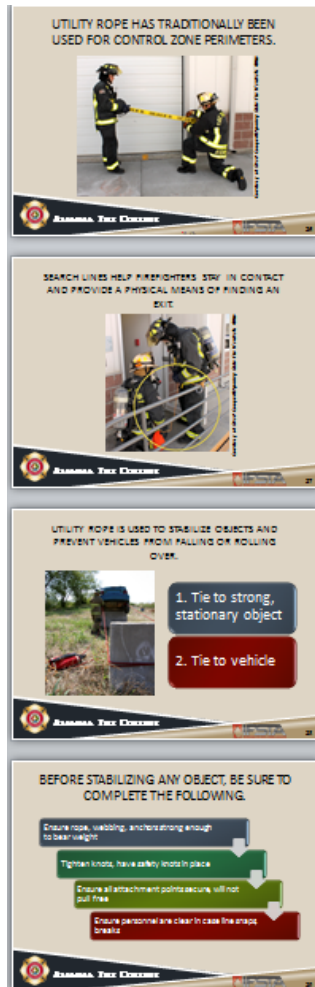


6. Safety guidelines
 - a. Before starting, make sure you are physically balanced and standing firmly ground
 - b. Use hand-over-hand method to maintain control of rope
 - c. Use edge roller or padding to protect rope from physical damage when pulling over sharp edges
 - d. Use pulley system for heavy objects
 - e. Work in teams when working from heights
 - f. Make sure that all personnel are clear of hoisting area



- g. Avoid hoisting operations near electrical hazards; if not possible, use extreme caution
 - h. Secure nozzles of any charged hoselines to prevent accidental discharge
 - i. Use tag line to help control hoisted object
 - j. Avoid hoisting tools and equipment if safer to hand carry them up stairs, ladder, or aerial device
7. Hoisting an axe
 - a. Use same procedure for pick-head or flat head
 - b. Hoisting rope can be used as tag line
 8. Hoisting a pike pole
 - a. Raise with head up
 - b. Tie clove hitch near butt end of handle
 - c. Follow with halfhitch in middle of handle, another around head
 9. Hoisting a ladder
 - a. Tie bowline or figure-eight on bight and slip through two rungs of ladder; about one-third way from top
 - b. Pull loop through, and slip over top of ladder
 - c. Secure tag line to ladder near foot
 10. Hoisting hoselines
 - a. Often fastest and safest way to get to upper floors
 - b. Take care to avoid damage to nozzle or coupling
 - c. Safer, easier to hoist dry hoseline; may hoist charged hoseline if necessary
 11. Hoisting power saw
 - a. Tie bowline or figure-eight bight through closed handle of rotary or chain saw
 - b. Attach tag line through handle

Review Question: What are three safety guidelines that must be used when hoisting tools or equipment?
See pages 390-391 of the textbook for answers.



D. Other Emergency Scene Uses

1. Control zone perimeter
 - a. Utility rope traditionally used
 - b. Clove hitches with half-hitch overhand knots used to tie rope to trees, sign posts, and other stationary objects
2. Search lines
 - a. Used to help teams working in dark, smoke-filled, and confined spaces
 - b. Allow team members to remain in contact with each other and those at entry point
 - c. Provide physical means of finding exit route
3. Object stabilization
 - a. May be used to prevent vehicle from falling after rolled on side or suspended over edge
 - b. Secure rope, and webbing to strong stationary object, then tie to object to be stabilized
 - c. Before stabilizing ensure
 - i. Rope or webbing and anchor point are strong enough to hold weight of object
 - ii. Knots are tight and safety knots are in place
 - iii. Attachment points at both ends are secure and will not pull free
 - iv. Personnel are clear from stabilizing line in case it breaks and snaps back

III. SKILLS

pp. 397-398

Objective 10 — Inspect, clean, and store rope.

p. 399

Objective 11 — Tie an overhand knot.

p. 400

Objective 12 — Tie a bowline knot.

p. 401	Objective 13 — Tie a clove hitch.
p. 402	Objective 14 — Tie a clove hitch around an object.
p. 403	Objective 15 — Tie a handcuff (rescue knot).
p. 404	Objective 16 — Tie a figure-eight knot.
p. 405	Objective 17 — Tie a figure-eight bend.
p. 406	Objective 18 — Tie a figure-eight on a bight.
p. 407	Objective 19 — Tie a figure-eight follow through.
p. 408	Objective 20 — Tie a Becket bend.
p. 409	Objective 21 — Tie a water knot.
pp. 410-411	Objective 22 — Hoist an axe.
p. 412	Objective 23 — Hoist a pike pole.
p. 413	Objective 24 — Hoist a roof ladder.
p. 414	Objective 25 — Hoist a dry hoseline.
p. 415	Objective 26 — Hoist a charged hoseline.
p. 416	Objective 27 — Hoist a power saw.

IV. SUMMARY AND REVIEW



A. Chapter Summary

1. Firefighters use rope and webbing to hoist tools and equipment, stabilize objects, designate control zones, perform rescues, and escape from life-threatening situations.
2. To use them safely and effectively, you must know the various types of ropes, their applications and how to tie a variety of knots quickly and correctly.

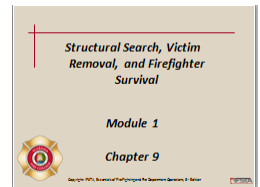
3. Finally, you must know how to inspect, clean, maintain, and store ropes and webbing so that they are ready for use when needed.

B. Review Questions

1. What are the differences in the characteristics of life safety and utility rope? (*pp. 370-372*)
2. What are the basic guidelines for rope maintenance? (*pp. 376-381*)
3. Why would a rope need to be placed out of service? (*pp. 376-381*)
4. What are the two main uses for webbing? (*p. 382*)
5. What are the three parts of a knot? (*p. 384*)
6. What are the three main elements of a knot that can be combined to create knots and hitches? (*p. 385*)
7. What are three knots commonly used in your jurisdiction and what are their different uses? (*pp. 386-389*)
8. What kinds of rope hardware may be encountered when hoisting using rope? (*p. 390*)
9. What are three safety guidelines that must be used when hoisting tools or equipment? (*pp. 390-391*)

Chapter 9

Structural Search, Victim Removal, and Firefighter Survival



Lesson Goal

After completing this lesson, the student shall be able to describe, as well as perform, search and victim removal methods to use during structural search and rescue. Students shall also be able to explain and perform firefighter survival skills used during structural search and rescue.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Summarize the impact of building construction and floor plans on structural search techniques. *[NFPA[®] 1001, 5.3.9]*
2. Explain size-up and situational awareness considerations during structural searches. *[NFPA[®] 1001, 5.3.9]*
3. Summarize safety guidelines for structural search and rescue. *[NFPA[®] 1001, 5.3.9]*
4. Differentiate between primary and secondary search techniques. *[NFPA[®] 1001, 5.3.9]*
5. Recognize basic search methods. *[NFPA[®] 1001, 5.3.9]*
6. Describe victim removal methods. *[NFPA[®] 1001, 5.3.5, 5.3.9]*
7. Explain firefighter survival methods. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
8. Explain what survival actions firefighters can take when needed. *[NFPA[®] 1001, 5.3.1, 5.3.5]*
9. Describe the actions of a rapid intervention crew or team (RIC/RIT) when locating a downed firefighter. *[NFPA[®] 1001, 5.3.5, 5.3.9]*
10. Demonstrate the procedure for conducting a primary search. *[NFPA[®] 1001, 5.3.9]*
11. Demonstrate the procedure for conducting a secondary search. *[NFPA[®] 1001, 5.3.9]*
12. Demonstrate the incline drag. *[NFPA[®] 1001, 5.3.9]*
13. Demonstrate the webbing drag. *[NFPA[®] 1001, 5.3.9]*
14. Demonstrate the cradle-in-arms lift/carry — One-rescuer method. *[NFPA[®] 1001, 5.3.9]*
15. Demonstrate the seat lift/carry — Two-rescuer method. *[NFPA[®] 1001, 5.3.9]*
16. Demonstrate the extremities lift/carry — Two-rescuer method. *[NFPA[®] 1001, 5.3.9]*



17. Demonstrate the actions required for transmitting a MAYDAY report. *[NFPA[®] 1001, 5.2.4, 5.3.5, 5.3.9]*
18. Demonstrate the proper procedures for an SCBA air emergency. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
19. Demonstrate the actions required for withdrawing from a hostile environment with a hoseline. *[NFPA[®] 1001, 5.3.5, 5.3.9]*
20. Demonstrate low profile maneuvers without removing SCBA – Side technique. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
21. Perform low profile maneuvers without removing SCBA – SCBA- first technique. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
22. Demonstrate the method for breaching an interior wall. *[NFPA[®] 1001, 5.3.5, 5.3.9]*
23. Demonstrate the steps for disentangling from debris or wires. *[NFPA[®] 1001, 5.3.5, 5.3.9]*

Instructor Information

This is the lesson covering structural search, victim removal, and firefighter survival. This lesson describes basic structural search methods, explains victim removal methods, and details firefighter survival methods and skills.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

I. STRUCTURAL SEARCHES

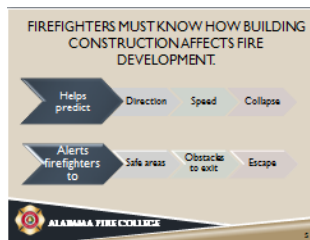
pp. 422-426

Objective 1 — Summarize the impact of building construction and floor plans on structural search techniques.

Objective 2 — Explain size-up and situational awareness considerations during structural searches.

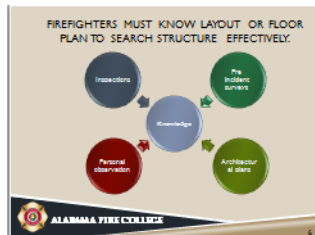
A. Building Construction – Knowing how it affects fire development

1. Helps predict
 - a. Where the fire will spread
 - b. How quickly it will develop
 - c. Potential for structural collapse
2. Alerts firefighters
 - a. To safe areas within structure
 - b. Design aspects that may prevent exit
 - c. Walls or partitions for escape



B. Building Floor Plan

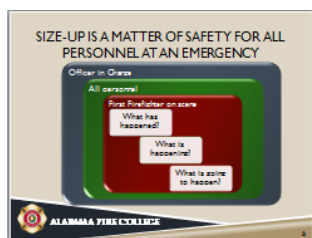
1. Must know layout to conduct effective structural search
2. Knowledge may come from
 - a. Inspections
 - b. Preincident surveys – Performed on target hazards in response areas
 - c. Architectural plans – Submitted to authority having jurisdiction (AHJ) when built or when modified
 - d. Personal observation – Tour buildings under construction or renovation to learn about construction materials and floor plan





3. Residential dwellings – Department will not have access once building complete
 - a. New construction surveys important
 - b. Can also observe when installing smoke detectors as part of fire prevention
4. Observe layout of structures in response area, including commercial buildings
 - a. Note similarities between residential structures
 - b. After emergency incident observe floor plan and location of doors, windows, vent pipes, and chimneys
 - c. Interior alterations can change layout, prepare for unexpected
5. Also learn by attending local zoning meetings, going to realtors' open houses, and getting to know local building officials

Review Question: How do building construction and floor plans impact structural search techniques?
See pages 422-425 of the textbook for answers.



C. Size-up and Situational Awareness

1. Size-up
 - a. Observe incident scene to answer
 - i. What has happened?
 - ii. What is happening?
 - iii. What is going to happen?
 - b. Initially performed and reported by first firefighter on scene
 - c. Actively monitored by all personnel throughout incident
 - d. Ultimate responsibility rests with officer in charge
2. Situational awareness
 - a. Begins when arriving on scene
 - i. Observe exterior of structure for indications of size and location of fire



- ii. Determine if building is occupied based on clues – Vehicles in driveway, lights visible in windows
- iii. Assess probable structural integrity of building, how long it will take to effectively search
- iv. Identify possible escape routes before entering – Doors, windows, and fire escapes

b. Communication

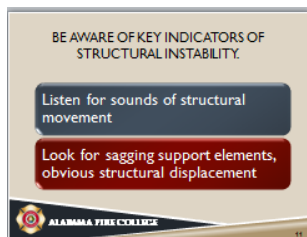
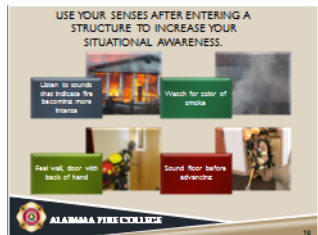
- i. Conditions change rapidly – Tell others what you observe, and pay attention to what they observe
- ii. Listen to radio reports from communication center, other units – They are observing other sides of structure you cannot see
- iii. Keep team members, and supervisors informed of any changes

c. After entering structure – Use senses to increase awareness

- i. Listen for sounds that indicate fire is becoming more intense
- ii. Watch for color of smoke – Indicates type of fuel, and phase of fire
- iii. Feel walls and doors with back of hand to determine if fire on other side
- iv. Sound floor before advancing to determine if it will support weight
- v. Key indicators of structural instability can alert to impending danger

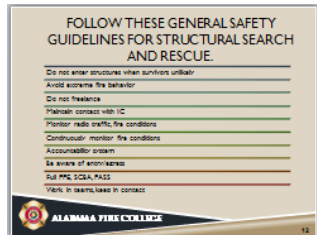
(a) *Listen for sounds of structural movement*

(b) *Look for sagging support members, obvious structural displacement*

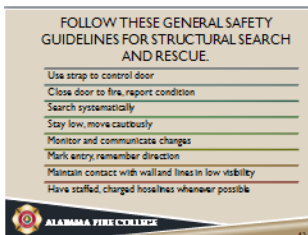


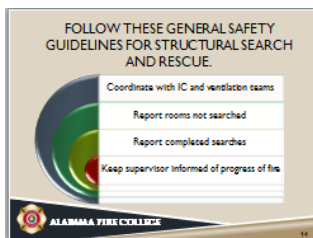
Review Question: What information can size-up and situational awareness provide during structural searches?
See pages 425-426 of the textbook for answers.

pp. 426-428

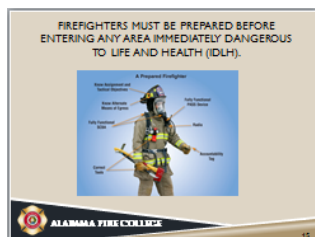
Objective 3 — Summarize safety guidelines for structural search and rescue.**D. Search Safety Guidelines**

1. Do not enter structure in which survivors are not likely to be found – Report conditions that indicate lack of survivors to supervisor
2. If there is possibility of extreme fire behavior, do not attempt entry until coordinated fire control and ventilation implemented
3. Do not freelance – Work according to incident action plan (IAP)
4. Maintain radio contact with IC
5. Monitor radio traffic for important information, and changes in orders
6. Continuously monitor fire conditions that might affect safety
7. Use department's personnel accountability system
8. Be aware of entry point and secondary means of egress
9. Wear full personal protective equipment, including SCBA and personal alert safety system (PASS) device
10. Work in teams of two or more – Always remain in physical, visual, or vocal contact
11. When opening or forcing doors, maintain control by placing a strap around the door knob
12. When encountering fire in a room, close door, and report condition
13. Search systematically to increase efficiency and reduce possibility of becoming disoriented
14. Stay low and move cautiously when visibility is low
15. Continuously monitor structure's integrity and communicate changes





16. Mark entry doors into rooms and remember direction you turned when entering – To exit building, turn in opposite direction when leaving room
17. When visibility is obscured, maintain contact with wall, hoseline, or search line
18. If possible, have staffed charged hoseline available when working on fire floor or floors immediately above or below – Hoseline can be used for fire suppression, crew protection, and indicating path out
19. Coordinate with IC and ventilation teams before opening windows to relieve heat and smoke
20. Inform supervisor immediately of any room or rooms that could not be searched
21. Report promptly to supervisor once search is complete
22. Keep supervisor informed of progress of fire and physical condition of building



E. Search Preparations – Before entry into immediately dangerous to life and health (IDLH) areas

1. Know who you report to
2. Have all necessary tools and equipment – Including forcible entry tools, hand light, thermal imager, search line
3. Turn portable radio on – Check it is working properly, and set to correct fireground channel
4. Check SCBA is turned on, working properly, and contains full cylinder
5. Ensure PASS device is turned on and working properly
6. Sign in with Accountability Officer or Incident Safety Officer
7. Know assigned duties and tactical objectives of crew or team

8. Be aware of alternate means of egress from structure

Review Question: What are five safety guidelines that should be followed during structural search and rescue?
See pages 426-427 of the textbook for answers.

pp. 428-439

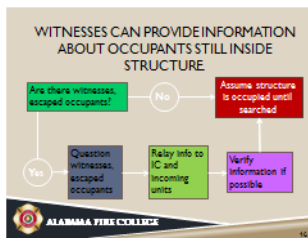
Objective 4 — Differentiate between primary and secondary search techniques.

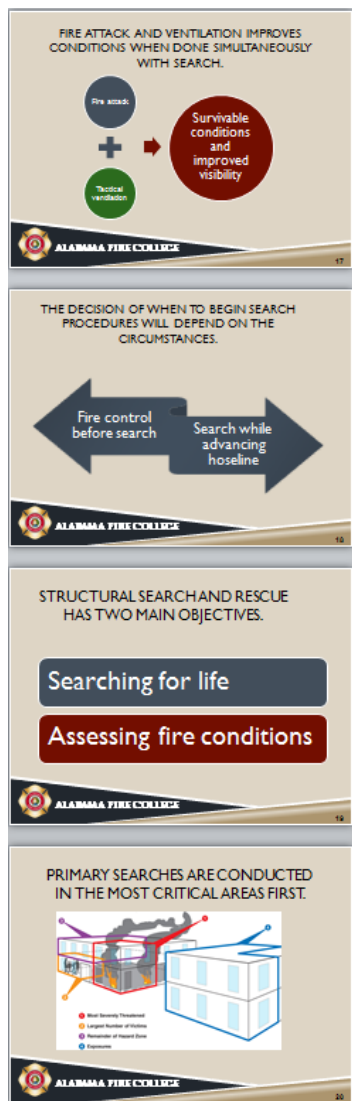
Objective 5 — Recognize basic search methods.

F. Search Procedures

1. Occupants

- a. Witnesses – Source of information about occupants not accounted for
- b. Question escaped occupants
 - i. About who might be inside and possible location
 - ii. Location and extent of fire
- c. Neighbors
 - i. If familiar with occupant habits and room locations may suggest locations
 - ii. May have seen someone near window before fire crew arrival
- d. Relay relevant information to IC and all incoming units – Verify all information
- e. Never assume all occupants are out until building searched
- f. Assume structure is occupied if no witnesses
 - i. Vacant, boarded-up structures may contain homeless or indigent people
 - ii. Commercial, educational, institutional, industrial occupancies occupied 24 hours a day by shift-workers, janitorial staff, and security personnel





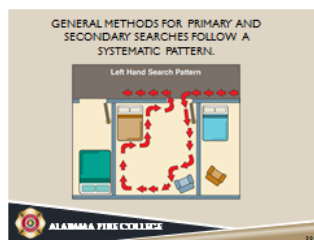
2. Fire attack and ventilation should be started simultaneously with interior search if possible
 - a. Creates more survivable conditions for firefighters and trapped occupants
 - b. Can improve visibility – Enables search crews to quickly find and remove victims
3. Fire control may have to take place before search
4. When resources are limited or if local policy requires – Search may be performed while advancing hoseline into structure
 - a. Use extreme caution
 - b. Excess steam production can severely burn potential victims
5. Two objectives
 - a. Searching for life – Locating and removing victims
 - b. Assessing fire conditions – Obtaining information about location and extent of fire
6. Primary search
 - a. Quickly check known or likely locations of victims and all affected areas of structure
 - b. At same time – Check fire conditions as appeared from outside, report any changes
 - c. Search most critical areas in order
 - i. Most severely threatened – Area closest to fire on fire floor and floor directly above – In multistory structures, top floor is also considered severely threatened due to accumulation of smoke
 - ii. Largest numbers – Areas that contain largest possible number of victims
 - iii. Remainder of hazard zone – Areas farthest from fire on same level, upper floors, and floors below fire floor
 - iv. Exposures – Interior and exterior
 - d. Always use buddy system, and work in teams of two or more
 - e. In IDLH atmosphere – Maintain physical, visual, or voice contact with team members



7. Secondary search

- a. Performed after initial fire suppression and ventilation
- b. Completed by personnel who did not participate in primary search – Allows search team to get unbiased view of scene
- c. Conducted slower and more thoroughly than primary
- d. Must be as systematic as primary to ensure no rooms and spaces are missed
- e. Report structural instability and area fire is starting to rekindle immediately
- f. Do not remove SCBA even if building appears free of smoke
 - i. Fire gases may still be present – Carbon monoxide and hydrogen cyanide
 - ii. Air monitoring only effective way to determine presence of gases – Supervisor or safety officer will tell when atmosphere is determined safe

Review Question: What are the main differences between primary and secondary search techniques?
See pages 430-431 of the textbook for answers.



G. Search Methods

1. General methods

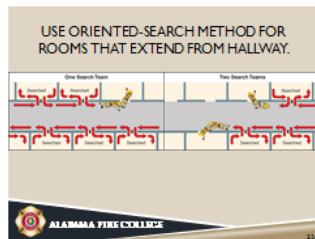
- a. Follow systematic pattern
 - i. Enter room – Turn right or left, follow walls around until returning to start point
 - ii. Leave room – Turn in same direction used to enter, continue to next room to search
 - iii. Remove victim to safety or exit building – Turn opposite direction used to enter
 - iv. Always exit through same doorway entered to ensure complete search.

b. On fire floor

- i. Start search as close to fire as possible, work back toward entrance – Allows team to reach those in greatest danger first
- ii. Reach point nearest fire by proceeding directly as possible from entry point
- iii. Advancing hoseline or deploying search line will provide way to remain oriented to find way out quickly if fire conditions change

c. Rooms that extend from hallway

- i. Search both sides using oriented-search method
 - (a) *Two teams – Each one searches opposite sides of hallway*
 - (b) *One team – Search down one side, and back up other side*
- ii. Always control egress passageways to allow teams escape if conditions change
 - (a) *Wedge doors open to prevent from shutting behind or closing on hoseline*
 - (b) *Close doors to rooms adjacent to passageway after searched*
 - (c) *Position hose teams at intervals along path to cool accumulated gases*



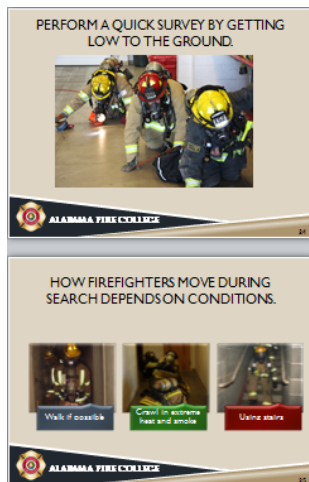
d. Get low to floor to perform quick survey

- i. Thermal layering of heat and buoyance of smoke will produce clear vision of area just above floor level
- ii. Identify victims, obstacles, and general layout more quickly

e. Walk upright or crawl on hands and knees –
Depending on conditions

- i. Walking preferable if minimal smoke and heat
- ii. In heavy smoke or extreme heat – Crawling on hands and knees below smoke level

- (a) *Can increase visibility, and reduce risk of tripping or falling*



- (b) Slower, with added advantage – Much cooler near floor*
- iii. Using stairs while crawling
 - (a) Proceed head first ascending, and feet first descending*
 - (b) Keep hands, feet far apart to distribute weight close to side of stairs – Allows you to brace if stairs collapse*

Instructor Note: Discuss the SAFETY BOX “When to Crawl During a Search” on page 432 with students. Emphasize your local protocol for deciding when to walk and when to crawl.



- f. Victims may be found in paths of egress and areas to seek shelter from fire
 - i. Bathrooms
 - ii. Bathtubs
 - iii. Shower stalls
 - iv. Closets
 - v. Under beds
 - vi. Behind furniture
 - vii. Under stairs
 - viii. Basements
 - ix. Attic rooms
 - x. Cabinets



- g. Search perimeter of each room
 - i. Occupants may be overcome with smoke while trying to escape – Always check behind doors, on floor below windows
 - ii. Extend arms, legs, and handle of tool to reach completely under beds and other furniture
- h. After searching perimeter – Search middle of room by placing tool against wall, and extending arm or leg toward center of room



- i. During primary search visibility may be limited
 - i. Identify objects by touch – May be only clue to what type of room you are in
 - ii. Search all sides of any object
 - iii. Do not move objects – May disorient you
 - iv. If smoke obscures vision, report to IC – Additional ventilation may be needed
- j. Search teams
 - i. Maintain radio contact with supervisor or IC
 - ii. Report progress in accordance with departmental SOPs
- k. Progress reports and new information especially important during primary search – Can enable search teams to be assigned to areas not completely searched
- l. Close doors to rooms not involved in fire unless used for ventilation
 - i. Prevents fire from spreading into rooms
 - ii. Opening doors and windows can disrupt ventilation efforts and even spread fire by drawing it toward opening
- m. Clear unused hoselines and other equipment from exit pathways
 - i. Reduces tripping, makes egress less difficult
 - ii. Be aware of exit pathway location in case of need to remove victim quickly

Review Question: What is the general search method used during structural search?

See pages 431-435 of the textbook for answers.



- 2. Oriented-search method – Used for team to search room
 - a. Team leader remains anchored at door, wall, or hoseline – Other team members spread out in room
 - b. All members stay in constant communication with leader and others – Update on progress
 - c. Must coordinate efforts to prevent confusion and avoid clustering in one section of room



- d. After search complete – Searchers return to anchored team leader, and proceed to next room
3. Wide-area-search method – Used to conduct primary search of large or complex area filled with smoke
 - a. Employs dedicated search line – Typically 200 feet (60 m) of 3/8 inch (10 mm) rope with KevlarTM sheath to resist heat and abrasion
 - b. Minimum of three team members required – Larger teams more effective
 - c. About 10 feet (3 m) outside entry point – End of search line is tied to fixed object about 3 feet (1 m) above floor
 - d. Tag indicating unit or company designation left at entry point – Attendant sometimes stationed to maintain communication, and monitor air management
 - e. Lead picks up rope bag containing search line, enters search area – Accompanied closely (shoulder to shoulder) by navigator
 - f. Navigator directs lead using hand light or TI if available
 - g. Lead, navigator followed by one or more radio-equipped searchers
 - h. Each searcher carries tether wrapped around one wrist and forcible entry tool in other hand
 - i. As team progresses – Search line pays out behind, all members maintain contact with line
 - j. Every 20 feet (6 m) along length – 2 inch (50 mm) steel ring tied into search line
 - k. Immediately behind ring, one or more knots tied in search line to indicate distance
 - i. After first ring – One knot indicates 20 feet (6 m) from beginning
 - ii. After second ring – Two knots indicate 40 feet (12 m) from beginning
 - iii. After third ring – Three knots, etc.
 - iv. Knots indicate distance from beginning of search line, are always behind ring





- v. Knots provide directional indication – Knots toward fire, and rings toward exit
- l. Rings provide anchor point for lateral tethers
 - i. Tethers – 20-foot (6 m) lengths of ¼ inch (6 mm) rope with Kevlar™ sheath
 - ii. Each has ¾ inch (19 mm) steel ring tied to one end, knot at mid-point, either nonlocking carabiner or snap hook on other end
 - iii. Each member carries one tether
- m. Tethers enable team to search areas perpendicular to search line
 - i. Snap tether to one of search line's steel rings, or at any point between rings
 - ii. Pay out tether while moving away from search line
 - iii. Reaching mid-point knot allows searcher to make 10-foot (3 m) arc from attachment point
 - iv. If nothing found searcher progresses additional 10 feet (3 m) to end of tether – Can sweep 20-foot (6 m) arc
 - v. If more area needs to be searched – Second searcher attaches tether to ring on end of first tether
 - vi. Allows second searcher to sweep 40-foot (12 m) arc away from search line
 - vii. When returning to search line, disconnect from ring and rewind tethers around wrists
- n. Any time team member moves off search line – Must stay in voice contact with navigator
- o. Navigator constantly updates IC – Reports on fire conditions, what team has found, how many knots into building team progressed
- 4. Thermal-imager-search method
 - a. Allow firefighters to see sources of heat through darkness and thick smoke
 - b. Used to locate victims and hidden fires
 - c. Typically assigned to chief officer or specialized units – Heavy rescue companies, and rapid intervention teams



- d. May be assigned to all companies for use in search and overhaul operations
- e. Can detect heat through barriers – But have limitations
 - i. Cannot detect person under or behind furniture, or on opposite side of wall
 - ii. Cannot see through water or glass
 - iii. In carpeted structure may not be able to detect fire on floors below – May cause firefighters to think room is safe to enter when floor has been weakened
 - iv. Are very fragile and prone to mechanical failure
- f. Operate according to manufacturer's instructions and department SOPs
 - i. Slowly scan around the room close to floor level, then rise to scan at higher level
 - ii. Open closet and cabinet doors and scan inside
 - iii. Screen may white out when it detects high levels of heat – Allow time to readjust before proceeding into room that has shown high heat level
- g. Inspect after every use – Follow manufacturer's instructions
 - i. Replace batteries as needed
 - ii. Clean regularly
 - iii. Store properly
 - iv. Report damage or malfunction immediately

Review Question: When is the appropriate time to use the oriented-search method, wide-area-search method, and thermal-imager search method?

See pages 435-438 of the textbook for answers.

H. Marking Systems

1. Consistent system necessary to ensure thorough and effective search
 - a. Mark rooms with – Chalk or crayon markers, specially designed door markers, or latch straps over doorknobs



- b. Place marks low so they can be seen under smoke – Lower third of door, lower third of adjacent wall, and landing of adjacent stairs
- c. Latch straps adds advantage of preventing door from closing
- d. Never mark by blocking door open with furniture – Can contribute to fire spread
- e. Never mark inside room – Subsequent searchers would have to enter to find mark



2. Federal Emergency Management Agency's Urban Search and Rescue System (FEMA US&R)

- a. Consists of diagonal marks that fit into 2 foot by 2 foot (0.61 m by 0.61 m) square
- b. Diagonal mark from upper right to lower left indicates search underway
- c. When search complete second mark made from upper left to lower right, forming X
 - i. Marks alert other teams they do not have to search room or floor
 - ii. If team fails to report, does not respond to calls for personnel accountability report (PAR) – Rescuers use marks as starting point for search
- d. Adjacent marks convey additional information
 - i. Search unit noted to left of X
 - ii. Time of completion noted above X
 - iii. Hazards noted to right of X
 - iv. Victims and condition noted below X – Can indicate fatalities still in room, live victims sheltered in place, or no victims located during primary search



II. VICTIM REMOVAL

pp. 439-442

Objective 6 — Describe victim removal methods.

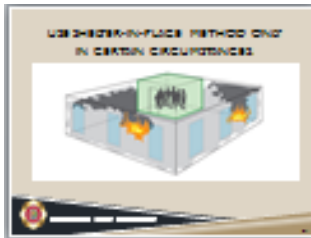
A. Self-Evacuation

1. Most occupants can evacuate structure on own, with minimal assistance
2. May have to direct them to alternate exit or close stairwell doors to maintain integrity of exit path
3. May have to establish safe haven away from structure where occupants can be accounted, for treated, and interviewed
4. Actual duties depend on staffing levels and local SOPs



B. Shelter-in-Place

1. Moving victims to protected location in structure
2. Used when
 - a. Hazard is minor
 - b. Safer to keep victims inside structure
 - c. Victims incapacitated, cannot be moved
 - d. Limited staffing to assist evacuation
 - e. Structure can provide protective barrier between victim and hazard
3. Common in hospitals, nursing homes, correctional facilities, high-rises, and high-hazard industrial sites
4. Protected location may be predetermined during preincident survey or chosen base on incident size-up
5. Decision can only be made by supervisor or IC
6. Report any conditions that influence safety of method immediately



C. Rescue



1. Required when conditions prevent self-evacuation, shelter-in-place, or victims directly threatened
2. Actions you may have to take
 - a. Extinguish fire that cuts victims off from exit
 - b. Provide with alternate exit pathway
 - c. Remove debris from pinned victim
 - d. Carry injured and unconscious victims to safety
3. Injured victims should not be moved until assessed and treated unless in immediate danger
 - a. Primary danger is possibility of aggravating spinal injury
 - b. Preserving life first priority in extreme emergency
 - c. Never pull victim sideways – Pull along long axis of body
 - d. If on floor, pull on clothing in neck or shoulder area
4. Improper lifting technique – Common cause of injury
 - a. Keep back straight, lift with legs; not with back
 - b. One rescuer can safely carry small child – Two to four may be needed to safely carry adult
 - c. Safety guidelines
 - i. Lift as a team
 - ii. Focus on keeping balance
 - iii. Support head and neck
 - iv. Avoid unnecessary jostling
 - d. Never drag or carry victim through hazard zone unless no other choice
5. Incline drag
 - a. Enables rescuer to move victim up or down stairway or incline
 - b. Useful for moving unconscious victims
6. Webbing drag
 - a. Rescuer pulls section of webbing wrapped around victim's body

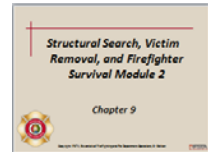
- b. Useful when heat and smoke force firefighter to stay low or victim is downed firefighter wearing SCBA
7. Cradle-in-arms lift/carry
 - a. Used to carry children or small, conscious adults
 - b. Not practical for unconscious adults – Victim's weight, relaxed body, and difficulty supporting head and neck
 8. Seat lift/carry – Enables two rescuers to carry conscious or unconscious victim
 9. Moving a victim onto a litter
 - a. Types – Long backboard litter, standard ambulance cot, army litter, basket litter, and scoop stretcher
 - b. Use similar techniques for moving people onto stretchers and basket litters
 10. Extremities lift/carry – Enables two rescuers to move conscious or unconscious victim



Review Question: What are the main differences in the three types of victim removal methods?
See pages 439-440 of the textbook for answers.

Chapter 9

Structural Search, Victim Removal, and Firefighter Survival



Lesson Goal

After completing this lesson, the student shall be able to describe, as well as perform, search and victim removal methods to use during structural search and rescue. Students shall also be able to explain and perform firefighter survival skills used during structural search and rescue.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Summarize the impact of building construction and floor plans on structural search techniques. *[NFPA® 1001, 5.3.9]*
2. Explain size-up and situational awareness considerations during structural searches. *[NFPA® 1001, 5.3.9]*
3. Summarize safety guidelines for structural search and rescue. *[NFPA® 1001, 5.3.9]*
4. Differentiate between primary and secondary search techniques. *[NFPA® 1001, 5.3.9]*
5. Recognize basic search methods. *[NFPA® 1001, 5.3.9]*
6. Describe victim removal methods. *[NFPA® 1001, 5.3.5, 5.3.9]*
7. Explain firefighter survival methods. *[NFPA® 1001, 5.3.1, 5.3.5, 5.3.9]*
8. Explain what survival actions firefighters can take when needed. *[NFPA® 1001, 5.3.1, 5.3.5]*
9. Describe the actions of a rapid intervention crew or team (RIC/RIT) when locating a downed firefighter. *[NFPA® 1001, 5.3.5, 5.3.9]*
10. Demonstrate the procedure for conducting a primary search. *[NFPA® 1001, 5.3.9]*
11. Demonstrate the procedure for conducting a secondary search. *[NFPA® 1001, 5.3.9]*
12. Demonstrate the incline drag. *[NFPA® 1001, 5.3.9]*
13. Demonstrate the webbing drag. *[NFPA® 1001, 5.3.9]*
14. Demonstrate the cradle-in-arms lift/carry — One-rescuer method. *[NFPA® 1001, 5.3.9]*
15. Demonstrate the seat lift/carry — Two-rescuer method. *[NFPA® 1001, 5.3.9]*
16. Demonstrate the extremities lift/carry — Two-rescuer method. *[NFPA® 1001, 5.3.9]*



17. Demonstrate the actions required for transmitting a MAYDAY report. *[NFPA[®] 1001, 5.2.4, 5.3.5, 5.3.9]*
18. Demonstrate the proper procedures for an SCBA air emergency. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
19. Demonstrate the actions required for withdrawing from a hostile environment with a hoseline. *[NFPA[®] 1001, 5.3.5, 5.3.9]*
20. Demonstrate low profile maneuvers without removing SCBA – Side technique. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
21. Perform low profile maneuvers without removing SCBA – SCBA- first technique. *[NFPA[®] 1001, 5.3.1, 5.3.5, 5.3.9]*
22. Demonstrate the method for breaching an interior wall. *[NFPA[®] 1001, 5.3.5, 5.3.9]*
23. Demonstrate the steps for disentangling from debris or wires. *[NFPA[®] 1001, 5.3.5, 5.3.9]*

Instructor Information

This is the lesson covering structural search, victim removal, and firefighter survival. This lesson describes basic structural search methods, explains victim removal methods, and details firefighter survival methods and skills.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

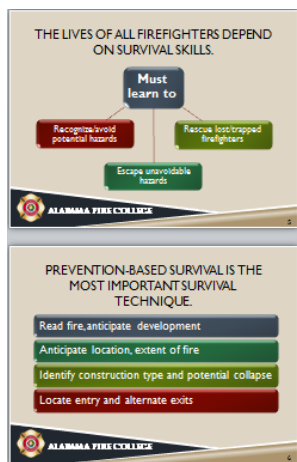
I. FIREFIGHTER SURVIVAL

pp. 443-449

Objective 7 — Explain firefighter survival methods.

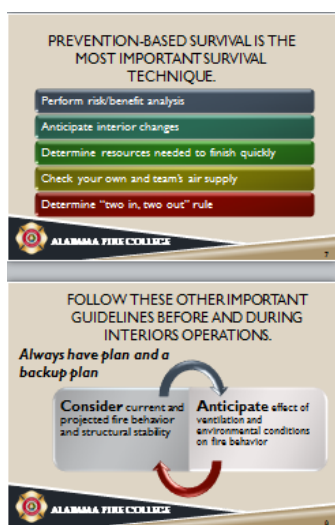
A. Firefighter Survival – Skills to learn to ensure survival

1. Recognize and avoid potential hazards
2. Escape unavoidable hazards
3. Rescue lost or trapped firefighters



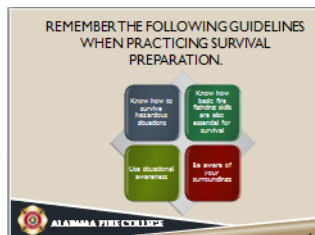
B. Prevention-Based Survival

1. Most important survival technique
2. Based on effective size-up
 - a. Read fire and anticipate stages of fire development and spread
 - b. Anticipate location and extent of fire
 - c. Identify building's construction type and potential for collapse
 - d. Locate best means of entry
 - e. Locate alternate exits
 - f. Perform risk/benefit analysis
 - g. Anticipate how interior conditions may change
 - h. Determine whether there are enough resources to complete operation quickly
 - i. Check own and team members' air supply
 - j. Determine whether you can adhere to the "two-in, two-out" rule – Requires two firefighters available outside structure to rescue two firefighters working inside
3. Guidelines for actions both before and during interior operations
 - a. Consider both current and projected fire behavior
 - b. Consider both current and projected structural stability
 - c. Anticipate how ventilation may affect fire behavior



- d. Anticipate how fire dynamics may be affected by environmental conditions
- e. Always have plan and backup plan

C. Preparation for Survival

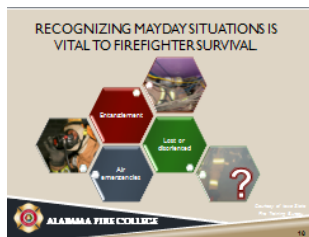


1. If hazardous situation cannot be avoided – Know how to survive
 - a. Practice basic fire fighting techniques
 - b. Practice situational awareness
 - c. Anticipate types of survival situations you may face
 - d. Practice MAYDAY and self-rescue techniques
2. Basic fire fighting skills are essential survival techniques
 - a. Forcible entry techniques can be applied in escape
 - b. Hoseline used in fire attack can protect from progressing fire or help find way out of smoke-filled room
 - c. When trapped, air management increases amount of survival time before escaping or rescue
 - d. Extreme stress of emergency makes conscious thought difficult – Practice skills until automatic
3. Situational awareness
 - a. Will warn of extreme fire behavior or structural collapse – Recognize signs and withdraw to safety
 - b. Know personal physical limitations to monitor stress level, air consumption, work load and withdraw before incapacitated
 - c. Ways to physically and mentally prepare
 - i. Practice basic skills
 - ii. Train for hazards you will encounter
 - iii. Practice air management techniques
 - iv. Practice emergency exit techniques
 - v. Make sure that PPE matches hazard and is working properly
 - vi. Know your duties

- vii. Know own physical limitations – Watch for signs of fatigue, increased breathing, and increased heart rate
 - viii. Know limitations of your PPE and air supply system
 - ix. Look out for members of crew
 - x. Listen to team members
 - xi. Follow orders thoughtfully – If it does not sound right, ask for clarification
4. Be aware of surroundings
- a. Look for signs of key fire behavior indicators - Particularly flashover, backdraft, and fire gas ignition
 - b. Listen, feel, and watch for changes in environment

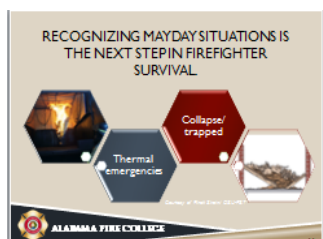
Review Question: What are the three behaviors firefighters must learn and follow to ensure their own survival and that of fellow firefighters?

See pages 443 of the textbook for answers.

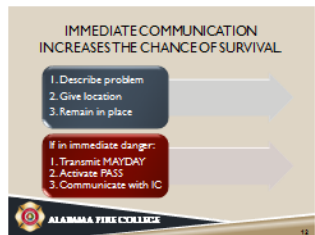


D. Recognition – Know potential types of MAYDAY situations

1. Air emergencies
 - a. Facepiece is dislodged
 - b. Run out of air
 - c. SCBA malfunctions
 - d. Also occurs if low-pressure alarm activates and you are unable to immediately exit hazard area
2. Lost/disoriented
 - a. Are in extreme darkness
 - b. Lose contact with partner, hoseline or search line, or orientation point
3. Entanglement – Caught on exposed wires, a fallen ceiling grid, or other debris
4. Thermal emergencies – Rapid rise in temperature exceeds PPE's level of protection
5. Collapse/trapped



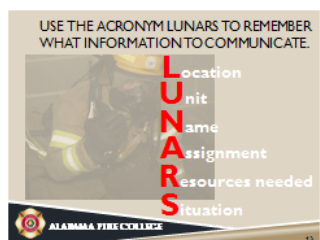
- a. Unable to exit due to structural collapse
- b. Most common when structure has been on fire for an extended period of time; affected by earthquake or explosion; or under construction, renovation, or demolition
- c. Can also occur if structure has been intentionally damaged to create traps for responders



E. Communication

1. Increase chances of survival if you immediately communicate you are in danger
2. Describe problem, give location to partner, team leader, and supervisor – Remain in place until firefighter reaches you

Instructor Note: Discuss SAFETY BOX “Making a MAYDAY Communication” on page 446 with students. Discuss how this information is specifically applied in your jurisdiction.



3. If life is in immediate danger
 - a. Transmit department’s MAYDAY signal
 - b. Activate PASS device
 - c. Communicate situation to IC immediately
4. Use acronym LUNARS to remember information to provide
 - a. Location
 - b. Unit
 - c. Name
 - d. Assignment
 - e. Resources needed – Air or extrication
 - f. Situation
5. Communicate air supply status and actions taken if possible
6. Describe location as clearly as possible so rescuers know where to search
7. Stay in contact with Command – Keep them informed of changes to situation

8. After transmitting MAYDAY report, activate PASS device

Note: Ensure that students understand the NOTE box on page 447 regarding the PASS device's signal that prevents being heard over the radio.

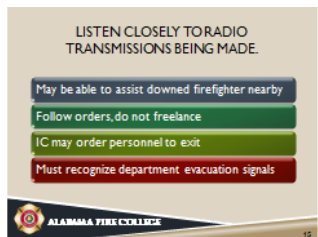
9. MAYDAY – Used whenever firefighter in immediate danger
10. Actions taken immediately when MAYDAY is broadcast

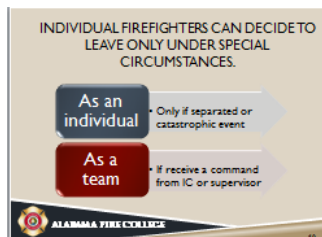
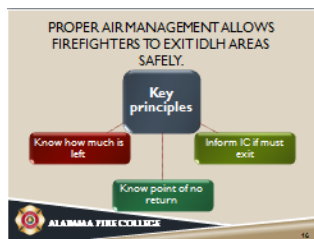
- a. All radio traffic ceases and only traffic relating to MAYDAY is allowed
- b. Communication center allocates available radio channel specifically for MAYDAY communications
- c. Nonessential activities cease and units directed to assist with searching for firefighter who broadcast MAYDAY
- d. Rapid intervention crew or team (RIC/RIT) dispatched to locate downed firefighter



Instructor Note: Discuss the SAFETY BOX, "MAYDAY Fireground Response," on page 448 with students. Emphasize how your local jurisdiction defines non-essential activities that will cease after a MAYDAY communication.

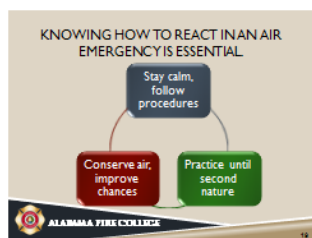
11. Always listen when transmission made – May be able to assist if near downed firefighter
12. Listen closely for orders after transmission – Do not freelance
13. IC may give orders for all personnel to exit if conditions in hazard zone change rapidly
14. Be familiar with ways department sounds evacuation signal
 - a. May be audible warning devices on apparatus or radio messages ordering interior crews to exit
 - b. When given all units on scene must give personnel accountability report (PAR)
 - c. Exiting crews – Proceed to designated safe areas outside collapse zone





F. Air Management

1. Need to regulate air consumption in order to exit IDLH safely
2. Past practice was to stay until low pressure alarm activated
 - a. Placed firefighters at risk – That amount of air is not enough to exit deep inside large and complex structure
 - b. Even in small structure not enough if encountering emergency or waiting for assistance
3. Key principles
 - a. Always know how much air you have left
 - b. Know your point of no return
 - c. Inform IC if you must exit structure
4. Check air gauge regularly
 - a. Before entering IDLH atmosphere
 - b. When moving from one area to another
 - c. After periods of heavy work
 - d. At specific intervals, based on SOPs
 - e. When resting
 - f. Before beginning a new assignment
5. Point of no return – Based on
 - a. How much air required to exit IDLH
 - b. Lowest cylinder gauge reading of any member of team
 - c. Department's SOPs
 - d. Environmental conditions
 - e. Team's physical and mental condition
6. Test air consumption rate by simulating emergency conditions during training – Measure how long it takes to consume full cylinder of air
7. Exiting structure



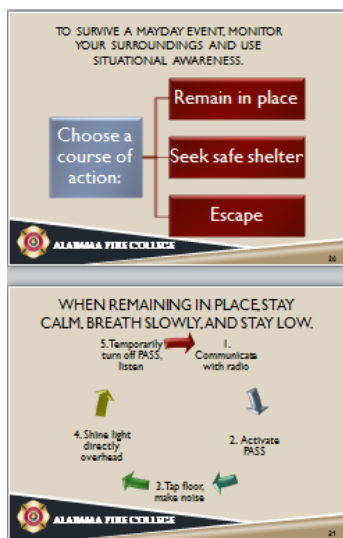
pp. 449-457

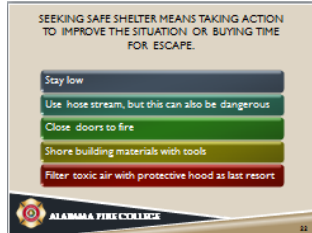
Objective 8 — Explain what survival actions firefighters can take when needed.

Objective 9 — Describe the actions of a rapid intervention crew or team (RIC/RIT) when locating a downed firefighter.

G. Survival Actions

1. Best tactic is to constantly monitor surroundings, and use situational awareness to stay safe
2. When MAYDAY event occurs
 - a. Choose course of action
 - b. Remain calm – Panic is leading contributor to firefighter death
3. Remain in place
 - a. Stay calm, breath slowly to conserve air, and stay low where temperature is cooler
 - b. Actions to take after completing MAYDAY report
 - i. Continue to communicate on radio
 - ii. Activate PASS device
 - iii. Tap floor with tool, or find another way to make noise
 - iv. Shine flashlight or hand light directly overhead

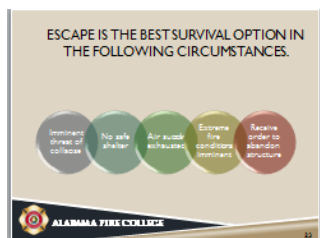




- v. If unsure of location, momentarily turn off PASS device and listen for sounds that provide clues to location – Traffic, crews working with tools, or sound of pumper

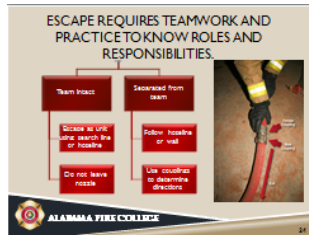
4. Seeking safe haven

- a. Taking actions that either improve situation or buy more time to escape
- b. Actions – May be performed before communicating MAYDAY
- c. Staying low to the floor – Temperatures are cooler, air may be less contaminated
- d. Using hose stream for protection
 - i. In thermal emergency, turn nozzle pattern to a full fog and point above you while flattening yourself on floor
 - ii. Only be done as a last resort when too late to exit – Can result in steam burns as water rapidly turns to steam
- e. Closing doors between you and fire – Places barrier between yourself and fire, allowing time to find egress point or breach wall to escape
- f. Using tools to shore building material
 - i. During building collapse, may be able to use hand tools to shore up building materials
 - ii. Gives time to find egress point or escape collapse area
- g. Filtering toxic air
 - i. Should be done with face low to floor and without removing regulator
 - ii. Break seal of mask and use protective hood to filter each breath
 - iii. Be aware – This will not remove toxins such as carbon monoxide (CO) and hydrogen chloride (HCl).
 - iv. Only last resort if SCBA cylinder completely exhausted



5. Escape

- a. Best option in these circumstances
 - i. Imminent threat of structural collapse



- ii. No safe haven to shelter
 - iii. Completely exhausted air supply
 - iv. Extreme fire conditions about to occur
 - v. Been ordered to abandon structure
- b. Requires teamwork – Practice so all members know individual roles and responsibilities
- c. If team intact
- i. Escape as unit by following hoseline or search line to original point of entry
 - ii. In event or threat of rapid fire progression – Do not leave nozzle, withdraw line and operate as needed

Instructor Note: Discuss the SAFETY BOX “Controlling the Fire” on page 451 with students. Explain why controlling the fire may help increase survival time.

d. If separated from team

- i. Follow hoseline, search line or wall in direction you came from
- ii. When following hoseline – Female coupling is on nozzle side, male coupling on water source side
- iii. Female coupling has smaller lugs on swivel, and male coupling has lugs on shank
- iv. Following hoseline will lead to either exit or nozzle team – Communicate progress to supervisor or Command

e. Safety guidelines

- i. Remain calm
- ii. If you have hoseline – Maintain control of nozzle and use for protection
- iii. Orient yourself to points of reference – Hoselines, search lines, walls, and points of exterior light
- iv. Stay low
- v. Keep in contact with wall
- vi. Stay in radio communication
- vii. Remember which level of structure you are on
- viii. Control breathing
- ix. Check air supply frequently and report to Command

f. Use duck walk or low profile maneuver if smoke dense and low

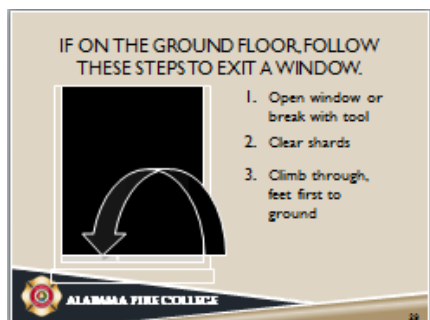
- i. Use crouched, duck, walk – Slightly faster than crawling but more dangerous unless you can clearly see floor
- ii. Low profile maneuver involves crawling – Effective way of moving in areas of low visibility
- iii. Crawling advantages – Area close to floor cooler, may have better visibility, allows you to feel area in front of you, and warning of objects or dangerous openings

g. To search for exit

- i. Locate wall and crawl along it
- ii. With one hand sweep floor ahead to avoid openings



- iii. With other hand sweep wall to find window – Reach as high as you can without standing
- iv. When you locate window that can be opened – Determine if window will allow you to exit
- v. Notify Command of location – Ask if opening window will make conditions worse
- vi. If on ground floor



- (a) *Open window or break with forcible entry tool*
- (b) *Ensure frame is completely clear of glass shards*
- (c) *Climb through window and lower feet first to ground*

vii. If on upper story

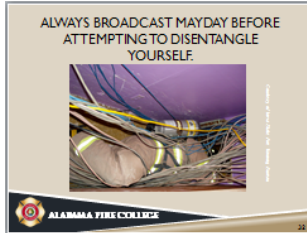


- (a) *Find out if aerial or ground ladder is at or near window*
- (b) *If not – Report location and need for means of egress*
- (c) *If you have escape rope system – Secure to sturdy interior point, climb through window, descend to ground; only use if properly trained*



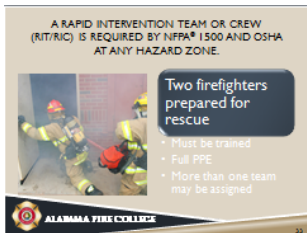
h. Breach a wall

- i. Should be last resort – Requires strength, will use air supply
- ii. Interior easier to breach than exterior
- iii. Remain low and use forcible entry tool to make opening
- iv. Remove enough wall material to make space large enough to crawl through; then make opening in wall on other side
- v. Use forcible entry tool to sound the floor on the other side of wall and locate any obstructions
- vi. May have to adjust SCBA to fit through opening – Loosen right shoulder strap and waist belt, then shift until SCBA is tucked under left arm; exit on side



- i. In wall with standard 16 inch (406.4 mm) stud spaces may exit SCBA first
 - i. Sit back against open stud space – Push SCBA through followed by one arm, then next
 - ii. Push against wall to pull body through in swimming motion
 - iii. Only use this method as last resort – Increases risk of becoming separated from air supply
- j. If entangled
 - i. Immediately broadcast MAYDAY before attempting extrication
 - ii. Free yourself by using type of swim stroke to back out
 - iii. Easier to move back the way you came than to move forward
 - iv. Good practice to carry wire cutters in pocket that can be accessed even when movement limited – Use to cut nonelectrical wire to free

Review Question: How does a firefighter decide on the best survival action to take if a MAYDAY event does occur?
See pages 449-451 of the textbook for answers.



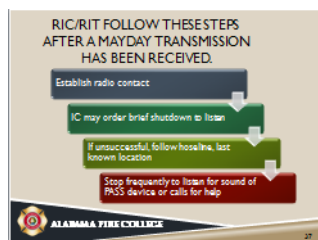
H. Rapid Intervention

1. Required by Occupational Safety and Health Administration (OSHA) regulations and NFPA® 1500 when firefighters in any hazard zone
2. Rapid intervention crew or team (RIC/RIT) consist of at least two members prepared to rescue injured or trapped firefighters
 - a. Must be trained in firefighter rescue and equipped with same PPE as interior fire fighting crews at incident
 - b. May have more than one team assigned to stand by – Especially if interior entry is at multiple points



Caution: Do not underestimate the time and personnel required to rescue a downed firefighter. Carrying one unconscious firefighter can require four rescuers, and fully removing the firefighter from the hazard zone can require up to twelve rescuers. This process can take as long as 20 minutes to complete.

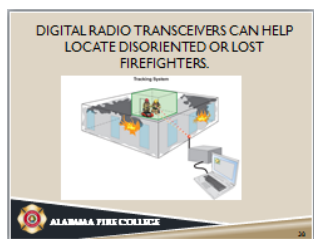
3. Mandatory equipment described by AWARE acronym
 - a. Air
 - b. Water
 - c. A Radio
 - d. Extrication
4. Teams carry
 - a. Spare SCBA to provide breathing air for downed firefighter
 - b. Hoseline to create defensive space
 - c. Radio to communicate with Command
 - d. Forcible entry tools for extrication
 - e. Flashlights or handheld lights
 - f. Search lines
 - g. Thermal imager
 - h. May include – Litter, power saw, attic ladder, and spare breathing air cylinders
5. After MAYDAY transmission
 - a. RIC/RIT first tries to establish radio contact with downed firefighter
 - b. IC may order brief shutdown of pumps, generators, fans, other noise-producing devices – So PASS device can be heard better
 - c. If these actions not successful – RIC/RIT follows hoseline or search line into structure, begins search from last known location



6. RIC/RIT should stop frequently and briefly remain silent – Helps hear PASS device sounding
 - a. May hold breath for few seconds when signaled by search team leader for complete silence
 - b. May allow to hear faint calls for help or sounds of downed firefighter's SCBA exhalation valve opening

7. Tracking devices

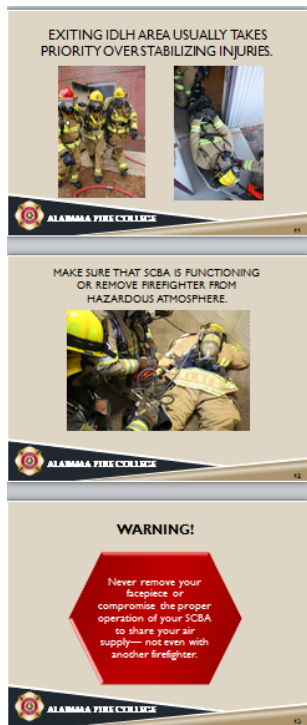
- a. Digital radio transceivers enable lost or disoriented firefighters to be located
- b. About the size of a PASS device, mounted on SCBA harness
- c. Operate on 457 kHz, and have range of approximately 100 feet (30 m)
- d. Do not interfere with other on-scene radio transmissions
- e. Always turned on when entering IDLH atmosphere
- f. Signal not blocked by walls, floors, or other solid objects
- g. Allows rescuers to locate downed firefighter – Even from outside building
- h. Can be switched from standby to search mode – Search mode displays distance and direction toward another transceiver or egress transmitter positioned near exit



8. Removing located firefighters

- a. After locating downed firefighter
 - i. RIC/RIT checks air supply, may need to connect full replacement cylinder
 - ii. Deactivate PASS device
 - iii. Confirm firefighter's identity
- b. Next notify Command of location and status
 - i. Request assistance if firefighter trapped or injured
 - ii. Mitigate any hazards that threaten downed firefighter while waiting
 - iii. May need to move to safe haven





- c. Exiting IDLH area usually takes priority over stabilizing injuries
 - i. If unable to walk – Rescuers move to safety
 - ii. If uninjured, able to walk – Rescuers assist to safety
- d. If firefighter has functioning SCBA – Move carefully so not to dislodge mask
- e. If firefighter does not have functioning SCBA – Either connect facepiece to functioning SCBA or remove victim from hazardous atmosphere

WARNING! Never remove your facepiece or compromise the proper operation of your SCBA to share your air supply— not even with another firefighter.

Instructor Note: Discuss the SAFETY BOX “Buddy Breathing is Not a Recommended Technique” on page 457 with students. Explore reasons that help explain why buddy breathing is not recommended, even though it may seem like a good idea.

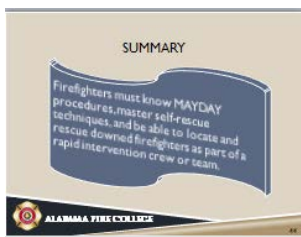
Review Question: When does a rapid intervention crew or team (RIC/RIT) begin work on an incident scene?
See pages 454 of the textbook for answers.

II. SKILLS

- | | |
|--------|---|
| p. 459 | Objective 10 — Demonstrate the procedure for conducting a primary search. |
| p. 460 | Objective 11 — Demonstrate the procedure for conducting a secondary search. |
| p. 461 | Objective 12 — Demonstrate the incline drag. |
| p. 462 | Objective 13 — Demonstrate the webbing drag. |
| p. 463 | Objective 14 — Demonstrate the cradle-in-arms lift/carry — One-rescuer method. |

p. 464	Objective 15 — Demonstrate the seat lift/carry — Two-rescuer method.
p. 465	Objective 16 — Demonstrate the extremities lift/carry — Two-rescuer method.
p. 466	Objective 17 — Demonstrate the actions required for transmitting a MAYDAY report.
pp. 467-469	Objective 18 — Demonstrate the proper procedures for an SCBA air emergency.
p. 470	Objective 19 — Demonstrate the actions required for withdrawing from a hostile environment with a hoseline.
p. 471	Objective 20 — Demonstrate the side technique for low profile maneuvers without removing SCBA.
pp. 472	Objective 21 — Perform the SCBA-first technique for low profile maneuvers without removing SCBA.
p. 473	Objective 22 — Demonstrate the method for breaching an interior wall.
pp. 474-475	Objective 23 — Demonstrate the steps for disentangling from debris or wires.

III. SUMMARY AND REVIEW



A. Chapter Summary

1. The first priority at any structural fire is that of survival, both for the individual and of fellow firefighters.
2. In order to meet this goal firefighters must learn to size-up a situation, practice situational awareness, manage air supply, and remove victims to safety.
3. Firefighters also must know MAYDAY procedures, master self-rescue techniques, and be able to locate and rescue downed firefighters as part of a rapid intervention crew or team.

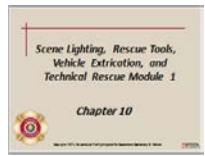
B. Review Questions

1. How do building construction and floor plans impact structural search techniques? (pp. 422-425)
2. What information can size-up and situational awareness provide during structural searches? (pp. 425-426)
3. What are five safety guidelines that should be followed during structural search and rescue? (pp. 426-427)
4. What are the main differences between primary and secondary search techniques? (pp. 430-431)
5. What is the general search method used during structural search? (pp. 431-435)
6. When is the appropriate time to use the oriented-search method, wide- area-search method, and thermal- imager-search method? (pp. 435-438)
7. What are the main differences in the three types of victim removal methods? (pp. 439-440)
8. What are the three behaviors firefighters must learn and follow to ensure their own survival and that of fellow firefighters? (p. 443)
9. How does a firefighter decide on the best survival action to take if a MAYDAY event does occur? (pp. 449-451)
10. When does a rapid intervention crew or team (RIC/RIT) begin work on an incident scene? (p. 454)

Chapter 10

Scene Lighting, Rescue Tools, Vehicle Extrication, and Technical Rescue

FF I Content



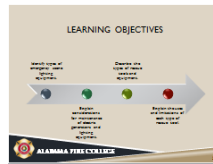
Lesson Goal

After completing this lesson, the student shall be able to identify emergency scene lighting equipment.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Identify types of emergency scene lighting equipment. [NFPA[®] 1001, 5.3.17]



Instructor Information

This is the lesson covering emergency scene lighting equipment.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture and discussion. The level of learning is comprehension.

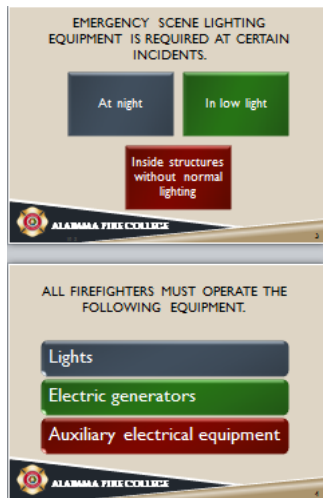
I. EMERGENCY SCENE LIGHTING EQUIPMENT

pp. 479-484

Objective 1 — Identify types of emergency scene lighting equipment.

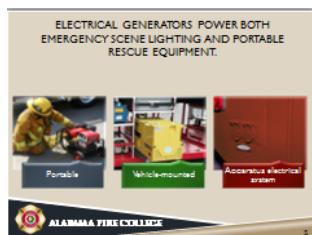
A. Emergency Scene Lighting Equipment

1. Required at all incidents that occur
 - a. At night
 - b. In low-light conditions
 - c. Inside structures where normal lighting not available
2. Equipment includes
 - a. Lights
 - b. Electrical generators
 - c. Auxiliary electrical equipment



B. Electric Generators

1. Power emergency scene lighting and portable rescue equipment
2. Most common power source used by emergency services personnel
3. Portable electric generators
 - a. Powered by small gasoline or diesel engines
 - b. Have 110- and/or 220-volt capacity outlets
 - c. Most light enough to be carried by two people
 - d. Useful when vehicle-mounted systems not available
4. Vehicle-mounted generators
 - a. Produce more power than portable units
 - b. Powered by gasoline, diesel, propane gas engines or hydraulic or power take-off (PTO) systems
 - c. Typically have 110- and 220-volt outlets, produce more than 50 kW of power
 - d. Disadvantages



- i. Noisy if equipped with a separate engine – Makes communication difficult
- ii. Exhaust fumes may contaminate scene if vehicle not positioned downwind

Instructor Note: Discuss the Safety Box “Hearing Protection is Required when Using Generators” on page 480 of the textbook. Emphasize with students the importance of wearing hearing protection.

5. Apparatus electrical system

- a. Used for small amounts of power needed to operate lights and tools
- b. Inverter converts 12- or 24-volt direct current (DC) into 110- or 220-volt alternating current (AC)
- c. Advantages – Fuel efficiency, minimal noise
- d. Disadvantages – Constant apparatus exhaust, limited power supply, and limited mobility

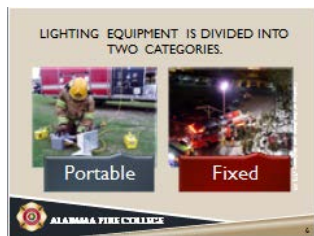
C. Lighting Equipment – Two categories

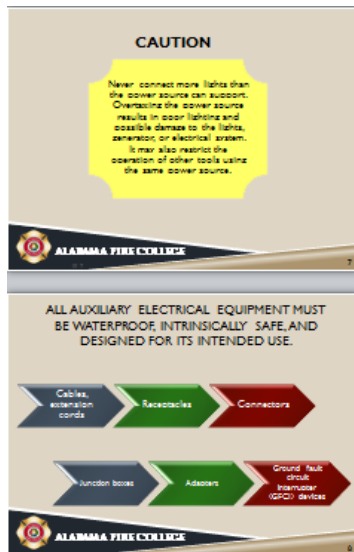
1. Portable lights

- a. Used in building interiors or remote areas of scene
- b. Range from 300 to 1,000 watts
- c. Typically have carrying handles and large bases for stability
- d. Some mounted on telescoping stands – Allows them to be raised and directed more effectively

2. Fixed lights

- a. Mounted on vehicle, wired directly to vehicle-mounted generator or apparatus electrical system
- b. Used to provide overall lighting of scene
- c. Usually mounted on telescoping poles – Can be raised, lowered, or rotated
- d. Some consist of large banks of lights mounted on hydraulically operated booms – Generally have capacity of 500 to 1,500 watts per light
- e. Number of units mounted on apparatus limited by amount of power produced by vehicle-mounted generator or apparatus electrical system

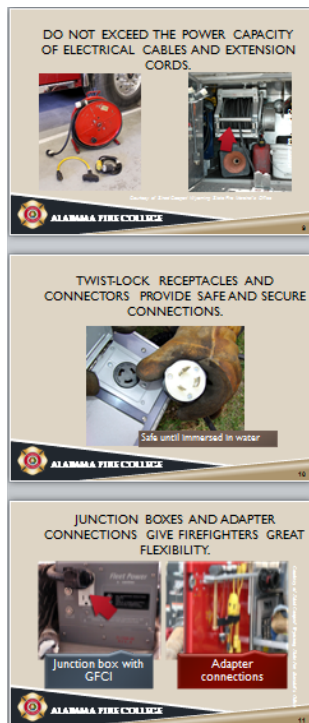




CAUTION: Never connect more lights than the power source can support. Overtaxing the power source results in poor lighting and possible damage to the lights, generator, or electrical system. It may also restrict the operation of other tools using the same power source.

D. Auxiliary Electrical Equipment

1. Consists of following
 - a. Electrical cables
 - b. Extension cords
 - c. Receptacles
 - d. Connectors
 - e. Junction boxes
 - f. Adapters
 - g. Ground fault circuit interrupter (GFCI) devices
2. Must be waterproof, intrinsically safe, and designed for amount of electrical current intended to carry
3. Electrical cables and extension cords
 - a. Can only carry limited amount of electricity
 - b. Do not use with equipment whose power demands exceed cord capacity – Creates electrical hazard, can damage equipment
 - c. May be stored in coils, on portable cord reels, or on apparatus-mounted automatic rewind reels
 - d. Should have adequate insulation, and no exposed wires
4. Twist-lock receptacles and connectors equipped with grounding wires – Provide secure, safe connections as long as not immersed in water
5. Junction boxes
 - a. Provide multiple outlets or connections supplied through one inlet from power source
 - b. All outlets must be equipped with ground fault circuit interrupter (GFCI) devices, must meet requirements of NFPA[®] 70E



6. Adapter connections

- a. Used to permit different types of plugs and receptacles to be connected together
- b. Allow mutual aid departments to operate electrical lights and tools off each other's generators and power sources
- c. May also allow fire department lights and tools to be plugged into standard electrical outlets in structures

Review Question: What types of emergency scene lighting equipment can be used rescue incidents?
See pages 479-484 of the textbook for answers.

Chapter 10

Scene Lighting, Rescue Tools, Vehicle Extrication, and Technical Rescue

FF II Content

Lesson Goal

After completing this lesson, the student shall be able to maintain extrication and rescue tools and equipment. The student shall also be able to perform basic vehicle extrication skills as well as describe the role of a Firefighter II in supporting specialized technical rescue teams.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain considerations for maintenance of electric generators and lighting equipment. *[NFPA[®] 1001, 6.4.2, 6.5.4]*
2. Describe the types of rescue tools and equipment. *[NFPA[®] 1001, 6.4.2, 6.5.4]*
3. Explain the uses and limitations of each type of rescue tool. *[NFPA[®] 1001, 6.4.1, 6.4.2, 6.5.4]*
4. Identify the role of a fire department during vehicle extrication. *[NFPA[®] 1001, 6.4.1]*
5. Describe safety considerations that must be identified and mitigated during vehicle extrication. *[NFPA[®] 1001, 6.4.1]*
6. Explain the use of cribbing material during vehicle extrication. *[NFPA[®] 1001, 6.4.1]*
7. Describe the methods used for gaining access to victims during vehicle extrication. *[NFPA[®] 1001, 6.4.1]*
8. Explain the role a Firefighter II will play in technical rescue operations. *[NFPA[®] 1001, 6.4.2]*
9. Describe the various types of technical rescue operations. *[NFPA[®] 1001, 6.4.2]*
10. Explain the unique hazards associated with each type of technical rescue operation. *[NFPA[®] 1001, 6.4.2]*
11. Demonstrate the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment. *[NFPA[®] 1001, 6.5.4]*
12. Prevent horizontal movement of a vehicle using wheel chocks. *[NFPA[®] 1001, 6.4.1]*
13. Stabilize a vehicle using cribbing. *[NFPA[®] 1001, 6.4.1]*
14. Stabilize a vehicle using lifting jacks. *[NFPA[®] 1001, 6.4. 4]*

15. Stabilize a vehicle using a system of ropes and webbing. *[NFPA[®] 1001, 6.4.1]*
16. Stabilize a side-resting vehicle using a buttress tension system. *[NFPA[®] 1001, 6.4.1]*
17. Remove a windshield in an older model vehicle. *[NFPA[®] 1001, 6.4.1]*
18. Remove a tempered glass side window. *[NFPA[®] 1001, 6.4.1]*
19. Remove a roof from an upright vehicle. *[NFPA[®] 1001, 6.4.1]*
20. Remove a roof from a vehicle on its side. *[NFPA[®] 1001, 6.4.1]*
21. Displace the dashboard. *[NFPA[®] 1001, 6.4.1]*

Instructor Information

This is the lesson covering extrication and rescue tools and equipment. This lesson describes the types and uses for various extrication and rescue tools and equipment. The lesson explains how to perform basic extrication methods and what the role of the Firefighter II is during specialized technical rescue operations.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

II. MAINTENANCE OF ELECTRIC GENERATORS AND LIGHTING EQUIPMENT

pp. 484-486

Objective 1 — Explain considerations for maintenance of electric generators and lighting equipment.

A. Must follow manufacturer's instructions and department SOPs



1. Inspect generators, lighting units, and lighting accessories periodically also after each use
2. Review manufacturer's service manual for specific directions
3. Carefully inspect spark plugs for damage, visible corrosion, carbon accumulation, or cracks in porcelain – Make sure spark plug wire is tight
4. Replace spark plug if it is damaged or if the service manual recommends replacement
 - a. Ensure proper gap prior to installing
 - b. Replace any plug with signs of arcing, indicated by presence of carbon soot around ground electrode
5. Check the generator carburetor and identify any signs of fuel leaks
6. Check fuel level, and refill as needed
7. Visually inspect fuel in tank to ensure not contaminated – Discard contaminated fuel in approved manner
8. Check oil level and refill as needed
9. Start generator and run tests required in service manual
 - a. If problem is found with generator, consult manual to determine proper action
 - b. Only qualified service personnel or a licensed electrician should perform repair work on generator
10. Avoid starting generator while under a load (lighting or other equipment turned on and plugged in) – Can damage electrical system

11. Do not run generator for a long period of time without a load – Will overheat and damage generator
12. Inspect all electrical cords for damaged insulation, exposed wiring, or missing or bent prongs
13. Test operation of lighting equipment
 - a. Connect each light to generator one light at a time to prevent overloading
 - b. Avoid looking directly into lights when powered
14. Replace lightbulbs as necessary
 - a. Shut off power and allow bulb to cool before replacing
 - b. If bulb must be replaced immediately – Wear leather gloves to prevent being burned
 - c. Discard faulty bulbs in approved manner
15. Clean work area and return all tools and equipment to proper storage areas
16. Document maintenance on appropriate forms or records
17. Some types of equipment and maintenance are **NOT** responsibility of Firefighter II
 - a. Driver/operator typically inspects and maintains
 - i. Apparatus electrical systems
 - ii. Apparatus-mounted lights
 - iii. Generators
 - b. Detailed maintenance and modification must be performed by qualified technicians

Review Question: What types of tasks may be required to maintain electric generators and lighting equipment?
See pages 484-486 of the textbook for answers.

III. RESCUE TOOLS

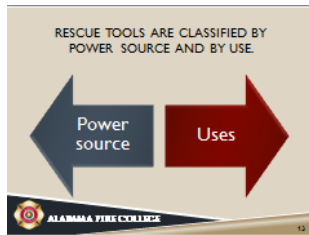
pp. 486-504

Objective 2 — Describe the types of rescue tools and equipment.

Objective 3 — Explain the uses and limitations of each type of rescue tool.

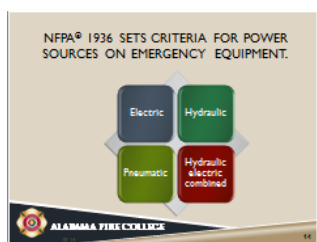
A. Rescue Tools

1. Classified based on power source and use
2. Power sources – Manual or power-operated
3. Uses
 - a. Cutting – Removing materials or debris to free victim
 - b. Stabilizing – Ensuring that vehicle or structural member will not move during rescue
 - c. Lifting – Raising vehicle, vehicle component, or structural member off victim or raising victim out of space
 - d. Pulling – Dragging away materials to free victim
 - e. Other Activities – Securing materials in place or breaking up materials to free victim



B. Power Sources

1. May be electric, hydraulic, pneumatic, or hydraulic and electric combined
2. Criteria established in NFPA[®] 1936
3. Tool capabilities vary depending on manufacturer and power source
4. Electric
 - a. Types – Rechargeable batteries, apparatus electrical systems, and portable or vehicle-mounted generators
 - b. Advantages
 - i. Power source readily available at incident scene
 - ii. Lightweight



- iii. Portable when battery powered – Do not require electric power cord or cable
- c. Battery powered disadvantage – May be less powerful
- d. Rechargeable batteries
 - i. Always follow manufacturer's recommendations for maintaining
 - ii. Keep fully charged
 - iii. Dispose if damaged or unable to hold charge
 - iv. Some need to be completely discharged periodically to ensure they can maintain full charge

5. Hydraulic

- a. Most powered rescue tools powered by hydraulic pumps
- b. Pumps
 - i. May be operated by hand, electric motor or gasoline engine
 - ii. May be portable, carried with tool, or mounted on vehicle, and connected through hose reel line
- c. Inspect regularly
 - i. Ensure hoses and connections do not leak
 - ii. Ensure connections are clean and work properly
- d. Leave all maintenance to qualified personnel

Instructor Note: Discuss SAFETY BOX on page 488 with students. Discuss what types of equipment exists in your jurisdiction that could cause these injuries.

6. Pneumatic

- a. Powered by pressurized air from compressed air cylinders – SCBA cylinders, vehicle-mounted cascade systems, portable or vehicle-mounted air compressors
- b. SCBA cylinder power requires adequate quantity of cylinders on hand to meet tool's high demand
- c. Follow manufacturer's recommendations for general care and inspection

- d. All maintenance must be performed by qualified personnel

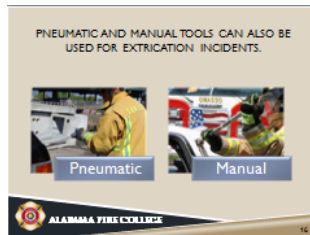
Review Question: What are the main uses of rescue tools?
See pages 486-504 of the textbook for answers.



C. Powered Rescue Tools – Four basic types of hydraulic and electric powered

1. Spreaders
 - a. First powered hydraulic tool used in fire service
 - b. Used for pushing and pulling when combined with chains and adapters
 - c. Produce tremendous force at tips, may spread as much as 32 inches (800 mm) apart
2. Shears
 - a. Can cut almost any metal object that fits between blades
 - b. Used to cut plastics, wood, other materials
 - c. Blades typically have opening spread of approximately 7 inches (175 mm)
3. Combination spreader/shears
 - a. Has removable spreader tips that can be replaced with set of shears
 - b. Excellent for small rapid-intervention vehicle or departments with limited resources
 - c. Is less expensive than individual tools – Cannot cut or spread as forcefully as individual units
4. Extension rams
 - a. Designed primarily for pushing, but can be used for pulling
 - b. Typically used when objects must be pushed farther than maximum opening distance of hydraulic spreaders

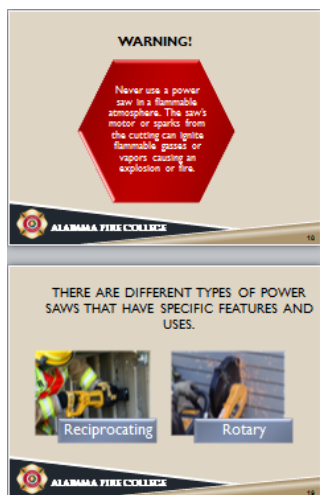
- c. Largest can extend from closed length of 3 feet (1 m) to extended length of nearly 5 feet (1.5 m)
- d. Opening force used for pushing is about twice as powerful as closing force used for pulling
- 5. Currently only one available electric powered tool system – Lightweight and compact, not as powerful as hydraulic
- 6. Pneumatic and manual rescue tools
 - a. Used for lifting, pushing, pulling, hammering, chiseling, and cutting
 - b. Lightweight, inexpensive, more portable than electric and hydraulic tools
 - c. Slower, less powerful, and more labor-intensive
 - d. Most are vehicle repair tools adapted to fire service use



D. Cutting Tools

- 1. Used to cut material away from trapped victim
- 2. Most are power saws
 - a. Faster and easier to handle than powered shears
 - b. More powerful – Some exotic metals can only be cut by saw
 - c. Can be gasoline, electric, or battery powered

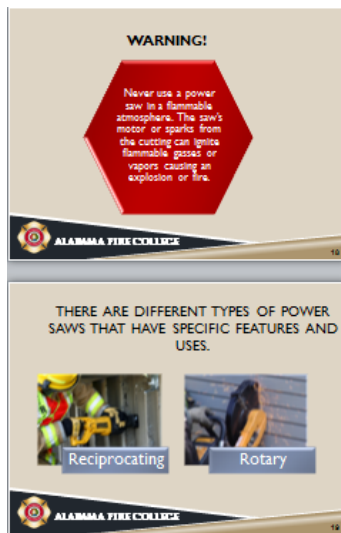
WARNING! Never use a power saw in a flammable atmosphere. The saw's motor or sparks from the cutting can ignite flammable gasses or vapors causing an explosion or fire.



- 3. Reciprocating saw
 - a. Powerful, versatile, and highly controllable
 - b. Has short, straight blade that moves in and out, like handsaw
 - c. Can use variety of blades for cutting different materials
 - d. When equipped with metal-cutting blade – Ideal for cutting sheet metal body panels and structural components on vehicle

4. Rotary saw

- a. Typically gasoline powered, with different blades for cutting wood, metal, and masonry
- b. Large-toothed blades used to make quick, rough cuts; fine-toothed blades used for precision cutting
- c. Blades with carbide-tipped teeth less prone to dulling
- d. Blades can spin up to 6,000 revolutions per minute (rpm)



WARNING! Never use a rotary saw to cut the shell of a flammable liquid or gas storage tank. Sparks can ignite flammable vapors.

5. Circular saw – Versatile, lightweight, easy to handle; small battery-powered available

6. Whizzer saw

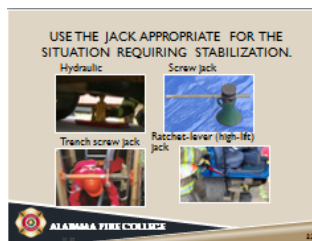
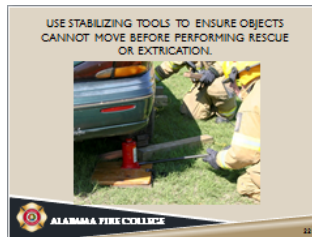
- a. Weighs about one-tenth as much as circular saw – 2 pounds (0.9 kg)
- b. Quiet, highly portable, and easy to handle
- c. Often used for delicate cutting operations – Removing rings from swollen fingers
- d. 3-inch (75 mm) Carborundum[®] blade cuts through case-hardened locks and up to ¾ inch (20 mm) of steel
- e. Has clear Lexan[®] blade guard to protect operator and victim
- f. Driven by compressed air at 90 psi (630 kPa) from SCBA cylinder with regulator; will run approximately three minutes on full air cylinder

7. Air chisel

- a. Pneumatic powered, operate at pressures between 90 and 250 psi (630 and 1 750 kPa)
- b. Bits available for cutting, breaking locks, and driving in plugs
- c. Used to cut medium- to heavy-gauge sheet metal, remove rivets and bolts

- d. Follow manufacturer's recommendations for general maintenance, keeping cutting tips sharp

E. Stabilizing Tools



1. Must ensure scene is stabilized before beginning rescue or extrication
2. Vehicle, object, structural component, and trench wall must not be able to move – Can cause injury to victim or rescuer if it does
3. Placing jacks
 - a. Should always be placed on flat, level surface
 - b. If must be on soft surface – Place solid base of cribbing, flat board, or steel bearing plate under to prevent sinking
4. Hydraulic jack – Designed for heavy lifting, used for stabilization in conjunction with cribbing; read manual to determine weight capacity
5. Nonhydraulic jack – Much less powerful than hydraulic jacks
 - a. Screw jacks – Extended or retracted by turning threaded shaft; use male-threaded stem (similar to bolt) and female-threaded component
 - i. Bar screw jacks – Typically used to support collapsed structural members
 - (a) *Not normally used for lifting*
 - (b) *Primary use to hold object in place*
 - (c) *Shaft turned with long bar inserted through hole in top of shaft*
 - ii. Trench screw jacks – Durable, inexpensive, easy to use and replace wooden cross braces during trench rescue
 - (a) *Has two swivel footplates – First has stem inserted into a section of 2-inch (50 mm) steel pipe up to 6 feet (2 m) long; second has threaded stem inserted into other end of pipe*
 - (b) *Adjusting nut with handles on threaded stem turned to vary length of jack and tighten between opposing members in shoring or stabilizing system*

- b. Ratchet-lever jack – Also known as high-lift jacks
 - i. Primarily used for stabilization and lifting; may be modified for pushing or pulling
 - ii. Least stable of all types of jacks; if load shifts jack can fall over
 - iii. Prone to failure under heavy loads; sometimes release if less than 100 pounds (45.36 kilograms) is resting on tongue
 - iv. Consist of rigid I-beam with perforations along side and jacking carriage that fits around I-beam

(a) Geared side has two ratchets

(b) One holds carriage in position; other works with lever to move carriage up or down



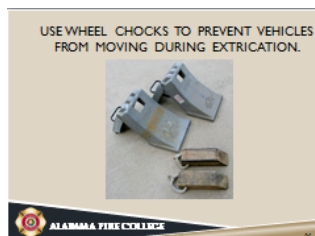
WARNING! Never work under a load supported only by a jack. If the load shifts or the jack fails, you can be severely injured, or even killed. Loads should always be supported by properly placed cribbing. Live by the saying “lift an inch, crib an inch.” As the jack lifts the load one inch (25 mm), add one inch (25 mm) of cribbing.

6. Buttress tension system

- a. Used to stabilize vehicle resting on side or top
- b. May be minimum of three 4 x 4 inch (101 by 101 mm) posts wedged between ground and vehicle; may be commercial system composed of metal rods and straps
- c. Two posts placed on bottom of vehicle, one placed on top
- d. Placement determined by condition and weight of vehicle, stability of soil, and condition of victims
- e. Purpose of system is to prevent vehicle from moving or tipping over during extrication

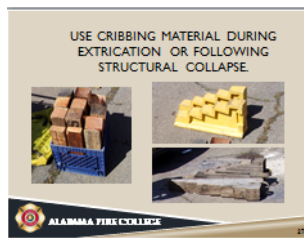
7. Wheel chocks

- a. Prevent emergency vehicles from moving when parked
- b. Placed against downhill side of rear tires – Can hold vehicle in place on 10 to 15 percent grade
- c. During extrication – Can stabilize vehicles involved in accidents



- d. Constructed of aluminum, hard rubber, wood, and urethane plastic
- e. Designed to resist corrosion from oils, fuels, and solvents
- f. Typically have pad or traction cleat on bottom; as well as handles, ropes, or grab holds to make easier to carry
- g. Must comply with NFPA[®] 1901, NFPA[®] 1906, Society of Automotive Engineers standard SAE-J348

8. Cribbing materials



- a. Used to stabilize vehicle during extrication or stabilize debris following structural collapse
- b. Consists of wooden or plastic blocks 16 to 36 inches (400 mm to 900 mm) long; typically measure 2 x 4 inches (50 mm by 100 mm), 4 x 4 inches (100 mm by 100 mm), and 6 x 6 inches (150 mm by 150 mm)
- c. Block ends may be painted to indicate length
- d. Flat surface never painted – Can hide defects and cause surface to be slippery when wet
- e. Individual blocks may have rope or webbing handle stapled to end – Can be easily carried or safely removed from under objects
- f. Can be locally constructed or commercially purchased
- g. Wooden – Made from construction grade lumber
- h. Plastic
 - i. Preferred – It is lighter and lasts longer
 - ii. Cannot be contaminated by absorbing fuel, oil, and other substances
 - iii. Disadvantage – May slip under wet conditions

Review Question: What are some common limitations of rescue tools?

See pages 486-504 of the textbook for answers.

F. Lifting Tools

1. Used to lower rescuers, remove object from trapped victim, or lift victim out of hole or confined-space

2. Tripods

- a. Used to create anchor point above manhole or opening
- b. Allows rescuers to be safely lowered into confined-spaces and rescuers/victims to be hoisted out

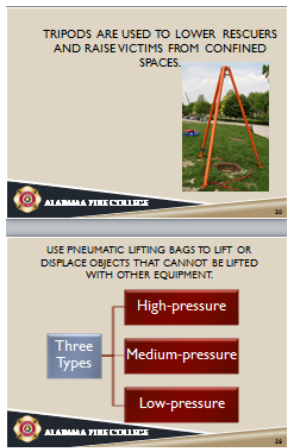
3. Pneumatic lifting bags

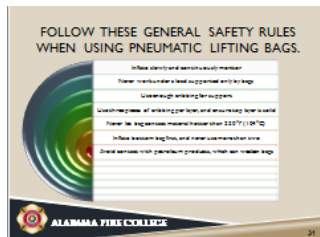
- a. Air-pressurized devices that give rescuers ability to lift or displace objects that cannot be lifted with other equipment; made in three basic types
- b. High-pressure bags
 - i. Constructed from tough, neoprene rubber exterior reinforced with steel wire or KevlarTM Aramid fiber
 - ii. Deflated – Lie completely flat, about 1 inch (25 mm) thick
 - iii. Surface area ranges from 6 x 6 inches (150 mm by 150 mm) to 36 x 36 inches (900 mm by 900 mm); inflate to height of 20 inches (500 mm)
 - iv. Loses stability and lifting power as it inflates
- c. Low- and medium-pressure bags
 - i. Larger than high-pressure bags
 - ii. Inflate to greater height – Up to 6 feet (2 m)
 - iii. Used to lift and stabilize large vehicles or objects
 - iv. Most stable when fully inflated

- d. Lifting bag safety rules

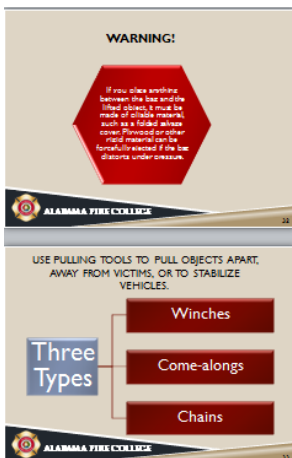
- e. Always plan lifting operation before you begin – Make sure you have adequate air supply and sufficient cribbing materials

- i. Be familiar with equipment's operating principles, methods, capabilities, and limitations
- ii. Follow manufacturer's recommendations for specific system used
- iii. Keep all components in good operating condition





- iv. Make sure all safety seals are in place
- v. Position bag on or against solid surface
- vi. Keep sharp objects away from bag as it inflates
- vii. Never inflate a bag without load
- viii. Inflate slowly and continually monitor load for signs of shifting
- ix. Never work underneath load supported only by air bags
- x. Use enough cribbing to support load in case of bag failure
- xi. Use at least three pieces of cribbing per layer, make sure top layer is solid – Openings in center of cribbing may cause bag to shift or rupture
- xii. Never let bag contact materials hotter than 220°F (104°C)
- xiii. When stacking bags, inflate bottom bag first and put smaller bag on top; never stack more than two bags; single, multi-cell bags are more effective
- xiv. Fuel and other petroleum products can weaken bags and shorten working life – Never store, use, or place bag in area where contact may occur



WARNING!: If you place anything between the bag and the lifted object, it must be made of pliable material, such as a folded salvage cover. Plywood or other rigid material can be forcefully ejected if the bag distorts under pressure.

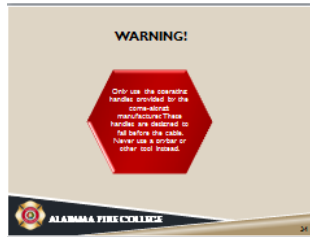
G. Pulling Tools

1. Used to pull vehicles apart, pull object away from trapped victim, and stabilize vehicle resting over edge
2. Winches
 - a. Typically mounted on front, rear, side of vehicle
 - b. Stronger, faster to deploy, have greater travel or pulling distance than other pulling devices
 - c. Powered by electric or hydraulic motor or PTO system
 - d. Used in conjunction with chains and/or cables

- e. Cables made from steel or synthetic fiber
 - i. Steel cable
 - (a) *Made from thin strands of wire wound together*
 - (b) *Durable and long lasting*
 - (c) *Heavy and rigid, and difficult to handle*
 - ii. Synthetic fiber cable
 - (a) *Lighter, stronger than steel*
 - (b) *Floats in water, resists ultraviolet light, not affected by temperature variations*
 - (c) *Does not recoil or whip like steel if it breaks, safer to use*
- f. Handheld remote-control devices allow operator to stand outside danger zone
- g. Danger zone – Area on either side of winch cable where cable can whip around if it breaks
- h. Position as close as possible to object being pulled so if it breaks there is less recoil
- i. Inspect cables regularly – Can develop memory on coil; vehicle vibrations can cause to fray

Instructor Note: Discuss SAFETY BOX “Reducing Danger During Winch Operations” on page 500 with students. Discuss how the SOPs in your jurisdiction can help prevent these dangers.

- 3. Come-alongs
 - a. Portable cable winches operated by manual ratchet lever
 - b. Must be attached to secure anchor point, then cable attached to object to be pulled
 - c. Use ratchet lever to rewind cable, pulling object back to anchor point
 - d. Typically have load capacity ranging from 1 to 10 tons (0.9 t to 9.1 t)



WARNING!: Only use the operating handles provided by the come-along's manufacturer. These handles are designed to fail before the cable. Never use a prybar or other tool instead.

4. Chains

- a. Used in conjunction with winches and come-alongs
- b. Two main types – Alloy steel chain and proof coil chain, known as common or hardware chain
- c. Only use alloy steel in rescue operations – Designed to resist abrasion, corrosion, and effects of hazardous substances

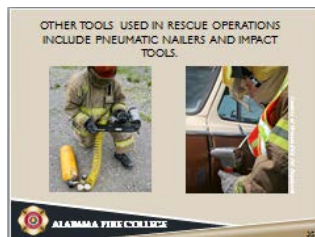
H. Tools Used in Other Activities

1. Pneumatic nailers

- a. Used to drive nails or heavy-duty staples into wood
- b. Useful for nailing wedges and other wooden components of cribbing systems into place or securing canvas or vinyl covers over roof openings

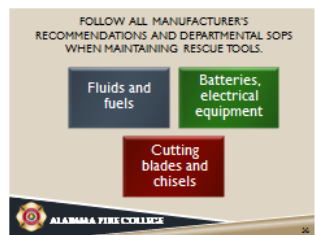
2. Impact tools

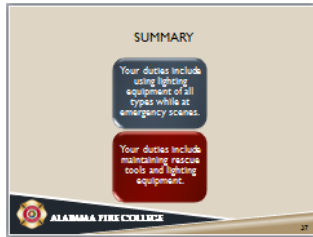
- a. Have square drive onto which socket is attached – Socket then applied to nut or bolt head of same size to tighten or loosen quickly
- b. Ideal for disassembling machinery in which victim is entangled



I. Rescue Tool Maintenance – Follow manufacturer's recommendations, departmental SOPs, and general guidelines

1. Check all fluid levels
2. Use only recommended types of lubricants, hydraulic fluids, and fuel grades
3. Keep battery packs fully charged
4. Inspect power tools at beginning of each work shift and make sure they start
5. Inspect saw, chisel, and cutter blades regularly – Replace blades that are worn or damaged



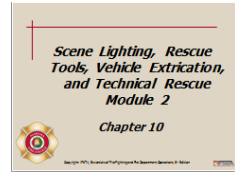


6. Check all electrical components, such as cords and portable receptacles, for cuts or other damage
7. Make sure all protective guards are functional and in place
8. Make sure that fuel is fresh – Mixture may separate or degrade over time
9. Inspect hydraulic and fuel supply hoses for damage
10. Inspect hydraulic hose couplings (quick disconnect fittings) to ensure they are clean and functional
11. Make sure all parts and support items are easily accessible

Chapter 10

Scene Lighting, Rescue Tools, Vehicle Extrication, and Technical Rescue

FF II Content



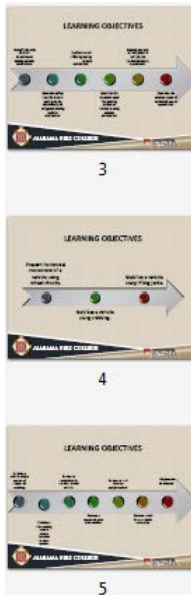
Lesson Goal

After completing this lesson, the student shall be able to maintain extrication and rescue tools and equipment. The student shall also be able to perform basic vehicle extrication skills as well as describe the role of a Firefighter II in supporting specialized technical rescue teams.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain considerations for maintenance of electric generators and lighting equipment. *[NFPA® 1001, 6.4.2, 6.5.4]*
2. Describe the types of rescue tools and equipment. *[NFPA® 1001, 6.4.2, 6.5.4]*
3. Explain the uses and limitations of each type of rescue tool. *[NFPA® 1001, 6.4.1, 6.4.2, 6.5.4]*
4. Identify the role of a fire department during vehicle extrication. *[NFPA® 1001, 6.4.1]*
5. Describe safety considerations that must be identified and mitigated during vehicle extrication. *[NFPA® 1001, 6.4.1]*
6. Explain the use of cribbing material during vehicle extrication. *[NFPA® 1001, 6.4.1]*
7. Describe the methods used for gaining access to victims during vehicle extrication. *[NFPA® 1001, 6.4.1]*
8. Explain the role a Firefighter II will play in technical rescue operations. *[NFPA® 1001, 6.4.2]*
9. Describe the various types of technical rescue operations. *[NFPA® 1001, 6.4.2]*
10. Explain the unique hazards associated with each type of technical rescue operation. *[NFPA® 1001, 6.4.2]*
11. Demonstrate the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment. *[NFPA® 1001, 6.5.4]*
12. Prevent horizontal movement of a vehicle using wheel chocks. *[NFPA® 1001, 6.4.1]*
13. Stabilize a vehicle using cribbing. *[NFPA® 1001, 6.4.1]*
14. Stabilize a vehicle using lifting jacks. *[NFPA® 1001, 6.4. 4]*



15. Stabilize a vehicle using a system of ropes and webbing. *[NFPA[®] 1001, 6.4.1]*
16. Stabilize a side-resting vehicle using a buttress tension system. *[NFPA[®] 1001, 6.4.1]*
17. Remove a windshield in an older model vehicle. *[NFPA[®] 1001, 6.4.1]*
18. Remove a tempered glass side window. *[NFPA[®] 1001, 6.4.1]*
19. Remove a roof from an upright vehicle. *[NFPA[®] 1001, 6.4.1]*
20. Remove a roof from a vehicle on its side. *[NFPA[®] 1001, 6.4.1]*
21. Displace the dashboard. *[NFPA[®] 1001, 6.4.1]*

Instructor Information

This is the lesson covering extrication and rescue tools and equipment. This lesson describes the types and uses for various extrication and rescue tools and equipment. The lesson explains how to perform basic extrication methods and what the role of the Firefighter II is during specialized technical rescue operations.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

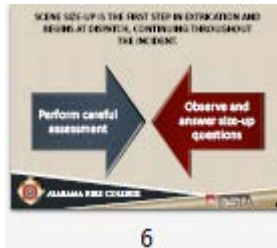
I. VEHICLE EXTRICATION

pp. 504-512

Objective 4 — Identify the role of a fire department during vehicle extrication.

A. Scene Size-Up

1. First step of extrication – Begins during dispatch, and continues throughout incident
2. Careful assessment needed to
 - a. Prevent injury to rescuers
 - b. Prevent further injuries to victims
 - c. Identify potential hazards
 - d. Clarify required tasks
 - e. Identify needed resources
3. Observe and answer the following questions
 - a. What are the traffic hazards, and what types of traffic control devices are needed?
 - b. How many and what types of vehicles are involved?
 - c. What type of fuel or power system (hybrid or electric) do the vehicles use?
 - d. Where and how are the vehicles positioned?
 - e. Are the vehicles located on the roadway?
 - f. How many victims are there, and what is their status?
 - g. Is there a fire or potential for a fire?
 - h. Is there a fuel or fluid leak? What control methods need to be implemented?
 - i. Are there any hazardous materials involved?
 - j. Are there any utilities, such as water, gas, electricity or downed power lines, that may have been damaged? If so, do they pose a hazard to victims or rescuers?
 - k. Is there a need for additional resources?
4. Controlling hazards – Reduce risk of injury by following proper safety procedures



a. Primary hazard – Traffic

- i. Park apparatus to form protective barrier between scene and ongoing traffic from all directions
- ii. Deploy signs and cones to detour traffic around scene – Law enforcement officers can provide additional traffic control
- iii. Maintain constant situational awareness
- iv. Keep an eye on traffic flow – Always stay within protective barrier
- v. Wear retroreflective vest at all times – Unless directly involved in fire fighting or extrication

WARNING! Before you dismount the apparatus, size-up the traffic flow and other scene conditions. Remember that drivers are often distracted by emergency vehicles and flashing lights.



b. Other hazards – Fire

- i. Extinguish open flames immediately if present
- ii. Isolate spilled fuels and other ignition sources before addressing other operational concerns
- iii. Other ignition sources include – Vehicle batteries, undeployed air bags, downed power lines, and energy-absorbing struts
- iv. Isolate hazards
 - (a) Disconnect vehicle batteries
 - (b) Deactivate undeployed air bags
 - (c) Cordon off downed power lines or ground level transformers
 - (d) Protect shock absorbers and struts from excessive heat and/or physical damage
 - (e) Avoid pyrotechnic seat belt pretensioners
- v. Hazards found in vehicle trunk and interior
 - (a) Flammable adhesives, pressurized solvents, or flammable liquids (such as gasoline)
 - (b) Illegal substances used to produce methamphetamine (meth)

(c) *Vehicle wheels and tires – Alloy wheels made with magnesium can burn with intense heat; high pressure tires can create explosion hazard*

(d) *Other vehicle components made with magnesium*

- (i) Valve covers
- (ii) Steering columns
- (iii) Mounting brackets on antilock braking systems
- (iv) Transmission casings
- (v) Engine blocks
- (vi) Frame supports
- (vii) Exterior body components

c. Other hazards – Bloodborne pathogens

- i. Bodily fluids from patient injuries can contaminate interior and exterior of vehicle
- ii. Follow bloodborne pathogen procedures; wear appropriate protective clothing and equipment
- iii. Boots and cuff of protective trousers can become contaminated – Avoid contaminants when removing; follow SOPs for decontamination

d. Other hazards – Sharp objects

- i. Broken glass and sharp metal create hazard during and after incident
- ii. Cover sharp edges with short sections of used fire hose, clear broken glass away from door sills and windshield edges, wear full personal protective clothing when performing extrication
- iii. Remove glass or metal shards embedded in boots following incident

e. Other hazards – Environmental conditions

- i. Be extra careful dismounting apparatus when roads are icy
- ii. Spread absorbent on ice until able to use sand or salt to help protect others

5. Vehicle fuel types – Determine type of fuel system during size-up

- a. Conventional and alternative fuels are easily ignitable



- i. Conventional fuels – Gasoline and diesel
- ii. Alternative fuels
 - (a) *Methanol*
 - (b) *Ethanol*
 - (c) *Reformulated gasoline*
 - (d) *Reformulated diesel (for trucks only)*
 - (e) *Natural gas*
 - (f) *Propane*
 - (g) *Hydrogen*
 - (h) *Electricity (including total electric and hybrid electric vehicles)*
 - (i) *Biofuels*
 - (j) *Coal-derived liquid fuels*
 - (k) *Alcohol blended with other fuels*
- b. Leaks from fuel lines and tanks must be controlled; fire protection must be established to prevent ignition of vapors
- c. Minimal protection – Single firefighter standing by with portable extinguisher
- d. May be necessary to activate foam-generating systems and deploy several charged lines
- e. Follow department SOPs – At least one 1½ inch (38 mm) hoseline should be charged and ready to use
- f. Electrically powered vehicles classified as total electric vehicles (EV) or hybrid electric vehicles (HEV)
 - i. EV – Relatively short driving range; powered by bank of batteries that must be plugged into charging station
 - ii. HEV – Powered by multiple propulsion systems

6. Vehicle electrical systems



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- a. System in conventional fuel vehicles designed to store and deliver electricity needed to start engine, power and operate various electrical components
 - i. Composed of
 - (a) Battery to store electricity
 - (b) Alternator that produces electricity
 - (c) Wiring
 - (d) Fuses that protect electrical system
 - (e) Lights, fans, and other ancillary equipment
 - ii. Use either 12- or 24-volt system
- b. System in electric and hybrid vehicles
 - i. Danger is high voltage stored within batteries, running through wiring connected to electric motor
 - ii. Wires can carry as much as 650 volts of direct current (DC)
 - iii. HEVs can be identified by nameplate or logo
 - iv. Personnel attempting to isolate electrical power system and batteries are exposed to danger of electrical shock
 - v. Most hybrid vehicles have color-coded wiring – Orange and covered with orange shielding or tape
 - vi. 36-volt system on Saturn color-coded blue – Classified as intermediate voltage



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Instructor Note: Point out to students the “Vehicle Voltage Chart” on page 511; discuss how this information could be useful during extrication.

B. Assessing the Need for Extrication

1. In immediate area around vehicle – One crew member will
 - a. Assess condition and position of vehicles
 - b. Determine extrication tasks that may be required
 - c. Note any hazardous conditions

2. On the entire scene – Other crew member will check
 - a. Other involved vehicles that may not be visible
 - b. Victims who might have been ejected from vehicles
 - c. Damage to structures or utilities that may present hazard
 - d. Other circumstances that require special attention
 - e. Thermal imager (TI) can be helpful in locating ejected victims at night or in low light
3. Firefighter trained in emergency medical care will
 - a. Determine number of victims
 - b. Assess injuries
 - c. Assess extent of entrapment
4. Information helps incident commander (IC) determine resources needed to stabilize and order in which victims should be extricated
 - a. Seriously injured take higher priority than those with minor injuries
 - b. Remove those not trapped first to make more working room when trying to remove entrapped
5. Report information as each assessment is complete
6. Report should also include type of accident – Roll over, head-on, side impact, etc and other identifiers helpful when determining injuries

Review Question: What role does the fire department play in size-up and assessing the need for extrication after a motor vehicle accident?

See page 504 of the textbook for answers.

pp. 513-522



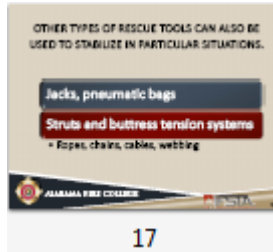
Objective 5 — Describe safety considerations that must be identified and mitigated during vehicle extrication.

Objective 6 — Explain use of cribbing during vehicle extrication.

C. Stabilizing the Vehicle

1. Use equipment to support key points between vehicle and ground
2. Goal – To prevent vehicle from moving unexpectedly; movement can cause severe injury to both victims and rescuers
3. Never move vehicle or attempt extrication until fully stabilized
4. Never place any part of body under vehicle while putting stabilizing devices in place
5. Using wheel chocks
 - a. Vehicle must be stabilized even with all wheels on the ground – Simple approach is to deflate tires
 - b. If deflating is insufficient or impossible – Chocking can accomplish same result
 - c. Chocking can be accomplished with standard apparatus wheel chocks, pieces of cribbing or other similar-sized objects
 - d. General wheel chock guidelines
 - i. Place chocks in front of and behind tires
 - ii. Place chocks on downhill side of vehicle on incline
 - iii. Place chocks on both sides of tires if ground is level or direction of grade undetermined
 - iv. Test and apply parking brake before placing chocks
 - v. Center chocks snugly and squarely against tread of each tire
 - e. If mechanical system operable – Use to supplement chocks
 - i. Shift automatic transmission to park; put manual transmission in first gear
 - ii. Turn ignition off, and engage parking or emergency brake
6. Using cribbing materials
 - a. Typically used in box formation
 - b. Can be placed under sides to prevent lateral movement



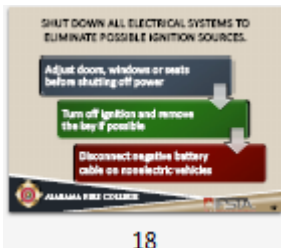


- c. Pieces typically pushed into position with mallet or another piece of cribbing
 - d. Wedges may be necessary to ensure solid contact between cribbing and vehicle
7. Using lifting devices – Lifting jacks and pneumatic lifting bags
- a. Used to
 - i. Raise vehicle on its roof or side
 - ii. Support frame of vehicle
 - iii. Gain access to interior by lifting object resting on vehicle
 - b. Lifting jack
 - i. Advantages – Can be adjusted to required height; may be inserted into tight space
 - ii. Disadvantages – Time-consuming to place; may limit access to vehicle; may shift, allowing vehicle to move
 - c. Pneumatic lifting bags
 - i. Used to temporarily stabilize vehicle
 - ii. Two bags needed to be effective – Positioned on either side of vehicle or one in front, one in rear
 - iii. Can be damaged or jarred loose – Solid cribbing must be used to supplement
8. Using struts and buttress tension systems
- a. Used when vehicles found upside down, on side, or on slope
 - b. Combination of cribbing, ropes, webbing, chains, winch cables can be used
 - i. Secure ropes, webbing, or chains between frame of vehicle and secure object
 - ii. May also use cable and winch on apparatus or tow truck – Be aware cable can be dangerous if breaks
 - iii. Ensure cables, chains, webbing, ropes, and winches have safety margin in excess of weight being secured
 - iv. Ropes and webbing need sufficient load capacity
 - c. Adjustable struts used when vehicle is on side

- i. Struts consist of square tube attached to base plate – Spreads vehicle load
 - ii. Lower end of tube houses another tube that telescopes out – Holes run down sides of both tubes, pin can be inserted to hold at desired length
 - iii. Space between top of tube and bottom of vehicle can be taken up with screw jack in end of tube
 - iv. May use 4 x 4 inch (100 mm by 100 mm) wood post in place of adjustable struts
- d. Buttress tension system
- i. Used to stabilize vehicles that are upside down or lying on side
 - ii. Use minimum of three buttress tension posts
 - iii. Place two on least stable side of vehicle
 - iv. Longest side of unit extends to a 50 to 70 degree angle from ground to high point on vehicle – Two tension straps extend from base of long leg to points on vehicle

D. Securing the Electrical System

1. Electrical system must be shut down to eliminate potential source of ignition
2. Newer vehicles – Power may activate restraint systems and cause injury
3. **Before** shutting off power
 - a. Lower power windows
 - b. Unlock power doors
 - c. Move power seats back only if victim's medical condition has been evaluated and it is safe to do so
4. Simplest method – Turn off ignition and remove key
5. If ignition not accessible use correct method depending on type of vehicle
6. Nonelectric vehicles
 - a. Those powered by conventional and alternative fuels

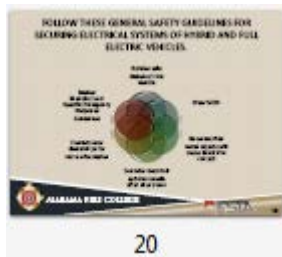


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- b. Disconnect or isolate negative cables to vehicle's 12-volt battery
- c. Cut negative first then positive
- d. Remove approximately 2 inches (50 mm) of each cable

7. Electric vehicles (fully electric and hybrid) –
General safety guidelines

- a. Always assume vehicle is powered-up despite lack of engine noise
- b. Place wheel chocks in front and behind tires to prevent unexpected vehicle acceleration
- c. Place transmission in park, turn off ignition, and remove key to disable high-voltage system
- d. Disconnect 12-volt electrical system in same way you disconnect battery in conventional vehicle – Cutting 12-volt negative and positive cables will isolate high voltage system
- e. Because vehicle can hold charge from capacitors that can cause it to start, remove key to safe distance of 25 feet (7.62 m)
- f. Stabilize vehicle to prevent unexpected air bag deployments
- g. Never touch, cut, or open any orange cables or components protected by orange shields – Orange cables and components contain high voltage charges
- h. Never touch, cut, or open any blue cables – Blue cables contain intermediate voltage charges
- i. Remain safe distance from vehicle if it is on fire
- j. Fire in high voltage battery pack of electric car will produce toxic fumes – Always wear SCBA during and after fire suppression
- k. Be aware that metal tools, metal buckles on personal protective equipment, and metal jewelry can cause electrical shock if in contact with an energized portion of vehicle



- l. Consider electrical system unsafe for at least 10 minutes after ignition has been shut down, and be aware that it may hold charge for up to 24 hours
- m. Contact local auto dealerships for more information about their electric and hybrid electric vehicles
- n. Review Manufacturer Specific Emergency Response Guidelines of common electric vehicles in response area

E. Passenger Safety Systems

1. Systems that pose immediate danger to victims and rescuers
 - a. Supplemental Passenger Restraint Systems (SPRS)
 - b. Side-Impact Protection Systems (SIPS)
 - c. Head Protection Systems (HPS)
 - d. Extendable Roll Over Protection Systems (ROPS)
2. Seat belts
 - a. Pretensioners
 - i. Lock belt during crash to prevent further travel
 - ii. Devices are pyrotechnic – If not disabled present ignition hazard
 - iii. Hidden inside B-post or center console; may be accessed by removing B-posts' interior trim
 - iv. Side-impact protection systems (SIPS) – Known as side curtain air bags also located in B-post area; never cut during extrication
 - b. To disable – Cut seat belt webbing, unbuckle, and retract seat belts

WARNING!: Never cut a cable or touch a component with yellow/black or orange tapes, insulation, or tags. Doing so may cause electrocution or activate undeployed air bags.



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- c. Deploy at up to 200 mph (322 km/h) – Generate potentially lethal force
- d. Always wear protective equipment and be extremely careful when working in and around
- e. Can still deploy after battery has been disconnected – Reserve energy lasts anywhere from 2 to 60 minutes; some have key-operated system to drain power

Instructor Note: Discuss the Safety Box “Safety Zone Distances” on page 520 with students. Point out how these general guidelines work in conjunction with the SOPs in your jurisdiction.

- f. SIPS restraints mechanically operated – Cannot be disabled by disconnecting battery
 - i. Cut connection between sensors and control unit; usually under dashboard or in center console
 - ii. Procedures vary depending on make and model

4. Head protection systems (HPS)

- a. Deploy from above top of door frame during side-impact collision
- b. Two main types
 - i. Window curtains – Automatically deflate shortly after deployment
 - ii. Inflatable tubes – Do not automatically deflate; must puncture and deflate tube
- c. Rescuers may be in deployment path when working through window
 - i. Danger can be mitigated by removing roof
 - ii. Be careful not to cut into high-pressure cylinders and other devices used in conjunction with HPS

5. Extendable Roll Over Protection Systems (ROPS)

- a. Designed to deploy automatically if vehicle rolls over
- b. Found behind front seat of small sports cars, in rear window deck of convertibles
- c. Stay in safe working position during operations
- d. Deploy rapidly when vehicle approaching angle of 62 degrees laterally, 72 degrees longitudinally, or achieves weightlessness for at least 80 milliseconds
- e. Also deploy if vehicle experiences 3G acceleration force or becomes weightless for at least 80 milliseconds
- f. Disable – Power down vehicle as soon as possible; may have to deploy intentionally to prevent from being hazard during extrication

Review Question: What safety considerations must be identified and mitigated during vehicle extrication operations?
See pages 505-511 of the textbook for answers.

pp. 522-530

Objective 7 — Describe the methods used for gaining access to victims during vehicle extrication.**F. Gaining Access to Victims**

1. Best method is simplest and fastest – Lengthier methods prolong suffering and are more dangerous for victims and rescuers
2. Seriously injured victims more likely to survive if they receive medical treatment quickly
3. Opening a normally operating door
 - a. Examine door closest to victim, and try to open normally
 - b. If you cannot – Try vehicle's other doors
 - c. Use tool to release locks if none open normally
4. Removing a window
 - a. Done to gain access to victims or reduce danger posed by remaining fragments of broken glass
 - b. Wear full protective equipment, including eye protection to protect against loose or flying glass
 - c. Protect occupants by covering with salvage cover or protective blanket
 - d. Removing safety glass
 - i. Consists of two glass sheets bonded to sheet of clear plastic between them
 - ii. Commonly used for windshields, rear windows
 - iii. Breaks into long, pointed shards on impact – Plastic laminate keeps most fragments in place
 - iv. Windshield is commonly used as a structural component,



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(a) Removing windshields no longer standard practice during extrication

(b) Seriously weakens vehicle body and may cause collapse

(c) Leave intact whenever possible



- v. More complicated and time-consuming than removing tempered glass
 - (a) *Does not disintegrate and fall out like tempered glass*
 - (b) *Extra layer of laminate makes harder to chop through*
 - (c) *Saws most effective for removing doubly laminated glass*
 - (d) *Other tools to remove standard safety glass – Axe, air chisel, hay hook, reciprocating saw, coarse blade handsaw, windshield cutter or glass saw*
- e. Removing tempered glass
 - i. Most commonly used in side and rear windows
 - ii. On impact small fractures spread throughout glass – Separates into many small pieces
 - iii. Eliminates long, pointed shards produced by shattered safety glass – Can create nuisance lacerations and enter eyes or open wounds
 - iv. Break lower corner of window with sharp, pointed object or spring-loaded center punch
 - v. Always use opposite hand to support hand holding center punch
 - (a) *Prevents you from putting hands through glass when it breaks*
 - (b) *Prevents center punch from hitting victim close to window*
 - vi. Also can break by driving non-spring-loaded center punch or Phillips screwdriver into window with hammer or mallet
 - vii. May also use Halligan tool or pick end of pick-head axe if nothing else available
 - viii. Most broken glass will drop straight down
 - (a) *Break window farthest from victim*
 - (b) *Cover victim with blanket or salvage cover before breaking*



ix. Contain glass with other materials

- (a) *Apply contact paper to window – Most of glass will stick to paper, allowing it to be removed as unit*
- (b) *Same effect gained by applying duct tape, then spraying glass with aerosol adhesive*
- (c) *May use duct tape to form handles to help carry or control broken glass*
- (d) *These methods require more time – Only use if time and patient care are not critical*

5. Prying a door open

- a. In older cars – Use lockout tool (known as Slim Jim) to disengage door lock
 - i. Tool is strip of metal approximately 24 inches (600 mm) long and $\frac{3}{4}$ to $1\frac{1}{2}$ inches (20 to 40 mm), notches cut into sides at one end
 - ii. Insert tool into door between window and sill; engage and release lock
- b. Spreader can be used to open or completely remove stuck door
 - i. Insert into crack on hinge side
 - ii. If outer door panel plastic – May have to remove panel to reach metal frame
 - iii. If interior molding plastic – Remove molding, check for curtain bag initiators or composite metal frames
- c. Other techniques
 - i. Cut hinges
 - ii. Break latch mechanism – Known as Nader pin
 - iii. Compromise door locks



6. Removing the vehicle roof

- a. In unibody construction removing roof and doors can seriously compromise structural integrity
- b. Always place step chock or other support under B-post of vehicle before removing roof
- c. Leave windshields, A-post, forward edge of roof intact – All contribute to structural integrity



- d. Cut roof just behind A-posts
- e. Remove roof by cutting remaining door posts and lifting entire roof off as unit
- f. Cut just below roof level to avoid cutting into seat belt pretensioners or side air bag gas cylinders
- g. Vehicle on its side – Gaining access through roof is effective
 - i. Use air chisel to make vertical cut in roof panel – Starting 6 inches (152 mm) from edge of windshield and moving toward ground
 - ii. Make similar vertical cut starting about 6 inches (152 mm) away from edge of rear window
 - iii. Make horizontal cut to connect top ends of vertical cuts – Flap down roof panel to expose headliner
 - iv. Cut headliner support struts with shears or bolt cutters
 - v. Use knife to cut same pattern as on roof if you need to remove headliner



G. Cutting Posts

1. Vehicle components made from case-hardened steel or exotic metals are lighter, stronger, result in greater fuel efficiency – Make them difficult to cut through
 - a. Hand tools cannot cut posts made from exotic metals
 - b. Reciprocating and rotary saws may cut through boron metal posts – But causes permanent damage to saw blade
 - c. May require specially designed shears to cut through
2. Roof support posts house seat belt pretensioners or side curtain air bags – Make sure you do not activate while cutting; remove interior trim before cutting

H. Displacing the Dashboard



1. Common after front-end collisions – When victims are pinned under steering wheel or wedged under dashboard
2. Roll or displace entire dashboard to extricate
3. Use method most appropriate based on tools, local SOPs, vehicle condition
 - a. After removing door, make relief cut in lower part of A-post
 - b. Position extension ram or hi-lift jack in doorway between B-post and side of dashboard
 - c. Insert cribbing or other supports under base of A-post on unibody vehicles; between frame and body on full-frame vehicles
 - d. Prevents the dashboard from returning to original position
 - e. Extract rescue tools once victims have been extricated
 - f. Procedure may be accomplished without removing windshield or flapping roof – Often by removing only one door
4. May be unnecessary or impossible in some cases
 - a. May be necessary to cut steering wheel post to extricate driver
 - b. May be cut to remove entire assembly if accessible
 - c. Steering column may also be lifted off victim by removing windshield – Placing hook or chain around column, using power lifting tool to raise straight up
5. Cutting steering wheel can be hazardous to victim and responders – Accidental deployment of air bag and spring action of wheel when cut



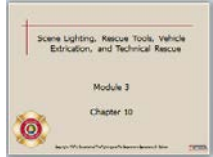
Review Questions: How can cribbing material be used during vehicle extrication?

See page 515 of the textbook for answers.

Chapter 10

Scene Lighting, Rescue Tools, Vehicle Extrication, and Technical Rescue

FF II Content



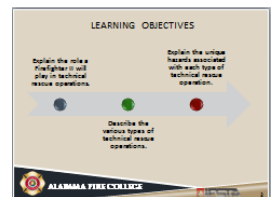
Lesson Goal

After completing this lesson, the student shall be able to maintain extrication and rescue tools and equipment. The student shall also be able to perform basic vehicle extrication skills as well as describe the role of a Firefighter II in supporting specialized technical rescue teams.

Objectives

Upon successful completion of this lesson, the student shall be able to:

1. Explain considerations for maintenance of electric generators and lighting equipment. *[NFPA® 1001, 6.4.2, 6.5.4]*
2. Describe the types of rescue tools and equipment. *[NFPA® 1001, 6.4.2, 6.5.4]*
3. Explain the uses and limitations of each type of rescue tool. *[NFPA® 1001, 6.4.1, 6.4.2, 6.5.4]*
4. Identify the role of a fire department during vehicle extrication. *[NFPA® 1001, 6.4.1]*
5. Describe safety considerations that must be identified and mitigated during vehicle extrication. *[NFPA® 1001, 6.4.1]*
6. Explain the use of cribbing material during vehicle extrication. *[NFPA® 1001, 6.4.1]*
7. Describe the methods used for gaining access to victims during vehicle extrication. *[NFPA® 1001, 6.4.1]*
8. Explain the role a Firefighter II will play in technical rescue operations. *[NFPA® 1001, 6.4.2]*
9. Describe the various types of technical rescue operations. *[NFPA® 1001, 6.4.2]*
10. Explain the unique hazards associated with each type of technical rescue operation. *[NFPA® 1001, 6.4.2]*
11. Demonstrate the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment. *[NFPA® 1001, 6.5.4]*
12. Prevent horizontal movement of a vehicle using wheel chocks. *[NFPA® 1001, 6.4.1]*
13. Stabilize a vehicle using cribbing. *[NFPA® 1001, 6.4.1]*
14. Stabilize a vehicle using lifting jacks. *[NFPA® 1001, 6.4. 4]*



15. Stabilize a vehicle using a system of ropes and webbing. *[NFPA[®] 1001, 6.4.1]*
16. Stabilize a side-resting vehicle using a buttress tension system. *[NFPA[®] 1001, 6.4.1]*
17. Remove a windshield in an older model vehicle. *[NFPA[®] 1001, 6.4.1]*
18. Remove a tempered glass side window. *[NFPA[®] 1001, 6.4.1]*
19. Remove a roof from an upright vehicle. *[NFPA[®] 1001, 6.4.1]*
20. Remove a roof from a vehicle on its side. *[NFPA[®] 1001, 6.4.1]*
21. Displace the dashboard. *[NFPA[®] 1001, 6.4.1]*

Instructor Information

This is the lesson covering extrication and rescue tools and equipment. This lesson describes the types and uses for various extrication and rescue tools and equipment. The lesson explains how to perform basic extrication methods and what the role of the Firefighter II is during specialized technical rescue operations.

Important instructor information is provided in shaded boxes throughout the lesson plan. Carefully review the instructor information before presenting the lesson.

Methodology

This lesson uses lecture, discussion, and skills practice. The level of learning is application.

I. TECHNICAL RESCUE INCIDENTS

pp. 531-549

Objective 8 — Explain the role a Firefighter II will play in technical rescue operations.

Objective 9 — Describe the various types of technical rescue operations.

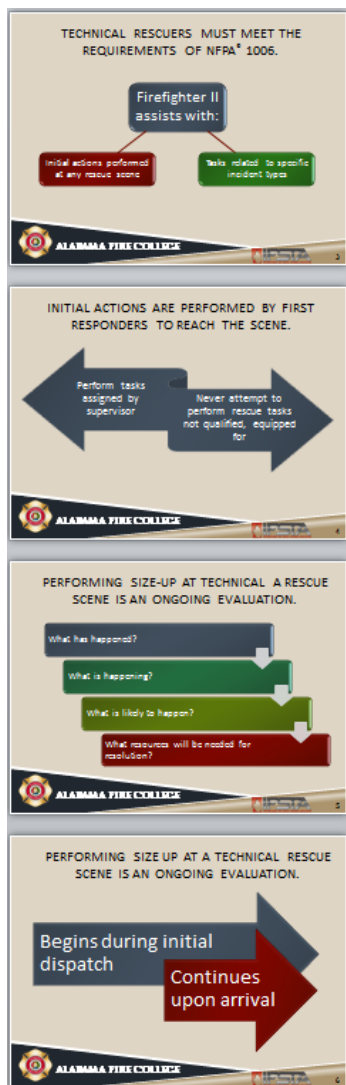
Objective 10 — Explain the unique hazards associated with each type of technical rescue operation.

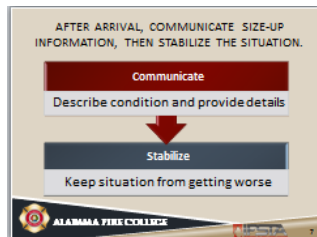
A. Technical Rescue Incidents

1. Technical rescuers must meet requirements of NFPA[®] 1006
2. Role of Firefighter II – To assist technical rescuers
 - a. Initial actions performed at any rescue scene
 - b. Tasks related to specific incident types

B. Initial Actions

1. Performed by first responders to reach scene
 - a. Tasks assigned by supervisor
 - b. Never attempt to perform rescue tasks for which you are not qualified or equipped
2. Size-up
 - a. On going evaluation
 - i. What has happened?
 - ii. What is happening?
 - iii. What is likely to happen?
 - iv. What resources will be needed to resolve the situation?
 - b. Begins during initial dispatch
 - i. Dispatcher relays – What has happened; including location, type of rescue, weather conditions, units dispatched, and possibly number of victims
 - ii. Information may be inaccurate when gathered from witnesses or victims
 - c. Upon arrival
 - i. Verify accuracy of dispatch report; note hazards

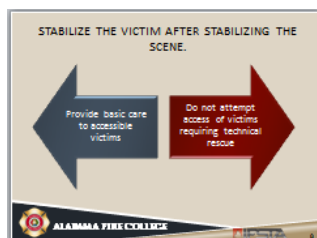




- ii. Assess what is likely to happen if no action is taken
- iii. Determine priority of actions that should be taken
- iv. Determine if additional resources must be dispatched

3. Communicate the information – Send to dispatch center and responding units

- a. Arrival report contains
 - i. Unit arriving on scene
 - ii. Correct address of incident if different from dispatch report
 - iii. Description of conditions found at scene
 - iv. Special considerations
 - v. Intended initial actions
 - vi. Water supply if needed
 - vii. Establishment of Command
 - viii. Any additional resources needed, including medical units
- b. Describe conditions so other fire crews know what to expect
- c. Provide details about barriers to access and victims in need of assistance
- d. State location of command post, and give description of initial actions
- e. Communications center will tell responding units to switch to specific radio frequency, if used for operation, during dispatch
- f. Transfer command when superior officer arrives – Provide description of observations and initial actions



4. Stabilize the situation

- a. Preventing situation from getting worse
- b. May involve
 - i. Blocking traffic
 - ii. Shutting off utilities
 - iii. Suppressing fires that can effect rescue operations

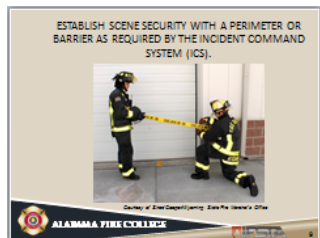
- c. Incidents with machinery may require equipment to stay on until an expert determines it is safe to shut down

5. Stabilize the victim

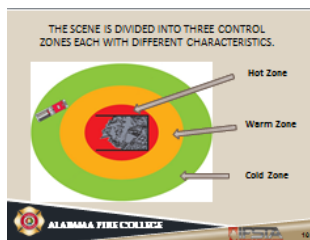
- a. Next priority after stabilizing scene – Provide basic patient care to accessible victims
- b. Do not put yourself at risk in attempt to access victim that will require qualified technical rescuer

6. Establish scene security

- a. Required by Incident Command System (ICS)
- b. Goals for perimeter or barrier
 - i. Provide a controlled work space
 - ii. Protect bystanders from hazards at incident
 - iii. Ensure use of personnel accountability system
 - iv. Ensure victims are accounted for
 - v. Protect evidence in event of suspicious incident
 - vi. Prevent further collapse of structure or trench due to vehicle vibrations
- c. Incident commander determines location of outer perimeter – You may be assigned to mark
 - i. Stretch utility rope or barrier tape between available objects – Signs, trees, utility poles, and parking meters
 - ii. Leave controlled opening near command post – Monitored by accountability officer
 - iii. Another opening may be necessary to provide access for ambulances, and other emergency equipment



- d. Scene divided into three control zones – Size, shape, and distance from hazard depends on
 - i. Weather conditions
 - ii. General topography
 - iii. Amount of room needed by working personnel
 - iv. Nature of hazard
- e. Hot zone – Most critical area of scene, includes site of actual emergency



- i. Only personnel directly involved in resolving emergency allowed
- ii. Personnel working in must
 - (a) *Sign in to accountability system*
 - (b) *Wear PPE designed for specific hazard*
 - (c) *Be trained to manage situation*
- f. Warm zone – Immediately outside hot zone
 - i. Access limited to personnel directly supporting work in hot zone
 - ii. Personnel working in must be
 - (a) *In full PPE*
 - (b) *Ready to enter hot zone*
 - iii. Decontamination station usually in this zone at hazardous materials incidents
- g. Cold zone – Area furthest from incident
 - i. Access limited to working personnel
 - ii. Outer boundary forms crowd-control line for general public

Review Question: What are the different rescue practices and goals used during technical rescue operations?
See pages 531-549 of the textbook for answers.

C. Incident Specific Tasks

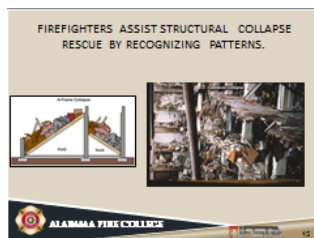
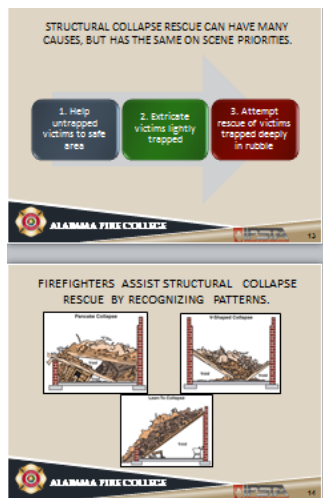
1. Assist technical rescue team
 - a. Be able to recognize, locate, and sometimes operate equipment
 - b. Recognize hazards associated with each type of incident and methods for mitigating
2. Rope rescue operations
 - a. Involve use of life safety rope, harnesses, tripods, accessories to access and remove victims – May be assigned to retrieve equipment
 - b. Divided into two categories
 - i. High angle urban/structural – Rescuing injured workers from scaffolding on side of structure



- ii. Wilderness/mountain – Removing victim from base of cliff or steep slope
- c. Main hazard to rescuers – Working without safety net in same environment as victims

3. Structural collapse rescue operations

- a. May be caused by fire, extreme weather, earthquakes, explosions, and deteriorated condition of aging structure
- b. On scene priorities
 - i. First – Help get untrapped victims to safe area
 - ii. Next – Extricate victims lightly trapped by debris
 - iii. Final – Attempt to rescue victims trapped deep within rubble
- c. Assist by recognizing collapse patterns – Helps predict location of trapped victims
 - i. Pancake
 - (a) Occurs when exterior walls collapse simultaneously – Roof and floors stack on top of each other
 - (b) Least likely to contain voids where live victims are found
 - (c) Always assume there are survivors until proven otherwise
 - ii. V-shaped
 - (a) Occurs when outer walls remain intact and upper floors and/or roof structure fail in middle
 - (b) Offers good chance of habitable void spaces created along outer walls
 - iii. Lean-to
 - (a) Occurs when one outer wall fails while opposite wall remains intact
 - (b) wall drops to floor – Forms triangular void in which victims likely to survive
 - iv. A-frame



- (a) *Occurs when floor and/or roof assemblies on both sides of load-bearing center wall collapse*
- (b) *Creates pair of lean-to collapses on opposite side of load-bearing wall – Good chance of victim survival on both sides of wall*

v. Cantilever

- (a) *Occurs when one or more walls of multistory building collapse – Leaves floors attached to and supported by remaining walls*
- (b) *Offers good chance of habitable voids*
- (c) *Most vulnerable to secondary collapse*

d. Hazards

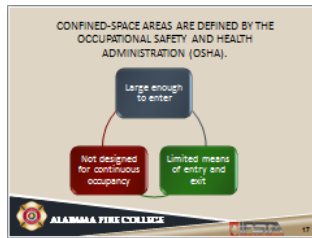
i. Physical

- (a) *Debris that is sharp, jagged, or unstable*
- (b) *Exposed wiring and rebar*
- (c) *Broken glass*
- (d) *Confined-spaces*
- (e) *Unprotected openings*
- (f) *Heights*
- (g) *Secondary collapse*

ii. Environmental

- (a) *Fire*
- (b) *Noise*
- (c) *Darkness*
- (d) *Temperature extremes*
- (e) *Adverse weather conditions*
- (f) *Damaged and leaking utilities*
- (g) *Atmospheric contamination*

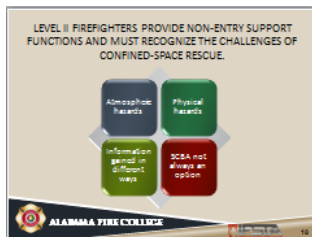


*(h) Hazardous materials contamination*

4. Confined-space rescue operations

- a. Defined by Occupational Safety and Health Administration (OSHA)
 - i. Large enough to enter
 - ii. Limited means of entry and exit
 - iii. Not designed for continuous occupancy
- b. Examples of confined-spaces

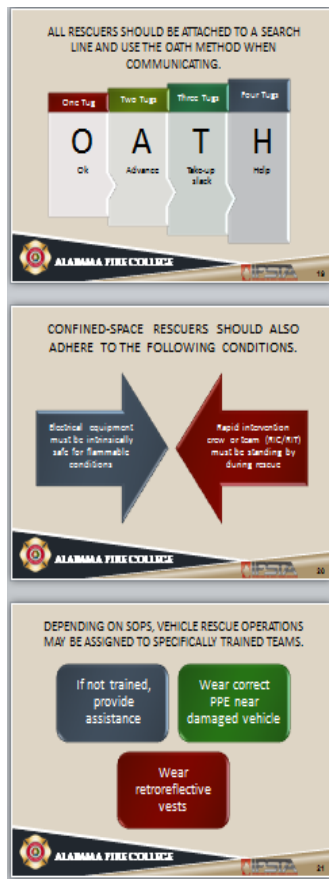
Instructor Note: Point out the list of confined- spaces on pages 538-539 of textbook. Discuss with students what types of confined-spaces are most likely to occur in your area.



- c. Firefighters without confined- space rescue training – Limited to performing non-entry rescues and support functions outside space
- d. Atmospheric hazards
 - i. Oxygen deficiency due to inadequate ventilation
 - ii. Flammable gases and vapors
 - iii. Toxic gases
 - iv. Extreme temperatures
 - v. Explosive dusts
- e. Physical hazards
 - i. Limited means of entry and egress
 - ii. Tight constricted spaces
 - iii. Cave-ins or unstable support members
 - iv. Standing water or other liquids
 - v. Utility hazards, such as gas, sewage, and electricity
- f. Information may be gained
 - i. Preincident plans

(a) Describe lighting, ventilation, and communication at scene

(b) Have details relevant to protecting victims and rescuers, controlling utilities and other hazards



- ii. Knowledgeable people at scene – May be able to tell number of victims, probable location, and potential hazards
 - g. May not be able to wear SCBA due to space limitations
 - i. Supplied air respirators (SAR) used – Hoses connect facepieces to air outside entrance
 - ii. May be assigned task of setting up and monitoring SAR system
 - h. All rescuers have search line attached to harness – Must be constantly monitored; communication system prearranged
 - i. Portable radios may not work; hard-wired phones preferred
 - ii. Use OATH method with line
 - (a) One tug represents O – OK
 - (b) Two tugs represents A – Advance
 - (c) Three tugs represents T – Take-up slack
 - (d) Four tugs represents H – Help
 - i. Electrical equipment must be intrinsically safe for use in flammable atmospheres
 - j. Rapid intervention crew or team (RIC/RIT) must be standing by while rescuers working inside space
5. Vehicle rescue operations
- a. Depending on SOPs – May be assigned to technical rescue team or to engine or truck company trained and equipped to perform task
 - b. If not trained
 - i. Assist by setting up equipment
 - ii. Providing care to victims
 - iii. Standing by with charged hoseline
 - iv. Providing security barrier
 - c. Must wear correct PPE when working near damaged vehicle
 - d. Wear retroreflective vest when not engaged in fire suppression or extrication

6. Water rescue operations

a. Occur under various conditions

- i. Ice
- ii. Surface
- iii. Dive
- iv. Swiftwater
- v. Surf

b. Occur in variety of locations

Instructor Note: Point out the list of water rescue locations on pages 540-541 of textbook. Discuss with students what types of water rescue situations are most likely to occur in your area.

c. First task during size-up – Determine if incident requires rescue or recovery

- i. Rescue – Incidents where victim may be saved; typically stranded or floundering
- ii. Recovery – Incidents where victim has been submerged for long period of time, likely dead; main goal to recover body

d. Personal flotation devices (PFDs)

- i. Mandatory for all personnel entering water, working within 10 feet (3 m) of water's edge, or riding in waterborne craft
- ii. Must be approved by U. S. Coast Guard or Transport Canada

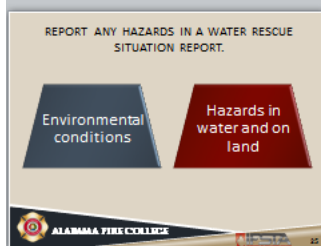
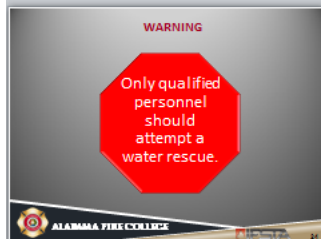
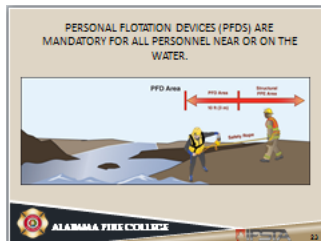
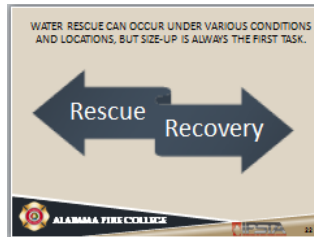
e. Firefighters assisting rescue team may wear structural PPE for warmth

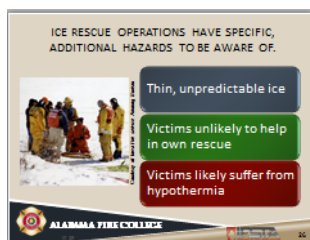
- i. DO NOT approach water's edge
- ii. PPE can become water-logged and pull you underwater

WARNING! Only qualified personnel should attempt a water rescue.

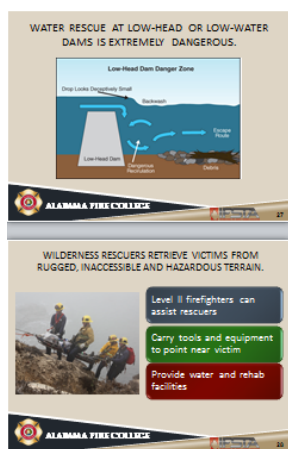
f. Hazards to include in situation report

- i. Undercurrents
- ii. Unstable or slippery soil at water's edge
- iii. Debris

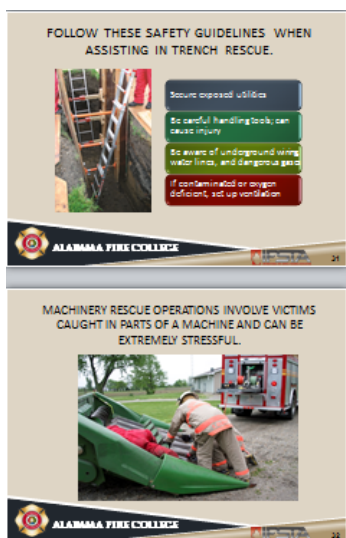




- iv. Sink holes
 - v. Quicksand
 - vi. Sharp rocks
 - vii. Extreme temperatures
 - viii. Chemical or biological contamination
 - ix. Poisonous or dangerous reptiles
- g. Hazards specific to ice rescue
- i. Thin and unpredictable ice – Just because it appears thick does not mean it is strong
 - ii. Victims unlikely to help with own rescue
 - (a) Hands extremely cold, possibly frozen; making it difficult to grasp rope or other aid
 - (b) Heavy, wet clothing makes difficult to keep heads above water
 - iii. Victim suffering from hypothermia – Critical to have advanced life support unit on scene



- h. Low-head or low-water dams dangerous for victims and rescuers
- i. Dams create pool of standing water – Water recirculates as it passes over dam, creating powerful undercurrents
 - ii. Debris trapped against upstream face poses additional hazard
7. Wilderness rescue operations
- a. Take place in rugged, inaccessible terrain
 - b. Rescuers typically use ropes and harnesses to descend to victim, stabilize injuries, and remove victim in basket or stretcher
 - c. Assisting includes
 - i. Establishing rehab facilities
 - ii. Carrying tools and equipment to point near victim
 - d. Hazards
 - i. Climate extremes
 - ii. Possibility of long term search before victim located



iii. Heat stress and dehydration – Wearing structural PPE in hot climates not recommended

iv. Rough terrain – Structural boots do not protect feet and ankles

e. Large quantities of water should be available; rehab facilities mandatory

8. Trench rescue operations

a. Assisting – Monitor for hazardous atmospheres or create safe zone around trench

b. Vibrations can cause secondary cave-ins – All bystanders, nonessential personnel, apparatus, and heavy equipment should be kept well back

c. Safety guidelines when assisting

i. Do not enter trench

ii. Cordon off area 100 feet (30 m) in each direction from trench

iii. Eliminate sources of vibration within 500 feet (150 m) of trench, such as apparatus and heavy equipment

iv. Place exit ladders no more than 50 feet (15.24 m) apart, with the initial ladder near location of victim

v. Ladders should extend at least 3 feet (1 m) above top of the trench

vi. Secure any exposed utilities

vii. Be careful when handling tools; dropped or mishandled tools can injure both rescuers and victims

viii. Be aware of additional hazards, such as underground wiring, water lines, toxic or flammable gases

ix. If trench is contaminated or oxygen-deficient, set up ventilation fans to allow rescuers to continue working

9. Machinery rescue operations

a. Involve victim caught between parts of machine

b. Type of injuries that result make incidents extremely stressful

c. Occur at variety of locations

Instructor Note: Point out the list of machinery rescue locations on page 544 of textbook. Discuss with students what types of machinery rescue situations are most likely to occur in your area.

- d. Note during size-up
 - i. Victim's medical condition and degree of entrapment
 - ii. Type of machinery
 - iii. Number of rescue personnel needed
 - iv. Extrication equipment needed
 - v. Presence of fire or hazardous material
 - vi. Scene safety issues
 - vii. Precautions necessary before securing power to machinery



WARNING!: If the victim is entangled in a machine that is still running, DO NOT turn it off until the mechanism has been stabilized. Turning off the machine may cause it to reverse itself or complete its cycle – either of which could harm the victim further. Contact the machinery owner, operator, or plant personnel for guidance in securing the mechanism.

- e. Stabilize machine with cribbing, chains, or heavy-duty nylon webbing; then shut off power
- f. Use lock out/tag out device to secure power switches
- g. May need outside expertise to resolve situation – Plant personnel or off-site expert

10. Elevator and escalator rescue operations

- a. May not be limited to technical rescue personnel
- b. Hazardous types of elevator rescues require certified technical rescuers

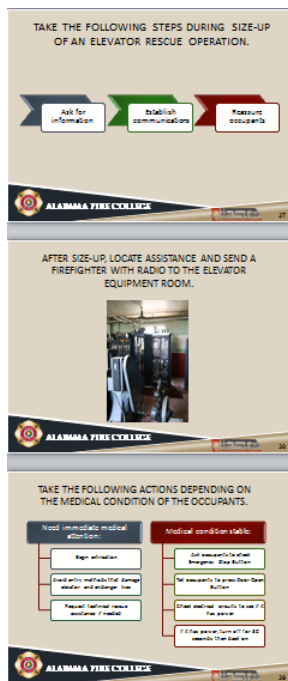
11. Elevator rescue

- a. Classified based on use
 - i. Passenger – Small, accelerate quickly, have automatic controls





- ii. Freight – Slower, large access doors, either manual or automatic controls; carry up to 3 tons (3.05 t), be as large as 12 x 14 feet (3.66 by 4.27 m)
- iii. Construction – Similar to freight, temporary installations during construction
- b. Cable operating systems – Used in structures of any size
 - i. Consist of fully enclosed shaft, car, cables attached to car, counterweights, vertical tracks, emergency safety brakes, and equipment room
 - ii. Variation – Observation elevator mounted on wall of atrium or exterior to provide passengers with scenic view
- c. Hydraulic operating systems – Used in structures less than 6 stories high
 - i. Have ram pistons beneath car that raise and lower; hydraulic oil providing necessary pressure
 - ii. Mechanical room containing power unit usually located on lower level of building within 100 feet (30 m) of elevator shaft
 - iii. May have cables and counterweights
- d. May become inoperative for various reasons
- e. During size-up



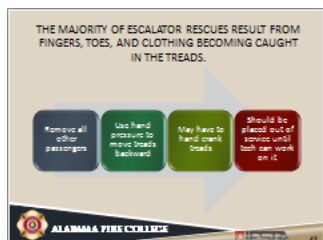
- i. Ask building representatives and witnesses for detailed information about situation
- ii. Establish communications with elevator's occupants – By telephone, calling out from nearest floor, or establishing intercom link
- iii. Reassure occupants you are working to extricate them
- f. Locate building maintenance person or call elevator service company for technical assistance
- g. Send firefighter equipped with portable radio to elevator equipment room – Rest of crew remains at elevator door on floor nearest car
- h. If occupants require immediate medical attention
 - i. Begin extrication
 - ii. Avoid entry methods that damage elevator and endanger passengers and firefighters

- iii. Request technical rescue team assistance if needed
- i. If occupants' medical condition is stable
 - i. Ask them to check status of Emergency Stop Button – Must be activated if stalled due to malfunction
 - ii. Tell occupants to press Door Open Button – May cause to resume operation
 - iii. Check electrical circuits to see if elevator has power – May be able to reset
 - iv. If elevator has power, turn off for 30 seconds, then turn back on – May reset relays and reactivate; instruct occupants to push Door Open Button
- j. If equipped with recall system
 - i. Will return to ground floor by inserting key into control panel
 - ii. Ask occupants to press Door Open Button if doors do not open when it returns to ground floor



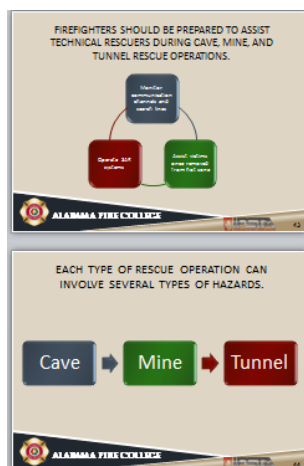
12. Escalator rescue

- a. Also called moving stairways – Chain-driven mechanical stairways that move continuously in one direction
- b. Steps linked together, each step rides track – Flexible rubber handrails move at same rate
- c. Each is individual installation with separate machinery, controls
- d. Drive unit usually located under upper landing – Covered by landing plate
- e. Variation called moving walkway/sidewalk – Similar to conveyer belt, transports people through large structures
- f. May have manual stop switch
 - i. Located on nearby wall or handrail at top and bottom of unit
 - ii. Activating – Slowly stops stairs, sets emergency brake
 - iii. Key-operated switch located at bottom is used to restart after using
- g. Stairs should be stopped during rescue operations



- h. Escalator mechanic should be requested to restart after victim removed
- i. Majority of rescues result from fingers and toes becoming caught between step treads and guard plates, or sandals becoming wedged between treads
 - i. Remove all other passengers, use hand pressure to move treads backward – Frees trapped fingers, and toes
 - ii. May have hand crank to move treads backward – located under covered landing plate
- j. After extrication – Should be placed out of service until technician can work on

13. Cave, mine, and tunnel rescue operations

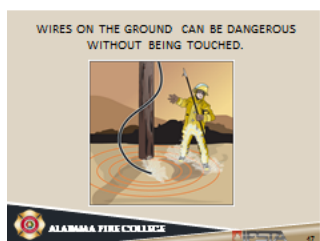
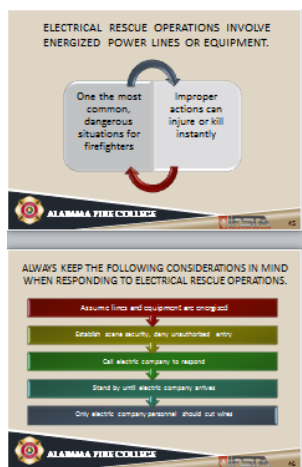


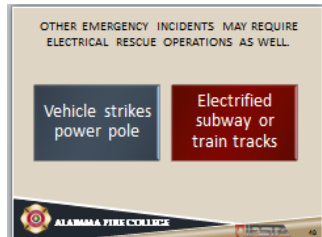
- a. Be prepared to assist
 - i. Monitoring communication channels and search lines
 - ii. Operating SAR systems
 - iii. Assisting victims once removed from hot zone
- b. Cave hazards
 - i. Toxic gases
 - ii. Oxygen deficiency
 - iii. Tight spaces
 - iv. Sharp rocks
 - v. Potential for cave-ins
 - vi. Lack of available light
 - vii. Standing or swift running water
- c. Mine hazards
 - i. Toxic gases
 - ii. Oxygen deficiency
 - iii. Explosive atmospheres
 - iv. Cave-ins
 - v. Abandoned tools and equipment
 - vi. Lack of available light
 - vii. Standing water
- d. Tunnel hazards

- i. Toxic gases
- ii. Oxygen deficiency
- iii. Smoke
- iv. Fire
- v. Tangled debris
- vi. Electrified rails or wires
- vii. Lack of available light
- viii. Standing water or other fluids
- ix. Biological waste in sewers

14. Electrical rescue operations

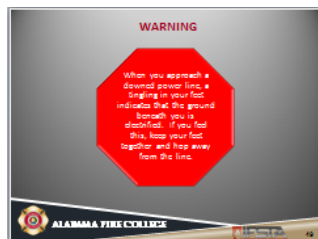
- a. Rescues involving energized power lines or equipment – Some of the most common and dangerous situations firefighters are called to
- b. Improper actions can injure or kill you instantly
- c. When responding, always
 - i. Assume that electrical lines or equipment are energized – Power line in contact with telephone line or wire fence (out of sight) can energize entire length
 - ii. Establish scene security and deny unauthorized entry
 - iii. Call for electric company to respond
 - iv. Stand by until electric company arrives
 - v. Allow only electric company personnel to cut electrical wires
- d. Wires on the ground can be dangerous without being touched
 - i. Downed lines can energize wire fences or other metal objects when in contact
 - ii. When energized wire comes into contact with ground, current flows in all directions from point of contact
 - (a) *Voltage drops progressively as current flows away from point of contact*
 - (b) *Energized area called ground gradient – Can extend for several yards (meters) from point of contact*





(c) *Estimate the distance between two nearby power poles – Stay that distance away from downed line until sure power has been shut off*

- e. When vehicle strikes power pole – Can sever high voltage line that falls onto vehicle
 - i. First priority – Contact electric company to shut off power
 - ii. Once power off – Becomes vehicle extrication operation
- f. Electrified subway or train tracks pose hazards – Never work around tracks unless proven that power is off



WARNING! When you approach a downed power line, a tingling in your feet indicates that the ground beneath you is electrified. If you feel this, keep your feet together and hop away from the line.

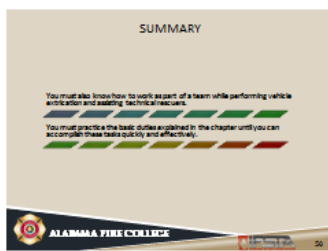
Review Question: How do the hazards for structural collapse rescue operations compare to hazards of rope rescue operations? See pages 535-538 of the textbook for answers.

II. SKILLS

- | | |
|-------------|---|
| pp. 551-552 | Objective 11 — Demonstrate the steps for inspecting, servicing, and maintaining a portable generator and lighting equipment. |
| pp. 553 | Objective 12 — Prevent horizontal movement of a vehicle using wheel chocks. |
| pp. 554 | Objective 13 — Stabilize a vehicle using cribbing. |
| pp. 555-556 | Objective 14 — Stabilize a vehicle using lifting jacks. |
| pp. 557 | Objective 15 — Stabilize a vehicle using a system of ropes and webbing. |
| pp. 558-559 | Objective 16 — Stabilize a side-resting vehicle using a buttress tension system. |
| pp. 560-561 | Objective 17 — Remove a windshield in an older model vehicle. |

pp. 562	Objective 18 — Remove a tempered glass side window.
pp. 563-565	Objective 19 — Remove a roof from an upright vehicle.
pp. 566	Objective 20 — Remove a roof from a vehicle on its side.
pp. 567-568	Objective 21 — Displace the dashboard.

III. SUMMARY AND REVIEW



A. Chapter Summary

1. Your duties include maintaining rescue tools and lighting equipment.
2. You must also know how to work as part of a team while performing vehicle extrication and assisting technical rescuers.
3. You must practice the basic duties explained in the chapter until you can accomplish these tasks quickly and effectively.

B. Review Questions

1. What types of tasks may be required to maintain electric generators and lighting equipment? (*pp. 484-486*)
2. What are the main uses of rescue tools? (*pp. 486-504*)
3. What are some common limitations of rescue tools? (*pp. 486-504*)
4. What role does the fire department play in size-up and assessing the need for extrication after a motor vehicle accident? (*p. 504*)
5. What safety considerations must be identified and mitigated during vehicle extrication operations? (*pp. 505-511*)
6. How can cribbing material be used during vehicle extrication? (*p. 515*)

7. What methods can be used to gain access to victims during vehicle extrication? (*p. 522*)
8. What role does a Firefighter II play during technical rescue operations? (*pp. 531-549*)
9. What are the different rescue practices and goals used during technical rescue? (*pp. 531-549*)
10. How do the hazards for structural collapse rescue operations compare to hazards of rope rescue operations? (*pp. 535-538*)