Fire Inspection Principles

FIP-Student Manual

1st Edition, 11th Printing-November 2013

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FEMA/USFA/NFA
FIP-SM
November 2013
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U.S. DEPARTMENT OF HOMELAND SECURITY

UNITED STATES FIRE ADMINISTRATION

NATIONAL FIRE ACADEMY

FOREWORD

The U.S. Fire Administration (USFA), an important component of the Department of Homeland Security (DHS), serves the leadership of this Nation as the DHS's fire protection and emergency response expert. The USFA is located at the National Emergency Training Center (NETC) in Emmitsburg, Maryland, and includes the National Fire Academy (NFA), National Fire Data Center (NFDC), and the National Fire Programs (NFP). The USFA also provides oversight and management of the Noble Training Center in Anniston, Alabama. The mission of the USFA is to save lives and reduce economic losses due to fire and related emergencies through training, research, data collection and analysis, public education, and coordination with other Federal agencies and fire protection and emergency service personnel.

The USFA's National Fire Academy offers a diverse course delivery system, combining resident courses, off-campus deliveries in cooperation with State training organizations, weekend instruction, and online courses. The USFA maintains a blended learning approach to its course selections and course development. Resident courses are delivered at both the Emmitsburg campus and the Noble facility. Off-campus courses are delivered in cooperation with State and local fire training organizations to ensure this Nation's firefighters are prepared for the hazards they face.

This course, while providing a sound basis for professional development, is not intended to cover all of the required skills and knowledges. It is the academy's intention to provide you with a sound instructional package that addresses the critical areas of the topic. As a practicing professional, you will need to continue studying and practicing the skills and knowledge required to become a truly competent individual.

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ACKNOWLEDGMENTS

The preparation of this course was made possible through the assistance, cooperation, and dedication of many people. The National Fire Academy wishes to thank all of the following persons and organizations for their roles in the development of this course.

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MEDIA AND EDITORIAL PRODUCTION SUPPORT

Media support by Academic Support and Operations, Office of Management and Administration, Media Production Center.

Editorial support by Tracy Boyd, Lily Crebbs, Pat Newton, Reba Spielman, Jane Stoner, Betsy Weaver, and Lee Wren, Scientific and Commercial Systems Corporation, Falls Church, Virginia.

MEDIA

We wish to thank the Fairfax County, Virginia Fire/Rescue Department for use in this course of the videotapes concerning example inspections of flammable/combustible liquids, gases, chemicals, and explosives.

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SCOPE AND PURPOSE OF THE COURSE

Fire Inspection Principles has been designed to provide the student with the fundamental knowledge, skills, and attitudes to conduct basic fire safety inspections effectively and confidently. This course is appropriate for the fire prevention or code enforcement official, and other allied professionals with limited fire inspection and code enforcement experience, who have the responsibility for conducting fire safety inspections. Students will be introduced to various codes and standards in order to develop a working knowledge of their application in the inspection process.

Due to the variety of regional and local codes and ordinances with which each of you must deal on a daily basis, the academy must, for the purpose of this course, assume that each of you is familiar with the codes and standards in effect in your jurisdiction. All of the activities have been designed to allow you to accomplish them from the perspective of the code **being enforced in your local jurisdiction**.

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SCHEDULE--WEEK ONE

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
AM	Course Introduction Module 1: Code Enforcement: Your Role LRC Orientation	Module 1: Code Enforcement: Your Role (cont'd) Module 2: Fire and Codes: Their Relationship	Module 2: Fire and Codes: Their Relationship (cont'd)	Module 3: General Fire Safety (cont'd)	Module 4: Life Safety (cont'd)
PM	Module 1: Code Enforcement: Your Role (cont'd)	Module 2: Fire and Codes: Their Relationship (cont'd)	Module 3: General Fire Safety	Module 4: Life Safety	Quiz on Modules 1-3 Module 4: Life Safety (cont'd)
Evening	Read text for Module 2	Read text for Module 3	Assign topics for Group Presentations (Module 7 Activities) Read text for Module 4	Activity 3.3	Weekend Project Assignment Read text for Module 5

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SCHEDULE--WEEK TWO

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
AM	Module 5: Hazardous Materials and Processes	Module 5: Hazardous Materials and Processes (cont'd)	Module 6: Special Hazards (cont'd) Module 7: Fire Protection Systems and Equipment	Module 7: Fire Protection Systems and Equipment (cont'd)	Course Summary Graduation
PM	Module 5: Hazardous Materials and Processes (cont'd)	Module 6: Special Hazards	Module 7: Fire Protection Systems and Equipment (cont'd)	Quiz on Modules 5-7 Module 7: Fire Protection Systems and Equipment (cont'd)	
Evening	Read text for Module 6 Review Activity 4.6 by selected code groups	Read text for Module 7			

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COPYRIGHT CLEARANCE

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From: National Fire Protection Association, Inc., Quincy, MA 02269

For each of the following excerpted from Installation of Sprinkler Systems, NFPA 13-1991.

- Automatic sprinkler density curves table, table for water supply requirement for pipe schedule systems, and the table for hose stream demand and water supply duration.

For each of the following excerpted from Installation of Standpipe for Hose Systems, NFPA 14-1990.

- Figure A-5-6.1
- Figure A-2-1A

For *National Electrical Code NFPA #70* (NEC 70-1990), Article 500-3 on page 663; and Article 500-3 FPN Number 14 on page 666.

National Electrical Code® and NEC® are registered trademarks of the National Fire Protection Association, Inc., Quincy, MA 02269.

For Standard for Installation of Warm Air Heating and Air Conditioning Systems, NFPA 90B-1989. Article 4-1.8.2 page 90-13.

For each of the following excerpted from the *Fire Protection Handbook,* 16th Edition.

- Table 7-1A on page 7-4

For each of the following excerpted from the *Fire Protection Handbook,* 17th Edition.

- Table 3-3c, page 3-26
- Table 1-2B, page 1-28
- Figure 2-4x, page 2-72
- Figure 2-3CC, page 2-47
- Figure 2-3DD, page 2-47
- Figure 2-3EE, page 2-47
- Figure 2-4 O, page 2-60
- Figure 2-4 N, page 2-60
- Figure 2-4 T, page 2-62
- Figure 2-13 A, page 2-152
- Figure 2-12 D, page 2-145

For each of the following excerpted from *Fire Alarm Signaling Systems Handbook* 87th Edition.

- Figure 6-1 and 6-2 on page 123
- Figure 6-3 and 6-4 on page 124
- Figure 6-7 and 6-8 on page 127

For the Code of Ethics for Fire Marshals, adopted May 17, 1966, Sections 5 thru 12 (Relations with the Public) as published on page 22 of *Fire Marshal's Association of North America 1990-91 Directory.*

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FIREFIGHTER CODE OF ETHICS

Background

The Fire Service is a noble calling, one which is founded on mutual respect and trust between firefighters and the citizens they serve. To ensure the continuing integrity of the Fire Service, the highest standards of ethical conduct must be maintained at all times.

Developed in response to the publication of the Fire Service Reputation Management White Paper, the purpose of this National Firefighter Code of Ethics is to establish criteria that encourages fire service personnel to promote a culture of ethical integrity and high standards of professionalism in our field. The broad scope of this recommended Code of Ethics is intended to mitigate and negate situations that may result in embarrassment and waning of public support for what has historically been a highly respected profession.

Ethics comes from the Greek word ethos, meaning character. Character is not necessarily defined by how a person behaves when conditions are optimal and life is good. It is easy to take the high road when the path is paved and obstacles are few or non-existent. Character is also defined by decisions made under pressure, when no one is looking, when the road contains land mines, and the way is obscured. As members of the Fire Service, we share a responsibility to project an ethical character of professionalism, integrity, compassion, loyalty and honesty in all that we do, all of the time.

We need to accept this ethics challenge and be truly willing to maintain a culture that is consistent with the expectations outlined in this document. By doing so, we can create a legacy that validates and sustains the distinguished Fire Service institution, and at the same time ensure that we leave the Fire Service in better condition than when we arrived.

FIREFIGHTER CODE OF ETHICS

I understand that I have the responsibility to conduct myself in a manner that reflects proper ethical behavior and integrity. In so doing, I will help foster a continuing positive public perception of the fire service. Therefore, I pledge the following…

- Always conduct myself, on and off duty, in a manner that reflects positively on myself, my department and the fire service in general.
- Accept responsibility for my actions and for the consequences of my actions.
- Support the concept of fairness and the value of diverse thoughts and opinions.
- Avoid situations that would adversely affect the credibility or public perception of the fire service profession.
- Be truthful and honest at all times and report instances of cheating or other dishonest acts that compromise the integrity of the fire service.
- Conduct my personal affairs in a manner that does not improperly influence the performance of my duties, or bring discredit to my organization.
- Be respectful and conscious of each member's safety and welfare.
- Recognize that I serve in a position of public trust that requires stewardship in the honest and efficient use of publicly owned resources, including uniforms, facilities, vehicles and equipment and that these are protected from misuse and theft.
- Exercise professionalism, competence, respect and loyalty in the performance of my duties and use information, confidential or otherwise, gained by virtue of my position, only to benefit those I am entrusted to serve.
- Avoid financial investments, outside employment, outside business interests or activities that conflict with or are enhanced by my official position or have the potential to create the perception of impropriety.
- Never propose or accept personal rewards, special privileges, benefits, advancement, honors or gifts that may create a conflict of interest, or the appearance thereof.
- Never engage in activities involving alcohol or other substance use or abuse that can impair my mental state or the performance of my duties and compromise safety.
- Never discriminate on the basis of race, religion, color, creed, age, marital status, national origin, ancestry, gender, sexual preference, medical condition or handicap.
- Never harass, intimidate or threaten fellow members of the service or the public and stop or report the actions of other firefighters who engage in such behaviors.
- Responsibly use social networking, electronic communications, or other media technology opportunities in a manner that does not discredit, dishonor or embarrass my organization, the fire service and the public. I also understand that failure to resolve or report inappropriate use of this media equates to condoning this behavior.

Developed by the National Society of Executive Fire Officers

A Student Guide to End-of-course Evaluations

Ten Things You Can Do to Improve the National Fire Academy

The National Fire Academy takes its course evaluations very seriously. Your comments and suggestions enable us to improve your learning experience.

Unfortunately, we often get end-of-course comments like these that are vague and, therefore, not actionable. We know you are trying to keep your answers short, but the more specific you can be, the better we can respond.

Actual quotes from student evaluations:	Examples of specific, actionable comments that would help us improve the course:
1 "Update the materials."	• The (ABC) fire video is out-of-date because of the dangerous tactics it demonstrates. The available (XYZ) video shows current practices. • The student manual references building codes that are 12 years old.
2 "We want an advanced class in (fill in the blank)."	• We would like a class that enables us to calculate energy transfer rates resulting from exposure fires. • We would like a class that provides one-on-one workplace harassment counseling practice exercises.
3 "More activities."	• An activity where students can physically measure the area of sprinkler coverage would improve understanding of the concept. • Not all students were able to fill all ICS positions in the exercises. Add more exercises so all students can participate.
4 "A longer course."	• The class should be increased by one hour per day to enable all students to participate in exercises. • The class should be increased by two days so that all group presentations can be peer evaluated and have written abstracts.
5 "Readable plans."	• The plans should be enlarged to 11 by 17 and provided with an accurate scale. • My plan set was blurry, which caused the dotted lines to be interpreted as solid lines.
6 "Better student guide organization," "manual did not coincide with slides."	• The slide sequence in Unit 4 did not align with the content in the student manual from slides 4-16 through 4-21. • The instructor added slides in Unit 4 that were not in my student manual.
7 "Dry in spots."	• The instructor/activity should have used student group activities rather than lecture to explain Maslow's Hierarchy. • Create a pre-course reading on symbiotic personal relationships rather than trying to lecture on them in class.
8 "More visual aids."	• The text description of V-patterns did not provide three-dimensional views. More photographs or drawings would help me imagine the pattern. • There was a video clip on NBC News (date) that summarized the topic very well.
9 "Re-evaluate pre-course assignments."	• The pre-course assignments were not discussed or referenced in class. Either connect them to the course content or delete them. • The pre-course assignments on ICS could be reduced to a one-page job aid rather than a 25-page reading.
10 "A better understanding of NIMS."	• The instructor did not explain the connection between NIMS and ICS. • The student manual needs an illustrated guide to NIMS.

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MODULE 1: CODE ENFORCEMENT: YOUR ROLE

TERMINAL OBJECTIVES

The students will:

1. *Explain the code enforcement system and the fire inspector's role in that system.*

2. *Handle situations that are typical of the fire inspector's role in a professional manner.*

ENABLING OBJECTIVES

The students will:

1. *Identify the benefits of a code enforcement system and the effects of the community's attitude on that system.*

2. *Define the essential elements of a code enforcement system.*

3. *Describe the legal authority and limitations relevant to fire code inspections.*

4. *Explain "compliance" and describe methods for achieving it.*

5. *Describe the critical importance of thorough documentation.*

6. *Demonstrate elements of effective communication necessary to achieve compliance.*

7. *Explain the rationale for the permit process and list permits required by their code.*

8. *Contrast a formal appeals process with an informal appeals process.*

9. *Contrast proper and improper standards of behavior for an inspector.*

10. *Identify interpersonal skills necessary to effect compliance.*

11. *Recognize ethical and unethical situations for the code enforcement officer.*

INTRODUCTION

What is Fire Prevention?

The lives and property of everyone in a community can be threatened by fire. Therefore, everyone can (and should) play a role in fire prevention. The head of a household who decides to buy (or not to buy) a smoke detector; the child who has learned (or has not learned) what steps to take if his or her clothing catches fire; or the restaurant patron who makes a point of checking exits in a crowded establishment before enjoying a meal are undertaking (or not undertaking) fire prevention activities.

Within the fire department, the duties normally carried out by a Fire Prevention Bureau are related to fire code enforcement, public education, and fire investigation. Each of these functional areas embodies complex and detailed activities and may well involve close ties with other local government agencies.

Code Enforcement

Code enforcement begins with code application during the review of plans and specifications to assure compliance with fire safety features of the building and fire prevention codes; control of structures through inspection to assure proper exits, interior finishes, fixed fire protection equipment, and other related features; control of occupant capacity and smoking regulations; and control of sales and use of materials and equipment. The last function includes control or limitation of the storage, handling, and use of explosives, fireworks, flammable liquids and gases, and other hazardous materials.

The purpose of a fire prevention code is to provide reasonable protection of life and property from the hazards of fire and explosive materials. Fire codes exist to minimize hazards to life and property from fire and panic, exclusive of those hazards considered in building code regulations.

Approximately 75 percent of all current editions of the three model codes relate to fire protection and safety concerns. The scope of these codes addresses all matters pertaining to the construction of new structures, additions, alterations, remodeling, or the change of use of an existing structure. This includes all permanent, or built-in fire protection equipment and other safeguards such as firewalls and separations.

In preparing the fire prevention code, extreme care is necessary to avoid possible conflict concerning building code requirements. Each of the three model building code groups also has developed model fire prevention codes. Specific laws, rules, and regulations are necessary to delineate the authority of both fire and building officials. These specific regulations are also necessary when dealing with special hazard situations.

Within a given jurisdiction, building and fire officials must cooperate fully if they are to obtain their goal of enforcing both the fire prevention/building codes for effective community fire safety. This effort must consist of **communications**, **cooperation,** and **coordination**.

Fire Protection Requirements

A building code is a legal document that establishes the building requirements necessary for the protection of public safety, health, and welfare.

A fire prevention code is defined as an ordinance regulating the storage, handling, production, and use of hazardous materials. The fire prevention code sets the requirements for testing and maintaining fire suppression and fire detection systems, regulating general fire safety requirements, and maintaining life safety features within a structure. It also authorizes the fire department to assume responsibility for inspection, code enforcement, and code administration duties.

Nationally Recognized Fire and Building Codes and Standards

In general, most jurisdictions use nationally recognized model codes and standards which have been developed at that level by committees representing many interest groups and people concerned with the enactment or enforcement of those codes and standards. Most codes are written and developed to establish minimum and reasonable requirements for fire protection and fire safety. Codes usually are adopted by reference; often these codes are nationally recognized standards or codes.

All of the consensus code development organizations have a system whereby they can be changed or amended by submission of suggested revisions to the appropriate committee. The proposed changes would be reviewed and presented at the appropriate time for a hearing and, ultimately, ratification by the consensus organization membership.

The fire department may be responsible for the enforcement of certain fire protection requirements within the building. The fire department must establish effective working relationships with other code enforcement agencies to prevent conflicts that result from the assignment of duties and authorities by other local and state ordinances.

Authority Having Jurisdiction

In most jurisdictions, there is a municipal officer designated as the one legally responsible for enforcing the fire prevention codes. This person is referred to as the Authority Having Jurisdiction (AHJ). This official may bear the title of Fire Marshal, Chief of Fire Prevention Bureau, Chief Inspector, Code Administrator, or Building Inspector.

The code official (AHJ) is the administrator and the code enforcement officer who is responsible for:

- Applying and enforcing of the code requirements.
- Conducting the necessary inspection to determine code compliance.

- Determining alternate methods of satisfying the intent of the code.

Codes and Standards Legally Adopted Locally

Historically, codes and standards are adopted locally by ordinance or required by state statute. Only after a code has been legally adopted can it be enforced as law. These enforcement responsibilities include:

- Conducting an initial inspection.
- Conducting periodic inspections.
- Issuing notices of violations and corrections.
- Conducting hearings.
- Entering complaints in court.
- Maintaining records.
- Issuing Certificates of Occupancy.
- Issuing permits.

BENEFITS OF A CODE ENFORCEMENT SYSTEM

Until the twentieth century, building conditions in the United States were marked by excessive use of highly combustible materials put together without much regard for protection of life or property from fire. Large individual buildings housing vast combustible stocks under one roof; lack of firewalls and vertical cutoffs, wood shingle roofs, and other unsafe factors that contributed to rapid spread of fires were characteristic of the American scene. In many parts of the United States, seasonal droughts and high winds aggravate fire conditions and result in area conflagrations that contribute substantially to the overall high national fire losses.

The *Municipal Fire Service Workbook* notes that "almost 95% of all jurisdictions with populations over 5,000 are covered by some kind of code (building, electrical, fire safety, housing, boiler, or mobile home)." The report notes that in towns with populations under 5,000, the incidence of fire and fire loss per capita is disproportionately high. It further notes that towns/cities which invest more in prevention activities have a relatively low threat of fire incidence.

A good code enforcement system:

- Reduces risks of hazards.

- Provides improved fire-safe structures.

- Reduces fire exposure, when a fire does occur.

- Minimizes fire death and injuries.

- Reduces hazards for firefighters, when a fire does occur.

- Controls inherent hazards that cannot be eliminated.

- Reduces workload of firefighters.

- Promotes a more stable community (jobs, confidence, trust, etc.).

- Minimizes property loss (money).

- Minimizes fire insurance costs.

- Improves image of community.

- Maintains/improves community's economic structure.

- Increases community awareness of fire safety.

- Makes code enforcement easier (previous hazards-violations).

- Balances the cost of fire protection between the public and the private sector.

It is accurate to say that effective enforcement can be enhanced through the knowledge of your community's makeup. In today's society, the role of the code official is no longer viewed as an isolated function, but is becoming more active and involved everyday.

For effective code enforcement, knowledge of the physical structures in your community and department is necessary. Some of the factors influencing relationships between officials and the general public, businesses, and developers are:

A. Citizens.

   1. Apathy/Attitude toward code enforcements.

   2. Education.

   3. Cost to business of code enforcement.

   4. Ethnic makeup.

5. Age of population.

B. Politicians.

1. Political climate.

a. New/Old - governing body.

b. Conservative.

c. Liberal.

2. Proactive/Reactive group.

3. Power base - elected/nonelected.

C. Fire Service.

1. Chief's position supportive or nonsupportive.

2. Responsibility of fire prevention bureau.

3. In-service inspector's program.

4. Recruit training--must be part of the program for the firefighters to understand the importance of fire prevention.

ESSENTIAL ELEMENTS OF A CODE ENFORCEMENT SYSTEM

Legally Adopted Code

To be effective, any code enforcement program must have essential elements, which, at a minimum, must consist of the following:

- A legally adopted code which establishes the minimum fire safety requirements in the community. These requirements must address the local community's fire problem. The community is made up of special interest groups which consist of citizens, private sector, elected officials, and the fire service itself.

  - Scope of the adopted code: does it apply to new and existing structures and conditions?

  - Does the code conflict with any other locally adopted code requirements?

- Establishes code administration requirements that address:

- Who will be the Authority Having Jurisdiction?

- Authority to inspect the structure.

- Authority to issue notices of violation or correction notices.

- Establishes a charging or penalty clause for violation of the code.

• Establishes an administrative appeals process

Adoption of a Code Package

There are four major code-writing groups in the United States today. Three of these groups are referred to as model code groups. Each of these model code groups publishes building, fire prevention, gas, mechanical, and plumbing codes. These codes are written in imperative language. The term "shall" explains "when and where" something must be done.

a. Building Officials and Code Administrators International, Inc. (BOCA) (BOCA/National Codes).

b. Southern Building Code Congress International (Standard) (SBCCI).

c. International Conference of Building Officials (ICBO) (Uniform Code).

Each of these model code groups are consensus code organizations.

The National Fire Protection Association (NFPA) is the other code group. Although it is a consensus code group, it is not considered one of the model consensus code groups because it does not publish a building code. The National Fire Protection Association publishes the Life Safety Code 101 which is a code that relates to life safety requirements in structures.

These codes are written in imperative language. The term "shall" explains "when and where" something must be done.

Standards are written to tell you "how" something must be done; they are written in imperative language.

Rather than writing its own code, a community can adopt one of the existing model codes. Adopting this type of code provides or allows for:

- Code interpretation.

- Sound regulation.

- Performance requirements.

- Technical background of development committee.

- Minimum initial cost.

- Uniformity.

- Convenient and economical updating and revisions.

- Flexibility.

- Reasonable enforcement through prior testing.

Codes and standards can be adopted locally by:

- **Reference**: The ordinance states that a specific edition of the model code will be law (usually the latest edition).

- **Transcription**: Actual publication and advertisement of the laws in their entirety.

Training Education

When adopting one of the model codes, the code groups will provide training and certification for both building and fire code inspectors. Whatever code is to be adopted must be followed with the required training of inspection personnel before they are allowed to enforce the code requirements in the community.

Code Reference Materials

It is essential that adequate copies of the adopted codes, by edition, be available for use by all inspection personnel. Copies of other standards, by edition, that are referenced by the codes, must also be available.

Regardless of what type of code a community adopts, the code is only as effective as it is enforceable. This means that adequate resources (Inspection Personnel) must be trained and assigned the duty of conducting the required activities (inspections, etc.) required to enforce the codes. Major factors that will affect the required resources are:

- How many properties are required to be inspected?

- How often are these properties required to be inspected?

- Does the code apply to both new and existing structures?

- Does the code have retrofit requirements?

LEGAL AUTHORITY

It is critical that fire inspectors have a thorough understanding of the legal authority associated with code enforcement. This authority is usually established at the local or state level of government when laws or ordinances are passed under the powers granted through the United States Constitution, State Constitution, and Local Home Rule or Charter Powers. The local authority is established when a fire or building code is legally adopted, and addresses when and where your authority begins and ends. These authorities usually relate to the following:

- Where codes can be enforced.
- When codes can be enforced.
- The right to conduct an inspection.
- The right of entry into a property.
- Taking action to correct a code violation.
- Writing corrective orders or citations.
- Emergency powers.
- Issuing permits.

The following are legal concepts that the inspector should know about, pertaining to the right of entry into residential and commercial properties.

Administrative action or decision is subject to the

- Fourteenth Amendment to the U.S. Constitution.
- Right to appeal through court review.

Fourteenth Amendment

- Deals with civil rights or rights of individuals.
- Prohibits depriving any citizen of the U.S. of life, liberty, or property without due process of law, which prohibits arbitrary governmental action.

Probable Cause

- A state of facts or evidence on which action taken can be justified.
- Based on preponderance of evidence.

- Still room for doubt. (Level of evidence subject to local law or regulations.)

Fourth Amendment

- Safeguard against illegal search and seizure: "Right of the people to be secure in their persons, houses, papers and effects against unreasonable searches and seizures, shall not be violated, and no warrants shall issue, but upon probable cause, supported by oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized." (U.S. Constitution.)

LEGAL AUTHORITY EXAMPLES RELATED TO RIGHT OF ENTRY

Residential Case

Camera v. Municipal Court of the City and County of San Francisco, 387 U.S. (1967). Under the Fourth Amendment, the owner of a private residence had a constitutional right to insist that the housing inspector obtain warrant to search. He may not be constitutionally convicted for refusal to consent to inspection.

Commercial Case

See v. City of Seattle, 387 U.S. 541 (1967). Case arose from the conviction of a defendant for refusing to allow a fire department inspector to inspect a locked commercial warehouse without a warrant.

The Fourth Amendment prevents warrantless searches of commercial as well as private structures. Inspection was part of an areawide routine canvas to determine compliance with the fire code. The same reasoning used in *Camera* regarding residential searches and owners and occupants thereof applies to owners of commercial establishments not used as residences.

The court held that administrative entry into portions of commercial premises not open to the public may be compelled only through prosecution or physical force once a warrant has been obtained.

The inspector must be aware of when or where his/her legal authority may conflict with other local or state agencies.

PERMITS

Permits normally bring about code enforcement. A permit may be required to conduct a specified business or operation. The lack of a permit constitutes a violation of the fire code and the project/process can be shut down.

Know how establishing a permit program might conflict with other agencies, departments, or divisions.

This permit system is a method of dealing with and controlling hazardous conditions and operations. The permit requires that recognized practice as laid down in technical sections of the codes or standards be complied with.

In this way the Fire Prevention Bureau gains control or limits hazardous activities (welding, spray painting, etc.).

The purpose of a permit is to require that fire hazards be brought to the attention of the bureau so that an inspection can be made to ensure compliance with code requirements. This permission shall not be construed as a right to violate any provisions of the code.

Many local communities have established fees for the permits that are issued. These charges should be in an amount that offsets the cost of the community for the time and resources required to approve the permit.

THE APPEALS PROCESS

The purpose of the appeals board is to answer questions of interpretation and application, and to evaluate equivalencies. It is not the purpose of the appeals board to waive code requirements.

The board shall adopt reasonable rules and regulations for conducting its hearings. All proceedings shall become public record. The board may also require a fee for this hearing. The board should consist of members who are qualified to rule on matters pertaining to fire protection and fire prevention.

The city or county attorney also should be an *ex officio* member to address legal matters or potential conflicts of interest.

The members should address incorrect or unreasonable decisions, and grant variances from strict interpretations of law which would result in undue hardship.

The inspector must be aware that his/her administratively issued notices of violations or corrections may be appealed through the appeals process established in the adopted fire codes. Usually notices of corrections that involve an emergency condition are not subject to appeal.

Fire Marshal

In most cities or states, the Fire Marshal's office will have formal and informal hearings (on the record, off the record hearings).

The informal hearing is a nonrecord proceeding in which the property owner may request a hearing to determine if a solution can be worked out without going to the board of appeals or to court. The property owner may submit documents in an attempt to correct the deficiencies or to submit equivalencies that would meet the intent of the code.

The formal hearing is a record proceeding. It uses many of the same legal techniques involved in any court hearing.

- Testimony under oath.
- Subpoenas.
- Transcripts.
- Affidavits.
- Cross examinations.

Again, as in the informal hearing, the property owner/business owner still may wish to go to the board of appeals or to court.

COMPLIANCE

Within the purpose, scope, or enforcement authority of the model fire codes or National Fire Protection Association #1 (Fire Prevention Code) is the word compliance mentioned? We assume that if we do not note any violations of the code then the building is in compliance with the code. The word compliance means the act of conforming, or being in accordance with. Your duty as an Inspector is to inspect for the purpose of ascertaining and correcting conditions that are in violation of the code provisions or the intent of the code. If you state that a building is in compliance with the code, what does that mean? Is the building 100 percent, 90 percent, or 50 percent in compliance? You really have no way of determining compliance unless you were involved in the site inspection of the building during all phases of construction.

An example of this would be if you are inspecting an existing restaurant that has a fixed ceiling in place around a grease exhaust duct. How would you know if the required clearances between the duct and combustible construction have been provided when there is no attic space that would provide access? This condition could only have been determined during the construction and installation of the duct itself. Would it be reasonable to require that the ceiling around the duct be removed to determine if the clearance had been provided?

Your duty as an inspector is to determine if the building, conditions, or process meets or is in accordance with the intent of the code requirements. To do this the inspector has to have an understanding of what the code requirements are intended to accomplish, i.e., "whys" of the code, not just the written word. Getting violations corrected can be accomplished when the "whys" of the code can be explained. Knowing the "whys" or the intent of a given requirement will enable the inspector or the AHJ to determine if an alternate method or material could be used that would meet the intent of the code.

Effective Enforcement

The most effective method of code enforcement begins before the building is constructed. The fire department, in cooperation with the building department, should review the building construction plans jointly. The fire department should be involved in the review of all fire protection requirements and, when possible, make on-site inspections of facilities under construction to assure that the facilities are being constructed in accordance with both building and fire codes.

Interpersonal Skills

The inspector's ability to enforce the code within his/her community will depend greatly on his/her interpersonal skills. These skills will be enhanced greatly if the inspector has the ability to explain the intent of what is being required rather than stating that it is required by the code. Remember, for effective communication to take place, the receiver must be able to understand fully the sender's message. You, as the inspector, can be either the sender or the receiver. The ability to communicate is a personal skill that is essential for effective code enforcement.

EFFECTIVE COMMUNICATIONS

Fire departments should establish year-round campaigns to promote public interest in the department's goals and objectives. A large part of the public relations job of the fire department is to develop programs that address the fire dangers and secure the public help in maintaining fire safe buildings. This cannot be achieved by ordinances only, but requires public recognition of the necessity of the requirements of the codes.

Fire Safety Salesperson

Being able to sell fire safety is essential. Without this, a good code enforcement program will fail. Using the media to accomplish this is necessary. Sometimes bad press can be used to show the necessity for code enforcement. After a major fire, use the media to explain the reasons behind the fire's spread, the combustible materials, the large unprotected areas, the open vertical shafts, or that fire protection equipment was not maintained. Unfortunately, a disaster is an excellent opportunity for the fire department to make recommendations for improvements in the community and to show the relevance of code enforcement.

Barriers to Effective Communications

Effective communication also involves the inspector's ability to deal with the general public. The inspector must recognize that there are many barriers to effective communication. These barriers can lead to misunderstanding. The inspector must recognize and overcome these barriers. Some of these barriers are:

- Mannerisms in speaking and responding that turn people off.
- Attitudes, behavior, and assumptions that allow misunderstanding and undermine our ability to deal effectively with others.
- Not showing respect for those who differ with us and those who may know less than we do.

Improving Communication

Building improved communications can be accomplished by:

- Building your self-esteem.
- Building your self-confidence.
- Helping a person to save face.
- Making concessions when justifiable (admit when you are wrong).
- Keeping an open attitude toward another person or idea (be open minded).
- Minimizing objectionable aspects of another person's ideas, and building on the positive aspects if possible.
- Helping to clarify another person's thinking.
- Taking the time to see and understand another point of view.
- Giving credit where credit is due.
- Telling others in advance about changes that will affect them.

DOCUMENTATION

It is the responsibility of the inspector to have all of the hazards, no matter how small, corrected. All such hazards should be documented for the inspector's report to provide a complete record of all conditions found.

If violations are not documented, the department may be charged with negligence if a fire should occur and no records have been made of the request for abatement of a violation.

Reports are an important element in the operational procedure of an effective code program. The ability to enforce the code properly, to apply the code uniformly to all parties, and to defend successfully all enforcement actions centers on a good recordkeeping system. Accurate records of violations may act as indicators for the enforcement program. When records are evaluated properly, they may show trends and provide you with the basis upon which your enforcement program can be adjusted to meet the changing requirements. By accurately documenting violations, a chronological listing of previous inspections can be used.

Code enforcement documentation can be in several forms. In addition to inspections being conducted and violations noted which required corrective actions, documentation also is required for:

- Detailed building and occupant information.
- Permits issued.
- Complaints.
- Consultations.
- Plan review comments.
- Acceptance testing of fire protection equipment and systems.
- Approval based on alternate equivalent methods based on intent of code.

Most documentation by an inspector will be related to inspections, reinspections, violations noted, corrective actions required, and violations corrected or removed. This documentation will be in a written format that uses either preprinted forms or written inspection reports. When writing an inspection report, remember that legal actions are often won or lost on the basis of the written reports and records.

When writing a report, keep in mind that:

- Reports that are based on conjecture or derived from uncertain and questionable sources must not be used.
- Acceptable grammar should be used.
- A well-prepared report indicates that the inspector has the knowledge and has developed the experience to conduct a valid inspection and present it in an acceptable form.

Each violation listed on the report must:

- Describe in detail the specific violation noted.

- State what the code would require and describe the corrective action that has to take place in order to meet the code requirements.

- Provide the code references, including the edition, and sections numbered.

Remember that the accuracy of the report cannot be overemphasized. It is a legal document and may be used by several different legal representatives. Code enforcement officials who write inaccurate, sloppy, or incomplete reports may leave themselves, their departments, or their city open to possible legal ramifications.

INSPECTOR'S STANDARDS OF BEHAVIOR

The inspector's attitude is important and should be a positive one. If the inspector is critical, he/she can expect little or no cooperation from the building owner or manager.

Negativism will reduce the effectiveness of code compliance.

The professionalism of the inspector will assist in getting the job done. Knowing how to question someone about a problem without causing undue stress on the building owner or manager will make the inspector's job easier and make the inspector more efficient. To reflect the proper image for himself/herself as well as the department, his/her closing interview and report should **recommend/identify** corrective action to be taken without opinions or biases; don't sacrifice accuracy and completeness.

Department rules and regulations usually address the rules of conduct. However, in public, the inspector must conduct himself/herself as a professional--friendly and polite at all times. Remember, it costs nothing to be polite.

Your organization's image can be based solely on your conduct of behavior and attitude when conducting an inspection.

CODE OF ETHICS FOR FIRE PREVENTION

Ethics is the code of morals of a particular person. Honesty, justice, and courtesy form a moral philosophy.

One of the underlying purposes of codes is to see that general fire safety is observed. These laws have established correct procedures and proper rules of conduct. If an individual's rights are not respected to the fullest extent of the law, then the code can be declared null and void. When we develop the inspection program, we must include the traits of leadership: honest motives, correct attitudes, and practical wisdom. Deep down, we need principles to guide us during the discharge of our duties. We must maintain our integrity and discharge our duties with fairness and impartiality at all times. We must avoid any association with enterprises of questionable character.

Questions and conditions arise from time to time regarding what may or may not be ethical. Many states and local communities have, by law, established ethical standards that must be followed by government employees during the course of their employment. We may have established our own personal ethical behavior that relates to our own moral standards. The following questions may be used when determining if a decision on an action you are about to make or take is an ethical one:

- Do I feel embarrassed, guilty?
- Do I object to my decision being published?
- Am I willing to risk criticism for my decision?
- Could I justify and defend my decision to my greatest critics and enemies?
- Have I considered everyone who will be affected?
- Does it feel right?

*Code of Ethics For Fire Marshals

On May 17, 1966 the Fire Marshals Association of North America adopted a code of ethics. The code established conduct for the fire marshal's professional life, relations with employees, relations with other fire marshals, and relations with the public. The code of ethics for relations with the public, as published by the Fire Marshals Association of North America section of the National Fire Protection Association, is as follows:

RELATIONS WITH THE PUBLIC

The fire marshal will endeavor to extend public knowledge of fire protection and will discourage the spreading of untrue, unfair and exaggerated statements regarding fire protection. He will avoid any endorsement of any specific product, trade name or company.

He will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible.

He will express an opinion only when it is founded on adequate knowledge and honest conviction while he is serving as a witness before a court, commission, or other tribunal.

He will not issue *ex parte* statements, criticisms or arguments on matters connected with public policy which are inspired or paid for by private interests, unless he indicates on whose behalf he is making the statement.

He will refrain from expressing publicly an opinion on a fire protection subject unless he is informed as to the facts relating thereto.

He will act with fairness and justice with the public when dealing with fire protection. He will never act officiously or permit personal feeling, prejudices, animosities or friendship to influence his decisions.

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*He will disclose no information concerning the business affairs or technical processes to the public without their consent.

Required Equipment

Basic equipment for inspection includes:

1. Inspection form; clipboard.
2. Graph and note paper; six-inch ruler.
3. Colored pencils; an eraser.
4. A 12-foot tape measure; 50-foot tape measuring wheel.
5. Coveralls; hard hat.
6. Flashlight.
7. Camera.
8. Safety shoes, glasses, and earplugs.
9. Pitot tube and gauges (for water flow tests).
10. Reference books.
11. List of special hazards commonly found in the type of occupancy being inspected.
12. Copy of previous inspection forms and building maps/plans.

Nationally Recognized Standards

All of the model code documents require certain types of construction methods, materials and equipment. In most jurisdictions, "approved" means "acceptable to the authority having jurisdiction" (AHJ). Most code enforcement officials do not have the facilities or expertise to conduct the testing necessary to assure that the construction methods, materials, and equipment meet the code requirements. Instead they rely upon outside testing and listing organizations. There are numerous testing and listing laboratories in the United States. ICBO, BOCA, and SBCCI all maintain a listing of recognized facilities.

Three of the most well known are Underwriters Laboratories, Factory Mutual Research Corporation, and Southwest Research Institute.

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Underwriters Laboratories (UL) is located at 333 Pfingsten Road, Northbrook, Illinois 60062. The UL was founded in 1894 by William Henry Merrill. UL not only conducts laboratory tests but is a leader in the development of testing criteria. They publish the *Building Materials Directory, Fire Protection Equipment Directory, Fire Resistance Directory,* and others. Items that are tested by UL bear the UL trademark and are identified as listed. They will be listed in the appropriate publication, which is available at no cost to code enforcement officials.

Factory Mutual Research Corporation (FMRC) is located at 1151 Boston-Providence Turnpike, Norwood, Massachusetts 02062. FM was founded in 1916. Like UL, FM not only conducts laboratory tests but is also a leader in the development of testing criteria. Factory Mutual Research is part of the Factory Mutual System which also includes insurance companies for highly protected risks (HPR). Unlike UL, FM approves materials and equipment. This means that the material or equipment is approved to be used in the facility which is insured by one of the Factory Mutual System Companies. Items tested by FM will bear the FM mark and will be listed in FM publications. Factory Mutual Research publishes the *Approval Guide* and *Specification Tested Products Guide*. Both of these are available at no cost to code enforcement officials.

Southwest Research Institute is located at 6262 Culebra Road, San Antonio, Texas 78224. Southwest Research is a nonprofit organization which was founded in 1947. Like numerous other testing organizations, testing is conducted in accordance with criteria established by UL and FM.

Also mentioned in the Model Codes are testing criteria or standards. Some of these standards may be from UL or FM. Others come from additional standards organizations.

The American Society for Testing and Materials (ASTM) is located at 1916 Race Street, Philadelphia, Pennsylvania 19103. ASTM has more than 140 standards writing committees, and produces voluntary consensus standards for materials, products, systems, and services. The standards written by ASTM are consensus standards, developed by ASTM committees and subject to approval by the membership. Quite often, ASTM, UL, and NFPA will have identical standards criteria.

The American National Standards Institute (ANSI) is located at 1430 Broadway, New York, New York 10018. ANSI writes no standards of its own but approves standards written by other organizations. One of the criteria for this approval is that the standards be developed under an open process that gives directly and indirectly affected interests an opportunity to express their views.

The American Petroleum Institute (API) is located at 1220 L Street, N.W., Washington, D.C. 20037. API represents those individuals and companies involved in the petroleum industry. The institute writes several standards concerning the storage and handling of flammable and combustible liquids.

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MODULE 2: FIRE AND CODES: THEIR RELATIONSHIP

TERMINAL OBJECTIVES

The students will:

1. *Given specific building materials, recognize the potential hazards of fire spread.*

2. *Given simulated situations, identify construction types and building systems; analyze the strengths and concerns related to fire, smoke, and heat travel.*

3. *Given a scenario, identify the key characteristics of each occupancy class.*

4. *Describe categories of human behavior in fire situations and analyze what variables affect this behavior.*

5. *Explain the development, application, and interrelationship of codes and standards.*

ENABLING OBJECTIVES

Given the content of the module, the students will:

1. *Identify what is fire.*
2. *Describe methods of fire travel.*
3. *Describe the stages of fire growth and development.*
4. *Recognize the effects of fire on building construction materials.*
5. *Differentiate among the types of construction and identify the protection associated with each.*
6. *Explain the factors used to establish the occupancy classes.*
7. *Identify the occupancy classes in their codes.*
8. *Locate fire safety requirements in companion code documents.*
9. *Identify and describe the characteristics that impact occupant behavior during a fire. (Age, mobility, knowledge of the building, etc.)*
10. *Differentiate among "code," "standard," "recommended practices," and "guides."*
11. *Describe how local codes apply to new and existing structures.*

FIRE GROWTH AND DEVELOPMENT

Fire is the chemical decomposition of matter by heat. Combustion is an exothermic, self-sustaining reaction involving a solid, liquid, and/or gas phase fuel. Combustion does not have to involve fire. The combustible material may have to be heated before it will ignite or support flame. Burning will continue until:

- Fuel is removed.
- Heat is removed.
- Oxygen is consumed.
- Chemical reaction is interrupted.

Both fuel and oxygen molecules must be activated before they can interact chemically to produce heat. This can be by other molecules from a nearby flame or spark, or by the general temperature of the fuel. Ignition temperature is the minimum temperature to which a substance must be heated for it to ignite. **Piloted ignition** is initiated by a small external flame, spark, or glowing ember. **Auto-ignition** is ignition without the assistance of an external pilot source. For most combustibles the flame reaction occurs in the gas or vapor phase and is influenced by:

- Rate of air flow (oxidant).
- Rate of heating.
- Size and shape of the solid or liquid.

Fire growth hazard is based on the combustion characteristics within the room. Factors that influence the likelihood of full involvement are:

- Fuel load (type of materials and their distribution).
- Interior finish.
- Air supply.
- Size, shape, and construction.

Fire development is not a consistent progression from ignition to full involvement. Risk of a full involvement is dependent on the ability of the flame to reach the ceiling. If the flames are unable to reach the ceiling, fire growth potential is usually low. Where, because of room content and density or interior finish, fire grows to ceiling height, then fire growth potential is comparatively high.

*Major Factors Influencing Fire Growth

Realm	Approximate Ranges of Fire Sizes	Major Factors That Influence Growth
1 (Preburning)	Overheat to Ignition.	Amount and Duration of Heat Flux. Surface Area Receiving Heat from Material Ignitability
2 (Initial Burning)	Ignition to Radiation Point (10 in. [254 mm] high flame).	Fuel Continuity. Material Ignitability. Thickness. Surface Roughness. Thermal Inertia of the Fuel.
3 (Vigorous Burning)	Radiation Point to Enclosure Point (10 in. to 5 ft. high flame [254 mm to 1.5 m]).	Interior Finish. Fuel Continuity. Feedback. Material Ignitability. Thermal Inertia of the Fuel. Proximity of Flames to Walls.
4 (Interactive Burning)	Enclosure Point to Ceiling Point (5 ft. [1.5 m] high flame to flame touching ceiling).	Interior Finish. Fuel Arrangement. Feedback. Tallness of Fuels. Proximity of Flames to Walls. Ceiling Height. Room Insulation. Size and Location of Openings. HVAC Operation.
5 (Remote Burning)	Ceiling Point to Full Room Involvement.	Fuel Arrangement. Ceiling Height. Length/Width Ratio. Room Insulation. Size and Location of Openings. HVAC Operations.

Fire growth depends on **different** factors as it progresses. Growth and development is a complex issue. The Standard Time Temperature Curve (STTC) utilizes 8,000 Btus per pound to determine the heat of the fire at particular times, which is not realistic. It is conservative in certain occupancies such as residential, institutional, and some commercial and should not be used as an indicator of fire severity in combustibles having a light heat release or when fire conductors produce temperatures higher than the STTC.

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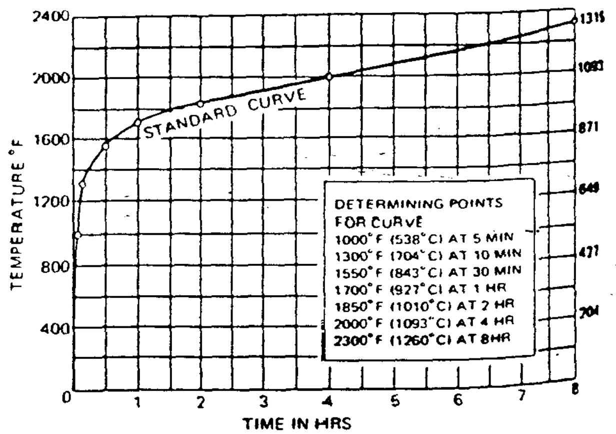

The standard time-temperature curve.

Flashover occurs when combustible materials in fire are heated to ignition temperature. Flashover of enclosure is likely to occur if the temperature of the upper gas layer reaches approximately 1,100 °F (600 °C). This depends on:

- Heat released by the burning fire.
- Ventilation of the enclosure.
- Dimensions of the enclosure.
- Type of material lining the enclosure.

Fire hazards can be thermal, heat and flame, or nonthermal, which is smoke and gases.

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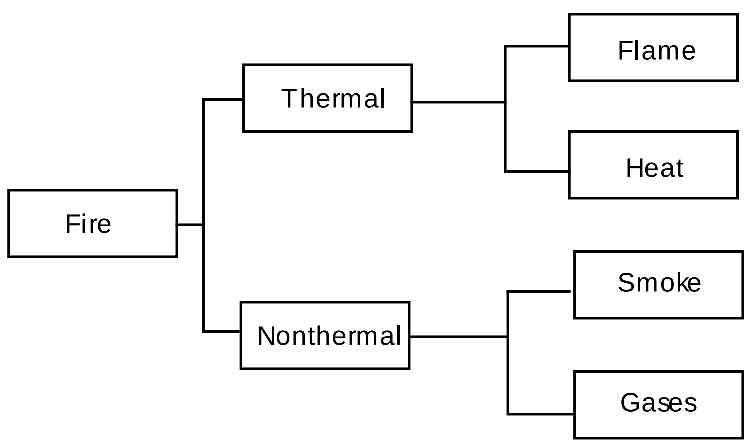

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Heat and flame are transferred through:

- Radiation.
- Conduction.

Gases and smoke are spread by:

- Convection.
- HVAC systems.

Recognizing the hazards posed by each component, and the dangers posed by products is a challenge for the fire inspector.

Fast flame spread over finish materials or building contents is the primary concern. The ability of the fire service to contain or extinguish a fire is significantly reduced if the fire can spread vertically two or more floors. Vertical fire spread is influenced principally by architectural and structural design.

Radiation is a process in which energy in the form of rays of light, heat, etc., is sent out through space from atoms and molecules as they undergo internal change.

It travels at the speed of light and in a straight line. Heat and flame can move quickly through the building. Your eyes see only a fraction of the energy being emitted by radiation. Intensity of heat transfer cannot be determined easily. The receiving surface will absorb most of the radiant heat. If it is black or dark in color. Most nonmetallic materials are effectively "black" to radiant heat even if they appear light. Radiant heat energy transmitted from a point source to a receiving surface will vary inversely with separation distance (doubling the distance will decrease the radiant heat by a factor of four).

Conduction is the transfer of heat through a material. For heat conduction the most important physical properties of a material are:

- Thermal conductivity: the degree to which an object will transfer heat. For example, wood is a poor conductor; steel is a good conductor.
- Density: the mass per unit volume.
- Specific heat: defines the amount of heat a substance absorbs as its temperature increases.

Convection is the transfer of heat by its absorption by a fluid at one point followed by motion of the fluid and rejection of the heat at another point. This heat transfer method is most responsible for the spread of fire. Heat generated in a room is initially transmitted by convection (air), then by conduction. Heated air expands and rises upward, resulting in extension of a fire.

The primary function of the HVAC system (heating, ventilation, and air conditioning) is to maintain a controlled environment for the building occupants or equipment. These systems may also contribute **actively** or **passively** to the overall building fire protection design. System may simply shut down and protect openings or the system may actively protect by pressurization of exits or exhausting smoke from the fire area.

BUILDING MATERIALS AND FIRE SPREAD

The amount of heat produced on burning is determined almost entirely by the chemical composition of the material. The speed with which heat is produced is determined by the physical form of the material. Hydrocarbon-based materials consume fifty percent more oxygen, and thus produce about fifty percent more heat than equivalent amounts of other materials. On a weight basis, pound-for-pound hydrocarbons produce twice the heat. For example, 16,000 Btus per pound, are produced for plastics versus 8,000 Btus per pound for wood.

*Substance	Btus per lb
Wood sawdust (oak)	8,493†
Wood sawdust (pine)	9,676†
Wood shavings	8,248†
Wood bark (fir)	9,496†
Corrugated fiber carton	5,970†
Newspaper	7,883†
Wrapping paper	7,106†
Petroleum coke	15,800
Asphalt	17,158
Oil (cottonseed)	17,100
Oil (paraffin)	17,640

† Dry

The selection of building materials and the design of the details of construction play an important role in building fire safety. Two considerations are:

- Structural frame to avoid collapse.
- Ability of barriers to prevent ignition and flame spread to adjacent spaces.

Structural collapse potential and fire endurance of beams, girders, and columns that comprise the structure's frame were determined by the American Society for Testing and Materials (ASTM) in 1907 using the standard time/temperature curve, by fire resistance tests established in 1918 by the NFPA, and by fire resistance ratings which are commonly referred to as:

- 15 minutes
- 30 minutes
- 45 minutes
- 1 hour

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- 1-1/2 hours
- 2 hours
- 3 hours
- 4 hour assembly rating.

A 1 hour rating indicates that the assembly withstood the standard test for 1 hour or longer, 2 hour rating indicates the assembly withstood a 2 hour or longer test without failure of a critical element. Acceptance criteria are specific and **may** include:

- Failure to support load.
- Temperature increase on the unexposed surface 250 °F above ambient.
- Passage of heat or flame sufficient to ignite cotton waste.
- Excess temperature on steel members.
- Failure under hose stream (walls and partitions).

Steel

The popularity of steel frame building construction is due to its high strength, ease of fabrication, and assured uniformity of quality. Exposed structural steel is vulnerable to fire damage and structural collapse. Fire protection generally is provided for steel by:

- Encasing the members in concrete, lath and plaster, and/or sprayed fibers.
- Installing a ceiling membrane barrier such as tiles in a grid system.

The intensity of stress in a steel member influences the load carrying capacity. The higher the load stress, the more quickly a member will fail at elevated temperatures. A temperature of 1,100 °F is normally considered to be the critical temperature. At 1,100 °F steel has lost sixty percent of its carrying capacity at room temperatures (sixty percent capacity is normally used as the design working stress). If the ends of a structural member are restrained, expansion due to heat under load can cause rapid collapse. Fifty feet of steel heated uniformly over its length from 721 ° to 972 °F expands 3.9 inches. Fire testing of steel uses 1,000 °F as the point of test failure.

Concrete

Although collapse of reinforced concrete structures is rare, loss in strength and damaging effects do occur. Factors that influence strength reduction are:

- Type of aggregate.
- Moisture content.
- Type of loading.
- Level of stress.

The greatest problem of prestressed concrete involves the elevated temperature of the stressed steel. Elasticity is reduced by twenty percent when the temperature of the steel reaches 600 °F. Prestressed wires are permanently weakened when they reach 800 °F.

Wood

Depending on its form, wood may or may not provide reasonable structural integrity in a fire. Factors are:

- Physical size.
- Moisture content.

Fire retardant treatment delays ignition and retards combustion; however, all wood will burn. Burning wood produces charcoal. The charcoal initially provides a protective coating that insulates the unburned wood. Thicker members provide much more structural integrity over the period of fire exposure than do thin ones. Heavy timber has proven to be an excellent form of construction. Wood frame uses structural members smaller than mill construction; when exposed to fire it offers relatively little structural integrity.

BUILDING SYSTEMS

Building systems are the building services that provide for the practical use of a structure. These include:

- Electrical.
- Heating.
- Ventilation.
- Air conditioning.
- Plumbing.
- Transportation.

A basic knowledge of these systems and their relationship to the structure are needed to understand how they may affect fire safety. These systems may be considered separately. However, it must be understood that each system is only one part of the total building system.

Electrical System

If properly designed, installed, and maintained, electrical systems are both convenient and safe; otherwise they may be responsible for both fire and injury. When an electric circuit carrying current is interrupted intentionally or unintentionally, arcing or heating is produced. Fire protection standards are requirements intended to prevent:

- Arcing and overheating.
- Accidental contact, which may cause electric shock.

Electrical fires can be divided into three categories. The first category consists of fire started by worn-out or "tired" electrical equipment.

These cause the largest percentage of electrical fires. Examples include:

- The electric motor.
- Worn-out insulation.
- Electronic appliances.
- Appliance cords.
- Fixtures.
- Heating appliances.

The second category of electrical fires is caused by improper use of approved equipment. The most commonly misused electrical equipment includes:

- Electric motors.
- Extension cords.

The third cause of electrical fires is an accidental occurrence or operator error such as:

- Clothes left in contact with lamps.
- Items dropped into electric equipment.
- Heating equipment left on.
- Defective installations.

Heating

Heat-producing appliances and associated equipment are the most prevalent accidental cause of fire. Heat-producing appliances normally operate at temperatures above the ignition temperature of many common materials. Installation, use, and maintenance of heating systems must be considered to have ignition potential. Examples include:

- Fuels and fuel controls.
- Available air and air-fuel mixtures.
- Fuel storage, boilers, and boiler controls.
- Solid fuel heating (woodstoves, fireplaces, etc.).
- Cooking equipment.
- Steam systems venting.

Ventilation and Air Conditioning

Ventilation and air conditioning is the process of treating air to control its temperature, humidity, cleanliness, and distribution simultaneously. The system of ducts usually associated with ventilation presents the possibility of spreading fire, fire gases, and smoke throughout the area served. Filters, ducts, and fire separation penetrations are rated for a specified use that depends on a building's needs or use. Generally, smoke detectors must be installed in all systems over

2,000 cfm and are not to be used as replacements for the smoke detectors required for the occupancy.

Transportation

Building transportation systems such as elevators and escalators make modern buildings possible. Special precautions must be taken to prevent elevator use during fires and to prevent spread of fire due to escalator floor openings. Signs prohibiting the use of elevators in the case of fire are widely used. Modern elevator systems usually are designed to operate in a special emergency mode during a fire. Openings for escalators must be protected to prevent the spread of smoke and fire.

Plumbing

Plastic pipe must be protected to prevent the spread of fire and is usually accepted by providing a chase or enclosure. Other aspects of plumbing usually are not considered fire-spread hazards.

TYPES OF BUILDING CONSTRUCTION

Fire Spread

At the turn of the century, conflagrations were a common occurrence. Increased knowledge of fire behavior and building design helped to confine the fire to the building of origin. Recent development has led to fire designs which contain the fire to the floor of origin and, further, to the room. At present, technology has enabled the control of hostile fire in even smaller areas within a room.

Fire-Safe Design

The objectives of fire-safe designs in building construction are: **life safety, property protection, and the continuation of building operations**. The first step of life safety is to identify the occupant characteristics of the building. A design for life safety may involve:

- Evacuating occupants, which depends on both the availability of a path of escape and alerting the occupants.
- Defending the occupants in place, which is used when evacuation has an unacceptably low likelihood of success.
- Providing an effective area of refuge, which involves movement through the building to a refuge space.

Items of high monetary or other value, i.e., vital records, computers, etc., must be identified for protection. Special protection should be considered in relation to the property to be protected.

Downtime of the building may have a serious impact that must be evaluated. Sensitive areas must be protected.

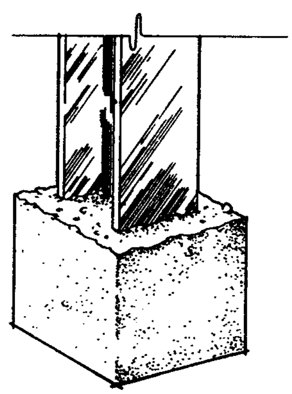
A Comparison of Construction Types

NFPA 220	I (443)	I (332)	II (222)	II (111)	II (000)	III (211)	III (200)	IV(2HH)	V (111)	V (000)
UBC		I FR	II FR	II-1 hr	II N	III-1 hr	III N	IV HT	V 1-hr	V-N
BNBC	1A	1B	2A	2B	2C	3A	3B	4	5A	5B
SBC	I	II	_	IV 1-hr	IV unp	V 1-hr	V unp	III	VI 1-hr	VI unp

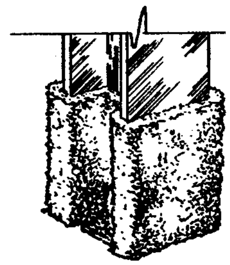
Fire Resistive

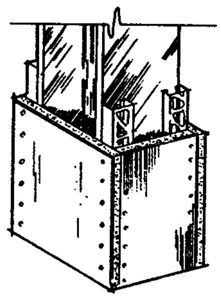
In fire-resistive construction the structural members are noncombustible and are fire protected as specified. There are usually two (2) subtypes with the basic difference between the subtypes being the level of fire protection specified for the structural frame. Only noncombustible materials are permitted. A building in which no structural steel is exposed, and all vertical openings are protected with approved doors would be fire resistive. The bearing walls may be made of steel with a fire-resistive covering applied. Structural steel often is protected by encasing, sprayed-on protection, or membrane ceilings. Exterior walls generally will be curtain walls and not structurally supporting. Exterior or interior nonbearing walls will have a varying degree of fire resistance. Stairwells **are** enclosed in fire-resistive materials. Roof construction may be similar to that used for floors.

Examples of Noncombustible Protected Spray and Encasement



Fire Resistive



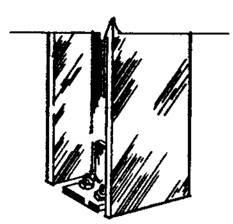


Fire Resistive--Encasement

Noncombustible

Structural elements are entirely of noncombustible or limited combustible materials, as permitted. This category is usually subdivided based upon fire-resistive requirements.

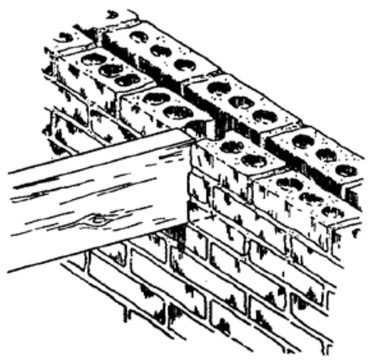
Often noncombustible construction is steel, which provides a totally noncombustible building in which the structural elements are exposed to the effects of fire. Totally noncombustible refers only to **structural** materials, not to interior finish and contents. The building's structural framework is made of steel bolted, riveted, or welded together. This is susceptible to expansion, distortion, or relaxation of steel members resulting in early collapse. Wall enclosures may be masonry, steel, aluminum, glass, or other material. Once wall coverings are in place, it may be difficult to determine if structural elements are exposed or protected. Concrete construction also can be considered noncombustible. The floor and roof support system will often be lightweight bar joists, trusses, or other lightweight steel.



Non-Combustible
Unprotected

Ordinary Exterior Protected

In this construction type all or part of the interior structural element may be combustible. Exterior walls are required to be noncombustible or of noncombustible materials. They can have a fire resistance rating depending upon the horizontal separation and the fire load. This category is usually divided into protected and unprotected subtypes. The building will have masonry exterior walls (usually brick), and wooden structural members and interior construction. The building generally will not exceed six stories, and will most often be two or three stories in height; often called "Main Street USA." Floor and roof supports are usually wood, but other materials such as steel bar joists may be found. Floor and roof decking will most frequently be wooden boards, tongue-and-groove boards, plywood, or composition board. Common walls between buildings may share wall sockets for floor joists and roof rafters.



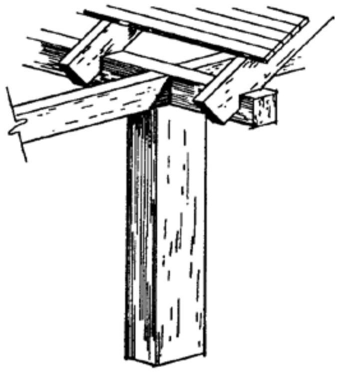
Ordinary

- solid masonry bearing walls
- wood floor or roof members
- fire cut joist

Heavy Timber

Heavy timber structural members--columns, beams, arches, floors, and roofs--are unprotected wood with large cross-sectional areas. Concealed spaces usually are not permitted. These buildings consist of masonry (noncombustible) exterior walls and structural members of substantial timber construction.

Minimum dimension of structural wood supports is eight inches for columns, beams, girders, and arches. All exposed wood has a minimum dimension of two inches. This is commonly found in older factories and mills. Wood floors will generally be a minimum thickness of three inches and may be oil soaked from years of supporting heavy machinery with lubricating oils. Roof supports will be wood with minimum dimensions of four by six inches, and a minimum roof decking thickness of 1-1/8 inches.



Heavy Timber

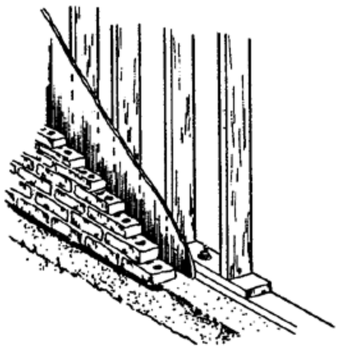
- glu-lam or solid wood beams
- check your code for minimum dimensions for each element

Wood Frame

Wood frame construction uses structural members entirely of wood. Usually wood frame is subdivided into two types.

- Protected--Structural elements protected as required.
- Unprotected--No fire protection requirement.

Walls, floors, and roof structure are of wood framing. **Post-and-beam** construction has a frame of substantial dimension wood and is sided with a lightweight covering such as wood boards. The construction is commonly used for barns, sheds, and storage buildings but may also be used in dwellings and other occupancies. In **balloon frame** construction, studs run from the foundation to the attic. This was used extensively in many parts of the country until the late 1930s for residential and light commercial. Floor joists are tied into the wall, allowing for fire extension in any direction. Fire stopping was not a common practice. In **platform frame** construction the walls of each successive story are built on a platform formed by the preceding floor. The joists for the deck may be full-dimension lumber or of lightweight construction. Once the floor/deck is in place, walls are placed on it with a sill at the bottom of the wall and a plate at the top. Platform frame construction provides a natural fire barrier for vertical extension within walls. Openings in walls for water, sewer, ventilation, or heating/air conditioning pipes can create a void for fire extension.



Frame

- may or may not have masonry veneer

OCCUPANCY CLASSES

Occupancy classes are based on an assessment of life safety from fire in buildings which is determined through an analysis of:

- Characteristics of occupants.
- Purpose served by the occupancy. (What is going on?)

The use of an occupancy is determined by the **processes** occurring within a building. These are categorized into occupancy classes in order to identify and deal with special needs. As an example:

Whether a building is fire resistive or not is unimportant until there are occupants in that building. When the building is used as an office it becomes important for the building to be fire resistive. Occupancy classes are the foundation of the code process. Fire prevention does not involve regulation of building construction. Codes regulate what occurs in the building. The relationship among building materials and construction and occupancy classes involves a complex interrelationship. The major code groups have developed occupancy classes which do not correspond in every case. Building types, rather than rooms within buildings, have been grouped with regard to their relative hazards.

- Residential and educational = low hazard.
- Mercantile = moderate hazard.
- Industrial and storage may be high hazard.

These types of classifications are the basis for building code requirements.

BASIC NATIONAL BUILDING CODE

Use Group Classification

Use Group A, Assembly Uses

All buildings and structures, or parts thereof, which are used or designed for the gathering together of persons for purposes such as civic, social or religious functions, recreation, food or drink consumption or awaiting transportation, shall be classified as Use Group A. A room or space used for assembly purposes by less than 50 persons and which is accessory to another use group shall be included as a part of that main use group.

Use Group A-1, theaters:

viewing of performing arts or motion pictures;

with fixed seats.

Use Group A-2 structures:

dance halls, nightclubs.

Use Group A-3 structures:

in which persons assemble for amusement, entertainment or recreation purposes as well as incidental motion picture, dramatic or theatrical presentations, lectures or other similar purposes without theatrical stage other than a raised platform;

used without permanent seating.

Use Group A-4 structures:

as churches and for similar religious purposes.

Use Group A-5, outdoor assembly:

Use Group B, Business Uses

All buildings and structures, or parts thereof, which are used for the transaction of business, for the rendering of professional services, or for other services that involve stocks of goods, wares or merchandise in limited quantities for uses incidental to office uses or sample purposes.

Use Group E, Educational Uses

All buildings and structures, or parts thereof, other than those used for business training or vocational training, which are used by more than five persons at one time for educational purposes through the 12th grade less than 50 shall be classified as Use Group B.

Day care facilities:

five persons more than 2 1/2 years of age for less than 24 hours per day shall be classified as Use Group E.

Group F, Factory and Industrial Uses

All buildings and structures, or parts thereof, in which occupants are engaged in work or labor in the fabricating, assembling or processing of products or materials.

Use Group F-1, Moderate-Hazard Factory and Industrial Uses

Table 305.3, Use Group F-2, Low-Hazard Factory and Industrial Uses

Use Group H, High-Hazard Uses

All buildings and structures, or parts thereof, which are used for the manufacturing, processing, generation or storage of corrosive, highly toxic, oxidizing, pyrophoric, water reactive, highly combustible, flammable or explosive materials that constitute a high fire, explosion or health hazard, including combustible fibers, dust and unstable materials.

Group H-1 structures:

a detonation hazard.

Use Group H-2 structures:

hazard from accelerated burning.

Use Group H-3 structures:

contain materials that readily support combustion or present a physical hazard.

Use Group H-4 structures:

health hazards.

Use Group I, Institutional Uses

All buildings and structures, or parts thereof, in which people suffering from physical limitations because of health or age are harbored for medical or other care or treatment, or in which people are detained for penal or correction purposes, or in which the liberty of the inmates is restricted, shall be classified as Use Group I.

Use Group I-1:

six or more individuals who, because of age, mental disability or other reasons, must live in a supervised environment but who are physically capable of responding to an emergency situation without personal assistance.

Use Group I-2:

used for medical, surgical, psychiatric, nursing or custodial care on a 24-hour basis of six or more persons who are not capable of self-preservation.

A child care facility which accommodates more than five children 2 1/2 years of age or less shall be classified as Use Group I-2.

Use Group I-3:

Six or more persons who are under some restraint or security.

Use Group M, Mercantile Uses

All buildings and structures, or parts thereof, which are used for display and sales purposes involving stocks of goods, wares or merchandise incidental to such purposes and accessible to the public.

Use Group R, Residential Uses

All buildings and structures, or parts thereof, in which families or households live, or in which sleeping accommodations are provided (with or without dining facilities).

Use Group R-1 structures:

hotels, motels, boarding houses;

occupants are primarily transient in nature, making use of the facilities for a period of less than 30 days.

Use Group R-2 structures:

multiple-family dwellings having more than two dwelling units;

shall also include all boarding houses and dormitory facilities.

Use Group R-3 structures:

one- or two-family dwelling units,

five lodgers or boarders per family.

A child care facility which accommodates five or less children of any age shall be classified as Use Group R-3.

Use Group R-4 structures:

detached one- or two-family dwellings not more than three stories in height.

Use Group S, Storage Uses

All buildings and structures, or parts thereof, which are primarily used for the storage of goods, wares or merchandise, except those of Use Group H, shall be classified as Use Group S. This includes, among others, warehouses, storehouses and freight depots.

List of moderate-hazard storage uses:

contents which are likely to burn with moderate rapidity, but which do not produce either poisonous gases, fumes or explosives shall be classified as Use Group S-1.

List of low-hazard storage uses:

used for the storage of noncombustible materials, and of low-hazard wares that do not ordinarily burn rapidly.

Use Group U, Utility and Miscellaneous Uses

Utility and miscellaneous uses shall include fences over 6 feet (1829 mm) high, tanks, cooling towers, retaining walls and buildings such as private garages, carports, sheds and agricultural buildings.

UNIFORM BUILDING CODE

Occupancy Descriptions

A--Assembly

A-1 Assembly with legitimate stage 1000 or more.

A-2 Assembly with legitimate stage less than 1000.

A-2.1 Assembly no stage 300 or more.

A-3 Assembly no stage less than 300.

A-4 Stadiums, reviewing stands, amusement park structures.

B--Business

B-1 Service stations, repair garages (no open flame).

B-2 Catch all occupancy including: colleges and universities, business, mercantile, warehouse, industry, etc.

B-3 Aircraft hangers (no open flame) and open parking garages, helistops.

B-4 Ice plants, power plants, etc., and factories (noncombustible materials).

E--Education

E-1 Over 50 people grades through 12.

E-2 Under 50 people grades through 12.

E-3 Day care.

H--Hazardous

H-1 Explosives.

H-2 Flammable and combustible liquids (open use), combustible dusts (woodworking shops).

H-3 Flammable and combustible liquids (closed systems).

H-4 Repair garages - using flammable liquids and open flame.

H-5 Aircraft repair hangers - using flammable liquids and open flame.

H-6 Semiconductor fabrication facilities.

H-7 Occupancies with high health hazards.

I--Institutions

I-1 Hospitals, nursing homes, nonambulatory patients.

I-2 Nursing homes, ambulatory patients.

I-3 Mental hospitals, jails, prisons.

M--Miscellaneous

M-1 Private garages, carports, sheds, agricultural buildings.

M-2 Fences over 6' high, tanks, and towers.

R--Residential

R-1 Hotels and apartment houses.

R-3 Dwellings (homes).

R-4 Residential ambulatory care - less than 16 clients.

STANDARD BUILDING CODE

Classification of Building by Occupancy

404 Assembly Occupancy--Group A

Group A occupancy is the use of a building or structure, or any portion thereof, for the gathering together of persons for purposes such as civic, social or religious functions or for recreation, or for food or drink consumption or awaiting transportation.

Shall include, among others, the following:

Amusement park buildings

Auditoriums
Churches
Dance halls
Gymnasiums
Restaurants that accommodate 50 or more people, or provide dancing or entertainment
Motion picture theaters
Museums
Passenger depots
Public assembly halls
Recreation halls
Stadiums and grandstands
Tents for assembly
Theaters for stage production

Assembly occupancies shall be divided into two subclassifications.

Large Assembly shall include theaters and places of assembly having a capacity of 1000 or more persons.

Small Assembly shall include theaters and places of public assembly having a capacity of 50 or more persons but having a capacity less than designated for Large Assembly.

Business Occupancy--Group B

Group B occupancy is the use of a building or structure, or any portion thereof, for office, professional, or service type transactions including normal accessory storage and the keeping of records and accounts.

Group B occupancy shall include, among others, the following:

Animal hospitals, kennels, pounds
Automobile and other motor vehicle showrooms
Automobile or other vehicle service stations
Banks
Barber shops
Beauty shops
Bowling alleys
Car wash
Civic administration
Clinic - outpatient
Dry cleaning; pick-up and delivery stations and self-service
Educational occupancies above the 12th grade
Electronic data processing
Florists and nurseries
General post offices

Greenhouses
Laboratories; testing and research (nonhazardous)
Laundries; pickup and delivery stations and self service
Libraries (other than school)
Office buildings
Police stations
Print shops
Professional services; attorney, dentist, physician, engineer, etc.
Radio and television stations
Telephone exchanges

Educational Occupancy--Group E

Group E occupancy is the use of a building or structure, or any portion thereof, by six or more persons at any one time for educational purposes through the 12th grade.

Child care facilities which accommodate six or more children of any age who stay less than 24 hours per day shall be classified as Group E.

Parts of buildings used for the congregating or gathering of 50 or more persons in one room shall be classified as Group A.

Factory--Industrial Occupancy--Group F

Group F occupancy is use of a building or structure, or any portion thereof, for assembling, dissembling, repairing, fabricating, finishing, manufacturing, packaging or processing operations that are not otherwise classified in this Code.

Manufacturing plant
Factory
Assembly plant
Processing plant
Mill

Hazardous Occupancy--Group H

Group H occupancy is the principal use of a building or structure, or any portion thereof, that involves highly combustible materials or flammable materials, or explosive materials or materials that have inherent characteristics that constitute a high fire hazard.

Group H occupancies shall include, among others, the following:

Dry cleaning establishments using flammable solvents
Explosive manufacturing
Grain elevators

Paint or solvent manufacturing (flammable base)
Pyroxylin plastic manufacturing
Sodium nitrate or ammonium nitrate
Storage of combustible film
Storage of highly combustible materials
Tank farms--used to store flammable liquids or gases

Storage and handling of flammable liquids, gases and other hazardous substances shall be in accordance with the Standard Fire Prevention Code.

Group H occupancies shall not be permitted in the Fire District.

Institutional Occupancy--Group I

Group I Unrestrained includes buildings or portions thereof used for medical, surgical, psychiatric, nursing or custodial care on a 24 hour basis of six or more persons who are not capable of self-preservation, and shall include among others:

Hospitals, nursing homes (both intermediate care facilities and skilled nursing facilities), mental hospitals and detoxification facilities. Facilities such as the above with five or less persons not ancillary to other uses shall be classified as a residential occupancy.

Group I Restrained Occupancy

Group I Restrained includes buildings or portions thereof which provide sleeping accommodations for six or more persons under some degree of restraint or security who are generally incapable of self-preservation due to security measures not under the occupants' control and:

Jails
Detention centers
Correctional institutions
Reformatories

Mercantile Occupancy--Group M

Group M occupancy is the use of a building or structure, or any portion thereof, for the display and sale of merchandise including stocks of goods, wares or merchandise incidental to such purposes and accessible to the public and shall include, among others, the following:

Department stores
Drug stores
Markets

Retail stores
Shopping centers
Sales rooms
Wholesale stores (other than warehouses)

Residential Occupancy--Group R

Group R occupancy is the use of a building or structure, or any portion thereof, for sleeping accommodations not classed as a Group I occupancy.

Group R occupancies shall include, among others, the following:

R1: Residential occupancies where the occupants are primarily transient in nature (less than 30 days) including:

Hotels
Motels
Boarding housing (transient)

R2: Multiple dwellings where the occupants are primarily permanent in nature, including:

Apartment houses
Boarding houses (not transient)
Convents
Fraternities and sororities
Monasteries

R3: One and two family dwellings where the occupants are primarily permanent in nature and not classified.

Storage Occupancy--Group S

Group S occupancy is the principal use of a building or structure, or any portion thereof, for storage that is not classed as a Group H occupancy or used for the purpose of sheltering animals.

S1: Moderate hazard storage

S2: Low hazard storage

NFPA--LIFE SAFETY CODE

Assembly

Assembly occupancies include, but are not limited to, all buildings or portions of buildings used for gathering together 50 or more persons for such purposes as deliberation, worship, entertainment, eating, drinking, amusement, or awaiting transportation.

Educational

Educational occupancies include all buildings or portions of buildings used for educational purposes through the twelfth grade by six or more persons for four or more hours per day or more than 12 hours per week.

Educational occupancies also include day-care facilities of any occupant load.

Health Care

Health care occupancies are those used for purposes such as medical or other treatment or care of persons suffering from physical or mental illness, disease, or infirmity; and for the care of infants, convalescents, or infirm aged persons. Health care occupancies provide sleeping facilities for four or more occupants and are occupied by persons who are mostly incapable of self-preservation because of age, physical or mental disability, or because of security measures not under the occupants' control.

Detention and Correctional Occupancies

Detention and correctional occupancies are those used to house occupants under some degree of restraint or security. Detention and correctional occupancies are occupied by persons who are mostly incapable of self-preservation because of security measures not under the occupants' control.

Residential

Residential occupancies are those occupancies in which sleeping accommodations are provided for normal residential purposes and include all buildings designed to provide sleeping accommodations.

Exception: Those classified under Health Care or Detention and Correctional Occupancies.

Mercantile

Mercantile occupancies include stores, markets, and other rooms, buildings, or structures for the display and sale of merchandise.

Business

Business occupancies are those used for the transaction of business, for the keeping of accounts and records, and similar purposes.

Industrial

Industrial occupancies include factories making products of all kinds and properties devoted to operations such as processing, assembling, mixing, packaging, finishing or decoration, and repairing.

Storage

Storage occupancies include all buildings or structures utilized primarily for the storage or sheltering of goods, merchandise, products, vehicles, or animals.

Special Structures

Special structures that house occupancies include the occupancies from the preceding groups that are in special structures or buildings including, among others, the following:

Open structures
Towers
Underground structures
Vehicles
Vessels
Water surrounded structures
Windowless buildings

Change of Use

All major code groups deal with change of use in a similar way.

When a different use is proposed as the principal use of a building or structure, the requirements for a new structure of similar use is required.

Often major revisions to the structure are required.

Firewalls to limit building size.

Fire protection enhancements i.e., sprinklers, alarms. HVAC controls are required for the new use.

Sometimes the use is denied because the code does not permit that use in the type of construction i.e., high-hazard storage in a large open wood structure.

Construction materials must meet new construction requirements; the requirements for interior finish and fire separation must meet what would be required under the code now in effect, not what was required by the code in effect at the time of construction.

CODES AND STANDARDS

Codes

Codes are mandatory provisions using the word **shall** to indicate requirements and in a form generally suitable for adoption into law. They set forth minimum requirements to protect the health and safety of society and generally represent a compromise between optimum safety and economic feasibility. Codes are written in legally adapted language and are intended to be adopted by the authority having jurisdiction (AHJ) into the local or state statutes. There are two types of codes:

- Specification--Spell out in detail what materials can be used, the size of components and how they are to be assembled.

- Performance--Detail the objective to be met and establish criteria for determining if the objective has been met.

Standards

Methods and materials can be selected as long as it can be shown that the performance criteria can be met. Performance-oriented codes still embody a fair amount of specification-type requirements but the provision exists for substitution of alternate methods and materials if they can be proven adequate "trade-offs." Standards are mandatory provisions using the word **shall** to indicate requirements. Requirements found in codes are excerpts from, or based on, the standards published by nationally recognized organizations. The most extensive use of standards is their adoption into the code by reference, thus keeping the code to a workable size and eliminating duplication of effort. Examples of such standards are those that deal with:

- Extinguishing systems.
- Flammable liquids.

- Hazardous processes.
- Combustible dusts.
- Building materials.
- Water systems.
- Mechanical systems, etc.

Recommended Practices

Recommended practices are only advisory provisions (using the word "should" to indicate recommendations) in the body of the text. **Should** indicates a recommendation which is advised but not required. They are published by nationally recognized organizations, and are intended to deal with maintenance and operational standards for the various systems required by the code. Recommended practices can be adopted into the code by reference and are usually used by the AHJ as the guide to determine compliance with the intent of the code writers.

Guides

Guides are advisory in nature and may give instructions, but do not contain mandatory provisions. They are written by nationally recognized organizations. Guides are intended to explain the codes' and standards' written intent. Guides provide methods to the AHJ or testing agencies to assess the degree to which the system has met the intent of the standard.

Guides are not adopted by reference, but can be included in a standard.

Code Groups	Standards	Listing and Testing Agencies
International Conference of Building Officials (ICBO)	National Fire Protection Association (NFPA)	Underwriters' Laboratories Inc. (UL)
National Fire Protection Association (NFPA)	American Society for Testing and Materials (ASTM)	Factory Mutual System (FM)
Building Officials and Code Administrators International (BOCA)	American National Standards Institute (ANSI)	Independent Labs
Southern Building Code Congress International (SBCCI)		

HUMAN BEHAVIOR AND FIRE

How one reacts during a fire emergency is related to:

- Role assumed.
- Previous experience.
- Education.
- Personality.
- Perceived threat.
- Means of egress.
- Actions of others.

Role Relationship

Studies show that in groups people use the reactions of others to determine the level/degree of threat, i.e., a group room occupant stays longer in a room full of smoke than an individual. The group will stay until a member of the group starts action or movement role. Role relationship has been shown to affect the outcome of critical incidents as people look to those in charge during a fire incident. At the Beverly Hills Supper Club the staff of the facility took charge and were responsible for saving multiple lives--even the busboys and waiters led people to safety. Students in school look to the teachers, and aircraft passengers easily take direction from the flight attendants during a fire threat. Fire safety training is essential for assembly occupancies.

Previous Experience

Previous experience affects ability to size up and compare the present experience with any previous fire experience. This is a dynamic process which alters choices.

Education

Fire Extinguisher

An individual's emotional reaction to a fire will be largely influenced by familiarity with the extinguisher, experience in using it or observing its use, training and self-confidence, and role perceived.

Training is, therefore, very important. Many facilities practice with extinguishers when the extinguisher is scheduled for recharging.

Fire Drill

Well-marked exits do not ensure life safety during a fire. Exit drills are necessary so that occupants will know how to make an efficient and orderly escape. Exit drills are usually required in schools, health care facilities, and are common in high-hazard industries.

Drills should be conducted whenever it is possible, or wherever confusion during occupant escape might lead to greater confusion. Generally, drills conducted a few minutes before a meal break have been found to minimize loss of time and production. A recommended practice is to establish fire wardens to train and monitor evacuation procedures.

In a health care facility, a drill might just be for the staff training and it is recommended that a drill be conducted once a month for the staff to learn and reinforce proper evacuation procedures, i.e., closing doors, moving patients.

Reactions to Special Hazards

Plant/Industrial fire safety--often protection is provided by specially trained plant personnel such as fire brigade or haz mat responders.

Flammable material, unstable material, and manufacturing or transportation of flammable, hazardous materials require special procedures and staff reaction during a fire/spill incident.

Personality

Occupants who engage in firefighting behavior are usually male, and it has been determined that this is culturally determined/expected as a male role. Women predominantly notify the fire department first.

Perceived Threat

Occupants will move through smoke in an evacuation process. Panic is a rare event that occurs under specific conditions. Most important individual decisions and behavior occur prior to the arrival of the fire department. The way in which an individual is alerted determines the degree of threat perceived.

Perception of threat is based on the smoke thickness and the degree to which an individual has available clearly demonstrated visual paths or system to utilize.

Means of Egress

Clear, unobstructed means of egress reduces the perception of threat.

Special consideration must be provided for occupants who, because of age, are unable to evacuate. The very young and elderly are not as likely to be able to manage the threat of fire.

The very young--usually under six--are usually very mobile, but have great difficulty in utilizing steps and in following the predetermined path of travel. Unless special education has been provided they do not understand **EXIT** signs and must be directed for movement; door and door latches are barriers.

Those over sixty may replicate characteristic behavior of the very young. Possible compensations for both age groups include direct exit to the exterior, and ramps in lieu of steps.

Handicapped and infirm individuals sometimes are unable to utilize most common methods of escape. Assigned assistants and special provisions for movement on stairs are valid considerations. It is recommended that areas of refuge and handicapped closets with special equipment be established in high-rise occupancies and educational facilities. By designating special emergency procedures the arriving suppression forces are enhanced in their efforts to provide for those of limited mobility.

Restrained individuals (jails, detention-psychiatric institutions) also require special emergency procedures.

Actions of Others

The following is excerpted from an NFPA article by Dr. John L. Bryan.

> The recognition of ambiguous threat cues as signaling an emergency condition may be inhibited by the presence of other people. Experimental studies of the inhibition of adaptive reaction to emergencies (Latane and Darley 1968) created an experimental situation involving college students. While the students were completing a written questionnaire, the experimenter would introduce smoke into the room through a small vent in the wall. If the student left the room and reported the smoke, the experiment was terminated. If the student had not reported the presence of smoke within a six-minute interval from the time smoke was first noticed, the experiment was considered completed. Students alone in the room reported the smoke in 75 percent of the cases. When two passive non-committal persons joined each student, only 10 percent of the groups reported the smoke. When the total experimental group consisted of three naive subjects, in only 38 percent of the groups did one individual report the smoke. Of the 24 persons involved in the eight naive subject groups, only one person reported the smoke within the first four minutes of the experiment. In the single subject situations, 55 percent of the subjects had reported the smoke within two minutes and 75 percent in four minutes.
>
> It was reported in the study that noticing the smoke was apparently delayed by the presence of other persons, with the median being five seconds for single subjects but 20 seconds in both of the group conditions. These results undoubtedly reflect the constraints

that people accept regarding their behavior in public places. The performance of naive subjects in the passive confederate situation was reported as follows:

> "The other nine stayed in the waiting room as it filled up with smoke, doggedly working on their questionnaires, and waving the fumes away from their faces. They coughed, rubbed their eyes, and opened the window, but did not report the smoke."

It has been suggested that while trying to interpret the emergency potential of ambiguous threat cues, the individual is influenced by the behavioral reaction of others. Should these others remain passive and seem to interpret the situation as a nonemergency, the individual will tend to have this interpretation modified by this inhibiting social influence (Latane and Darley 1968). This behavioral experiment may help explain the reported tendency of people to (1) disregard threat cues, or (2) interpret them as being nonthreatening when the threat situation occurs where there are many other people such as in a restaurant, motion picture theater, or department store. These experimental results may be of assistance in explaining the incidence of calls received by fire departments minutes or even hours after the incident was first detected. In the report of the Arundel Park Hall fire (Bryan 1957), several of the sample population indicated that when they entered the hall after observing the fire from outside the building, they warned their friends and suggested they should leave, but were laughed at and their warning apparently disregarded.

HUMAN BEHAVIOR AND FIRE

Joseph Swartz

How one reacts during a fire emergency is related to: (1) status with the group, past experience, and personality; (2) the perceived threat of the fire situation; (3) the escape alternatives available within the structure, and (4) the actions of others who are sharing the experience. Behaviors may be described as adaptive or nonadaptive, effective or ineffective, altruistic or aggressively antisocial, or in many other pairs of opposites that compare actions for enhancing or degrading an individual's chances of survival and that indicate how an individual's behavior affects the survival chances of others.

Until about 1972 when Wood's[1] classic study was made, very little, if any, rigorously objective study had been undertaken of how people really behave under various fire situations. In fact, popular cliches such as "panic" were used to describe what happened in such tragic multiple death fires as the 1942 Cocoanut Grove Fire in Boston and the 1958 Our Lady of the Angels Grade School Fire in Chicago, even though objective accounts of these fires[2,3] contradicted many of the connotative meanings the word panic elicits. By 1978 when the Second International Seminar on Behavior on Fire convened, objective research on how people really behave in fire situations had been conducted in many countries. Based on this research, seminar participants generally agreed that more descriptive terms must be used to relate how people behave in fire situations. They supported the findings of Woods,[1] Pauls,[4] and many other researchers[5] that encouraged dropping long-held but inaccurate ideas of how people behave in fire situations.

Such research has led to an intensive interest about how actual human behavior impacts on other efforts to increase levels of firesafety, and the human factor has been written into the systems approach[6] to firesafety pioneered by the General Services Administration[7] (GSA). Most professionals in fire protection would agree that much was learned about human behavior and fire during the 1970s, but that there is still much more to be learned, since this knowledge is basic to improvements in overall firesafety efforts.

A. The Problem

People can be taught that during a fire emergency, they should touch doors before opening them. But will they, and under what conditions? Some may touch them first when located on the lower levels of a motel, but will they do the same on the upper levels of a high-rise building? Will a nurse touch the door before entering a patient's room of fire origin? Will she first call the fire department or first evacuate the people? The answers to questions of this nature are essential as are the reasons for other behaviors in a fire situation if *effective* public firesafety education programs are to be developed.

Fire fighters instinctively look for children in closets, corners, and under beds. They have learned how children usually behave under severe fire conditions. But how do they plan for fire rescue from complex structures—whether they are commercial establishments, apartment houses, or mass transit systems—to ensure the maximum probability that the civilians involved will remain calm and follow instructions? There is still much to be learned that could help the fire service to plan more effective rescue efforts.

Building officials, fire marshals, and others should support their code enforcement and administration responsibilities with objective research into the psychology of how best to encourage compliance with firesafety regulations. Knowing what educational approaches motivate people to avoid creating conditions likely to lead to serious fires is just as important, if not more so, than development of the fire prevention codes themselves.

Where does the development of codes and standards enter into the behavioral picture? It is essential to know how people will behave and "engineer out" unnecessary hazards. For example, sensor activated (including fusible links) self-closing doors were developed as a solution to the problem that under certain conditions (e.g., where work assignments require frequent traverse), people would prop open doors despite codes and signs that prohibited such action. "Panic hardware" is another example of a "human engineering" solution—in response to the need for both physical security and available safe egress. Much of the controversy about isolated power systems with line isolation monitors versus conventional grounding systems with operational controls, really involves the question of the comparative reliability of a complex engineering solution versus a simple engineering solution when the human performance factor is considered in the reliability equation. Simply stated, people may not follow a code or standard if what it requires produces an operationally onerous condition or demands unreasonable technical skills, or for many other reasons. Therefore, how people really perform under various fire situations should be an essential consideration in all codes and standards development.

In designing and constructing two buildings of the same capacity and intended use, it is possible to meet the intent of all applicable codes and standards, yet have two vastly different levels of firesafety if the human factor is omitted. NFPA 101, *Life Safety Code* inherently addresses this problem because the human factor is a major consideration in all deliberations of the NFPA Safety to Life Committee. However, this committee needs more accurate data on human behavior and fire, as do all code-making bodies. Many of the systems approaches to firesafety in building design and construction (see Sec. 5, Chap. 2) are aimed at both examination of the interaction of various code provisions and the interaction of code provisions with likely fire scenarios and known behavioral patterns. The work of Wood,[1] Bryan,[8] and others was aimed at determining these patterns; that is, what do people do first? second? third, etc.? and what are the conditional probabilities; that is, if Action A is taken first, what are the probabilities that the second action will be B?, C?, etc., and under what conditions? Such information is an essential input when considering alternative designs to produce a structure at the lowest cost that will meet the level of firesafety intended by applicable codes.

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B. What is Known?

Occupant Activities Affecting Fire Ignition and Growth

Except in industrial occupancies, the affects of occupant activities on fire ignition and growth has received little attention. Careless smoking habits and alcohol consumption greatly influence fire ignition and human survival possibilities, but aside from their statistical prominence they have not been a major concern of behavioral studies. Drug use affecting the ability to respond is also an important factor, especially in homes for the elderly.

Included among recent studies of occupant activities and social conditions influencing fire ignition in health care institutions is one by Haber,[9] who found that in five of seven fires investigated, the room of origin was in the extreme corner of the fire floor, far removed from the nurses' station. It was suggested that because individuals in such rooms tend to be ignored and neglected, a casual relationship between the point of fire origin and certain institutional policies may exist.

Study reports note that people often approach a fire area to attempt control and extinguishment, very often with success, rather than simply leave a building when they learn of fire. A nationwide survey in the U.S. indicates that over 90 percent of the fires in homes are extinguished by occupants, not by fire department personnel.[10] Wood's study lists fire fighting as a frequent first action and indicates a greater tendency to fight fire when occupants are familiar with a building, and a smaller tendency when the fire is judged to be serious.[11] It was also found that the more frequently people receive training or instruction on what to do in fire, the more likely they are to sound the alarm or organize evacuation as a first action.

Behavior in Fires

Behavior in fires consists of a far richer behavior process than much conventional wisdom would suggest. Recent studies reveal a largely adaptive, often complex, pattern as people carry out first activities such as searching for the fire, fighting the fire, closing doors to the fire area, pulling a fire alarm, notifying others, calling the fire department, and getting dressed.[11] The whole behavioral process, including first actions and perhaps many subsequent ones, takes place while the fire itself may be rapidly developing, making what may be an appropriate action at 1 min quite inappropriate the next.

Early case studies of human behavior in fires revealed the importance of the interaction of human behavior and the fire environment. A relatively early approach developed by Lerup and others mapped, or graphically modelled, "realms" of fire development (i.e., stages separated by critical events such as flashover) along with "episodes" of human behavior.[12] This descriptive approach is employed in extensive case studies of fires in hospitals.[13]

Canter, Breaux, and Sime[14] also make use of a graphical technique, in this case more abstract "decomposition diagrams" which show the relations of people's acts in fire situations. These diagrams were used in the analysis of 4,007 acts reported by 198 people interviewed after 29 fires in buildings. The researchers' explanatory model "postulates that behavior in fires can be understood as a logical attempt to deal with a complex, rapidly changing situation in which minimal information for action is available."[14]

Normal Roles in the Occupancy as an Indicator of Behavior in Fire Emergency: This aspect of behavior during a fire was identified at an early stage of research. Its significance was particularly evident in the 1977 Beverly Hills Supper Club fire in Kentucky. Roles established before the fire continued to operate during it: staff members took care of patrons at the tables, rooms, and stations to which they were assigned; patrons looked to the staff for guidance.[15] Based on findings from this fire, it was recommended that "firesafety plans for places of public assembly should examine the roles that people normally play and not seek to prescribe emergency actions that are contrary to these roles."[16] The same may be said for occupancies other than public assembly.

Anecdotal accounts and detailed studies support this view that familiar roles continue during a fire emergency and provide evidence of related behavior, such as choosing a familiar exit in preference to a closer and perhaps safer but less familiar one. The design and management implications of the relationship between normal occupancy activities and emergency behavior have not yet been considered in detail. For example, codes credit the exit capacity of stairs; however, an exit that is not normally used may not be seen to exist in an emergency, or as has been suggested, an exit that is not a convenient occupancy amenity will carry significantly fewer people in evacuations.[17]

Panic: The word "panic" is used frequently in media accounts of fire and in firesafety literature to describe a variety of behavior, real and imagined. Here conventional wisdom, backed by naive psychology, is wrong. Study after study, including a great many carried out after large-scale natural disasters, concludes that panic rarely occurs.[11] Based on an examination of interview and questionnaire data from the many survivors of the Beverly Hills Supper Club fire, it was concluded that "fire reports or other accounts of fires should delete the term 'panic' and report factually what happened or what people said."[15] The Supper Club fire was marked by a maximum occurrence of altruistic behavior and not by antisocial, aggressive, nonadaptive behavior.[15]

People do what appears to them to be the best thing under whatever circumstances *they are aware of* during a fire. With hindsight, especially that of an observer in possession of more complete information, such actions may appear to be nonadaptive, but this does not justify using the term "panic."

Evacuation: Immediate, rapid, well-organized evacuation appears to be the exception rather than the rule when people hear an alarm. The assumption that behavior in fire is essentially a simple process largely controlled by alarm and exit systems has led to an emphasis on such systems in building and fire codes. Recent research has identified not only this oversimplification in exit design assumptions, but also misconceptions regarding long-accepted relations between crowd flow and exit width.[17]

Based on the observation of forty evacuation drills in Ottawa office buildings during the 1970s, errors in the traditional 22-in. unit-exit-width basis for exit rules were exposed.[17] Performance-based alternatives to the traditional width rule were recommended, as was the need to consider operational or management aspects of evacuation, particularly in nontraditional, selective evacuations.[17]

In selective evacuations, the total time taken to ascertain fire conditions, to make evacuation decisions, to communicate selective evacuation directions over communication systems, and to actually relocate people in safer areas of a building can be significantly longer, even several times longer, than is required for a relatively simple, traditional, total evacuation of the same number of people.[18,19] Even in simple, total evacuation drills, evacuation times have been observed to be as much as twice as long as had previously been predicted.[17] Given the much improved knowledge of crowd movement, both normally and in drills, and the improved awareness of the complexity of behavior in fires, evacuation time predictions—even those based on realistic, conservative flow assumptions—should be thought of as *minimums* and not as maximums.

Communication and Information Needs of People in a Fire

"Behavior in fires can be understood as a logical attempt to deal with a complex, rapidly changing situation in which minimal information for action is available."[14] It is suggested that the goal of regulations should be "re-oriented to increase the likelihood of informed decisions being made by people in fires."[14] The examinations of the behavior in the Beverly Hills Supper Club fire led to the recommendation that "fire safety education should consider and be based on people's erroneous conceptions about distance being related to safety, and the time needed to escape from a fire emergency."[15] This concern prompted the Center for Fire Research of the National Bureau of Standards to produce a film about flashover. This film provides people with useful information about the "rapidly changing situation" they can encounter in an uncontrolled fire.

To what extent do regulations, and firesafety practices generally, lead to the availability of better information for people facing fire? A simple fire alarm system, a key feature of commonly-required firesafety measures, confuses as much as it informs. Even automated public address systems with prerecorded announcements are regarded as sources of annoyance and confusion for building occupants.[20,21]

Long-term performance of fire-emergency communication systems was not addressed in the well-publicized but very limited 1974 study by Keating and Loftus of the Seattle Federal Office Building's communication system.[20,21] Further research, also based heavily on a review of literature, was subsequently done by Glass and Rubin[22] and did not address these as well as many other issues. Research must go beyond these early efforts if firesafety systems are actually to work.

Physiological Factors

Physiological factors that affect perception and movement activities must be considered when firesafety is evaluated. Work related to such factors includes sleep research and a related study pertaining to characteristics of emergency alarm signals.[23] An adequate basis for specifying signal characteristics offering a high assurance of arousal has not been identified; however, serious research is being conducted in this area.[24] In addition, the problem of performance following abrupt arousal has been studied but needs to be better understood. Physiological and, to a lesser extent, psychological effects of smoke and fire gases have been examined.[25] Behavioral studies have begun to identify factors that affect whether people will move through smoke and over what distances.[1,26] These studies show that people will often move significant distances through smoke and survive.

People tend to underestimate their ability to move out of tall buildings, given a safe exit route. For example, after complete evacuation of a 21-story office building in Ottawa, only 64 percent of the occupants surveyed felt they were capable of descending at least 20 stories of stairs "without stopping, at a normal speed, and without assistance from others."[27] Considering the finding that crowds descending stairs in total evacuations do so at a relatively slow speed and studies of occupants in high-rise bildings, it was estimated that only "about three percent of those usually present in high-rise office buildings cannot or should not attempt to evacuate by means of crowded exit stairs." The three percent includes people with heart disorders and convalescents from recent illness, surgery, or accident, as well as those with more lasting disabilities.[18,19] In buildings increasingly accessible to disabled persons and in a wide variety of health care and residential buildings, the number of people requiring special evacuation assistance can be quite large. This is of particular concern in a major program of research organized by the U.S. National Bureau of Standards and the Department of Health and Human Services. Some reports prepared under this program discuss the behavioral and physical characteristics of the disabled and their building-use activities.[28,29]

C. What Needs to be Done?

The current state of knowledge concerning human behavior and fire obviously needs to be expanded. Questions still abound concerning all aspects of the behavior of people in preventing fire and in coping with an uncontrolled fire. As important as this is, it is more important that the knowledge being developed is used. Public education programs should be based on what studies show people do and not on what tradition says they do. The development of codes and standards should take into consideration current knowledge of human behavior in fire.

Plans for building design and construction must not merely meet the letter of firesafety codes, but consider what people will use the structure, how they will use it, and the current knowledge of human behavior and fire. Public fire protection strategies and tactics should be preplanned with a knowledge of human behavior in fire.

D. What Is Being Done?

NFPA's "Learn Not to Burn" Campaign, which includes both a curriculum and a public information program, is based on a formal study of human behavior and fire. The programs of the U.S. Fire Administration's Office of Planning and Education are based on sound behavioral studies. "Project People," a program developed by the Fire Research Center, National Bureau of Standards, has resulted in an extensive development of insight into human behavior. This has been documented[8] and presents a consolidated source of information on human behavior and fire. Also encouraging is the use of literature on the subject by fire protection engineers in the design of large structures such as the George R. Moscone Convention Center[30] in San Francisco and new transportation systems.[31]

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MODULE 3: GENERAL FIRE SAFETY

TERMINAL OBJECTIVE

The students will be able to evaluate the general fire safety of a structure by researching the concepts within their codes.

ENABLING OBJECTIVES

Given the content of this module, the students will be able to:

1. *Identify appropriate codes, and apply them in evaluating the general fire safety of a site.*

2. *Identify appropriate codes, and apply them in evaluating the general fire safety of a structure.*

3. *Identify appropriate codes, and apply them in evaluating the general fire pertaining to a structure's use.*

INTRODUCTION

In this module we are going to look at the general fire safety of three areas of our environment: the site, the structure or building, and the use of that structure or building.

Fire hazards associated with our environment frequently are classified as "common" and "special." Common fire hazards are those found in most occupancies. Special fire hazards are those associated only with specific occupancies. You will be able to recognize the difference as we deal with the three areas of our environment.

GENERAL FIRE SAFETY OF A SITE

Any structure will burn. Our problem is that we can't tell just when that is going to occur or how, so we must anticipate all conditions and make provisions for handling any emergency. Each of the model codes has requirements for the accessing of sites. The best architectural designs will incorporate accessing the site for the fire department right along with that of the patrons. Keep in mind that fires occur in all parts of structures and, therefore, the main front door may not be the one the fire department must use for effective attack. For that reason, access must be available at least to within 150 feet of all exterior parts of a building. The access must also be sized to accommodate fire department apparatus as to width (normally a minimum of 20 feet), height (codes usually require a minimum of 13'6" clear height) and may call for "all-weather driving surface." Remember that the weight of apparatus is such that it is generally impossible to drive across a lawn to achieve access to a site. We might also note that if asphalt paving for either roads or parking lots is not designed properly for the weight of heavy apparatus, a pumper will probably tear it up just driving over it.

Considerations for Access

As you inspect the site of a structure and are evaluating the access, you must also take into account the turning radius of the apparatus likely to respond to an incident. You must find out ahead of time the turning radii of your equipment. Most sites will be easy to evaluate, posing no problem for the responding apparatus. There will be those, however, which will pose a real challenge due to long access drives and which will require a turnaround for the apparatus. These turnarounds can appear as "hammerheads," "Y's," "shunts," or "cul-de-sacs."

Grades must also be taken into account as you evaluate a site. Some grades may be such that the apparatus may not be able to pull them. This may be particularly true in ice and snow, or on hot days when the asphalt is soft.

Where access to the site requires on-site roadways there is usually a need for "Fire Zones" where parking is restricted. It is not enough to just paint the curb in these cases, nor is it enough to stripe the area. These restricted parking areas also must be identified by signs which clearly designate the restriction. These signs must be at least approximately the size of the universal handicapped sign. Some jurisdictions have found that without the signs just described, judges often will dismiss the charges of parking in posted zones.

There may be any number of obstructions to site access. In addition to cars and trucks, a merchant may be having a sidewalk sale, etc. It is important as you make your inspections that the business owners understand the whys of the codes. You must be sure that you do not come across as an adversary. Try to become their friend and let them know that if they are going to be doing something that may be a violation of the code, they should contact you. This may enable you to ward off an otherwise difficult situation. With your knowledge of the codes you may be able to suggest an alternative which will allow them to do what they wanted to do in the first place.

Obstructions to Access

Unattractive access requirements can be avoided by the use of "turf-blocks." A turf-block is a block designed to be installed low enough so that grass is grown over it. The block creates a solid base that apparatus usually has no problem driving over. Be sure that:

- The fire chief approves of the turf-block, and
- The area of turf-block is clearly delineated so that the engineer will not drive off the turf-block onto soft grass and sink in up to the axles of the apparatus.

While we are quite conscious of obstructions that occur on the site itself as we review plans, we often fail to examine the approaches to the site. Some of the things you should watch for are:

Bridges--Bridges may be too narrow, too low (clearances overhead), or too lightweight to carry or permit passage of fire department apparatus.

Trees--Low limbs, improperly trimmed, may cause an approach to be inaccessible.

Turning Radius--Narrow approaches or bollards to direct normal traffic can be terrible obstructions to fire department access. Again, we must know the turning radius of our equipment and include "approach" in our prefire planning.

Gutters--Deep gutters can cause the front bumper or tail of the apparatus to drag or even hang up, blocking access.

Barricades, Chains, and Gates--We frequently see approach drives or parking lot access entries blocked by chains or padlocked gates. This is especially true at night and on weekends when we see a good percentage of our emergencies. Even though we can cut the chains or break the locks, this causes delays. If a chain is not seen it could cause serious damage to apparatus.

Parked Cars--Probably the most common complaint of fire departments is that of careless parking at sports events. It seems that the people don't care and ignore signs, painted curbs, and all other attempts to keep a clear passage for apparatus in the event of an emergency.

Narrow Roads--Like the trees that overgrow access, narrow roads cause great concern because anything projecting into the roadway can cause it to be inaccessible.

Construction Litter--A construction site is almost always a problem because few, if any, are neat and tidy. Debris, equipment, materials, etc., always hinder the free access to a construction site. Your job as an inspector is to work with contractors during the construction phase of a building to help them to understand the problem. If they understand the why's, they may be more willing to work with you to keep the access clear.

Integrity of the Water Supply

Having access to a site is not enough if the fire department has no water to fight the fire with. The integrity of the water supply is most critical, and you should permit **no** obstructions to any fire hydrants. Along with fire hydrants you must include the fire department connection (FDC) on sprinklered buildings. No obstructions are permitted to either of these most critical elements. Remember that an obstruction may just mean difficult to access.

Note also that fire hydrants and fire department connections must be properly maintained (with caps on) so that debris does not clog the system. Other problems include leaking valves in hydrants, causing them to fill with water and freeze. They could also have cracked caps. If a clapper check valve in the FDC is not working, you could have water in the piping. This could freeze. Check for dripping water at the caps.

Post indicator valves must be examined during each inspection to be certain they have not been turned off. The wrench should be padlocked to the valve. Note that these are usually set out on the site in a position where they are easily vandalized.

From time to time water supplies change due to additions or construction in the area, possible taps for other water sources, closed valves, down pumps, etc. Don't assume that, because the water supply was apparently acceptable at one time, there is no need to keep a watch on it. One of the greatest reasons for failure of sprinkler systems or a fire department to fight a fire is closed valves in a water system.

Required water supply for a site and the systems thereon will be covered in Module 7.

GENERAL FIRE SAFETY OF A STRUCTURE

We have established that all buildings can burn. Our next concern is how that building or structure will fare in any given fire. Since we know that we cannot prevent fires entirely, we must try to minimize the effects of the fire. Building fire-resistant structures and using compartmentation can help slow the progress of the fire to:

1. Get people out.

2. Give the fire department time to attack the fire.

When we do an inspection of a structure, particularly a new (under construction) structure, we must evaluate the integrity of the protection of the structural elements. In other words, we must determine if the proper protection has been installed on or around an element.

Integrity of Protection of Structural Elements

If we are dealing with an unprotected structure this is simple, as there is nothing to evaluate; but should a fire start, there is nothing to slow the spread of fire, and we could lose the building early. A protected structure then becomes a little more complex, in that it could be protected by one-hour assemblies, or it may have to be protected by two-hour or three-hour ratings.

The majority of all construction within the United States is unprotected combustible construction. Note that under "normal" conditions (fire is not considered normal), this is good construction and you can feel very comfortable with it; problems occur when people move in. This part of fire safety will be covered later.

Unprotected noncombustible construction, or bare steel construction is also very good construction under normal conditions. With this type of construction, however, we sometimes have a false sense of security because steel is so strong. What we fail to realize is that even though steel essentially will not burn, it does lose its ability to carry a load at rather low temperatures.

Protected noncombustible construction is obviously the best, which is why all of the model codes require this type of construction for high-rise structures. The important part that you must play here is to ensure that the proper protection is given to the structural elements. The best way to ensure that the proper amount of spray protection is on structural elements is to require a separate testing lab to certify that the specifications have been met. Short of this, you personally will have to do a good deal of research to be able to tell if it is properly installed and of the required thickness. After the spray is installed, it is important that it remain intact without being knocked off or scraped off in order to attach something to it. We must realize that the protection is compromised when it is removed, and that heat absorbed through that spot is transferred to the weakest point, where failure may occur. We should be quick to suggest something more substantial when there is the potential for the spray to be damaged.

Where encasement is selected for the protection of structural elements, it is important for connections and joints to be tight. We should be sure that the encasement goes above the ceiling to include the joint of columns to beams rather than stopping at the ceiling line.

With both spray and encasement protection we should require that rated design assemblies, such as those from the UL design manual or from the USG design manual be used. By requiring tested assemblies we remove ourselves from tremendous liability. We then must ensure that the specified design is followed religiously.

Integrity of Compartmentation

Probably the most frustrating thing we face as inspectors is penetrations in rated walls and assemblies. Most notorious for creating poke-throughs are electricians, plumbers, phone installers, computer installers, sprinkler installers, etc.

Sprinkler installers tend to be the worst, probably because they feel as if the sprinklers they are installing will take care of all the problems they create.

As you inspect structures you must be consciously aware of all penetrations and gaps left around other elements of the structure such as conduits or duct work. Again, just because a structure was considered satisfactory at one time, such as at the final inspection of construction, does not mean it still is today. Changes are being made constantly in every business, and you can be sure that none of the workers has the slightest concern for the destruction they make in firewalls. Fire-rated walls must be complete, and generally are required to go all the way to the structure above. Gypsum board on only one side of a stud wall does not make a one-hour rating. Plywood in place of gypsum board to prevent having holes kicked in the wall does not make a rating. Walls required to be rated must be constructed properly and must have the correct materials.

Integrity of Fire-Rated Assemblies

The idea behind fire or area separation walls is to create a separate building, the wall serving as the space between them. It is important to be sure that no penetrations (not properly handled) occur in such a wall.

Firewalls have one-hour, two-hour, and four-hour ratings and, as stated above, must be complete. In some cases, parapets are required by code. Fire or area separation walls, which are used to separate buildings by the building codes, allow you to start again in figuring allowable area; but within the fire codes when figuring the water necessary to fight a fire or the hazard it represents these walls are ignored.

Unlike the fire or area separation walls which separate structures, the occupancy separation walls separate different occupancy classifications according to their hazard. This gives rise to mixed occupancy situations which help to complicate things for the inspector.

Occupancy separation walls come in one-hour, two-hour, three-hour, and four-hour-rated assemblies and, unlike the fire separation walls which must go only in a vertical plane, these may be horizontal. Therefore, you may have one occupancy on one floor and a different one on the floor above or below requiring a rated separation. When these occur, you as an inspector must be just as conscientious in assuring that they are complete and unpenetrated as you are with fire separation walls.

Assemblies are combinations of parts put together to create a unit which works together for a specific purpose. Assemblies are tested and rated as a whole, so everything must be complete, AS TESTED, to be a rated assembly.

A door assembly must consist of a rated (labeled) door set in a rated (labeled) frame with all hardware rated and tested as part of that assembly. Note that if the hinges are not ball bearing hinges, they cannot be a part of a fire-rated door assembly.

A counter roll-down shutter door has forever been a problem in rated walls.

Some of the problems we see with these at present are:

1. They require careful installation by specially trained installers to work properly.

2. They are usually very difficult to reset after being tripped.

3. They become guillotines if they are not adjusted properly.

4. The protection they are supposed to give is compromised by anything left on the counter.

These problems are being looked at, and efforts to correct them are being pursued. After initial installation, the problems we frequently find with these counter doors include:

1. Being wired open.

2. Being blocked open.

3. Being disconnected from the activator.

As with all other assemblies, these must be complete as tested to make the rating shown. You must be very careful when substitutions are made because they will usually nullify the rating of the assembly.

One of the problems we all see constantly with lay-in ceilings is the fact that tiles are left out for any number of reasons. In fires, the ceiling suspension wires, unless properly installed, have a tendency to straighten out, thus dropping the ceiling.

It is very important when dealing with a rated ceiling/floor or roof/ceiling assembly that tested designs from nationally recognized testing laboratories such as UL are followed exactly. This is again important due to the liability connected with any assembly you may permit to be used that is not so tested and listed.

Whenever it is necessary to penetrate a fire-rated wall with duct work it is usually required to install a fire damper which is almost always activated with a fusible link. When closed, the damper completes the rating of the wall up to the rating of the damper installed. These ratings are usually 1-1/2 hour. These dampers must be tested and properly labeled to be acceptable. Sometimes you will see a fire damper which has been painted for one reason or another. If painted you **must** test the damper to be sure that the paint has not compromised the damper in any way. A painted damper may be stuck by the paint or the paint may prevent the damper from closing all of the way because of buildup. The fusible link must never be painted as the paint changes the temperature at which it will activate, if it would activate at all.

You must also be sure that proper access is provided to each damper to reset the damper in case of activation. This access must be of sufficient size and within close enough proximity to actually allow the resetting of the damper. On an acceptance inspection, if there is a question regarding the ability to either reach or reset a damper, ask the mechanical contractor to demonstrate the activation of the damper by releasing it and then resetting it. You will find that they will be very surprised and say "I never thought about that before."

Some of the common impairments to fire dampers are:

1. Wires run through them.

2. Damage to guides.

3. Wired open.

4. Blocked open.

5. Heavily painted.

Smoke walls are usually found only in health care or institutional occupancies where the codes require that they be separated into smoke compartments. This is required because, in many cases, it would be impractical or impossible to evacuate the occupants. Therefore, they must be protected in place.

Where mechanical ductwork passes through smoke walls, the codes require that a smoke damper be installed. These differ from fire dampers in that they resist the passage of smoke as well as the fire, and they usually are motorized. By being motorized they are reset automatically when the incident is over. It has been proposed to the model code committees that any transfer grilles that expose corridors to other rooms should be fitted with motorized smoke dampers.

For some time there has been quite a controversy over whether a gypsum board wall should be considered as good as a masonry wall when it comes to protection and separation. No one would argue the fact that the masonry wall would appear to be the more substantial. It is surprising, however, how well the gypsum wallboard assembly stands up. It is also felt by quite a number that fire or area separation walls between two buildings should be of masonry construction and also should be parapeted in all cases. This of course is not required specifically in any of the codes at this time. However, the masonry wall would be more difficult to penetrate and easier to seal.

Before air conditioning was commonplace, older buildings had many vertical openings which were used to move air for circulation. This worked well, but in our society, we demand greater comfort. These shafts have become avenues for fire spread. Open stairs also create vertical avenues for the spread of fire, and the codes generally permit only two floors to be open to each other. Some exceptions include atriums. On the other hand, health-care codes do not permit any floor to be open to any other.

Elevator doors, while making a fire rating, do not make a smoke rating and, therefore, the shaft becomes another avenue for vertical spread. Many high-rise building fires result in someone dying in the elevator because of the smoke that infiltrates the shaft and elevator car. This is why the codes now require in high-rise buildings the inclusion of smoke lobbies exclusive of the means of legal egress.

All mechanical shafts within a building must have all penetrations protected by dampers, with some prohibitions as to where these penetrations may be made. For instance, none of the codes permit penetrations of shafts to occur into a corridor.

Equivalencies

Our discussion about the fire safety of a structure would not be complete without a brief discussion about equivalencies. All of the codes provide for the fact that in some cases it is impossible to meet the exact letter of the code, requiring something else to be substituted. When this occurs the codes permit the Authority Having Jurisdiction to evaluate the circumstances and judge, on an equivalency basis, the proposed substitution or change. In all cases the burden of proof as to the equivalency clearly rests with the individual requesting acceptance. As inspectors we should be very careful and, unless we have a great deal of experience or know specifically about that which is being proposed, we should consult our superiors for their assistance. Again we must be very careful for what may seem on the surface to be equal may indeed be anything but equal in actual practice. Don't be afraid to say "I don't know." Don't be afraid to spend a little time in researching assemblies and quotes of reference. There are many reference books you may use to evaluate whether or not something is equal, chief among them being the publications of the model code groups.

Using Approval Directories and Listings

Each of the model code groups publishes interpretations, and test results which they have accepted, such as ICBO's research recommendation reports.

In evaluating assemblies and elements for the fire safety of a structure there are tests that have been accepted nationally as reasonable criteria by which to judge the acceptance. For the most part these are the ASTM tests. Some of these are:

E-119--Rated assemblies.
E-152--Doors.
E-163--Glazing.
E-814--Penetrations of rated walls needing fire stopping.
UL 555--Fire dampers.
UL 555 S--Smoke dampers.

Underwriters Laboratories Fire Resistance Directory, 1992 Edition

Most important in understanding this directory is to be familiar with the prefix letters, as they associate with the "groups of constructions" (as listed below and on page 6 of the directory).

The prefix letters representing the various groups of constructions are listed below:

Prefix Letters	Group of Construction
A	Floor-Ceiling Designs--Concrete with Cellular Steel Floor Units and Beam Support.
D	Floor-Ceiling Designs--Concrete with Steel Floor Units and Beam Support
G	Floor-Ceiling Designs--Concrete and Steel Joists
J or K	Floor-Ceiling Designs--Precast and Field Poured Concrete
L	Floor-Ceiling Designs--Wood or Combination Wood and Steel Joists Assemblies
N	Beam Designs--For Floor-Ceiling Assemblies
P	Roof-Ceiling Designs
S	Beam Designs--For Roof-Ceiling Assemblies
U	Wall and partition Designs
X	Column Designs

* Prefix letters reserved for future use

Also the following chart, which shows the numbering system for the fire rated assemblies.

NUMBERING SYSTEM FOR FIRE RATED ASSEMBLIES

	TYPES OF PROTECTION									
	Membrane Protection					**Direct Applied Protection**				**Unprotected**
Groups of Construction	000-099	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999
Floors-Ceilings A B* or C* Concrete and Cellular Steel Floor Units	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
D E* or F* Concrete and Steel Floor Units	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
G H* or I* Concrete and Steel Joists	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
J or K Concrete	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
L or M* Wood Joist or Combination Wood and Steel Assemblies	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
Beams N or O* for Floor-Ceiling	Building Units	(Reserved)	Exposed Grid System	Batts and Blankets Or Mineral And Fiber Boards	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
Roof Ceiling: P, O* or R*	Concealed Grid Sys.	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titous	Sprayed Fiber	Unprotected
Beams: S or T* Roof-Ceiling	Building Units	(Reserved)	Exposed Grid System	(Reserved)	Metal Lath	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	Unprotected
Wall & Partition: U, V* or W*	Bldg or Partition Panel Units	(Reserved)	Insu-lating Con-crete	Wood Stud Gypsum Bd Lathe &/or Plaster	Metal Stud Gypsum Bd Lath &/or Plaster	Misc.	Metal Panels Gypsum Bd Lath &/or Plaster	Metal Panels or Supports Cemen-titious	Metal Panels or Supports Sprayed Fiber	Masonry
Columns: X, Y* or Z*	Building Units	Prefab-ricated	(Reserved)	Batts and Blankets or Mineral and Fiber Boards	Metal Lath & Plaster	Gypsum Board	Miscel-laneous	Cemen-titious	Sprayed Fiber	(Reserved)

The prefix number with an asterisk (*) and the design number indicated as "Reserved" in the above table are for future expansion and to cater to new types of system developed in the future.

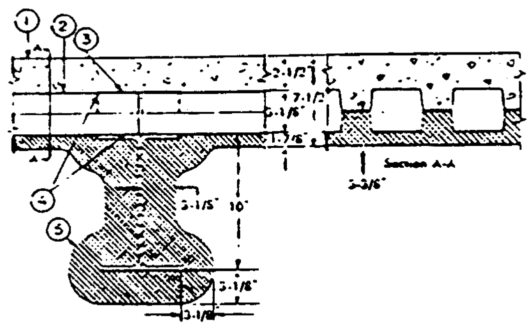
The directory starts with "A" (floor-ceiling assemblies) and follows in alphabetical order throughout the book.

Note: All of the designs to be considered as complying with the listing must be followed explicitly. Substitutions of "assumed equivalent" status should be rejected.

Also note that when an assembly is shown to have a rating such as one hour it means that the entire assembly must be complete. An assembly, such as floor-ceiling, must include the floor, structural members, hangers, ceiling, and protection of penetrations. No single element of the assembly may be assumed to have the rating in and of itself: such as a "lay-in ceiling which may be a part of the assembly."

You will note that by reading the numbering system for fire-rated assemblies and the prefix letters from the group construction chart that any design that starts with "A" will be a floor-ceiling design and the numbers A800 through A899 will be designs that consist of sprayed fiber, as design A807 has indicated, and designs A200 through A299 consist of designs that use an exposed grid system, as design A203 is indicating.

Design No. A807
Restrained Assembly Rating--4 Hr.
Unrestrained Assembly Rating--2 Hr.
Unrestrained Beam Rating--2 Hr.



Beam--W10 x 21, min size

1. Sand and Gravel Concrete-1:2:3 mix. 4000 psi compressive strength.
2. Steel Floor and Form Units*--Non-composite 3 in. deep galv units 24 in. wide, 20/20 MSG min cellular units. Welded to supports 12 in. O.C. Adjacent units button-punched or welded to supports 36 in. O.C. at joints.

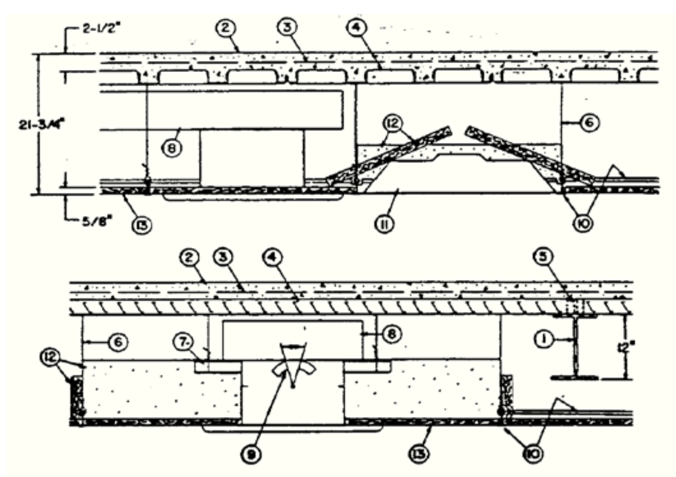
Walker, Div. Of Butler Mfg. Co.--Type BB.

3. Cover Plate--No. 16 MSG galv steel.
4. Tack Welds--12 in. O.C.
5. Fiber Sprayed*--Applied by spraying with water, in several coats and tamped to final thickness as shown above, to surfaces which are free of dirt, oil and scale. Use of adhesive is required. Min avg tamped density is 13 pcf with min ind density of 11 pcf. Tamping is required. For method of density determination refer to General Information Section.

   Air-O-Therm Application Co., Inc.--Type "400" adhesive.

*Bearing the UL Classification Marking.

Design No. A203
Restrained Assembly Ratings--2 and 3 Hr. (See Item 10)
Unrestrained Assembly Ratings--2 and 3 Hr. (See Item 10)
Unrestrained Beam Ratings--2 and 3 Hr. (See Item 10)



Factory Mutual System Approval Guide, 1990 Edition

Factory Mutual differs from UL and the Gypsum Association in that they test and approve items, specific equipment, or materials such as penetration sealants listed as starting at 18-137, or fire doors listed as 18-160 in the 1990 edition of the approval guide.

It has a table of contents beginning on page III. Familiarize yourself with the numbering systems which begins with 1- Automatic Sprinkler Systems. Items associated with sprinkler systems all will start with the number 1 and a dash. Another example, Electrical Equipment 14-1 through 36.

In the rear of the book is a manufacturers' index, with the manufacturers listed in the guide in alphabetical order. If you do not know the number and cannot find it in the table of contents, but you do know the manufacturer's name you can find it in the index. Following the manufacturer's index is another index for types of equipment. Both indexes are cross referenced.

Gypsum Products Fire Resistance Design Manual

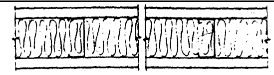
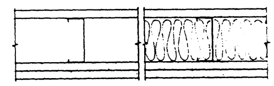
Page 2: Includes contents listing.

Page 3-11: Has instructions as to the use of the manual. From there on, the manual is broken down from front to back into sections on:

- Walls and interior partitions
- Chase walls
- Movable office partitions
- Shaft walls
- Exterior walls
- Metal clad exterior wall
- Area (party or firewalls) separation walls
- Floor-ceiling assemblies
- Columns
- Beams, girders, and trusses

The last page (inside back cover) has a list of fourteen companies with a reference letter following. This letter and a star is found beneath the number of some of the assemblies. This means that this is a proprietary design and no deviation of the materials in the assembly from one manufacturer to another is permitted.

Architects like to use this manual because it is the clearest and easiest to use. Become familiar with it. Shown below is an example of a design from the walls and partition section of the manual. Column one is the fire resistive rating. Column two is the sound transmission class, column three is a gypsum file number for the assembly identification, column four is a brief listing of the elements used in the assembly construction, and column five contains a cross sectional view of the assembly and the fire and sound test reference with code initials for the agency who certified the test. Example design WP1080 was tested for fire by OSU (Ohio State University) test file # T-3240 dated 10/1/65.

1 Hr	45 to 49	WP 1076 (d, w)	**Construction Type: Gypsum Wallboard, Metal Studs** One layer 5/8" proprietary type X gypsum wallboard or veneer base applied parallel to each side of 2-1/2" metal studs 24" O.C. with 1-1/4" type S drywall screws 8" O.C. around perimeter of assembly and 12" O.C. at board edges. Wallboard fastened to intermediate studs with continuous 1/4" beads of adhesive or 1-1/4" type S drywall screws 12" O.C. 2-3/4" glass fiber 0.65 pcf friction fit in stud space. Stagger joints 24" O.C. each side. (NLB)	 Thickness: 3-3/4" Limiting Height: 13' 5" Approx. Weight: 6 psf Fire Test: ULC 78T55, Design W409, 1-9-79 Sound Test: DRC 70-2-2, 1-6-70
		WP 1080	**Construction Type: Gypsum Wallboard, Metal Studs** One layer 5/8" type X gypsum wallboard or veneer base applied parallel to each side of 3-5/8" metal studs 24" O.C. with 1" type S drywall screws 8" O.C. to edges and vertical joints and 12" O.C. to intermediate studs. Face layer 5/8" type X gypsum wallboard or veneer base applied on one side parallel to studs with 1-5/8" type S drywall screws 8" O.C. to edges and sides and 12" O.C. to intermediate studs. Apply 1/2" beads of laminating compound 2" O.C. to full field of face layer. Stagger joints 24" O.C. each layer and side. Sound tested using 3-1/2" glass fiber in stud space. (NLB)	 Thickness: 5-1/2" Limiting Height: 17' 3" Approx. Weight: 8 psf Fire Test: OSU T-3240, 10-1-65, Sound Test: RAL TL 77-12, 10-8-76

GENERAL FIRE SAFETY PERTAINING TO A STRUCTURE'S USE

Our focus now moves to the **use** of structures. The biggest problem we have in fire safety is people.

People must be educated about fire and our environment so that they will, on their own, make the change from hazard to safety in all they do. For instance weeds, rubbish, and combustibles are not to be permitted to become fire hazards. This can be done simply by creating an attractive building site and keeping it clean.

General Storage Requirements

One of the most common of all fires is the dumpster fire. In and of itself this kind of fire is not a hazard unless it exposes other structures. A good example occurred in the small city of Grantsville, Utah, a few years ago. One evening an individual set fire to two dumpsters, one at a middle school and the other at a large high school. The dumpster at the middle school was positioned about sixty feet away from the building and burned itself out. The high school was a different story. The dumpster was set right next to the building. The flames reached the eaves of the building, found a good fuel source, and were off and running. The entire building was lost. This was a case of the dumpster causing a major disaster. The codes are quite uniform in requiring dumpsters to be five feet away from combustible walls. This would not have saved the above noted high school, however, so maybe this distance should be increased. Note also that plastic lids on dumpsters can double the temperature of any fire in them.

Storage Areas

The codes require storage to be neat and orderly. Remember that combustibles not properly stored become litter.

Storage also must be kept 24 inches away from ceilings.

Storage within warehouses must be kept away from the exterior walls by an aisle, to provide fire department access and to keep material from swelling with water and pushing out the wall.

None of the codes permit storage in attic spaces, or in boiler rooms for obvious reasons.

Persons should not be permitted to accumulate piles of material improperly. It is interesting the way some people have the feeling that they cannot throw anything away. A good rule of thumb is: "If you don't use it at least once each year . . . you don't need it. Get rid of it."

Where business processes create litter or combustible wastes, containers should be supplied, and these should be properly disposed of at least once each day.

Special Storage Problems

Buildings which have been left vacant must be properly secured against vagrants or vandals. They must also have all waste and rubbish removed. This type of building seems to attract the individuals who, through carelessness or by design, cause fires, resulting many times in large property loss. All of the codes address what must be done with these buildings and even go so far as to tell what must be done if the vacancy is temporary or long-term. If the vacancy is for over a prescribed time the codes say it could be declared a public nuisance and torn down. This isn't very frequently done unless it is really a building in very poor condition. If you have a building like this you should consult with your superior and the owner of the property and together reach a mutually beneficial decision as to its disposition.

Remember that all such decisions on any fire safety problem must be followed up within time limits prescribed in the agreements reached. If you do not follow up properly, the courts will not support you and you could lose your professional and expert status.

Any situation where open flame devices are used must be within the parameters of the code and must also be approved by the chief. There are usually reasonable alternatives to open flame devices or safe ways to handle open flame situations. These may require the hiring of off-duty firefighters to watch over the situation and be ready in case of any problem.

All of the codes agree that flammable material must be carefully taken care of. Many times as you make inspections you will become aware of a feeling of careless abandon that some people get when they are constantly working around flammables. We hope you get "goose flesh" when you see this occurring and take immediate steps to correct it since you must always try to leave a building safer than when you went in. A misused flammable material is an incident trying to happen. All of the fire codes give allowable limits of flammables permitted to be within buildings. Become familiar with these limits and with the recommended safe practices for proper storage. Flammables, for the most part, must be properly stored as in a "flammable liquid storage cabinet."

Under no conditions are flammables to be permitted in a boiler room or in an environment where sources of ignition are prevalent. Where flammables must be used, they must be used with care and be stored in safety cans, proper cabinets, or flammable liquid storage rooms properly designed by code for that purpose.

As you make your inspections be aware of the decorative materials that are being used. In most cases they must be rendered flame retardant. This is most frequently violated, especially by teachers who want to illustrate anything and everything with combustible materials such as paper, paper napkins, sheets, trees, papier mâché, etc.

Atria also must be very carefully watched since they are not permitted to have any flammables in them. Combustibles are limited to 9,000 Btu per pound (normal combustibles). This becomes very difficult to judge and regulate. Note also that no open flame devices are permitted in atria.

A common problem, especially in shops, is the fact of pressure cylinders of gases that are not properly secured in the upright position. Reactive gases must also be separated, and all flammables or gases which may be toxic must be properly stored.

Storage file rooms become a concern due to the excessive amount of combustibles contained therein. The good part about these rooms is that they are usually neat and orderly and frequently the files are in filing cabinets. The rolling shelf type storage rooms have shelving tightly packed so that even though there are a lot of combustibles they would be hard to ignite and slow to burn.

Mechanical air plenums such as above ceiling spaces for return air, must be free of all combustible materials, including the wiring which must be of the type approved for use in plenum spaces.

The codes talk of groupings of storage materials called commodities. These are grouped into four types by NFPA 231, and five types by ICBO in the Uniform Building Code, according to the degree of hazard they present.

The listing below is from the Uniform Fire Code Article 81.

Class I commodities are essentially noncombustible products packaged in highly combustible cartons, pallets, or containers.

Class II commodities are Class I products in heavier containers providing for more to burn.

Class III commodities are ordinary combustible products, including Group C plastics.

Class IV commodities may be Class II or III products containing an appreciable amount of Group A plastics packaged in ordinary corrugated containers.

Class V commodities are high-hazard products such as flammables or highly toxic products.

Gas operated equipment is not to be stored inside buildings except within rooms designed especially for this type of hazard. It is obvious from the leaks that continually occur from gasoline powered equipment that they should not be inside buildings, yet this is something we find continually. One gallon of gasoline fully vaporized can produce an explosion equal to many sticks of dynamite. As an inspector you must not permit any such equipment to remain anywhere except in properly designed and constructed storage rooms.

Exits must be considered the most important part of a building and must not be permitted to be obstructed in any way, by storage, furniture, or anything else which could confuse or delay egress. You must also consider the combustibility of any products permitted to be in any means of egress. This is especially true since corridors that possibly could burn become unsafe as a means of egress.

Ignition Sources

Smoking has become so commonplace in our society that little thought is given to the fact that it is one of the most frequent causes of fires. People become careless, and smoke in the most hazardous places. A rather serious example is the individual who was smoking while spray painting a car.

Wiring of any sort to any piece of equipment must be replaced whenever it is worn, frayed, or cracked. Electrical problems are, like smoking, a major cause of fires.

As you inspect existing buildings, be conscious of older pieces of electrical equipment and check their cords carefully. You also should check how each piece of equipment is wired.

Ask whether it is it hard wired, i.e., connected directly to electrical source without a plug. Is it directly plugged into an outlet? Does it have a special plug and outlet? Has a special adapter been used to connect it, such as a multiple plug adapter? Is an extension cord being used? Remember that extension cords are to be used for temporary wiring only.

An example of temporary wiring may be that used for audiovisual equipment within a classroom. An example of wiring that is a violation is the secretary's typewriter that is plugged into an extension cord along with a copier and a fan or heater. Remember that multiple plug adapters are generally not permitted by any of the codes. This is because it becomes too easy to overload circuits. The question often is raised as to the acceptance of heavy-duty cords with multiple plug ends that are equipped with built-in circuit breakers. The codes are silent about these so you must decide for yourself after taking the conditions of use into full consideration.

Generally, by code, temporary wiring is permitted during construction projects, which, of course, includes remodeling.

As an inspector you must develop a keen sense of recognition. Bells should start going off in your mind, many times even before you are fully aware of why. Learn to listen for those warning bells and investigate them thoroughly.

When inspecting equipment look at how clean it is and, if you find dirty or dusty equipment, check the motor carefully. Motors overheat and start fires when they get dirty and ventilation is inhibited. Like anything else, motors are required to have some maintenance.

As you go into a room quickly look around at the duplex outlets. You will be amazed at the number of blackened cover plates you will find from arcing due to either faulty equipment or wiring within the box. Be sure to have it checked at once.

You may also find when doing new construction inspections that outlets have been installed in walls and covered with carpet which has not been trimmed properly. A small arc in a case like this could start a major fire; particularly when the wrong class of carpet is used for wall finish.

Another problem you will find in restaurants and theaters is that of candles or the use of open flame devices. Be aware of the severe restrictions in the codes regarding these, and be sure that each case is reviewed individually. The codes permit these only with the approval of the Chief, so find out ahead of time what your department's policies are regarding candles and open flames.

Fireplaces, inserts, solid fuel and/or kerosene heaters, and chimneys with all of their parts are a major source of fires also. The codes talk of minimum clearances of 36 inches from combustible materials with some reduced dimensions if certain conditions exist. Most of the above equipment is called out to be installed as per the manufacturers' installation instructions. If these instructions are followed properly, many reduced clearances are permitted. Most of your work with this equipment will probably be with new home construction, or if a concerned citizen calls for help and asks you for information or an inspection. Make sure you are ready with good information when these calls come in.

Be sure that you do not overlook the combustion air requirements for these heaters. New homes today are being built so tight that infiltration of air that used to take care of the problem doesn't work anymore. Also address the problem of unvented gases if that type of heater is used. Be certain that you caution people regarding burns, especially those with small children; advise them to keep combustibles away from hot stoves. Reports show that the above items are the most common problems associated with the use of alternative heat sources.

Welding and cutting with torches are also common ignition sources for fires and many times occur some time after the welding or cutting operation is over. Sparks or hot slag on a combustible surface may smolder for some time before igniting into open flame. Remember when something starts small and grows slowly and we are exposed to it all of the time we sometimes do not register the smell. An inspector went onto a construction site fresh and smelled a smoldering fire. When he asked about it no one on the site could smell it, or at least didn't until he brought it up. Upon investigation they found celotex smoldering thirty minutes after a piece of roof decking had been cut off right above it. When the piece of celotex was picked up, it burst into flame.

Control of Environment

One of the most effective controls within our environment is proper storage, since improper storage is an invitation for a fire to start. We grow careless with our storage habits, especially when we do not have enough storage space, which is almost all cases.

Interior finishes, if properly controlled, are also a most effective way to control our environment. The model codes give us guidelines to follow; however, so many new finish products come on the market every day that it is very difficult to stay on top of them. Whenever you are confronted with a product you are unfamiliar with, be sure that you investigate it. If it is in a new construction project the burden of proof is on the architect or contractor to prove its compliance with the code. If it is in an existing building, the burden of proof lies with the owner. Be sure you know the testing laboratory before you accept test results. Some testing labs have been found to leave out part of the ASTM requirements. Other labs have been found to be a division of the company producing the product. An acceptable lab should be a nationally recognized lab that is independent of the manufacturer so that there is no conflict of interest.

Paint booths, rooms, or areas are notorious as environmental problems for fire safety. Each of the fire codes address this issue calling out minimum requirements for safe spraying operations. One of the most universal requirements is that the operation be protected by a sprinkler system. In all cases, a filter bank should be required with the proper draw of air being designed for safe use. Along with the draw of air, makeup air also must be provided, which must be properly designed and protected. As you inspect spray operations be sure that proper cleaning is being carried out, with the filters being replaced as necessary. Another thing you must also check, which so often is overlooked, is where the discharged air goes to. You must be certain that the discharge does not create a problem in and of itself.

Wood shops are generally classified as hazardous operations due to the dust produced. All dust-producing equipment must be connected to a sawdust collection system. Even though a collection system is used it does not completely eliminate the dust problem and shops should have a rigorous cleanup program to minimize the potentially serious problem. A dirty, dusty wood shop is a problem trying to happen.

Like wood shops, shops that use flammable materials, e.g., auto shops, need to be inspected carefully. Again, a dirty shop is an indication that you should look more closely into how they are handling the operations of the shop. A frequently found problem is the open waste-oil container, usually a cut-off 55-gallon drum. Another is cleaning tanks with flammable solvents, with the lids wired open or disconnected. Frequently, welding is carried on carelessly in close proximity to flammable atmospheres.

Another shop often overlooked is the manufacturing plant which uses resins to cast cultured marble items. These need proper protection and ventilation and are not properly covered at the present time by the codes. You must use the requirements for those most nearly resembling them, such as paint rooms, to cover the hazards.

Custodial closets are famous for their fires, frequently starting from spontaneous combustion from oiled dust mops. Dust mops should be hung to air properly. These closets also become "catch-alls" for everything, and usually contain many flammable materials. You also will find that the doors to custodial closets are most frequently held open with a large variety of wedges. Again, "familiarity breeds contempt." The custodians work with these materials so much that they become careless and have to be reminded often about the hazards they create.

Lab storage rooms must be carefully inspected to be sure that reactive chemicals are properly separated. Most inspectors do not have a knowledge of chemicals which would allow an intelligent inspection, so we would recommend you invite the professor or chemistry teacher to accompany you. They are usually very willing to go with you and when you explain that you are concerned about reactives, caustics, flammables, and explosive chemicals you will find that they are too. They are most anxious to explain chemicals you may be unfamiliar with, and usually will do a good job of inspecting for you, provided you go in with the right attitude. You will always come away with a greater knowledge if you listen. Don't try to make out that you know when you don't; it shows very quickly when it comes to hazardous chemicals.

The transfer of fuels, whether it be as simple as gasoline into a lawn mower, or from a tanker truck into an underground tank at a service station, is a dangerous situation. You must be certain that all of the proper precautions are taken to insure that incidents are not encouraged by carelessness. Static electricity is a real concern with the transfer of fuels from tanker trucks. Bonding and grounding must be done to mitigate the possible problems.

Grain elevators, because of the chutes and lifts, create static electricity problems. The grain dusts which accumulate also create explosive atmospheres which can only be countered by keeping the elevators properly cleaned.

This section would not be complete without a brief comment on the problem of arson. Obviously, we in prevention cannot eliminate this threat, but, through conscientious efforts of code enforcement, we can minimize the effect that arson can have within a structure.

Common Hazards By Occupancy

The following are hazards particular to different occupancies, and ones you frequently will find violated.

Multi-Unit Residences

1. Blocked exits
2. Unserviced or missing extinguishers
3. Excessive storage in basement
4. Cluttered attic, garage, under stairs, heating room
5. Lack of (and/or not visible) exit signs
6. Accumulation of dust and lint in laundry room
7. Combustibles next to water heater
8. Transoms in old buildings (window over door)

9. Faulty fire escapes or escapes blocked at ground level
10. Faulty, untested standpipes
11. Penetrations in fire separations
12. Incomplete or missing evacuation plans
13. Stairway doors blocked open

Assembly Occupancies

1. Blocked exits (constant problem)
2. No exit signs; exit lights out
3. Doors locked during hours of occupancy
4. Extinguishers not serviced or nonexistent
5. Overcrowding, no occupant load sign
6. Aisles not adequate
7. Candles on tables in unsafe holders
8. Extension cords and other electrical problems
9. Decorations (combustible or flammable type)
10. Non-flame-retardant drapes
11. Smoking problems
12. Heating hazards

Restaurants

1. Grease accumulation on filters and in ducts
2. Hood system not serviced, nonexistent, or improperly installed
3. Exiting problems the same as assembly
4. Decoration problems the same as assembly
5. Smoking problems
6. Cluttered storeroom
7. Electrical hazards
8. Heating hazards
9. Extension cords

Warehouses

1. Fire protection equipment not in service
2. Overhead doors obstructed by stock
3. Exits obstructed
4. Electrical machinery hazards
5. Extension cords
6. Flammable liquid storage
7. Oily rags, etc.
8. Trash and debris

9. Poor storage practices
10. Poor smoking practices
11. Stock obstructing sprinklers
12. Fire separations violated
13. Propane or gasoline operated lift trucks
14. Separation and isolation of hazardous materials

Hospitals

1. Fire protection equipment not in service
   - Sprinklers
   - Alarms
   - Extinguishers
2. Extension cords
3. Concealed smoking by patients
4. Cafeteria hazards
5. Exits locked and blocked
6. Fire separations and doors blocked open
7. Excessive storage of combustibles
8. Emergency generator not tested
9. Sterilizer room cluttered with combustibles
10. Employees smoking in linen storage room
11. Improper storage of gases
12. Improper storage, handling, and use of anesthetics
13. Combustibles next to heating equipment
14. Lack of proper maintenance of heating equipment
15. Evacuation plan outdated, inadequate, or not posted

Office Buildings

1. Exiting problems
2. Extension cords
3. Extinguishers not serviced or missing
4. Poor record storage
5. Wastepaper handling
6. Smoking hazards
7. Heating equipment near combustibles
8. Fire escape maintenance and obstruction
9. Lack of proper maintenance and testing of fire protection systems

Manufacturing

1. Electrical machinery
2. Misuse of extension cords

3. Improper use and storage of flammable liquids
4. Faulty use and storage of chemicals
5. Improper use and storage of gases
6. Blocked and obstructed exterior doors, fire doors, etc.
7. Improper storage of fire protection equipment
8. Improper maintenance of fire separations
9. Cluttered storerooms
10. Unsafe smoking practices
11. Inadequate aisles and exits
12. Cluttered storage of business records
13. Heating equipment problems
14. Combustibles too close to heating equipment
15. Spontaneous ignition
16. Paint spraying operations
17. Dip tanks with faulty lids, etc.
18. Paint and chemical storage
19. Inherently hazardous processes
20. Sparks from welding
21. Inadequate exhausting of vapors, dust, etc.
22. Disposal of trash, sawdust, fires, debris

Schools

1. Blocked exits
2. Chained exits
3. Exit lights not functioning
4. Fire protection equipment not maintained
5. Unsafe chemistry lab (storage and equipment)
6. Flammable liquids such as solvents, paints, cleaners, and duplicating fluids stored in offices, shops, and classrooms
7. Shop hazards same as "manufacturing"
8. Excessive storage
9. Lack of fire drills
10. Non-flame-retardant drapes in auditorium
11. Extension cords and octopus connections
12. Combustibles near heating equipment
13. Improper, older electrical equipment
14. Chlorine and acid storage for pool
15. Hazards caused by lab experiments
16. Spray painting in shops and illegal/unapproved booths
17. Dip tanks
18. Oily rags
19. Welding hazards

Summary

Take your time during the inspection and be observant. Ask to see all areas of the occupancy. Be methodical and accurate. You don't want to miss any vital details or facts.

If a situation doesn't look right, check into it to determine its safety. Common sense and good judgment must be used in inspecting existing occupancies. Use the code as a guide. Remember that the purpose of the inspection is to enforce code compliance and leave the place safer than when you first entered it. Report all violations in writing and keep file copies. When identifying a hazard, also identify ways of correcting it according to code.

Some hazards must be corrected immediately. Others can be corrected within a prescribed timeframe. Remember that you cannot memorize all the codes but you can make sure that reasonable fire and life safety conditions exist.

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MODULE 4: LIFE SAFETY

TERMINAL OBJECTIVE

Using their codes, the students will be able to verify that an acceptable level of life safety is provided for the occupants of a structure.

ENABLING OBJECTIVES

The students will:

1. *Determine the occupancy classification for a given structure.*

2. *Distinguish between "evacuation" and "defend in place."*

3. *Calculate the occupant load for a given structure, using their codes.*

4. *List the basic components of an exit system.*

5. *Define exit as used in their codes.*

6. *Determine and rationalize the number of required exits for a given structure.*

7. *Evaluate the adequacy of the egress system for a given structure.*

8. *Determine the code requirements for interior finishes.*

9. *Describe the method of classifying interior finishes and identify the limitations of the classification methods.*

10. *Describe the impact of the fire suppression and detection systems on life safety.*

11. *Explain the life safety hazards associated with furnishings.*

12. *Identify the elements necessary for emergency preparedness and training.*

INTRODUCTION

Traditionally, life safety has been considered as an evaluation of the number, arrangement, and capacity of a building's exit system. In fact, the *Life Safety Code, NFPA 101*[1] was originally titled the Building Exits Code. More recently, however, we have come to realize that life safety involves much more than just exits. In simple terms, life safety involves avoiding exposure to the harmful effects of the products of combustion. The exposure may be to personnel who are in the process of evacuating a building, to persons who are within the building in an area considered to be an area of refuge, or to persons who are not aware of the fire.

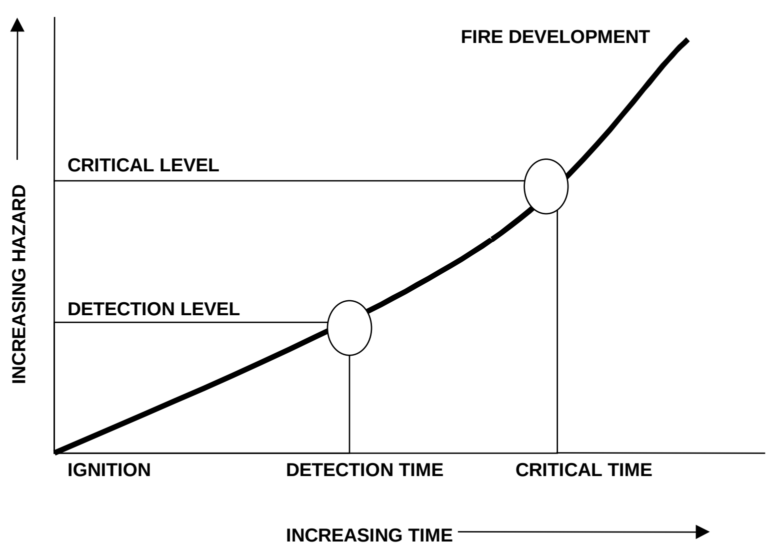
FUNDAMENTALS OF LIFE SAFETY

There are three major factors to consider when evaluating both the life safety risk and the level of life safety: time, characteristics of the occupants, and nature of the fire.

Time

Providing life safety to occupants who are capable of exiting a building can be defined in terms of a safe egress time--the time interval from detection (or notification) to the hazard threshold (time to reach lethal conditions). However, the time interval between detection and ignition must also be considered. Therefore, three times must be considered: time to ignition; time to detection; and time to hazard threshold (See Figure 4-1).

Figure 4-1



RATE OF DETERIORATION OF THE ENVIRONMENT AS A FIRE PROGRESSES

Characteristics of the Occupants

The ability and likelihood of occupants to respond to a fire emergency are affected by six factors: age, mobility, awareness, knowledge, density, and discipline. The various occupancy classifications previously discussed attempt to generalize the occupants' characteristics within each occupancy classification.

Age. The age of the occupant affects his/her ability to negotiate portions of the means of egress. For example, young children will have more difficulty in traversing a stair than will young adults. Therefore, it is common to find code requirements addressing the location of preschool, kindergarten, and first grade classrooms in an elementary school. Statistically, the very young and the very old are at the greatest risk from fire. Age usually has an effect on the other five occupant characteristics.

Mobility. Some occupants are not capable of responding to a fire emergency, or respond with some degree of difficulty. For example, the codes generally assume that the occupants of a health care facility will not be capable of self-preservation. Thus, the codes will address requirements for staff training to assist the occupants, and for building compartmentation (smoke barriers and horizontal exits) to facilitate evacuation to an area of refuge. Likewise, the occupants of a correctional facility are generally not as mobile as the general population. The mobility of the occupants also affects the components permitted within the means of egress. For example, fire escape ladders and alternating tread devices are usually only permitted when the area is to be occupied by able-bodied individuals.

The increasing awareness of the need to provide egress for the physically disabled will affect significantly the egress provisions of the various codes. Some code requirements, such as minimum clear width dimensions of doors, are related to the need for a person in a wheelchair to use the door. It is expected that additional code requirements for accessible egress routes and areas of refuge for the physically disabled will be incorporated into the codes soon.

Awareness. The awareness factor involves occupants' ability to notice a fire emergency. For example, in residential occupancies it is assumed that the occupants will be asleep at some time. Therefore, the package of protection features must consider that a fire could develop without the occupant being aware of the changes to the environment caused by the fire. The codes contain other provisions related to awareness, including the height of movable partitions in open offices and the need to have mezzanine areas open to the space below so that the occupants can detect a fire.

Knowledge. Through increasing public fire safety education, it is anticipated that the general population will have an increasing knowledge of fire and life safety. This increasing knowledge should result in proper responses to fire emergencies. However, knowledge also involves occupants' familiarity with the environment and egress routes. Code provisions for single-family dwellings differ from those for hotels because occupants of single-family dwellings are more familiar with the layout of the unit and available egress or escape routes.

Density. Occupant density will have a dramatic impact on the time necessary to evacuate a given space. High densities can increase the time necessary to reach an exit both in speed of travel and in queuing at the entrance to the exit. Codes may vary with respect to maximum densities permitted to provide some controls on this factor.

Discipline. Some occupancies, by the nature of the use, will provide a higher degree of discipline which will affect how the occupants respond. For example, the occupants of an elementary school are usually in a more disciplined environment than the occupants of mercantile or retail establishment. It is assumed that the occupants in the elementary school will respond to the direction of their teacher more than the occupants of a store may respond a salesclerk's directions.

Nature of the Fire

The likelihood of a fire (ignition potential), the fire growth rate, and the spread of smoke and fire are also major factors in evaluating occupants' life safety. The package of code requirements related to life safety from fire address all three factors in attempting to provide an acceptable level of life safety.

The potential for ignition relates to available ignition sources and the proximity and configuration of available fuel sources. Obviously, normal functions within a building, e.g., lighting, heating, and cooking, introduce potential ignition sources. Other activities associated with the occupants, such as smoking, introduce additional ignition sources. Furnishings, decorations, clothing, and other building contents provide fuel sources with varying degrees of ignitability. Frequently, codes will address these issues by requiring smoking restrictions, clearances from combustibles, treated fabrics, and separation of certain hazardous areas.

Once ignition occurs, the fire growth rate becomes the most important factor. As previously discussed, life safety involves avoiding exposure to the harmful effects of the products of combustion. Therefore, the hazard increases as a function of time based upon the growth of the fire, usually measured in terms of heat release rate. Early in the fire, the fuel is the most important factor in determining the fire growth rate. However, the surrounding environment also becomes critical in later fire development. For example, a fire in the corner of a room will be more severe than the same fire located in the center of the same room. The location of the fire in the room, the ceiling height of the room, and the interior finishes on the walls and ceiling will be critical in assessing life safety.

Depending upon the fire growth rate and smoke spread from the room, a room fire poses a life safety hazard to other building occupants. The codes generally attempt to contain the fire to the room of origin with either passive (compartmentation), active (automatic sprinklers), or a combination of both fire protection features. Vertical fire spread also is critical to the life safety of the occupants. Therefore the construction of the floor and the protection of vertical openings are critical. At times, the codes also will attempt to limit, by fire or smoke compartmentation, the number of people that might be exposed to a given fire. Finally, smoke control systems may be required to control or restrict the spread of smoke to adjacent areas or floors.

Fundamental Principles of Life Safety

Chapter 2 of the *Life Safety Code, NFPA 101* provides ten fundamental requirements for life safety. These fundamental requirements provide some basic life safety principles which are the basis of many life safety code requirements. These principles are:

1. **To provide for adequate exits without dependence on any single safeguard.** The exits must be sufficient in capacity for the number of occupants, and a single failure shall not result in an unacceptable level of life safety.

2. **To ensure that construction is sufficient to provide structural integrity during a fire while the occupants are exiting or in an area of refuge.** Note that from an occupant life safety perspective, the structural integrity need only be sufficient for safe egress time. Additional protection would be necessary for the safety of firefighters during interior fire suppression activities.

3. **To provide exits that have been designed to the size, shape, and nature of the occupancy.** The use of the space or building determines the design requirements for the exits. A 10,000-square-foot storage building requires neither the same number or capacity of exits as a 10,000-square-foot place of assembly due to the number and characteristics of the occupants. Because of the nature of the fire, a building in which bricks are stored does not have the same exit requirements as a building in which flammable liquids are stored.

4. **To ensure that the exits are clear, unobstructed, and unlocked.** The occupants of the building should have a clear path of travel to the exits and control over any component of the egress system. The occupants should be able to exit a building easily without the use of any special knowledge, effort, keys, or tools. It should be noted that in certain instances, codes will allow some deviation from this fundamental principle, provided the occupants have the necessary knowledge to effect safe egress.

5. **To ensure that the exits and routes of escape are clearly marked so that there is no confusion in reaching an exit.** While the need for exit marking does vary from occupancy to occupancy, depending on the occupants' familiarity with the building, the codes generally require some degree of exit marking in case occupants become confused or disoriented.

6. **To provide adequate lighting.** Adequate lighting is essential to the safe use of the egress system, especially components such as stairs.

7. **To ensure early warning of fire.** This does not necessarily mean that automatic detection is required in all buildings. Depending upon the awareness of the occupants and their ability to detect changes in their environment, automatic detection may not be necessary. It should also be noted that, from a life safety standpoint, when automatic detection is required it usually involves smoke detection and not heat detection, unless the space is not occupied and is separated from occupied areas.

8. **To provide for backup or redundant exit arrangements.** With a few limited exceptions, the codes require at least two exits to be accessible from every area.

9. **To ensure the suitable enclosure of vertical openings.** Many large-life-loss fires have occurred in buildings with unprotected vertical openings. The vertical openings allow smoke and fire to spread easily to adjacent floors with little advance warning for the occupants on the adjacent floors.

10. **To make allowances for those design criteria that are tailored to the normal use and needs of the occupancy.** While adequate fire protection and life safety are critical, they are not the primary purpose for constructing a building. Therefore, it is critical that codes provide an acceptable level of safety without creating an undue hardship or inconvenience. This is not to say that the needs of the operation or use should compromise life safety, but rather, that attempts should be made to provide life safety without interfering with the operation or use of the building. For example, it is obvious that locks must be permitted in correctional facilities. The codes recognize this and provide acceptable life safety by addressing the operation and reliability of the locking system without compromising security.

Total Concept of Life Safety

Using the fundamental principles and the life safety factors, a systematic approach to life safety can be developed. In theory, if one component of the following list can be accomplished with total certainty (100 percent assurance), the remaining components are not necessary. However, since total certainty typically is not achievable, codes tend to incorporate all of the following components of life safety. While this total concept of life safety is outlined in several chapters of *NFPA 101*, it is applicable to all codes addressing life safety from fire.

The Total Concept of Life Safety involves the following:

Prevent Ignition. Code requirements which address potential fuel sources, the ignitability of materials, and clearances to combustibles are examples of provisions which prevent ignition.

Detection of Fire. The detection of fire may be by the occupants or by automatic detection.

Control of Fire Development. Codes address controls on fire development primarily by restrictions on interior finishes. However, more recently codes also have addressed the heat release rates of upholstered furniture and mattresses in certain occupancies.

Confinement of the Effects of Fire. Confinement typically is accomplished through passive fire protection features such as fire barriers, occupancy separation walls, fire separation walls, tenant separations, firewalls, area separation walls, corridor walls, and smoke barriers.

Extinguishment of Fire. As with the detection of the fire, the extinguishment may be by manual or automatic means.

Provision of Refuge and/or Evacuation Facilities. The occupants must be capable of exiting the building, or have a safe area of refuge within the building.

Occupant/Staff. While the human behavior aspect of life safety is the most difficult to control, fire experience and research have indicated that many people will respond appropriately if they have received proper training.

OCCUPANCY CLASSIFICATION

Life Safety Factors

It is important to remember that life safety factors are one consideration in the development of the occupancy classifications contained in the codes. For example, the following life safety factors are considered in developing the code requirements for an acceptable level of life safety in health care facilities.

- Fatal fires in health care facilities typically have been rapidly developing fires which are detected early in the fire's development.

- The patients may be of different ages, but are considered to be incapable of self-preservation.

- The staff is considered to be alert, aware of changes to the environment, and trained in fire emergency procedures.

- The density of the occupants is considered to be relatively low.

- Visitors who will not be familiar with the surroundings most likely will respond to the direction of the health care staff.

- The fuel load is considered to be relatively low. However, fire experience has demonstrated that some furnishings and mattresses used in health care facilities will have high heat release rates.

- Health care facilities usually are well compartmented to restrict the spread of smoke and fire. However, this same compartmentation is what results in short times-to-hazard thresholds of fires in small rooms, such as patient sleeping rooms.

- Interior finishes generally are limited to low flame spread ratings.

- Cubicle curtains, draperies, and decorations usually are flame retardant.

- Smoking usually is restricted to certain areas and recently many facilities are instituting "smoke-free" environments.

While this list is not all-inclusive, it does demonstrate characteristics of the occupancy relative to life safety. Some of the items on the list are due to the nature of the occupancy and some are due to existing code requirements. Similar lists can be developed for each occupancy classification.

Mixed Occupancies

Most buildings are mixed occupancies. A typical hotel, for example, will consist of residential, assembly, storage, industrial, retail, and business areas. This combination of hazards must be considered in evaluating the life safety of the entire building.

In some instances, the egress facilities are totally independent, and the different occupancies can be divided using separations that have some degree of fire resistance. For example, a neighborhood shopping center may contain spaces leased to retail, assembly, and business uses. However, each space has its own exits and the tenant separations can have a fire resistance rating so that a fire in one space initially will have minimal impact on the occupants of adjacent spaces. In such cases, one can apply the requirements of each occupancy classification to the individual spaces.

Many times the different occupancies cannot be separated clearly. For example, the typical first floor of a hotel contains assembly, business, and retail uses. These areas may be occupied at different times of the day. The hazards associated with a fire in the retail spaces may present a threat to the occupants, or to the egress facilities provided for the patrons in the restaurant and lounge. When this occurs, one must review the life safety requirements applicable to assembly, business, and retail to determine what is necessary to provide an acceptable level of life safety. The codes generally tell us to apply the most restrictive requirements throughout the area.

Some codes also address concepts such as incidental use, or hazardous areas with specific uses. The incidental use concept usually indicates that a small portion of an occupancy may have a different use, provided that use is incidental to the major use of the space. For example, a warehouse manager may have a small office in the warehouse without considering the office a separate occupancy or the building a mixed use. In some instances, the codes limit the size of the incidental use to ten percent of the overall floor area.

Hazardous areas with specific uses are areas within a building in which the hazard is considered more severe than the principal use of the building. For example, because of its higher fuel load, a storage closet may be more hazardous than a general office area. Instead of using the mixed occupancy criteria, the codes often allow the closet to be separated and/or protected with automatic sprinklers to compensate for the additional hazard.

PEOPLE MOVEMENT

With respect to life safety, the primary concern is the safety of the occupants during the fire. As such, there are two options available: evacuation to a place of safety, or defend in place. Each of the strategies requires specific actions and protection features to be successful. While some are quick to point out that most people die in the process of evacuation and, therefore, we should direct our efforts to defending in place, there is no one single approach which is applicable to all occupancies or to all fire scenarios.

Evacuation

The protection features required for safe evacuation can be divided into two main categories: actions necessary to cause occupant movement, and protection features required to provide an evacuation route (means of movement).

With respect to occupant movement, the first action required is to detect the fire. Depending on the occupancy and, in particular, the awareness of the occupants, the detection may be by manual or automatic means. Fire growth rate is another factor to consider in determining whether the detection should be manual or automatic. A contributing factor identified in many fatal fires is the delay in discovery of the fire. This results in an inadequate amount of time to accomplish egress.

Once the fire is discovered, a means must be available to notify the other occupants in the building. Depending on the size, configuration, and use of the building, such notification may require a fire protective signaling system. The fire protective signaling system may be initiated by automatic or manual means. While the automatic initiation of the fire protective signaling system decreases the time between detection and notification, such systems also are prone to a high number of unwanted alarms. Unwanted alarms have the potential for creating a "cry-wolf" syndrome with the building's occupants.

Detection and notification are effective only if the occupants have been taught how to respond to a fire emergency. In many cases, normal public education efforts are sufficient to provide adequate instructions to the occupants. It should be noted, however, that there is no one standard audible fire alarm signal in the United States; therefore, the occupants must first identify the alarm signal as a fire alarm. In larger and more complex buildings, specific instructions must be provided to the building's occupants. In high-rise buildings, the concept of partial or zoned evacuation often is used. The occupants in the vicinity of the fire are evacuated to an area of refuge; further evacuation occurs as required. Such an evacuation strategy often requires the use of a voice communication system to provide the instructions appropriate to the specific fire.

Provide Movement Means

If the occupants are to be evacuated, the egress system clearly must have adequate capacity for the number of occupants within the building or area being evacuated. The capacity of exits usually is determined by calculating the occupant load (to be discussed in the next section) and multiplying by a factor identified in the codes for a specific egress component (i.e., door, stair, ramp, etc.). The capacity of the exits includes access to the exit as well as the exit itself, and should be based on the highest anticipated (calculated) occupant load.

It is not sufficient merely to provide doors and stairs of adequate capacity. The egress system must allow for the safe movement of the occupants to a safe area. A safe area may be a public way (as defined in the codes) or an area of refuge within the building. For example, travel through a horizontal exit is considered as egress to a safe area even though the occupants are still within the building.

The exits must be accessible to the occupants. Access to exits involves the path of travel to the exit. The occupant should have control over anything within the egress path without the use of any special knowledge, effort, tools, or keys. Aisles, corridors, and other egress routes shall be clear and unobstructed.

Finally, the egress path shall be protected against the products of combustion and provided with structural integrity. The codes also usually require that once an occupant enters an area with a certain level of protection, the level of protection shall be maintained or increased throughout the remainder of the egress route. For example, once an occupant enters a corridor which is separated from other areas by construction having a fire resistance rating of at least one hour, the corridor should lead to an outside door, horizontal exit, stair, or other egress component with a similar or higher level of protection. The occupant should not be required to leave the protected corridor and travel through a room to access a stair. It should be noted that many codes do not require the floors, beams, columns, or other structural elements supporting corridor walls to have the same fire resistance rating as may be required for the corridor walls.

In addition to some degree of fire resistance, which varies depending on the occupancy, size, and construction of the building, the egress paths must also be protected against the products of combustion. For this reason, automatic closing corridor and stairway doors must close upon the detection of smoke and not by fusible link or other heat-actuated device. There is substantial variation among the codes on the degree to which egress routes must restrict smoke spread. However, the requirements typically vary by occupancy classification and the presence of automatic sprinkler protection.

While it was stated earlier that life safety is a function of time, the codes do not identify a required evacuation time for buildings. The required egress widths are based on a flow time concept, which is the amount of time required for a given number of people to flow through a point (e.g., door opening). However, total evacuation time would require travel to the door, travel through the door, and then travel to the designated safe area. There are, however, some time expectations upon which some of the code requirements have been developed. For example, the provisions in *NFPA 101* for board and care facilities vary depending upon the evacuation capability of the occupants. One method of determining evacuation capability is to conduct regular, documented fire drills. The time required for the residents and staff to relocate to a point of safety (which is specifically defined within the Code) then is used to determine the level of protection required. The documented requirements for high-rise buildings are based on an assumed time of 90 seconds to evacuate a floor.[2]

Defend in Place

One of the difficulties in implementing a defend-in-place concept is the need to restrict the movement of the occupants. People in fire emergencies typically locate an exit and get out of the building. In fact, this is what our public fire safety education emphasizes. Therefore, in order for the defend-in-place concept to be effective, a means must be provided to restrict the movement of the occupants. This is why the defend-in-place concept is often limited to health care and detention and correctional occupancies. The very nature of the use of such facilities involves occupants who are not capable of self-preservation, and therefore are not capable of self-assistance. In such occupancies, arrangements can be made so that the fire protective signaling system is intended primarily to notify the staff, and not necessarily all the occupants within the building, of the fire emergency.

If the occupants' movement can be restricted, the only other protection feature required is to protect the area against the products of combustion and to provide structural integrity. Such protection is often more severe than the protection required for evacuation since the duration of exposure typically will be longer. Whereas it may take 90 seconds to evacuate a fire floor, the defend-in-place concept requires occupants to remain in the protected area for the duration of the fire.

One means of providing the necessary protection is prompt extinguishment of the fire. For this reason, many codes require the installation of automatic sprinkler protection in health care and detention and correctional facilities. Other protection features may include the proper equipment and training to suppress fires manually in their incipient stage, prior to sprinkler actuation. The advent of quick response and residential sprinklers has helped in the implementation of the defend-in-place concept. In fact, tests have demonstrated the ability of such sprinklers to maintain tenability in the room of fire origin during certain fire exposures.[3]

In some instances, the desired protection strategy may provide for evacuation and defend in place. For example, the fire emergency plan for many high-rise buildings indicates that only certain occupants need to evacuate. Occupants on other floors may remain in place unless conditions develop that require their evacuation. Total evacuation of buildings typically is only practical in small buildings with able-bodied occupants. However, as defined herein, the evacuation strategy also may include the evacuation of the occupants to an area of refuge. This is becoming increasingly popular for buildings which are accessible to the physically disabled.

OCCUPANT LOAD

The codes use factors for determining the occupant load which relate to the anticipated density of people within the area. The codes also require that adjustments be made when it is anticipated that the occupant load factor is too low. For example, the occupant load factor for office areas typically is one person per 100 square feet, but the occupant density ratio in some government office buildings has been determined to be one person per 60 square feet. Therefore, the occupant load factors in the codes should be used as a guide which can be exceeded when necessary. However, the codes generally do not permit the use of a lower occupant load factor.

Some occupant load factors are based on the gross floor area and some are based on the net floor area. The gross floor area is the area within the inside perimeter of the outside walls. The net floor area is the actual occupied floor area not including accessory unoccupied areas or the thickness of the walls. For example, a rectangular room has a measured length (wall to wall) of 100 feet and a measured width of 50 feet. Within the room is a storage closet of 8 square feet, encased columns which total 12 square feet in area, and a fixed piece of furniture, such as a bar, of 24 square feet. The gross and net floor areas would be calculated as follows.

GROSS FLOOR AREA = 100 ft. x 50 ft. = 5,000 sq. ft.

NET FLOOR AREA = 5,000 sq. ft. - (8 + 12 + 24) sq. ft.

= 5,000 sq. ft. - 44 sq. ft.

= 4,956 sq. ft.

Occupant Load Calculation Examples

1. If the above room were used as an office area with an occupant load of one person per 100 square feet (gross), the calculated occupant load would be:

   OCCUPANT LOAD = (5,000 sq. ft.) / (100 sq. ft./person)

   = 50 people

2. If the above room were used for concentrated assembly, and the occupant load factor of one person per 7 square feet (net) were used, the calculated occupant load would be:

   OCCUPANT LOAD = (4,956 sq. ft.) / (7 sq. ft./person)

   = 708 people

3. The above room is to be used as an office area for a department which is expanding. Presently, the department has 60 people working in a 4,800 square foot space. The department head advises you that the additional area is so that the staff can expand and that the density of employees will be about the same as the existing space. The occupant load of this area would be determined as follows:

   OCCUPANT LOAD = (4,800 sq. ft.) / (60 people)

   = 80 sq. ft./person

   OCCUPANT LOAD = (5,000 sq. ft.) / (80 sq. ft./person)

   = 62.5 persons

The third example illustrates two points. First, the density of the occupants is greater than one person per 100 square feet as was used in the first example. Therefore, an occupant load factor representing the actual intended use must be determined. An alternative would be to use the actual number of people anticipated to occupy the area, if the number is known. The second point is that the calculation will not always result in a whole number. The codes generally do not specify what to do with respect to rounding off. General mathematical procedures of rounding off to the nearest whole number should be sufficiently accurate. Therefore, in this example, the calculated occupant load would be 63. Some code officials prefer always to round up to the next highest whole number. Such a procedure is acceptable and will be more conservative.

EXIT SYSTEMS

In this segment of the Life Safety module we will be dealing with the exit system of a structure both in relation to the physical construction within a building, and to human factors. A corridor or protected way out of a building may look good on the plan, yet in reality create confusion in an emergency.

The most important fact which we must realize is that people must be able to get out of a structure safely.

As an inspector you must be able to put yourself in the same position as anyone using the building and visualize what they would have to do to get out. Obviously if the owner has exits blocked, or is using furniture in the means of egress, the system is going to be compromised. Your job will be to educate the owner as to what is being done is wrong and what must be done to correct it. This is a tricky job because if the owner is offended or becomes angry the correction may be temporary at best. Your goal should be to increase the owner's understanding so he/she will want to keep the building safe.

Remember that codes are tools to be used to make conditions reasonably safe. It is impossible to memorize the codes. It is far better to become completely familiar with them so that you can find an item quickly rather than trying to quote it. Often, when an individual quotes a code, he/she is perceived as making it up or putting a personal interpretation on it that may be wrong.

Exit systems are quite simple in theory. They are ways of safely getting occupants from any part of the building to the outside.

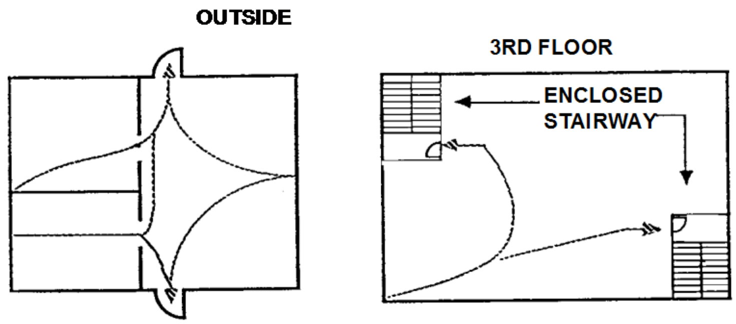
We will break down the system into three easily recognized parts: exit access, exit, and exit discharge.

Exit access is that part of the system that leads from any point in the building to a protected (rated) way. This part is essentially unprotected.

MEANS OF EGRESS

EXIT ACCESS–IS THAT PORTION OF A MEANS OF EGRESS WHICH LEADS TO THE EXIT ENTRANCE. TRAVEL DISTANCE IS DIRECTLY ASSOCIATED WITH THE LENGTH OF EXIT ACCESS PERMITTED.

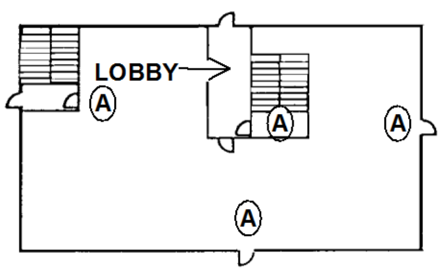
EXAMPLE: 1 STORY BUILDING | **EXAMPLE: 3 STORY BUILDING**



Exit is that part which is essentially protected, such as a rated corridor or an exit passageway; it may be as simple as a doorway.

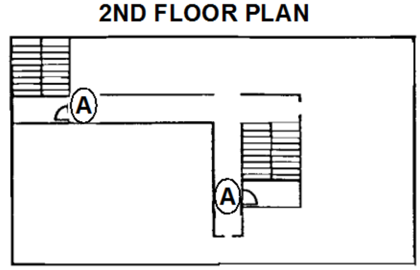
EXIT–THAT PORTION OF A MEANS OF EGRESS WHICH IS SEPARATED FROM OTHER SPACES OF A BUILDING OR STRUCTURE BY CONSTRUCTION OR EQUIPMENT TO PROVIDE A PROTECTED WAY OF TRAVEL TO THE EXIT DISCHARGE.

FIRST FLOOR PLAN



Ⓐ EXIT LOCATION

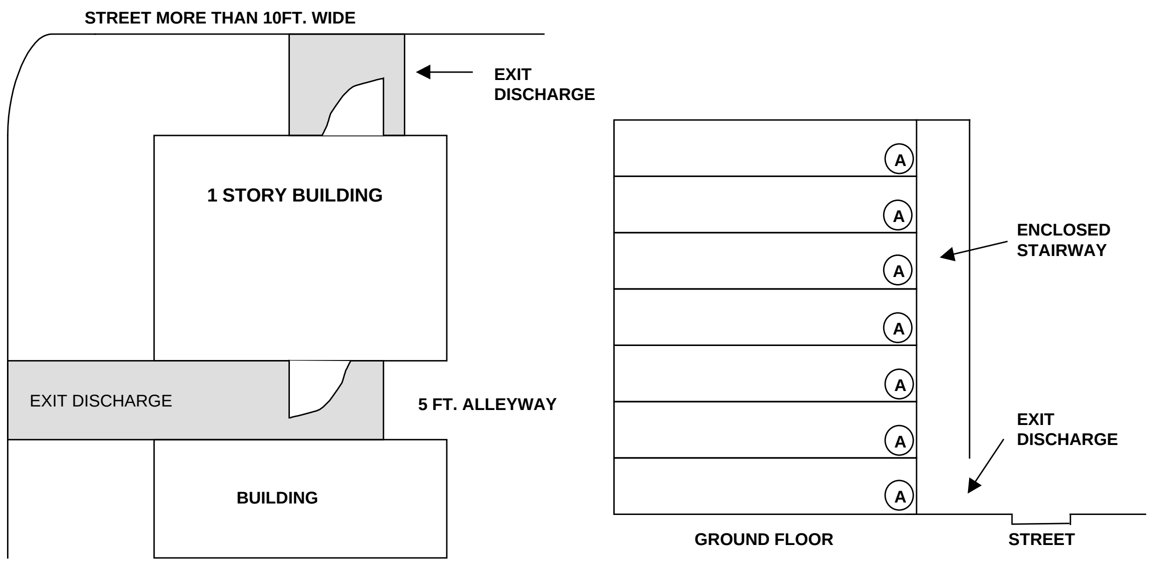
2ND FLOOR PLAN



Exit discharge is that part of the system where the person leaves the building and enters a public way.

It is important to realize that both exit access and exits will at times, consist of doorways, corridors, exterior exit balconies, smokeproof enclosures, stairways, ramps, exit passageways, horizontal exits, exit courts, or yards, depending on whether or not they are protected or rated.

EXIT DISCHARGE--THAT PORTION OF A MEANS OF EGRESS BETWEEN THE TERMINATION OF AN EXIT AND A PUBLIC WAY

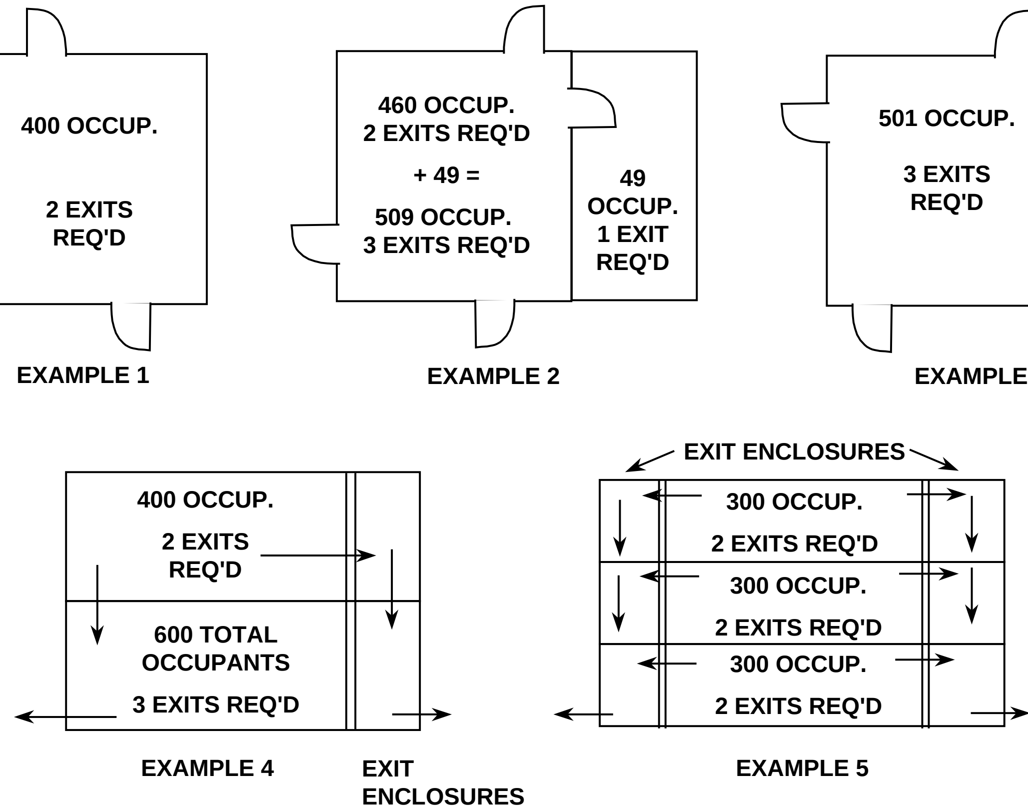


The basic concept of exiting provides that all persons are entitled to be able to get out of any structure. It also insists that people within a structure have control of the elements of the exiting system. This means that all hardware on doors must be operable from the inside without the use of a key, without having any special knowledge, or without exerting any special effort.

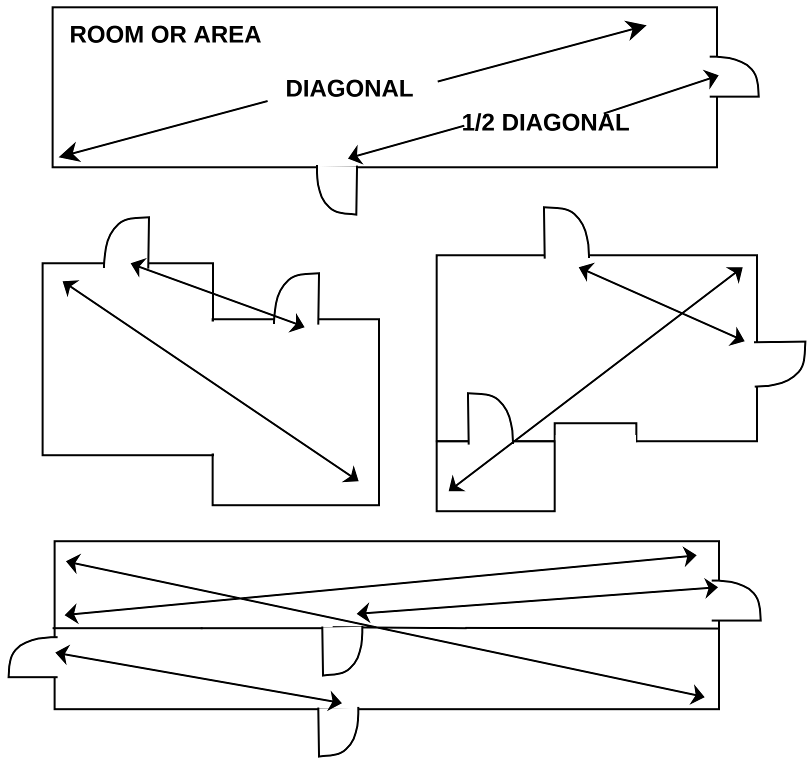
Once the exit size, or number of exits, and/or the protection level have been established, they may not be reduced. This protection level must extend all the way to the public way.

In general, all of the model code groups agree that when fifty or more people are assembled in one room, two exits, remote from each other, are required. There are some exceptions to the magic number of fifty, depending on the type of occupancy or hazard. At a minimum, two exits are required from floors above the level of exit discharge. Three remote exits are required from any story or portion thereof with 501 to 1,000 occupant load. Four remote exits are required where there is an occupant load of 1,001 or more. When the occupants of one room or floor must exit through another room or floor, both of the occupant loads must be added together to reach the number of required exits. However, if the occupant load of a second or third floor exits into an enclosure and then to the outside, it is assumed that the first floor will exit before the second gets there, and so on. The Uniform Code makes an exception to this theory: it requires fifty percent of the immediate floor above, and 25 percent of the next floor to be added to that of the first to calculate the exits.

EXITS REQUIRED

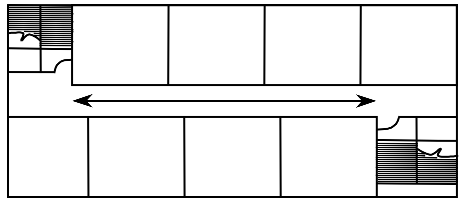


The term remote has been defined in different ways. The intent always has been to have the exits separated so that if an incident were to render one unusable, occupants could use the others. A reasonable rule of thumb criterion to use is "1/2 the diagonal distance of the area served apart." This has been used for some time in the Uniform Code and is now being used in the other codes.

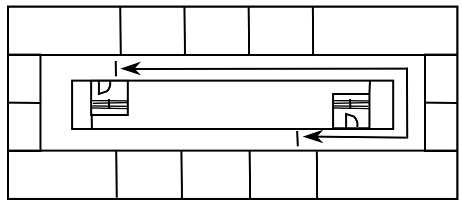


ARRANGEMENTS OF EXITS

This can increase exit time in multistory buildings. Owners and developers want exterior wall spaces for rental, not stairs. They insist on "core" construction which places the stairs, restrooms, mechanical shafts, and custodial closets in the center. Once again, 1/2 the diagonal distance must be used between entrances to the stair enclosures, and great care must be used to ensure that stair shafts are properly separated and constructed.



REMOTE STAIR LOCATIONS



"CORE" CONSTRUCTION--REMOTE STAIR ENCLOSURES ARE MANY TIMES A REAL CHALLENGE AND A PROBLEM

The BOCA, SBCCI, and NFPA Standard and codes previously used the Unit of Exit Width method to calculate units of exit widths. Now they use a fraction of an inch measurement for each occupant depending on the egress component. Generally the fraction of 0.2 inch is used when traveling through doors, ramps, or corridors that involve level travel, and 0.3 when traveling stairways involving vertical travel. The reasoning for this is based on the fact that people will move more slowly traveling stairs than traveling in a level position. Stairways of a given width cannot handle the same egress capacity as doorway openings of the same width. There are exceptions to each of these fraction widths noted. These fractions are multiplied by the occupant load, which is then divided by 12 to find the lineal foot width requirement.

The Uniform Code uses a simpler method: the occupant load is divided by 50 for any type of egress component which, surprisingly, gives very nearly the same calculation as those of the other two code groups.

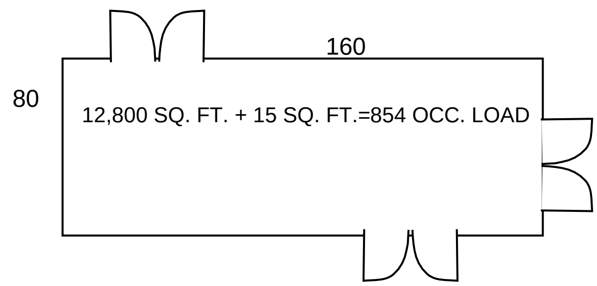
The width of the exits must be divided equally among the separate exits.

WIDTH OF EXITS

METHOD OF CALCULATING WIDTH OF EXITS DIFFER IN THE MODEL CODES BUT ALL COME UP WITH SUPRISINGLY CLOSE END RESULTS.

NFPA - 101-5.33.1		*"A" OCCUP 0.2"*
BOCA - TABLE 1009.2	*DOORS*	*"A" OCCUP 0.2"*
SCBBI - TABLE 1104	*LEVEL "*	*A" OCCUP 0.2"*

ICBO - (ALL OCCUPANCIES - TOTAL OCCUPANT LOAD + 50) (3303(B)



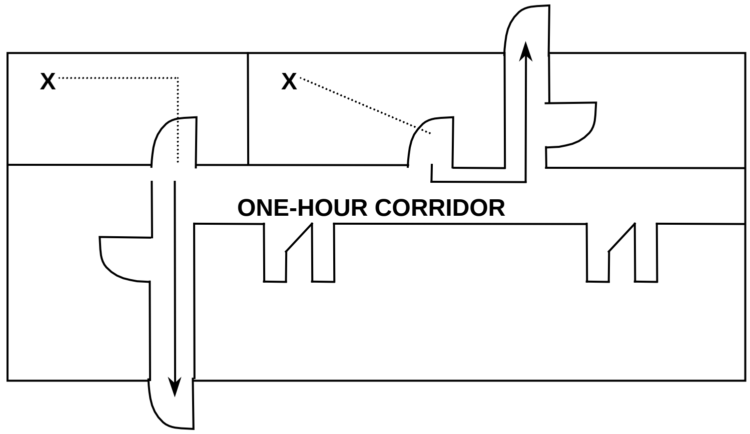
BOCA & STANDARD -*OCCUPANT LOAD MULTIPLIED BY 0.2 = NUMBER OF INCHES + 12 = LIN. FT. EXIT WIDTH..*

ICBO -*OCCUPANT LOAD + 50 = LIN. FT. EXIT WIDTH.*

WIDTH OF EXITS TO BE DIVIDED APPROXIMATELY EQUALLY AMONG THE SEPARATE EXITS

The travel distance to an exit varies with the occupancy, but generally is 200 feet under BOCA, NFPA, and SBCCI codes, and 150 feet under ICBO for unsprinklered buildings. The building is measured from a point one foot away from the wall in the most remote spot, in a line you would travel to an exterior exit door, horizontal exit, exit passageway, or enclosed stairway.

DISTANCE TO EXITS



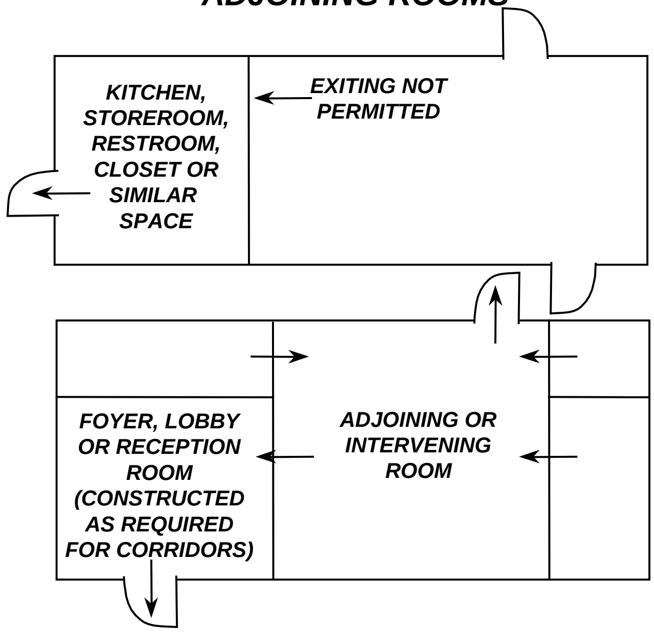
MAXIMUM TRAVEL DISTANCE

	UNSPRINKLERED	*SPRINKLERED*
NFPA	*200'*	*250'*
BOCA	*200'*	*250'*
SBCCI	*200'*	*250'*
ICBO	*150'*	*200'*

(EXCEPTION ICBO--MAY BE INCREASED 100' IF LAST 100' IS IN A RATED CORRIDOR)

Mazes can be created within buildings just by having room after room exit through one another. Generally speaking, the code requires a room to exit into a clearly marked way to an exit. There are some exceptions in the codes that give architects latitude. All agree, however, that no room may exit through kitchens, storerooms, restrooms, closets, or similar spaces. Foyers, lobbies, or reception rooms, which are constructed and treated as corridors, are exceptions to the rule that a corridor may not pass through an intervening room.

EXITS THROUGH ADJOINING ROOMS

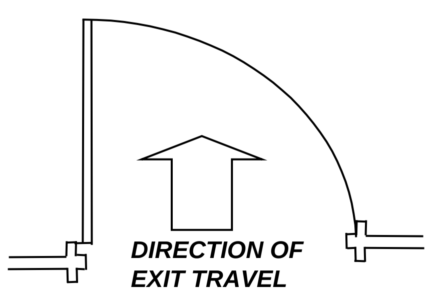


ROOMS TO BE EXITED THRU MUST BE ACCESSORY TO THE OTHER, NOT SMALLER THAN, AND NOT MORE HAZARDOUS.

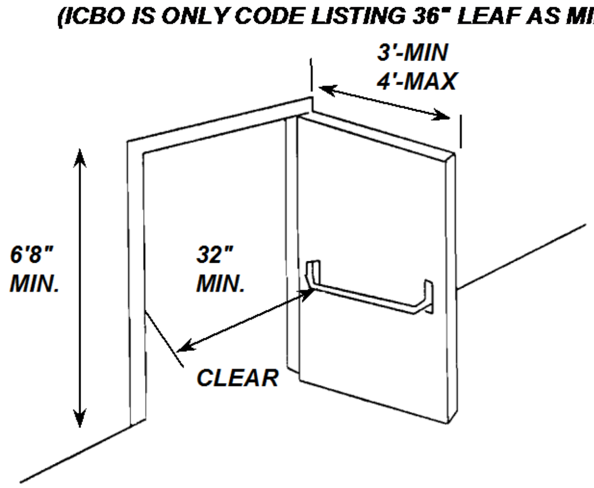
Doors must swing in the direction of exit travel when the occupant load exceeds fifty, or when occupants exit from a hazardous space. Again, as is so prevalent throughout the codes, there are exceptions to this rule. You must become familiar with the exceptions permitted by the code for the occupancy that you are inspecting. Don't be afraid to look it up if you are unsure of a specific requirement.

DOOR SWING

EXIT DOOR SERVING ANY HAZARDOUS AREA
OR
GENERALLY
SERVING AN OCCUPANT LOAD OF 50 OR MORE



Minimum and maximum door widths are spelled out clearly in the codes, but generally are 32 inches clear when fully opened, with a minimum width of 36" and a maximum width of 48 inches per leaf.



DOOR SIZE

There are also some very common doors that are not accepted by the codes as legal for normal egress from a building. These include revolving, sliding, and overhead type doors which generally are assumed to require special effort to operate.

Fire door assemblies must be complete and must include a rated and labeled frame in addition to the rated door. It must also include a self-closing device, positive latching lockset, or fire exit (panic) hardware, and rated ball-bearing hinges. Be certain that the gap between pairs of doors is not excessive. Labeling companies will not install labels on pairs of doors that have greater than 1/8 inch between doors; some may have to have an astragal to make the required rating. Note, also, that there are very strict regulations regarding the cutting in of windows, or adjusting, trimming, or altering rated doors. Almost all cutting of any sort into wood doors must be done either at the factory or by a shop which has been authorized by the factory to make such adjustments.

Panic hardware is not required in all instances for egress from rooms or buildings. It is required, however, in assembly, educational, and institutional occupancies, and, usually, whenever the occupant load exceeds fifty. If panic hardware is to be installed on any fire-resistive rated door, it must be listed fire exit hardware. Panic hardware installed on other than fire-rated doors can be listed exit hardware.

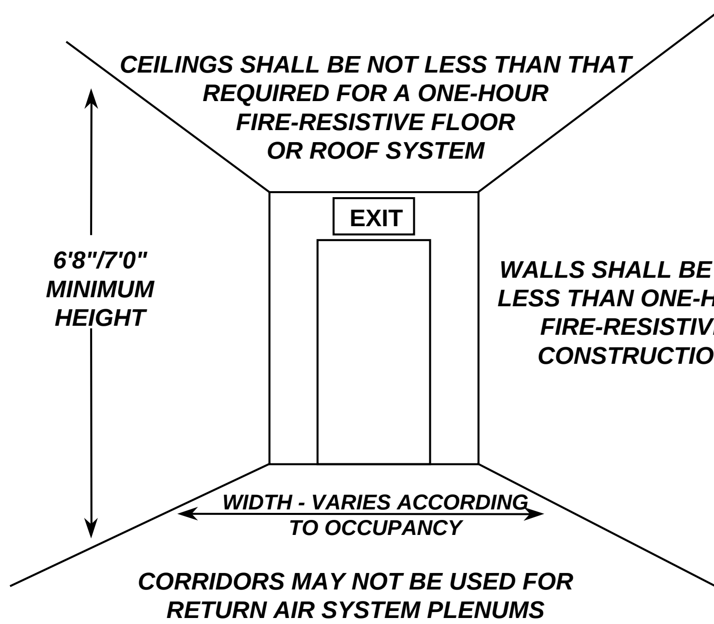
As noted above, everyone is entitled to be able to get out of a building in an emergency. There are, however, some circumstances where special control devices are necessary and are permitted by code. A good example of this is the deadbolt permitted on the main door of a business occupancy when there is a sign adjacent to it which reads, "This door to remain unlocked during business hours." Another example may be the controls for doors in jails or prisons.

Many mishaps occur at doors. Lawsuits are filed every day concerning people tripping on thresholds or risers located at the door. The codes have tried to eliminate these problems by requiring that a proper landing be installed on both sides of a door. No door may swing over any stair riser. The exception to this is in single-family occupancies. Handicap codes usually are not addressed in the model codes, but are very important. You may not be required to enforce them but you must be aware of them because owners will feel they are in compliance with them when you leave after an inspection. Some states adhere to the federal guidelines; others have created handicap codes of their own. Your job will be to find out just which codes are in effect in your area and then become well-versed in them.

In some circles, corridor construction is a disputed issue. Some codes completely relax the protection requirements if the building is sprinklered. Whether this is a valid position or not is not a part of this course; the model codes vary somewhat on this and other features of construction.

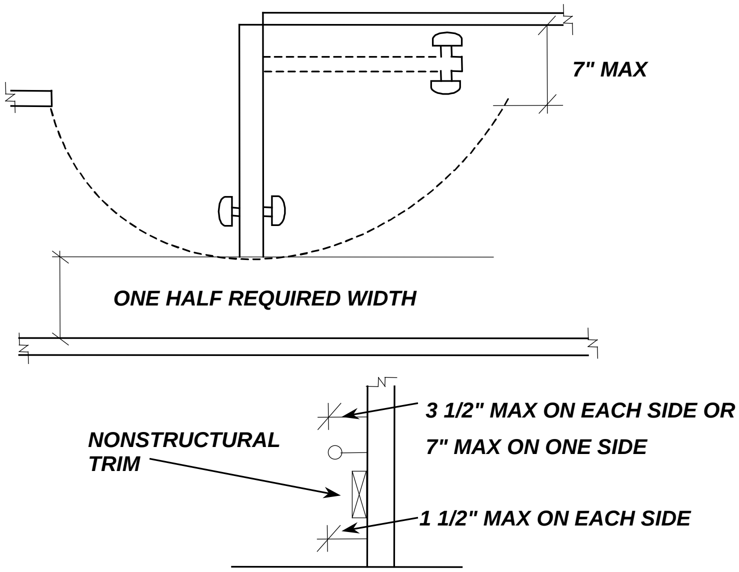
Generally speaking, corridors are required to be of at least one-hour construction, with a minimum height of between six feet, eight inches and seven feet. The width of corridors varies greatly according to the occupancy. All codes prohibit the use of corridors as air plenums. This is to eliminate the hazard of smoke being pushed or drawn to the rest of the building by the mechanical system during an incident.

CORRIDOR CONSTRUCTION



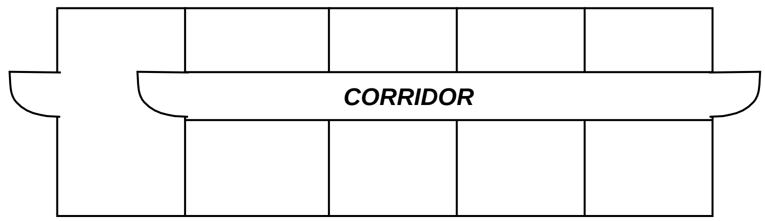
Projections into the corridor space are limited to 3-1/2 inches on each side, or seven inches on one side of the corridor. A door may not, in its most restrictive position, obstruct more than 1/2 of the required width of the corridor. Good judgment must be used by inspectors regarding projections.

PROJECTIONS

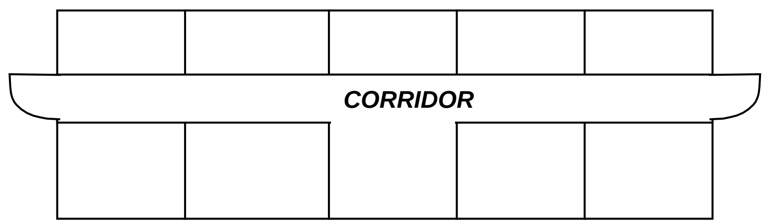


Frequently in older buildings, and occasionally in new buildings, you will find the corridor ending in a room, or having to pass through a room to get to the exit. The codes state explicitly that no corridor may be interrupted by intervening rooms. As stated earlier, lobbies, foyers, or reception rooms constructed and treated as corridors are exceptions to this rule. An inspector must be very careful about using this exception, so that abuses do not occur. For instance, the reception room becomes an office for six or eight secretaries, lobbies become exhibit halls, etc. Be certain that you can defend your decision to correctly call a space what it is.

CORRIDORS
INTERVENING ROOMS



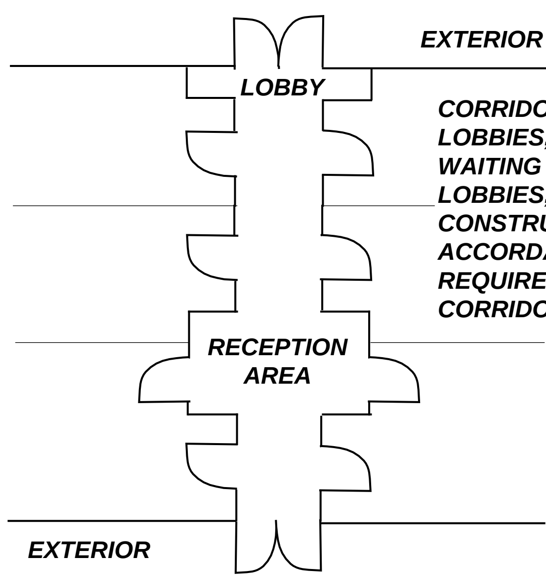
NOT PERMITTED



EXIT CORRIDORS SHALL NOT BE INTERRUPTED BY INTERVENING ROOMS

EXCEPTION: FOYERS, LOBBIES OR RECEPTION ROOMS CONSTRUCTED AS REQUIRED FOR CORRIDORS SHALL NOT BE CONSTRUED AS INTERVENING ROOMS.

CORRIDORS
INTERVENING ROOMS

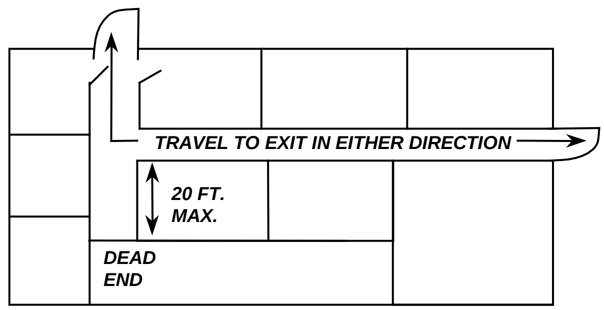


CORRIDORS MAY PASS THRU LOBBIES, RECEPTION, WAITING ROOMS WHEN THE LOBBIES, ETC. ARE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF CORRIDORS.

When more than one exit is required in a corridor, you must be able to travel in either direction to an approved exit. Dead-end corridors greater than twenty feet in length are not permitted.

ACCESS TO EXITS

WHEN MORE THAN ONE EXIT IS REQUIRED



A MAXIMUM OF 20 FOOT DEAD END IS PERMITTED. THIS 20 FOOT FIGURE VARIES WITH SOME OCCUPANCIES WITH NFPA.

Stairway treads generally are required to be a minimum of eleven inches with the rise being a minimum of four inches and a maximum of seven inches. This is true under ICBO and BOCA, but the SBCCI code stipulates a 7-3/4 inch maximum rise and a tread run minimum of nine inches. Again, NFPA differs from the model codes. Class "A" stairs are 7-1/2 inch rise, with a ten inch run and Class "B" stairs eight inch rise with a nine inch run. Safety is the most important consideration when it comes to stairs. Is the tread sufficiently deep to have a foot planted firmly on it? Is the rise an easy step or is it so high that you tire quickly? Another serious consideration is whether or not the treads vary in height or depth from one another. When tread heights and depths vary, the stairs are awkward to climb. Trips and falls occur and safety is compromised.

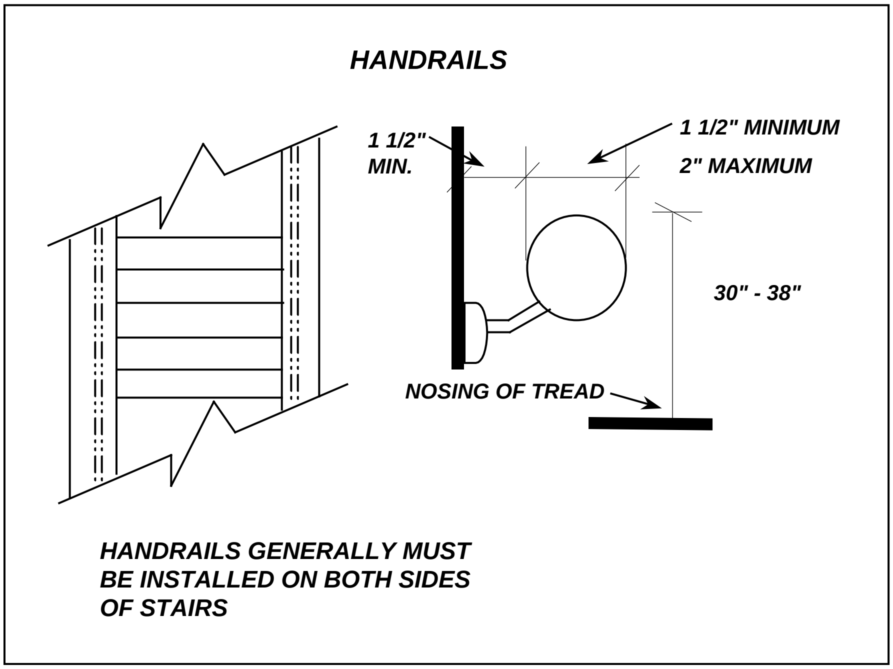
Minimum headroom generally is accepted as six feet, eight inches measured from the nose of the stair vertically to the lowest projection of the ceiling of the stair. Handrails should be placed between thirty inches and 38 inches above the nose of the tread.

Stair landings generally must be at least the width of the stair in length, but, depending on the code used, do not have to exceed 44 inches or 48 inches.

Barriers at the level of exit discharge must be placed across the stair so that in an emergency people will not continue into the basement or to a level from which they cannot escape.

Signs must also be placed in stairways of buildings four or more stories in height to identify the stairway and to tell occupants from which level they may exit. The codes also say that the sign must tell whether or not the stair has access to the roof.

Handrails must be on both sides of stairs that are greater than 44 inches in width. The handrail must be a minimum of 1-1/2 inch from the wall, and the size of the rail itself must be a minimum of 1-1/2 inches and a maximum of two inches in diameter.

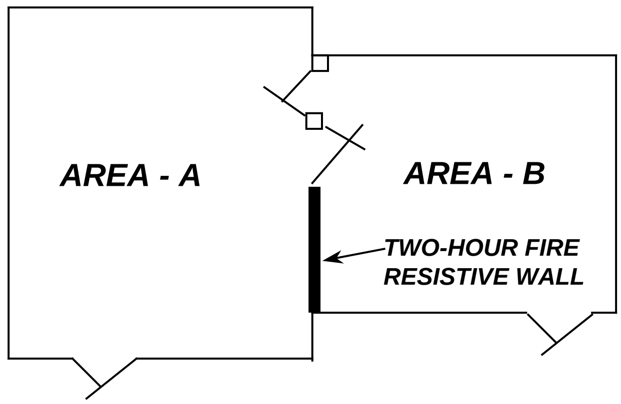


Ramps required for the handicapped must not exceed a slope of one-in-twelve. Other ramps must not exceed one-in-eight. As an inspector you will see all kinds of ramps and you will have to determine whether or not they are acceptable.

Try to catch ramp problems during plan reviews, when changes are made easily. Remember that removing a ramp once it is in place usually is very expensive. Note also that the surface of ramps must be of a slip-resistant material.

A horizontal exit is essentially an exit from one building into another on the same level. The wall of a horizontal exit must be of two-hour construction. This separation wall must go through the entire building continuously from the foundation through the roof. The doors which penetrate this wall, as well as any other penetrations, must be of a 1-1/2-hour rating, and must be complete fire assemblies. Note that horizontal exits are not permitted to serve as the only exits from an area, and usually are allowed to function only for up to fifty percent of the required exits. Horizontal exits are designed to protect people when it is not practical to exit completely from the building. You must be certain that the walls forming the horizontal exit are completely without penetrations.

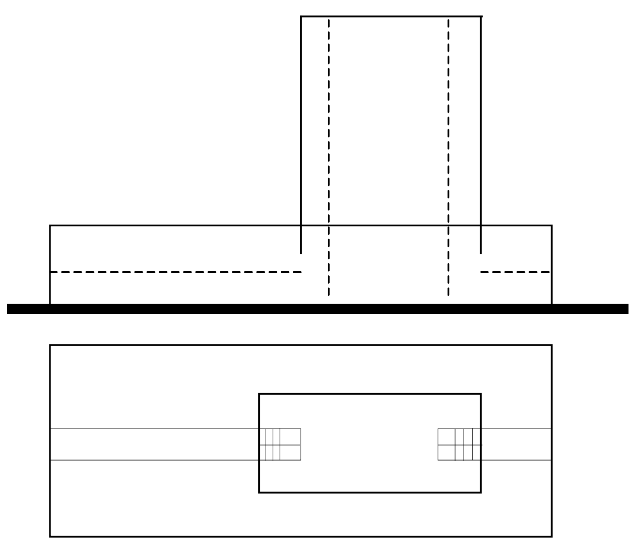
HORIZONTAL EXIT



- *HORIZONTAL EXIT SHALL NOT SERVE AS THE ONLY EXIT FROM AN AREA.*
- *ALL OPENINGS SHALL BE PROTECTED BY AN ASSEMBLY RATED AT NOT LESS THAN 1 1/2 HOURS.*

Stairway enclosures must exit directly to the outside or into what is called an "exit passageway." When a stairway serves a building over four stories in height, such an enclosure must be of two-hour construction. Whatever the rating of the enclosure, if it does not go directly to the outside, the area it passes through (a passageway, corridor, etc.), must continue the same rating all the way to the outside. Openings into exit enclosures must be limited to exit access to the enclosure from normally occupied spaces. This means that no storage rooms, custodial closets, or mechanical rooms may exit directly into them.

EXIT STAIRWAY ENCLOSURES



CONSTRUCTION:
DEPENDS ON THE NUMBER OF STORIES OR LEVELS IT SERVES EITHER 1 HR OR 2 HR

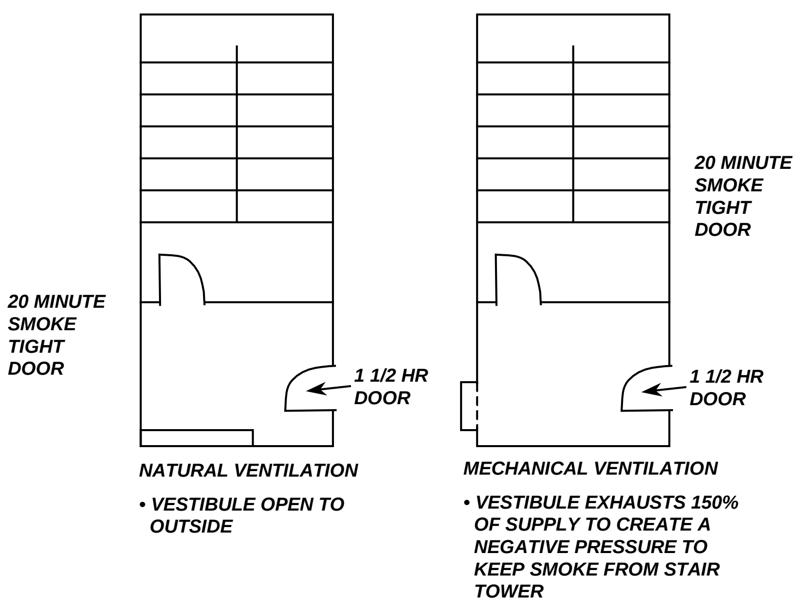
DOORS:
- *SELF-CLOSING*
- *ONE-HOUR RATING IN ONE-HOUR CONSTRUCTION*
- *ONE AND ONE-HALF HOUR RATING IN TWO-HOUR CONSTRUCTION*

OPENINGS:
OPENINGS ARE LIMITED TO THOSE NECESSARY FOR EXIT ACCESS FROM NORMALLY OCCUPIED SPACES

Smokeproof enclosures differ in two essential ways from normal stair towers. First, smokeproof enclosures are associated with high-rise buildings, usually over seven stories high. They also differ in that they provide a protection against the stair shaft becoming filled with smoke. This is done in two ways: either by mechanical means, or with natural ventilation. In both ways a vestibule is added to the entry of the stair tower. Using the mechanical method, a negative pressure is produced by exhausting 150 percent of the supply so that air flows to the vestibule rather than the stair. Using the natural ventilation method, an opening in the wall of the vestibule opens directly to the outside, permitting any smoke to flow into the atmosphere rather than into the stair. In all cases, these stair towers must be of two-hour fire rated construction, with a 1-1/2-hour door into the vestibule and at least a twenty-minute smoke control door to the tower.

SMOKE PROOF ENCLOSURE

REQUIRED IN BUILDINGS EXCEEDING 75' IN HEIGHT
CONSTRUCTION: 2 HOURS



All codes state that the means of egress in a building must be provided with exit illumination. This lighting must provide at least one foot of candlelight at the floor. This is about equal to moonlight, which is accepted as that which would be required to permit individuals to exit the building.

Exit signs must be provided throughout the building, wherever necessary, to show the way out clearly. You should never be in a corridor system where you cannot see exit signs. The size of the letters, and the level of illumination are pretty much standard throughout the codes, but the color seems to give rise to some controversy. One code requires a contrasting color, another only the color red, and another mentions no color at all. The most important factor is that they are there, and that they are lighted at all times the building is occupied.

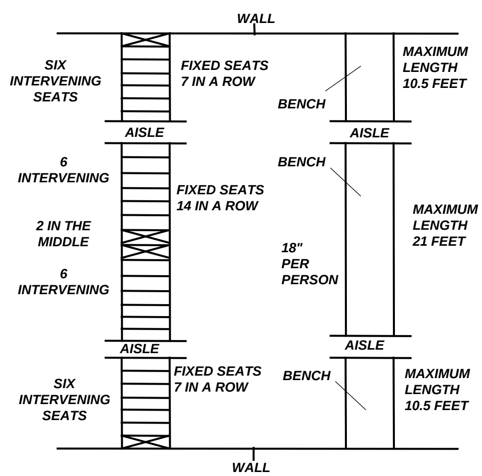
All of the codes accept the self-illuminating signs which use a ten- or twenty-year-life radioactive material for their illumination.

One concern is the public assembly occupancy where large groups of people gather who are not familiar with the exit locations of the building. There are a number of code concerns about public assemblies which will be addressed, one at a time.

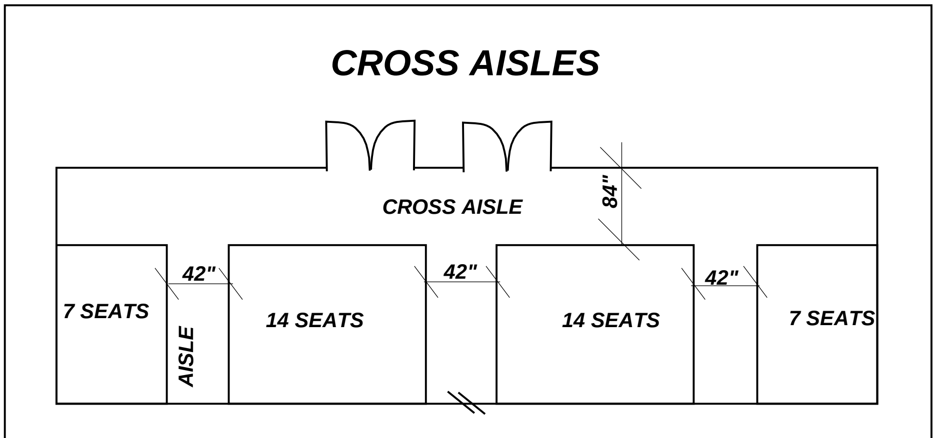
Aisle widths depend on whether or not the aisle is fed from both sides or just from one side. If only one side feeds into the aisle, the width must be a minimum of 36 inches. If it is fed from both sides, it may range from 42 inches to 44 inches in width. Continental seating, or seating which has more than fourteen seats per row, requires a 44 inch row along the outside wall. Be certain you check the travel distance, which may be a special distance, or may be the normal travel distance to an exit depending on the code you are using.

All of the codes agree that the maximum number of seats in a row is limited to six intervening seats, which means if you are in a center section you could have as many as fourteen seats in the row between aisles. A side section against a wall could only have a maximum of seven seats. This pertains to the standard seating arrangements in a theater.

AISLES



Cross aisles become a little more difficult to figure because they must be the width of the widest aisle plus 1/2 of the rest of the aisles which lead into it. This becomes rather large if there is only one multidoor exit at the rear. This certainly would be a good reason to provide at least two widely spaced exits at the rear where you can divide the numbers using each exit.

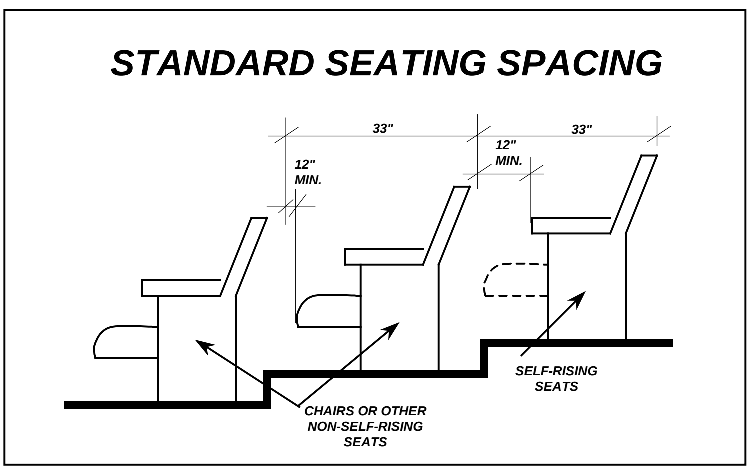


CROSS AISLES (CONVERGING AISLES)

THESE TERMS DIFFER IN THE CODES BUT THE INTENT IS THE SAME. WIDTH OF CROSS AISLES ARE REQUIRED TO BE THE WIDTH OF THE LARGEST AISLE (IN THIS CASE 42") PLUS 50% OF THE REST OF THE AISLES FEEDING INTO IT. (IN THIS CASE 21" + 21" OR 42") TOTAL WIDTH = 84"

The maximum slope of a ramp in a theater is one-in-eight and all slopes less than this must be by ramp. If the slope exceeds this figure, steps must be used.

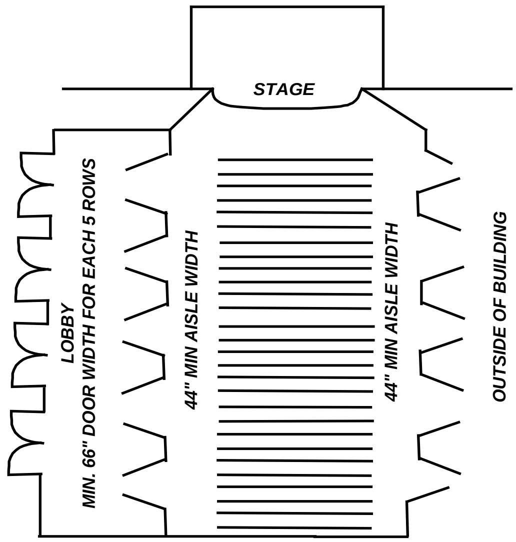
The spacing between seats in standard seat spacing is twelve inches from the back of the seat in front to the most forward projection of the seat behind, whether the seat is in the down or upright position. This seems quite close, but, remember, there can only be six intervening seats maximum to the nearest aisle.



When dealing with Continental seating or seating which has a greater number of seats in the row than fourteen, the codes require greater distance between the seat rows. The actual distance varies by the code and the number of seats in the row. A minimum 44 inch aisle is required down the outside edge of the seating and a set of double doors, or six-foot opening, is required for every five rows of seats. Note that the doors for each five rows of seating must be at the rows of seating.

It is not correct to have two sets of doors close together located toward the middle of the auditorium for the first rows. These doors may open to the outside or into a lobby or rated corridor space which leads to a lobby or the outside.

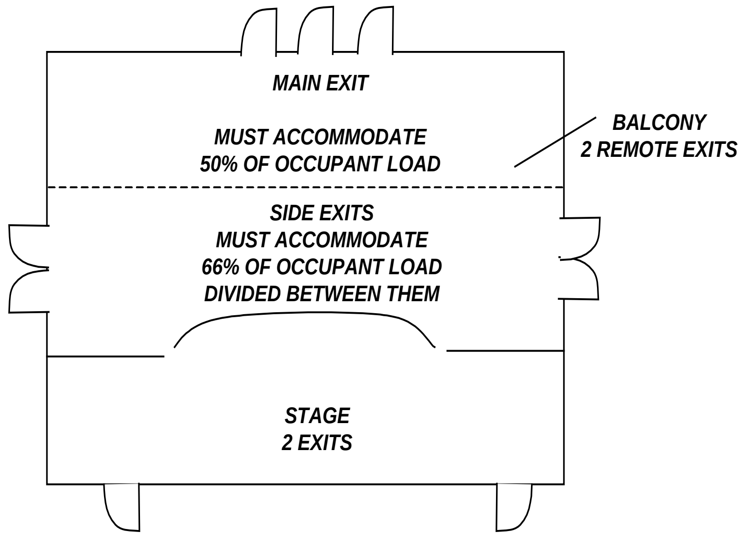
CONTINENTAL OR THEATER SEATING



In Class "A" places of assembly, the main entrance usually is considered the main exit, and it must accommodate at least fifty percent of the occupant load of the auditorium. Side exits also are required, and they must each accommodate 33 percent of the occupant load. This 100 percent + exiting capability is built into the code in case exits are blocked by an incident.

Balconies are required to have at least two exits. Again, this is to provide for exiting using a worst-case scenario.

ASSEMBLY OCCUPANCIES



EXAMPLE: AUDITORIUM WITH 501 SEATS
MAIN FLOOR

MAIN EXIT=250	*250*
SIDE EXIT=167 EACH	*334*
TOTAL	*584*

In addition to all of the above information, there are several other very significant points about the main occupancy groups that must be taken into consideration as you inspect buildings. These deal with people, programs, processes, etc.

Assembly
- Large numbers of people.
- Panic situations.
- Highly combustible stage sets.
- People wanting to leave the way they came in.

Institution
- Immobility of patients.
- High-tech equipment.
- Very large buildings.
- No evacuation (defend in place).

Schools
- Children (varied ages and capabilities).
- Programs, including displays.

Hazardous Occupancies
- HPM (hazardous production materials).
- Industrial processes.
- Sources of ignition.
- Industrial equipment.
- Very large buildings.

INTERIOR FINISHES

The characteristics of the interior finish may be the most important building characteristic related to the potential fire hazard that is addressed by most codes. Interior finish generally is defined as the exposed surfaces of the walls and ceilings in a building. Depending on the code, the floor surface may be considered an interior finish or separately as an interior floor finish. The floor finish often is separated from other interior finishes since the role of a floor finish is significantly different from the role of an interior wall or ceiling finish.

The interior finish in a building affects fire growth and, consequently, life safety in four ways. The first concern, and the one typically regulated by the codes, is the ability of the material to spread flame over its surface. A second concern, the concern most commonly regulated with respect to textile materials placed on walls and ceilings, is the effect that the interior finish has on the rate of fire buildup to a flashover condition. The final two concerns relative to interior finish involve the potential to produce smoke and toxic gases.

The performance of a particular interior finish material may be greatly affected by substrate material (the surface to which the interior finish is attached) or lack thereof. For example, thin plywood paneling will perform differently if it is attached to gypsum wallboard than if it is attached directly to the studs. Likewise, multiple layers of an interior finish, such as wall coverings, will perform differently than a single layer. The orientation of some materials is also critical to the fire behavior. One of the more notable examples, which has led to changes to the various model codes, is the placement of textile materials on a wall surface. In previous editions of the codes, such materials were regulated the same as any other interior finish material. However, full-scale fire tests have demonstrated that traditional test procedures produce results which are not representative of true fire performance when the textile material is located on a wall or ceiling. It is important that the code official evaluate the test results provided for an interior finish material based on its orientation and substrate material.

Since typical code requirements are concerned with flame spread across the surface of the wall or ceiling, interior finishes usually are considered continuous surfaces. Draperies, for example, usually are not considered an interior finish and are regulated by other sections of the codes for specific occupancies. Likewise, furniture generally is not considered an interior finish. However, if there is a significant amount of furniture, such as built-in booths in a restaurant, that produce a continuous surface, the interior finish requirements may be applicable.

ASTM E 84

The fire test most commonly referenced for the evaluation of interior finishes is ASTM E 84[4]. The test method is used to determine the relative burning behavior of a material by observing the flame spread across the surface of the material. The test procedure includes both flame spread index and smoke developed ratings. Previous editions of the test standard and the model codes referenced a fuel contribution evaluation. However, this characteristic is no longer reported as part of the test procedure.

The test procedure consists of placing a 25-foot-long specimen at the top of a tunnel. A gas burner, located at one end of the tunnel, is ignited, and visual observations are made to determine how quickly the flame moves across the bottom surface of the specimen. The flame spread ratings are relative using cement asbestos board as a 0 rating and red oak flooring as a 100 rating. The maximum flame spread recognized by current codes usually is 200, but certain occupancies or areas may not permit flame spread ratings in excess of 25 or 75. Figures 4-2 and 4-3 illustrate the general configuration of the test tunnel.

Figure 4-2

SECTION B-B

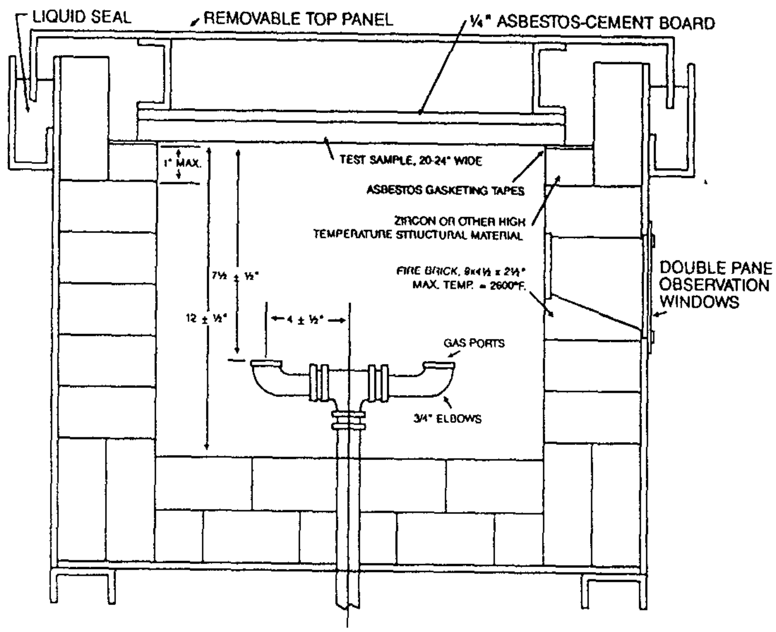
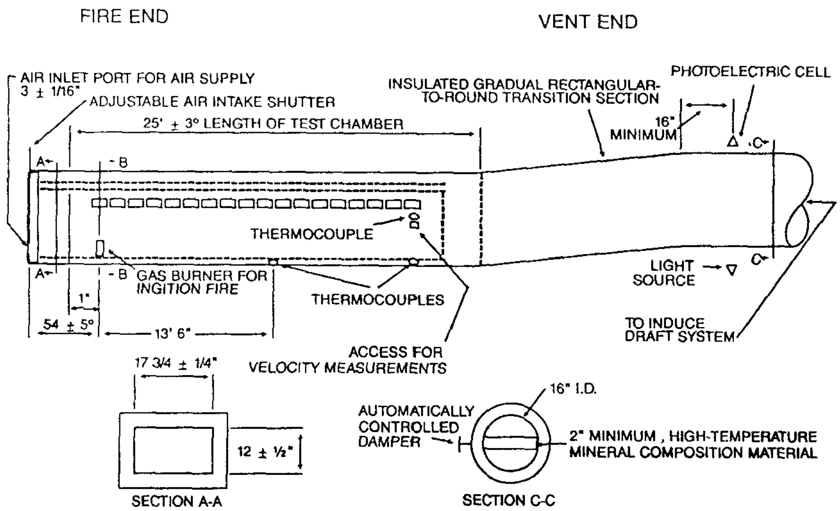


Figure 4-3

DETAILS OF TEST FURNACE



Because of the burning characteristics of certain materials, the test procedure has some limitations. The limitations typically apply to materials that, when tested, produce flame spread ratings which are not representative of actual fire performance. The test method is not considered appropriate for some cellular plastic materials. The test also is not appropriate for materials that melt, drip, or delaminate to such a degree that the continuity of the flame front is destroyed. For example, certain materials have a tendency to melt away from gas burners. Once the material has melted to a certain point, the gas burners no longer impinge on the material and the flame front does not spread any further, resulting in a low flame spread index. However, in an actual fire with a larger fire exposure, the material may contribute significantly to rapid flame spread or to the development of flashover.

ASTM E 648

Recognizing that floor finishes contribute to a fire differently than do wall and ceiling finishes, and that the fire exposure is different, a different test procedure, ASTM E 648[5], is used for floor finishes. It should be noted that the test procedure refers to the orientation of the material on the floor, and not the type of material. For example, the test would not be applicable to carpeting placed on the ceiling.

The test method measures the critical radiant flux of a horizontal specimen exposed to a flaming ignition source. The critical radiant flux is the level of radiant energy on the specimen at the distance from the source where flameout occurs. It should be noted that in evaluating test reports, the higher numbers, reported in terms of watts per square centimeter, indicate a material which is less likely to contribute to the fire. For example, 0.45 watts per square centimeter indicated that flameout will occur at a higher radiant energy level than a critical radiant flux of 0.22 watts per square centimeter.

Special Considerations

The various codes have specific provisions which apply to certain interior finish materials or configurations as well as to sprinkler protection. For example, many codes permit the reduction of one class if the area or building is protected with an automatic sprinkler system. This reduction is based on the ability of the sprinkler system to contain the fire and to reduce the probability of flashover. Typically, the codes also permit a reduction for incidental trim, which is defined as generally not providing a large continuous surface. The typical restriction is ten percent of the wall area, with a general assumption that the trim is spread out as in molding and is not one significant area.

Recognizing that the height of the materials is a factor when the material will become involved in the fire, many codes permit lower classifications on interior finishes located in the lower half of a wall, such as wainscotting. It should be noted that the provision is based upon tests conducted in corridor configurations. Other special interior finish considerations involve special testing requirements for textile materials placed on walls and ceilings and foamed plastics. Finally, the use and limitations of fire-retardant coatings that can improve the flame spread index of interior finishes usually is addressed by the codes.

FIRE SUPPRESSION AND DETECTION SYSTEMS

While fire suppression and detection systems will be addressed in more detail in Module 7, it is important to recognize the impact and role of fire suppression and detection systems in life safety.

Fire Detection

As previously noted, in order to evacuate or relocate the occupants of the building, the fire must first be detected. In some occupancies, it may be necessary to provide automatic detection because the occupants will not be alert or will otherwise not be capable of detecting the fire quickly enough. However, in other occupancies, automatic detection may not be required to provide an acceptable level of life safety due to the nature of the occupants.

Occupant Notification

Regardless of how the fire is detected, there is a need to notify the occupants of the fire emergency. Such notification also may be important in a defend-in-place facility so that the occupants are advised that there is a fire but that they are to remain in place. Occupant notification usually is by audible devices and may include visual devices. The audible devices may include bells, chimes, horns, speakers, or other audible notification. There is no standard fire alarm signal throughout the United States. Recently however, there have been modifications to the codes to require a certain level of audibility to ensure that the alarm is heard above background noise.

The codes generally allow various types of notification systems such as general alarms, zoned alarms, coded alarms, and presignal alarms. General alarms are the most basic and commonly used signal, in that the alarm sounds throughout the protected premises. A zoned alarm is one in which certain areas, such as the fire floor and floor above, are notified of the fire emergency. Occupants of other areas either receive no signal or receive instructions to remain in place and await further instructions. Such systems are particularly effective when total building evacuation is not practical.

Coded fire alarm signals notify the occupants of the fire emergency and the area in which the initiating device is activated. For example, a coded signal of 3-1-1 might indicate that the alarm is being received from Building No. 3, First Floor, North Wing. Such information may be helpful to building occupants who have a responsibility in the fire emergency plan for that particular building. Unfortunately, the occupants may not understand the code being used or may not bother to listen to the code.

Finally, in some occupancies a presignal system is permitted. Presignal systems are only as effective as the person who is stationed at the constantly attended location where the alarm is received. When an initiating device is activated and a presignal system is used, the alarm is not transmitted throughout the building but rather to a constantly attended location. The personnel at the location are then responsible for activating the general alarm. However, fire experience has indicated that such alarms may result in a delayed notification to the building occupants due to improper training or fear of sounding a false alarm.

Emergency Forces Notification

Fire protective signaling systems can also be arranged to notify the fire department responsible for responding to a fire at the protected premises. Such notification, when required by the code, is automatic and does not rely on personnel involved in the fire to call the fire department. For example, a fire protective signaling system may be arranged to sound an alarm automatically at a central monitoring station. The personnel at the station then are responsible for immediate notification of the appropriate fire department. While human intervention is required, the personnel at the monitoring station should have no conflicting responsibilities and should not be involved in immediate rescue or evacuation within the fire area.

Emergency Control

Fire protective signaling systems also can initiate various control functions related to fire containment, control, or suppression. Fire protective signaling systems often are utilized to close fire doors, recall elevators, unlock doors, shut-down or activate HVAC fans, and to actuate fire suppression systems such as a preaction sprinkler system or a halon system.

Fire Suppression Systems

While the automatic sprinkler was initially developed for property loss protection, standard automatic sprinklers have been excellent in protecting occupants outside the room of origin. Depending on the specific fire scenario, standard sprinklers may also provide protection for individuals in the room of origin. However, the advent of residential and quick response sprinklers has resulted in the ability to maintain tenability in the room of origin during certain fire scenarios.

While complete coverage by an automatic fire suppression system is desirable from a fire protection standpoint, the codes recognize that partial protection of specific hazards or hazardous areas may be adequate in providing an acceptable level of life safety. The intended protection and other compensatory features must be considered in determining the adequacy of partial coverage by the suppression system. In some instances, the codes permit the elimination of sprinklers in some areas to reduce the installation costs while still providing acceptable life safety.

Many codes allow modifications to various code requirements if a supervised automatic sprinkler system is installed. Such modifications have originated for two reasons. First, the codes may not require automatic sprinkler protection and therefore, the modifications provide a cost-effective alternative to provide either an equivalent or superior level of fire protection. Second, the performance of supervised automatic sprinkler systems has been well documented. Based on the performance of such systems, other code requirements for fire resistance, flame spread, travel distances, and so forth may be modified to a level necessary for adequate safety.

CONTENTS AND FURNISHINGS

Historically, the codes have required that fortresses be constructed so as to minimize the impact of a fire involving the contents and furnishings within the building. However, as fire protection technology advances, increased knowledge, improved test procedures, and analytical methods have developed to enable us to understand and control fire ignition and growth better resulting in restrictions on contents and furnishings.

Whereas one of the approaches to providing acceptable life safety is to prevent ignition, some code requirements regulate the ignitability of furnishings. The primary concern to date has been the ignition of furnishings by items such as cigarettes. Some test procedures also evaluate the ability of the item to resist ignition by small flaming sources which may include small wastebasket fires.

With respect to tenability, the most critical characteristic of the furnishing may be the heat release rate. Heat release rates are commonly used by analytical methods and computer models to predict conditions that result from a fire. Some codes have adopted provisions to restrict the maximum rate of heat released from a single item of furniture. Such restrictions are based on a desire to limit the likelihood that a fire involving a single item of furniture can result in flashover.

Another method by which contents and furnishings can be regulated is by fuel load. As was previously mentioned, the occupancy classifications assume a relatively consistent fuel load within an occupancy class. However, such fuel loads generally are averages throughout the building, and specific areas may have substantially higher fuel loads. Fuel load estimates also have been used to determine required fire resistance ratings. Some codes also have developed specific fuel load limitations for certain areas or uses within a building.

For certain occupancies, the codes also may regulate wastebaskets, draperies, and decorations in that these items are frequent fuel sources. When regulated, draperies and decorations usually are required to be flame resistant with the fire exposure typically a small flame. With respect to wastebaskets, the requirements attempt to reduce the probability that a fire in the wastebasket will spread to other items by the wastebasket collapsing, thus allowing the burning material to spread across the floor.

EMERGENCY PROCEDURES

At the beginning of the unit, it was discussed that human behavior and occupant characteristics are vital to life safety. Therefore, the codes require certain emergency plans, training, and drills to provide the occupants with the knowledge of proper procedures to use in a fire emergency. The extent and nature of such training is dependent upon the occupancy. For example, training in industrial occupancies usually is provided for all the occupants since anyone may discover or attempt to extinguish a fire and all the occupants typically are expected to evacuate unless they are a member of the fire brigade. However, in a health care facility, the training and drills are conducted solely for the staff and need not include the patients in the building.

SUMMARY

The codes provide a mechanism by which a life safety analysis can be performed on a given building. The occupancy classifications, upon which code requirements are made applicable, attempt to group the various risk factors associated with life safety. In certain instances, such groupings may not be applicable and the code official should evaluate the risk and protection features to ensure that adequate life safety has been provided.

Life safety is more than exits. In fact, many would argue that the controls on fire growth and fire development are more critical to life safety, in that such restrictions provide additional safe egress time. The use and effectiveness of the egress system is highly dependent upon the characteristics of the occupants. However, as the safe egress time is increased, inappropriate action by the occupants may not be as critical.

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ADDITIONAL READINGS

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Cote, Arthur E. (ed.). *Fire Protection Handbook*, 16th Ed. National Fire Protection Association, Quincy, MA, 1986.

DiNenno, Philip J., et. al. (eds.). *SFPE Handbook of Fire Protection Engineering*. National Fire Protection Association, Quincy, MA, 1988.

Green, Henry L., and W. E. Koffel. "Establishing Threshold Limits for Fire Suppression Systems." *The Building Official and Code Administrator*, November/December, 1988.

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FOOTNOTES

[1]*NFPA 101, Code for Safety to Life from Fire in Buildings and Structures*, National Fire Protection Association, Quincy, MA (1988).

[2]*Public Buildings Service International Conference on Firesafety in High-Rise Buildings, Sponsored by General Service Administration, April 12-16, 1971,* Warrenton, Virginia.

[3]Notarianni, Kathy A. *Five Small Flaming Fire Tests in a Simulated Hospital Patient Room Protected by Automatic Sprinklers.* Report of Test FR 3982. National Institute of Standards and Technology, October 31, 1990.

[4]Standard Test Method for Surface Burning Characteristics of Building Materials, ASTM E 84-89a.

[5]Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source, ASTM E 648-88.

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MODULE 5: HAZARDOUS MATERIALS AND PROCESSES

TERMINAL OBJECTIVE

The students will be able to recognize the presence of hazardous materials or processes.

ENABLING OBJECTIVES

The students will:

1. *Recognize and properly categorize hazardous materials and processes.*

2. *Explain the general principles for controlling fire hazards associated with hazardous materials.*

3. *Describe fire prevention procedures for controlling hazards associated with the storing, handling, and use of hazardous materials.*

4. *Select the appropriate techniques and recommend a solution to a problem involving flammable liquids.*

HAZARDOUS MATERIALS IN YOUR JURISDICTION

History of Hazardous Materials Development

Explosives were the first hazardous materials which were developed by the Chinese. Explosives remained essentially the only bulk hazardous material until the discovery of oil, natural gas, and alcohols. The period from 1880 through 1940 produced some remarkable developments in "miracle" materials including: rubber, nylon, rayon, crude plastic, gasoline, heavy fuel oils, city gas, electricity, radio waves, vacuum tube, high explosives, acids, corrosives, and combustible metals. From 1940 to the present a technological explosion of useful new hazardous substances was developed for modern society.

Perceiving the Presence of Hazardous Materials

One of the problems for the basic level fire prevention inspector is identifying the presence of hazardous materials. Hazardous materials are common in the "normal" environment of a routine inspection. You **expect** to find hazardous materials at a chemical manufacturer but you must also be **aware** of their possible presence in many of your more routine inspection environments.

For example:

- Swimming pool supply stores will carry chlorine.
- A sewer plant also uses chlorine.
- There are cryogenic materials and radiation sources in a doctor's office.
- Hospitals also have radiation sources as well as chemicals.
- Hardware, lawn supply, railroad yard, truck terminal, manufacturing plants all handle hazardous materials.

Life Cycle of Hazardous Materials

Hazardous materials are processed, stored, handled, and transported. At each step in the life cycle of these materials different hazards are created.

First the material is manufactured. Then hazardous materials are often shipped or transferred to a facility closer to their point of end use. Here they can be stored and/or transferred to a smaller container for distribution and sale. Finally, hazardous materials may either be totally consumed, or waste may be generated for disposal (used motor oil, nuclear fuel core). This clearly illustrates the need for code enforcement initiatives at various levels in your community. The following list separates code actions into functional areas:

- Manufacturing of hazardous materials.
- Transfer and storage.
- Distribution and/or retail sales.
- End-user.

Responsibilities of the Inspector

You must be able to perceive the hazard from these materials in various settings within the community.

In order to determine the hazard you will need to identify the nature of the material and the occupancy classification of the structure.

What questions should you answer when dealing with a hazardous material? Some examples might be:

- How much gasoline can be stored in a single-family dwelling, or garden apartment storage room?
- How much "white" gas can be stored and displayed in a mercantile occupancy?
- Can cryogenic materials be stored and used in a doctor's office? If so, how much?
- Are there any requirements for the storage or sale of fertilizers and pesticides?
- Does a hardware store need a magazine for the storage of black powder and munitions?

Before you can work methodically toward the solution of the problem by using the proper code requirement, you must be able to recognize that a hazard exists. Your jurisdiction may not have code requirements for some of the hazardous materials.

Become totally familiar with your jurisdiction's codes and with what types of materials the codes address.

No community is immune to the use of a hazardous material or the threat such use may present.

CODES

There are four types of fire prevention codes;

- Standard Fire Prevention Code (Southern Building Code Congress International) (SBCCI).

- Uniform Fire Code (International Conference of Building Officials) (ICBO).
- National Fire Code (Building Officials and Code Administrators International, Inc.) (BOCA).
- National Fire Protection Association (NFPA).

The model codes devote one chapter or section to each of the major groups of hazardous materials. Many requirements are similar in the various codes. The National Fire Codes (NFPA) have several different standards that deal with each of the hazardous materials. Model fire codes reference those NFPA standards for requirements that deal with hazardous materials.

The inspector should:

- Become familiar with the basic requirement each code addresses.
- Know where to look to find the correct detail requirements that would apply to the condition noted.

SARA TITLE III

On October 17, 1986, the President signed into law the "Superfund Amendments and Reauthorization Act of 1986" (SARA) [Pub. L. 99-499] which included

- Community right to know.
- Worker right to know (OSHA).

MSDS--Material safety data sheets must be provided for emergency response agencies.

MSDS contain:

- Name, address, and telephone number.
- Chemical and trade name.
- Health and hazard data.
- Hazardous ingredients.
- Fire and explosive information.
- Precautions and protection information.
- Physical and reactivity data.

- Environmental information.

Manufacturers must submit copies of MSDS to:

- Local emergency planning committee.
- State emergency response commission.
- Local fire department.

Emergency response planning is required on local/ regional/state basis. A plan must include

- Identification of facilities and extremely hazardous substances transportation routes.
- Emergency response procedures, on-site and off-site.
- Designation of a community coordinator and facility coordinator(s) to implement the plan.
- Emergency notification procedures.
- Methods for determining the occurrence of a release and the probable affected area and population.
- Description of community and industry emergency equipment and facilities and the identity of persons responsible for them.
- Evacuation plans.
- Description and schedules of a training program for emergency response personnel.
- Methods and schedules for exercising emergency response plans.

National Response Team (NRT) composed of 14 federal agencies developed the Hazardous Materials Emergency Planning Guide.

Any facility that produces, uses, or stores any of the listed chemicals in quantities greater than its listed threshold is subject to the emergency planning.

Emergency notification includes

- The chemical name.
- An indication of whether the substance is extremely hazardous.

- An estimate of the quantity released into the environment.
- The time and duration of the release.
- The medium into which the release occurred.
- Any known or anticipated acute or chronic health risks associated with the emergency, and where appropriate, advice regarding medical attention necessary for exposed individuals.
- Proper precautions, such as evacuation.
- Name and telephone number of contact person.

An emergency response plan shall be developed and implemented to handle anticipated on-site emergencies prior to the commencement of hazardous waste operations. Emergency response activities to all other hazardous waste operations shall follow an emergency response plan meeting the requirements of this section.

The employer shall develop an emergency response plan for on-site and off-site emergencies which shall address, as a minimum, the following:

- Pre-emergency planning.
- Personnel roles, lines of authority, training, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination.
- Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Critique of response and follow-up.
- Personal protective equipment (PPE) and emergency equipment.

IDENTIFICATION OF HAZARDOUS MATERIALS

Task Encountered by Inspector

Identification of hazardous materials is one of the most difficult tasks encountered by an inspector. Often very little information is available. The owner or employee of an occupancy containing hazardous materials may not be of much help.

Initial Information

The initial information that should be obtained includes the name of the substance. This may be more difficult than one may think. The name may be a trade name only, which doesn't tell you anything about the hazard, or the name may be the chemical name only. It is very important to record the correct spelling of the chemical name. Some of the spellings will be very similar but there can be a big difference in the hazard or way that the material reacts.

In order to determine the classification, consult MSDS. An invaluable source of information for classification is the *Code of Federal Regulations--Title 49 Transportation Parts 100-177.* Virtually every chemical is listed in paragraph 172.101. The hazard class is listed in the column beside the name. The DOT label is required on the container or package.

Additional Information Needed

It is not enough to know that a substance is a flammable or combustible liquid; its class must also be determined.

Additional information needed may include: boiling point, vapor density, flammable limits, and flashpoint.

There are several other sources for obtaining this information:

- *Fire Protection Guide on Hazardous Material* (NFPA).
- *Flammable Hazardous Materials* (James H. Meidle).
- *Chemistry of Hazardous Materials* (Eugene Meyer).
- *Fire Protection Handbook, 16th Edition* (NFPA).
- *Standard on Basic Classification of Flammable and Combustible Liquids* (NFPA) #321.
- *Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids* (NFPA) #325M.

There are also several chemical dictionaries on the market which may be helpful.

Manufacturers' special information that may also offer assistance:

- Chemical Hazard Response Information System (CHRIS) Manual.
- Chemical Emergency Transportation Center (CHEMTREC), a service provided by the Chemical Manufacturers Association.
- State level EPA or Health Department.
- *Hazardous Materials 1993 Emergency Response Guide* D.O.T.-P 5800.5.

Marking Systems for Special Hazard Materials

Department of Transportation labeling system is used for materials involved in interstate shipping. The system only identifies the general hazardous characteristics of the material labeled. In some categories such as explosives and poisonous materials, there are different classifications within the general category. If the material has more than one hazard classification, the shipper should attach the appropriate label for each significant hazard. The DOT system requires that placards be displayed on the transporting vehicle itself and labels displayed on the containers or packages that are being carried inside the transporting vehicle. The system requires the displaying of a 4-digit ID number on the placard or orange panel display. The inspector can locate the ID number in the DOT *Emergency Response Guide*.

After locating the number in the book, you will find a guide number listed. Even with the labeling aids provided for interstate transportation of hazardous materials, we still must identify other characteristics of the material when we encounter it in use. Again--we have to do our homework. **Caution: Just because a product doesn't have a label doesn't mean it is not hazardous.**

The National Fire Protection Association, Standard # 704M (degree of fire hazards of materials) establishes a marking system used where materials are stored, handled, or used. It applies only to stationary facilities, **not transportation.** The system can be used for buildings, tanks, and piping that handle the material. This is the best marking system of hazardous materials available, both from a prevention point of view and a firefighting point of view. It is a complete system that identifies the characteristics that are most important for safety. These include:

- Fire hazard (flammability).
- Health hazard (toxic, irritant).
- Chemical reaction hazard.

In addition, a portion of the sign can be used to identify such other special hazards as radiation and water reactivity. Use of a combination of colors and numbers allows someone who is familiar with the system to easily identify the relative hazard of the materials involved in all important safety categories. The numbers used indicate the relative hazard within each main category beginning with zero (0) which indicates no special hazard, through four (4) which indicates a severe hazard. Unfortunately this system is not widely used yet because it is difficult to get everyone to agree to a national system. Some model fire codes require facilities that store, handle, or use hazardous materials to post the 704 signs.

Another color code system available is the Compressed Gas Association's system for color coding compressed gas cylinders. This system is not used at all times and may be unreliable. Colors are as follows:

- Green--oxygen.
- Blue--nitrous oxide.
- Brown--helium.
- Red--ethylene.
- Orange--cyclopropane.
- Gray--carbon dioxide.
- Color combinations are used for gas mixtures of certain percentages.

Remember, the DOT label doesn't identify the complete hazard that a given material may offer, but does provide the inspector a good starting point. Find out a material's complete hazard.

FLAMMABLE AND COMBUSTIBLE LIQUIDS--CODE REQUIREMENTS

Overview

The use of flammable and combustible liquids produced by chemical and petrochemical companies is increasing rapidly. These liquids can be found daily in all types of occupancies. With the recent conservation and shortage of energy sources, alternate sources are being developed or used by both industry and the general public, which has caused an even larger increase in their use. Gasoline and fuel oil are the most common and widely used examples of flammable and combustible liquids. There are many other flammable and combustible liquids, some of which have names that give no indication of the hazard or characteristics of the liquid. In association with the flammable hazard, some liquids may also have additional hazards such as being unstable (reactive) or toxic. The storage and handling of these types of liquids will require special attention and precautions.

Generally the principles of controlling the fire hazards associated with flammable and combustible liquids are

- Containing the liquid and vapors.

- Minimizing the exposure of the liquid to air.

Flammable and combustible liquid fire and explosion prevention measures embrace one or more of the following techniques:

- Exclusion of sources of ignition.

- Exclusion of air.

- Keeping the liquid in closed containers or systems.

- Ventilation to prevent the accumulation of vapors within the flammable range.

- Use of an atmosphere of inert gas instead of air.

Of all the hazardous materials, flammable and combustible liquids are probably of the greatest concern. They are not more dangerous than explosives or toxic gases, but they are found more frequently in a wider variety of occupancies and comprise more of the emergency calls received by the fire department. Fire codes address in more detail the requirements for the safe storage, handling, and use of these liquids.

Flammable Liquids

Flammable liquid is a term used to designate any liquid having a flashpoint below 100 °F and having a vapor pressure not exceeding 40 psi (2068.6mm) at (37.8 °C).

Flammable liquids are further classified as:

- Class I Liquids--Having flashpoints below 100 °F (37.8 °C) and subdivided as follows:

  - Class IA--Flashpoint below 73 °F (22.8 °C) and having a boiling point below 100 °F. An example is ethyl chloride.

  - Class IB--Flashpoint below 73 °F and having a boiling point at or above 100 °F. An example is gasoline.

  - Class 1C--Flashpoint at or above 73 °F and below 100 °F. An example is butyl alcohol.

Combustible Liquids

Combustible liquid is a term used to designate any liquid having a flashpoint at or above 100 °F (37.8 °C).

This classification is subdivided as follows:

- Class II--Liquids having a flashpoint at or above 100 °F (37.8 °C) and below 140 °F (60 °C) such as kerosene.

- Class IIIA--Liquids having a flashpoint at or above 140 °F (60 °C) and below 200 °F (93.4 °C) such as fuel oil #6.

- Class IIIB--Liquids having a flashpoint at or above 200 °F (93.4 °C) - 16 such as fish oil.

There are many chemicals that are solids at 100 °F or above and therefore are classified as solids. When heated the solids become liquids, giving off flammable vapors, and flashpoints can be determined. When in a liquid state these solids should be treated as liquids with similar flashpoints. These solids include paste waxes and polishes. The flashpoint and amount of liquid in the material will determine the degree of hazard.

The concept of the above classification system is to divide liquids that burn into three categories. It is anticipated that in most areas the indoor temperature could reach 100 °F at some time during the year; therefore, all liquids with flashpoints below 100 °F are called Class I liquids. In some areas the ambient temperature could exceed 100 °F so only a moderate degree of heating would be required to heat the liquid to its flashpoint. Based on this, an arbitrary division of 100 °F to 140 °F was established for liquids with this flashpoint. These are known as Class II liquids. Liquids with flashpoints above 140 °F would require considerable heating from a source other than ambient temperature before ignition could occur, and they have been identified as Class III liquids. All the model fire codes use this classification except the Standard Fire Prevention Code. This code does not separate Class III liquids into the Class IIIA and IIIB. Only the Class III designation is used and is defined as a liquid with a flashpoint at or above 140 °F and below 200 °F. In determining fire prevention code requirements, it is important to remember that it is the vapor of a flammable or combustible liquid, rather than the liquid itself, which will burn or explode.

The violence of flammable vapor explosions also varies. It will depend on the concentration and nature of the vapor, as well as the quantity of the vapor-air mixture and type of enclosure containing the mixture.

Flashpoint, commonly accepted and one of the most important measures of the relative hazard of flammable and combustible liquids, is by no means the only factor in evaluating the hazard. The ignition temperature, flammable range, rate of evaporation, reactivity when contaminated or exposed to heat, density, and rate of diffusion of the vapor also have a bearing. The flashpoint and other factors which determine the relative susceptibility of a flammable or combustible liquid to ignition have comparatively little influence on its burning characteristics after the fire has burned for a short time.

In determining the physical and fire characteristics of a liquid, the following material is helpful:

- *NFPA Standards #321*, Basic Classification of Flammable and Combustible Liquids.

- *NFPA Standards #325M*, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.

Most of the violations concerning flammable and combustible liquids will occur with improper storage. This includes storage of excessive quantities, improper or unsafe storage containers, and improper handling or misuse of the liquid.

Permits

Usually the codes require a permit for the storage, handling or use of flammable and combustible liquids that exceed a given amount. The permit is used to control where and when and by whom liquids are stored, handled, and used.

Storage Tanks

The codes address construction and fabrication requirements for atmospheric, low pressure, and pressure vessels.

They specify requirements for aboveground tanks (outside) which include minimum distance from property lines, public ways, nearest important building, and spacing between tanks and water. The type of tank and protection are conditions that affect the distance requirements.

Venting

Normal and emergency relief venting for fire exposure requirements are noted to prevent the development of a vacuum or overpressurization during the filling or unloading of tanks. Venting also is required for tanks to prevent the excessive internal pressure caused by exposure fires.

Dikes and drainage requirements are noted for tanks that may endanger important facilities, adjoining property, or waterways by accidentally dischanging their liquids. Either drainage areas or fire walls can be provided to meet those requirements. Tanks in diked areas also are required to be subdivided by drainage channels or intermediate curbs to prevent spills from endangering adjacent tanks within the diked area.

Requirements for the location of underground tanks in regard to the nearest building foundation and property line are noted in the codes. Also the depth and cover, corrosion protection, and venting installations are noted.

Requirements for tanks that are permitted inside buildings under special conditions are noted in the codes. Special venting, fire protection, piping arrangements, and control valves also are listed.

Special requirements for supports, foundations, and anchorage for tanks are noted, and fire prevention or fire protection requirements for tanks that are supported above the foundation also are noted.

Special requirements for anchoring of tanks that may be subject to flooding are noted. In locations where flammable vapors may be present, precautions must be taken to eliminate or control ignition sources.

Container and Portable Tank Storage

Requirements for the construction and venting of portable containers, maximum allowable sizes for containers and portable tanks and requirements for capacity and construction of storage cabinets are specified in codes.

Special requirements are noted for the rooms used for storage. These include requirements for maximum amounts of materials stored depending on the fire-resistive enclosure, fixed fire protection systems in the room, doorsill heights, ventilation, and electrical wiring and equipment. Also, limited amounts of the liquids may be permitted outside of a storage cabinet or room depending on the type of occupancies. Requirements for outside storage locations, drainage, maximum amount of liquid in each pile, distances between piles, property lines and public ways are noted.

Loading and Unloading

Requirements for the method of transfer are noted, as well as drainage and ventilation requirements and bonding. Requirements for the location and distances from tanks, property lines, and buildings are noted. Special fire control equipment is also required. Requirements for electrical bonding and grounding are also noted, along with filling controls, ignition sources, and drainage requirements.

Electrical Equipment

Requirements for proper type of explosive-proof equipment, fixtures, and wiring are noted. The class of liquid, location, and distance from the activity determine the requirements.

Fuel Dispensing

Requirements for the type of nozzles, dispensing units, dispensing locations, special controls, emergency shutoffs, attendance, or supervision of dispensing are noted.

GASES

Overview

Most fire inspectors will have major contacts with gases that are considered hazardous materials. Gases in themselves are not dangerous. It is the use to which a gas is put and how it is handled that determines whether or not that gas is hazardous. Improperly used, gases can be responsible for major disasters. Chemical properties of a gas are a primary fire protection concern as they reflect the ability of a gas to react chemically with other materials (or with itself) with the production of potentially hazardous quantities of heat or reaction products, as well as the production of physiological effects hazardous to humans. The hazards of gases confined in their containers basically reflect their tendency to expand when heated. When the gas is confined, heating results in an increase in pressure which can result in gas release or cause container failure.

Containers can fail from contact with flames from an exposing fire due to loss in strength of the material from which the container is fabricated.

Generally the principles of controlling the fire hazards associated with gases are

- Storing in the proper type of container.
- Minimizing the exposure of the liquid to air.
- Knowing the chemical and physical properties of the gas.
- Limiting the gas/air mixture accumulation in a structure.

Fire and explosion prevention measures for gases embrace one or more of the following techniques:

- Use of containers, fitting regulators, valves, and piping that have been approved for use with a given gas.
- Preventing the overpressurization of the storage container, regulator, valves, and piping.
- Preventing the storage container from overheating.
- Limiting the amount of storage at a given location.

- Segregation of storage to prevent interreaction among gases.
- Ventilation to prevent the accumulation of vapors.
- Exclusion of ignition sources.
- Proper training for persons employed in handling gases.
- Installation of systems, regulated as to qualification of installers.

In order to deal effectively with the great number and variety of gases in commerce or the environment, it is advantageous to establish certain classifications for gases. These classifications recognize certain "common denominators" reflecting the chemical and physical properties of gases and their primary uses. Compressed gases may be toxic, flammable, corrosive, oxidizing, etc. Release of a gas for any reason may have a detrimental effect on life and/or property.

Gases Defined

Gas is a term applied only to substances which exist in the gaseous state at so-called "normal" temperature and pressure (NTP) conditions (approximately 70 °F and 14.7 psia). Gases are further grouped into the following classes:

- **Compressed Gas**--at normal temperature inside its container exists solely in the gaseous state under pressure. (Example: Hydrogen.)
- **Liquefied Gas**--exists at normal temperature inside its container partly in the liquid state and partly in the gaseous state and under pressure as long as any liquid remains in the container. (Example: Liquified Petroleum Gas.)
- **Cryogenic Gas**--is a liquefied gas which exists in its container at temperatures far below normal atmospheric temperatures, usually slightly above its boiling point at (NTP). (Example: Liquid Oxygen.)

The three gas groupings above can be classified further into the following:

- **Flammable Gas**--any gas that will burn in normal concentrations of oxygen in the air. (Example: Acetylene.)
- **Nonflammable Gas**--any gas that will not burn in any concentration of air or oxygen. (Example: Nitrogen.) Some non-flammable gases will support combustion and are referred to as "oxidizers." (Example: Oxygen.)
- **Reactive Gas**--any gas that will react with other material or by itself (with the production of potentially hazardous quantities of heat or reaction products). (Example: Fluorine.)

- **Toxic Gas**--any gas that presents a serious life hazard if released into the atmosphere. Included are gases that are poisonous or irritating when inhaled or contacted. (Example: Chlorine.)

Another classification of gases can be made according to principal use as follows:

- **Fuel Gases**--flammable gases used for heating.
- **Industrial Gases**--used for welding and cutting, chemical processing, refrigeration, etc.
- **Medical Gases**--used for medical purposes such as anesthesia and respiratory therapy.

The model fire codes address requirements for gases in three selections:

- Compressed gases.
- Liquefied petroleum gases.
- Cryogenics.

The National Fire Code (NFPA) also has a code for liquefied natural gas (LNG). NFPA 59A.

The Model Fire Prevention Codes have sections on gases, liquefied petroleum gases, and some of the model codes have a section for cryogenic gases.

Most of the model codes reference the following NFPA Standards for code requirements.

- NFPA #43C--Storage of Gaseous Oxidizing Materials.
- NFPA#50--Bulk Oxygen Systems at Consumer Sites.
- NFPA 50A--Gaseous Hydrogen Systems.
- NFPA#50B--Liquefied Hydrogen Systems.
- NFPA#56F--Non-flammable Medical Gas Systems.
- NFPA#58--Installation of LP Gas systems.
- NFPA#59A--Storage of LNG.
- NFPA#99--Standards for Health Care Facilities.

CHEMICALS

Overview

Chemicals are hazardous because of properties other than combustibility. Although many chemicals possess more than one hazardous property, it is customary to classify each by its predominant hazard. The danger of such a procedure, of course, is that an unmentioned hazardous property may be overlooked.

It is necessary to refer to:

- Chemical dictionaries.
- Data sheets.
- Hazardous chemical data.
- Manufacturers' information.

Hazardous chemicals like flammable and combustible liquids can be found and are used in all types of occupancies that may or may not be obvious to the inspecting authority. Dangerous reactions can occur when certain chemicals are mixed. Some chemicals mixed with a combustible material increase the ease of ignition or the intensity of burning of the combustible material. In order to recognize the innumerable combinations of so-called incompatible chemicals, it is necessary to have a knowledge of the potentially dangerous reactions of individual chemicals. NFPA No. 491 M, *Manual of Hazardous Chemical Reactions,* contains more than 3,400 dangerous reactions that have been reported in chemical literature.

Generally the principles of controlling the fire hazards associated with chemicals include

- Safe storage and handling.
- Education and training.
- Knowledge of the toxicity of the chemical for control of the chemicals.
- Isolation and separation.
- Storage quantities kept to a minimum.
- Chemical fire and reaction prevention measures embrace one or more of the following techniques:
- Knowing the hazardous properties of the chemicals to be stored or handled.

- Educating persons in the area where the chemical is handled as to its hazard, precautionary procedures, danger signals and proper steps to take in case of an emergency.
- Providing reference sources, knowing where to look for help in finding the answers to problems beyond your area of knowledge, and knowing how experts can be contacted.
- Regulating by permit the use and storage quantities permitted.
- When possible, substituting a less toxic chemical that should be a suitable replacement.
- Controlling and confining the chemical so that the toxic material cannot be contacted, swallowed, or inhaled in dangerous quantities during normal operations.
- Providing automatic toxic gas indicators and alarms.
- Providing natural or mechanical exhaust ventilation systems.
- Keeping combustible materials and packaging away from the storage area.
- Providing a storage building of noncombustible or resistive construction.
- Using good housekeeping techniques.
- Cleaning up spilled material immediately in accordance with safe practices.
- Removing defective containers which permit leakage or spillage, in accordance with recognized safe practices.
- Controlling all sources of ignition such as open flames and smoking.
- Providing for storage of flammable liquids, gases, 2 percent explosives, and blasting agents stored in the same building or in close proximity to chemicals that are unstable (reactive).
- Keeping storage containers away from all sources of heat, including direct exposure to sunlight.
- Removing all opened containers from the storage area.

Chemicals Defined

Chemicals are classified as: oxidizers, combustible chemicals, unstable chemicals, water- and air-reactive chemicals, corrosive chemicals, radioactive materials, and toxic chemicals.

Oxidizers provide oxygen for combustion. In most cases the oxidizing chemicals themselves are not combustible. If you increase the ease of ignition of a combustible material you invariably increase the intensity of burning. Oxidizing agents such as some of the organic peroxides are themselves combustible.

Examples are

- Nitrates.
- Nitrites.
- Chlorates.
- Chlorites.
- Peroxides.
- Perchlorates.
- "Per" Acids.

Oxidizers are used in rocket fuels and fertilizers, and are used in the plastics industry to initiate polymerization of a monomer to form plastics out of certain substances.

Those agents give off toxic gases when heated. They are also highly flammable and explosive when exposed to combustible materials. They need no outside source of oxygen as they form the oxygen side of the fire triangle.

Combustible chemicals include

- Carbon black.
- Lamp black.
- Sulfides.
- Sulfur.
- Organic peroxides. (All organic peroxides are combustible and some are explosive when confined.)

Unstable chemicals are chemicals that spontaneously polymerize, decompose, or otherwise react with themselves in the presence of a catalytic material, or even when pure such as hydrogen cyanide,or organic peroxides.

Unstable organic peroxides deserve special attention in storage and handling. Unstable chemicals can be decomposed by heat, shock, or friction, the rate of decomposition depending on the particular chemical and temperature.

Water- and air-reactive chemicals are a group of chemicals that, when exposed to air or water, react and produce significant quantities of heat. If the chemical itself is combustible, it is capable of self-ignition. If noncombustible, the heat reaction may be sufficient to ignite nearby combustible materials.

Examples include

- Alkalies (caustics).
- Anhydrides.
- Carbides.
- Phosphorus.
- Charcoal.
- Coal.
- Hydrides.
- Quicklime.
- Sodium.
- Corrosive chemicals.

Those chemicals that have a destructive effect on living tissues.

They are usually strong oxidizing agents but are separately classified as corrosive chemicals to emphasize their injurious effects on contact or inhalation.

For example:

- Inorganic Acids:
  - Hydrochloric Acid.
  - Hydrofluoric Acid.
  - Nitric Acid.

- Sulfuric Acid.

- Halogens:

  - Bromine.

  - Chlorine.

  - Fluorine.

Radioactive materials have fire and explosion hazards identical to those of the same material when not radioactive. An additional hazard is introduced by the various types of radiation emitted. The possibility of accidental release of radioactive materials because of a fire or explosion is a strong argument for careful attention to methods of fire prevention and control in occupancies handling radioactive materials. There are several types of radioactive rays released: ALPHA, BETA, GAMMA.

Radioactive chemicals may be found in hospitals and include

- Cobalt 60.

- Radium 226.

- Iodine 131.

- X-ray.

Examples of radioactive chemicals in industry include

- X-ray.

- Krypton 85.

- Plutonium 238.

- Uranium 238.

Toxic chemicals are materials that in the event of fire would present a hazard to life, and are defined as those materials that when inhaled, ingested, or absorbed through the skin in small quantities can cause serious injury or death. Toxic chemicals can be further divided into the following classes:

- Alkaloids--This group is mainly used for medical purposes. Examples - cocaine and quinine.

- Antimony compounds--Used in printing operations involving type metal.

- Aromatic Hydrocarbons--Used in fabric-coating operations, particularly rubber spreading. Example - benzene.

- Arsenate and Arsenites--Used in the manufacturing of insecticides and pesticides.

- Cyanides and Fluorides.

- Fumigants (insecticides and pesticides).

The key to hazardous material fire prevention is proper handling and storage. The hazard is generally a container and dispensing problem. Hazardous materials must be separated from incompatibles to avoid a chemical reaction. As an example, oxidizers must not be stored with combustibles. The oxidizer in contact with a combustible can "complete" the fire triangle without any outside help. Research is essential in determining what fire prevention techniques to employ. One cannot trust to memory the tremendous number and variety of hazardous materials.

The fire inspector is not expected to make on-the-spot decisions about hazardous materials (other than in an emergency situation). Consult reference books and other experts. The decision on how to abate the hazard properly does not have to be made in ten minutes. There are some situations where some type of immediate action is necessary. This decision should be followed by more in-depth research.

Code Requirements and Chemicals

The National Fire Codes (NFPA), the model fire codes, lump hazardous chemicals into one chapter. They use several standards to cover those materials.

The code requirements are primarily to prevent mixing of incompatible substances, to eliminate ignition sources, to prevent storage of excessive amounts of hazardous chemicals, etc. Those are basically common-sense requirements. Below is a list of codes that may be helpful to the inspector in addition to the requirements as noted in the model fire codes.

- NFPA 43A--Storage of Liquid and Solid Oxidizing Materials.

- NFPA 43C--Storage of Gaseous Oxidizing Material.

- NFPA 43D--Storage of Pesticides in Portable Containers.

- NFPA 45--Fire Protection for Laboratories Using Chemicals.

- NFPA 49--Hazardous Chemical Data.

- NFPA 325M--Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids.

- NFPA 490--Storage of Ammonium Nitrate.

- NFPA 491M--Manual of Hazardous Chemical Reactions.
- NFPA 704--Standard System for Identification of Fire Hazards of Materials.

EXPLOSIVES

Overview

The hazardous nature of explosives has long been recognized, and the rapid increase in their production and use makes it necessary to point out those properties that contribute most to the inherent dangers of these very important industrial and military products. As early as 1972, in the industrial field alone, almost 2.67 billion pounds of explosives and blasting agents were used. Of this total, 82 percent were used in mining. The remainder was used principally in construction operations. An understanding of the nature of explosive materials is essential before one can understand the fire and explosion potential and evaluate the hazard. Accidents with explosives are not frequent because great care normally is used in handling these materials. Despite the detailed regulations governing explosives, their potential hazard is so great that it would be dangerous to assume that there will never be an accident or a failure to live up to basic safety precautions.

For this reason, inspectors should understand the basic precautions and have access to applicable regulations for the explosives and operations involved. Fire is a principal cause of accidents involving explosive materials. Explosives and blasting agents vary in their sensitivity to fire conditions. All such materials are liable to produce a disastrous explosion when exposed to fire.

Generally the principles of controlling the fire and explosive hazards associated with explosives are

- Provide protection for such materials from their surroundings.
- Train persons to handle such materials safely.
- Eliminate sources of fire.
- Provide proper storage facilities and sites.
- Control storage and use.

Explosive fire prevention measures embrace one or more of the following techniques:

- Proper identification.
- Handling by qualified personnel.
- Provision of special remote and isolated storage and manufacturing sites.

- Separate storage of different explosive materials.
- Elimination of all ignition sources.
- Protection of materials from accidents, shock, heat, etc.
- Security from theft and saboteurs.
- Protection to the industrial worker involved and to the general public in the vicinity of storage or use.
- Training employees to provide maximum attainable safety.
- Regulation of the manufacture, distribution and storage by the Bureau of Alcohol, Tobacco, and Firearms (BATF).
- Regulation of the user and use location.
- Informing firefighters of the location of such materials (storage/use).
- Providing proper fire protection systems.

Role of the Inspector

The area of explosives and blasting agents is very specialized and, for the most part, will not be encountered by the beginning inspector.

The beginning inspector should have a basic knowledge of the requirements for explosives and an understanding of the nature and terminology of explosives in order to evaluate the hazard.

Definition

An explosive is a substance, a mixture of substances, or a chemical compound of which the primary use is to function by explosion. Examples include

- Dynamite.
- Black powder.
- Initiating explosives.
- Detonators.
- Safety fuses.

- Squibs.
- Detonating (det) cord.
- Igniter cord.
- Igniters.

A blasting agent is a material or mixture consisting of a fuel and an oxidizer (contains its own oxygen) for the purpose of blasting operations, or a substance that cannot be detonated by a Number 8 blasting cap when unconfined. "Explosive material" is defined as explosives, blasting agents, water gels, and detonators. There are deflagrations (rapid burning) and detonations (explosions) associated with different types of "explosive material." The Department of Transportation divides commercial explosive into separate classes for transportation, labeling, and placarding purposes. They regulate the transportation of explosives. When inspecting an occupancy containing explosives, you should know or be able to determine:

- The contents of the package.
- Its classification.
- The code requirements pertaining to it.
- Conditions that may need further inspection by more knowledgeable persons in authority.

The Department of Transportation (DOT) divides explosives into separate classes. Industry has generally accepted this classification system since it corresponds roughly to the procedures for handling, storage, and transportation. The classifications are listed in the order of decreasing sensitivity.

Class "A"--Maximum hazard.

- Dynamite.
- Desensitized nitroglycerin.
- Lead azide.
- Mercury fulminate.
- Black powder.
- Blasting caps.
- Detonating primers.

- Certain smokeless propellants.

Class "B"--High flammability hazard. Includes most propellant materials. Less hazardous than Class A. Class "C"--Manufactured articles containing limited quantities of A or B explosives. They will not ordinarily detonate en masse under fire conditions. Blasting agents generally are considered safer than Classes A, B, or C, yet when properly initiated can function in the same manner as Class A explosives.

The Department of Transportation has a list of forbidden explosives. These cannot be transported by interstate commerce and include

- Liquid nitroglycerin.
- Dynamite (except gelatin dynamite) containing over 60 percent liquid explosive.
- Nitrocellulose in a dry, uncompressed condition, and greater than 10 pounds in one package.
- Dry fulminate of mercury.

Fireworks

The most common explosive material that will be found is fireworks which is a Class C explosive and sometimes a Class B explosive.

NFPA 1121 L (The Model Fireworks Law) can be consulted for further information. Many states have adopted this as their fireworks law. Your biggest problems will be grass, roof, and trash fires caused by fireworks around the 4th of July. Class B and C fireworks are used in public shows. The DOT regulates transportation and shipping of these items. NFPA Standard #1123 covers public display of fireworks and defines Class B fireworks as: Fireworks designed primarily to produce visible or audible effects by combustion or explosion NFPA 1123 spells out site selection requirements and addresses requirements of operator. Class B fireworks includes, but is not limited to: Firecrackers and salutes containing more than 2 grams of explosive composition and aerial shells containing more than 40 grams of pyrotechnic composition, and other display pieces that exceed the classification limits of Class C fireworks. The definition of Class B fireworks is based on the definition of "special fireworks" which appears in the Code of Federal Regulations, Title 49. Class C fireworks are less dangerous fireworks designed primarily to produce visible effects by combustion. Some small devices designed to produce audible effects are included, such as whistle devices and explosive devices containing 2 grains (.13 grams) or less of pyrotechnic composition. Some examples are

- Roman candles.
- Sky rockets.

- Helicopter type rockets.
- Cylindrical fountains.
- Cone fountains.
- Wheels.
- Illumining torches.
- Mines and shells.
- Firecrackers and salutes.
- Novelties.

Fire prevention problems that need to be addressed include

- Does operator have adequate bond posted for liability purposes?
- Is operator licensed?
- Is the operator drinking or using drugs, etc.?
- Is site in proper location per NFPA 1123 and your own personal judgment?
- Are crowd control provisions adequate?
- Are fire extinguishment provisions (based on your requirements) adequate?
- Is there probability of an exposure fire due to firework discharge?
- Is there evidence of poor/unsafe handling per 1123?
- Are no smoking signs posted?
- Is site clean and uncluttered?

The model fire prevention codes have sections that deal with explosives as well as fireworks. Most of the model codes also reference the following standards for requirements:

- NFPA 1122--Code for model rocketry.
- NFPA 1124--Code for manufacture, transportation, and storage of fireworks.

- NFPA 1126--Pyrotechnic use before a proximate audience.
- NFPA 490--Separation distances of ammonium nitrate and blasting agents (from explosives).
- NFPA 495--Code for the manufacture, transportation, storage, and use of explosive materials.
- NFPA 498--Standard for explosives motor vehicle terminals.

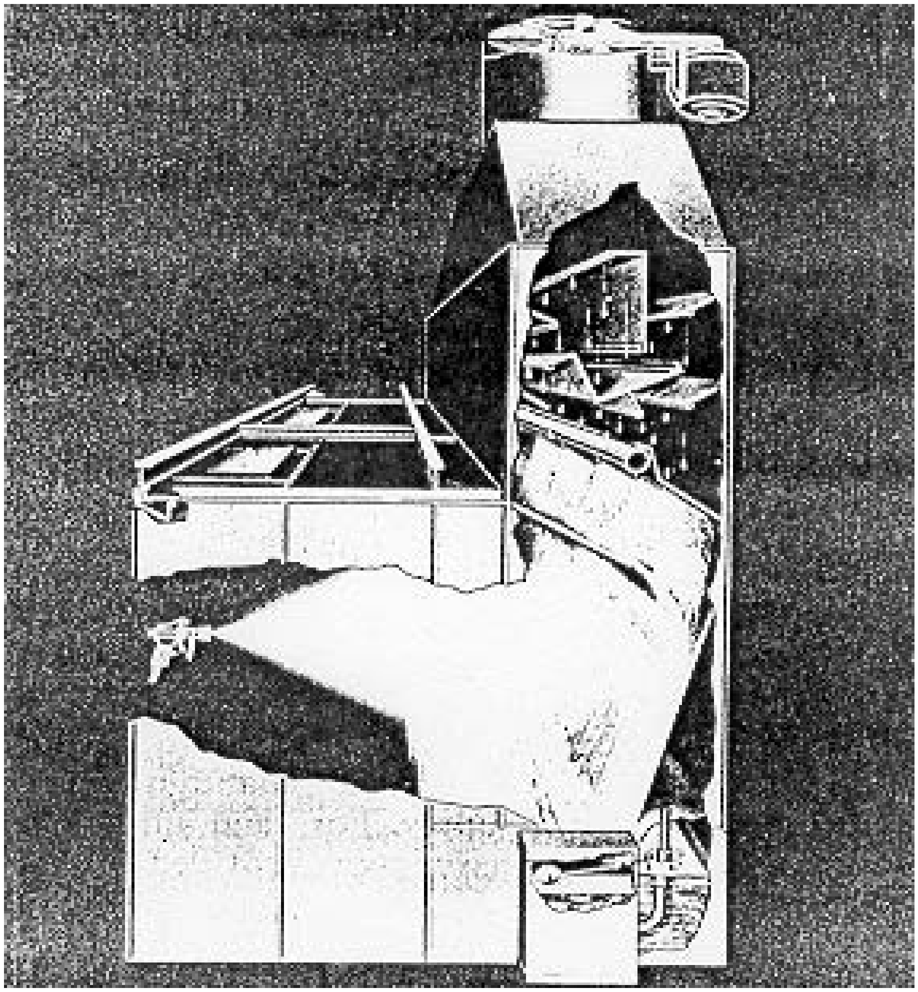
APPLICATION OF FLAMMABLE FINISHES

Spray Booths

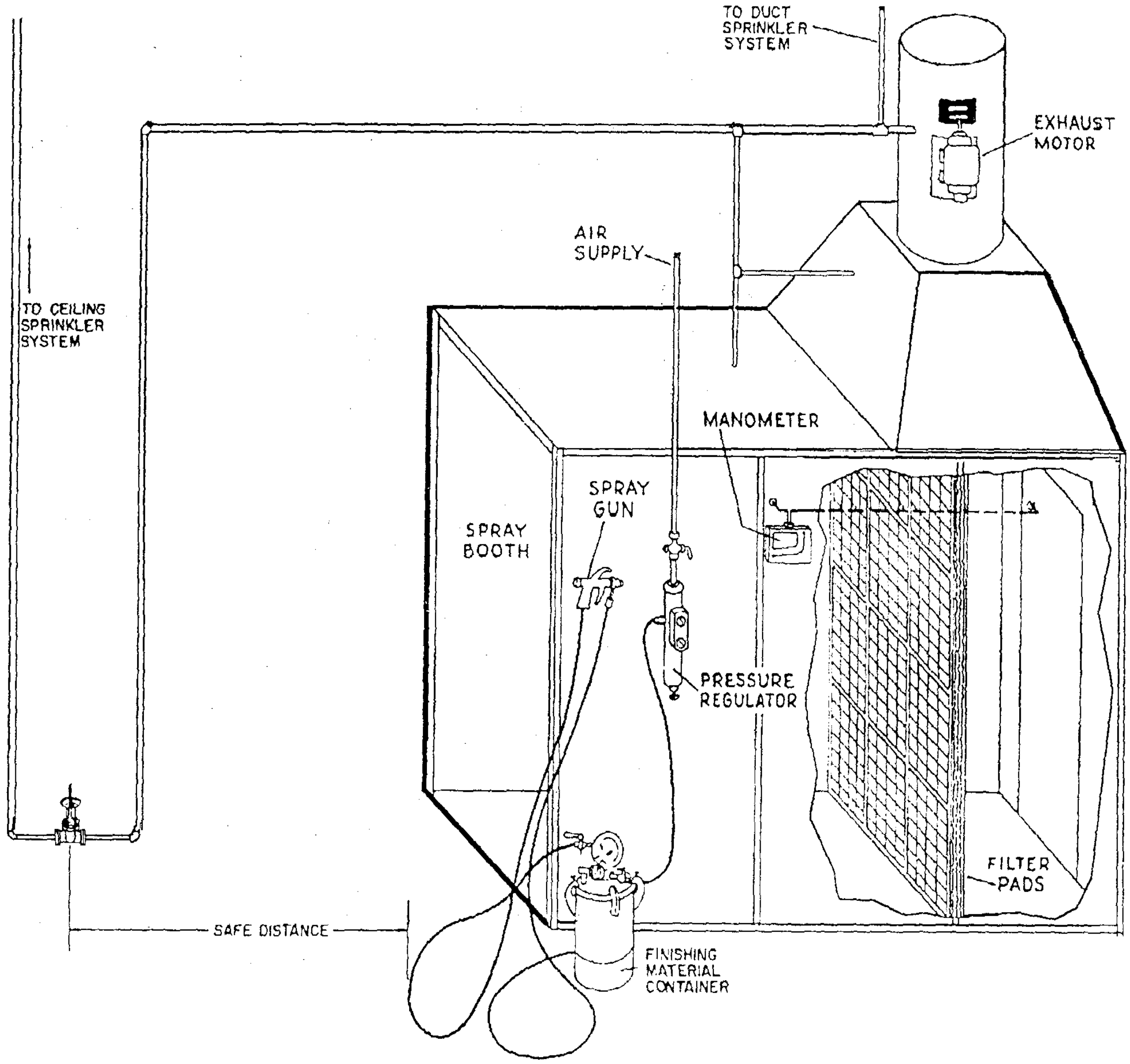
Application of flammable finishes by spray process is more hazardous than brush application because of the volume of flammable liquids used, the method of application and drying and the foundation of flammable residue, which in some cases may be subject to spontaneous heating.

The water wash booth is used to minimize overspray deposits in exhaust ducts and reduce air pollution. Water wash booths employ a water spray curtain to separate the excess overspray. The residue is collected in the water and carried to a tank from which it is later removed as a sludge. Water spray booths generally require the same protection as other booths although the hazard in the exhaust ducts is materially reduced.

In exhaust air filter booths filters are used to collect the overspray. An air velocity over the open face of the spray booth cannot be less than 100 linear feet per minute.



* Water wash booth



Dry filter spray booth equipped with filter pads. Also shown is gauge used to indicate minimum air velocity.

Another type of finish is called electrostatic spraying. This type of spraying involves maintaining a difference of electrical potential between the spray nozzle and the work being sprayed. The paint particles become electrically charged so they are attracted to the work. Model fire codes address requirements for spray finishing. Fire prevention requirements that are addressed by the codes are

- Ignition sources.
- Electrical equipment and wiring.
- Location of spray operation.
- Booth and spray room construction.
- Air flows.
- Ventilation requirements.
- Filter requirements.
- Booth fire protection.
- Exhaust duct construction and installation.
- Storage and handling of flammable and combustible liquids operation and maintenance.
- Personnel exits.

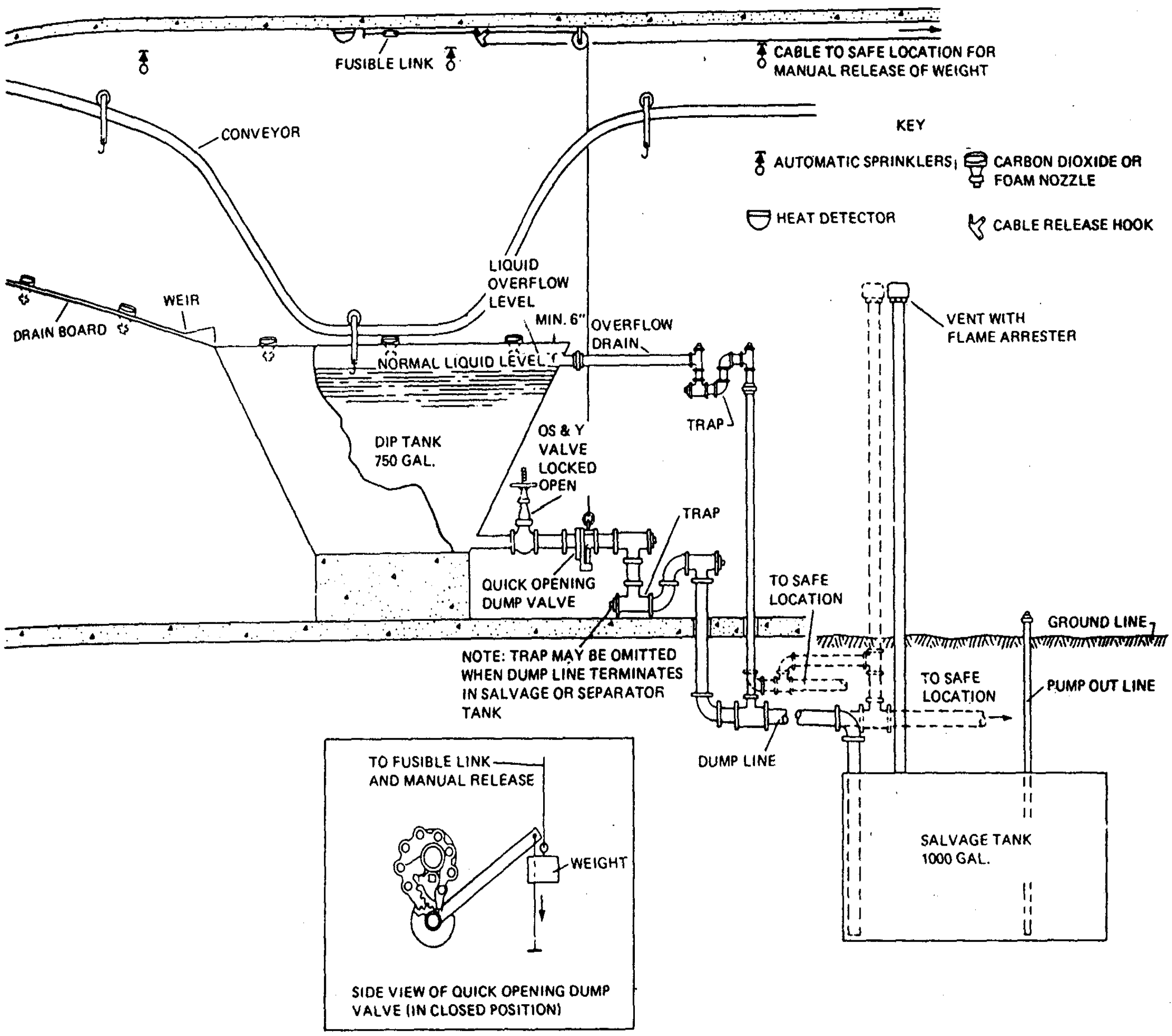
Dip Tanks

Finishes which involves dipping articles or materials by passing them through flammable or combustible liquids in tanks or vats usually involves fire or explosion hazards.

The severity of the hazard depends on the character and flammability of the liquid and solvents employed and the rate of evaporation and quantities of liquid present. Model fire codes address requirements for dip tanks. Fire prevention requirements that are addressed are

- Location of the dip tank operation.
- Ventilation of vapor areas.
- Construction of the dip tank.
- Conveyor system.
- Electrical and other sources of ignition.

- Dip tank covers.
- Fire protection.
- Operation and maintenance.



**Dip tank, drainboard, and conveyor system*

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Appendix I

Title III Fact Sheet

Emergency Planning And Community Right-To-Know

INTRODUCTION

On October 17, 1986, the "Superfund Amendments and Reauthorization Act of 1986" (SARA) was enacted into law. One part of the new SARA provisions is Title III: the Emergency Planning and Community Right-to-Know Act of 1986. Title III establishes requirements for Federal, State, and local governments and industry regarding emergency planning and 'community right-to-know' reporting on hazardous and toxic chemicals. This legislation builds upon EPA's Chemical Emergency Preparedness Program (CEPP) and numerous State and local programs aimed at helping communities to better meet their responsibilities in regard to potential chemical emergencies. The community right-to-know provisions of Title III will help to increase the public's knowledge and access to information on the presence of hazardous chemicals in their communities and releases of these chemicals into the environment.

Title III has four major sections: emergency planning (§301-§303), emergency notification (§304), community right-to-know reporting requirements (§311, 312), and toxic chemical release reporting-- emissions inventory (§313).

§301-303: Emergency Planning:

The emergency planning sections are designed to develop State and local governments' emergency response and preparedness capabilities through better coordination and planning, especially within the local community.

Title III requires that the Governor of each State designate a State emergency response commission by April 17, 1987. If a State commission is not designated, the Governor makes such designation. While existing State organizations can be designated as the State emergency response commission, the commission can have broad-based representation. Public agencies and departments concerned with issues relating to the environment, natural resources, emergency services, public health, occupational safety, and transportation all have important roles in Title III activities. Various public and private sector groups and associations with interest and expertise in Title III issues also can be included in the State commission.

The State commission must designate local emergency planning districts by July 17, 1987, and appoint local emergency committees, for establishing procedures for receiving and processing public requests for information collected under other sections of Title III, and for reviewing local emergency plans.

This local emergency planning committee must include elected State and local officials, police, fire, civil defense, public health professionals, environmental, hospital, and transportation officials as well as representatives of facilities subject to the emergency planning requirements, community groups, and the media. No later than September 17, 1987, facilities subject to the emergency planning requirements must designate a representative to participate in the planning process. The local committee must establish rules, give public notice of its activities and establish procedures for handling public requests for information.

The local committee's primary responsibility will be to develop an emergency response plan by October 17, 1988. In developing this plan, the local committee will evaluate available resources for preparing for and responding to a potential chemical accident. The plan must include

- Identification of facilities and extremely hazardous substances transportation routes
- Emergency response procedures, on-site and off-site
- Designation of a community coordinator and facility coordinator(s) to implement the plan
- Emergency notification procedures
- Methods for determining the occurrence of a release and the probable affected area and population
- Description of community and industry emergency equipment and facilities and the identity of persons responsible for them
- Evacuation plans
- Description and schedules of a training program for emergency response personnel
- Methods and schedules for exercising emergency response plans.

In order to assist the local committees in preparing and reviewing plans, Congress required the National Response Team (NRT), composed of 14 Federal agencies with emergency response responsibilities, to publish guidance on emergency response planning. This guidance, the Hazardous Materials Emergency Planning Guide, will be published by the NRT and incorporates emergency planning aspects of the CEPP Interim Guidance. It also replaces the Federal Emergency Management Agency Planning Guide and Checklist for Hazardous Materials Contingency Plans (popularly known as FEMA-10). See Federal Register dated 12/2/86.

The emergency response plan must be reviewed by the State commission as well as annually by the local committee. The Regional Response Teams, composed of the Federal Regional officials and State representatives, may review the plans and provide assistance to the local committees upon request.

Those planning activities of the local committees and facilities should be focused on, but not limited to, the 402 extremely hazardous substances published in the November 17, 1986, Federal Register. The list included the threshold planning quantities for each substance. EPA can revise the list and threshold planning quantities based on the toxicity, reactivity, volatility, dispersability, combustability, or flammability of a substance.

Any facility that produces, uses, or stores any of the listed chemicals in a quantity greater than its threshold planning quantity is subject to the emergency planning requirements. In addition, the State commission or the Governor can designate additional facilities, after public comment, to be subject to these requirements. By May 17, 1987, covered facilities must notify the State commission that they are subject to these requirements. If a facility begins to produce, use, or store any of the extremely hazardous substances in threshold quantity amounts, it must notify the State commission within 60 days.

Each State commission must notify EPA of all facilities designated by the State commission or the Governor.

§304: Emergency Notification

Facilities must immediately notify the local emergency planning committee and the State emergency response commission if there is a release of a listed hazardous substance that exceeds the reportable quantity for that substance. Substances subject to this requirement are substances on the list of 402 extremely hazardous substances as published in Federal Register on 11/17/86 and substances subject to the emergency notification requirements under CERCLA Section 103(a).

The initial notification can be by telephone, radio, or in person. Emergency notification requirements involving transportation incidents can be satisfied by dialing 911, or in the absence of a 911 emergency number, calling the operator.

This emergency notification needs to include

- The chemical name
- An indication of whether the substance is extremely hazardous
- An estimate of the quantity released into the environment
- The time and duration of the release
- The medium into which the release occurred
- Any known or anticipated acute or chronic health risks associated with the emergency, and where appropriate, advice regarding medical attention necessary for exposed individuals
- Proper precautions, such as evacuation
- Name and telephone number of contact person.

Section 304 also requires the follow-up written emergency notice after the release. The follow-up notice or notices shall

- Update information included in the initial notice, and
- Provide information on:

  - Actual response actions taken

  - Any known or anticipated data or chronic health risks associated with the release

  - Advice regarding medical attention necessary for exposed individuals

Until State commissions and local committees are formed, releases should be reported to appropriate State and local officials.

§311-312: Community Right-to-Know Reporting Requirements

There are two "community right-to-know" reporting requirements which apply primarily to manufacturers and importers. **Section 311** requires that facilities which must prepare or have available material safety data sheets (MSDS) under the Occupational Safety and Health Administration (OSHA) regulations to submit either copies of its MSDS or a list of MSDS chemicals to:

- The local emergency planning committee
- The State emergency response commission
- The local fire department.

If the facility owner or operator chooses to submit a list of MSDS chemicals, the list must include the chemical name or common name of each substance and any hazardous component as provided on the MSDS. This list must be organized in categories of health and physical hazards as set forth in OSHA regulations unless modified by EPA.

If a list is submitted, the facility must submit the MSDS for any chemical on the list upon the request of the local planning committee. Under **Section 311**, EPA may establish threshold quantities for hazardous chemicals below which no facility must report.

The initial submission of the MSDSs or list is required no later than October 17, 1987, or 3 months after the facility is required to prepare or have available an MSDS under OSHA regulations. A revised MSDS must be provided to update MSDS which were originally submitted if significant new information regarding a chemical is discovered.

The reporting requirement of **Section 312** involves submission of an emergency and hazardous chemical inventory form to the local emergency planning committee, the State emergency response commission and the local fire department. The hazardous chemicals covered by **Section 312** are the same for which facilities are required to submit MSDS or the list for **Section 311**.

Under **Section 312**, EPA may also establish threshold quantities for hazardous chemicals below which no facility must be subject to this requirement.

The inventory form incorporates a two-tier approach. Under Tier I, facilities must submit the following aggregate information for each applicable OSHA category of health and physical hazard:

- An estimate (in ranges) of the maximum amount of chemicals for each category present at the facility at any time during the preceding calendar year
- An estimate (in ranges) of the average daily amount of chemicals in each category
- The general location of hazardous chemicals in each category.

Upon request of a local committee, State commission or local fire department, the facility must provide the following Tier II information for each substance subject to the request:

- The chemical name or the common name as indicated on the MSDS
- An estimate (in ranges) of the maximum amount of the chemical present at any time during the preceding calendar year
- A brief description of the manner of storage of the chemical
- The location of the chemical at the facility

An indication of whether the owner elects to withhold location information from disclosure to the public.

The public may also request Tier II information from the State commission and the local committee. The information submitted by facilities under **Sections 311 and 312** must generally be made available to the public by local and State governments during normal working hours.

EPA published a uniform format for the inventory forms on January 27, 1987. Tier I information shall be submitted on or before March 1, 1988, and annually thereafter on March 1.

§313: Toxic Chemical Release Reporting

Section 313 of Title III requires EPA to establish an inventory of toxic chemical emissions from certain facilities. Facilities subject to this reporting requirement are required to complete a toxic chemical release form for specified chemicals. The form must be submitted to EPA and those State officials designated by the Governor, on or before July 1, 1988, and annually thereafter on July 1, reflecting releases during each preceding calendar year.

The purpose of this reporting requirement is to inform government officials and the public about releases of toxic chemicals in the environment. It will also assist in research and the development of regulations, guidelines, and standards.

The reporting requirement applies to owners and operators of facilities that have 10 or more full-time employees, that are in Standard Industries Classification Codes 20 through 39 (i.e., manufacturing facilities) and that manufactured, processed or otherwise used a listed toxic chemical in excess of specified threshold quantities.

Facilities using listed toxic chemicals in quantities over 10,000 pounds in a calendar year are required to submit toxic chemical release forms by July 1 of the following year. Facilities manufacturing or processing any of these chemicals in excess of 75,000 pounds in 1987 must report by July 1, 1988. Facilities manufacturing or processing in excess of 50,000 pounds in 1988 must report by July 1, 1989; thereafter, facilities manufacturing or processing more than 25,000 pounds in a year are required to submit the form. EPA can revise these threshold quantities and covered SIC categories.

The list of toxic chemicals subject to reporting consists initially of chemicals listed for similar reporting purposes by the States of New Jersey and Maryland. There are over 300 chemicals and categories on these lists. In adding a chemical to the combined Maryland and New Jersey lists, EPA must consider the following factors:

- Is the substance known to cause cancer or serious reproductive or neurological disorders, genetic mutations, or other chronic health effects?
- Can the substance cause significant adverse acute health effects outside the facility as a result of continuous or frequently recurring releases?
- Can the substance cause an adverse effect on the environment because of its toxicity, persistence, or tendency to bioaccumulate?

Chemicals can be deleted if there is insufficient evidence to establish any of these factors. State governors may petition the Administrator to add or delete a chemical from the list for any of the above reasons. Any person may petition for the first two reasons.

Through early consultation with States or EPA Regions, petitioners can avoid duplicating previous petitions and be assisted in locating sources of data already collected on the problem of concern to support their petitions. EPA will conduct information searches on chemicals contained in a petition, focusing on the effects the petitioners believe warrant addition or deletion.

EPA is required to publish a format for the Toxic Chemical Release form by June 1, 1987. The following information must be included

- The name, location and type of business
- Whether the chemical is manufactured, processed, or otherwise used and the general categories of use of the chemical
- An estimate (in ranges) of the maximum amounts of the toxic chemical present at the facility at any time during the preceding year
- Waste treatment/disposal methods and efficiency of methods for each wastestream

- Quantity of the chemical entering each environmental medium annually

- A certification by a senior official that the report is complete and accurate.

EPA must establish and maintain a national toxic chemical inventory based on the data submitted. This information must be computer accessible on a national database.

In addition to the requirements for the emissions inventory in **Section 313,** EPA will arrange for a mass balance study to be carried out by the National Academy of Sciences using information collected from States that conduct a mass balance-oriented annual quantity toxic chemical release program. Mass balance is the accounting of the total quantity of substances brought into a facility versus the amount that is shipped out. The difference is an indication of the amount released into the environment. A report of this study must be submitted by EPA to Congress no later than October 17, 1991.

The purpose of this study is to assess the value of obtaining mass balance information to determine the accuracy of information on toxic chemical releases. Also, the study will assess the value of using the information for determining the waste reduction efficiency and for evaluating toxic chemical management practices at categories of facilities. In addition, the study must determine the implications of mass balance information collected on a national scale including for use as part of a national annual quantity toxic chemical release program.

Other Title III Provisions

Section 322 of Title III addresses trade secrets and applies to emergency planning, community right-to-know, and toxic chemical release reporting. Any person may withhold the specific chemical identity of a hazardous chemical for specific reasons. Even if the chemical identity is withheld, the generic class or category of the chemical must be provided. The withholder must show each of the following:

- The information has not been disclosed to any other person other than a member of the local planning committee, a government official, an employee of such person or someone bound by a confidentiality agreement, that measures have been taken to protect the confidentiality, and that the withholder intends to continue to take such measures

- The information is not required to be disclosed to the public under any other Federal or State law

- The information is likely to cause substantial harm to the competitive position of the person

- The chemical identity is not readily discoverable through reverse engineering.

However, even if chemical identity information can be legally withheld from the public, **Section 323** provides for disclosure under certain circumstances to health professionals who need the information for diagnostic purposes or from local health officials who need the information for assessment activities. In these cases, the person receiving the information must be willing to sign a confidentiality agreement with the facility.

Information claimed as trade secret and substantiation for that claim must be submitted to EPA. This includes information that otherwise would be submitted only to State or local officials, such as the emergency and hazardous materials inventory (**§312**). People may challenge trade secret claims by petitioning EPA, which must then review the claim and rule on its validity.

EPA must publish regulations governing trade secret claims. The regulations will cover the process for submission of claims, petitions for disclosure and a review process for these petitions.

Section 305 of Title III authorizes the Federal Emergency Management Agency to provide $5 million for each of fiscal years 1987, 1988, 1989, and 1990 for training grants to support State and local governments. These training grants are designed to improve emergency planning, preparedness, mitigation, response, and recovery capabilities. Such programs must provide special emphasis to hazardous chemical emergencies. The training grants may not exceed 80 percent of the cost of any such programs. The remaining 20 percent must come from non-Federal sources.

Under **Section 305**, EPA is required to review emergency systems for monitoring, detecting, and preventing releases of extremely hazardous substances at representative facilities that produce, use, or store these substances. EPA will report interim findings to Congress no later than May 17, 1987 and issue a final report of findings and recommendations to Congress by April 17, 1988. The report must include EPA's findings regarding each of the following:

- Status of current technological capabilities to (1) monitor, detect, and prevent significant releases of extremely hazardous substances; (2) determine the magnitude and direction of the hazard posed by each release; (3) identify specific substances; (4) provide data on specific chemical composition of such releases; and (5) determine relative concentration of the constituent substances.

SUMMARY FOR CHEMICAL LISTS FOR TITLE III

List	Section	Purpose
List of Extremely Hazardous Substances (FR 11/17/86) [402 substances]	§302: Emergency Planning §304: Emergency Notification	• Facilities with more than established planning quantities of these substances must notify the State commission • Initial Focus for preparation of emergency plans by local emergency planning committees • Certain releases of these substances trigger Section 304 notification to State commission **and** local committees
Substances requiring notification under Section103(a) of CERCLA [717 substances]	§304: Emergency Notification	• Certain releases of these substances trigger Section notification to State commission **and** local committees as well as Section 103(a) requirement for National Response Center notification

Hazardous Chemicals considered physical or health hazards under Communication Standard [This is a performance standard, there is no specific list of chemicals]	§304: Emergency Notification Material Safety Data Sheets Emergency Inventory	• Identifies facilities subject to emergency notification requirements • MSDS or list of MSDS chemicals commission, local committee, **and** local fire department • Covered facilities provide site-specific information on chemicals to State commission, local committees and local fire departments
Toxic Chemicals identified as of concern by States of New Jersey and Maryland [329 chemicals/ chemical categories]	§313: Toxic Chemical Release Reporting	• These chemicals are reported on an emissions inventory to inform government officials and the public about releases of toxic chemicals in the environment.

KEY DATES TO REMEMBER

November 17, 1986	EPA published List of Extremely Hazardous Substances and Planning Threshold Quantities in Federal Register (§302,303,304)
November 17, 1986	EPA initiates comprehensive review of emergency systems (§305(b))
January 27, 1987	Format for Emergency Inventory Forms and reporting requirements published in Federal Register (§311, 312)
March 17, 1987	National Response Team published guidance for preparation and implementation of emergency plans (§303(f))
April 17, 1987	State governors appoint State emergency response commissions (§301(a))
May 17, 1987	Facilities subject to Section 302 planning requirements notify State emergency response commission (§302(c))
June 1, 1987	EPA publishes toxic chemical release (i.e., emissions inventory) form (§313(g)
July 17, 1987	State emergency response commission designates emergency planning districts (§301(b))
August 17, 1987 (or 30 days after designation of districts, whichever is sooner)	State emergency response commission appoints members of local emergency planning committees (§301(c))
September 17, 1987 (or 30 days after committee is formed, whichever is sooner)	Facility notifies local planning committee of selection of a facility representative (§303(d)(1))

October 17, 1987	MSDS or list of MSDS chemicals submitted to State commission, local committee and local fire department (§311(d))
March 1, 1988 (and annually there- after)	Facilities submit their emergency inventory forms to State commission, local committee and local fire department (§312(a)(2))
April 17, 1988	Final Report on emergency systems study due to Congress (§305(b))
July 1, 1988 (and annually there-after)	Covered facilities submit initial toxic chemical forms to EPA and designated State officials (§313(a))
October 17, 1988	Local emergency planning committees complete preparation of an emergency plan (§303(a))
June 30, 1991	Comptroller general report to Congress on toxic chemical release information collection use and availability (§313(k))
October 17, 1991	EPA report to Congress on Mass Balance Study (§313(1))

For more information on Title III and EPA's Chemical Emergency Preparedness Program, contact the CEPP Hotline:

1-800-535-0202
(in Washington, D.C. (202) 479-2449)

Hours: 8:30 a.m. - 4:30 p.m. (EST)
Monday - Friday

This is **not** an emergency number.

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INCOMPATIBLE CHEMICALS IN STORAGE, USE OR HANDLING

CHEMICAL	INCOMPATIBLE WITH:
Acetic acid	Azides, chromic acid, chromium, cumene hydroperoxide, cyanides, ethylene glycol, fluorine, hydroxyl compounds, nitric acid, nitrites, perchloric acid, peroxides, permanganates, hypochlorites, potassium chlorate, potassium perchlorate, sulfides
Acetic acid (glacial)	Azides, chromic acid, chromium, cumene hydroperoxide, cyanides, ethylene glycol, fluorine, hydroxyl compounds, nitric acid, nitrites, perchloric acid, peroxides, permanganates, hypochlorites, potassium chlorate, potassium perchlorate, sodium peroxide, sulfides
Acetic anhydride	Fluorine, perchloric acid, sodium peroxide
Acetone	Concentrated nitric and sulfuric acid mixtures, fluorine, hydrogen peroxide
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury, Iodine and their compounds
Acids	Ammonium nitrate, azides, cumene hydroperoxide, cyanides, fluorine, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, sulfides
Air	Fluorine, phosphorous, white
Alcohol	Chromic acid, chromium, fluorine, hydrogen peroxide, perchloric acid, sodium peroxide
Alkalies	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, fluorine, phosphorous, white
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, chlorates, fluorine, hydrocyanic acid, sulfuric acid
Alkaline metals (general)	Fluorine, hydrocyanic acid, sulfuric acid
(Powdered aluminum)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, ammonium nitrate, chlorates, chlorine, fluorine, hydrocyanic acid
(Powdered magnesium)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, ammonium nitrate, chlorates, chlorine, fluorine, hydrocyanic acid
Amines	Fluorine, nitroparaffins
Ammonia (anhydrous)	Mercury, bromine, chlorine, chlorine dioxide, calcium hypochlorite, fluorine, iodine, hydrogen fluoride, hydrofluoric acid (anhydrous), iodine
Ammonia (aqueous)	Bromine, chlorine dioxide, fluorine, hydrofluoric acid (anhydrous), iodine, mercury
Ammonium compounds	Silver
Ammonium nitrate	Acids, powdered metals, flammable liquids, fluorine, chlorates, nitrites, silver, sodium nitrite, sulfur, finely divided organic combustible materials
Ammonium salts	Chlorates, fluorine, silver, sodium nitrite
Aniline	Fluorine, nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agents, fluorine
Azides	Acids, fluorine
Bases, inorganic	Fluorine, nitroparaffins
Benzaldehyde	Fluorine, sodium peroxide

THIS LIST SHOULD NOT BE CONSIDERED ALL INCLUSIVE!

For additional information, you should contact a qualified chemist, laboratory, manufacturer, Material Safety Data Sheet or testing specialist. This information was extracted from the University of Kentucky's Model Chemical Hygiene plan, "Safety in Academic Chemistry Laboratories" and "Better Science Through Safety."

CHEMICAL	INCOMPATIBLE WITH:
Bismuth and its alloys	Fluorine, perchloric acid
Brass	Fluorine, nitric acid (concentrated)
Bromine	Acetylene, Ammonia (anhydrous), fluorine, hydrocarbons, hydrogen, petroleum gases, sodium benzene, finely divided metals
Butadiene	Chlorine, Fluorine
Calcium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, fluorine
Calcium hypochlorite	Ammonia (anhydrous), Carbon (activated), fluorine
Calcium oxide	Water, fluorine
Camphor	Chromic acid, chromium, fluorine
Carbon (activated)	Calcium hypochlorite, fluorine, oxidizing agents, hypochlorites
Carbon dioxide	Alkalies, alkali metals, calcium, fluorine, lithium, potassium, sodium, lithium
Carbon disulfide	Fluorine, sodium peroxide
Carbon tetrachloride	Alkalies, alkali metals, calcium, fluorine, lithium, potassium, sodium, lithium
Chlorates	Ammonium nitrate, ammonium salts, acids, fluorine, powdered metals, sulfur, finely divided organic or combustible materials
Chlorine	Acetylene, Ammonia (anhydrous), benzene, butadience, butane, finely divided metals, fluorine, hydrogen, methane, propane, sodium carbide, turpentine, hydrocarbons
Chlorine dioxide	Ammonia, fluorine, methane, phosphine, hydrogen sulfide
Chlorinated hydrocarbons	Alkalies, alkali metals, calcium, lithium, potassium, sodium, lithium
Chromic acid	Acetic acid, acetic acid (glacial), azides, naphthalene, camphor, cumene hydroperoxide, cyanides, glycerol, gycerin, alcohol, flammable liquids in general, fluorine, hydrocarbons, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, sulfides, turpentine
Chromium	Acetic acid, azides, naphthalene, camphor, fluorine , glycerol, alcohol, flammable liquids in general, hydrogen peroxide
Combustible substance (finely divided)	Chlorates, fluorine, hydrogen peroxide
Copper	Acetylene, fluorine, hydrogen peroxide, nitric acid (concentrated)
Cumene hydroperoxide	Acids, fluorine
Cyanides	Acids, fluorine
Ethyl acetate	Fluorine, sodium peroxide
Ethyl alcohol	Fluorine
Ethylene glycol	Acetic acid, fluorine, potassium permanganate, sodium peroxide
Flammable liquids	Ammonium nitrate, chromic acid, chromium, fluorine, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Flammable gases	Fluorine, nitric acid (concentrated), oxygen
Flammable substances	Fluorine, oxygen
Fluorine	All other chemicals
Fulminic acid	Azides, cumene hydroperoxide, cyanides, fluorine, hypochlorites, mercury, nitrites, potassium chlorate, potassium perchlorate, silver, sulfides

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CHEMICAL	INCOMPATIBLE WITH:
Furfural	Fluorine, sodium peroxide
Glycerin	Chromic acid, fluorine, potassium permanganate , sodium peroxide
Glycerol	Chromic acid, chromium, fluorine
Halogens	Alkalies, alkali metals, calcium, flammable liquids, fluorine lithium, potassium, sodium
Hydrocarbons	
(Butane)	Bromine, chlorine, chromic acid, fluorine, sodium peroxide, oxygen
(Benzene)	Ammonium nitrate, bromine, chlorine, chromic acid, fluorine, sodium peroxide, oxygen
(Gasoline)	Ammonium nitrate, bromine, chlorine, chromic acid, fluorine, sodium peroxide, oxygen
(Grease)	Fluorine, oxygen, perchloric acid
(Diesel)	Ammonium nitrate, bromine, chlorine, chromic acid, fluorine, oxygen, sodium peroxide
(Methane)	Bromine, chlorine, chlorine dioxide, chromic acid, fluorine, oxygen, sodium peroxide
(Propane)	Bromine, chlorine, chlorine dioxide, chromic acid, fluorine, oxygen, sodium peroxide
Hydrocyanic acid	Alkalies, azides, cumene hydroperoxide, cyanides, fluorine, nitric acid, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, sulfides
Hydrofluoric acid (anhydrous)	Ammonia (anhydrous), ammonia (aqueous), azides, cumene hydroperoxide, cyanides, fluorine, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, sulfides
Hydrogen	Bromine, chlorine, fluorine, iodine
Hydrogen fluoride	Fluorine
Hydrogen peroxide	Aniline, copper, flammable liquids, fluorine, chromium, iron, most metals and their salts, alcohols. acetone, organic materials, aniline, nitromethane, flammable or combustible materials
Hydrogen sulfide	Chlorine dioxide, fluorine, fuming nitric acid, oxidizing gases
Hypochlorites	Fluorine, acids, activated carbon
Hydroxl compounds	Acetic acid, fluorine
Iodine	Acetylene, ammonia (anhydrous), ammonia (aqueous), fluorine, hydrogen
Iron	Fluorine
Lithium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, fluorine, sulfuric acid
Mercury	Acetylene, Ammonia (anhydrous), fluorine, fulminic acid, oxalic acid
Metals, powders or finely divided	Ammonium nitrate, bromine, chlorates, chlorine, fluorine, hydrogen peroxide
Metals, heavy	Fluorine, hydrogen peroxide, nitric acid (concentrated)
Methyl acetate	Fluorine, sodium peroxide
Methyl alcohol	Fluorine
Naphthalene	Chromic acid, chromium, fluorine
Nitrates	Fluorine, sulfuric acid
Nitric acid (concentrated)	Acetic acid, acetone, aniline, azides, brass, chromic acid, copper, cumene hydroperoxide, cyanides, flammable liquids, flammable gases, fluorine, heavy metals, hydrocyanic acid, hydrogen sulfide, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, sulfides

THIS LIST SHOULD NOT BE CONSIDERED ALL INCLUSIVE!

For additional information, you should contact a qualified chemist, laboratory, manufacturer, Material Safety Data Sheet or testing specialist. This information was extracted from the University of Kentucky's Model Chemical Hygiene plan, "Safety in Academic Chemistry Laboratories" and "Better Science Through Safety."

CHEMICAL	INCOMPATIBLE WITH:
Nitric acid (fuming)	Acetic acid, aniline, azides, cumene hydroperoxide, cyanides, flammable liquids, fluorine, hydrocyanic acid, hydrogen sulfide, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, sulfides
Nitrites	Acids, ammonium nitrate, fluorine, potassium chlorate
Nitromethane	Fluorine, hydrogen peroxide
Nitroparaffins	Amines, bases (inorganic), fluorine
Organic peroxides	Fluorine
Organic substance (finely divided)	Ammonium nitrate, chlorates, fluorine, hydrogen peroxide, potassium chlorate
Oxalic acid	Cumene hydroperoxide, cyanides, fluorine, hypochlorites, mercury, nitrites, silver, potassium chlorate, potassium perchlorate, sulfides
Oxygen	Carbon (activated), fluorine, grease, hydrogen, flammable liquids, solids or gases, oils, phosphorous, white
Oxidizers (solid, liquid, gas)	Carbon (activated), fluorine, hydrogen sulfide
Paper	Fluorine, perchloric acid
Perchloric acid	Acetic acid, acetic anhydride, alcohol, azides, bismuth and its alloys, cumene hydroperoxide, cyanides, fluorine, grease, hypochlorites, nitrites, oils, paper, wood, potassium chlorate, potassium perchlorate, sulfides
Permanganates	Acetic acid, fluorine
Peroxides (organic)	Acetic acid, acids (organic or mineral), fluorine [avoid friction, store cold]
Phosphine	Chlorine dioxide, fluorine
Phosphorous, white	Air, alkalies, fluorine, oxygen, reducing agents
Phosphorous pentoxide	Fluorine, water
Potassium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, fluorine, water
Potassium chlorate	Fluorine, sulfuric and other acids, any organic materials
Potassium perchlorate	Fluorine, sulfuric and other acids
Potassium permanganate	Ethylene glycol, fluorine, glycerin, sulfuric and other acids
Reducing agents	Arsenical materials, fluorine, phosphorous, white, selenides
Selenides	Fluorine, reducing agents
Silver	Acetylene, ammonium compounds, fluorine, fulminic acid, oxalic acid, tartaric acid
	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens, Fluorine
Sodium benzene	Bromine, fluorine
Sodium carbide	Chlorine, fluorine
Sodium nitrite	Ammonium nitrate and other ammonium salts, fluorine
Sodium peroxide	Acetic acid (glacial), acetic anhydride, benzaldehyde, carbon disulfide, ethyl acetate, ethyl or methyl alcohol, ethylene glycol, flammable liquids, fluorine, furfural, glycerin, hydrocarbons, methyl acetate
Sulfides	Acids, fluorine
Sulfur	Ammonium nitrate, Chlorates, Fluorine
Sulfuric acid	Acetone, azides, cumene hydroperoxide, cyanides, fluorine, hypochlorites, lithoium, nitrites, potassium chlorate, potassium perchlorate, potassium permanganate, sodium, sulfides

THIS LIST SHOULD NOT BE CONSIDERED ALL INCLUSIVE!

For additional information, you should contact a qualified chemist, laboratory, manufacturer, Material Safety Data Sheet or testing specialist. This information was extracted from the University of Kentucky's Model Chemical Hygiene plan, "Safety in Academic Chemistry Laboratories" and "Better Science Through Safety."

CHEMICAL	INCOMPATIBLE WITH:
Tartaric acid	Azides, cumene hydroperoxide, cyanides, fluorine, hypochlorites, nitrites, potassium chlorate, potassium perchlorate, silver, sulfides
Turpentine	Chlorine, chromic acid, fluorine
Water	Alkalies, alkali metals, calcium, calcium oxide, lithium, potassium, sodium, lithium, fluorine
Wood	Fluorine, perchloric acid, phosphorous pentoxide

THIS LIST SHOULD NOT BE CONSIDERED ALL INCLUSIVE!

For additional information, you should contact a qualified chemist, laboratory, manufacturer, Material Safety Data Sheet or testing specialist. This information was extracted from the University of Kentucky's Model Chemical Hygiene plan, "Safety in Academic Chemistry Laboratories" and "Better Science Through Safety."

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MODULE 6: SPECIAL HAZARDS

TERMINAL OBJECTIVES

The students will:

1. *Recognize hazards associated with electrical, heating, and cooking systems and equipment.*
2. *Identify methods of mitigating the recognized hazards.*
3. *Educate others about hazards associated with electrical, heating, and cooking systems.*

ENABLING OBJECTIVES

The students will:

1. *Define electrical terminology and identify electrical equipment.*

2. *Identify common electrical hazards.*

3. *Given a list of questions, research appropriate electrical codes and determine appropriate action to mitigate electrical hazards.*

4. *Identify appropriate fuel storage and heating equipment installation.*

5. *Research appropriate heating codes and determine appropriate action to mitigate heating equipment hazards.*

6. *Identify common cooking equipment and fuels.*

7. *Given a scenario, research appropriate codes to mitigate hazards associated with cooking equipment and fuels.*

8. *Explain compliance and describe methods of achieving compliance.*

ELECTRICAL

If properly designed, installed, and maintained electrical systems for lighting, power, heating, and other purposes are convenient and safe, but if not installed and maintained in accordance with established standards, they may introduce both **fire** and **personal injury hazards**. This has been recognized since electric power first came into general commercial use.

Electrical systems hazards are from arcs and sparks and heat. Lack of maintenance and improper installation are mostly responsible for the fires that do occur. Fire experience has shown us that electricity ranks **third** of the main causes of fires. Most of us are not electrical inspectors, engineers, or experts, so it is important to recognize electrical hazards and to work closely with the electrical inspector or department to correct these hazards.

The **fire prevention inspector** must become familiar with the following terms:

Definitions

Ampere

The amount or volume of electric flow is measured in amperes. An electrical instrument utilized to measure flow is called an ammeter.

Volt

Volt is the unit of electrical force, and is defined as that force which causes an electrical flow of one ampere through a resistance of one ohm. Thus, the term volt and ohm are complementary, both being dependent upon the one quantity capable of precise physical definition: the ampere. This can be compared to pressure, or pounds per square inch (psi) of water.

Ohm (Resistance-R)

The term representing opposition to flow of electricity in a conductor (wire) is the ohm. The ohm is defined as the resistance of a conductor or wire in which an electrical pressure of one volt causes an electric current of one ampere to flow. This can be compared to friction loss in fire hydraulics.

Watt

The rate at which electrical energy is consumed in an electrical circuit is called power. The unit of electrical power is the watt. Wattage is determined by multiplying volts by amps. The kilowatt is customarily employed for large amounts of power, a kilowatt being equal to 1,000 watts.

Nameplates on appliances and equipment are always marked in kilowatts, vir.: 14 kw, 16 kw, etc. Electrical lamps, etc., on the other hand, are labeled in watts, such as 100 watts, 150 watts, and so on.

Conductors

Materials in which electrical flow is readily established are known as conductors. Metals, generally, fall into this class, with copper being termed a good conductor; although silver is superior to copper in this respect, the cost prohibits it from general use. Aluminum is used because of the costs, although only half as good a conductor as copper.

Insulators

Substances which strongly oppose flow of electricity through them are termed insulators. Paper is considered a good insulator. Insulators vary in quality, thus mica and bakelite are superior to paper.

Overload

An overcurrent which exceeds the normal full load current of a circuit. Also characteristic of this type of overcurrent is that it does not leave the normal current carrying path of the circuit.

Short Circuit

Can be classified as an overcurrent which exceeds the normal full load current of a circuit by a factor many times (tens, hundreds, or thousands) greater. Also characteristic of this type of overcurrent is that it leaves the normal current carrying path of the circuit--it takes a "short cut" around the load and back to the source.

Ground

Electrical systems must be properly grounded to prevent shock and fire hazards. A "ground" is defined as a conducting connection, whether intentional or accidental, between an electrical circuit or equipment, and the earth or some conducting body serving in place of the earth.

Circuit(s)

Branch circuit is that portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

> An appliance/equipment branch circuit is one supplying one or more outlets to which appliances/equipment are to be connected and which has no permanently connected lighting fixtures. Amperes of 15/20/30 or more, and can be 120/240 volts.

Power circuits provide 20 amperes at 120 volts and have the ability to provide lighting. This also is called a **general purpose branch** sometimes as it supplies lighting and appliance/equipment, but is only rated at 15 amperes at 120 volts.

Receptacle branch, 15/20 amperes are to provide receptacle outlets around the perimeter of a room so that any appliance, lamp, etc., placed along the wall could be served by an existing outlet without the need for using an extension cord.

An individual branch circuit is one which supplies only one circuit for the use or utilization of equipment.

Overcurrent Protection Devices

The most commonly used overcurrent devices for the protection of circuits and equipment are fuses, circuit breakers, and thermal overload units. (Overcurrent and undervoltage relay, etc., are used on high voltage, high amperes systems.)

Plug fuses consist of two basic types; (1) the "s" type; and (2) the ordinary Edison base type. Either of these may or may not be of the time-delay type.

Approval and Listing of Equipment

All electrical installations in the United States should be made, used, and maintained in accordance with the National Electrical Code and other NFPA codes that apply to specific locations.

The most common listing found on electrical appliances and equipment is that of the Underwriters' Laboratories (U/L). This listing means that a sample of the device was tested by the U/L. Each individual device is not tested; samples of the devices are tested. Therefore the listing assumes proper assembly and maintenance. The listing obviously cannot guarantee that an individual device, which happens to be of a listed type, is proper and safe. U/L conducts field tests at times for purposes of quality control.

Under current U/L practices, only replacement cords carry the U/L label. Formerly, all cords were labeled. Consumers thought that the label on the cord of the appliance signified that the appliance itself was U/L tested. This was not always the case. Cords on new appliances do not carry the U/L label.

U/L publishes lists annually. Shown below are some typical U/L Labels:

IDENTIFICATION OF LISTED PRODUCTS

The Listing Mark may appear in various forms as authorized by Underwriters Laboratories Inc. Typical forms which may be authorized are shown below:

Factory Mutual also maintains an electrical testing laboratory and is a highly reputable testing agency. U/L however, is the most common testing lab for electrical devices in the United States.

> Most FMRC Approved produces will bear one of the following marks. Only companies providing Approved products or services may use these marks on their products or in their literature or advertising. The marks may be used only for the specific products or services Approved.

The key point in labeling is for the inspector to investigate devices and equipment that do not appear to be of an approved type. The inspector should make it a habit to look for labels during inspections.

Some of the sources that may be helpful to the Fire Inspector are:

- The local electrical inspector.
- A reputable electrician.
- U/L listing publications.

- The manufacturer.
- National Fire Codes, (including NEC).

Equipment

Wire

A conductor. The size of conductors varies as to the amps they carry. The smaller the numerical designation of the wire, the higher the capacity. The National Electrical Code (NEC) specifies sizes of conductors. Conductors can be copper, copper clad, or aluminum.

There is much controversy nationally about aluminum wiring. Aluminum conductors require a larger size than copper for the same carrying capacity. A general rule is that aluminum needs to be one size larger than copper for the same carrying capacity. Aluminum is now found most commonly in commercial and industrial occupancies on the service side of the panel. It was used extensively in new housing tracts in southern California for a while. Many fires occurred in houses wired with this conductor.

Aluminum wire exposed to air (as at the connection point) will oxidize. An oxidation film will form on the wire, and will insulate the wire. This occurrence causes a resistance which generates heat. Electricians use an oxide inhibitor on the wire to prevent the oxidation.

Aluminum should not be used in conductors of less capacity than a #6 wire. This is a result of the problems incurred in residences. Number 6 or larger capacity conductors can be aluminum if used with an oxide inhibitor, proper wire stripping, and UL listed connectors approved for use with aluminum. Students should check their local electrical and building codes for local regulations on aluminum wiring.

If aluminum conductors are found in circuit wiring, it is important that all switches and receptacles be replaced with CO/ALR rated devices by a qualified electrician.

If a conductor is not the appropriate size, the conductor will be overloaded, regardless of whether it is aluminum or copper, etc. Excessive heat will be generated.

Deterioration of the insulation of the conductor will occur and the excessive heat may cause a fire.

Overcurrent Protection Devices

Electrical wires are constantly heated by current flowing through them. If too much current is allowed to flow (amps), wires will burn away their insulation and cause a fire. Such wires are said to be overloaded. A fuse is an overcurrent protection device. The fuse is part of the electrical system. It is designed to melt an element within it at a certain amperage level. The fuse not only prevents fires but it protects the circuit and electrical equipment from damage.

Many different sizes and types of fuses are in use. They are used in homes, and in commercial and industrial systems. New homes typically use circuit breakers. The fuse is quicker acting than a circuit breaker. The typical residential fuse could be tampered with and nullified by putting a penny behind the fuse (Edison base). A cartridge fuse can be tampered with by the installation of a jumper wire, which bypasses the overcurrent protection.

Cartridge fuses protect large load carrying circuits. The "s" type is so designed that tampering or bridging usually can not be accomplished, or at least not without extreme difficulty. They are designed with adapters that fit Edison base fuse holders. After an adapter has been installed properly, it cannot be removed without damaging the fuse holder. The adapters are designed to prevent the use of Edison base fuses in the fuse holder, to prevent the high amp rated type "s" fuses in circuits, designed for a lower rating, and to prevent the use of pennies and other bridging schemes.

Edison base fuses of any size will fit Edison base fuseholders of any size.

Time-delay type fuses, whether of the type "s" or Edison base design, permit short-time current surges. These momentary surges are harmless. This makes it possible to use "s" type fuses in sizes small enough to give better protection than a nontime-delay type that must be oversized to allow for such surges.

Cartridge fuses are of both time-delay and nontime-delay types. They are also of the one-time and the renewable type.

Circuit Breakers

There are two basic types of circuit breakers. They are: (1) adjustable-trip, and (2) nonadjustable-trip. The adjustable-trip has a setting of the trip point and is adjustable between a minimum and a maximum range, and is installed usually only on large installations having qualified operating and maintenance personnel. They are designed to trip when the current reaches that of the setting.

The nonadjustable-trip comes in a molded case, making it impossible or extremely difficult to change its rating. It is of the time-delay type and designed so that the current has to exceed its rating (as is also true with all types of fuses) before it will trip.

Panel Board/Panels

Single and group.

Cover--non/open.

Identified.

Knockout--not closed.

Wiring entering panel unsecured.

Cable connection loose.

Some contents of panel:

- with/without switches;
- light controls;
- heat or power circuits; and
- automatic overcurrent device.

Raceway

An enclosed channel for wires or cables, usually metal or insulating material.

Cable tray: Used as support cables; a rigid structural system; ladders, troughs, channels, solid bottom trays.

Outlets

A point on the wiring system at which current is taken to supply the equipment.

Switches

General use: in general distribution and branch circuits.

General use snap: constructed so that it can be installed in flushboxes or outlet box covers.

Isolating switch: cuts off an electric circuit from the source of power.

Motor circuit switch: rated in horsepower; capable of interrupting the maximum operating overload current of a motor with the same horsepower rating.

Lights and Lamps

Lamps often operate at temperatures sufficient to ignite combustible material, or are not mounted to provide safe clearances.

Portable lamps, if unguarded, may ignite paper, wood, cloth, etc., if in contact with them.

A broken lamp, such as a mechanic's trouble lamp, can ignite flammable vapors.

Portable lamps should not be used in areas such as paint spray rooms, etc. Portable lamps should be of suitable approved types having sturdy guards and cords.

Transformers

A device used to change the voltage of alternating currents. Transformers can be used to raise or reduce voltage. There are three types of transformers in electrical systems:

- Dry (no oil installation);
- "Askarel" (PCB) noncombustible insulating fluid; and
- Mineral oil (combustible insulating fluid).

Both Askarel and mineral oil can be found in industrial vaults and pole mounted transformers. "Askarel" is Poly Chlorinated Bi Phenol (PCB). It is a noncombustible fluid that is used as a cooling and insulating medium in large transformers and capacitors. Recently it was found that PCB is a highly toxic and carcinogenic substance. It is a nonflammable synthetic chlorinated hydrocarbon. Arching can cause generation of hydrogen chloride gas, among others. These transformers are being taken out of service. The ones that are still in service are identified as PCB transformers. Other trade names for PCB include:

- elemex;
- inerteen;
- pyranol;
- chlorextol;
- dykanol; and
- diaclor.

Appliances

Utilization of equipment built in standard sizes or types, which when installed or connected as a unit, perform one or more functions.

Motors

Sparking, arcing, or overheating may occur in the motor itself, or in its starting equipment.

Requirements for motors include:

Location of motor and starting equipment to be away from combustible material, or installation to be protected per NEC.

Dust and lint in motors should be removed. Good housekeeping should be maintained at switches, controllers, and other safety devices. Cleaning and overhauling should be done according to the needs of the equipment. Be suspicious of noisy electric motors. The noises could indicate burned-out bearings, or other serious mechanical problems. This is common with heating and air conditioning units and with commercial refrigeration units.

- Clean and replace the filters as needed.

- Proper overcurrent protection.

Equipment for Hazardous Locations

"Hazardous" locations are those where ignitable vapor, dust, or residue is, or may be, present in sufficient quantity to cause a fire or explosion if ignited by an electrical device. Arcs, sparks, or overheating could cause an explosion in these areas. The best technique is to locate the electrical system outside of the area, but this is not always possible.

You will need to determine if "explosion proof" wiring and fixtures are needed. The idea being that if vapor gets into the electrical system and ignites, the flame will not propagate outside the fixture or wiring; thus electrical equipment will not be destroyed by the internal pressure etc., of such ignition. In addition, the equipment is designed to minimize the entrance of hazardous materials.

Electrical equipment for use in hazardous locations is listed in the Underwriters' Laboratories "Hazardous Location Equipment List." In these references, the locations in which the **tested** equipment may be used is given by **Class** (I, II, or III), **Division** (1 or 2), and **Groups** (A, B, C, D, E, F, or G).

These designations correspond to those given in the National Electrical Code denoting different hazardous conditions. These designations are:

Class I	Areas containing combustible or flammable gases and/or flammable liquid vapors.
Class II	Areas containing combustible dusts.
Class III	Areas containing combustible fibers.

The division designation indicates the frequency with which the special hazard occurs, with Division 1 areas consisting of those that have hazardous atmospheres during normal operations, and Division 2 areas consisting of those where the hazardous atmosphere is intermittent.

The group designation indicates the type of hazardous materials that may be involved, with relative hazard listed from A to G.

From a fire prevention officer's standpoint, choosing the right equipment, based on the hazard involved, will require the close advice and cooperation of a qualified electrical inspector. From the information given above, you should be able to discern the needs for hazardous location. Specific information should be obtained at the time it is required from the (*1)National Electrical Code®, the National Fire Codes, and the local electrical inspector.

Hazardous Locations. (Condensed information, see **National Electrical Code** NFPA No. 70-1990.)

(*2)Class I Locations

GROUP A	Acetylene	
GROUP B	Butadiene Manufactured gas	Ethylene Oxide Propylene Oxide
GROUP C	Acetaldehyde Diethyl ether Isoprene	Cyclopropane Ethylene Unsymmetrical dimethyl hydrazine (UDMH)
GROUP D	Acetone Alcohol Benzine Ethylene dichloride Lacquer solvent vapors Styrene Xylenes Vinyl acetate	Acrylonitrile Ammonia Butane Gasoline Hexane Naphtha Natural gas Propylene

Group D equipment may be used for an atmosphere of butadiene, and Group C equipment may be used for an atmosphere of ethylene oxide or propylene oxide if such equipment is isolated by sealing all conduits 1/2-inch size or larger.

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*Class II Locations

Atmosphere containing the following combustible dusts:

Conducting Dusts

GROUP E Metal dusts, including:
Aluminum
Magnesium
Alloys of Aluminum, Magnesium

Nonconducting Dusts

GROUP G Flour
Starch
Grain

GROUP F: Atmospheres containing carbon black, charcoal, coal, or coke dusts which have more than eight percent total volatile material (carbon black per ASTM D 1620; charcoal, coal and coke dust per ASTM D 271) or atmospheres containing these dusts sensitized by other materials so that they present an explosion hazard, and having resistivity greater than 10^2 ohm-centimeter but equal to or less than 10^8 ohm-centimeter.*

Underwriters' Laboratories, Inc., and Underwriters' Laboratories of Canada, Ltd., test and list electrical equipment for hazardous locations according to safety of its operation in the seven groups of atmospheres tabulated.

Certain chemical atmospheres may have characteristics which would require safeguards beyond those required for any of the above groups. Carbon disulfide is one of these chemicals because of its low ignition temperature (100 °C) and the small joint clearance required to arrest its flame. See Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, NFPA No. 325 M.

Equipment for use in Class I hazardous locations, as defined in the **NEC**, is sometimes referred to as "explosion-proof" equipment. The basic design criterion for Class I equipment is that it withstand internal explosions of flammable-gas or vapor-air mixtures. In other words, it is recognized that surrounding flammable-gas or vapor-air mixtures will, under certain conditions, enter the enclosure of this equipment and that there is the possibility of their ignition within the enclosure. To prevent the propagation of flame to the outside surrounding atmosphere, which may likewise contain flammable vapor-air mixtures, the enclosures of this equipment must: arrest flame at joints or other openings to the outside; be strong enough to resist (without rupture or serious distortion) the internal pressure; and keep the temperature of the enclosure low enough so as not to ignite the surrounding gas or vapor. The various gas or vapor-air mixtures vary considerably with respect to the propagation of flames through joints of such assemblies; the pressure developed within the enclosure following ignition; and the ignition temperature of the gas or vapor-air mixture.

Equipment for use in Class I hazardous locations must also be designed to operate under full load conditions without developing surface temperatures above the ignition temperature of the flammable gas or vapor in which they are intended to be used.

As an alternative to "explosion-proof" motors and generators--equipment approved for use in Class I locations--it is permissible to use either of the following two designs:

- Totally enclosed equipment supplied with positive-pressure ventilation from a source of clean air with discharge to a safe area, so arranged as to prevent energizing the machine until ventilation has been established and the enclosure purged with at least ten volumes of air; and arranged to automatically de-energize the equipment when the air supply fails.

- Totally enclose inert gas-filled equipment supplied with a suitably reliable source of inert gas for pressurizing the enclosure, with devices provided to assure a positive pressure in the enclosure, so arranged as to automatically de-energize the equipment when the gas supply fails.

When either of these two designs is used, no external surface of the motors, generators, or the rotating electrical machinery should have an operating temperature (in degrees Celsius) in excess of 80 percent of the ignition temperature of the gas or vapor involved as determined by ASTM test procedure D2155-69. Appropriate devices are also to be provided to detect any increase in temperature of the equipment beyond its design limits and then to automatically de-energize the equipment; this equipment should be approved for the location in which it is installed.

NFPA No. 496, Purged and Pressurized Enclosures for Electrical Equipment, provides information for the design of purged enclosures for the purpose of eliminating or reducing within the enclosure a Class I hazardous location (gases or vapors in air in quantities sufficient to produce explosive or ignitable mixtures). Protective measures include supplying an enclosure with clean air or an inert gas at sufficient flow and positive pressure to achieve an acceptably safe level of the atmosphere and to maintain this safe level.

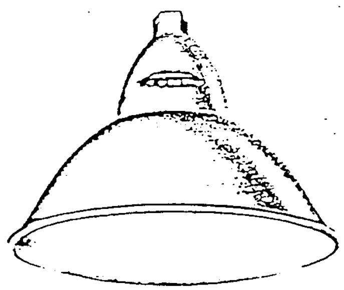
Another alternative is the use of "intrinsically safe" equipment and wiring--this is equipment and wiring incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of the specific hazardous atmospheric mixture.

In many cases, the amount of "explosion proof" equipment required can be reduced, through the exercise of ingenuity in the layout of electrical installations, by locating much of the equipment in nonhazardous areas. The extent of the hazardous areas is normally defined by the codes and standards relating to the storage and handling of the specific liquids, gases, or solids.

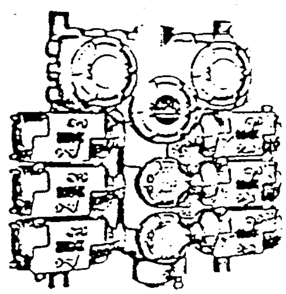
Equipment for use in Class II and Class III hazardous locations presents a somewhat different problem because such equipment is designed to be dust and ignition-proof for Class II, Division 1, and for some Class II, Division 2, locations, and for Class III locations. Thus, it is not intended to resist internal explosion of dust-air mixtures. Such equipment is tested in specific dust-air mixtures to determine that the enclosures are dust-ignition proof for Class II locations and that overheating does not occur when the device is blanketed with dust or lint and flyings.

Considerable judgment is required when classifying or defining hazardous locations. Your responsibility is to identify a hazardous situation and, with assistance of experts (i.e., Electrical Inspector and the **National Electrical Code**), get the hazard mitigated.

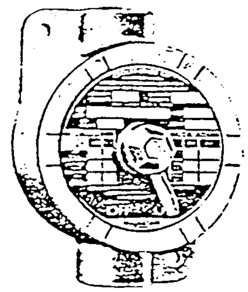
ELECTRICAL SYSTEMS AND APPLIANCES



A dust-tight tight fixture for use in Class ii hazardous locations. (Crouse-Hinds Company)



An example of a panel board for use in Class I hazardous locations. (Crouse-Hinds Company)



Tumbler switch for use in Class I and Class II hazardous locations. (Crouse-Hinds Company)

*FIG. 8-2CC REPRESENTATIVE LIGHTING FIXTURES FOR USE IN VARIOUS HAZARDOUS LOCATIONS LOCATIONS

*FIG. 8-2DD REPRESENTATIVE SWITCHING AND PANEL-BOARD EQUIPMENT FOR USE IN VARIOUS HAZARDOUS

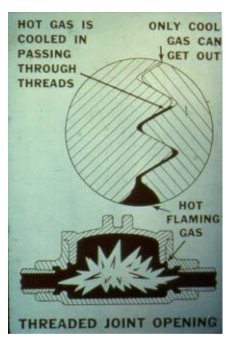


*Fig. 8-2BB. Explanation of the principle of Explosion proof equipment, indicating containment of hot gas within the enclosure. (Crouse-Hinds Company)

Static Electricity

Precautions against sparks from static electricity are needed in locations where flammable vapors, gases, or dusts are present, or where there are easily ignited materials.

Flowing gases, liquids, or granular solids will generate static electricity. An electrical charge can be built up. If a discharge of the electrical energy occurs, a spark is caused and ignition of surrounding combustibles (gases, flammable liquid vapor, dust, etc.) can occur.

Static electricity means "the electrification of materials through physical contact and separation." The development of electrical charge may not in itself be a potential fire and explosion hazard unless the discharge of electricity occurs.

In order for static electricity to be a source of ignition, four conditions must be present:

- An effective means of static generation.
- A means of accumulating the separate charges and maintaining a difference of potential.
- A spark discharge of adequate energy.
- The spark must occur in an ignitable mixture.

Static electricity may appear as the result of motions that involve changes in relative positions of contacting surfaces, usually of dissimilar substances whether liquid or solid. One of these, or both, must be a **poor** conductor of electricity.

Examples of this type of motion which you will find in industry, are:

- Flow of fluid through pipes and the accumulation of a charge on the surface of a nonconducting liquid.
- Breaking up into drops of a stream of liquid and the resultant impact of such drops onto a solid or liquid surface.
- Steam, air, or gas flowing from any opening in a pipe or hose when the steam is wet or the air or gas stream contains particulate matter.
- Pulverized materials passing through chutes or pneumatic conveyors.
- **Nonconductive** power or conveyor belts in motion.
- Moving vehicles.

You can see that you need to suspect static electricity generation in any process involving transfer of liquids, gases, and particulate matter as well as conveyor belts.

The best fire prevention is elimination of ignitable mixtures in areas where sparks of static electricity can occur.

Methods for bringing the situation under control include:

- humidification;
- bonding, grounding;
- ionization; and
- a combination of the three.

Humidification

Relative humidity in the atmosphere should be high. Static electricity is less prevalent in humid air. The static charge will dissipate. Humidities should be maintained up to approximately 75 percent relative humidity if possible and practical.

Bonding and Grounding

These are the most common methods of prevention, especially with flammable liquids.

Bonding is done to minimize differences in electrical potential between metallic objects. There is practically no differential between two metal objects connected by a bond wire. The current carried by the wire is usually small.

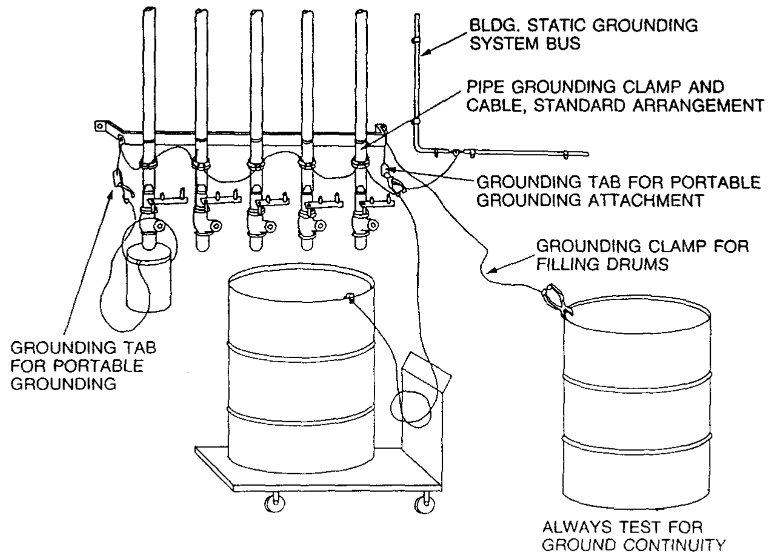
When gasoline, as an example, is transferred from a drum to a can, the drum and can should be bonded together **before transfer** by a tube which is conductive and firmly in contact at both ends, or a bonding wire should be securely attached to both containers **before transfer**. A bonding wire is necessary except where containers are inherently bonded together.

Grounding refers to connections made to minimize differences in electrical potential between objects and the ground. Ground connections must be properly designed and of proper capacity. They must be tested frequently to detect impairment by corrosion, loose connection, or injury.

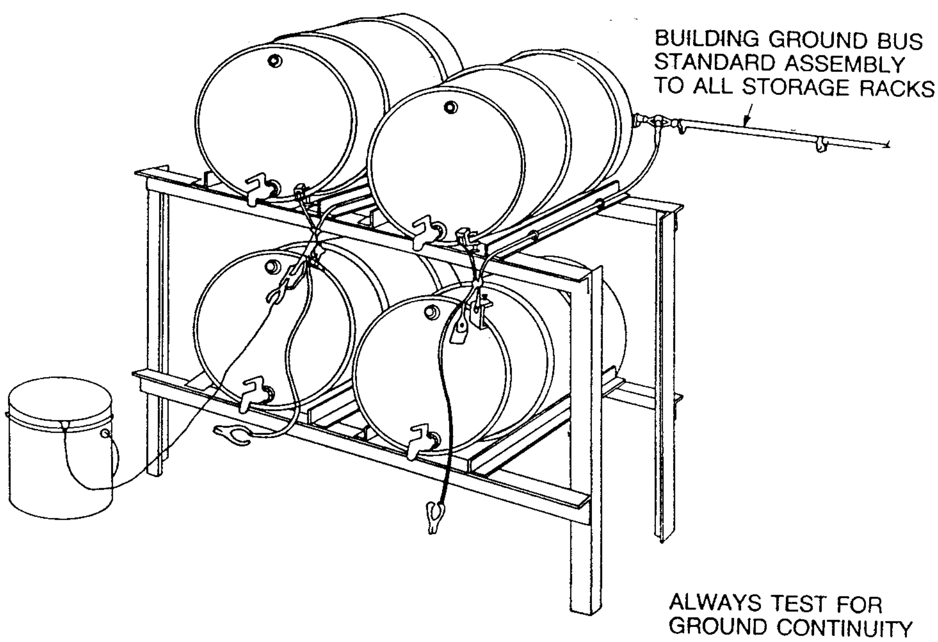
In general, grounding and bonding connections should be of substantial construction so that they are not easily broken, and installed so you can tell that they are in place and intact.

Water pipes are usually suitable grounds. Any ground suitable for power circuits or lightning protection is adequate for static electricity.

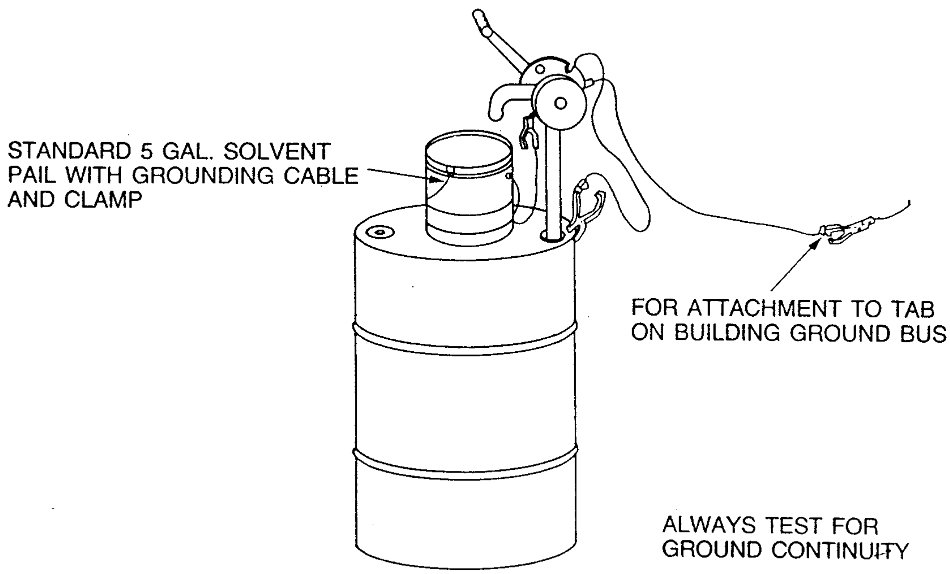
TYPICAL GROUNDING SYSTEM FOR MULTI-SOLVENT DROP TRANSER POINT



TYPICAL ARRANGEMENT--FOR STANDARD STATIC GROUNDING OF 55 GALLON DRUMS IN STORAGE RACK



TYPICAL GROUNDING SYSTEM FOR SMALL VOLUME SOLVENT HANDLING



Ionization

Increasing the conductivity of the air so that charges will be conducted away. As an example: a flame ionizes surrounding air.

Alternating electrical fields are used when dealing with electrified sheet material. (Sheet is passed through the field.) This is called electrical neutralizer.

Ionization is a specialized technique which must be properly designed.

Methods of Control

Conductive type flexible liquid transfer hose with metal lining or bonding wire is available.

Water pipes, as previously mentioned, are suitable grounds.

Inert gas may be used to eliminate oxygen in mixing and grinding operations.

Humidification helps in dry cleaning operations.

Conductive rubber compounds with sufficient carbon content to make them conductive are used for conveyor, power belting, floors, and other uses.

Conductivity of power and conveyor belts can be increased by special dressings.

At pipeline joints where insulating gaskets are used or where severe corrosion is present, bonding should be provided.

When inspecting a facility where liquid gas or particulate transfer is occurring, be sure to evaluate the following:

- Type of process.
- Product involved.
- Ignitable mixtures present.
- Provisions for bonding and grounding.
- Maintenance of static elimination systems.

When in doubt about the suitability or safety of the operation, research the subject in the NFPA Fire Codes, Local Fire Codes, Electrical Codes, etc.

You can call your local electrical inspector for this input, or you may need to get assistance from an electrical engineer.

You could require that the business owner provide you with written certification from an electrical engineer that all the static electricity protection devices meet all applicable codes and are in good working order.

The Fire Inspector should always recommend the use of listed devices installed by a licensed electrician. The inspector should always recommend that the installation be within the requirements of applicable local codes and the NEC. In some jurisdictions, it may be proper to require a permit from the building department prior to installation.

Remember, no matter what you do to eliminate static electricity, a static charge cannot be totally eliminated.

Common Hazards Found in Inspection of Electrical Systems

It is important for the Fire Inspector to be able to identify the common faults found in electrical systems. Here is a list which will be very helpful in conducting inspections of electrical systems.

Open Wiring and Knob-and-Tube

Wires are bare or insulation is badly deteriorated.

Wires not properly separated from each other or from metal pipes or other objects.

Wires not properly supported or protected from mechanical injury.

Outlet boxes missing.

Wires not separately bushed when entering enclosures.

Overcurrent Protection of Circuits and Feeders

Feeder or circuit not protected by proper size fuse or circuit breaker.

Fuses or circuit breakers not of approved type.

Branch Circuits and Receptacles

Sufficient number of circuits not provided.

Circuit or feeder wires not of sufficient size.

Sufficient number of receptacles not provided.

Conduits and Raceways

Badly deteriorated conduits or raceways.

Conduits or raceways not securely fastened in position.

Conduits or raceways not properly secured to outlet boxes, cabinets, and other equipment.

Outlet Boxes and Cabinets

Door of cabinet missing or does not close.

Inadequate covering of outlet boxes adjacent to combustible material.

Unused openings in box or cabinet not closed.

Excessive number of wires in box or cabinet.

Inadequate clearance in front and around cabinets.

Switches

Switches not enclosed in approved metal cabinets or boxes.

Switches badly deteriorated, dirty, or poorly maintained.

Switches not of sufficient capacity.

Switches not properly wired.

Fixtures

Fixtures deteriorated, dirty, poorly maintained, or subject to moisture.

Fixtures not properly secured.

Exposed or bare conductors in fixtures.

Lamp guards missing where required.

Sockets defective.

Sockets in closets not properly located on ceiling or wall.

Electrical Appliances

Appliances not approved or without evidence of proper construction.

Approved outlet not provided for appliance.

Flexible Cords

Cords used in place of approved method of wiring.

Cords badly frayed or deteriorated.

Cords not an approved type.

Cords not properly secured in sockets and attachments.

Service Equipment

Service equipment is dirty or obstructed by storage.

Service wires are overloaded.

Service equipment is overloaded.

Conductors

Conductors overloaded.

Unapproved or badly deteriorated conductors.

Joints not properly soldered, jointed, or taped.

Two or more wires under one terminal not approved for purpose.

Conductors subject to excessive heat.

Switchboards and Panelboards

Badly deteriorated, dirty, or poorly maintained.

Conductors and bus bars not properly supported.

Switchboard or panelboard not protected against moisture.

Switchboard or panelboard with live parts exposed to accidental contact.

Inadequate clearance in front and around cabinets.

Grounding

Grounding connectors, clamps, and related equipment not properly secured.

Motor

Motors are dirty or dust covered.

Motors not provided with proper overcurrent protection.

Armored and Nonmetallic Sheathed Cable

Cable badly deteriorated.

Cable not securely fastened in position.

Cable not properly protected from mechanical injury when passing through floors or walls.

Cable does not terminate in approved fittings.

Resistance Devices

Rheostats not isolated from combustible materials.

Rheostats not properly installed.

Signs and Outline Lighting

Sign conductors not properly bushed or supported.

Cut-outs and flashers not properly enclosed.

Hazardous Locations

Motors, appliance, fixtures, other equipment, and wiring systems not suitable for the location.

Reference: NFPA Inspection Manual.

Additional Inspection Tips for Reference

Here are some things to look for on inspections. These are all fire hazards and need correction. Each of the following hazards is listed with a corresponding correction:

Problem	Correction
Frayed cords (bad insulation).	Replace cord.
Extension cords (this is a serious problem).	Extension cords are not to be used in place of approved wiring. Should not be tacked to walls, run through walls, or run under carpets.
Problems with pennies behind fuses, breakers taped, fuses of too large a capacity.	Add more circuits or run fewer devices at any one time. The typical fuse capacity in a dwelling is 15 amps for outlets and 20 amps for appliance circuits. In commercial occupancies, if in doubt, call electrical inspectors. Thirty amp fuses may be used if the circuit has large enough wire. Be suspicious when you see 30 amp fuses. If in doubt, get an electrical inspector to come out and look at it.
Electrical panels:	
Wires exposed, frayed, etc.	Occupant should have electrician repair wires.
Panel obstructed by junk, trash, etc.	Remove junk and trash. Keep panels accessible and clean.
Panel not labeled as to what it serves (in large occupancies).	Label panels.
Switches in panel not labeled.	Label the switches.
Door missing.	Replace door.
Electrical outlets:	
Cracked, broken, show evidence of arcing.	Have electrician replace the outlet when you see evidence of arcing (char on the outlet). Investigate the cause. Find out what is usually plugged into the outlet. The plug may be defective, or the appliance itself defective.
No cover plate.	Replace plate.
Wall switches. No cover plate.	Replace plate.
Fixtures:	
Wires not enclosed.	Enclose wires.
Not UL listed.	Have appliance replaced with listed device. (This is common with Christmas tree lights.)
Explosion proof devices.	Be sure it is required, and then specify that an electrician install it. Refer to NEC.
Frayed wires, taped wires, etc.	Have the wires replaced.

Problem	Correction
Combustibles next to electrical devices and susceptible to ignition from arcs.	Remove combustibles.
Cords, wires, tacked or stapled to walls, floors, etc.	Remove all wall or floor. Cords are not to be used as permanent wiring.
Cords taped to floor.	Install more outlets so this won't have to be done. Friction from walking on cord will break down insulation.
Heavy duty appliance and machinery cords not grounded.	These cords must have a grounding device, and be UL listed for safety.
Appliances, machines, motors, etc.:	
Improper ground.	Electrician can install proper ground.
Dirty motor.	Have motor cleaned.
No ventilation for motor.	Provide ventilation.
Dirty air filters.	Replace filter. Dirty filter on intake of a heating system can cause electrical motors to overheat and burn out.
Cord appears too small for its use.	Electrician should install proper capacity cords with ground.
Motor has no overcurrent protection.	Electrician should install overcurrent protection.
Evidence of arcing or burning.	Have electrician repair device.
Noisy motor (common in commercial refrigerators, air conditioning, and heating equipment).	Have motor checked and repaired by electrician. Bearings may be burned out. Brushes may need replacement.
Conduits badly deteriorated, etc.	Electricians should repair or replace.
Ceiling light fixtures.	
Loose.	Electrician can repair the problem.
Appear faulty.	Electrician should repair or replace.
Poor wiring.	Electrician should repair or replace.
Combustibles too close to fixture bulb.	Combustibles should be removed.

Code Requirements

National Electrical Code NFPA #70.

Fire prevention codes.

- UFC (1994 edition), Article #85 Electrical Equipment and Wiring.
- BOCA (1993 edition), Section F-310.0 Electrical.
- SFPC (1994 edition), Chapter 7 Electrical.
- FPC (NFPA #1 Fire Prevention Code 1992 edition), Chapter 42, Reference Publications, (NFPA #70).

The references available to the Fire Inspector, regarding electrical equipment and systems, are as follows:

- NFPA Fire Protection Handbook.
- NFPA Inspection Manual.
- NFPA National Electrical Code (NEC).
- NFPA National Fire Codes.
- State and local codes where applicable.
- Federal codes where applicable.
- Handbook of Practical Electrical Design McGraw/Hill.
- Popular Mechanics Sunset House.

Summary

The biggest problems you will find with electricity will be wiring, as you have noticed. Check all visible wiring closely. Always specify that an electrician make repairs when needed.

Be observant. The electrical hazards will be evident. Trace visible cords to see where they go. You will find cords running through walls, doorways, windows, etc. These are hazards and must be corrected. Cords should not be coiled or tied in knots, etc.

Typically, the messy occupancy is going to have electrical hazards as well as other types of hazards.

Clean, newer buildings are less likely to have electrical hazards than are older occupancies.

You will probably find the most electrical hazards at:

- stores;
- industrial occupancies; and
- schools.

Remember: Worn out electrical equipment is a common cause of fires. Be observant.

Static Electricity

In order for static electricity to be a source of ignition, four conditions must be present:

- Means of static generation.
- Means of accumulating the charge and maintaining a difference of potential.
- A spark discharge of adequate energy.
- Spark occurs in ignitable mixture.
- Methods for bringing the situation under control include:

    - Humidification.

    - Bonding, grounding.

    - Ionization.

    - A combination of the three.

No matter what you do, static electricity cannot be totally eliminated.

Work with your electrical inspector in your local area for treatment of code violations.

HEATING

General Information

Heating, ventilating, and air conditioning systems are found in most occupancies and present unique problems for the inspector.

Various types of heating systems the inspector will come in contact with during his/her duties include:

- boilers;
- warm air furnaces;
- wall furnaces; and
- unit heaters.

Heating appliances and equipment are one of the most prevalent causes of fires, because their function is to operate at above the normal ignition temperature of many combustible materials.

Defective or overheated heating units are one of the leading causes of fires. Some hazards commonly found are:

- Improper installation.
- Improper maintenance.
- Improper operation.
- Inadequate clearance of appliance and combustible materials.
- Inadequate clearance of flue pipes and vents.
- Inadequate clearance of steam pipes.

Equipment

Warm-air Furnaces

The various warm-air furnaces are broken down into four types:

1. Gravity.
    - Movement of air is by gravity.
    - Gravity furnaces are floor mounted and heat the space around them.
2. Gravity with integrated fan.
    - Fan is part of the construction of the furnace, for overcoming internal resistance to air flow.
3. Gravity boost fan.

- Fan does not restrict flow of air.

- Flow of air is by gravity when fan is not operating

4. Forced air.

   - Movement can be horizontal, vertical, or downflow.

   - Equipped with fan that provides the primary means of circulating air.

   - May be on the floor or suspended, in the attic, or on the roof; uses flue, ducts, registers; all need adequate clearance.

These forced-air and central warm-air furnaces may be classified according to the direction of the airflow through them as horizontal, upflow, or downflow.

The following may cause fires:

Inadequate clearance. Combustible materials, either the building itself or the contents.

Lack of proper limit controls.

Heat exchanger burnout.

Improper installation, service, or maintenance.

Warm Air Stove (wood stove)

U/L Standard #182 (room heaters, solid fuel type) is used to determine safe operation and clearance from combustible materials. The standard also requires the manufacturer to provide complete installation and operating instructions, how to dispose of ashes, and the prevention and removal of creosote with each unit.

***Note: These appliances shall not be installed in hazardous locations.

The following may cause fires:

- overheating;
- carelessness with ashes;
- inadequate clearance; and
- creosote buildup.

Steam or Hot Water Type Boilers

American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code defines low-pressure boilers as steam boilers operating at pressures not exceeding 15 psi, and hot water boilers operating at pressures not exceeding 160 psi and temperatures not exceeding 250 °F, and some other boiler safety devices according to type:

- Equipped with safety devices to prevent overpressure.
- Automatic boilers have a control to shut off the burner or electric heating element when the boiler water is low.
- Predetermined pressure or temperature has been reached.
- Controls for fuel-oil burners.
- Primary safety control-shut off in the event of ignition failure.
- Control valves must be placed near equipment being supplied.

The following may cause fires:

- Clearance.
- Mounting.
- Explosion--buildup of unburned fuel in fire box.
- Overpressure.

Heat Pump

Two systems in one unit, heat and refrigeration.

Heating, ventilation, and air conditioning system components whose energy input in the cooling mode is entirely electric.

The following may cause fires:

- Electrical power.
- Refrigeration equipment.
- Heater equipment.
- Dirty filter in heater unit.
- Motor and fan--dust, oil, and accumulations.

Solar

The solar energy system's components contain pressurizing fluids, and temperatures exceeding the design limits, with pressure and temperature relief valve(s).

Some codes (Mechanical, Building) allow solar energy systems to be installed in, on, or adjacent to an existing building without having to bring the entire building into compliance as required for a new construction, provided that the affected portion of existing building's mechanical, plumbing, and electrical systems comply with applicable provisions of the requirements. Check your code for these requirements for installing solar energy systems.

Solar energy systems designed and constructed so that air temperature in the supply systems shall not exceed 250 °F.

*Flammable and combustible heat transfer fluid from the solar energy systems shall not be used in a heat exchanger located in a duct system.

The following may cause fires:

- High temperatures (400 °F)--there is a risk of combustion after prolonged use.

Fireplaces/Chimneys

Basically, an inspector will come in contact with three types of chimneys: masonry, factory built, and metal. With the increased use of wood heaters as a secondary means of heating, fireplaces have caused the fire service serious problems. These problems can be attributed to unsound design, cracking, old mortar, lining cracked or broken, combustible material too near fire box, or combustible material in the chimney wall.

Masonry construction (low-duty lining).

- Eight inches of brick or equivalent for the back and sides.
- Two inches clearance to combustibles at the sides and four inches minimum clearance at back.
- If low-duty lining is not used, a thickness of twelve inches is required for both back and sides.
- Hearth--sixteen inches in front and eight inches beyond the sides for openings less than six feet; for openings larger than six feet, twenty inches on front, and eight inches on the sides.

(The above clearances may vary with each code.)

Factory built (must meet U/L 103).

- Metal construction.
- Prefactory hearth.
- Liners.
- Insulation to obtain required level of safety.

These consist of the fire box, chimney sections, and roof assemblies. All clearances are given in the manufacturer specifications.

Metal

Metal chimneys are not subjected to safety testing of any kind. Metal chimneys are suitable for all classes of appliances. They are located outside the building but not inside one- and two-family dwellings or buildings of wood-frame construction. NFPA Inspectors Manual 5th Edition.

They must be of adequate thickness and properly braced. The part of the chimney inside a building over one story should be in a one-hour fire resistance shaft (check your code for proper requirements).

The following may cause fires:

- Ignition by radiation of combustibles.
- Ignition by sparks.
- Combustion of structural members.
- Burning highly combustible materials.
- Improper use of flammable liquids.
- Failure to clear creosote in chimney.
- Failure to have chimney inspected, cleaned, and maintained.
- Using unapproved material in a woodburning stove (coal, for example).

Unit Heaters

These heaters are self-contained units automatically controlled; they may be mounted or suspended type. The unit heater consists of a combination of heating elements and a fan in a common enclosure. The unit heater may be connected to a duct system; it is then considered a central heating system and must meet the requirements of such.

The following may cause fires:

- Improperly vented.
- Clearances (in range of). 18" sides.
  6" top.
  18" front and rear.

  (The above clearances may vary with each code.)
- Maintenance of fan and burner.

Portable Heaters

A self-contained unit.

- Kerosene--has fuel tank.
- Electric--may have fan for heat movement.
- Liquid Petroleum.

The following are hazards due to portable heaters:

- Not properly vented.
- Too close to combustibles.
- Not following the manufacturer's instructions for use and clearances.

Fuels Used

There are various types of fuels used today: coal, oils, natural gas, LPG, electricity, wood, and solar energy. All of these can, except for electricity, contribute to a fire if not properly stored or handled. Electricity does not possess a fuel-storage hazard.

Coal--seven types.

1. Anthracite.

   - Hard coal, minimum smoke, minimum dust hazard.

2. Semianthracite.

   - Higher volatile content, not as hard as anthracite.

3. Bituminous.

   - Gives off considerable amounts of smoke and soot; subject to spontaneous ignition; dust hazard.

4. Semibituminous.

   - Subject to spontaneous ignition under some storage conditions.

5. Subbituminous.

   - Subject to spontaneous ignition under some storage conditions.

6. Lignite.

   - Subject to spontaneous ignition under some storage conditions; burns with little smoke or soot.

7. Coke.

   - Made from the distillation of coal.

Along with wood, coal is the principal solid fuel used in heat-producing appliances. In coal storage the following conditions must be met:

- No more than 25 to 30 tons in any one bin.
- Kept cool, below 80 °F.
- Well ventilated.
- Kept free of debris.

Other Solid Fuel

Wood.

- logs;
- scrap lumber;
- wood waste; and
- hogged fuel.

Paper.

Charcoal.

Peat.

Fuel Oil

Fuel oil #1 and #2 kerosene, range oil, furnace oil, star oil, and diesel oil are distilled oils. Fuel oils #4, 5, and 6 are Bunker C Residual oils.

Oil burners that are listed by U/L have the permissible grade of fuel oil to be used marked on the attached U/L listing label.

In the storage of oil, the following conditions must be noted

- Fuel-oil storage inside a building cannot exceed 660 gallons unless the tank is protected by special fire-resistive enclosures.

- For storage located above the lowest story no more than 60 gallons is permitted without being protected by special fire-resistive enclosures.

- The oil storage tank must be at least five feet from the burner or other flame-producing appliances.

- Fills and vents for tanks must be located on the outside of the building.

- Control valve to shut off fuel supply is required at tank.

Primary safety control for fuel oil burners causes the fuel to be shut off in the event of ignition failure.

Control valves must be placed near equipment being supplied.

Types of tanks include

- Unenclosed tanks in buildings.
- Enclosed tanks in buildings.
- Outside above-ground tanks.
- Underground tanks (check local laws).
- Centralized oil-distribution systems.

Gas

Natural gas is the most commonly used. Gas-fired heat-producing equipment uses either liquefied petroleum gas (LPG) or natural gas.

Natural gas.

- Methane, some ethane, propane, butane, and small amounts of CO_2 and nitrogen.
- Liquefied Petroleum Gas (LPG).
- Propane.
- Propylene.
- Butylene.
- A mixture of any of the above.

Gas Fuel

Natural gas or LPG (Propane and Butane) gas burners that are listed by U/L or approved by A.G.A. (American Gas Association) have the permissible type of gas to be used marked on the attached appliance label.

Changing from one type of gas to another without changing the burner control can be very dangerous.

Storage of gas fuels:

- Natural gas.

  - large tanks;
  - cryogenic tanks; and
  - pipelines.

- LPG.

  - cylinders; and
  - large tanks.

Electricity

Electricity involves two basic properties:

- resistance; and
- induction.

All electrical heating systems should be installed according to your electrical code.

Resistance heating is used in unit heating, central hot water systems, warm air heaters, and radiant heating systems (walls, floors, and ceilings). Induction heating is used in furnaces for melting metals, and to heat metal below melting point.

Installation

Part of the condition of listing is that printed instructions are included with the equipment.

These instructions include:

- Clearances.

- Type of fuel.

  - natural gas; and
  - LPG.

Suitable material for equipment mounting.

Ample air be provided for combustion and ventilation.

For additional information for installation of equipment, check your local codes and these additional standards:

- NFPA 31 — Oil-Burning Equipment, Installation
- NFPA 54 — Fuel Gas Code, National
- NFPA 90A — Air Conditioning and Ventilating Systems
- NFPA 90B — Warm-Air Heating and Air Conditioning Systems

Clearance

Access to boilers for inspection, maintenance, and repair passageway width of eighteen inches.

Power boiler--excess of 5,000,000 Btu/h, seven feet clearance top of boiler to ceiling. Check your local code.

Low pressure heating boiler and hot water supply boilers.

Over 5,000,000 Btu/h, or 5,000 pounds steam per hour, or 1,000 sq. ft. heating surface and power boiler under 5,000,000 Btu/h, three feet clearance to top of boiler and ceiling. Check your local code.

Packing boilers, miniature boilers, low heating boilers, and hot water supply boilers.

Minimum of two feet clearance from top of boiler to ceiling.

(The above clearances may vary with each code.)

Unit heaters must be floor mounted clearance:

- Above top 18"
- Front 48"
- Side 18"
- Back 18"

(The above clearances may vary with each code.)

Suspended (according to type of fuel and code used):

- Above 1" to 18"
- Front 1" to 48"

- Back 1" to 18"
- Sides 1" to 18"

***Note: The above clearance figures are in the range of each code but may vary.

Warm-Air Furnaces (according to fuel):

- Above 6"
- Front 18" to 24"
- Back 6"
- Sides 6"

***Note: The above clearance figures are in the range of each code but may vary.

Solid fuel burning stoves.

- 18" from side or front to combustible floor.
- 36" from rear corner to combustible wall.
- 18" from vent pipe to combustible wall.

***Note: For clearance to combustible wall with protection, check NFPA 211 (Chimneys, Vents, Fireplaces and Solid Fuel Burning Appliances), local mechanical code and NFPA Fire Protection Handbook 17 Edition.

All appliances shall be installed according to manufacturer's specification. Such appliances may be installed in rooms but not in closets. Such rooms shall meet the requirements of your local codes.

All boiler rooms/furnace rooms must meet the requirements of the building code and mechanical code for the proper fire rating and combustion air makeup. (Other than electrical appliances, all other heating equipment must have combustion air. Check your mechanical code for proper combustion air makeup.)

Appliances should be installed so that surrounding exposed combustible materials will not overheat to dangerous limits. The temperature should not exceed more than 90 °F from a normal temperature of 70 °F, or a maximum of 160 °F.

Appliances that have been tested by laboratories have the proper clearances noted on their listings in the manufacturer's installation manual.

These clearances are noted from the rear, sides, top, front, and bottom of the appliances.

Modifications of the clearances can only be made with special insulation requirements that are noted by the local codes.

Underwriters' Laboratories Standard #182 (room heaters, solid fuel type) is used to determine the safe operation and clearance from combustible materials. The standard also requires the manufacturer to provide complete installation and operating instructions, how to dispose of ashes, and the prevention and removal of creosote with each unit.

Evaluate any special hazards present in the room (possible flammable liquid vapors, compressed gas storage, hazardous dusts, paint spray vapors).

Check proposed installation for any restrictions in the codes, standards, and testing lab listing. What may be safe in one occupancy may not be in another.

If the device is approved, make sure it is installed according to the manufacturer's directions (which should be on a plate attached to the equipment or in the installation manual provided with the equipment).

Check that all required control valves and other safety features are installed and working properly.

Operational Problems

Vents are a major maintenance problem, and must be checked. Their purpose is to remove unburned fuel and products of combustion. Vents used over cooking appliances also handle grease-laden vapors which can build up in the vent and be a serious fire hazard.

With the exceptions of appliances listed for use without vents, all gas, oil, and solid-fuel heaters as well as heat-producing appliances are required to be vented. Be alert for old, illegal, unvented gas heaters. These devices, primarily used in dwellings, produce lethal amounts of carbon monoxide and have killed many people. When inspecting dwellings, apartment houses, old hotels, homes of the elderly, etc., be alert for these. Get them removed through your fire code or state housing laws.

The types of vents are:

- Single-wall metal pipe for use when venting can be run directly through roof or wall to exterior of building.
- Type B for gas appliance with draft hood.
- Type BW for recessed gas wall furnace.

- Type L for oil-burning equipment and appliances listed for use with Type L vents.
- ABS--Plastic vent approved for high efficiency heating units.

Factory-built or masonry chimneys must be used with solid-fuel burning equipment (wood or coal). If you have a question about the proper venting material, check with your local building officials. You can also check U/L and A.G.A. Listings. NFPA standards can also give you information on installation of venting.

Vent connectors should be:

- As short as possible.
- Well supported.
- Pitched up toward chimney.
- Adequately cleared from combustible materials.

Special attention must be given to the connection between the heating device and the chimney or vent where the connection passes through a combustible wall partition.

Items to look for when checking vents:

- Connections must be tight fitting.
- Surrounding combustible material must be protected from heat radiating from the vent itself.
- Vents must have adequate clearance from combustibles such as wood, roof materials, cabinets, etc., to prevent pyrolytic breakdown of the wood at low temperatures (as low as 212 °) over a long period of time.

This breakdown lowers the ignition temperature of the wood and causes it to ignite. This is common also with steam pipes next to wood.

Any vent that shows loose connections, corrosion, or is too close to combustible construction must be replaced.

You will only be able to see portions of the vent system. This observation will have to indicate to you the probable condition of the hidden sections.

Vents must be of the proper type for the appliance or equipment.

The lack of proper servicing and good maintenance can result in fires. The following items should be checked when inspecting a heating appliance:

- Filters in heating units, for cleanliness and proper type.
- Motors and fans are free from dust, oil, accumulations, etc.
- Gas burners properly adjusted (look for excessive soot).
- Air supply for combustion in burners is adequate. The gas company will adjust them free of charge.
- Filters and ducts in cooling appliances should be clean and unobstructed.

If you find serious, unsafe, life-threatening situations, you may have to order the system shut down until repaired. Place your findings in writing and keep a copy. If the heating system is reactivated after you leave, you have a written record of your order to leave it off and get it fixed.

Summary

Problems associated with heating.

- Improper installation.
- Improper maintenance.
- Improperly operated.
- Inadequate clearance of appliance.
- Inadequate clearance of flue pipe and vent.
- Inadequate clearance of steam pipe.
- Overpressure of boiler.
- Improper mounting of appliance.
- Explosions--buildup of unburned fuel in fire box.
- Excessive temperatures.

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REFERENCE BOOKS

BOCA--National Mechanical Code

Uniform Mechanical Code

Standard Mechanical Code

NFPA Standards

NFPA 31	Oil-Burning Equipment, Installation of
NFPA 54	Fuel Gas Code, National
NFPA 90A	Air Conditioning and Ventilation Systems
NFPA 90B	Warm-Air Heating and Air Conditioning Systems

NFPA Fire Protection Handbook

ASME--Boiler and Unfired Pressure Vessel Code

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COOKING

General Information

The main problem with cooking equipment is the circulation of grease in the duct, hood, and fan housing, both in residential and commercial systems. If a fire should start in the system, burning grease can reach temperatures of 2,000 °F.

The entire system should be arranged so that cleaning is readily possible. Grease filters must be removed and cleaned or replaced at intervals to prevent grease buildup, which in time will allow grease vapors to accumulate in the duct. The system should be cleaned inside to prevent grease accumulation. The frequency will depend on what type of cooking equipment is used and how often it is used.

The entire system should be treated as a chimney. The system should not be interconnected with air conditioning systems or any other venting or exhaust systems in the building. Where ducts pass through combustible walls, floors, attic, and roof framing, they should be provided with a clearance of 18". Ducts should not pass through fire walls or fire-rated partitions.

Equipment

Commercial

- ranges;
- deep fat fryers (separate high-limit control to shut off fuel or energy when fat reaches 475 °F);
- portable ovens;
- convection ovens;
- steamers (check fuel supply);
- broiler;
- warmer (hot plate);
- microwave ovens; and
- tilting skillet.

Some of the above equipment can produce grease-laden vapor that contributes to the spread of fire and installation next to combustible materials also can contribute to fire causes.

The above equipment shall be installed according to the manufacturer's instructions. Equipment used in commercial cooking is either **listed** or **unlisted**. For allowed installation clearances, check your local code or NFPA 54 for gas equipment.

Residential

- ranges;
- wall-mounted ovens;

- drop-in ranges;
- countertop units; and
- microwaves.

Can be either electric or gas. The electrical equipment must have a means of disconnection, not wired directly into the electric distribution system.

Listed built-in household appliances shall be installed according to the manufacturer's specifications and listing. This equipment may be installed next to combustible materials unless otherwise noted in the installation instructions. Unlike listed equipment, the unlisted shall not be installed in, or next to, combustible materials.

Adequate clearance and installation must be followed according to manufacturers' directions.

Fuel Used

Gas--Natural and Liquefied Petroleum

Piping.

Cutoffs.

Automatic shutoff of fuel or heat with the operation of an extinguishing system.

Electrical

Disconnects.

Power shutoff.

Automatic shutoff of fuel or heat with the operation of any extinguishing systems.

Other

Portable gas and electric grills.

Charcoal grills.

Hot plates.

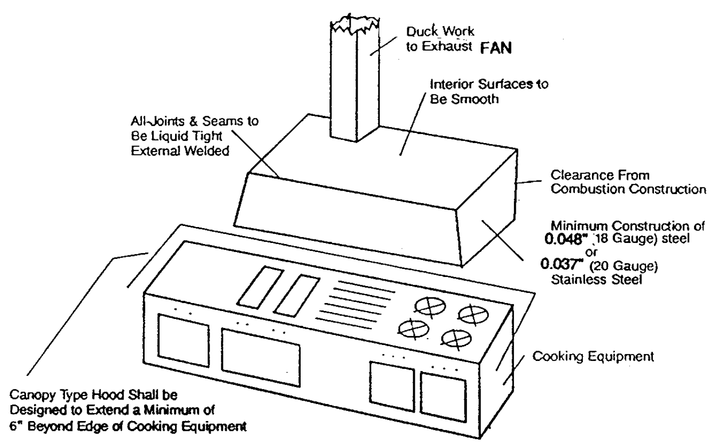
Adequate clearance from combustibles is essential. The use of portable equipment next to or in the means of egress is prohibited. Check your local codes.

Related Equipment

Hood

- Tested in accordance with U/L 710.
- Conforms to all of the requirements of the code for hoods.
- Installed according to the manufacturer's instructions.

KITCHEN HOOD



Construction.

- Minimum normal thickness shall be 0.048 inch (18 gauge) steel/0.037 inch (20 gauge) stainless steel.
- Check local code for required thickness.

Joints/Seams.

- External welded; and
- Liquid tight.

Interior surface shall not have any areas where grease can accumulate except where there is a grease collection system including filters and troughs on the outer edge of the canopy hood.

Canopy hood shall be designed to cover cooking equipment and shall extend a minimum of six inches horizontally beyond the edge on all sides.

Noncanopy type shall be a maximum of three feet above cooking surface and shall be set back a maximum of one foot from the edge.

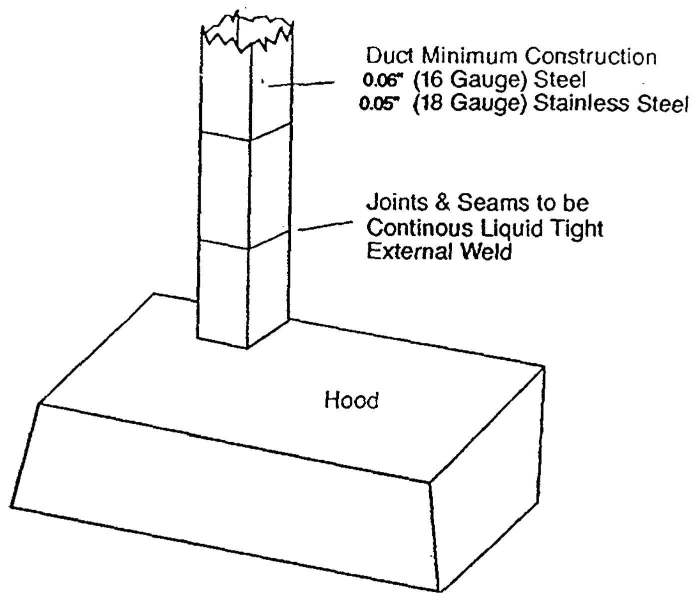
Exhaust shall be designed to create a draft from the cooking surface into the hood.

Ducts

- Design.

- As an independent system to remove kitchen exhaust without obstruction. Places where grease may collect shall not be interconnected with any other building ventilating or exhaust system.

DUCT WORK



- Construction.

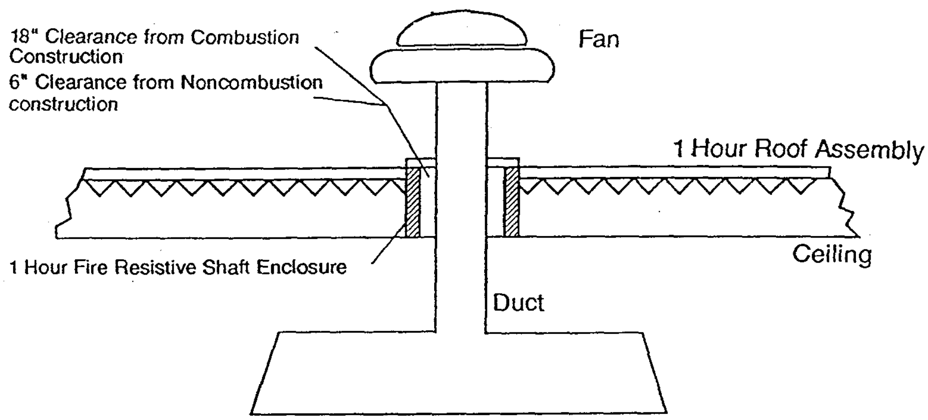
- Minimum thickness of 0.060" (16 gauge) steel, or 0.050" (18 gauge) stainless steel.
- All joints, seams, and connections should be welded liquid tight.

- Enclosed shaft.

- Shall be enclosed in a fire-resistant rated shaft; six-inch clearance between shaft and duct.

DUCT WORK ENCLOSURES

Example 2



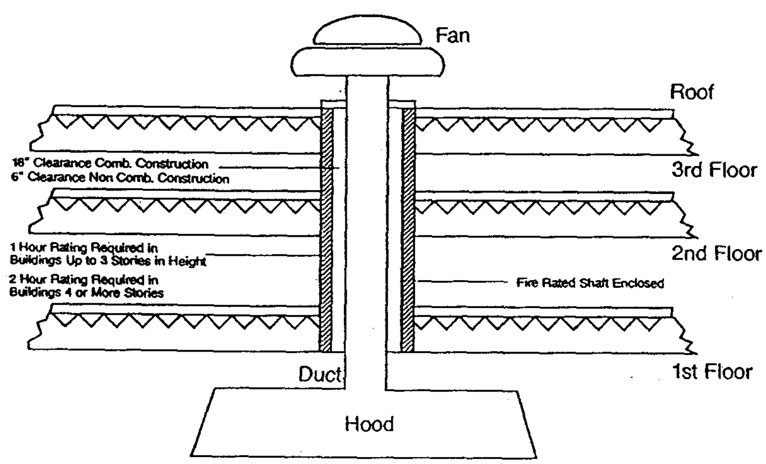
Example of Installation in 1 Story Building
WITH a Fire Rated Roof/Ceiling Assembly

- Example:

- One story--where the ceiling and roof assembly have a fire rating, the integrity of the fire separations required by the applicable building code must be maintained.

- Two or three stories--one-hour rated shaft.

DUCT WORK ENCLOSURES



- Four or more stories--two-hour rated shaft.

Duct shall not penetrate a two-hour wall or partition of the interior.

- Clearance (exposed duct).

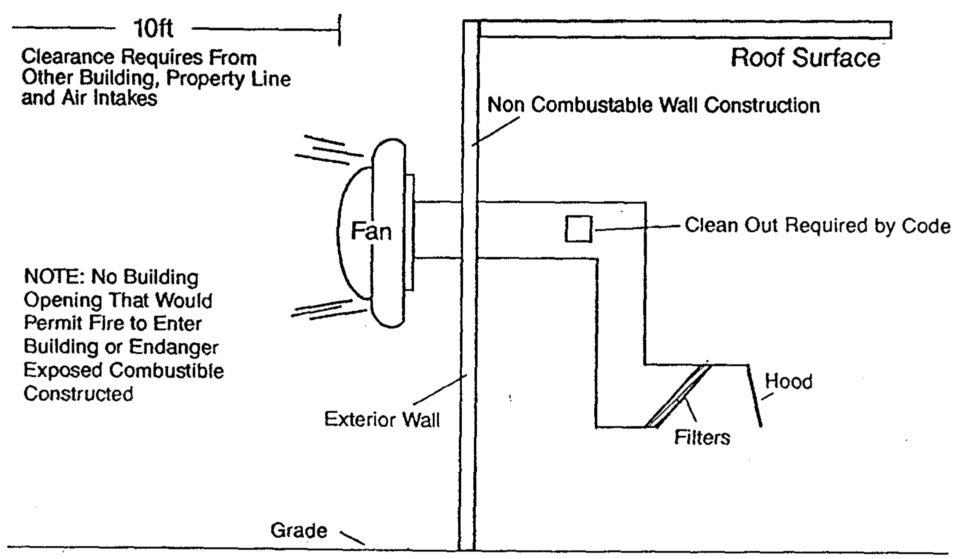
- Eighteen inches from combustibles.
- Three inches if it is one-hour rated to protected combustibles, with a clean out twenty feet on horizontal.

- Termination.

- Outdoor, above roof, exterior wall.

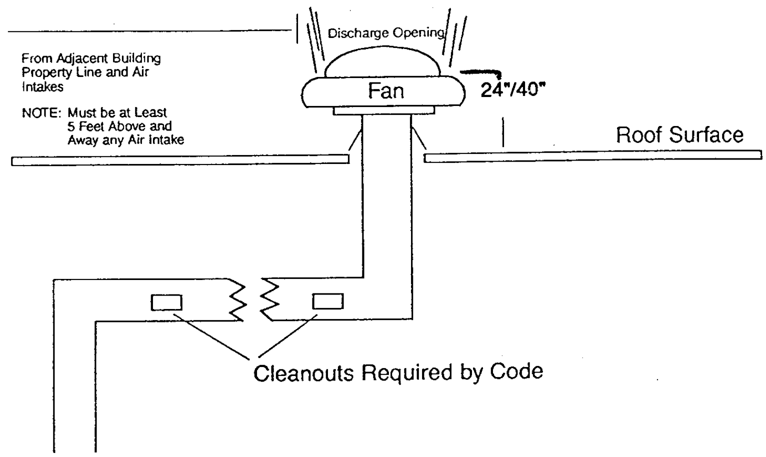
  Ten feet above adjoining ground level.

DUCT WORK TERMINATION



Forty inches above roof (depending on code).

DUCT WORK TERMINATION



If through exterior wall, shall be of noncombustible construction, not located within three feet of an opening.

Grease Removal Devices

- Must be accessible for cleaning.
- Know distance between the lowest edge of grease filter and cooking surface (check your local code).

  Example:

  Exposed flame 1-1/2' to 2-1/2' with fire extinguishment system varies with different codes.

Filters shall be approved/listed specifically for grease removal.

Filters shall be installed at an angle (according to your code) to capture and drain grease to a point of collection of no more than one gallon in a noncombustible container.

Grease extractor must be specifically listed for this service and must meet the requirements for the material to be used.

Air Movement

- Exhaust fan.

- Motors shall not be installed inside duct.

- **Exception** NEMA Class I explosion-proof motors.
- Fan blades shall be rigid, of noncombustible material.
- Rated for continuous operation.

- Wiring for fan shall not be exposed within hood.

- Air movement within the duct 1,500 fpm.

- Replacement air shall be in an amount sufficient to prevent negative pressure.

- Make up air openings terminating in the hood, may require a fire damper.

***Note: Test data or performance test shall be provided if requested; both may be requested.

Wiring and Lighting

Motor and receptacle for flammable vapor or combustible dust must be listed for Class, Group, and Division.

Wiring shall not be installed in the duct.
Fixtures (lights).

Corrosion-resistant or protection against corrosion; listed for use in commercial cooking hoods.

Fume-recovery and air-pollution devices.

May be installed or located in the path of travel of exhaust when approved for such uses and do not increase the fire hazard.

All electrical equipment shall be installed according to the electrical code. All electrical equipment shall be specifically approved for such use.

Code Requirements For Fire Suppression

Fire extinguishing equipment shall be provided (exception: when cooking equipment is served by listed grease extractor the AHJ may omit the fire suppression equipment). (Check your local code.)

Portable extinguisher in cooking and kitchen area. (Note: Agents must be compatible.)

Duct, hood, and grease-removal devices covering the cooking equipment and cooking surface protected by fire suppression systems.

Automatically shut off all sources of fuel and heat; all gas appliances under the hood, but requiring protection, shall shut off automatically.

A manual release is required for each system.

Review of systems plans before installation certification by the installer that the system has been installed and tested properly.

Installed in accordance with the manufacturer's instructions.

Fusible links and automatic sprinkler heads shall be replaced as frequently as necessary, or annually if of the metallic type.

During the inspection, according to the manufacturer's listed procedures, all actuation components shall be checked and operated at least annually (tested).

Hazards

Accumulation of grease on hood, grease removal device, fan, and ducts.

Lack of maintenance on fire-suppression systems.

> Fusible links.
>
> Heads/Nozzles.
>
> Control cables.

Dirty filters.

Improper (unlisted) filters.

Filters not tight.

Drip trap full.

Shutoff device locked out.

Has not been serviced at least every six months.

Inadequate clearance to combustibles.

Using flammable cleaning solvents.

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REFERENCE BOOKS

BOCA National Mechanical Code

Uniform Mechanical Code

Standard Mechanical Code

NFPA 96 Removal of Smoke and Grease Laden Vapor for Commercial Cooking Equipment

NFPA Fire Protection Handbook

NFPA National Electrical Code

NFPA 10 Fire Extinguisher Portable

NFPA 12 Carbon Dioxide Extinguishing Systems

NFPA 13 Sprinkler Systems, Installation

NFPA 16 Foam-water Sprinkler and Spray Systems

NFPA 17 Dry Chemical Extinguishing Systems

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Standard Fire Prevention Code--Southern Building Code Congress International, Birmingham, Alabama.

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NFPA 13, *Standard for the Installation of Sprinkler Systems*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 31, *Installation of Oil Burning Equipment*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 70, *National Electrical Code*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 90A, *Air Conditioning and Ventilating Systems*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 90B, *Warm Air Heating and Air Conditioning Systems*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 96, *Vapor Removal Cooking Equipment*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 211, *Chimneys, Vents, Fireplaces and Solid Fuel Burning Appliances*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 325M, *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 496, *Purged and Pressurized Enclosure for Electrical Equipment*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 497A, *Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 497M, *Manual for Classification of Gases, Vapors, Dusts for Electrical Equipment in Hazardous (Classified) Locations*, National Fire Protection Association, Quincy, Massachusetts.

MODULE 7: FIRE PROTECTION SYSTEMS AND EQUIPMENT

TERMINAL OBJECTIVES

The students will:

1. *Be able to verify that commonly used fire protection systems and equipment are operational.*

2. *Be able to review and interpret fire protection system inspection and test reports to identify operational deficiencies.*

3. *Be able to describe common fire suppression agents and explain where they are used.*

ENABLING OBJECTIVES

Given the content of the module, the students will:

1. *Determine the suitability of portable fire extinguishers and their operational readiness.*
2. *Describe common types of fire extinguishing agents and explain how they suppress fires.*
3. *Identify the fire inspector's role in enhancing fire protection equipment reliability.*
4. *Identify five types of automatic sprinkler systems and describe their operation.*
5. *Explain how sprinkler selection may affect sprinkler system performance.*
6. *Identify common impairments to automatic sprinkler systems' effectiveness and recommend corrective actions.*
7. *Review a sprinkler system inspection and test report, and identify operational deficiencies.*
8. *Describe three sprinkler system tests and state the purpose of each test.*
9. *Utilize test documentation to verify the adequacy of the water supply for automatic sprinkler systems.*
10. *Identify the operational components of standpipe systems.*
11. *Identify the basic components of a fire alarm system.*
12. *Identify impairments to fire alarm system performance.*
13. *Create a commercial kitchen fire suppression system inspection procedure.*

INSPECTOR'S ROLE IN ENHANCING FIRE PROTECTION SYSTEMS' RELIABILITY

The fire inspector plays an important part in enhancing the reliability of fire protection systems and equipment. While manufacturers, designers, and engineers work together to create systems to protect a broad range of hazards, it is often up to the fire inspector to assure the finished product meets national standards and the designer's plan. Once the systems or equipment are installed, it is up to the fire inspector to assure they remain in an operable condition.

There are at least seven phases in a project where the fire inspector has the opportunity to influence the outcome. The first occurs during the plan review or permit phase, where the inspector verifies that the system and equipment designs are in compliance with the nationally recognized standards (such as NFPA 13, *Standard for the Installation of Sprinkler Systems*), the listing documents to make certain the product or system has been evaluated, or the manufacturer's requirements for design suitability. In some agencies, this responsibility lies with a highly trained plans examiner or fire protection engineer, but in many communities it falls upon the fire inspector to perform this service.

Second, the fire inspector must verify the work is being installed in accordance with the approved plans and specifications. This may require one or more visits to a construction site to watch the work progress toward completion.

Third, the fire inspector likely is involved in system commissioning or acceptance testing. For sprinkler systems, this may mean observing and verifying the hydrostatic and flush tests for underground water mains, the pressure tests on aboveground piping, and final tests before the building is issued a certificate of occupancy. Each type of fire protection system, ranging from water-based to electronic devices, has special acceptance testing criteria. In some instances, it may be up to the fire inspector to determine what is an acceptable test, and what constitutes successful passage of that test. For example, there is no national consensus on smoke control system tests to determine whether the system has performed as designed or not, primarily due to the complex variables that occur in smoke management design.

Postoccupancy

Once the building or facility is occupied, the fire inspector conducts periodic **inspections**, visual checks that verify whether the systems and equipment are in place, appear to be operational, and have been serviced as required. This is a routine part of every inspector's job.

All fire protection systems require periodic testing to verify their operational readiness. Testing is a task normally conducted by a third-party service, such as a fire protection systems contractor, that exercises the operational components of the fire protection systems to assure they are operational. This might include such things as sprinkler trip tests, hydrostatic tests on portable fire extinguishers, calibration tests on smoke detectors, and flow tests for standpipe systems. In most cases, the fire inspector is responsible for reviewing posttest reports to verify all work has been accomplished in accordance with minimum testing standards.

Should one or more components fail during the tests, or be identified as obsolete and in need of replacement, the fire inspector may have to encourage strongly the property owner to initiate repairs. From time to time, owners will defer repairs hoping that nothing catastrophic will occur while the system or equipment is inoperative.

Finally, any fire protection system is only as good as its regular maintenance. Just like manufacturers encourage us to change the oil and rotate the tires on our vehicles, fire protection systems need periodic tune-ups as well. The fire inspector may have to remind the system owner that the fire protection equipment is due for regular service to keep it operational and ready for that disaster we hope never occurs.

FIRE SUPPRESSION CHEMICALS AND AGENTS

Fire suppression and extinguishment involve two essential variables: the extinguishing agent and the system, equipment, or procedure for applying the agent. The primary methods of achieving fire suppression can be explained through the use of the fire tetrahedron, which evolved from the familiar fire triangle. The fire triangle is a graphic representation of the three components that must be present in adequate supply for combustion to occur: 1) fuel, 2) heat, and 3) oxygen. If one or more of these components is/are removed, or sufficiently reduced, combustion ceases. Fire protection professionals now characterize fire development with the addition of an "uninhibited chemical chain reaction" to sustain combustion.

Fire suppression is achieved by the process of removal or reduction of one or more components of the fire tetrahedron.

Water is the most common fire extinguishing agent used. Water has several features that make it a widely selected fire extinguishing agent. It also has some limitations that must be considered. Water can extinguish fire by cooling the fuel below the temperature at which the fuel can produce flammable vapors. Water also can extinguish by smothering, dilution, and emulsification.

Water has a very high specific heat. A great deal of heat must be applied to water before it can become steam; that is, before it can change from the liquid to the gaseous phase. Water applied to a fire will absorb a large portion of the heat released by the fire. If enough heat is absorbed the fire will be extinguished, since the fuel cools below the temperature required to liberate additional flammable vapors. Once water is converted to steam, it is still an effective fire extinguishing agent, since the steam can continue to absorb a great deal of heat. It is best to introduce water into the fire area in the form of a spray as opposed to a stream. A spray will allow for the quicker absorption of heat produced by the fire. For this reason, sprinklers discharge water in a spray pattern.

When water is transformed into steam, its volume increases approximately 1,600 times. This acts to displace the air and, thus, the oxygen from the fire area. This will result in the smothering, or oxygen depletion, of the fire. Without adequate oxygen, the fire soon will die. Thus, water transferring to steam acts as a suppression agent in two ways: heat absorption and oxygen displacement.

Extinguishment by dilution refers to the introduction of water into a burning liquid. The dilution acts to cool the liquid and reduces the vapor production at the fuel surface, since the flammable liquid is diluted. Emulsification is another method of fire extinguishment using water. An emulsion is formed when insoluble liquids are mixed and one of the liquids becomes dispersed in the other. The emulsion that forms at the surface will retard the liberation of flammable vapors and the fire will die. Dilution and emulsification have several limitations and are not generally a good way to extinguish a flammable liquid fire. Spills and boilovers may occur in some petroleum storage tanks, causing the fire to spread and possibly cause injuries.

Another benefit of water as a suppression agent is that it is relatively cheap and readily available in most areas, especially if a municipal water supply is present. The major limitations of water are that it is extremely heavy, it conducts electricity, it can damage property, and it can freeze. However, there are design methods, including the selection of other agents, which can be employed to minimize the negative aspects of water as a suppression agent.

Water with Modifiers

Occasionally the water used for fire suppression has modifiers added to alter its characteristics. Foam is perhaps the most common example. Low-, medium-, and high-expansion foam concentrates frequently are added to water to form a foam solution for fighting certain types of fire, such as flammable liquid spills. Additives also include surface tension reducing agents, frequently called wetting agents. These increase the water's ability to penetrate combustibles, which allows the water to attack deep-seated fires. Antifreeze is used to reduce the freezing point of water when temperatures at or below freezing threaten the proper use of water-based fire suppression systems. Other water additives used with less frequency are discussed in the *Fire Protection Handbook.*[1]

Carbon Dioxide

CO_2 is a substance that has many commercial uses. Perhaps the most familiar is the carbonation in soda pop and other carbonated beverages. CO_2 also has a number of properties that make it a good fire extinguishing agent. Some of the most common uses of CO_2 systems occur in flammable liquid storage rooms or commercial printing operations. The spaces and equipment may be protected with a total flooding application or may have local application protection to protect specific hazards.

At room temperature and pressure, CO_2 can exist as a vapor or a solid (eventually the solid form will transfer to the gaseous form). The solid form is known as dry ice. For fire extinguishing purposes CO_2 cannot exist at pressures below 75.1 pounds per square inch (psi) absolute (about 60 psi). At this pressure, the liquid, vapor, and solid phases of CO_2 all can exist simultaneously. This triple point is important when designing piping systems to carry liquid CO_2. Pressure in the pipeline must not be permitted to drop below the triple point, or the attendant dry ice formation will block the pipe and stop the flow.

In any fire, heat is generated by the rapid oxidation of the fuel. Some of the heat generated brings the unburned portion of the fuel to its ignition temperature, while a large portion of the heat and combustion is lost by radiation and convection to the surroundings. If the atmosphere that supplies oxygen to the fire is diluted by adding carbon dioxide, the rate of heat generated by oxidation is reduced. When the rate of heat generation is less than the rate of heat loss, the fire will die. Complete extinguishment will occur when all of the fuels involved are cooled below their ignition temperatures.

When the liquid is discharged to atmospheric pressure, it "flashes" over to vapor and dry ice. The percentage of dry ice and vapor produced is dependent primarily on the storage condition of the liquid. The superheated CO_2 vapor is about 50 percent denser than air. The dry ice has a temperature of about 110 °F at atmospheric pressure. In spite of the low temperature of the dry ice particles, the heat capacity of the CO_2 is rather low compared to other fire extinguishing agents such as water. Thus the cooling effect, though present, is not as significant on a pound-for-pound basis as the cooling produced by water. Most of the dry ice from a typical total flooding discharge is sublimated by the air in the enclosure.

The evaporation of the dry ice in the fire zone removes heat from surroundings at a rate between 60 and 110 British thermal units (Btu's) per pound of liquid CO_2 discharged. While this cooling is small compared with the cooling obtained with other agents (water provides 10 times the cooling effect per pound), it does contribute to extinguishing effectiveness.

The relative high density of CO_2 vapor makes it useful for blanketing the surface of a fuel. The oxygen in the surrounding air is separated physically from the surface of a fuel. This effect is noticeable particularly with local application.

Clean Agents

For many years, halogenated fire extinguishing agents (See Halon™ below) were popular chemicals used for fire suppression because they effectively removed the fourth side of the fire tetrahedron, the chemical chain reaction, while leaving no postfire residue.

Halogenated fire extinguishing agents were manufactured from chlorofluorocarbons that have been linked to atmospheric ozone depletion, and their production has been banned by international treaties.

In order to find products that have equally effective fire control features, as well as have the desirable trait of being residue-free, the fire protection industry has developed a number of alternative fire suppression chemicals generically called "clean agents." These agents fall into two broad chemical categories: halocarbon compounds and inert gases.

Halocarbon compounds include chemical compounds containing carbon, hydrogen, bromine, chlorine, fluorine, and iodine. Halocarbons suppress fires by a combination of chemical and physical methods depending upon the compound. Most rely on breaking the chemical chain reaction; others suppress fires by extracting heat from the fire or depleting oxygen. Product names include Inergen™, FM 200™, and Novec™ 1230.

Inert gas agents, including argon and nitrogen, reduce flame temperatures below those necessary to sustain combustion. The inert gas reduces the oxygen concentration while simultaneously raising the heat absorbing capacity of the atmosphere around the fire; essentially drawing the heat producing capability from the fire. Commercially available inerting systems include Argonite™ and argon gases.

Halon™

Halon™ is a fire extinguishing agent that was commonly used to protect electronic and electrical equipment, and surface burning solids such as some plastics, flammable liquids, and gases.

Halon™ extinguishes fire by entering into, and disrupting, the chemical combustion chain reaction; the exact mechanism still is not understood completely. This is unique for a fire extinguishing agent in that it affects the chemical chain reaction as opposed to quenching (removal of heat by water, for example) or by smothering (by CO_2, for example).

The breaking of the chain reaction allows Halon™ to suppress fires quickly. In addition, Halon™ is considered a "clean" agent, in that it leaves no residue to clean up after discharge. Halon™ agents, as they are commonly called, are hydrocarbons in which one or more of the hydrogen atoms have been replaced by atoms of the halogen series, such as fluorine, chlorine, bromine, or iodine. Typically Halon agents are named by their chemical composition. This method was introduced by the U.S. Army Corps of Engineers in 1950.[2] The naming scheme, or nomenclature, system works as follows: the first number in the sequence refers to the number of carbon atoms; the second number, fluorine atoms; the third, chlorine atoms; the fourth, bromine atoms; and the fifth, if present, is the number of iodine atoms. Therefore, Bromotrifluoromethane, Halon™ 1301, has 1 carbon, 3 fluorine, 0 chlorine, 1 bromine, and 0 iodine (the iodine is not shown, as it is zero and last in the series).

Dry Chemical

Dry chemical extinguishing agents can cause extremely fast extinguishment if introduced directly into the flaming area. Smothering and cooling result from the application of dry chemical agents, but the primary extinguishing capabilities are due to the combustion-chain-reaction-breaking abilities of the dry chemical agent.

Dry chemical fire suppression systems utilize a dry chemical powder mixture as an extinguishing agent. Common dry chemical agents include sodium bicarbonate, potassium bicarbonate, urea-potassium bicarbonate, and monoammoium phosphate. Mixed in with the base compound are additives to reduce caking, promote water repellency, and increase flow and storage characteristics. Examples of common additives include metallic stearates, tricalcium phosphates, and silicones. Multipurpose dry chemical usually refers to the monoammonium agent, which can be used to suppress fires involving ordinary combustibles and energized electrical equipment, as well as flammable liquids. Regular dry chemical is not considered a good agent for ordinary combustibles, since water must also be applied to attack any subsurface burning that the regular dry chemical cannot reach. The multipurpose agent does have penetrating abilities, thus its multipurpose listing. Agents should never be mixed unless specifically listed for mixing, as some agents will generate CO_2, which may cause containers to explode and the agent to cake.

Dry chemical agents can be applied to portable fire extinguishers, hand hoselines, or fixed systems.

Examples of hazards that dry chemical agents can be used for are

- flammable and combustible liquids and combustible gases;
- combustible solids that melt when involved in fire (such as naphthalene and pitch);
- those fuels listed above that are released from transfer facilities, including transfer piping leaks;
- electrical hazards similar to transformers and oil circuit breakers; and
- multipurpose, ordinary combustibles and some plastics, if all involved surfaces can be covered by the agent.

Examples of hazards with which dry chemical agents are **not** considered satisfactory include

- chemicals containing their own oxygen supply, such as cellulose nitrate;
- combustible metals, unless the agent is specifically listed for such use;
- deep-seated fires in ordinary combustibles when multipurpose dry chemical agent cannot cover all involved surfaces;
- preventing reignition if a heat source is present; and
- commercial kitchen hood systems, as well as surface cooking units where vegetable cooking oils and insulated deep fat fryers are used.

Dry chemical agents are likely to leave sticky residues; they may adhere to electrical components; they are slightly corrosive; and they may affect occupant breathing and reduce vision. If the agent becomes moist, it may not flow properly through the systems and will not discharge properly. Dry chemical agents are considered nontoxic.

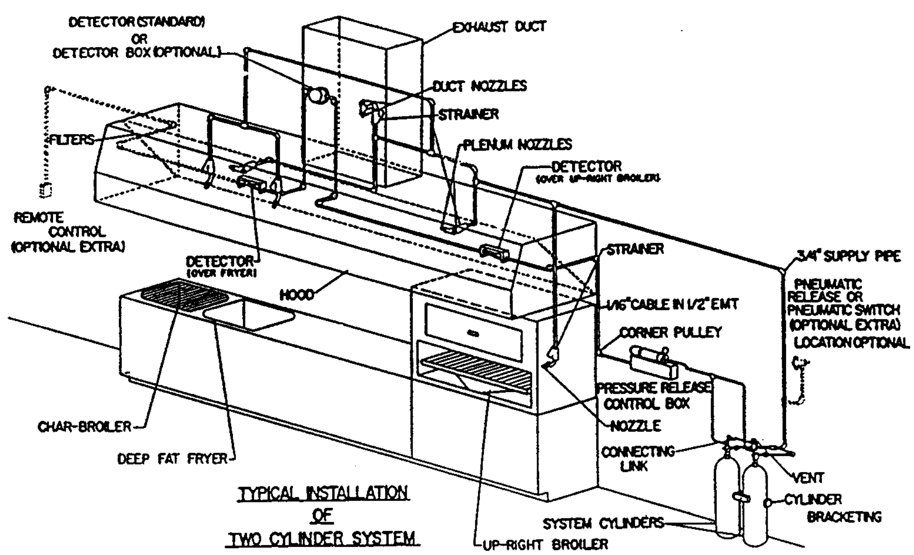
Wet Chemical

Wet chemical suppression agents are a common means of suppressing fires involving commercial cooking equipment. Leading manufacturers of wet chemical suppression systems introduced these systems in the early 1980's. Wet chemical suppression systems currently are accepted only for the protection of restaurant, commercial, and institutional hoods, plenums, ducts, and associated cooking appliances, and only pre-engineered systems are used.

Wet chemical extinguishing agents typically are potassium carbonate based, potassium acetate based, or a combination of these, mixed with water. These solutions are alkaline based and are discharged through system piping by an expellant gas. The wet agent's primary extinguishing capability is its characteristic of mixing with cooking grease to form a foam barrier over the burning fuel. This reaction is called "saponification." This causes a blanket effect, preventing the flammable volatiles from mixing with the oxygen needed for combustion. It also acts to cool the fuel surface, which aids in fire suppression.

The wet chemical agents generally are considered harmless to humans. Any effects that may occur usually disappear once contact with the agent is terminated. The agents may have corrosive effects on some metals; the manufacturer's literature should be consulted for such information. Also, the agents generally are listed for use in specific systems, and these warnings must be followed. In part, this is due to the testing of specific systems with specific wet chemical agents. Using nonapproved agents, or agents from other manufacturers, may render a system inoperative.

Restaurant Range Hood Wet Chemical System



PORTABLE FIRE EXTINGUISHERS

Purpose of Fire Extinguishers

The purpose of a portable fire extinguisher is to enable an individual with minimum training and orientation to extinguish an incipient fire after calling the fire department, and, when attempted, without risk to the operator. There are numerous significant fires where notification of building occupants and the fire department was delayed while extinguishment with portable fire extinguishers was attempted.

Extinguisher Use Based on Fire Classification

Fire extinguishers are classified by the type of fire(s) they are effective at extinguishing; therefore, a review of the standard fire-type classifications is required. These are

Class A: Fire in ordinary combustibles such as wood, cloth, paper, rubber, and many plastics, which can be extinguished by cooling, smothering, and insulation, or by inhibiting the combustion chain reaction.

Class B: Fire involving flammable or combustible liquids and gases, including greases and similar fuels, which can be extinguished by oxygen exclusion, smothering and insulation, and inhibiting of the combustion chain reaction.

Class C: Fire involving energized electrical equipment, which requires the use of a nonconductive agent for protection of the extinguisher operator. If electrical power is eliminated, these fires become Class A or Class B, and may be extinguished as appropriate.

Class D: Fire in combustible metals such as magnesium, potassium, sodium, titanium, and zirconium, which require the use of an agent that absorbs heat and which does not react with the burning metal.

Class K: With the advent of wet chemical fire suppression systems in commercial kitchens, manufacturers have developed K-rated extinguishers. These use an identical fire suppression agent to the fixed system. They are intended to be used to overspray the foam blanket from the fixed system to maintain its integrity.

Class A and Class B fire extinguishers also are given a numerical rating according to the size of the fire they can extinguish in the hands of a trained operator. Although somewhat subjective, a 2-A extinguisher is roughly equivalent to a 2-1/2-gallon water extinguisher; thus a 4-A extinguisher has about as much extinguishing capability as 5 gallons of water. Class B extinguishers are given a numerical rating based on the area of flammable liquid they can potentially extinguish. As an estimate, it can be assumed that for each unit of "B," 1 square foot of burning liquid can be extinguished. For example, a 10-B extinguisher can be used to extinguish a 10-square-foot shallow pan liquid fire. It must be emphasized that the numerical rating is for estimating only, as the actual effectiveness observed will depend on such factors as user qualifications and skill.

The classifications, including the numerical rating, can be compounded to provide multipurpose extinguishers. For example, a fire extinguisher listed as 4-A:20-BC has the capacity of two 2-A extinguishers, 20 times the capacity of a single 1-B extinguisher, and it can be used on electrical (C) fires. The C rating indicates the agent is electrically nonconductive.

To assist potential users, the National Fire Protection Association (NFPA) has developed a color-graphic identification system for rapid identification of fires that a particular extinguisher can be used on. This system is described in NFPA 10, *Standard for Portable Fire Extinguishers*.

Types of Portable Fire Extinguisher Agents

Water based: For the most part, extinguishers that use water are limited to use on Class A fires. One exception is foam-water type extinguishers discussed below. The remaining water-based extinguisher types include antifreeze additives, loaded streams, and wetting agents. Other foams may be used but are generally obsolete. Until 1969, there were three methods of water-based extinguisher operation: 1) stored pressure, 2) pump tank, and 3) inverting type. The latter type was discontinued in 1960 and this resulted in soda-acid type extinguishers becoming obsolete as well.

Carbon dioxide--CO_2: Compressed CO_2 provides both an agent and a discharge method, as the gas is under pressure while in the storage container. CO_2 extinguishes fire primarily by excluding oxygen from the combustion region, although there is some cooling effect. In fact, the operator of a CO_2 extinguisher must be careful not to touch the horn of the extinguisher due to risk of freezer burn injury. CO_2 is intended for use in fighting Class B and Class C fires, but can be used on Class A if needed. One beneficial attribute of CO_2 is that it leaves no residue. A negative characteristic of CO_2 is that it is a gas and, as such, may be carried away from the intended area by drafts and wind. Also, users must be careful not to be overcome by the lack of oxygen if the extinguisher is used in a confined place.

Dry chemical: Dry chemical agents can be further divided into ordinary and multipurpose agents. Ordinary dry chemical agents include sodium bicarbonate, potassium bicarbonate, urea potassium bicarbonate, and potassium chloride and are effective on Class B and Class C fires. Multipurpose dry chemical is based on ammonium phosphate and can be used for Class A, Class B, and Class C fires; hence, its "multipurpose" listing. Dry chemical agents extinguish fires by inhibiting the chemical chain reaction of the combustion process; they may also have a blanketing effect. Dry chemical extinguishers must be provided with either stored or cartridge-operated pressure to force the dry chemical agent from the extinguisher. Typically, CO_2 or nitrogen is used for this purpose.

Halon™: Halon™ 1211 may be used in portable fire extinguishers because it is not so volatile as Halon™ 1301, which instantly becomes gaseous when discharged. The low relative volatility of Halon™ 1211 allows the extinguisher user to direct the liquid flow toward the intended strike zone of the fire. As with the larger Halon systems, Halon™ 1211 extinguishes fires by inhibiting the combustion chemical chain reaction. Like CO_2, Halon™ is a clean agent that leaves no residue. Halon™ can be used on Class B and Class C fires as well as Class A if needed.

Dry powder: Dry powder agents are intended for fighting Class D (metal) fires and typically are sodium chloride based. This type of agent extinguishes fire by reacting with the heat of the fire to form a blanket over the fuel, which will prevent the fuel and oxygen from meeting.

Aqueous Film Forming Foam (AFFF): AFFF is a special type of water-based fire extinguishing agent that differs from other water-based agents in that it can be used successfully for combating Class B fires, where it extinguishes via oxygen exclusion, as well as Class A where it acts by cooling and penetrating.

Obsolete extinguishers: Obsolete extinguishers should be be identified in the field and removed. In addition to operating difficulties, these older type extinguishers had an unacceptably high test failure rate. **Soda-acid** extinguishers were quite popular years ago but are no longer acceptable because they may explode when inverted to activate the extinguisher. **Cartridge-operated water** extinguishers are similar to soda-acid extinguishers in operation and suffer from the same problems. **Foam** extinguishers look like the soda-acid extinguishers; these should be replaced by newer AFFF extinguishers. **Vaporizing liquid** extinguishers have been banned from service due to problems with toxicity of both the agent and products generated during fire extinguishment. The most common type of this agent is carbon tetrachloride--CCl_4. These were often deployed in pup handle sprayers, or glass bulbs that were thrown at the fire.

Distribution of Portable Fire Extinguishers

The first step in addressing extinguisher distribution requirements is determining the hazard classification according to NFPA 10 or your local fire code.

Light (low) Hazard: These are areas where the total amount of Class A type combustibles is minor. Examples include offices, classrooms, churches, and assembly halls. Small amounts of Class B fuels are anticipated but should be negligible, e.g., duplicating fluid or solvents in art rooms.

Ordinary (moderate) Hazard: These are areas where the total amount of Class A and Class B fuels is greater than that of Light Hazard areas. Examples include offices, classrooms, mercantile shops and storage, light manufacturing, research operations, auto showrooms, parking garages, and workshops.

Extra (high) Hazard: These are areas where the total amount of Class A and Class B fuels is greater than that of Moderate Hazard areas. Examples include wood-working shops, vehicle repair, aircraft and boat service areas, product display areas, storage and manufacturing processes such as painting, dipping, and coating, which use flammable liquids.

The total area of each hazard classification must be known. From here one simply consults tables in NFPA 10 that specify the fire extinguishers needed based on the hazard class and area to be protected. In addition, there are maximum travel distances allowed--for Class A extinguishers it is 75 feet; for Class B it is either 30 feet or 50 feet, depending on extinguisher size. The travel distance is a one-way measure from the hazard to the extinguisher.

For each location with Class C fire threats, a Class C rated extinguisher must be provided. Similarly, for each location with Class D fire threats, a Class D extinguisher must be provided.

Basis for Code Requirements

Portable fire extinguishers are not required in all buildings, nor are they required in all locations within a building that may be required to have extinguishers for a particular hazard.

In general, portable fire extinguishers are required in some occupancies that are expected to have people familiar with the building and the fire extinguishers. Hospitals, factories, and mercantile occupancies are examples of buildings that may require portable fire extinguishers. In some cases, the code may require portable fire extinguishers to provide protection from a given hazard. A magnesium milling machine or a flammable liquid process area are examples of locations where special portable fire extinguishers may be required. Locations where untrained occupants are the only people normally present generally are exempt from portable fire extinguisher requirements.

Fire Extinguisher Standards

Testing: Fire extinguishers are listed according to:

- UL 711, *Rating and Fire Testing of Fire Extinguishers*;
- UL 154, *Carbon Dioxide Fire Extinguishers*;
- UL 299, *Dry Chemical Fire Extinguishers*;
- UL 8, *Water-based Agent Fire Extinguishers*;
- UL 626, *Water Fire Extinguishers*;
- UL 2199, *Halocarbon Clean Agent Fire Extinguishers*; and
- UL 1093, *Halon-type Fire Extinguishers*.

Inspection, Testing, and Maintenance of Portable Fire Extinguishers

The responsibility for inspection, maintenance, and recharging belongs to the property owner. The local code official may wish to verify that the necessary efforts are being carried out by the owners or their representatives.

Fire extinguishers should be inspected every 30 days unless circumstances dictate more frequent inspections. An inspection is a visual check. The following items should be checked during the inspection:

- located in designated place;
- access or visibility not obstructed;
- operating instructions on nameplate legible and facing outward;
- seals and tamper indicators not broken or missing;
- determine fullness by weighing or "hefting";
- examine for obvious physical damage, corrosion, leakage, or clogged nozzle; and
- pressure gauge reading or indicator in the operable range or position.

Typical Extinguisher Service Tag

In addition, the presence of the recordkeeping tag should be confirmed and its contents reviewed. Any deficiencies should be immediately noted and corrected. Any extinguisher removed for repair or other reason should be replaced promptly, and a substitute placed in its location while it is out of service.

Extinguishers should be subjected to maintenance at least once a year and should cover three main areas:

1. Mechanical parts.

2. Extinguishing agent.

3. Expellent means.

Maintenance work is performed by a qualified service technician who has the tools and knowledge to maintain the equipment and make repairs.

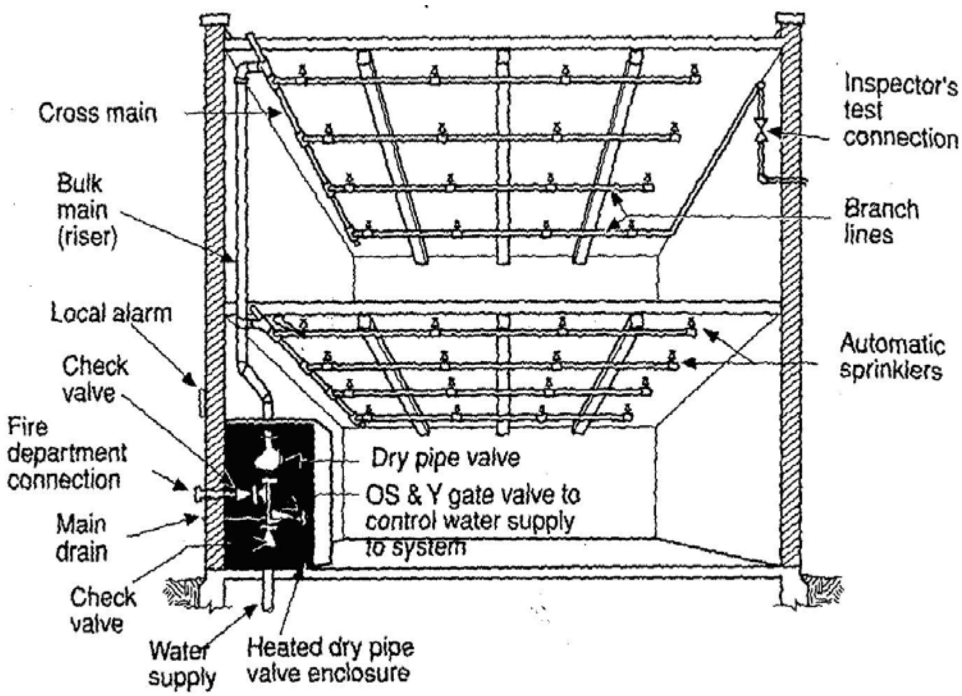
In addition:

- Stored pressure extinguishers should be discharged before service.
- Carbon dioxide extinguishers should have an electrical conductivity test of the hose assembly completed. If found conductive, the assembly should be replaced.
- Every 6 years, stored pressure extinguishers that require a 12-year hydrostatic test should be emptied and subjected to the applicable maintenance procedures.
- A recordkeeping tag should be placed on the extinguisher and indicate the month and year the service was completed and by whom. This tag should also indicate if recharging was performed.

NFPA 10 contains requirements for charging (regardless of use) and hydrostatic testing. Hydrostatic testing is required on either a 5-year or 12-year schedule. These requirements vary by agent and extinguisher type, and NFPA 10 should be consulted for the correct service and interval required.

AUTOMATIC SPRINKLER SYSTEMS

When building and fire codes require installation of an automatic suppression system, they do not specify any particular type. However, it is generally expected that an automatic sprinkler system will be installed unless the hazards or environmental conditions are not compatible with water. Automatic sprinkler systems are the most commonly installed automatic fire suppression systems. The systems consist of automatic sprinklers, which are devices that operate at a predetermined temperature and automatically distribute water upon an incipient fire in sufficient quantity at least to contain, and possibly to extinguish, the fire. The water is fed to the sprinklers through a system of overhead pipes, and a variety of valves are employed to control water flow. The overhead pipes are supplied by some reliable public or private water source.



Major Sprinkler System Components

Purposes of Automatic Sprinkler Systems

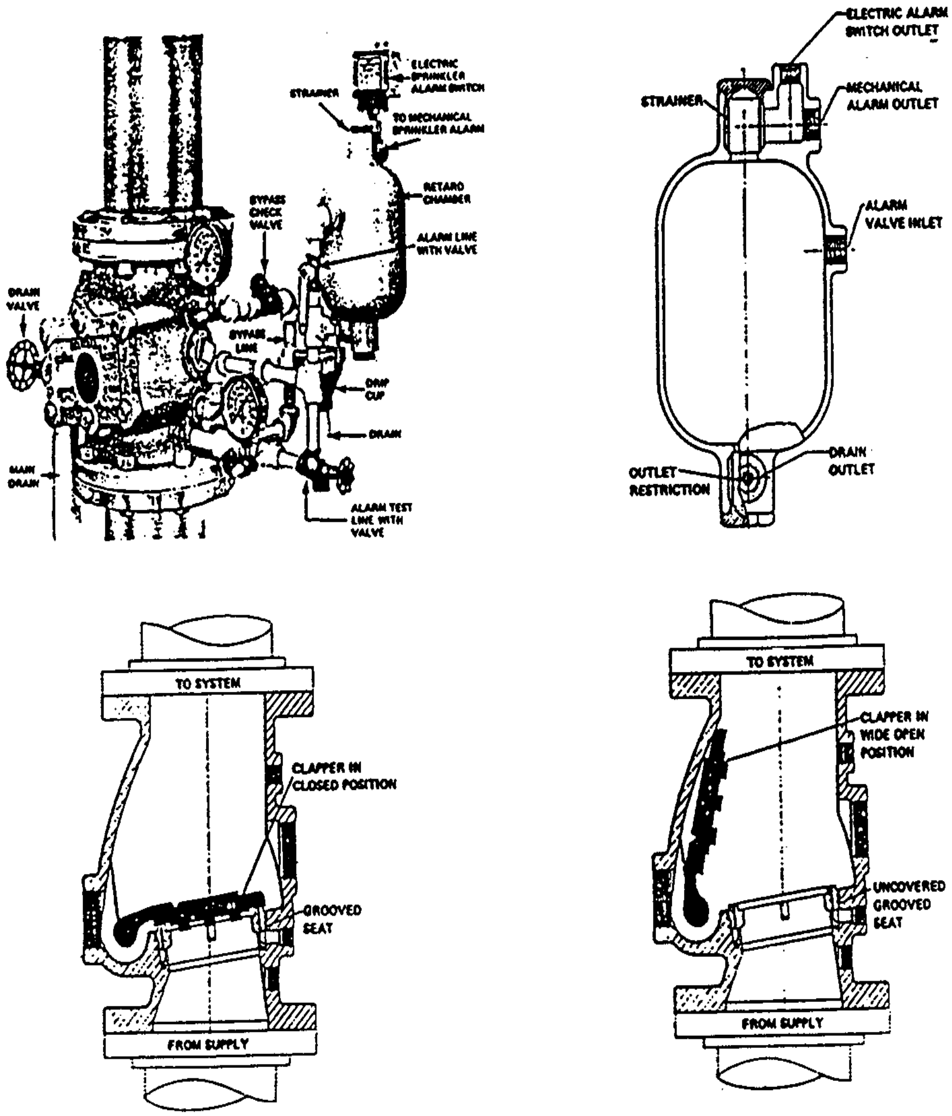
Sprinkler systems have two main purposes: to protect life and to protect property. They accomplish this by controlling or extinguishing unwanted fires. When connected to an approved fire alarm system, sprinkler systems provide the added benefit of acting as initiating devices to activate the fire alarm system.

Classifications of Automatic Sprinkler Systems

The six major classifications of automatic sprinklers systems defined in NFPA 13 are as follows.

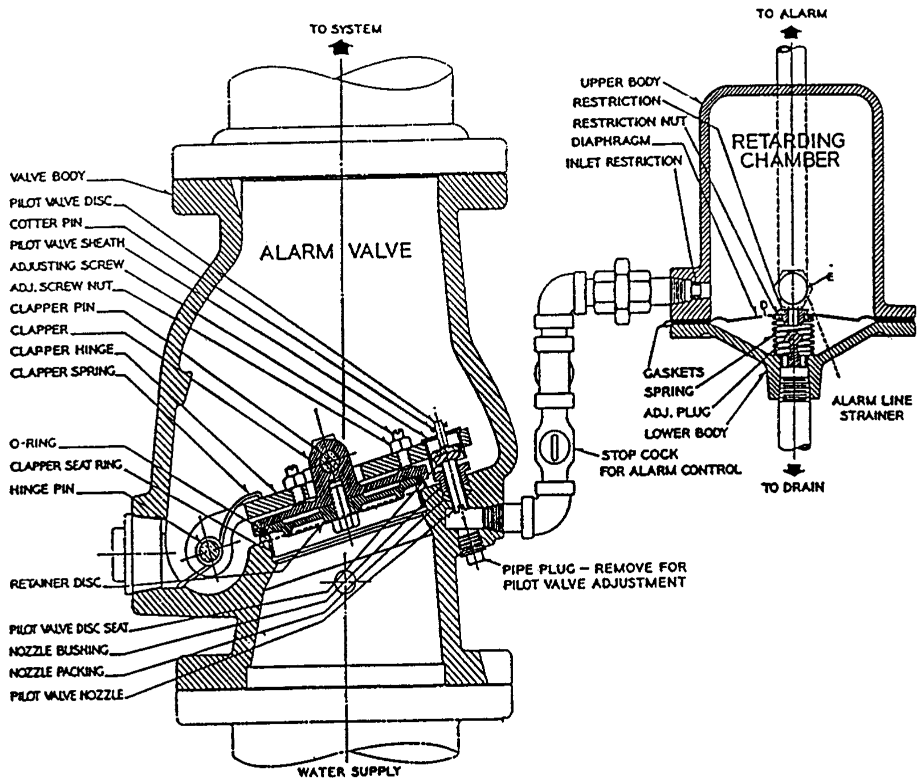
1. Wet pipe.

Wet pipe systems use closed automatic sprinklers attached to a piping system containing water under pressure at all times. The wet pipe system is the most common type of sprinkler system and generally is used unless there is danger of the water in the pipes freezing or when other special conditions require one of the other types of systems.



Alarm Check Valve

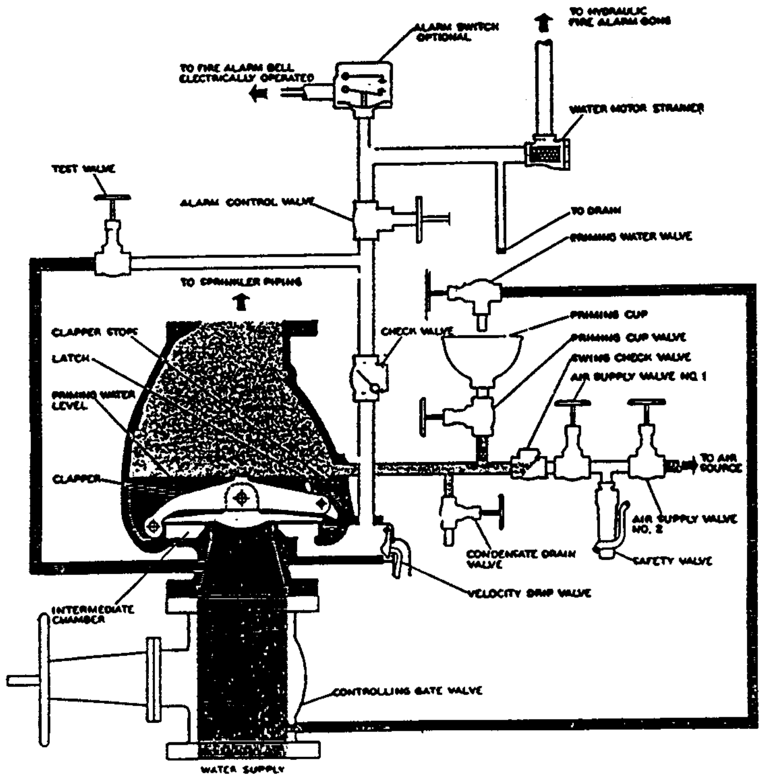
Alarm Check Valve (Section)



2. Dry pipe.

Dry pipe systems employ closed automatic sprinklers attached to a pipe network that contains air or nitrogen under pressure. When a fire occurs and an automatic sprinkler opens, the air or nitrogen is released, reducing the pressure in the system to a point at which the pressure on the water supply side causes the valve to operate, allowing water to flow through the system. Dry pipe systems usually are used only in locations that cannot be heated properly.

Differential Dry Pipe Valve



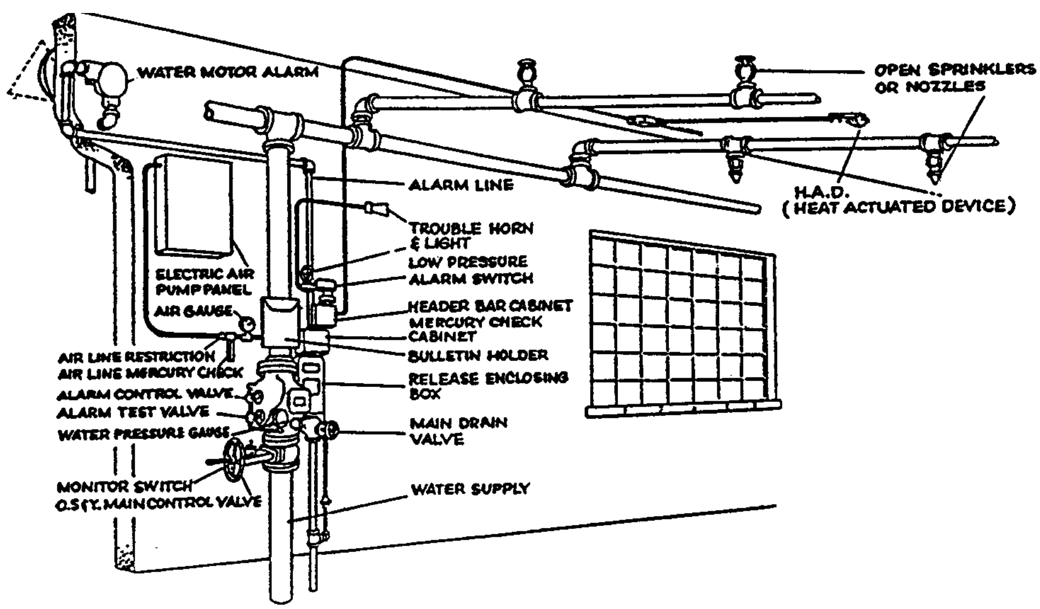
3. Preaction systems.

Preaction systems employ closed automatic sprinklers attached to a pipe network that contains air under only a small amount of pressure. When a fire occurs, a fire detecting device, such as a smoke or heat detector, operates first and causes the water control valve to open. Water then can fill the pipe system. Thereafter, when an automatic sprinkler opens, water will be available to flow immediately through the sprinkler. Preaction systems are commonly used in areas where there is danger of serious water damage as a result of a damaged automatic sprinkler or broken pipe. Electrical equipment rooms, computer rooms, and operating rooms are locations where preaction sprinkler systems are commonly found.

4. Deluge systems.

Deluge sprinkler systems employ automatic sprinklers that are open at all times. When a fire occurs, a fire detecting device activates and causes the deluge valve to open. Water then flows into the pipe and discharges through all the open sprinklers. Deluge sprinkler systems are effective in protecting severe hazards, such as flammable liquids, where there is a possibility that the fire could flash ahead of the operation of closed automatic sprinklers (in this example, a rapid detection system would be required).

Deluge System



5. Combined dry pipe and preaction.

These systems employ the fundamental features of each system and can operate as either system. Typically the dry pipe feature serves as a supplemental operation in case of failure of the preaction system. Such systems are effective in areas that are too large for a single dry pipe system.

6. Antifreeze systems.

In those areas subject to freezing, such as cold storage facilities, exterior loading docks, or otherwise unheated spaces, antifreeze systems may be employed as an alternate to a dry pipe system. Antifreeze systems employ water; and antifreeze solutions like ethylene glycol or glycerin to keep the fire protection water in a liquid state.

Antifreeze solutions usually are employed only to protect small areas because they require regular, complicated, and expensive maintenance to assure their operation.

Basis for Code-Required Automatic Sprinkler Systems

Total Building Protection

The model building codes do not require automatic suppression systems in all buildings. Automatic suppression may be required depending on the building height, the building construction type, the occupancy classification, hazardous operations or life safety considerations.

When required by code, the rationale usually can be traced to one or more of the following situations:

- The need to limit the potential fire size.
- Storage, handling, or use of unavoidably excessive fuel loads.
- The need for added automatic protection indicated by fire experience for the type of occupancy.
- The effectiveness of manual fire suppression is questionable (fire department access is limited).
- Openings and accessibility used by the fire department are limited (windowless or below-grade areas).
- The height of the occupied floors is above fire department access with available fire apparatus.
- Added assurance required for life safety, due to fast developing fires, large numbers of people present (assembly), or people who must be defended in place (hospitals or penitentiaries).

Over time the codes have adopted numerous incentives to encourage the installation of sprinkler systems in buildings. Typical incentives include

- Increased building area and height.
- Decreased exit capacity.
- Increased exit travel distances.
- Reduced fire resistance for vertical openings.
- Elimination of need for enclosure of certain hazardous areas.
- Reduction of interior floor finish (carpet) and wall finish requirements.

- Reduced corridor wall fire resistance and associated hardware, such as rated glazing, fire dampers, and closing devices.

- Reduced corridor door fire resistance.

- Increased size of areas open to the corridor (hospitals).

- Permitted use of atriums.

- Reduced requirements for furnishings.

- Reduced standpipe requirements.

It should be noted that some of the modifications require sprinkler protection throughout the entire building while others apply only to certain portions of the building or individual rooms or areas.

Special Hazard Protection

Automatic suppression typically is required for specific hazards such as commercial cooking equipment, central laundries, soiled linen rooms, combustible storage rooms, and trash collection rooms. Some codes permit other hazardous areas to be separated by 2-hour fire-rated construction, or protected with an automatic suppression system **and** separated by 1-hour fire-rated construction. Such areas include boiler or furnace rooms, paint shops, and maintenance shops. Other hazardous areas may be either separated by 1-hour fire-rated construction or protected with an automatic suppression system.

Automatic Sprinkler System Design and Installation Standards

When a sprinkler system is required by code or desired for trade-offs or other reasons, the following design and installation standards are used most often.

NFPA 13

NFPA 13 is the oldest of the sprinkler design standards, originally published in 1896. Unless allowed by code or by the authority having jurisdiction (AHJ) to use another design standard, NFPA 13 typically is the standard to be used.

NFPA 13-designed systems are intended to protect property. A building protected by a system designed in accordance with NFPA 13 is presumed to have sprinklers in all spaces (with some special exceptions). This assumption allows the sprinkler system to be used as a "substitute" for certain fire-resistive construction features.

The water supply for a NFPA 13 design system is required to be adequate for operating the sprinkler system **and** to provide water for the fire suppression forces when they arrive. The water supply for both must last for a period of up to 2 hours.

NFPA 13R

NFPA 13R, Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height, was produced in 1989 to address low-cost sprinkler applications for low-rise multifamily dwellings.

The NFPA 13R design goal has nothing to do with property protection. A system installed in accordance with this standard is intended to prevent flashover in the room where a fire begins, alert building occupants, and give them adequate time to escape. It is designed solely as a life safety system.

Since property protection is not an issue, the standard requires sprinkler protection only in those areas where--according to national fire loss statistics--fatal dwelling fires are most likely to begin. Low risk areas do not require sprinkler protection. This includes unused attics, small bathrooms and closets, garages, and exterior exit balconies.

The water supply for a 13R design system only has to supply four operating sprinklers for 30 minutes. There is no requirement for a fire suppression water supply.

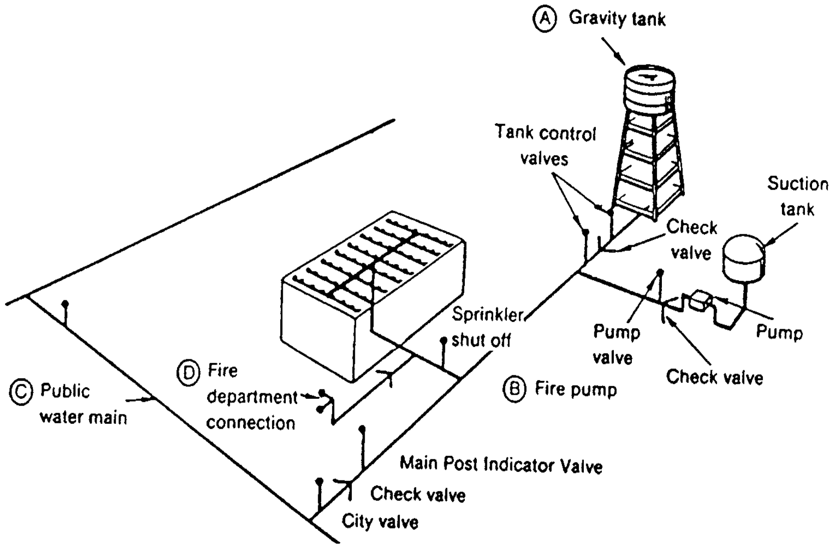
NFPA 13D

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, was developed in 1975 to address life safety issues in these structures. In order to encourage homeowners to install systems at lower costs, the 13D Standard allows omissions from areas where the likelihood of fatal fires occurring is statistically insignificant. Thus, sprinklers may be omitted from unused attics, small closets, small bath rooms, garages, and exterior balconies.

The water supply for a NFPA 13D system requires only enough to operate the system for 7 to 10 minutes; long enough to get occupants out of the structure. There is no requirement for fire suppression water supplies.

Since NFPA 13R and 13D design systems are "life safety systems" only, their use is limited to dwelling occupancies.

Water Supply Sources



Example of Sprinkler System Water Supplies

Generally, at least one **automatic** water supply is required for an approved sprinkler system. An automatic supply refers to a supply that does not require any human interaction to initiate the flow into the sprinkler system. Additional water supply sources frequently are provided to supplement the primary water supply. The more common components of a water supply include the following.

Public main: Perhaps the most common automatic water supply is the public water main. Here, the sprinkler system is connected through a series of check valves, backflow prevention devices, underground pipe, etc., to the public water supply.

Gravity tanks: A gravity tank serves two functions: it acts as a storage container for the needed water, and its elevation creates pressure. This can be a source of automatic water supply for a sprinkler system.

Pressure tanks: A pressure tank is similar to a gravity tank except that it uses gas pressure to push the water from the tank under pressure. Generally, an air pump can be used to pressurize such storage tanks adequately.

Static sources and fire pumps: Static sources include ponds, lakes, reservoirs, sea water, cisterns, or similar applications. To be considered "automatic," these require a fire pump to draw water from the source and pump it to the fire protection system. A fire pump takes water at a less-than-required pressure (often atmospheric) and discharges it at an adequate pressure to the sprinkler system.

Other Sources

Mobile sources: For many areas, water supplies are few and far between. The local fire services may have developed sophisticated plans for transporting water through shuttle systems, long-distance relay pumping, or commandeering available water transportation vehicles when needed.

Fire department tenders, converted fuel or milk trucks, swimming pool fill trucks, even cement mixers, can be used to carry water to a sprinkler system during an emergency.

Fire department connection: This is not an automatic source as it clearly requires human action to initiate the flow. The fire department can flow water into the connection to provide both flow and pressure to the system. Fire department connections usually are a secondary water source.

Fire Department Connection

Water Supply Requirements Based on Occupancy Hazard Classification

In addition to providing an approved sprinkler system complete with the required water supply source, it is important to assure that a sufficient **quantity** of water and **duration** is also available. The quantity and duration are based on the fire control challenges within the property.

The factors that influence water supply requirements include

- quantity and combustibility of contents;
- expected rates of heat release;
- total potential for energy release;
- storage height and potential obstructions; and

- presence of flammable and combustible liquids, or other hazardous materials.

For the purposes of sprinkler system design, occupancies are classified as:

- Light Hazard;
- Ordinary Hazard, Group 1 or 2;
- Extra Hazard, Group 1 or 2; and
- Special Occupancy Hazard.

A building may have one or more occupancy hazard classifications within it. It is important for the inspector to realize that these categories are fairly subjective. There is no specific point where changes in a Light Hazard occupancy make it an Ordinary Hazard category.

It is also important that the inspector realizes that the sample occupancies described in NFPA 13 for each hazard class are only representative and not absolute. For example, a museum is classified in NFPA 13 as Light Hazard, but what if the museum is storing and displaying highly combustible materials such as fabric wall hangings? The code official should help classify the occupancy based on realistic fire hazards rather than a broad category.

When conducting an inspection and evaluating the water supply of an existing sprinkler system, it is essential that the fire inspector verify that the occupancy hazard classification has not increased or conditions have changed that create additional fire hazards. These changes may require that that fire protection water supply be increased to compensate for the increased risk.

Automatic Sprinkler System Design

Hydraulic Engineering

Today's automatic sprinkler systems typically are designed using a hydraulic calculation method, which may involve the use of a computer. The designer can enter rapidly the general pipe layout and sizes, along with some additional data requirements, and the program will determine the pressure drop through the pipe network. This provides the minimum pressure and flow requirement for the system, which then can be compared to water supply data to determine if the required flow and pressure are available. If excess pressure is available, the system designer can reduce pipe sizes to provide a cost savings.

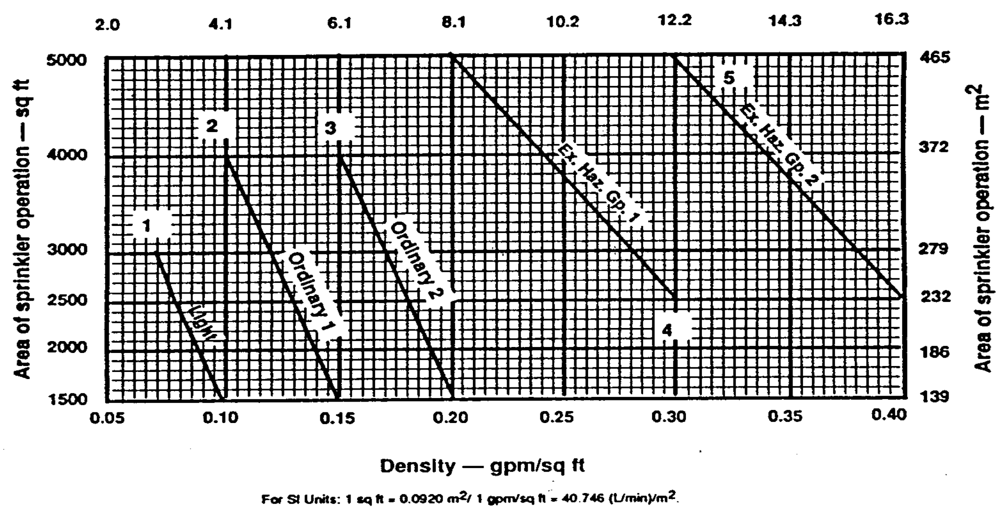
Design of such systems usually is based on a required "area/density" formula. The area portion of the formula is known as the "area of application," "remote area," "design area," or "hydraulically remote area." The size of this area varies depending upon the hazard classification; Light Hazard occupancies may have a small remote area, while Extra Hazard occupancies have a larger one. (Refer to the Area/Density figure.)

"Density" is the amount of water required to control or extinguish an incipient fire in the remote area. It is referenced in tenths or hundredths of a gallons per minute (gpm) per square foot. For example, a density of 0.18 means the sprinkler system will deliver 18 hundredths of a gallon of water per minute over each square foot of the remote area.

Area and density often are described in oral "shorthand" such as "point one eight over fifteen hundred (0.18/1,500)." This means the 0.18 gpm per square foot density will be applied over the 1,500 square foot remote area.

To get an approximate idea how of much water is needed to supply the sprinkler system, multiply to density by the size of the remote area. This will tell you how much water is required for protecting the remote area of application. For example, 0.18 times 1,500 equals 270 gpm. There will be some additional volume included in the calculations to account for filling the pipe network between the riser and the remote area.

The Area Density Curves are used to determine the required water supply for the sprinkler system.



Area Density Curves

NFPA 13 provides additional design criteria for various hazards based on the sprinkler type that will be installed. Sprinkler and branch line spacing also are affected by the hazard classification and the design density. Some sprinkler systems, such as those using residential sprinklers, utilize a specified number of sprinklers and the design density is thereby inherently incorporated into the design.

NFPA 13 requires that a nameplate be attached permanently to the base of risers of hydraulically designed systems. The nameplate indicates the location of the system and the basis of the design, including discharge densities and design area size, as well as the gpm flow and the residual pressure demand at the base of the riser.

Hose Stream Allowances

When a hydraulically engineered sprinkler system is designed, the water supply calculations must include an allotment for "hose stream allowances." This is the volume added to the sprinkler system demand to assure there is an adequate water supply for manual firefighting when the fire suppression forces arrive.

The hose stream allowances are based on the occupancy hazard classification:

- Light Hazard 100 gpm;
- Ordinary Hazard 250 gpm; and
- Extra Hazard 500 gpm.

In the previous example, we established a sprinkler system demand of 270 gpm based on a 0.18/1,500 design. In an Ordinary Hazard occupancy, 250 gpm would be added to this to establish the total water flow requirement: 270 + 250 = 520 gpm.

Duration

How long should this water supply last? If the system is connected to a large municipal water source, the timeframe may be immaterial. If the sprinkler designer has to erect a tank, though, the engineer will want to know how large to make it.

The length of time the water supply has to last is based on hazard classification:

- Light Hazard 30 minutes;
- Ordinary Hazard 60 to 90 minutes; and
- Extra Hazard 90 to 120 minutes.

The shorter duration usually is allowed if the sprinkler system water flow is monitored and reports right away to the fire suppression forces. In theory, if the fire suppression forces are notified early while the fire is small, they will not need so much water compared to a well-involved structure.

Determination of Water Supply Requirements

The flow rate from a sprinkler system and hose streams, times the flow duration in minutes, results in the total gallons required; this number should be less than or equal to the available water supply. For public mains, duration may not be an issue; for other sources such as water tanks, it may be a crucial consideration. The difficulty lies in determining what the flow will be and how long the sprinkler system may be in operation during any given fire incident.

Given the example above, an Ordinary Hazard design needing 520 gpm (system and hose streams) times 60 minutes would require at least 31,200 total gallons to satisfy the standard, and 46,800 gallons if a 90-minute duration is required.

Private Water Tank Sized to Supply Sprinklers and Hose Streams

Pipe Schedule Design

Before the advent of readily available computer programs and cost-effective computer hardware, sprinkler systems typically were designed using the pipe schedule method. This is a simple approach but often more costly to install. This approach utilizes the concept of the maximum number of heads that may be supplied by a given pipe diameter. The designer then selects pipe sizes, starting at the location most remote from the water supply, until all pipe sizes are determined. The pipe schedules also are based on the classification of the protected hazard.

NFPA 13 contains a guide for water supply requirements for pipe schedule sprinkler systems.

Water Supply Requirements for Pipe Schedule Sprinkler Systems			
Occupancy Classification	**Minimum Residual Pressure Required**	**Acceptable Flow at Base of Riser**	**Duration in Minutes**
Light Hazard	*15 psi	500 to 750 gpm	30 to 60
Ordinary Hazard	*20 psi	850 to 1,500 gpm	60 to 90

*Minimum pressure required at highest sprinkler elevation in the structure.

In order for the fire inspector to determine if the water pressure is adequate to supply the minimum residual pressure at the highest elevation, the inspector has to do some arithmetic.

The recognized formula for determining pressure loss due to elevation is "p = h x 0.4331," where "p" equals pressure loss due to elevation, and "h" equals height. Some engineers and jurisdictions use a constant value of 0.433, but the difference in the eventual product is insignificant for fire protection purposes.

Here is an example to determine if the water pressure is adequate:

A four-story office building has its highest sprinkler at 48 feet above the base of the sprinkler riser. A main drain test reveals the residual pressure at the base of the riser is 56 psi. What is the residual pressure at the highest sprinkler?

$$p = h \times 0.4331$$

$$56 \text{ psi} - (48 \text{ feet} \times 0.4331) = \text{residual pressure at highest point}$$

$$56 - (20.78) = 35.22 \text{ psi}$$

This value (35.22 psi) exceeds the minimum required in the table for a Light Hazard occupancy.

Evaluation of Water Supply

To determine if the water supply available meets the water supply requirements dictated by the system design, design engineers often use a hydraulic graph. The available water supply can be determined by conducting hydrant flow tests at the site. Figure 7-1 details the results of a flow test and shows the available water supply plotted on hydraulic graph paper.

Given a sprinkler demand example of 750 gpm at 20 psi, the demand point is plotted as shown on Figure 7-1. Any time the demand point is under the supply curve or to the left of the curve, the supply is adequate. Note this example did not incorporate any factor of safety or any allowance for hose streams.

A sprinkler system main drain test is very similar to conducting a hydrant flow test. The gauge on the sprinkler riser acts as the pressure hydrant, while the main drain acts as the flow hydrant. It is important that this test is conducted and accurate records are maintained. Comparing the initial test results with future test results will indicate if the water supply has deteriorated over time. Deterioration could be a result of closed valves, obstructions in the pipe, or added domestic demands on the system. (See Automatic Sprinkler System Inspection, Test, and Maintenance.)

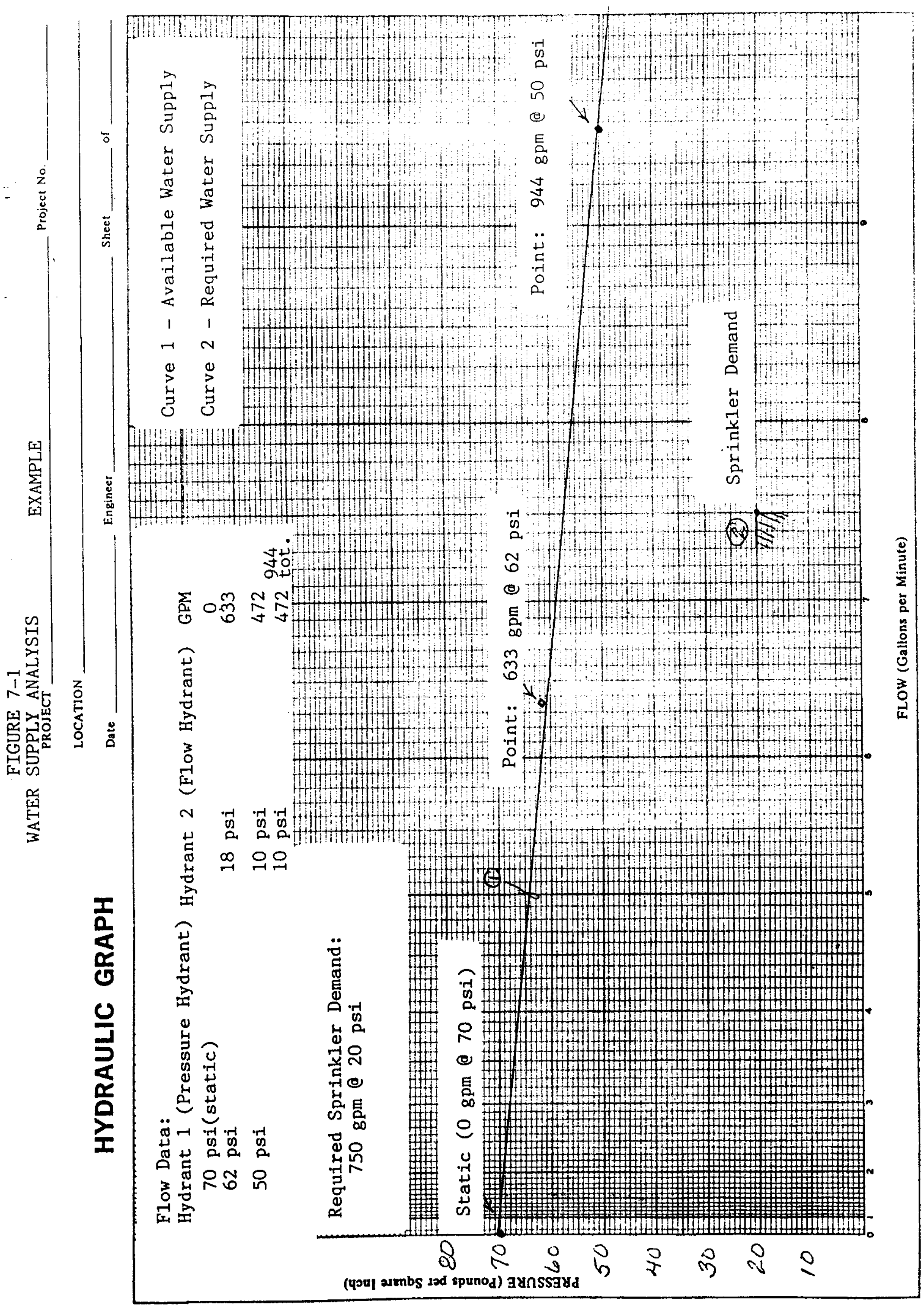
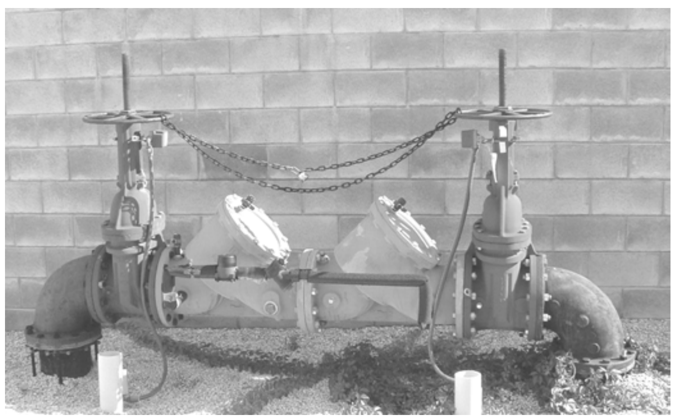


FIGURE 7-1
WATER SUPPLY ANALYSIS
HYDRAULIC GRAPH
PROJECT EXAMPLE
LOCATION
Date
Engineer
Sheet
of
Project No.
Flow Data:
Hydrant 1 (Pressure Hydrant)
Hydrant 2 (Flow Hydrant)
GPM
70 psi(static)
0
62 psi
18 psi
633
50 psi
10 psi
472
10 psi
472
944 tot.
Required Sprinkler Demand:
750 gpm @ 20 psi
Static (0 gpm @ 70 psi)
Point: 633 gpm @ 62 psi
Point: 944 gpm @ 50 psi
Curve 1 - Available Water Supply
Curve 2 - Required Water Supply
Sprinkler Demand
1
2
PRESSURE (Pounds per Square Inch)
80
70
60
50
40
30
20
10
FLOW (Gallons per Minute)

Backflow Protection

Some form of backflow prevention may be required for fire sprinkler installations. "Backflow" refers to the reverse flow of water in a water-based system. In the case of fire sprinklers, the concern is the backflow of water from the sprinkler system back into the domestic potable water supply. Contamination of the potable water supply is a potential hazard and backflow prevention provides one possible solution. Generally backflow is prevented by the placement of a check valve in the piping system. A check valve allows water to flow freely in one direction, but prevents its flow in the reverse direction.

Backflow prevention devices are called "fixed pressure loss" devices. When installed in a water service line, they reduce the flowing water pressure. Fire protection professionals are concerned that the backflow prevention device may have a negative effect on the fire protection system performance, especially where marginal water supplies exist.



Exterior Backflow Prevention Assembly

In general, unless required by local water authorities, backflow prevention check valves are not required for many installations. Most sprinkler systems are connected directly to the public water supply but do not present a hazard to the potable water due to the configuration and equipment used in standard fire sprinkler systems.

The American Water Works Association, publication M14, *Recommended Practices for Backflow Prevention and Cross-Connection Control,* contains guidelines for determining backflow protection needs based on the potential hazard. These are based on classes as follows:

Class 1: Direct connection from public water mains only; no pumps, tanks, or reservoirs; no physical connection from other water supplies; no antifreeze or other additives of any kind; all sprinkler drains discharging to atmosphere, dry wells, or other safe outlets.

Backflow protection recommended: none.

Class 2: Same as Class 1, except that booster pumps may be installed in the connection from the street mains. Pressure in the street main should not fall below 10 psi.

Backflow protection recommended: none.

Class 3: Direct connection from public water supply main plus one or more of the following: elevated storage tanks, fire pumps taking suction from aboveground covered reservoirs or tanks, and pressure tanks.

Backflow protection recommended: minimum protection such as approved double-check valves, to prevent stagnant waters from backflowing into the public potable water system.

Class 4: Directly supplied from public mains similar to Class 1 and 2, and with an auxiliary water supply dedicated to fire department use and available to the premises.

Backflow protection recommended: Backflow protection at the service connection normally is required. The type of protection is dependent on the type of auxiliary supply.

Class 5: Directly supplied from public mains and interconnected with auxiliary supplies, such as pumps taking suction from reservoirs exposed to contamination, or rivers and ponds; driven wells; mills or other industrial water systems; or where antifreeze or other additives are used.

Backflow protection recommended: maximum protection at the service connection, i.e., reduced pressure zone preventers. For systems with antifreeze or other additives, the device may be located at the point of connection to the portion of the system containing such additives.

Class 6: Combined industrial and fire protection systems supplied from the public water mains only, with or without gravity storage or pump suction tanks.

Backflow protection recommended: dependent on the requirement of both industry and fire protection, and could be determined only by a survey of the premises.

In general, the fire official should be aware of the concerns of cross-connections involving fire protection systems and the potable public water supply. The fire official should work closely with the water and health officials in their jurisdictions to assure that proper, but not unnecessarily excessive, backflow protection is provided.

If backflow prevention devices are retrofit onto existing sprinkler systems, the fire inspector may insist on a new set of hydraulic calculations to be confident the sprinkler system performance has not been reduced.

AUTOMATIC SPRINKLERS

Automatic sprinklers are heat-sensitive devices designed to react at predetermined temperatures and to release automatically a stream of water and distribute it in a specified pattern and quantity over designated areas. Under normal conditions, the discharge of water from a closed automatic sprinkler is restrained by a cap or valve held tightly against the orifice by the releasing mechanism. Most commonly used release mechanisms include fusible links, glass bulbs, and chemical pellets.

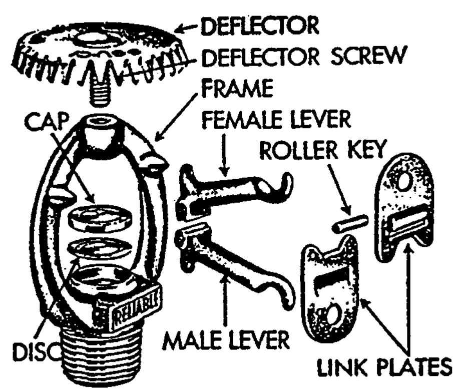
The fire sprinkler industry is heavily involved in research and development of new sprinklers that do a better job of fire control and extinguishment. Current trends seem to indicate that soon specific sprinklers may be developed for specific target hazards, thus increasing the inspector's responsibility to assure the correct sprinkler has been installed in the system.

Two broad categories of sprinklers exist today: control mode and suppression mode. **Control-mode sprinklers** confine a fire by prewetting combustibles surrounding the fire area and by cooling hot gases at the ceiling. In a warehouse fire, 20 or more control-mode sprinklers may be required for control.

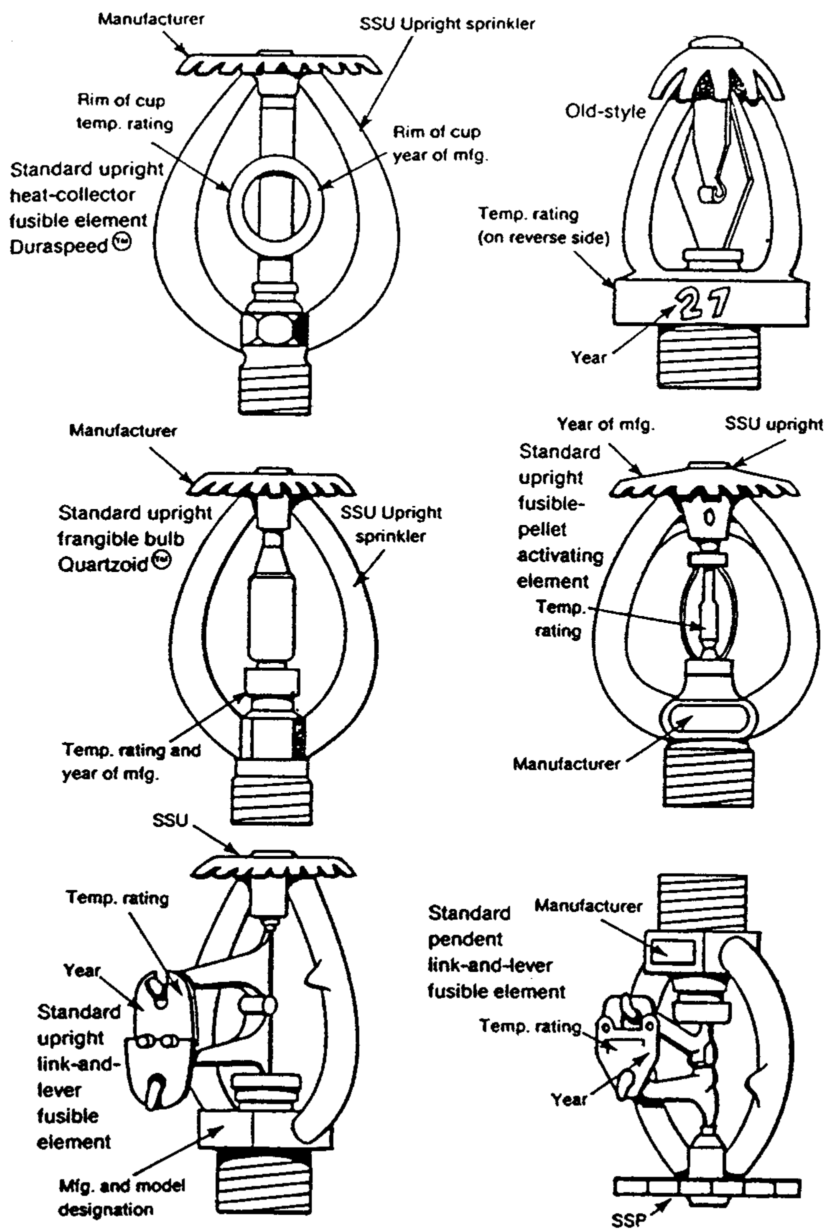
Suppression-mode sprinklers, such as early suppression, fast response (ESFR) sprinklers are designed to knock down a fire as fast as possible using an aggressive large-drop spray and a flame-penetrating central core of water. ESFR sprinkler performance depends on open-frame storage that includes enough space for water to penetrate should a fire break out. Because it is essential for the first few ESFR sprinklers to deliver enough water to suppress a growing fire, ESFR sprinklers are vulnerable to obstructions from building structures, lights, ducts, electrical conduits, and cable trays.

Standard Spray Sprinklers

<u>Fusible Link Automatic Sprinkler</u>



Standard spray sprinklers are one category of control mode sprinkler. Water flowing through the orifice strikes a deflector, which is designed to create the specified discharge pattern. Sprinklers are made for installation in an upright (SSU), pendent (SSP), or sidewall position. While the shape of the deflector usually indicates the proper position of the sprinkler, the letters "SSU" or "SSP" are stamped on the deflector's surface for easy identification. For upright and pendent sprinklers, the water spray flows downward in a hemispherical pattern from the deflector. For sidewall sprinklers, which are mounted in a horizontal or vertical position depending on design, the flow projects horizontally away from the wall mounted sprinkler. A small amount of water also impinges on the wall directly behind the sidewall sprinkler.



Sprinkler styles and types with location of identification information on the sprinkler. (ISO Commercial Risk Services, Inc.)

Extended Coverage

Extended coverage sprinklers are "sprinklers with special extended, directional discharge patterns." These are specially designed sprinklers and must be installed according to their listings and the appropriate sections of NFPA 13.

Fast Response

Fast response sprinklers, as the name implies, are specially designed to react more quickly than standard sprinklers when subjected to the effects of fire. This group of sprinklers is comprised of three types of fast-acting sprinklers: 1) quick response sprinklers, 2) residential sprinklers, and 3) ESFR sprinklers. A quick response, early suppression (QRES) is also under development.

Quick Response

Recent technology has resulted in the introduction of "quick response sprinklers." The sole criterion for this special designation is performance on the Underwriters Laboratories (UL) plunge test, presently a 14-second maximum operating time. The faster operating time holds promise of improved life safety and property protection.

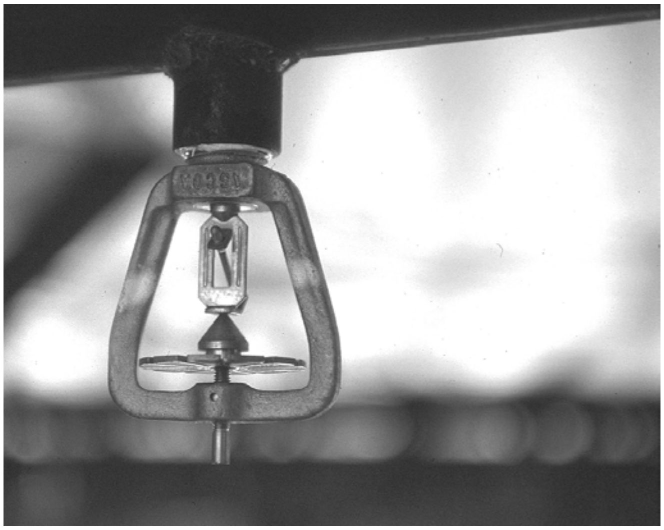
The quicker response time results from an actuation element that has a higher ratio of surface area to mass than normal sprinklers. The higher surface area allows for quicker transfer of heat into the element and the lower mass requires less heating, hence, a shorter time to reach the element's activation temperature. A sprinkler that responds more quickly is more likely to attack a fire before it can develop high velocity plumes. High velocity plumes are more difficult for water spray drops to penetrate. (See Large Drop Sprinklers.) Also, there is the probability that more sprinklers may activate, thus pre-wetting areas the fire has yet to reach. This can help prevent the spread of the fire. Clearly, the sooner a sprinkler activates, the sooner hazardous conditions are attacked.

Residential

These are sprinklers intended for use in residential applications only and which have been listed according to UL Standard 1626 and installed in accordance with the requirements of NFPA 13, NFPA 13D, and NFPA 13R. These sprinklers typically use less pressure and flow, and the design requirements are based on fires and conditions found in residential settings. Because of this, they must not be used outside their listed uses and applications.

Early Suppression, Fast Response

These sprinklers, intended for special fire threat applications, were developed as a result of the quick-response residential sprinkler research coupled with the high pressures and water flows associated with existing large drop sprinklers. The result is basically a large drop sprinkler with a quick response actuation element. It is intended that these sprinklers rapidly attack a fire with large amounts of water so that the spread of the fire is minimized or prevented by the activation of a small number of ESFR sprinklers.



ESFR Automatic Sprinkler

Dry

In some instances it is desirable to use dry sprinklers attached to wet pipe sprinkler systems. One common example is the protection of a walk-in freezer in an otherwise heated area. Dry sprinklers have mechanisms which keep a tight seal in place which prevents water from the wet pipe system flowing into the dry sprinklers. The dry sprinklers typically have extended pipe lengths that are dry (without water) and which extend into the unheated area. When the sprinkler fuses, the seal linkage drops out allowing water to flow into the previously dry sprinkler.

Large Drop

These sprinklers are designed to provide water spray characterized by large drops (as compared to other sprinklers). These larger drops have increased ability to travel through high heat and high-velocity fire plumes, thereby reaching the seat of the fire. Water drops from standard design sprinklers may be dispersed by high-velocity fire plumes, significantly reducing the sprinkler's ability to control and extinguish the fire.

Open

These sprinklers do not employ an actuating element. Therefore, when water flows into the piping all sprinklers will flow immediately.

Nozzles

Nozzles are sprinklers used in applications that require special discharge patterns and spray characteristics.

Water Spray Nozzle for Commercial Kitchen Range Hood Sprinkler System

On-Off

On-Off sprinklers refers to any sprinkler that has an integral water flow control mechanism that can allow or prevent the flow of water through the sprinkler. One common use of these sprinklers is in the protection of computer facilities where limited water flow is desirable. A common design uses a simple heat driven valve that will allow flow if heated, and will close if the sprinkler cools (i.e., if it appears the fire has been controlled).

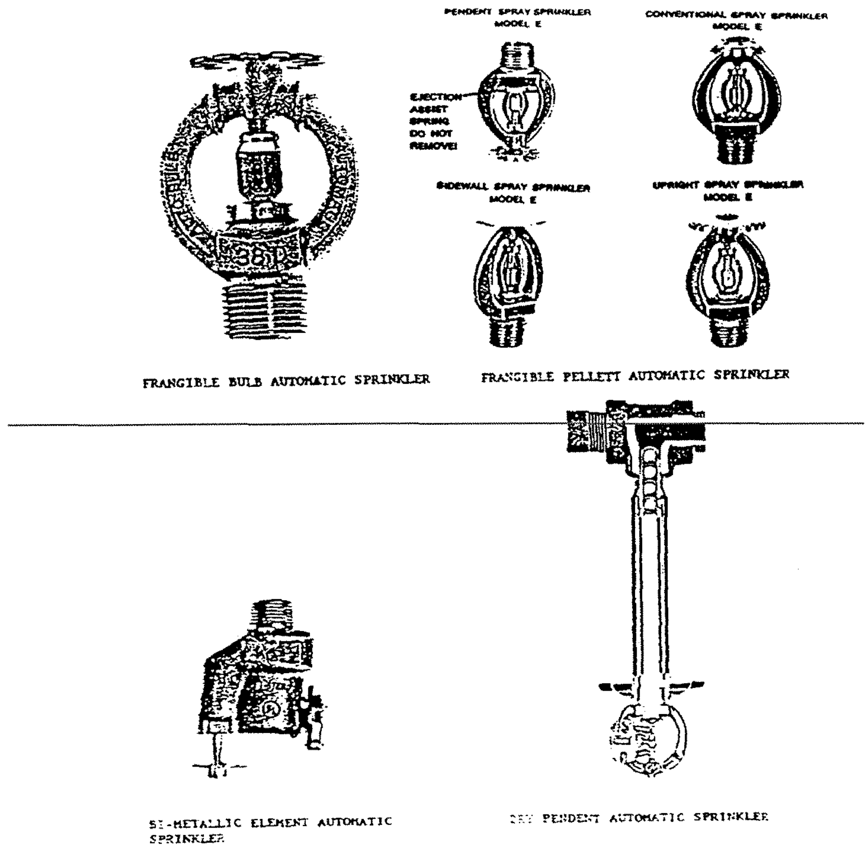
Intermittent Level

These sprinklers include a metallic shield located directly above the sprinkler, which is designed to prevent water from other sprinklers above it from cooling the sprinkler's operating elements. Without this protection, sprinklers would respond slower, or not at all, to fire conditions.

Corrosion Resistant

Sprinklers used in environments that are hostile to unprotected sprinklers may be designed to include corrosion protection. This generally is some form of protective coating applied to the special sprinkler.

Wax-Coated Corrosion Resistant Sprinkler



Ornamental, Flush, Recessed, and Concealed

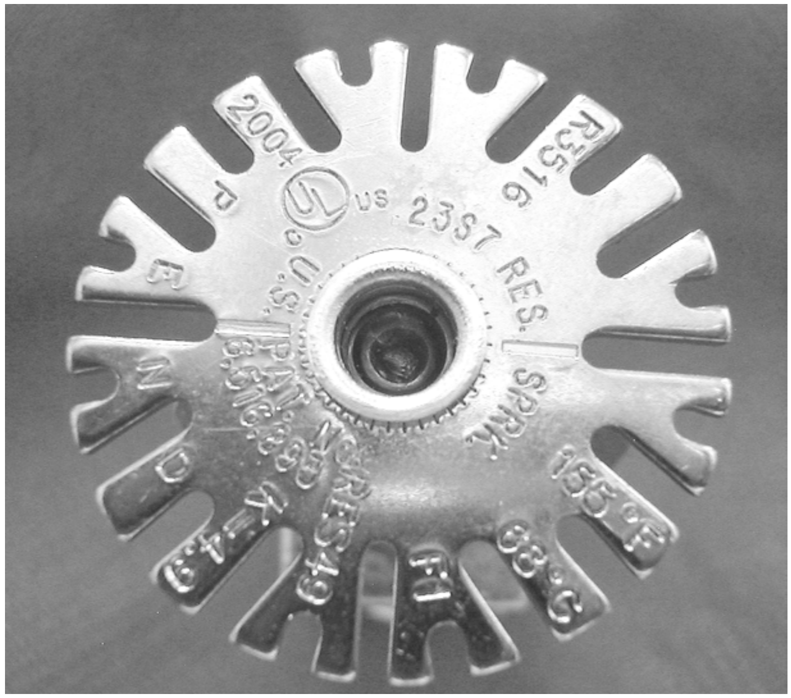
In some cases it is desirable to change the appearance from that normally associated with standard sprinkler installations. Aesthetics is one reason sprinklers are frequently not installed. Standard sprinklers are accused of being unsightly. Manufacturers have responded by painting or finishing sprinklers (ornamental), or by giving them a low profile so they do not project from the ceiling as much (flush, recessed, and concealed). In some cases, the latter can also be used to limit damage to the sprinklers and prevent tampering. Prisons are one example where low profile sprinklers are desirable, as inmates cannot hang themselves from the sprinklers, which has been done in the past with nonrecessed sprinklers.

Sprinkler Identification Numbers

Today's sprinklers include information that allows the fire inspector to identify the sprinkler's manufacturer, K Factor (see below), application, or use and response characteristics.

All sprinklers are embossed with what is called a Sprinkler Identification Number (SIN), a five- or six-character code that identifies the sprinkler. The SIN usually is found on the deflector, but may be on the sprinkler frame.

An inspector can obtain the SIN from the sprinkler, and then review the sprinkler data on the manufacturer's technical information bulletin for that sprinkler. These sheets also may be called "catalog cut sheets." A master list of SIN numbers can be obtained at www.ul.com



SIN on Sprinkler Deflector (R3516)

K Factors

For years, fire protection professionals referred to a sprinkler's orifice size in fractions of an inch to obtain a relative idea of the sprinkler performance. For example, a standard spray sprinkler was known as one having a 1/2-inch orifice.

Now, however, orifice sizes are referred to as a "K Factor," a mathematical coefficient of discharge based on the orifice size. A higher K Factor means the orifice has less internal friction loss, and therefore more water flows through it. A low K Factor means more friction loss and less flow. The SSU or SSP has a K Factor ranging from 5.3 to 5.8, depending upon the manufacturer. When the K Factor of an SSU or SSP is not known, the industry agrees that the nominal K Factor is 5.6.

Why is this important to the inspector? Using a common hydraulics formula, the inspector can compute the water flow from an open sprinkler: $Q = K\sqrt{p}$, where:

Q = flow in gpm (quantity)

K = sprinkler K Factor

p = sprinkler flowing pressure

Given an estimated flowing pressure of 30 psi, you can see how that K Factor influences the sprinkler output by the following arithmetic:

Example 1: Using a residential sprinkler with a common K Factor of 2.8, what is the flow at 30 psi?

$$Q = 2.8\sqrt{30}$$

$$Q = 2.8(5.477)$$

$$Q = 15.33 \text{ gpm}$$

Example 2: Using a SSP with a K Factor of 5.6, what is the flow at 30 psi?

$$Q = 5.6\sqrt{30}$$

$$Q = 5.6(5.477)$$

$$Q = 30.67 \text{ gpm}$$

Example 3: Using a sprinkler with a K Factor of 11.2, as is common in storage applications, what is the flow at 30 psi?

$$Q = 11.2\sqrt{30}$$

$$Q = 11.2(5.477)$$

$$Q = 61.34 \text{ gpm}$$

You can see by comparing the results that installing a small K Factor sprinkler where a larger K Factor has been specified in the design can have disastrous results. The small sprinkler would not flow enough water to control a fire in a higher hazard occupancy.

It is essential that the inspector confirm that the sprinklers called for on the plans are the ones actually installed in the building. The only way to confirm that information is to check the SIN.

Supervision

Sprinkler systems usually are supervised for abnormal alarm conditions. Abnormal conditions provide a warning that a sprinkler system condition has changed and that this should be investigated. The most common example of an abnormal condition is the monitoring of a valve supervisory switch, commonly referred to as a tamper switch. If the valve position is altered, the switch contacts are closed (or depending on wiring, opened), and this is detected at the fire alarm control unit (panel). The fire alarm panel generally is configured to provide a trouble signal to call attention to the abnormal condition of the valve. Several other supervisory devices available are discussed below, along with their testing requirements. Codes now require electrical supervision of the sprinkler control valves. Common design practice includes electrical supervision of main, floor, and sectional valves.

Initiating devices that supervise sprinkler systems are designed to detect a change in the sprinkler system, indicating an activation of the system. For wet pipe sprinkler systems, the most common example is a vane-type water flow detector. Under normal standby conditions, there is no water flow in a sprinkler system. If one or more sprinklers operate, water will flow through the system, causing the vane-type detector to operate. This signal is received at the fire alarm panel, which typically responds by operating water flow alarms. Any accidental water flow also will be detected by flow detectors, so these devices also provide protection from accidental discharges.

Dry pipe systems usually are supevised by pressure switches. Since the dry pipe system has pressurized gas (air for example) within the pipe during normal conditions, if one or more sprinklers operate, the gas is expelled, thus allowing the dry pipe alarm valve to flow water into the system. The pressure change also can be detected to provide an indication that the system has activated. The activation of a pressure device on a dry pipe system also would result in the operation of the warning signals.

The testing of these devices on a sprinkler system also will result in the operation of the fire alarm system. Therefore, the testing of such devices must be coordinated with the testing of the fire alarm system.

AUTOMATIC SPRINKLER SYSTEMS INSPECTION, TESTING, AND MAINTENANCE

Inspection, testing, and maintenance requirements may be required by local codes or ordinances, or adopted by reference in one of the model codes. NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, prescribes the required actions necessary to keep sprinkler systems in operation.

Code Enforcement Inspections

The fire inspector with little experience or training may be thrust into the responsibility for inspecting sophisticated fire sprinkler systems that protect lives or valuable property. While no inspector should feel he or she must be a fire sprinkler expert to accomplish the job, there are a number of simple things the inspector can do to feel confident the system is operational.

Remember that inspections are visual checks of observable conditions. The following list of questions can be used to prompt the inspector to perform a basic inspection. Testing and maintenance are required, but usually performed by the owner or a third-party service.

Essential Sprinkler Inspection Checks

- Have there been any occupancy or contents changes that would affect the sprinkler system performance?
- Has there been any change in storage heights or aisle widths?
- Is the system connected to at least one reliable and automatic water supply?
- Are yard hydrants or nearby municipal hydrants accessible and in good physical condition?
- If fire pumps are connected to the system, are they reliable, tested, and maintained on a regular basis?
- If the fire pump assembly has a bypass, is it secure in the "open" position?
- Are all control valves open and accessible; properly supervised with tamper switches, chains, locks, or seals; and documented weekly inspections?
- If possible, arrange to have all valves opened/closed in your presence.
- Are all control valves clearly identified with permanent signs indicating their function or the portion of the system or building they control?
- Are air and water pressure gauges reading with their appropriate ranges? (See Job Aid 7.2.)
- Are all fire department connections accessible, clearly marked, unobstructed, and in operating physical condition?
- Use caution if you remove the covers from the fire department connection and insert your fingers in the openings because there may be sharp objects.
- Are alarm devices (flow and pressure switches, tamper switches, low and high pressure alarms, low temperature alarms, etc.) in place and unobstructed?
- Are all hydraulic nameplates in place, if required?
- Are dry pipe and preaction air supplies or air maintenance devices in place and in a ready mode?
- Are all pipes supported by hangers and bracing, as required?
- Do dry pipe lines slope to low point drains?

- Are water temperature controls in place and in ready mode?
- Do pipes support any equipment, construction features, wires, or other nonsprinkler items?
- Are sprinklers in the correct orientation: pendant, upright, or sidewall?
- Are there any obstructions or physical damage to sprinklers?
- Is there adequate clearance (18 to 36 inches) between sprinkler deflectors and storage?
- Do sprinklers show any signs of corrosion, loading, or decay?
- Are sprinklers located in heater zones the correct temperature classification for the space?
- Are sprinklers in hazardous environments protected by listed wax or Teflon® coatings?
- Are guards provided on sprinklers subject to damage?
- Do special, concealed sprinklers have their covers in place?
- Are the types of sprinkles suitable for the occupancy?
- Are all sprinklers within 50 years of their manufacture date?
- Are extra high temperature sprinklers (greater than 325 °F) that have been continuously exposed to these temperatures within 5 years of their manufacture date?
- Are residential or quick response sprinklers within 20 years of their manufacture date?
- Is there an adequate supply of spare sprinklers and suitable sprinkler wrench?
- Are third-party inspection, test, and maintenance reports current?

Testing and Maintenance

Testing and maintenance for the fire protection system is the owner's responsibility. In addition to these operational tests and work, the owner or authorized representative is required to conduct regular inspections. This on-going care is necessary to assure the system will work properly in the event of a fire.

Owner's Inspections

Daily--dry pipe valves must be located in a heated enclosure if the system is located in an area subject to freezing. During inclement whether, the heated enclosure protecting a dry pipe valve should be inspected to verify that the enclosure is above freezing temperatures.

Weekly--dry pipe systems should have the air and water pressure gauges checked to verify that the pressures are within an acceptable range. These pressures should be recorded, and if abnormal losses occur, they should be investigated.

All systems should have the valve assembly inspected. All system valves, including yard hydrant valves, should be inspected to verify they are in the open (or proper) position. Piping and sprinkler heads should be visually inspected for damage and obstruction.

Monthly--fire department connections should be checked at least monthly. The connection should be accessible and caps protecting the thread should be present. During inclement weather they should be inspected for any water that can freeze. If needed, the threads may be lubricated.

Quarterly--dry pipe valves should be checked for proper water priming. This may require special assistance by those familiar with the sprinkler system.

Tests

Quarterly--one of the most important tests the fire inspector can require or observe is the main drain test. This quarterly test is a simple way to determine if there are water supply changes that need to be addressed.

A main drain test involves first recording static water pressure on the lower side of the alarm valve. (This is the supply side gauge.) Slowly open the main drain valve until it is fully open. After flow has stabilized (about 2 minutes), record the residual pressure from the same gauge. These numbers should be recorded and compared to previously recorded numbers.

A drop in recorded pressure over time (or a dramatic change from one test to another) may indicate problems with the water supply. Potential causes include

- obstructions or scale accumulations in the supply pipe;
- partially closed valves in the supply line;
- additional nearby development that is reducing the water supply throughout the area;
- water main leaks;
- less supply in the reservoir, tank, or other source; and
- fire pump failure.

The inspector should identify the source of the problem, and take corrective actions.

Test water flow alarms on wet pipe systems by opening inspector's test valves. The inspector's test valve allows a flow that simulates one sprinkler flowing. All water flow detection devices in the area served by the inspector's test should activate.

Dry pipe systems require a low air pressure test. To conduct this test, close the water supply into the system to prevent it from tripping. Slowly release air from the system by operating the inspector's test valve. The low air pressure detector should respond to the drop in air pressure within the system piping and sound an alarm. The alarm should activate before the pressure drops to a point where the alarm valve trips. Immediately after the test, open the air supply valve to allow the pressure in the system to come back to normal. **Important: slowly turn supply valve back to open position**. On dry pipe systems, water flow alarms can be tested by opening the alarm bypass valve.

Annually--dry pipe valves should be tested with the control valve only being partially opened (not fully as with the 3-year tests). This may require the assistance of a sprinkler contractor. Properly trained employees also may complete the test.

Wet pipe systems should have their antifreeze solution tested when utilized in the system. This can be accomplished by using a hydrometer.

Every 3 years--dry pipe valves should be full-flow trip tested every 3 years, or whenever alterations are made to the system. This test should be performed with the water supply in the fully opened position. The flow should continue until clear water flows from the open inspector's test. This test is required every 3 years instead of annually, as the water may introduce foreign materials into the sprinkler pipe and the system has to be drained. These concerns are minimized by the partial flow used in the annual test.

Automatic Sprinkler Systems

Quarterly Inspection and Tests

Year: 2005 **System:** B BUILDING : DRY VALVE #3
Location: B BUILDING ROOM 123

Y = Satisfactory N = Unsatisfactory (explain below)

Date	4·7	6·12	8/7	
Inspector	[illegible]	[illegible]	[illegible]	
Main Drain Test				
Record the static water supply pressure in psi (bar) as indicated on the lower pressure gauge. Open the main drain and allow water flow to stabilize.	48	50	50	
Record the residual water supply pressure while water is flowing from the 2-in. (51-mm) main drain as indicated on the lower pressure gauge in psi (bar). Close the main drain (slowly).	37	42	38	
Fire Department Connections Verify connection is visible and accessible, not damaged, caps or plugs are in place, identification sign is in place, and automatic drain is working properly.	Y	Y	Y	
Wet Pipe System Flow Alarm Test water-flow alarms by opening the inspector's test valve. (Notify alarm company to avoid false alarms.)	Y	Y	Y	
Dry Pipe Priming Level Check dry priming water level by opening the test valve and checking for a small amount of water to discharge. If no water flows out of the test line, add priming water.	Y	Y	Y	
Dry Pipe System Low-Air-Pressure Alarm Close the water supply valve and *carefully* open inspector's test valve to reduce air pressure *slowly.* (Do not reduce air pressure sufficiently to trip the dry pipe valve.) Confirm operation of low-pressure alarm, record air pressure at which low-pressure alarm activated, close inspector test, allow air pressure to rise to normal, then open water supply valve.	Y	Y	Y	
Dry Pipe System Flow Alarm Open the alarm bypass valve. (Notify alarm company to avoid false alarms.)	Y	Y	Y	
Quick-Opening Device Test in accordance with manufacturer's instructions.	Y	Y	Y	
Preaction System Flow Alarm Open the alarm bypass valve. (Notify alarm company to avoid false alarms.)	N/A			
Deluge System Flow Alarm Open the alarm bypass valve. (Notify alarm company to avoid false alarms.)	N/A			
Control Valves Close valves and reopen until spring or tension is felt—back valve 1/4 turn.	Y	Y	Y	
Hydraulic Nameplate If system was hydraulically calculated, assure nameplate is legible and securly attached to riser.	Y	Y	Y	
Notes Record any notes about the system that the inspector believes to be significant. Place a number in this block and number the corresponding note on the reverse of this form.	ok	ok	OK	

Sample Sprinkler System Inspection and Test Report

Every 5 years--for all types of sprinkler systems, a representative sample of sprinklers of the extra high temperature rating (325 °F), if present, should be removed and tested by an approved testing laboratory. Replacement sprinklers should be installed as the test samples are removed. If sprinklers fail the testing procedure, then all similar sprinklers must be removed from the system and replacements installed.

Additional System Maintenance

Quarterly--post indicator and outside screw and yoke (OS&Y) valves should be exercised to verify their operation. The valves must be returned to their normal position. A lack of resistance felt on the operating rod usually is an indication that the valve gate has become detached. This condition must be corrected immediately.

Annually--dry pipe systems should have all point drains cleared. This should be repeated daily until all signs of condensation are removed.

All systems should have their valve stems lubricated by an acceptable lubricant (such as graphite and light oil). The valve should be worked to verify its operation and to distribute the strainer unless it is a self-cleaning strainer.

Pipe blockage--if blockage is suspected, the system should be flushed again to clear any obstructions in the system piping and components. Indicators of possible obstruction include

- Defective screens at pump intakes due to contaminated water. Missing or defective screens can allow debris to be pulled into the pump and onto the system.
- Debris discharged during normal flow testing, including local hydrant testing.
- Debris found in dry pipe alarm valves during maintenance.
- Extremely contaminated water observed during flow tests, or blockage of inspector's test valve during tests.
- Blocked piping found during repairs.
- System failure during fire, which suggests water did not flow properly from system.
- Any indication original flushing was not properly completed.
- Any major repairs or alternations to local water mains that could cause debris to enter the system.

Impairments

All these inspections, tests, and maintenance are conducted toward one goal: to reduce the likelihood of system failure.

There are many things that can go wrong with automatic sprinkler systems, so the fire inspector should be aware of many of these "impairments" so the inspector can initiate corrective action (see Job Aid 7.1).

Some of the more common impairments include

- Closed water supply valves. This is the leading cause of sprinkler "failures." Valves that are closed inadvertently or intentionally restrict or stop water flow to critical portions of the system.

- Inadequate water supply. There are many reasons water supplies deteriorate over time, but the inspector must be aware of the potential problems and work with water purveyors to assure that adequate volume and pressure are maintained.

- Contents change. Adding more combustible materials, or products that have a greater heat release rate, may overpower sprinkler systems designed for a lower hazard classification.

- Pipe corrosion. Iron pipes filled with water or even moist air may have accumulations of rust, scale, corrosion, or other products that reduce water flow by increasing friction.

Internal Pipe Corrosion that Affects Flow

- Sprinkler damage. Although sprinklers are not "delicate," they are not indestructible, either. Damage may occur to deflectors, operating elements, or frames that reduce the operational effectiveness and discharge characteristics.

- Loading. Accumulations of grease, dirt, lint, paint overspray, and other obstructions are known as "loading." Fusible inks, glass bulbs, and chemical pellets in sprinklers need to be unobstructed to operate within their effective range.

- Discharge obstructions. To be effective, the sprinkler water spray must reach the burning materials or nearby combustibles. Obstructions such as storage, equipment, or construction may affect the water distribution pattern. In general, all storage must be at least 18 inches beneath sprinkler deflectors.

- Freezing. Frozen pipes or sprinklers develop ice plugs that may prevent water flow downstream to the rest of the system.

- Alarm failures. Many people fear the water damage from sprinklers more than they recognize the fire protection values. Alarms that are turned off or otherwise impaired increase the likelihood of delayed reporting, and the potential for excess water flow while the incident goes undetected.

- Outdated sprinklers. Generally, sprinklers more than 50 years old have to be replaced or a sample sent for performance testing. If sprinklers fail the testing, all similar sprinklers must be replaced. After the initial 50-year test, this procedure should be repeated every 10 years.

All sprinklers manufactured prior to 1920 must be replaced.

Fast response sprinklers that are more than 20 years old have to be tested. Fusible link sprinklers with operating temperature classification of Extra High (325 °F) or greater that are continuously exposed to high ambient temperature conditions should be tested every 5 years.

Representative samples should be the larger of the following:

- Two sprinklers per floor or individual riser but not fewer than a total of four.

- One percent of the total number of sprinklers on each individual system.

If sprinklers fail the testing, all similar sprinklers must be replaced. After the initial 50-year test, this procedure should be repeated every 10 years.

Summary

As with all inspections, testing, and maintenance programs, proper recordkeeping is important. In addition, it may be required that valves be tagged with test dates and other important information. Some facilities currently are using a computerized preventive maintenance program for scheduling and documenting all inspections, tests, and maintenance procedures. Part of the inspection process should include a review of the maintenance and testing documentation and a visual check of the system.

STANDPIPE SYSTEMS

Purpose of Standpipe Systems

Standpipe systems are installed in buildings to facilitate manual suppression by occupants or fire service personnel. Standpipe systems are an arrangement of piping, valves, hose connections, and related equipment installed in a building in a fixed manner. The systems may or may not have hoses permanently attached. Water supplies may or may not be continually provided to standpipe systems. These features of a standpipe system are dictated by the class and type of system. The primary use of standpipe systems is by fire department personnel who are trained in manual fire suppression methods. Many standpipe systems no longer have occupant hoselines (small diameter 1-1/2 inch). The fixed piping of a standpipe system in a building allows the fire service to connect its hoselines into a pressurized water source near the fire floor. The fire service is consequently relieved of the burden of extending hoses into the building from grade level to the location (floor) of the fire. In mid- to highrise buildings, standpipe systems are extremely important for the prompt manual extinguishment of fires.

Classes of Standpipe Systems

NFPA 14, the standard covering standpipe and hose systems, defines three classes of standpipe systems as follows:

Class I

Class I systems are those systems that have 2-1/2-inch hose connections on the system piping. This size of hose produces what is considered a heavy fire stream and is intended primarily for the fire service, which supplies its own hoses for firefighting.

Class II

Class II systems are those systems that have 1-1/2-inch hose connections. This size of hose is intended primarily for occupant control of a fire until the fire department arrives. A hose is connected to the system piping and is fitted with a nozzle.

Class III

Class III systems are those systems that provide both 2-1/2-inch and 1-1/2-inch hose connections for use by either the fire service or the building occupants. Typically, the two sizes of hose connections are provided by a 2-1/2-inch connection to the system piping and a 1-1/2-inch reducer connection on the 2-1/2-inch connection. The fire service can easily remove the reducer, thus providing the fire service with the 2-1/2-inch connection they require for manual suppression. A small hose (1-1/2-inch) and nozzle must be provided for occupant use.

Types of Standpipe Systems

There are three major types of standpipe systems with individual sub-categories.

1. Manual system. A manual system is not connected to a water supply that is capable of providing adequate volume or pressure. The fire department must connect to the system to provide fire protection water.

   Manual systems are subcategorized as "manual dry" and "manual wet." Manual dry systems have no water in them until the fire department arrives. Manual wet systems are full of "priming" water that enables water to be discharged from the hose outlets more quickly.

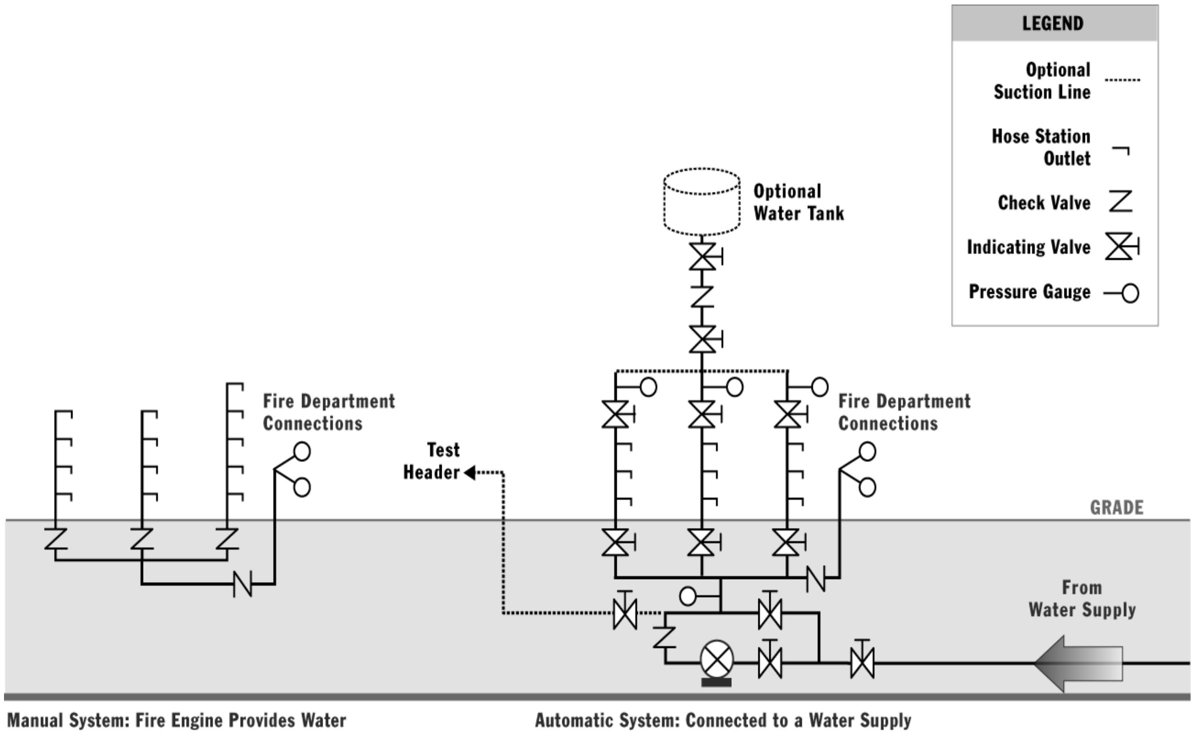
2. Automatic system. An automatic standpipe system is one connected to a permanent water supply that is capable of meeting flow and pressure demands. This category also is subdivided into "automatic wet" and "automatic dry." The automatic wet system is full of water at all times and discharges from the hose stations immediately upon opening the hose valve.

   An automatic dry system employs a dry pipe valve. The standpipe is filled with pressurized air that is discharged through the hoseline and replaced by water once the pipe fills.

3. Semiautomatic system. A semiautomatic system employs a deluge-type valve to hold the water back. A remote operating device, such as a pull station, is located next to the hose outlet. Once the remote device is operated, the deluge valve opens and water fills the pipe.

Standpipe System Standards

Where required, standpipe systems typically are installed in accordance with the requirements of NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*. If the system is a combined sprinkler-standpipe system, the requirements of NFPA 13 must also be met.



Standpipe System Design/Components

Design of Standpipe Systems Water Supply Sources

Water supply sources for standpipe systems are very similar to those of sprinkler systems noted in the beginning of this unit.

Water Supply Requirements

Standpipes are determined by building height, the size and number of fire streams expected to be used at the same time, and the distance of the hose connection to the water supply. Systems can be designed hydraulically or by pipe schedule in a manner quite similar to sprinkler system design. The class of a system indicates the required design flow through single and multiple outlets as well as minimum design diameters of piping. For Class I and III systems, a minimum of 500 gpm flow should be available through a single connection. If additional connections are required based on the system design, they must flow 250 gpm each, in addition to the first connection flowing 500 gpm. The maximum required flow of all connections combined is 1,250 gpm. If these systems are less than 100 feet in height, the standpipe must be no less than 4 inches in diameter. System design may require larger pipe sizes, and there are some exceptions to these requirements. Local code requirements may cause design criteria to vary.

Location and Number of Standpipes

The number and location of standpipes needed for effective coverage are based on the fire risk posed by a particular building. The type of occupancy, the type of construction, exterior exposure, and accessibility all must be considered when designing the system. The locations of standpipe hose connections are generally limited to noncombustible fire-rated stair enclosures.

Combined systems are systems that have piping that serves both the standpipe and an automatic sprinkler system within the same building. These types of systems must satisfy design requirements for both standpipe and sprinkler systems. See the section on automatic sprinklers in this chapter and NFPA 13 for further information.

Other design requirements, including hose connection, water supply, pipe, valves, fittings, and hangers, also are covered in NFPA 14.

Inspection, Test, and Maintenance of Standpipe Systems

Visual Inspection

All system piping, including that between the fire department connection and the system check valve in the inlet piping, should be flushed to clear any debris that may have accumulated during construction.

All hose connections should be inspected to assure that they are accessible and operable. Since there are different thread configurations used by fire departments, it is important to make sure that the threads are compatible with the threads used by the local fire department. Hose threads should also be checked for thread damage that could prevent proper use. In locations where freezing is a concern, all portions of the system must be inspected to verify that no sections will freeze. Fire department and occupant-use signs, including identification of fire department connections, must be provided and readily visible.

Periodic Test and Maintenance

Dry systems must be hydrostatically tested at least once every 5 years.

Routine inspection of standpipe and hose systems must be completed to assure the system remains functional. The proper position of valves should be verified, valve connections should be tight, any tanks must remain filled and pressure tanks must be charged to no less than 75 psi. Tanks that may be susceptible to freezing weather must be checked frequently to assure they do not freeze. Hose should be inspected according to NFPA 1962, *Standard for the Inspection, Care and Use of Fire Hose, Couplings and Nozzles; and the Service Testing of Fire Hose*. NFPA 25 also should be consulted.

Any time a standpipe system is removed from service, no matter how briefly, the fire department should be advised and the portions of the system out of service should be posted at all fire department connections. If repairs or other modifications have been made to the system, it must be retested to verify there are no leaks.

Annually, any fire pump should be tested. Also, any hoses should be removed from hose racks and reracked to prevent deterioration of hose at bends. Gaskets also should be inspected and maintained. Any swing-out hose racks or any hose reels should be lubricated to allow for proper movement and use.

FIRE ALARM SYSTEMS

Purpose of Fire Alarm Systems

A properly designed, installed, operated, and maintained fire alarm system can reduce the losses associated with an unwanted fire in any building. These losses include both property and, more importantly, human life. The primary motivation for fire alarm system requirements in building and fire codes is to provide early notification to building occupants so they can leave the building, and to notify the fire service so it can respond to the fire. In settings such as hospitals, the fire alarm system provides notification to staff so they can respond to the fire as opposed to evacuating the building. It should be noted that fire alarm systems also are referred to as "protective signaling systems," especially in NFPA documents and in other codes and standards.

Fire alarm design and installation may be regulated by local or State building or fire codes, but the predominant national standards that affect protective signaling systems are NFPA 72, *National Fire Alarm Code®*, and NFPA 70, *National Electrical Code®*.

All components of fire alarm systems should be listed for fire alarm system use by an acceptable testing agency such as UL. Additionally, all components must only be used for the specific function for which they have been designed and tested.

Fire Alarm System Components

Fire alarm systems commonly have these general components:

Fire Alarm Control Unit or Panel

The fire alarm control panel contains the electronics that supervise and monitor the fire alarm system. It receives signals from alarm initiating devices, processes the signals, and produces output signals. Power and fire alarm circuits are connected directly into this panel.

A fire alarm panel can also perform functions as needed or required. Examples of these would be to control a remote annunciator or operate relays that capture and recall elevators.

Primary Power Supply

The primary electrical supply powers the entire fire alarm system. Primary power for fire alarm systems typically is provided by connecting into the local commercial power service.

Secondary Power Supply

The secondary power supply is required so that fire alarm operation can continue if the main power supply fails. The secondary power supply should activate automatically within 30 seconds of the primary power failure to maintain its normal operating voltage. Secondary power supplies should be capable of powering the system at maximum load for at least a 24-hour period and then be capable of operating all alarm appliances for another 5 minutes. The time period requirements for secondary power operation capabilities vary and can be found in NFPA 72. Batteries with chargers are a common form of secondary power supply, and engine driven generators also are acceptable.

Alarm Initiating Devices

These are devices that initiate the alarm process: smoke detectors, heat detectors, manual pull stations, and water flow alarms. Additionally, many system monitor devices important to the overall fire safety of the building also are connected to initiating circuits. These devices indicate an "abnormal" condition, not a fire or "alarm" condition. They are referred to as "supervisory devices." One example would be the supervisory or tamper switch for an automatic sprinkler system valve.

Depending upon the wiring method, they may connect to alarm initiating or signaling line circuits.

Alarm Indicating Devices

Audible and visible alarm indicating appliances provide warning to the building occupants. Devices that send a signal off-premises can also be connected to these circuits.

Depending upon the wiring method, they may connect to alarm indicating or signaling line circuits.

Circuit Types

There are three predominant wiring circuit "types" described in NFPA 72: initiating, indicating, and signaling line.

Initiating device circuits carry electronic signals from initiating devices to the fire alarm control panel. Indicating appliance circuits carry electronic signals from the fire alarm control panel to the alarm devices.

Signaling line circuits carry signals both directions (to and from the fire alarm control panel) and are commonly used on multiplexing style fire alarm systems.

Trouble Signal

An important feature of any fire alarm system is the trouble signal. Upon the detection of an abnormal condition within the fire alarm system, the trouble alarm signal is activated to attract attention so that the condition can be repaired. NFPA 72 as a minimum requires that all systems provide an abnormal condition trouble signal for an open circuit or ground fault of the system's initiating, indicating circuits, and loss of primary power supply to the system.

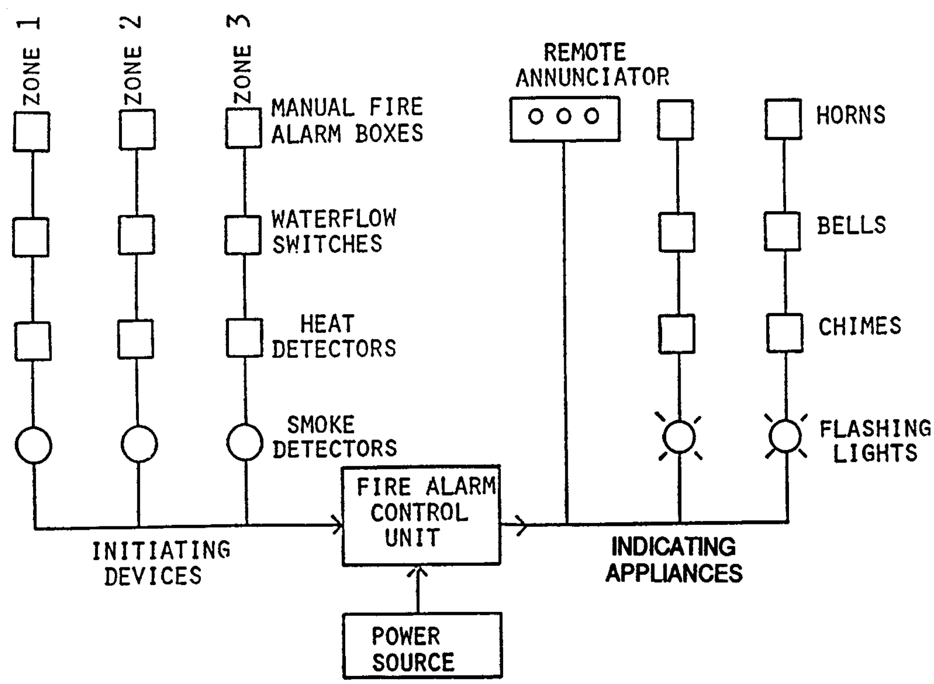
Voice/Alarm Communication System

Systems can have an emergency voice/alarm communication system included. Inclusion of this equipment within the fire alarm system provides for the transmission of information to occupants of the building. The fire department also can use this equipment while operating within the building.

Remote Annunciators

Remote annunciators are frequently included in fire alarm systems. Briefly, a remote annunciator "displays" the condition of the fire alarm panel at a remote location, usually through light-emitting diodes (LED's) on graphic or tabular displays. Remote annunciators can also be equipped with switches that control the main fire alarm panel. The fire alarm panel may be located in a secured area out of the public way. However, it must be remembered that those investigating an alarm need to inspect the indicators on a fire alarm or annunciator panel to determine the cause of the alarm and the location of the initiating device. Remote annunciators can be provided at locations such as the main lobby of a building, or at a security desk so that the needed information on the condition of the fire alarm panel is readily available.

Local Fire Alarm System Diagram



Types of Fire Alarm Systems

Fire alarm systems can be designed and configured to meet the requirements of the local fire codes. In addition to the basic features or components common to most fire alarm systems, there are several "types" of fire alarm systems. These "types" describe how they report alarms from the protected to responsible persons.

Local Protective Signaling System

This type of fire alarm is contained entirely within the building that it services. The main purpose of this type of system is to provide an evacuation alarm for occupants of that building. The system need not be connected by any means to the fire service. Therefore, notification of the fire service can occur only if someone hearing the evacuation alarm calls and reports it.

Auxiliary Protective Signaling System

This type of system is connected to a municipal coded fire alarm box dedicated to that building, often called a "master box." Upon activation of the fire alarm within the building, the municipal box is tripped and sends a signal to the fire service. It uses the same line as the street fire alarm boxes that are available to the public.

Remote Station Protective Signaling System

This type of system utilizes leased telephone lines to connect the fire alarm system of a given building to a remote receiving station such as the local fire or police station.

Central Station Protective Signaling System

This type of system has the fire alarm system connected to a privately owned central station. The central station monitors the fire alarm system and takes the necessary action when an alarm is received, such as to call the local fire department to report an activated fire alarm.

Proprietary Protective Signaling System

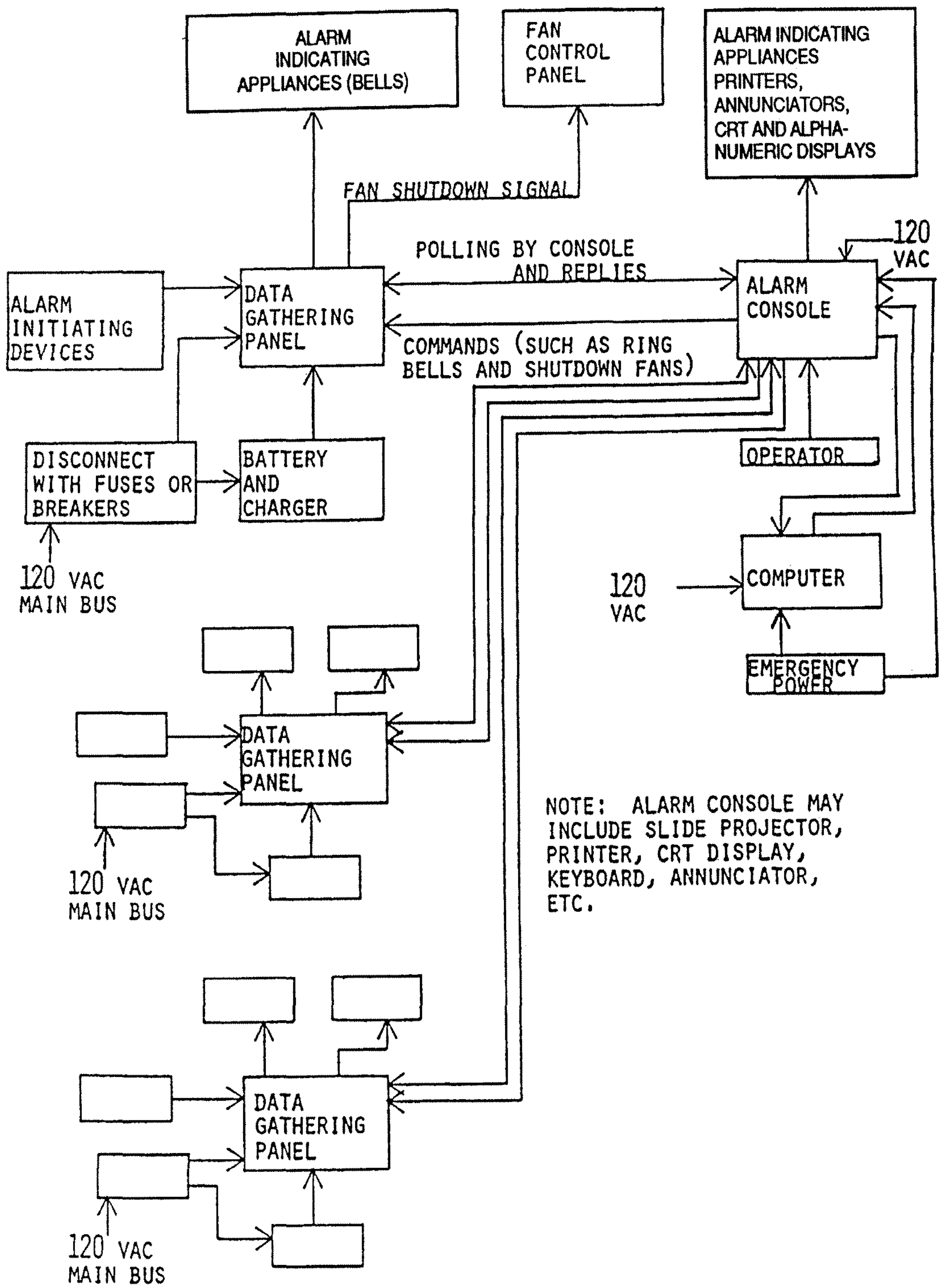
This type of system is similar to the central station system listed above with the exception that the central station is owned by the same concern as the building being monitored. The building(s) being protected may or may not be on the same property as the central station. Many large facilities utilize this type of system with the security center serving as the central station.

Multiplexing

Modern fire alarm equipment uses "multiplexing." Simply defined, multiplexing means the transmission of "multiple" signals over a single line (the signaling line circuit). This type of system allows the alarm initiating devices to be identified individually (addressable) or in a group through the interaction of the fire alarm control panel with each independent device. Remote devices, such as relays, can be controlled over the same line to which initiating and indicating devices are connected. This capability greatly reduces the amount of circuit wiring needed for large applications.

Wiring methods differ from the traditional fire alarm wiring methods mentioned above and can include T-tapping. Installation costs, including labor, can be reduced for some systems by using multiplexing systems as opposed to the traditional "hardwire" system. An economic comparison must be made on a system-by-system basis. The control panels for multiplexing systems can range from the simple and relatively inexpensive to the very sophisticated and expensive. Displays for the condition of the system can be accomplished through the use of monitors and printers and the system controlled through a computer keyboard. Some multiplex systems have the added advantage of being able to test the performance of devices, thereby reducing manpower requirements for preventive maintenance.

Multiplex Alarm System Block Diagram



General Considerations for Nonmultiplexing Fire Alarm Circuits

All fire alarm circuits have limitations regarding the types and number of devices that can be connected to them. Additionally, approved wiring methods and materials must be used to assure the devices are properly supervised. The annunciation requirements will also have an effect on the circuits' wiring and the devices connected to them. Generally, the more specific annunciation requirements will increase the number of zones and the number of wires in the zones. Generic limitations of devices are provided in NFPA 72.

Devices such as smoke detectors that are powered from the fire alarm panel have certain restrictions as to the number of detectors allowed per circuit. The number is limited by the power output of the zone module in the fire alarm panel and the number and power requirements of the smoke detectors on the circuit. This information is available from each manufacturer and may vary, but a general figure is from 20 to 30 detectors.

The types of devices that can be connected to a signal zone circuit are restricted by the manufacturer's performance criteria that are reproduced on the product data sheets.

Small zones can provide added annunciation and reduce the loss of devices if a circuit is damaged. This also allows for easier troubleshooting.

Certain wiring practices are forbidden on fire alarm circuits as they defeat the supervision capabilities of the zone circuit. One common wiring error is referred to as "T" tapping. A break in the T-tapped conductors will not be detected as the supervisory current is still provided through the non-T-tapped conductors. Also, no device should be installed electrically beyond an end-of-line device as this will result in those devices being unsupervised.

Another common mistake is to remove a malfunctioning device, leave the system in trouble, and silence the trouble alarm. Unfortunately, on some systems this may leave the devices electrically beyond the removed device out of service since the circuit would end at the base of the removed device.

Most fire alarm panels will initiate an alarm even if the alarm silence button has been depressed. The same situation applies to supervisory alarms. However, if a system does not have this ability, and the system is left in the alarm silence mode, all future alarms will be missed. It is important that one understands the operation and limitations of his/her fire alarm system so that it is not inadvertently defeated.

DETECTORS

Primary Methods of Fire Detection

Initiating devices fall into one of two main categories: either those that indicate an alarm condition, or those that indicate an abnormal condition of a monitored device.

Fire detection can be accomplished by using any device that responds to conditions caused by fire. The most common byproducts of fire are

- heat;
- smoke;
- flame; and
- fire gases.

In addition, humans can detect a fire and initiate an alarm by activating a manual pull station.

Heat Detectors

Heat detectors are commonly used for fire detection. Heat detectors are not so prone to false alarms and are less expensive than smoke detectors. However, the heat detectors' response time may not be adequate in many instances, thus precluding their use. Heat detectors are slower to respond to fires than are smoke detectors because they cannot respond to smoke. Heat detectors typically are best suited for detecting fast growing fires in small spaces. Heat detectors are also a means of fire detection in locations that cannot be protected by smoke detectors due to such environmental effects as mist, normally occurring smoke, and high humidity.

Heat Detector Operating Types

Fusible element type mechanisms use a eutectic alloy that melts rapidly at a predetermined fixed temperature. When a certain temperature is reached and the fusible alloy melts, an electrical contact is made, which gives an alarm. Fusible alloys are also commonly used in sprinkler heads. These mechanisms must be replaced after each operation.

Bimetallic type mechanisms combine two metals with different thermal expansion coefficients. As the mechanism heats, one metal expands more than the other, causing a deflection in the shape of the element. This deflection causes an electrical contact to be made, thus initiating an alarm. These types of mechanisms are self-resetting as the element cools.

Rate-compensated heat detectors are heat detectors that respond to a given temperature of the surrounding air regardless of the rate at which the temperature rises. This, in effect, compensates for thermal lag, while standard thermal detectors do not.

Some heat detectors operate on what is commonly referred to as the "**rate of rise**" principle. Regardless of the ambient temperature, if the detector senses a rise in temperature exceeding a set amount, an alarm is generated. One method of accomplishing this is through the use of a container that has a small vent hole. As air is heated it expands, which can cause a set of contacts to close and send an alarm. If the expanding air leaks out of a vent hole, the resulting internal pressure will be equalized. However, if the air expands at a rate faster than the vent hole can compensate, the contacts will be closed and an alarm sent.

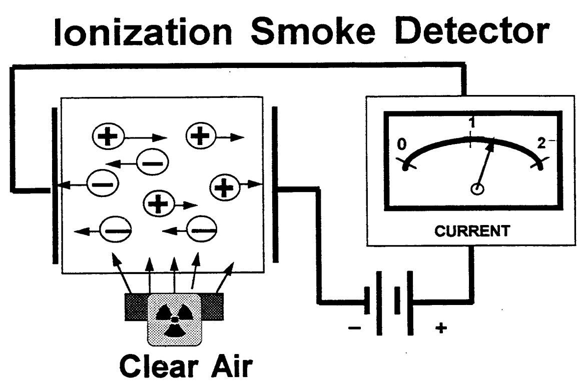
Combination heat detectors can combine the two operating principles of reaching a fixed temperature and reaching a set rate of rise. Additionally, smoke and heat detectors can also be combined into a single unit. It should be noted that some combination smoke/heat detectors activate when either condition is reached, while others require both the smoke and heat mechanisms to operate. In most cases, little benefit, if any, is obtained by the combination detector, which requires both heat and smoke to cause an alarm.

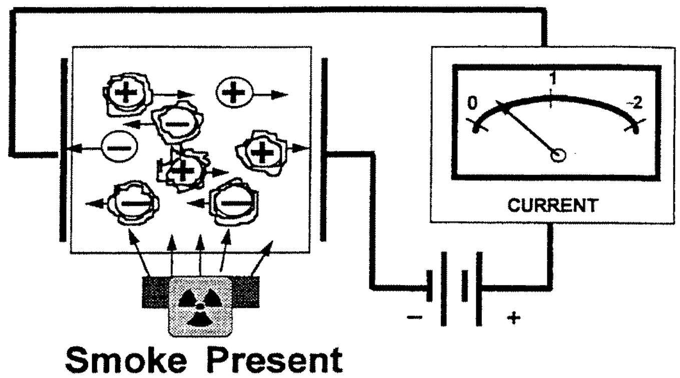
Other types of heat detectors include heat-sensitive cables and liquid expansion detectors.

Smoke Detectors

The benefits of smoke detectors cannot be overemphasized. However, smoke detectors are not useable in all environments and their effectiveness varies depending on the fire scenario and occupant capability. The two basic operating mechanisms used in current smoke detectors are photoelectric and ionization.

Ionization smoke detectors have a small amount of a radioactive material located within the detector that "ionizes" the air entering the detection chamber. Once ionized, the air particles become conductive, allowing a current to flow through the detector circuitry. Smoke entering the ionization chamber causes a reduction in the current flowing through the detector's circuitry. At a certain reduced level of current flow, the detector signals an alarm.





Photoelectric smoke detectors utilize one or two methods to detect smoke; however, both have as basic components a light emitting source and a receiver. Photoelectric smoke detectors that operate on the "light obscuration" principle work as follows:

A light source is directed at a receiver, which is accustomed to receiving a certain light intensity. When smoke particles enter the detection chamber, they partially block the light traveling from the emitter to the receiver. When the light reaching it is reduced or obscured by a certain amount, an alarm is generated by the detector's built-in circuitry.

The second operating principle used in photoelectric detectors is that of "light scattering," which is more common and which operates as follows. The receiver in the detection chamber is located so that the light emitted is normally not "seen" by the receiver. That is, the light emitter and receiver are not aligned as with the light obscuration method. When smoke enters the detection chamber, it is struck by light from the emitter. A fraction of the light striking the smoke particles is scattered or "reflected" away from the smoke particle. Some of this scattered light lands on, or strikes, the photo receiver. When a preset amount of light lands on the receiver, the detector signals an alarm.

Detectors that operate on the photoelectric principle generally are recommended for use in locations where slow-growing, smoldering fires are expected. These fires typically generate large size particles, 0.3 to 10 microns. They also respond better to light gray smoke as opposed to very dark smoke. Ionization type detectors respond better to fast-flowing, flaming fires that produce smaller particles, 0.01 to 3.0 microns. Ionization detectors respond better to dark smoke than to light smoke. Photoelectric detectors are better suited than ionization detectors for locations where the humidity is high. Air velocity may also affect smoke detector operation.

The **projected beam detector** is a special type of photoelectric smoke detector. Here the operating principle is the same as a light-obscuration-based detector but the light emitter and the receiver are physically separated across large areas (e.g., the length of a room) and smoke at any location between the two components can result in an alarm. These detectors can also be used in conjunction with mirror systems so that the projected beam is directed in several directions before ultimately striking the receiver.

Flame Detectors

Another method of fire detection is by detectors that are sensitive to the light waves emitted by fires. These typically operate by detecting **ultraviolet** (UV) or **infrared** (IR) energy. These detectors are extremely quick to operate and typically are used only in high hazard areas such as industrial process facilities, fuel loading areas, and areas where explosions may occur and are protected with explosion suppression systems. One problem with IR detectors is that they will respond to sunlight, creating an unwanted alarm problem; also, both types of flame detectors must "see" the flame to detect it so they usually have to be pointed toward the locations where fires are likely to originate.

Gas Sensing and Other Phenomenon Detectors

Gas sensing detectors and "other phenomenon" detectors are not as common as fire detectors. Specific gases given off by a fire can be detected by special gas detectors, and the presence of these gases may be indicative of a fire. For example, carbon monoxide detectors have become widely used in home applications. However, if a particular fuel gives off a known product of combustion, perhaps a special gas-sensing detector could be used to detect a fire involving that fuel.

Basically, any method of fire detection not already mentioned is considered under the "other phenomenon" category. One example is pressure. If a fire burns in a sealed room, excessive pressures quickly develop and can be detected. This is the way some explosion detection devices operate.

Manual Fire Alarm Boxes (Pull Stations)

A very common initiating device, the manual fire alarm box, is usually referred to as a manual pull station. These are simple devices, which operate manually, i.e., they require the actions of a person operating the mechanism. These are found throughout building hallways, near exits, and at other strategic locations such as a nurse's station or security center.

Fire Suppression Systems

Fire suppression systems can be connected into a fire alarm panel so that an activation of such a system causes the fire alarm to signal an alarm. Wet pipe automatic sprinkler systems are commonly fitted with water flow detectors. As water starts to flow in the sprinkler piping, it causes a vane to swing into an alarm position; this sends an alarm to the fire alarm panel. Dry pipe sprinkler systems can be fitted with pressure sensors for the same reason. All other fire suppression systems can also be connected to the fire alarm panel.

As mentioned above, not all devices signal an alarm condition. Many devices can be connected to the fire alarm system so that they can be monitored for abnormal conditions. Perhaps the most common example is that of a valve supervisory switch or "tamper switch" on a sprinkler system.

To assure valves that control a sprinkler system are in the proper position, they can be fitted with a tamper switch that will operate if the valve position is altered. If the valve is moved, a signal will be given at the fire alarm panel, indicating the valve should be inspected. This is important since someone could inadvertently, or purposely, close a valve on the sprinkler system, rendering the system inoperable.

Many other indicating devices can be connected into the fire alarm panel for supervision. The following is a partial list provided for information purposes:

- water level and temperature in a gravity tank;
- water level and air pressure in storage tank;
- status of fire pump;
- air pressure on dry pipe system; and
- temperature in wet valve room.

Indicating Appliances

When a fire alarm system goes into alarm because of the operation of an initiating device, several activities can occur. Codes now require that a signal be sent to the fire department. The fire alarm panel may cause other events to happen and these will be discussed in a later section of this chapter. In most cases the fire alarm system also provides audible and visible warning that an alarm condition has occurred. This latter function is the most important when considering an occupied building.

Audible and Visible Indicators

For occupants of a building to be aware of a possible fire in a building, they must be notified. Fire alarm systems typically accomplish this task through the use of audible and visible indicating devices. Both types of signals should be used so that occupants don't mistake the signals' purpose and because the building may be occupied by handicapped persons. For example, a deaf person will not hear a fire alarm bell and a blind person cannot see a fire alarm strobe light. Bells, chimes, horns, buzzers, and speakers as well as flashing strobe lights are common examples of these devices. It is common practice, but not always desirable, to locate the audible and visible devices in one unit.

Typical Combination Horn/Strobe

Other Functions Controlled by Fire Alarm Systems

As mentioned above, fire alarm systems can do more than receive an indication of an emergency and send an alarm. This section will identify some of the common functions controlled by fire alarm systems. The list is not intended to be all-inclusive.

The fire alarm panel can send a signal to the fire department, or other desired facility via one of the methods described at the beginning of this section. Elevator capture and recall is a common function that fire alarm panels can perform easily. Upon receiving an alarm, the fire alarm panel can operate one or more relays that control the actions of the elevator. The heating, ventilation, and air-conditioning system (HVAC) or a smoke control system can also be controlled through fire alarm panels.

It was previously stated that fire suppression systems can be connected into fire alarm panels so that their activation is monitored. Another important function that a fire alarm panel can control is the activation of fire suppression systems. In this function, the fire alarm panel identifies a fire through its initiating circuits, and activates a fire suppression system such as a clean agent or carbon dioxide system, through a control circuit. This means that fire alarm systems are capable of both alerting when a fire suppression system is activated, and as a control mechanism when suppression systems are activated. Other types of fire suppression systems that fire alarm panels can control are preaction and deluge sprinkler systems.

Unwanted Alarms

The high incidence of false alarms is a common complaint about automatic detection devices. Data indicate that health-care facilities, for example, are experiencing an average of approximately 15 unwanted alarms for every real alarm. One problem resulting from these high averages is that people may ignore the fire alarm's warnings during fire drills and emergencies, believing the alarm is "just another false alarm." Quite obviously this could lead to a tragedy.

Many of the unwanted alarms are attributed to "field" problems such as insects in the detector and other maintenance deficiencies. Some modifications in detector design are helping to reduce the unwanted alarm problem. Alarm verification allows the fire alarm panel to "wait" for a specified time period to see whether the signal from the detector is just from a brief exposure to smoke or from electrical "noise." As a code official, you should be consulted with respect to the allowable time delay. Device manufacturers are continually modifying their products to reduce the unwanted alarm rate. System maintenance can have a profound effect on the false alarms at their facilities.

The unwanted alarm situation can also be addressed with proper system design, installation, and acceptance test procedures. For example, the specification could specify a certain sensitivity rating such as 2.5 percent or 3 percent, which would eliminate detectors that are too sensitive. During the acceptance test, the sensitivity of the detectors should be verified. Also, proper location of smoke detectors with respect to air diffusers will assist in reducing unwanted alarms. As a general rule of thumb, detectors should not be located within 3 feet of an air diffuser.

INSPECTION, TESTING, AND MAINTENANCE

Fire alarm systems must be routinely inspected, tested, and maintained to assure proper operation. Since fire alarm systems provide life safety and property protection, these systems are extremely important. They should be subjected to an acceptable inspection, testing, and maintenance program. The building owner is responsible to assure that adequate test and maintenance frequencies are provided, and can delegate that responsibility to someone else only in writing.

The manufacturer's inspection, testing, and maintenance schedule should be followed, but if there is no documentation or the manufacturer has no recommendation, NFPA 72 outlines procedures that should be followed. The owner also should possess a set of "as-built" or record drawings of the system to keep track of how it was installed.

Acceptance Testing/Commissioning

When the fire alarm system is first put into service, there are a variety of tests that should be performed to assure reliability.

The installing contractor should provide the inspector a copy of a "Certificate of Completion" found in NFPA 72 that provides a detailed description of the fire alarm system, and documents that all devices and equipment have been tested.

The control panel should be inspected to assure it is in the normal operating (supervisory) condition. Panel indicator lights and alarms should also be checked to verify their operation. Fuses should be removed from the panel, the proper rating verified, and the fuses returned. When the fuse is removed, the panel should respond with a trouble signal.

The primary power supply should be tested by disconnecting the standby power and any redundant primary supplies. The system should then be tested under maximum load by operating for 5 minutes. This test should include operating all alarm indicating devices.

The secondary power supply also must be tested. Batteries should be inspected to verify they meet the requirements of the fire alarm system. The secondary supply should also be tested at the maximum operating load for 5 minutes. After this test the primary power should be reconnected. (Note: If the secondary power supply is a generator, NFPA 72 requires weekly operation under load by disconnecting the normal power supply for at least one-half hour.) Also, if there are redundant primary supplies, these must be tested.

If the fire alarm panel is connected to any type of receiving station, this connection must also be tested.

Finally, any function specific to the fire alarm panel should be tested according to the manufacturer's literature provided with the panel.

Initiating Devices and Indicating Appliances Tests

When conducting an acceptance test, every initiating device and indicating appliance must be tested to assure that the fire alarm panel responds properly. Whenever possible, the manufacturer's literature should be followed for the proper testing procedure for the device. Fire alarm testing is labor intensive. It also requires much coordination to assure that the testing runs smoothly and is executed properly. Communication among those involved with the testing is crucial. It may be advantageous to have an arrangement similar to the following.

Team 1: Located at the fire alarm panel to verify the proper signal is received at the panel. This is also a good location to coordinate from, where someone can record the entire test for the required records.

Team 2: Traveling throughout the building operating all initiating devices (one by one). It also may be possible for this team to verify the operation of all alarm indicating appliances. If not, an additional team may be needed.

Team 3: Located at the remote annunciator (if one is present). This is to assure correct annunciation at the remote location.

As an example of how this can identify problems, consider the following: A member of Team 2 is on the fifth floor of a hospital, a wing which houses the pediatric unit, and activates a smoke detector. Those at the fire alarm panel receive an alarm, but the panel indicates it is a heat detector near the emergency room on the first floor. And, finally, those at the annunciator see the basement parking garage. Obviously this is not what should happen. This could occur due to simply connecting the wires in the fire alarm panel incorrectly, a problem that is easily corrected if detected. If the teams do not coordinate well or do not communicate, this type of problem could possibly go unchecked for some time.

Initiating Devices

Smoke detectors of all operating principles can be tested with approved aerosols, smoke from punks, or other approved smoke-generating sources. The smoke or aerosol is directed into the smoke detector in a manner suggested by the manufacturer. As previously indicated, sensitivity tests should also be conducted in accordance with manufacturer's recommendations. Each detector should be tested to verify that the detector and the fire alarm panel operate as designed. It should be noted that at least one manufacturer has indicated that aerosols should not be used. Smoke or aerosols can be used if approved by the device manufacturer. This type of testing verifies that smoke can enter the detector, but does not verify correct sensitivity setting of the detector.

Heat detectors have different operating features that are tested according to their type.

Fixed temperature, **nonrestorable** detectors are **not** tested with heat. Fixed temperature heat detectors that are self-resetting can be tested with a heat producing tool such as a hair dryer or shielded heat lamp.

Rate of rise and combination type detectors should also be tested with a heat producing tool. (**Caution**, this test should not operate the fixed temperature element if it is nonrestorable.)

Other types of heat detectors should be tested according to guidelines provided by the manufacturer.

Manual pull stations are easily tested. The station is simply operated as it would be in an emergency. Some manual pull stations have glass rods or break glass features that must be replaced after testing.

Suppression system activation indicators should also be tested to assure that if these systems activate, a proper signal is received by the fire alarm. Automatic sprinkler systems, carbon dioxide, and clean agent systems, etc., connected into the fire alarm should be tested with the assistance of those knowledgeable of these systems. This will assure they are tested properly and restored to operating condition. Water flow detectors and pressure sensors in automatic sprinkler systems are examples of these initiating devices.

Supervisory Devices

Supervisory devices, such as those on gate valves and post indicator valves, are tested easily by briefly operating the valve they supervise. (**Caution**, any valve operated to test the supervisory device must be placed back in the normal operating position to assure the system is not rendered inoperable.) Other supervisory devices such as air pressure, air and water temperature, water level, etc., must also be tested. The tests needed for these devices are device specific and may require directions from the manufacturers.

Alarm Indicating Appliances

Alarm indicating devices, such as lights, strobes, horns, and bells, are tested easily. These devices should activate when the initiating devices, such as the smoke detectors, are tested. A person standing near each device can determine if it operates properly by observing the light's flash and hearing the horn/bell. It should be noted that once each circuit is tested, the device need not continue to activate throughout the test. However, the final test should include a test of the indicating devices to ensure that they have been reconnected.

In addition to just determining that the devices operate, the acceptance test must assure that all occupants or staff as may be appropriate, no matter where they are located, can be alerted (hear and or see warning devices) at all times. This is an important part of an acceptance test that is often overlooked. The alarm should be at least 15 decibels above background noise.

Ancillary Functions

Any ancillary functions controlled by the fire alarm control panel should also be tested. These include, but are not limited to: fire suppression system activation, elevator capture and recall, smoke control, and HVAC control. These functions can be very specific for a given design, and the testing of these functions should be conducted with the assistance of those knowledgeable of their design and operation.

Modifications to Fire Alarm Systems

Existing fire alarm systems that require modifications should be tested after the completion of the modifications. Minor modifications might not require such a rigorous retesting, but this would depend on the modifications implemented. The intent here is that changes to a fire alarm system may introduce problems affecting the operation of the base system. Only a complete reacceptance would assure proper operation of the "new" system. It should be noted that certain modifications such as introducing a different manufacturer may invalidate the system listing or warranty.

Periodic Maintenance and Testing

Testing fire alarm systems does not end after the completion of a successful acceptance test. All electric components are susceptible to failure. The greater the frequency of periodic testing of fire alarm system components, the greater the probability a device will be in a working condition at any given time, perhaps when a fire occurs. Some devices are less susceptible to failure (malfunction) so that different devices can be routinely tested at different intervals while providing a high probability that the fire alarm system will be in an acceptable condition at any given time.

The manner of testing for specific devices was listed above where possible and will not be repeated here. On occasion, the manufacturer's literature or special expertise must be consulted to determine the proper test method and interval.

Device Testing Schedule

Fire Alarm Panel

The fire alarm control panel should have the lamps (LED's) as well as the fuses inspected at least annually. The ground fault (if present) and supervisory signals should also be tested annually.

If the fire alarm transmits to an offsite location, then the connection must be tested monthly.

Initiating Devices

Smoke detectors should be tested at least semiannually. Calibration (sensitivity) tests should be included 1 year after installation and every other year thereafter. This may require special equipment from the specific manufacturer. Many modern detectors are provided with a convenient sensitivity test procedure or device. If a smoke detector has a built-in heat sensing element, this should be tested also. Many facilities have found it convenient to have a reserve supply of detectors so that detectors can be removed for testing in the shop. The reserve detectors are installed so that the system remains operational.

Heat detectors that are nonrestorable are tested in the following manner: At 15 years, and then every 5 years thereafter, two detectors out of every 100 should be removed from the system and tested by a laboratory. The two that are removed for testing must be replaced with two new ones. If two detectors fail, then all of the system's heat detectors must be removed and replaced with new ones. If only one fails, others can be tested or all detectors replaced. Restorable heat detectors should be tested semiannually as described above for acceptance tests.

Rate-of-rise heat detectors should have 10 percent of all detectors' tests semiannually so that 100 percent of the system's heat detectors are tested over a 5-year period.

Manual pull stations should be tested semiannually. Any break glass feature must be replaced.

Water flow devices, such as those found on automatic sprinkler systems, should be tested quarterly.

All supervisory type devices, such as valve position indicators, air pressure, etc., should be tested semiannually.

All alarm indicating devices such as horns and lights should be tested annually.

Remote annunciators should be tested semiannually. Any voice communication system should be tested annually.

Summary

If any problems with the fire alarm systems are found during periodic inspection and testing, or at any other time, they should be corrected as soon as possible. Where possible, manufacturers' literature should be consulted for routine maintenance requirements of specific devices.

Most components of fire alarm systems have no specific maintenance requirements beyond fixing any part that fails to operate properly during testing or other times where their operation is required. Smoke detectors are one exception.

Smoke detectors should be calibrated as mentioned above. This may require sensitivity equipment available from the manufacturer. Instructions provided with the instrument should be followed to assure proper calibration of the detectors. In addition to calibration, detectors should be closely inspected and cleaned if required. Finally, spare parts and devices should be kept on site for anticipated failures and repairs. The type and amount will depend on the specific system.

WET CHEMICAL FIRE SUPPRESSION SYSTEMS

As mentioned earlier, wet chemical suppression systems now are the most common means for suppressing fires involving cooking equipment. The NFPA Standard governing wet chemical suppression systems is NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*.

In accordance with NFPA 17A, wet chemical suppression systems currently are accepted only for the protection of restaurant, commercial, and institutional hoods, plenums, ducts, and associated cooking appliances. NFPA 17A currently acknowledges only "pre-engineered" systems. Pre-engineered systems are factory designed and tested for a broad range of hazards. As long as the installation matches the manufacturer's requirements, it is considered to be in compliance with the standard.

Wet Chemical Cylinder and Control Head

The pre-engineered package has specific pipe sizes, maximum and minimum pipe lengths, types and number of nozzles, and other devices. When a particular hazard needs protection by a wet chemical extinguishing system, the manufacturers can be consulted for a system that will satisfy the protection requirements. The system then is delivered and installed in accordance with the prescribed limitations. With these systems there is no design procedure beyond matching the hazard with the proper pre-engineered system. Since the manufacturers have produced many of these systems, it is rare that a hazard cannot be protected by one of them and that a full design and testing program is required.

The effectiveness of wet chemical suppression system comes from the cooling effect of the liquid, plus the creation of a foam-like blanket on top of the burning grease that prevents reignition. The fire suppression agent mixes with the cooking oils in a process called "saponifaction" that creates this soap-like blanket.

Wet chemical systems include a pressurized agent cylinder, sized to contain the amount of suppression agent needed to protect the hazard. A control head is connected to the agent cylinder and the operating elements (automatic and manual). When the control head operates, it releases the system agent through the pipe.

Wet chemical systems use black iron pipe to deliver agent to the cooking appliances, plenum, and exhaust duct. Special nozzles are attached to the pipe, depending upon the arrangement of the cooking equipment. The nozzles should be protected with small "blow-off" caps or covers to prevent grease accumulations from clogging the discharge.

The fire suppression systems typically have means for automatic and manual operation. The automatic operation consists of fusible links or electronic thermostats installed in the hot air exhaust stream in the plenum and duct. Manual releases should be located at the control head (if it is accessible) or a remote manual pull installed in the path of egress from the cooking area.

Once the system operates, all fuel and heat sources beneath the hood must be disconnected to reduce the possibility of reignition. This may require the installation of both electric or otherwise automatic gas shutoffs and solenoids, plus automatic shutdown of electrical appliances and outlets.

The Class K portable fire extinguisher that should be installed with the wet chemical system is **not** designed to be a first-aid appliance. It is intended to be used **after** the fire suppression system operates (automatically or manually) to fill in any gaps in the saponified blanket on the cooking surface.

Requirements with regard to specification and plans approval, installation approval, operation and control, arrangement, and installation as well as inspection, testing, and maintenance closely follow that for dry chemical fire suppression systems.

DRY CHEMICAL FIRE SUPPRESSION SYSTEMS

Dry chemical extinguishing systems are covered in NFPA 17, *Standard for Dry Chemical Fire Extinguishing Systems*.

Dry chemicals can be applied by the use of portable fire extinguishers, fixed systems, or hand hoselines. The most common use of dry chemical systems had been the protection of cooking equipment and ventilation systems, but fire incidence and testing revealed it no longer is a viable suppression agent with today's vegetable cooking oils and restaurant equipment, especially well-insulated deep fryers.

Dry Chemical System Design

Fixed Systems

Fixed systems are either local application or total flooding. Fixed systems consist of a supply of dry chemical agent, an expellent gas, an actuating method, and fixed piping and nozzle through which the agent flows and discharges onto the hazard. The types of dry chemical agents were mentioned earlier in this unit.

The agent is stored in a container that may or may not be under pressure. Carbon dioxide (CO_2) or nitrogen typically are used as expellants and pressurize the system to approximately 350 psi. The expellant may be in the container with the agent or it many be in another container so that when the system activates, the expellant flows into the extinguishing agent container, which causes the agent to flow through the system piping and ultimately out of the discharge nozzles.

The actuation method utilized may be automatic, manual, or as commonly found, a combination of the two methods. Manual methods of system actuation typically are by the use of manual pull stations located near the hazard, within the emergency egress path, and at the storage containers. A method to activate a system manually should always be included in a system design. Personnel also should recognize the difference between the system's manual activation and a fire alarm system manual pull station.

Automatic methods of activation can be designed to meet the need of a particular system. A detection system such as used in clean agent and CO_2 systems may be employed. One common method of automatic activation is through the use of fusible links, which release upon reaching a certain temperature. The link typically holds a cable in tension. The cable is connected to the control head of the agent/expellant container so that when tension is lost, the agent is discharged. These links are located in the path that the fire would be expected to follow if a fire occurred in a hazard. Systems that protect cooking equipment usually have fusible links located in the exhaust hood and in the hood plenum.

Total flooding can be used in areas where there is an enclosure and no appreciable leakage. Extinguishment by total flooding is considered ineffective in preventing reignition. Therefore, power should be interrupted to the hazard that is involved in fire, including both electrical power and gas supplies. If a total flooding system protects an area that is or may be occupied, safeguards should be provided to assure the prompt evacuation of the occupied area.

Local application systems discharge the agent directly onto the involved hazard. Electrical and gas supplies also should be disrupted when using local application systems.

Many dry chemical systems are pre-engineered systems. The systems, also referred to as package systems, have been designed and tested by the equipment manufacturer to meet the requirements of a specific hazard

In some cases multiple hazards can be protected by a single supply. This typically is done when one hazard involved in fire is separated from the other hazards so that they would not become involved in the fire.

Hand Hoseline Systems

Hand hoseline systems are those systems where a nozzle and hoseline are connected to a supply of dry chemical agent. The hose may be connected directly to the supply or it may be connected to fixed piping connected to the supply. The supply may be the same used for a fixed local or total flooding application system, as long as the system is designed accordingly.

Hand hoselines are supplemental; they are not a primary means of fire extinguishment. This means that fixed automatic systems should not be eliminated if hand hoselines are present. These systems are manually activated when needed by the personnel using the system. Typically, the discharge should be not less than 30 seconds of effective application. However, the designer should consider that the application will likely be by untrained personnel and that the actual discharge time should be increased well beyond the 30 seconds. If more than one line is connected to a single supply, the total number of hand hoselines that is expected to be used should be capable of discharging for no less than 30 seconds. The same concern for the training of those likely to use the hoselines applies to multiple lines. It is wise to design hand hoseline systems so that enough agent is available to provide suppression by untrained personnel. It is even more important to provide firefighting training using hand hoseline to all personnel that may need to use the system.

Dry Chemical Supply

The amount of agent in a system should be sufficient to protect the largest single hazard or group of hazards. If a system protects more than one hazard through the use of selector valves, then a reserve supply capable of one complete system recharge should be available. This includes the necessary expellent gas. If a single hazard is protected, then the hazard must remain shut down until the system is recharged, or a reserve supply capable of recharging the system must be provided. Agent supplies must be located at areas that will not adversely affect the condition of the agent. This includes areas that are susceptible to high moisture and temperature. Also, the agent must not be so close to the hazard that a fire involving the hazard threatens the stored agent. The storage containers, including the expellent gas, should be located where inspection and maintenance can be completed easily.

Inspection, Test, and Maintenance of Wet or Dry Chemical Systems

Installation Approval

After a wet or dry chemical system has been installed, it should be subjected to a rigorous acceptance test. The test must satisfy the AHJ. The actual installation should be compared to the installed system to verify that the installation is in accordance with the approved plans. The restrictions associated with pre-engineered systems should be reviewed to assure that the installation does not conflict with the laboratory tested design. A test of an expellant gas should be completed to assure that the proper flows are achieved, that there is no blockage, and that there is no leakage of the delivery piping and nozzles. Depending on the specific system and the

AHJ, a complete agent discharge test may be required to verify that the system will operate as required. Upon completion of the acceptance test, the system should be placed into normal operating condition.

At least once a year, all components of wet or dry chemical systems should be inspected and checked to verify that the systems are still in operating condition. This inspection should include all ancillary equipment. A review of the hazard protected by the system also should be done. If the hazard has changed, the system may no longer provide sufficient protection. If the condition of the system is questionable, a complete test of the system should be completed. The yearly inspection should be documented. Additional inspection is highly recommended as this will increase the probability of successful operation, if needed.

At least twice a year, the agent containers for wet chemical systems and expellant gas containers for dry chemical systems should be checked to verify that the proper weight and pressure are present. Containers that have combined agent and expellant should be weighed and the pressure checked.

At least yearly, the dry chemical agent should be inspected to check for caking and moisture problems. If any abnormal conditions exist, the agent should be replaced with new agent.

Certain portions of dry chemical systems, the containers for example, require hydrostatic testing at least every 12 years. NFPA 17 and manufacturers' literature can be consulted for further information regarding the required tests.

Repairs may result in the system having to be pressure tested again to verify the absence of leaks. This will depend on the nature and extent of the repairs.

Fusible link sensing elements in commercial cooking applications should be replaced at least yearly. Certain systems may require more frequent replacement.

Approved training should be provided to personnel charged with inspecting, testing, maintaining, and operating dry chemical suppression systems.

CARBON DIOXIDE FIRE SUPPRESSION SYSTEMS

The design, installation, testing, inspection, and maintenance of carbon dioxide systems, both high and low pressure, is regulated by NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems.*

Types of Carbon Dioxide Systems

High Pressure

CO_2 is stored at ambient temperature, which requires the CO_2 be kept under pressure. The pressure in the storage container varies directly with temperature, so that as the temperature goes up, pressure goes up. Since CO_2 in storage may easily reach pressures of over 2,000 psi, heavy walled spun steel cylinders are required. The largest commercially available cylinder for high-pressure storage will hold 100 pounds of carbon dioxide. Most systems encountered are high-pressure systems.

Low Pressure

CO_2 is stored in a refrigerated vessel. Typically temperature is controlled to 0 °F $\pm$ 5 °F. Pressure in the vessel thus is controlled to about 300 psi. The fill density has no effect on the pressure as long as sufficient vapor space is provided for expansion of the liquid at maximum storage temperature and pressure. Fill density ranges from 90 to 95 percent. The maximum liquid level during filling is controlled by a vapor return line installed at the maximum level of liquid. This line returns excess liquid to the delivery unit when the liquid reaches its desired maximum level. Safety relief valves are installed in the storage unit to prevent overpressurization due to refrigeration failure or accidental overfilling. There is no special limitation as to the size of low pressure storage units. Units as large as 60 ton capacity have been used for fire protection; however, the smallest container is usually around 750 pounds.

Carbon Dioxide System Design

Personnel Safety

Physiological effects of exposure--carbon dioxide is closely associated with the life processes in both plants and animals. The hemoglobin in animal blood has an affinity for carbon dioxide. The blood washes the carbon dioxide from the working cells in the body and carries it to the lungs. In the lungs, CO_2 is released from the blood and the blood is reoxygenated.

Carbon dioxide acts as a regulator of breathing, thus insuring an adequate supply of oxygen to the system. Up to a point, an increase in carbon dioxide in the blood causes an increase in breathing. The maximum increase in respiration occurs when breathing approximately 7 percent CO_2 in air. Reduced oxygen supplies will cause a very much lower concentration of carbon dioxide to suppress breathing and cause death from asphyxiation. The exact concentration of carbon dioxide in air, which will cause a decrease in respiration, varies from person to person and is not constant even in the same person from time to time.

Six to seven percent CO_2 is considered the threshold level at which harmful effects become noticeable in human beings. At concentrations above 9 percent, most people lose consciousness within a short time. Since the minimum concentrations of CO_2 in air used to extinguish fire far exceed 9 percent, adequate safety precautions must be designed into every carbon dioxide fire extinguishing system.

Safety precautions--since the minimum design concentration used in CO_2 total flooding system is 34 percent, exposure of humans to areas where total flooding systems have discharged must be prevented until the CO_2-enriched atmosphere is ventilated with fresh air. Obviously personnel must not be subjected to the direct impingement of a local application discharge of CO_2. Since CO_2 is about 1.5 times heavier than air, CO_2 will tend to flow into low-lying areas near the discharge. Thus careful consideration of means to prevent accidental exposure of personnel to hazardous atmospheres must be designed into every system.

Alarms and time delays--alarms that signal impending discharge of carbon dioxide are mandatory for all total flooding CO_2 systems as well as most local application systems. Alarms are also used to indicate that CO_2 has discharged in an area and that personnel should not enter the area without self-contained breathing apparatus (SCBA).

Most automatic total flooding systems and the majority of local application systems employ predischarge time delays. The time delay should be set long enough for personnel in and around the protected area to evacuate the area under worst-case conditions before the CO_2 discharge begins. The only total flooding system that might be designed without a time delay would be a system protecting an area that could not be occupied under any circumstances, such as a heat-treating furnace. Certain hazards protected by local application systems present a risk of such rapid fire spread that time delays are unacceptable, both from a property damage and life safety standpoint. If a sufficient time delay to permit evacuation under worst-case conditions cannot be incorporated, then a system lockout should be employed.

Most alarms used with modern day CO_2 systems are electrically operated. Electric warning horns and lights have the advantage of easily being arranged to sound during the predischarged time delay. The obvious disadvantage is their inability to provide warning if electric power to the system or to the alarms themselves is interrupted. Also, all CO_2 systems are designed with mechanical overrides that can discharge the system even in case of a power failure. The use of such overrides, even with system power on, may bypass the electric time delay and not provide an adequate warning alarm.

Audible alarms powered by CO_2 are used on some systems. The advantage of these pneumatically powered alarms is that the source of power, the carbon dioxide, will always be available theoretically; if there is no CO_2 available to power the alarms, there is no CO_2 available to discharge. On the negative side, providing for a time delay and corresponding predischarge alarm with pneumatic alarms requires more complex hardware.

Pneumatic time delays with blocking valves are required in many systems. Some measure of reliability in the CO_2 discharge system is thus sacrificed.

Careful hazard analysis that considers the life safety/human engineering factors along with the fire safety results, is necessary in determining the best combination of predischarge delays of alarms. Although audible alarms have been traditional for most fire protection systems, the use of both audible and visual alarms is mandatory if the ambient noise level is high or if persons with hearing impairment are involved.

Audible and visual alarms should continue until silenced manually. Silencing alarms should be limited to persons who are authorized to take responsibility for fire and personnel safety in the discharged area. The alarms are intended to indicate that response by firefighters is in order and a potential hazard to personnel exists. Appropriate signs should indicate that entry into the area is prohibited when the alarms are operating.

Odorizers such as oil of wintergreen are often added to the CO_2. The strong odor gives a tangible warning of the presence of an unusual gas in the area. With proper training, personnel will know that the hazard exists.

Lockouts---some areas such as pits, oil cellars, dust collectors, and other large pieces of machinery are extremely difficult to vacate quickly. Entry into such areas may be rare and usually is for maintenance purposes. Maintenance presents two serious problems:

1. The chance of fire usually is greater during maintenance and repair than during normal operation, thus the need for increased fire protection.

2. The chance of causing an accidental discharge is increased.

Obviously there is a great need for special provisions to be used when personnel enter protected areas, particularly for maintenance and repair of equipment. The chance of accidental discharge of CO_2 when personnel may not be able to exit the area readily calls for a means of disabling the CO_2 system--at the very least the automatic function of the system may have to be disabled. System lockouts can be arranged in various configurations, but several guidelines apply to all personnel safety lockouts:

- Access to the lockout must be limited to authorized, responsible personnel; these personnel must understand both the purpose and the function of the lockout.

- Only the person(s) initiating the lockout should be able to remove the lockout.

- A log identifying the person(s) initiating a lockout must be maintained.

- Some clear indication that the fire protection system is locked out must be provided at the entrance, and in the hazard.

- Lockouts of automatic systems must be supervised to indicate a trouble condition at the control unit.

- A fire watch to provide adequate manual response to fire and safety problems in the hazard must be maintained for as long as the lockout is in effect.

- The hazard must never be left unattended during a lockout. Procedures should be established to reinstate protection as soon as the need for personnel to be present in the hazard has ended.

Signage--all alarms and lockouts must be provided with clear signage indicating required responses. All possible entrances to total flooding hazards shall be provided with appropriate warning signs. The signs should indicate what actions are required should an alarm sound, and should be distinctive, easily noticed, easily read and in clear, simple language.

Seepage of gas to adjoining areas--since carbon dioxide is heavier than air, an atmosphere enriched with carbon dioxide gas will tend to flow into low-lying areas. For example, the CO_2-enriched atmosphere from a discharge will tend to sink to the floor of the room and then through any openings in the floor into the room below. System designers should survey the entire surrounding area and especially below a CO_2-protected hazard. Alarms and warning signs must be used in any areas to which a CO_2-enriched atmosphere would migrate and present a hazard to personnel. This applies to total flooding and local application systems.

Total Flooding Systems

A total flooding system provides a uniform concentration of CO_2 throughout the protected enclosure. The concentration is great enough to extinguish fire in the known fuels contained within the enclosure. For a total flooding system to be used, there must be a permanent enclosure around the hazard adequate to permit the required concentration of CO_2 to be attained and maintained for the required period of time to ensure complete extinguishment of fires in the fuels contained in the hazard. The relative tightness of the enclosure depends on whether the fuels result in a surface fire or deep-seated fire hazards.

Many surface fires are extinguished almost immediately once an extinguishing concentration of CO_2 surrounds the fuel. In the ideal situation, such fires would not require that the enclosure be capable of maintaining the concentration. However, this assumes that all fuels in the hazard are immediately cooled below their ignition temperature once the open flaming is stopped. It is also assumed that no objects in contact with the fuel become heated above the ignition temperature of the fuel--thus reflash due to close ignition sources is not a factor.

In actual installations, such is seldom the case. Therefore, some holding time during which the CO_2-enriched atmosphere is maintained should be achieved. A reasonably tight enclosure without leakage in the sides and bottom can easily maintain concentrations for more than 10 minutes. For deep-seated fires, NFPA 12 requires a minimum holding time of 20 minutes.

(Deep-seated fires are fires in which rapid combustion can take place below the surface level such as would occur with cardboard, bundles of electrical cables, and transformers.)

Design concentration--the minimum theoretical concentrations for CO_2 total flooding protection of surface fires, such as flammable liquid fires, in many common liquid and gaseous fuels are published by the U.S. Bureau of Mines, and also are published in NFPA 12. Laboratory tests should be performed for any fuels that are not already tested and published. The actual design concentration includes a safety factor of 20 percent added to the minimum theoretical concentration. In accordance with NFPA 12, the minimum design concentration for surface fires is 34 percent CO_2.

Design concentrations for deep-seated fires cannot be determined with the same accuracy as is possible for surface burning fires. However, NFPA 12 does contain concentrations for specific hazards often protected by total flooding CO_2 systems. These design concentrations range from 50 to 75 percent.

Amount of CO_2 agent--the basic quantity of CO_2 required is based on the design concentration and the volume of the protected space. The quantity may need to be increased because of:

- leakage in the enclosure;
- temperatures in excess of 200 °F or below 0 °F; and
- ventilation systems.

Local Application Systems

A local application system discharges carbon dioxide directly on the burning surface. The CO_2 blankets the surface, thus starving the fuel of oxygen and also providing some cooling. A minimum of 30 seconds of liquid carbon dioxide discharge must be used to permit cool down of the fuel. Special nozzles are used for this purpose. The nozzles are designed for relatively low velocity to avoid entrainment of air and splashing of fuel. Deep fat fryer protection is an example of a potential local application CO_2 system.

Design considerations--the minimum discharge time is 30 seconds of liquid. In local applications systems, only the liquid portion of the CO_2 discharge is considered effective for fire suppression. The actual amount of CO_2 agent required is based on the specific listing of the nozzle, the height the nozzle is located above the hazard, and the area or volume protected. For local application systems, the protected hazard, need not be located within an enclosure.

Activation--unlike automatic sprinkler systems, CO_2 systems require an automatic detection system to activate the system. Historically, the most common detection has been fixed temperature or rate-of-rise detectors. Kitchen systems usually are activated by fusible links. In addition, a manual means to activate the system is provided. The manual operating device must be identified as to the hazard protected, the function it performs, and the method of operation.

Fuel shutoff--when the continued operation of the protected equipment could contribute to sustaining the fire, the source of power or fuel shall be shutoff automatically. Power or fuel for kitchen cooking equipment is a prime example of the need for automatic fuel shutoff and is required by NFPA 12 and NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*.

Reserve supply--reserve supply is a supply of CO_2 that usually is connected to the system as a backup to the primary supply permanently. The final decision as to whether a reserve supply of CO_2 is required usually is made by the code official or enforcing agency. One consideration should be the availability and accessibility of having the system restored to operating condition. If the same supply protects more than one hazard, a reserve supply may need to be provided so that a fire in one area does not require the shut down or discontinuance of other operations or processes. Reserve supplies also should be provided if the hazard is subject to reflash.

Inspection, Test, and Maintenance of Carbon Dioxide Systems

A preventive maintenance program for CO_2 systems involves visual inspections and tests of the system at various frequencies. The frequencies indicated in Table 7-1 are considered minimum frequencies in accordance with NFPA requirements and recommended practice. The preventive maintenance program for an associated automatic detection system is discussed later.

Semiannually, CO_2 cylinders in high-pressure systems must be weighed and the control valves operated. To do this, first remove the control head from the cylinder. Once removed, activate detectors or manual releases and make sure the plunger is fully extended in the control head. The use of detectors and manual releases should be varied during each semiannual test.

To weigh the cylinder, the system piping must be disconnected from the discharge control valve. Remove the cylinders with the control valves intact and weigh each individually. Subtract the empty cylinder weight, which will be stamped into the cylinder body. The resultant weight is the amount of CO_2 in the cylinder. If the resultant weight is less than 90 percent of the original weight of CO_2 used to fill the cylinder, the cylinder must be refilled. Upon completion, reverse the process to restore the system to an operational condition.

The annual activation test should include a test of all system components without actually discharging the CO_2. Prior to performing the activation test, remove all control heads from cylinders. A complete operational test of all system components includes control panels, power supply, emergency power, detectors, time-delay devices, alarm devices, selector valves, door release devices, dampers, equipment shutdown, fuel shutoff valves, and manual releases. The system piping, nozzles, and storage containers should be inspected visually. Upon completion of the test, the system is restored to an operating condition.

The discharge test of the system should be performed every 12 years. The full discharge test is conducted in the same manner as the original acceptance test, except that if all other recommended tests are performed, each activating detector and manual release need not be tested. The discharge test should be conducted just prior to the hydrostatic test of the system cylinders or pressure tanks, which are required every 12 years.

Table 7-1

Sample Preventive Maintenance Program
CO_2 System

Weekly Visual Inspections

1. Condition of nozzle:

   a. Have orientation of nozzle and location of hazard changed?

   b. Clean?

   c. Secure?

   d. Seals where needed?

2. Make sure all doors of the room being protected by a total flooding system are self-closing or close automatically.

3. Check for changes in the hazard:

   a. Changed hazard size or location?

   b. Increased hazard severity (for example, additional deep fat fryer)?

   c. Altered ventilation system?

4. Check the liquid level in each low-pressure container by observing the liquid level gauges. Refill the container if the loss is more than 10 percent of the capacity.

5. Check for pins in manual releases.

6. Check automatic detection system.

7. Check to see if the system is in need of additional tests.

Monthly Visual Inspections

1. Check for signs of leakage at cylinders.

   Are cylinder connections tight?

2. Check for signs of physical damage to system components, including piping and hazards.

   a. Secure?

   b. Corrosion?

Semiannual Tests

1. Weigh high-pressure CO_2 cylinders with discharge control valve.
2. Operate control heads.

Annual Tests

Activating test of the system without CO_2 discharge.

Twelve-Year Discharge Test

Discharge test of the system (this test is recommended, but not required by NFPA 12).

CLEAN AGENT AND HALON™ FIRE SUPPRESSION SYSTEMS

Clean agent and Halon™ suppression systems are only part of an overall fire safety system. They are intended primarily for early, incipient fires where quick detection and suppression are desired. Therefore, depending on the level of protection intended, automatic sprinklers should not be forsaken if a clean-agent- or Halon™-based suppression system is within a given room. For example, a computer room protected by a clean agent or Halon™ system may require automatic sprinklers as well. Clean agent or Halon™ will afford little protection once a fire has grown past the incipient stage.

Clean agent systems are covered in NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems. Halon™-based extinguishing systems are covered in NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems, and NFPA 12B, Standard on Halon 1211 Fire Extinguishing Systems.

Clean Agent or Halon™ System Components

All clean agent and Halon™ systems possess three main components: a detection system, a control panel, and a means of agent delivery which includes the agent storage.

Detection System

The detection portion of a the system typically is designed using a cross-zoned or alarm verification concept. Cross zoning describes two separate circuits, perhaps with two different types of detectors, within the same hazard area. The section on fire alarm systems should be consulted for a review of the operating characteristics of fire detection devices. The combination of two separate circuits or alarm verification in the same area provides redundancy such that false activations are virtually eliminated. It should be noted that a smoke detector activating by the presence of the smoke given off by someone smoking a cigarette is simply a result of the detector performing its intended function. The cross zone may not protect against this type of unwanted alarm, but it will protect against a faulty detector or improper sensitivity setting.

A common operating principle in cross zoning is to have the first device detect a possible fire condition and activate an audible alarm. If a second device is tripped in the same area, the control panel initiates the discharge sequence.

Manual pull stations also can be used to activate clean agent or Halon™ systems. These typically activate the discharge sequence immediately. This is due to the assumption that the manual pull station will be operated by someone who observes a situation requiring the discharging of the clean agent or Halon™.

Control Panel

The control panel of a clean agent or Halon™ fire suppression system supervises the initiating circuits and functions as designed in the case of an alarm condition. The clean agent or Halon™ control panel has initiating, signaling, and release circuits for each hazard (fire) zone.

The clean agent or Halon™ panel may begin the discharge sequence upon receiving alarms from two devices in the same hazard area, or from a single manual pull station. In an occupied area it may be desirable or necessary to evacuate the occupants prior to allowing the discharge of the clean agent or Halon™. This can be accomplished by the panel initiating the audible and visible alarms, then delaying the actual discharge a short time to allow for evacuation. The control panel can be configured to trip the main fire alarm panel to notify occupants in the entire building, or to notify the fire department, as needed.

Agent Delivery

Agent delivery refers to all system components from and including the storage container(s) to the discharge nozzle(s) and the release mechanism. The three methods of agent delivery are 1) central storage, 2) modular, and 3) shared supply.

Central storage delivery systems are designed so that the agent storage container(s) are centrally located and the agent is delivered to the hazard area through a system of piping. Modular systems are those with one or more small containers located throughout the hazard area, resulting in minimal delivery piping and increased system reliability. The reduction in piping means a corresponding reduction in system design calculations. Modular systems can be heat actuated, which will allow their operation even if a portion of the total system is damaged. Other benefits include simplified inspection and maintenance, as well as future flexibility.

Shared supply refers to those systems that are similar to central systems but protect multiple hazards from one agent supply. Shared supply systems obviously have fewer storage containers, but the added system piping and directional valves may result in these systems being more costly. Also, once a shared system discharges its supply into one hazard, all other areas remain unprotected until the system is refilled and placed back in service. These systems also suffer from lower reliability and reduced flexibility.

Design Methodology

Clean agent or Halon™ fire suppression systems generally are either total flooding or local application. Similar to CO_2 systems, clean agent Halon™ total flooding systems are designed to develop and maintain a specific agent concentration within an enclosure for a minimum time period.

Total Flooding Systems

Total flooding systems are generally designed using the agent having low toxicity, low boiling point, and superb extinguishing abilities.

Hazard identification--the hazard that is to be protected with clean agent or Halon™ first must be defined. This includes identifying the fuels present, the size and shape of the compartment, the maximum and minimum net volume, the nature of the occupancy, the expected temperature ranges within the compartment, and any possible losses of clean agent or Halon™ through openings and vents.

The designer needs to select a design concentration based on the above information. Volumetric concentrations are available in NFPA Standards and other sources. As previously noted, a common design concentration for surface burning is on the order of 5 percent. For deep-seated fires the number is increased. The system may be designed to render an area inert in lieu of fire suppression, and values for this must also be determined.

Determine agent quality--the amount of agent required now can be calculated from the previously determined valves.

As was previously mentioned, the continuity and tightness of the enclosure is critical. Some contractors will attempt to compensate for improper enclosures by increasing the initial amount of suppression agent, to provide at least the design concentration for the required time. However, in light of the exposure issues previously discussed, initial concentrations in occupied areas should not exceed 7 to 10 percent. Therefore, the contractor should ensure that the enclosure is properly constructed, rather than increase the agent quantity.

System operation requirements--the designer should then decide how the system should operate. This will depend on the specific hazard, the occupancy, etc. Typically, smoke detectors as well as a manual switch are used for most systems.

System documentation--as with all systems, the final design and installation should be thoroughly documented for future use. Such documents should include the design calculations, system drawings as installed, and the proper testing, operation, and maintenance of the system. System inspection, testing, and maintenance will follow in a later section.

Clean Agent or Halon™ System Inspection, Test, and Maintenance

After a clean agent or Halon™ system has been installed, and the installation is documented as required, an acceptance test should be completed to assure the system functions as required.

The NFPA Standards require that for the approval of an installation the system should be tested to "meet the approval of the authority having jurisdiction," and that the system must pass a hydrostatic pressure test of the system piping. A physical inspection of the system should be completed, including all piping, nozzles, and supports to verify the system is installed as designed. As with fire alarm systems, all electrical circuits and devices should be tested to assure their proper operation. The storage containers also should be inspected to verify that they comply with the design and are filled properly.

Routine Inspection and Testing

At least annually, the entire system should be reinspected and all operational parts be tested by trained personnel to assure that the system is still in a fully operational condition.

At least semiannually, the agent storage containers should be inspected to assure that the proper quantity and pressure are available. The entire system should also be reinspected, but testing is not required.

System hoses require hydrostatic testing at least every 5 years.

Agent containers must be tested before being refilled, if the date of the last test was 5 or more years ago. If the containers have been in service for 20 years without a discharge, they must be tested regardless.

Summary

Clean agent and Halon™ systems have a great deal in common with regard to design. All inspections, testing, and maintenance should be documented carefully so that their completion can be verified during a code enforcement inspection.

Job Aid 7.1

Factors Influencing Fire Sprinkler Performance

Periodic and thorough inspections of buildings protected by automatic sprinkler systems are an important element in successful fire outcomes. Unfortunately, code enforcement or loss prevention officials may not visit every sprinklered building on a regular basis to ensure there have not been changes that could result in a catastrophic fire loss.

This job aid is intended to help Incident Commanders (IC's) identify some of the factors that influence fire sprinkler performance so they can report obvious changes that need attention before a disaster occurs. If conditions in an occupancy change it from a lower to a higher classification, that information should be reported to the building owner and the code enforcement authority.

NFPA 13
Hazard Classifications

Light	Quantity and combustibility of contents is low and fires with low rates of heat release expected. **Examples include, but are not limited to:** Churches, institutions, museums, offices, residential, and unused attics.
Ordinary Hazard Group 1	Quantity and combustibility of contents is low and fires with moderates rates of heat release expected. Storage does not exceed 8 feet high. **Examples include, but are not limited to:** Automobile parking and showrooms, bakeries, canneries, laundries, commercial kitchens.
Ordinary Hazard Group 2	Quantity and combustibility of contents is moderate to high and fires with moderates to high rates of heat release expected. Storage does not exceed 12 feet high. **Examples include, but are not limited to:** Cereal mills, distilleries, dry cleaners, horse stables, library stack rooms, machine shops, post offices, wood-working facilities.
Extra Hazard Group 1	Quantity and combustibility of contents is very high and dust, lint, or other materials are present, creating potential for fires with high rates of heat release expected. Little or no flammable or combustible liquids. **Examples include, but are not limited to:** Aircraft hangars, plywood and particle board manufacturing, saw mills, upholstery manufacturing.
Extra Hazard Group 2	Moderate to substantial amounts of flammable or combustible liquids are present, or where combustible shielding is extensive. **Examples include, but are not limited to:** Flammable liquids spraying, manufactured home assembly, plastics processing, solvent cleaning.
Special Occupancy Hazards	Areas with specific fire hazards. **Examples include, but are not limited to:** Storage more than 12 feet high, cotton bales, cellulose nitrate storage, piers and wharves, decompression chambers, anechoic chambers, flammable and combustible liquid warehouses, oxidizer and peroxide storage, aerosol storage and display.

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OCCUPANCY CONDITIONS OR CHANGES THAT MAY AFFECT SPRINKLER PERFORMANCE

Condition	Likely Causes(s)	Possible Impact
• Contents change	• Tenant may change. • Operations or storage may change. • Temporary changes may occur due to marketing needs (example, sale merchandise or holiday merchandise).	• May increase combustible load (Btus/lb) or rate of heat release where it can overpower sprinkler system design and its ability to control fire.
• Poor housekeeping	• Inattention to detail. • Temporary staffing changes. • Temporary or permanent materials handling changes.	• May increase combustible load (Btus/lb) or rate of heat release where it can overpower sprinkler system design and its ability to control fire. • May put too much combustible load in places not adequately protected by sprinklers.
• Storage racks added *("Racks" typically are 8 feet wide by 4 feet deep with 4-foot tiers like one finds in "big box" retail stores.)*	• Merchandising and storage methods may change. • Occupant may believe he/she is not fully using rentable space, so product is moved vertically.	• May create tall fire arrays that encourage vertical fire spread. • Too close to sprinklers to prevent adequate spray pattern discharge. • May spread horizontally among rack arrays before heat reaches ceiling, result is too many sprinklers open.
• Slatted decks installed	• Storage handling methods may change.	• May spread horizontally among rack arrays before heat reaches ceiling, result is too many sprinklers open.

Condition	Likely Causes(s)	Possible Impact
• Solid plywood decks installed	• Inattention to detail. • Temporary or permanent materials handling changes. • Prevent loose products from falling from storage arrays.	• May prevent sprinkler water from reaching burning materials.
• Flue spaces blocked *("Flue spaces" are the open spaces between back-to-back racks and between materials stored on the racks. The flue space is maintained to allow the fire to spread vertically to reach ceiling sprinklers. Otherwise, the fire may spread horizontally.)*	• Inattention to detail. • Temporary or permanent materials handling changes.	• May prevent sprinkler water from reaching burning materials.
• Pallet changes from conventional wood or steel to plastic	• Occupant may want to employ recyclable plastic pallets rather than disposable wooden ones.	• May increase combustible load (Btus/lb) or rate of heat release where it can overpower sprinkler system design and ability to control fire.
• Aisle storage • Narrower aisles	• Marketing methods may change. • Poor shipping and delivery planning. • Temporary overstocks.	• May encourage fire to jump horizontally from storage array to array due to radiant heat.
• Storage shelves *("Shelves" differ from racks. They usually are no more than 12 feet high and have narrower shelves.)*	• Merchandising and storage methods may change. • Occupant may believe he/she is not fully using rentable space, so product is moved vertically.	• May create tall fire arrays that encourage vertical fire spread. • Too close to sprinklers to prevent adequate spray pattern discharge. • May spread horizontally among shelves before heat reaches ceiling, result is too many sprinklers open.

Condition	Likely Causes(s)	Possible Impact
• Storage within 18 inches of ceiling sprinkler deflectors	• Merchandising and storage methods may change. • Occupant may believe he/she is not fully using rentable space, so product is moved vertically.	• Too close to sprinklers to prevent adequate spray pattern discharge.
• Fire Department Connection damage: - Missing caps - Damaged threads - Wrong threads - Missing gaskets - Obstructions	• Vandalism. • Physical injury from motor vehicles.	• May prevent fire department from supplementing system. • May allow debris or damage to accumulate in pipe, thereby blocking water discharge.
• Access	• Landscaping, trash receptacles, fences, or other obstructions are installed.	• May prevent fire department from supplementing system in timely fashion. • Inadequate volume and pressure may allow too many sprinklers to open.
• Sprinkler corrosion/damage/loading	• Paint overspray. • Grease, dust, or lint accumulations.	• May prevent sprinklers from operating in a timely fashion, if at all.
• Valve status problems	• Inattention to detail. • Failure to restore valves to "open" position after repairs or service.	• May limit water flow to all or a portion of the fire protection systems.
- Roadway box	• Closed by water purveyor for failure to pay utility bill. • Closed by water purveyor to work on water lines.	• May limit water flow to all or a portion of the fire protection systems.

Condition	Likely Causes(s)	Possible Impact
- Main control	• Inattention to detail. • Failure to restore valves to "open" position after repairs or service.	• May limit water flow to all or a portion of the fire protection systems.
- Sectional control	• Inattention to detail. • Failure to restore valves to "open" position after repairs or service.	
• Backflow prevention devices installed	• Water purveyor may require "cross contamination control" be added to existing systems.	• Friction loss created by new valve assembly may not allow adequate pressure to operate sprinklers.
• Water pressure drops due to lower tank volumes and water level elevation	• Seasonal - Water usage usually higher in summer, dry months, which leaves less water in storage for emergencies. • Diurnal - Daily water demand picks up during waking hours, drops at night when tanks and reservoirs may be refilled.	• May not provide adequate pressure to operate sprinklers at desired pressure.
• New neighborhood developments that have high water demands, especially industrial or commercial operations	• As community grows, water purveyor may not anticipate growth and develop adequate storage or pumping capacity, distribution system, or looping.	• May rob water from existing systems designed for higher pressures and flows.
• Obstructions - Ceilings - New construction	• Alterations without permits or inspections. • Additions for energy conservation or security.	• May prevent water from reaching fire or wetting adjacent combustibles.

Job Aid 7.2

Understanding Sprinkler Pressure Gauges at a Glance

Looking at gauges on sprinkler systems can be confusing. What do the numbers mean, and how are they interpreted so system performance can be evaluated?

This job aid is intended to provide a simple, quick reference to the most common gauge readings found in the field and to explain what the gauges are telling you. There are many other gauge configurations, especially when accelerators, exhaustors, air maintenance devices, and related fire protection equipment are installed, but the gauges shown in this job aid should be considered essential to understand.

You can take this job aid with you when conducting preincident surveys to get an idea of the current condition of air and water pressures on fire sprinkler systems.

The gauge pressures displayed in this job aid are hypothetical. The water and air pressures on actual fire sprinkler systems may vary widely depending upon local conditions. Caution: Gauge pressures should never exceed 200 psi. High pressure can create a dangerous situation and potentially result in sprinkler system failure. Pressures exceeding 200 psi should be reported to the property owner and code enforcement official for remedial action.

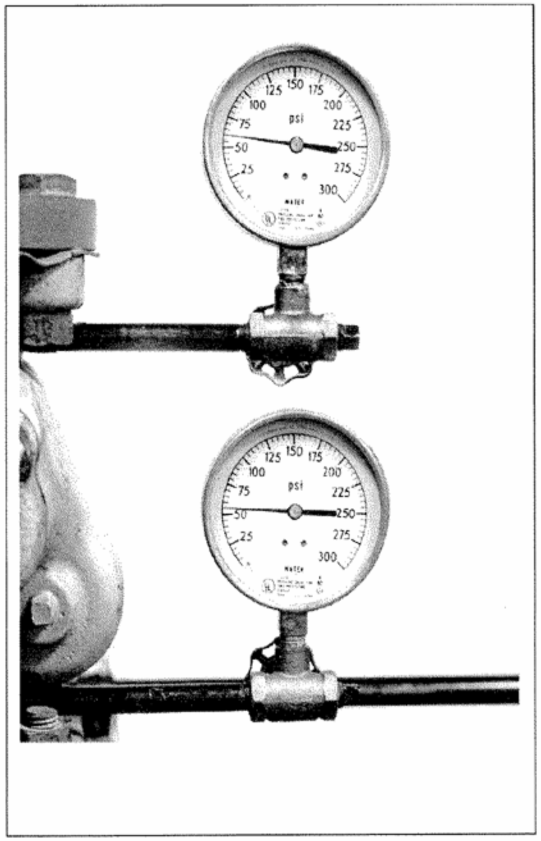
System gauges display the water or air pressure within the sprinkler system above the main alarm check or dry pipe valve. They usually are located at or above the level of the main alarm check or dry pipe valve.

Supply gauges display the water pressure coming into the system from the water source. Normally, they are located below the main alarm check or dry pipe valve.

If you have questions regarding the readings on any air or water pressure gauge, contact the property owner or a responsible fire protection system contractor for additional help.

Wet Pipe Sprinkler Systems

OBSERVATION: System side pressure gauge displays higher pressure than supply side.



System pressure: 54 psi

Supply pressure: 52 psi

Situation analysis: Okay

On a wet pipe system, it is common to find the system gauge displaying a higher pressure than the supply side. This is a result of water surges from the supply, causing the alarm check valve to open slightly before it returns to rest.

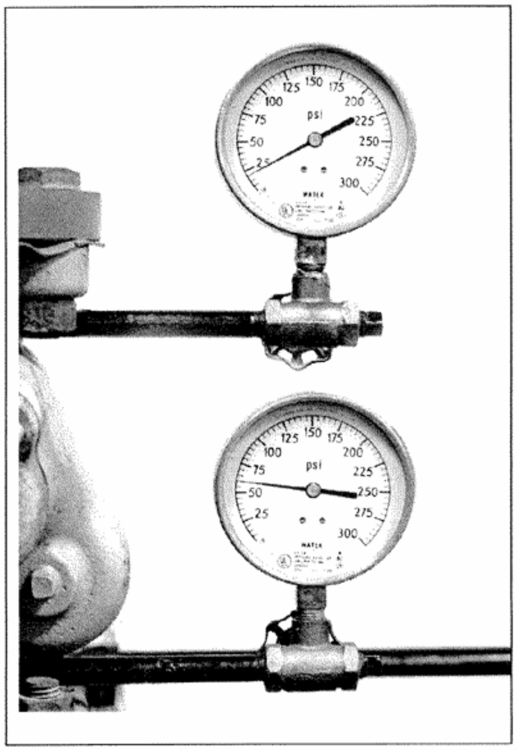
Since water is (for all practical purposes) incompressible, the excess pressure from the surge must be transferred somewhere on the system side. In this case, it appears on the system side gauge.

If the sprinkler system does not have a retarding or retard chamber, it is common to find system side pressures 10 percent to 20 percent higher than supply side readings.

As long as the upper gauge (system gauge) does not exceed 200 psi, this condition will not adversely affect the sprinkler system operation.

Once one or more sprinklers open, the higher pressure will be released from the pipe until it equals the supply side pressure. Then, the incoming water pushes the alarm check valve clapper to the "open" position.

Wet Pipe Sprinkler Systems



OBSERVATION: System side pressure gauge displays lower pressure than supply side.

System pressure: 20 psi

Supply pressure: 60 psi

Situation analysis: Not okay

Since the clapper in an alarm check valve is free to move with changes in water pressure, the gauges should display equal pressure on both sides, or slightly higher pressure on the system side.

With these gauge readings, you can interpret that the alarm check valve likely is rusted shut or otherwise damaged so it will not open.

This is a serious condition that needs immediate technical service because this sprinkler system is inoperable. Even if a sprinkler would fuse from a fire, or be broken off due to mechanical damage, the slight amount of pressure on the system side (20 psi) probably would not control a fire.

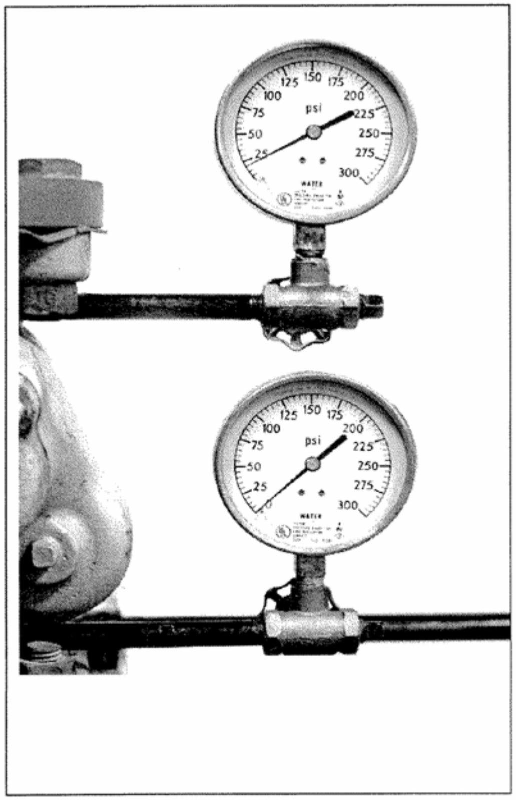
This condition should be reported to the property owner, maintenance staff, and code enforcement official.

Furthermore, all fire companies should be advised that this facility has no automatic fire protection.

Here, it is imperative that early arriving companies support the sprinkler system through the fire department connection because that will be the only water supply to the sprinklers.

Wet Pipe Sprinkler Systems

OBSERVATION: Supply side gauge reads zero pressure.



System pressure: 20 psi

Supply pressure: 0 (zero) psi

Situation analysis: Not okay

This sprinkler system is inoperable.

The water supply may have been shut off at the source, the street, or the main controlling valve.

Worse, the water supply may never have been connected to the sprinkler system.

Sprinkler supply control valves may be closed for a variety of reasons, including, but not limited to:

- Failure by the property owner to pay required water bills or surcharges.
- Leaks detected in the supply line, so the supply is shut off for repair.
- Intentional water shut down by someone attempting to damage or destroy the property.
- Routine maintenance.
- Leaks detected in the source (gravity or suction tank, reservoir, pressure tank, cistern, etc.), so the source is shut off for repair.

This is a serious condition that needs immediate technical service because this sprinkler system is inoperable. The "fix" may be as simple as checking all the supply control valves to assure they are fully open.

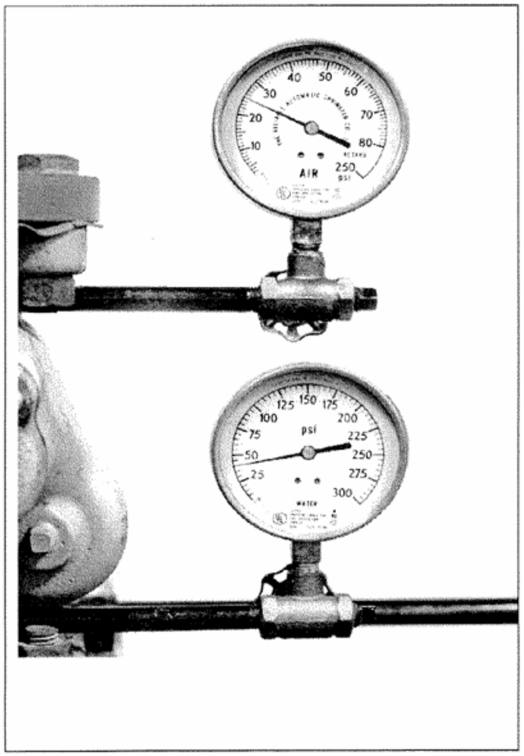
This condition should be reported to the property owner, maintenance staff, and code enforcement official.

Furthermore, all fire companies should be advised that this facility has no automatic fire protection until it is restored.

It is imperative that early arriving companies support the sprinkler system through the fire department connection because that will be the only water supply to the sprinklers until the condition is corrected.

Dry Pipe Sprinkler Systems

OBSERVATION: System side *air gauge* reads lower than supply water side.



System air pressure: 25 psi

Supply water pressure: 40 psi

Situation analysis: Okay

Dry pipe sprinkler systems rely on pressurized air or nitrogen to hold the clapper in the dry pipe closed until a sprinkler opens, allowing air to be released from the pipe, and water to flow through the dry pipe valve to the fire.

Dry pipe systems use a principle called "mechanical advantage" where a small amount of air pressure can restrain a greater amount of water pressure. This is accomplished in the design of the dry pipe valve assembly.

Most dry pipe systems are arranged with a mechanical advantage so that one pound of a pressure will restrain six pounds of water pressure. This is called a 1:6 ratio. Thus, usir mechanical advantage, 10 pounds of air pressure could hold back 60 pounds of water pressure.

In this example, the supply pressure is 40 psi. Using the 1:6 ratio, about 7 psi is all that wou be needed to keep the dry pipe valve closed.

However, to prevent inadvertent dry pipe valve operation, sprinkler technicians often will put small additional amount of air pressure on the system side.

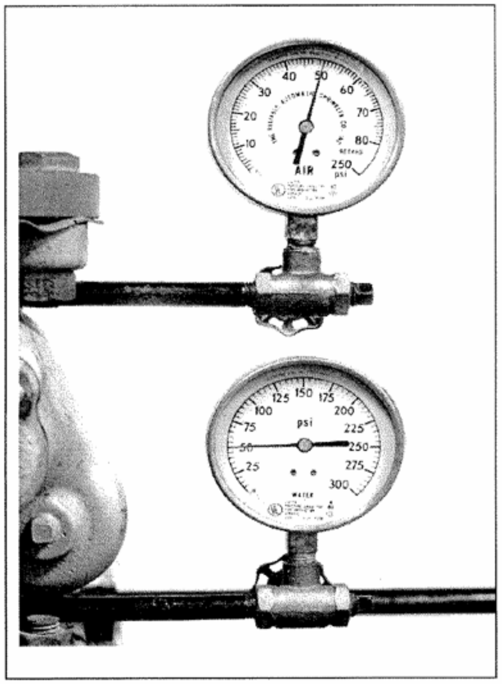
Usually, this amounts to an additional 10 to 20 psi over the amount needed to restrain the d pipe valve.

If a small leak occurs, or there is a water surge against the dry pipe valve, the higher than required air pressure will prevent the dry pipe valve from opening. (When a dry pipe valve opens inadvertently, it is said to have "gone wet.")

The automatic compressor installed on most dry pipe systems will maintain this extra pressure in the event of tiny air leaks.

When a sprinkler fuses, air is expelled from the sprinkler until water reaches it from the dry pipe valve. The automatic compressor will start, but not have the capacity to prevent the dry pipe valve from opening.

Dry Pipe Sprinkler Systems



OBSERVATION: System air pressure gauge and water supply gauge read the same.

System air pressure: 50 psi

Supply water pressure: 50 psi

Situation analysis: Okay, but needs technical service

This condition represents the gauge displays when a dry pipe system has "gone wet."

Dry pipe systems "go wet" for a variety of reasons, but the most common is an air leak that the compressor could not overcome. Once the air pressure drops below the amount needed to restrain the dry pipe valve clapper, the valve will open and water will fill the pipe.

When a dry system "goes wet," the pressure switch for the water flow alarm should operate, and the alarm should be sounding. However, the control valve to the alarm may be closed, silencing the water flow alarm.

From a fire protection perspective, this sprinkler system is considered operational and has become a wet pipe system.

However, since most dry pipe systems are installed in areas that are subject to freezing, the property owner should be notified to have a service technician inspect and restore the system. Water accumulated in the pipe may freeze, causing ice plugs that could prevent fire protection water from reaching a fire.

Although this generally is not an urgent condition that needs immediate service, it should be addressed soon.

If this condition occurs in occupancies of extreme cold (such as a commercial freezer or cold storage warehouse), it may result in significant damage to the fire protection equipment.

The building owner should be notified of this condition.

All fire companies should be advised that this facility may have no automatic fire protection until the dry pipe system is restored.

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MODULE 1:
CODE ENFORCEMENT: YOUR ROLE

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Activity 1.1

Benefits of a Code Enforcement System

Purpose:

This activity is designed to identify the results of a lack of codes on the community and the community's attitudes.

Directions:

1. View "The Great Chelsea Fire" video.

2. Take notes as the video is being shown and answer questions regarding the effects of the lack of codes on the community and the community's attitude.

    ____

    ____

    ____

    ____

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    ____

    ____

3. Select a spokesperson to report your responses to the rest of the class.

    You have sixty minutes to complete this activity at the conclusion of the video.

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Activity 1.1 (cont'd)

Benefits of a Code Enforcement System

"The Great Chelsea Fire"

Questions:

After viewing the video, answer these questions.

1. What was the community's attitude regarding code enforcement?

   ____`

   ____

   ____

   ____

   ____

2. In Chelsea, what made it difficult to create and/or enforce needed codes?

   ____

   ____

   ____

   ____

   ____

3. What were some of the contributing factors that led to the conflagration?

   ____

   ____

   ____

   ____

   ____

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Activity 1.2

Code Research for Legal Authority

Purpose:

This activity is designed so that you will have to research your codes to find the code section for the following three questions.

Directions:

Answer the following questions using your local code. Give the section and paraphrase the wording (for class only).

1. Your department has received a formal complaint from an individual about seeing his neighbor carrying a large amount of gasoline (5 gallons) into his garage. There is a strong odor of gasoline in the area and he is concerned about the hazard in a residential area. He has given his name and address and will sign a complaint. Do you have the right to enter, for inspection, a one-family dwelling?

   Code section: ______________________________

   Answer: ______________________________

   ____

2. When can you make an inspection in an inspectable building? (The time of day.)

   Code section: ______________________________

   Answer: ______________________________

   ____

3. What type of action or emergency power do you have to remove or correct a hazardous condition immediately?

   Code section: ______________________________

   Answer: ______________________________

   ____

You have 45 minutes to complete this activity.

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Activity 1.3

Effective Communications
(Salesmanship)

Purpose:

This activity is designed so that good, effective communications can be used to sell or achieve compliance with the code. Five scenarios are provided.

Directions:

1. Read your group's assigned scenario.

2. Answer the questions following the scenario.

3. Select a spokesperson to report to the rest of the class.

4. You have 30 minutes to complete this activity.

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

The New Church

A firefighter finds a building under construction. He reports this to the Fire Prevention Bureau after noting there is no permit showing on the building front. With research, it is found to be a new church being built with no building permit and no architectural drawing, only a design drawing. A joint stop work order is issued by the building and fire departments. It is not known by the Fire Prevention Bureau that some of the members of the church are elected officials of the city. These officials told the church committee to start building without an architect's drawings or permit, this would be taken care of by the officials. The expense of the permits and the delay of the drawings were not expected to slow the construction of the church.

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Questions:

1. How would you handle this situation with effective communications (salesmanship)?

2. Compose the appropriate statement/statements to explain the necessity for code compliance.

3. What action would you take if you saw that you were not accomplishing your objectives? With whom would you speak?

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Inspector Harris

Inspector Harris is assigned to conduct the biannual fire drill in the city school system. Upon arrival at Foxwood Elementary School (grades K-6, one story, fire resistive, doors out of each classroom), Inspector Harris went to the principal's office, explaining to the secretary the purpose of his visit. The principal came out of her office, interrupting the secretary, and told Inspector Harris he always came at the wrong times--lunch periods began in a very short time. Inspector Harris tried to explain the importance of the visit, and that there was time before lunch to conduct the fire drill. The lunch periods began at 11:00 a.m. and it was 10:30 a.m.

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Questions:

1. How would you handle this situation with effective communications (salesmanship)?

2. Compose the appropriate statement/statements to explain the necessity for code compliance.

3. What action would you take if you saw that you were not accomplishing your objectives? With whom would you speak?

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Inspector Jackson

Inspector Helen Jackson was assigned a new territory in the old part of the city with small businesses, mercantiles, and industrial occupancies.

Inspector Jackson entered a small industrial shop (welding structural steel for prefabricated buildings) with about 25 employees in the shop and four office personnel. She introduced herself and explained the nature of her business to the receptionist, Joan Sims. Joan notified the owner, who had her accompany Inspector Jackson on a tour of the plant. After the inspection, Inspector Jackson requested a meeting with the owner to discuss the results of the inspection. She explained that there were some conditions found that could jeopardize the safety of the employees and the building. The owner, replied, "That other inspector was a man and he knew his business and he never found anything wrong!"

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Questions:

1. How would you handle this situation with effective communications (salesmanship)?

2. Compose the appropriate statement/statements to explain the necessity for code compliance.

3. What action would you take if you saw that you were not accomplishing your objectives? With whom would you speak?

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Inspector Smith

Inspector Smith was following his daily routine when he entered an auto body repair shop. Introducing himself and the nature of his business, he was accompanied by the owner on an inspection of the shop. Numerous serious hazards were found and listed, with Inspector Smith pointing out the hazards as they toured the facility. Upon completion of the inspection, they returned to the owner's office where Inspector Smith explained each of the violations to the owner, who agreed with the findings. When Inspector Smith completed the list, the owner stated, "Why fix it? We've been doing business this way for twenty years with no problems."

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Questions:

1. How would you handle this situation with effective communications (salesmanship)?

2. Compose the appropriate statement/statements to explain the necessity for code compliance.

3. What action would you take if you saw that you were not accomplishing your objectives? With whom would you speak?

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Inspector Thomas

Inspector Thomas was assigned to inspect a building for a C.O. This building had just been bought by the owner, who was moving in to start a business. The inspection revealed that the sprinkler for the building was of light-hazard design (office space). The new business, wholesale liquor supplies, would require the sprinkler system to be upgraded to an Ordinary III classification. The owner's comment was "a sprinkler is a sprinkler; why the extra expense on a new business?"

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Activity 1.3 (cont'd)

Effective Communications
(Salesmanship)

Questions:

1. How would you handle this situation with effective communications (salesmanship)?

2. Compose the appropriate statement/statements to explain the necessity for code compliance.

3. What action would you take if you saw that you were not accomplishing your objectives? With whom would you speak?

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Activity 1.4

Evaluate Ethical Behavior Questionnaire

Purpose:

This activity will use a set of questions on ethical behavior and conduct.

Directions:

Answer, individually, the questions for each of the three situations. Be sure to answer both questions for each situation.

Situation 1

You go out to dinner with your spouse and four close friends. After you have been seated and have ordered your dinner, you walk through the restaurant to use the phone. On the way, you notice a serious fire code violation: an exit door is chained and locked, and a display table is placed in front of it. You decide since you are on personal time, you will do nothing.

Is your action: (choose one)

______ 1a.	Clearly ethical?

______ 1b.	Ethically questionable?

______ 1c.	Clearly unethical?

Is your action: (choose one)

______ 1d.	Clearly legal?

______ 1e.	Questionable?

______ 1f.	Clearly illegal?

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Activity 1.4 (cont'd)

Evaluate Ethical Behavior Questionnaire

Situation 2

Your Fire Chief has been quoted in the media, saying that Fire Prevention, including an aggressive fire inspection program, is the department's highest priority. You did a careful review of all the public assembly and commercial buildings within your station's boundaries, and developed a prioritized annual inspection plan.

You gave highest priority to some older, low-income apartment buildings, businesses with stored hazardous materials, several old church properties used for bingo and dances (as well as religious services), and an old warehouse converted into an artist's cooperative.

You began the inspection after training your crew. You discovered that it is slow going, because you are finding numerous serious violations, and it takes time to do a thorough job.

Yesterday, your Battalion Chief called you in, and said, "I know you're taking the inspection plan seriously, but you'll have to put your action plan on hold. For the next six months, we'll be doing only revenue-producing low hazard, 'quick-and-dirty' inspections. The City Manager gave the word to the Chief!"

You rewrite your inspection plan, targeting low-hazard but revenue-producing occupancies, as suggested by the Battalion Chief.

Is your action: (choose one)

______ 2a. Clearly ethical?

______ 2b. Ethically questionable?

______ 2c. Clearly unethical?

Is your action: (choose one)

______ 2d. Clearly legal?

______ 2e. Questionable?

______ 2f. Clearly illegal?

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Activity 1.4 (cont'd)

Evaluate Ethical Behavior Questionnaire

Situation 3

As Fire Marshal, you have recently completed a fire inspection on a local factory. You and your staff found a number of violations. Yesterday, the Chief told you to "write'em up" and to proceed with the normal enforcement steps.

Today the Chief received a call from the Mayor, who said "off the record" that the factory is in bad financial trouble, and the major work needed to come to code would bankrupt the factory's owners. The factory is the major employer in the town, providing work for over 700 people.

The Mayor also mentioned that the owners are in final negotiations with a large foreign investment company to sell out, which will guarantee that jobs will continue. The deal is supposed to be completed in less than a month.

You decide to wait 60 days before taking any action.

Is your action: (choose one)

______ 3a. Clearly ethical?

______ 3b. Ethically questionable?

______ 3c. Clearly unethical?

Is your action: (choose one)

______ 3d. Clearly legal?

______ 3e. Questionable?

______ 3f. Clearly illegal?

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Activity 1.5

Ethical or Unethical Situations

Purpose:

This activity is designed to help you recognize situations in which ethics become a issue. You must be able to handle these situations in order to maintain your position.

Directions:

1. Read the scenario.
2. Answer the questions following the scenario.
3. Select a spokesperson to report your responses to the rest of the class.
4. You have 45 minutes to complete this activity.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Inspector James

Inspector James is conducting an inspection at a large dinner restaurant which is frequented by several pro athletes. (The owner was very influential in getting the team for the city.) After completing the inspection, he started to discuss the findings with the owner, who suggested to have lunch while they discussed the problems. Inspector James declined the offer and continued to explain the findings, and set a date to return for the reinspection. (No real life-threatening problems existed.)

Inspector James continued his daily inspections and returned to the office at the conclusion of the day's activities. Upon entering the office, the secretary called him over to her desk and told him a messenger had delivered an envelope for him earlier in the day. When Inspector James got to his desk, he opened the envelope to find two tickets to the next home game.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Questions:

1. How would you handle this situation?

2. Was Inspector James right or wrong in dealing with the lunch offer? Should he have explained the reasons for declining the invitation? Explain.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Inspector Morgan

Inspector Morgan and his wife went out to celebrate her birthday at a very nice restaurant. The reservation was in his name with no reference to his job or position. The meal and service were excellent. When he requested the check, the waiter informed him the check had been taken care of by the owner. When the waiter was questioned more, he went to ask the owner to please come to the table. The owner explained he had recognized Inspector Morgan from inspections made at his other businesses and felt the inspector deserved a free meal for the excellent job he had performed over the years for the city, as well as for him, the small business owner. The check came to $109.50 plus tip. The restaurant was filled above capacity with other patrons, as well as other city personnel.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Questions:

1. How would you handle a situation such as this?

____
____
____
____
____
____
____
____

2. How would you end the situation tactfully?

____
____
____
____
____
____
____
____

*** Note: Remember to be professional and polite in deciding your answer.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Inspector Jones

Inspector Jones has been assigned the duty of inspecting day-care in the city. He is in his late 20s to mid-30s and is a male chauvinist. He addresses the female business owners as "Sweetie" or "Little Lady." His appearance is that of a macho man, with excessive jewelry and cologne and his uniform shirt and pants seem a bit too small. While inspecting one facility, he continuously made passes or remarks to the Director. No serious violations were noted; however, two re-inspections are conducted with the same attitude and approach. A complaint is received on Inspector Jones' behavior. An internal investigation was conducted by the department. The investigation found Inspector Jones in the wrong. He had not violated any codes or laws, but he was morally wrong. He had conducted all of his inspections with other female business owners or managers in the same manner.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Questions:

1. What image of the department did Inspector Jones project?

2. What can be done to correct the situations where he had inspected before?

3. How can the department re-inspect to ensure that all the violations have been corrected or noted, and a proper inspection was in fact conducted, and maintain the integrity of the department?

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Inspector Brown

A new Oriental restaurant was planning to open in a few days. This restaurant was part of a large chain from outside the state. Inspector Brown was assigned the responsibility of inspecting for the Certificate of Occupancy (C.O.). He arrived in full uniform at the restaurant and introduced himself to the manager, who was new to this country, explaining the reason for this visit and asking for permission to inspect the restaurant. The manager immediately went to the office and returned with a thick envelope and presented it to Inspector Brown. Inspector Brown explained to the manager that it was not necessary to pay him; there was no charge for the certificate or inspection. The manager insisted, stating that where he was from it was necessary to pay public officials.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Questions:

1. How do you explain to the manager that this is not the way things are done in this country without offending him or his country?

2. If code violations are found and the Certificate of Occupancy cannot be issued because of the violations, how would you explain the violations and correction procedures to the manager, as well as the fact there would be a re-inspection?

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

You

The corporate policy for some businesses is to allow for a discount, or free meals or drinks (coffee, soda, etc.) at their establishments for police and firefighters. However, the city policy is that gratuities cannot be taken.

You have been assigned to work with an older inspector, and the first day out both of you visit all the places in which he knows he can get free meals, coffee, pie or pastries.

The second day is the same except that the only places he inspects are those in which he can get free gifts or discounts on materials or equipment he needs.

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Activity 1.5 (cont'd)

Ethical or Unethical Situations

Questions:

1. What would you do in a situation like this?

2. Would you have accepted the free meals and gifts in the two days of inspecting? Explain your answer; do not answer only yes or no.

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MODULE 2: FIRE AND CODES: THEIR RELATIONSHIP

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Activity 2.1

Fire Spread and Building Materials

Purpose:

Recognize the potential hazards of fire spread given specific building construction materials.

Directions:

Examine each slide for two minutes and complete the worksheet for each scenario.

Warehouse

Warehouse/Retail sales facility as part of a strip shopping center. Masonry construction with retail sales area within the core of the warehouse. Rack storage and automatic stacking system designed for furniture storage and retrieval.

1. Describe the key building construction component systems in the slides.

2. Identify potential fire spread.

   Radiation ____

   ____

   Conduction ____

   ____

   Convection ____

   ____

   HVAC ____

   ____

   Direct Spread ____

   ____

3. Identify fire protective features. ____

   ____

Industrial Iron Works

Large steel fabrication and processing facility as part of an industrial park, i.e., warehousing and light manufacturing.

1. Identify potential fire spread.

   Radiation ______________________________

   ____

   Conduction ______________________________

   ____

   Convection ______________________________

   ____

   HVAC ______________________________

   ____

   Direct Spread ______________________________

   ____

2. Identify fire protective features. ______________________________

   ____

Residential

Three (3) story residential multifamily facility. Each unit is self contained except for shared plumbing and water supply system. Part of a large 200+ unit project. All rental.

1. Identify potential fire spread.

   Radiation ______________________________

   ____

   Conduction ______________________________

   ____

Convection ______________________________

____

HVAC ______________________________

____

Direct Spread ______________________________

____

2. Identify fire protective features. ______________________________

____

Lumber Yard

General purpose lumber yard within the urban environment.

1. Identify potential fire spread.

Radiation ______________________________

____

Conduction ______________________________

____

Convection ______________________________

____

HVAC ______________________________

____

Direct Spread ______________________________

____

2. Identify fire protective features. ______________________________

____

Public Assembly--Restaurant

General purpose restaurant with kitchen, public assembly, food storage, and bar. Interior finish and seating arrangement with combustible (non-rated) interior finish and contents.

1. Describe the key building construction component systems in the slide.

2. Identify potential fire spread.

   Radiation ______________________________

   ____

   Conduction ______________________________

   ____

   Convection ______________________________

   ____

   HVAC ______________________________

   ____

   Direct Spread ______________________________

   ____

3. Identify fire protective features. ______________________________

   ____

Activity 2.2

Building Construction Classification

Large Group

Purpose:

The purpose of this activity is to identify the construction classification of a building and to be able to predict paths of smoke, heat, and fire travel.

Directions:

The instructor will show the class a series of slides of a selected structure and a fire condition. As a large group you will be asked to answer a series of questions about the structure and fire travel predictions.

Walk-Through Scenario:

The structure has been converted from a dwelling to a truck repair and sales facility. It is approximately 35' by 35' and was built in 1938. The structure was modified in 1986 to accommodate the truck repair operation.

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Activity 2.2 (cont'd)

Building Construction Classification

Large Group

Questions:

1. What is the fire building construction type (classification)?____________________________

   ____

2. What problems might you expect regarding building systems? ________________________

   ____

3. What is the occupancy? ____

   ____

4. Was the structure constructed for the current occupancy? ____________________________

   ____

5. Do there appear to be any significant construction deficiencies? ______________________

   ____

6. What factors of this building could be considered strengths? _________________________

   ____

7. What factors of this building could be considered concerns? _________________________

   ____

8. What avenues of fire, smoke, or heat travel would you expect? ________________________

   ____

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Activity 2.2 (cont'd)

Building Construction Classification

Small Group

Purpose:

The purpose of this activity is to identify the construction classification of a building and to be able to predict paths of smoke, heat, and fire travel, in addition to concerns you as a fire officer would have for firefighter safety.

Directions:

The instructor will show you several series of slides for various classifications of structures. After reviewing the slides your instructor will assign your group one of the scenarios. As a group, answer the questions for your scenario. Each group will need a spokesperson to report the group's findings about its scenario.

Scenario 1

The structure is a storage barn, approximately 30' by 30'. It was constructed in 1934 with materials and techniques appropriate for that time. The barn currently is used for storage of fertilizer, seed, and pesticides.

Scenario 2

The structure is a single-family dwelling approximately 60' by 40', of irregular shape. The center portion was constructed in 1922; additions to both sides of the original structure were built in 1934.

Scenario 3

The structure is a single-family dwelling, constructed in 1951. The dwelling is 35' by 35' and the attic is used for the storage of old furniture. Prior to its sale in 1986, the structure was remodeled and a second bathroom was added on the second floor.

Scenario 4

The structure is a tavern which also serves light lunches and dinners. The building is 40' by 120' and was built in 1955. Since its original construction, the building has been remodeled twice. The kitchen equipment is fueled by natural gas and consists of a french fryer, grill, and two stoves.

Scenario 5

The grocery store was constructed in 1976 and is 250' by 350' with an attached loading dock. The building has the typical fixtures and equipment expected for a full-service grocery store.

Activity 2.2 (cont'd)

Building Construction Classification

Small Group

Questions:

1. What is the fire building construction type (classification)? ______________________________

   ____

2. What problems might you expect regarding building systems? __________________________

   ____

3. What is the occupancy? ____

   ____

4. Was the structure constructed for the current occupancy? ______________________________

   ____

5. Do there appear to be any significant construction deficiencies? _________________________

   ____

6. What factors of this building could be considered strengths? ___________________________

   ____

7. What factors of this building could be considered concerns? ___________________________

   ____

8. What avenues of fire, smoke, or heat travel would you expect? __________________________

   ____

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Activity 2.3

Occupancy Classes

Purpose:

To identify the key characteristics of each occupancy group within your code.

In order to know what you are going to enforce you need working knowledge of your own code definition.

Directions:

Read the occupancy classifications for your code group.

In your group, read each of the ten scenario descriptions and complete the following for each.

Be prepared to describe your code system to the rest of the class. You may use the applicable wall chart.

Scenario 1

One-story ordinary construction restaurant with bar and dance floor with occupant load of 200. Office for restaurant and one separate office used by restaurant to operate franchise of six other restaurants. Office staff of six. Used during normal business hours.

Classification by use: ______________________________

____

____

List key characteristics: ______________________________

____

____

Scenario 2

Day/Child care center for children under two years old, with special equipment for physically and mentally dependent children for a population of ten, plus trained staff.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Scenario 3

Ten-story office building with restaurant (occupant load of forty) and retail space on each side of the street floor lobby.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Scenario 4

Department store as an anchor in a large regional shopping mall. Store has restaurant with an occupant load of thirty and child care for "mother's day out program." Babysitting service is drop-off with up to 25 children under the age of twelve. Well staffed and has direct fire exit on the grade level that opens into a fence-enclosed playground.

Classification by use: ______________________________

____

____

List key characteristics: ______________________________

____

____

Scenario 5

Semiconductor fabrication facility that manufactures computers and printed circuit boards under a special contract for security-sensitive defense department. Building is two stories with general office, training, and meeting rooms on the second floor. Special storage center for parts delivery and shipment on the ground floor.

Classification by use: ______________________________

____

____

List key characteristics: ______________________________

____

____

Scenario 6

Air-supported structure used for tennis matches/tournaments at a local country club. Spectator area seats 300 when portable bleachers are set up for special events.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Scenario 7

High school sports complex used as a municipal special events convention center during school breaks and on weekends. The sports complex/convention center seats 8,000 and is used for university basketball games and other indoor athletic events.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Scenario 8

Storage structure used for small rent-by-the-month storage spaces; designed for use by small businesses and storage of household items. Structure is seven stories high and is serviced by a series of freight elevators.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Scenario 9

Hospital/Nursing home complex. Facility has 200 beds and is divided into an in-patient hospital and a long-term care nursing home for the elderly.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Scenario 10

Twelve-story multifamily apartment building with gym and indoor swimming pool for use by residents and convenience store open to the public. All nonresidential facilities are on the ground floor and there is a basement with underground parking.

Classification by use: ____

____

____

List key characteristics: ____

____

____

Activity 2.4

Change of Use

Purpose:

Given a scenario including building materials, systems construction, age, and occupancy, determine what, if any, modifications would be required to allow the new use.

Directions:

You have just completed an inspection of a wood frame building that is forty feet wide and eighty feet long. When the building was last inspected your records show that it was used for the storage of auto parts. You now discover that the building is being used for the storage of 6,000 cubic feet of oxygen in cylinders, 6,000 cubic feet of chlorine in cylinders and 4,000 cubic feet of acetylene in cylinders. The three types of cylinders are mixed together and not separated. There is no heat in the building and no automatic fire protection system. The building has one overhead door and one exit door located at one end of the building.

Using your local codes, what are the requirements that would address this situation?

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Activity 2.5

Human Behavior

Purpose:

At the conclusion of this activity, be able to describe categories of behavior and analyze what variables affect these behaviors.

Directions:

1. As you view the movie, think about what the people in the movie did in response to this fire situation. Consider the categories or dimensions of behavior presented earlier.

2. Having read the article by Joseph Swartz, *Human Behavior and Fire*, discuss the types of behavior exhibited by building occupants.

3. Discuss how these behaviors could be placed into categories.

4. What variables affected these behaviors?

    a. Role assumed?

    b. Experience?

    c. Education?

    d. Personality?

    e. Perceived threat?

    f. Means of egress?

    g. Actions of others?

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MODULE 3: GENERAL FIRE SAFETY

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Activity 3.1

Site Problem Identification

Purpose:

The purpose of this activity is to identify appropriate codes and be able to apply them in evaluating the general fire safety of a site.

Directions:

1. There are ten slides in this activity.
2. Each slide shows a concern regarding fire safety or access to a site.
3. Each slide will be shown for thirty seconds.
4. As you see a slide, write in the appropriate space below any violations seen.
5. When all ten slides have been seen, go to your code and write down the code reference for each.
6. The slides then will be shown again and discussed. Be prepared to tell what your code says about each.

Code working with _______________

Slide 1 ____

____ Code Ref. ______________________

Slide 2 ____

____ Code Ref. ______________________

Slide 3 ____

____ Code Ref. ______________________

Slide 4 ____

____ Code Ref. ______________________

Slide 5 ____

____________________________________ Code Ref. ________________

Slide 6 ____

____________________________________ Code Ref. ________________

Slide 7 ____

____________________________________ Code Ref. ________________

Slide 8 ____

____________________________________ Code Ref. ________________

Slide 9 ____

____________________________________ Code Ref. ________________

Slide 10 ____

____________________________________ Code Ref. ________________

Activity 3.2

Determining Ratings of Building Assemblies

Purpose:

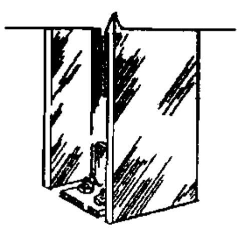
The purpose of this activity is to, by using your code and other reference books, identify building assemblies indicated and to be able to evaluate them as to their rating and thus apply it to the general fire safety of a structure.

Directions:

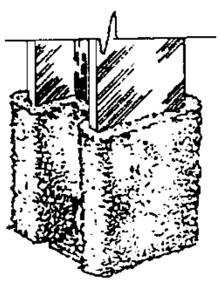
Using:

- Your code.
- The 1992 edition of the UL Fire Resistance Directory.
- The 12th edition of the Gypsum Products Fire Resistance Design Manual.

1. Find within your code the section that requires fire-rated assemblies to be maintained.

2. 

An unprotected steel column would be representative of what construction by your building code?

3. 

A protected steel column sprayed with material sufficient to give it a one-hour rating would be representative of what construction by your building code?

4. Find in your code where parapets are required.

5. Referring to U/L Design #XR707 from the U/L Fire Resistance Directory, 1992 Edition, determine the rating if the cementitious mixture that is applied with a 1-3/8" thickness.

6. What is the rating of the UL wall design #U440 from the 1992 edition of the directory?

7. Using the design shown for UL floor/ceiling design #P260 what fire resistance rating will be provided?

8. Using the design WP-1206 from the Gypsum Products Manual, 1990 edition, what is the fire resistance rating for this assembly?

9. Using the design WP1632 from the Gypsum Products, 1990 edition, determine: What is the rating of the gypsum products wall assembly WP1632?

10. Using the design FC5250 from the Gypsum Product Manual, 1990 edition, determine: What is the rating of the gypsum products floor/ceiling assembly FC5250?

Activity 3.3

Letter of Compliance

Purpose:

The purpose of this activity is to identify appropriate codes and apply them in evaluating the general fire safety of a structure.

Directions:

You are the inspector who has just completed the inspection of Hadley's Auto Repair. Your notes are the scenario as it is written. Your job now is to take those notes and compile an inspection letter to Hadley's noting all of the violations with the code references. In your letter also give instructions as to when you feel these violations must be corrected.

Only comment on those items in the scenario you feel are code violations, but be prepared to defend your position on those items you do not list.

This will be an overnight assignment. Bring your inspection letter to class tomorrow, where it will be reviewed and the assignment discussed.

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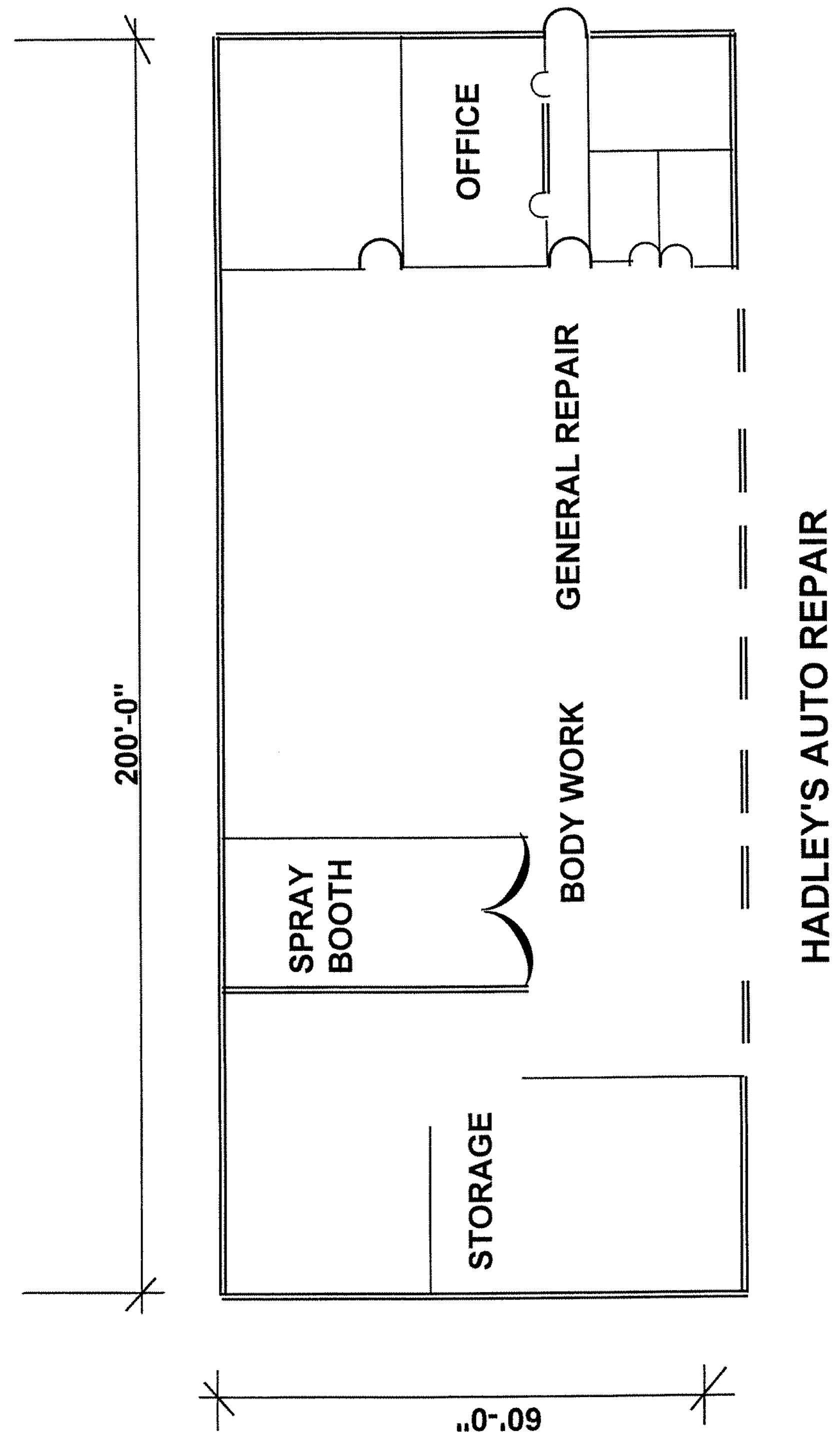
Activity 3.3 (cont'd)

Floor Plan to Hadley's Auto Repair Shop



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Activity 3.3 (cont'd)

Scenario

Inspection of Hadley's Auto Repair Shop

On March 3, an inspection of the above noted establishment was made with observations as follows:

The business consisted of a large concrete block building measuring 60 feet x 200 feet. The roof was constructed of truss-joist spanning thirty feet from the exterior wall to Glulam beams which were supported by pipe columns running the 200 foot length of the building. The roof was of built-up gravel on plywood deck. The building was not sprinkled except for a paint booth room which had large doors from the shop, permitting cars to be driven in.

There were five visible 4A-40BC fire extinguishers suspended on pipe columns in the center of the shop area. The front 25 feet of the building was office space, with one corridor which ran from the front to the shop door, which swung into the hall. No doors were equipped with closers. The corridor on one side had shelving for parts, books, and manuals floor-to-ceiling between two doors. No fire alarm system was installed in the building. The back 25 feet of the building consisted of a large storage room 25 x 60 feet with three 55-gallon drums of solvent (material undetermined, as no name was on drums). One section of the storage room had been partially separated by wood studs with plywood on one side with an opening to it with no door. In this area was stored 375 gallons of lacquer and thinners.

The main shop area consisted of ten 15-foot-wide repair bays. Against the wall between the paint booth and offices were tables for parts repair. There we found grinders, sanders, cut off saws, carts with welding gas cylinders, and several solvent vats without covers.

It was noted that six of the bays were used for general automobile repair while the other four seemed to be reserved for body work. We counted four cut-off 55-gallon drums on caster dollies each containing drained oil about 25 percent full.

While we were there, all areas of the shop were operating. We noted welding in the general shop. We also noted that the paint booth appeared not to have been cleaned in some time, with heavy residue of paint clogging the filters. Large overhead doors were situated at each bay. The one main exit was into the office hall. A second exit adjacent to the storage room was almost missed, due to equipment stored in front of it.

Outside, it was noted this second door was padlocked closed. The front of the building faced the street with a side yard giving access to the roll-up doors. The nearest hydrant was 300 feet away.

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Activity 3.3 (cont'd)

Letter of Compliance

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MODULE 4: LIFE SAFETY

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Activity 4.1

Determining Occupancy Classification

Purpose:

To determine occupancy classification using your own codes and whether the occupancy should utilize the "defend-in-place" or "evacuation" concept.

Directions:

1. Identify the appropriate occupancy classification for the following.

		Occupancy	Code	Section
a.	Retail Sales 'B'			
b.	Restaurant			
c.	Kitchen			
d.	Day Care			
e.	Multi-purpose			
f.	Suite 3A			

2. Can the mixed uses be separated? If yes, where should the separation be? If no, how would you determine the appropriate code requirements?

3. Which life-safety strategy would you use for the building, evacuation or defend in place? Would there be any areas in which you would use a different strategy?

4. Using your response to Item 3, identify the appropriate protection features necessary to implement your strategy. (Your responses should be conceptual and not code-requirement specific.)

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Activity 4.2

Evaluating Exit Capacity

Purpose:

Evaluate the adequacy of the exit capacity component of an egress system for a given structure.

Directions:

Using the same plan introduced earlier, calculate the following for the restaurant (not including the kitchen areas):

1. Occupant load.
2. Number of exits required.
3. Arrangement of exits.
4. Width of exits, including corridors.
5. Identify elements of the exit system.

The formula for finding the area of a triangle is 1/2 base times the height.

After your group has completed the activity, be prepared to present your group's answers to the class.

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Activity 4.3

Determining Number of Exits

Purpose:

Determine and rationalize the number of required exits for a given structure.

Directions:

Using the plan of the five-story building introduced earlier, use your own codes to verify:

1. Size of doors.
2. Direction of swing of doors.
3. Travel distance.
4. Corridor widths.
5. Intervening rooms.

Verify these for both the restaurant and the assembly area on the second floor.

After your group has completed the activity, be prepared to present your group's answers to the class.

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Activity 4.4

Evaluating Exit Adequacy

Purpose:

Evaluate the egress system for a given structure.

Directions:

Using the same plan of the restaurant and assembly area on the second floor introduced earlier, in code groups:

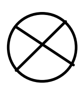
1. Place exit signs.

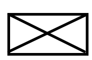
2. Indicate where emergency lighting must be provided.

Only pencils should be used to mark plans, which will allow for changes if required.

After your group has completed the activity, be prepared to present your group's answers to the class.

Use as symbols:

Exit Signs 

Emergency Lighting 

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Activity 4.5

Determining Suppression and Detection Systems

Purpose:

To determine requirements related to life safety for automatic fire suppression and detection systems in a building.

Directions:

Using the same building complex and code groups, identify the code requirements for **fire suppression, detection**, and/or **alarm systems**. As with previous activities, you should be encouraged to provide appropriate code reference citations. Your group may have to make some assumption about the occupancies in the building, which is okay. Make sure that your group makes note of these assumptions if required.

After your group has completed the activity, be prepared to present your group's answers to the class.

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Activity 4.6

Determining Life Safety Requirements and Assessing the Life Safety Factors in a Given Occupancy and Structure

Purpose:

To require you to conduct a complete life safety assessment of an occupancy and structure, taking into account those major life safety factors and principles that have been covered in this unit.

Directions:

Using the same building complex you have been working with in this unit, you are to apply and use your adopted codes that address conditions that affect life safety by answering the following questions in this activity. You will need an architect's scale or ruler and a calculator. Please show all math steps and numbers used to answer questions 1, 10, 19, and 20. Please note code used and edition.

The following questions are to be completed. Total points possible 200.

1. What is the occupant load for the third floor of the building? ______________________

   Reference code section: ______________________

2. What is the travel distance shown from Suite 3D on the third floor to the closest exit? ___

   ____

3. What is the minimum corridor width required on the third floor? ______________________

   Reference code section: ______________________

4. What are the required interior finishes for the following:

   a. Third floor corridor ceiling and wall ______________________

      Reference code section: ______________________

   b. Floor covering, if carpeting is used ______________________

      Reference code section: ______________________

   c. Suite 3A walls and ceiling ______________________

      Reference code section: ______________________

d. Enclosed stairway walls: ______________________________

Reference code section: ______________________________

5. Mark on third floor plan the location of required exit signs in the corridor.

6. How many exit locations are required from the third floor? ____________

Reference code section: ______________________________

7. Do the two exit locations on the third floor meet the requirements for remoteness?

______ Yes ______ No

Reference code section: ______________________________

8. Is emergency or standby lighting required for illumination of the third floor corridor?

______ Yes ______ No

Reference code section: ______________________________

9. What is the minimum clear door width required for doorways into Suite 3F ______ and doorways into both stairways on the third floor? ______________________

Reference code section: ______________________________

10. What is the total exit capacity of both doorways that enter into the stairways off of the third floor? ______________________________

Reference code section: ______________________________

11. Does the exit capacity for the third floor meet the requirements for the occupant load on the third floor?

______ Yes ______ No

12. Is any part of the third floor required to be protected by automatic sprinkler protection?

______ Yes ______ No

If yes, what part? ______________________________

Reference code section: ______________________________

13. Is this building required to be protected by an automatic sprinkler system?

______ Yes ______ No

Reference code section: ______________________________

Justify your answer: ______________________________

14. Does this building require the installation of a fire alarm system?

______ Yes ______ No

Reference code section: ______________________________

15. What is the occupant load for the day care center?

____

Reference code section: ______________________________

16. Are the exit arrangements for the day care center satisfactory?

______ Yes ______ No

Reference code section: ______________________________

Justify your answer: ______________________________

17. What additional information do you need to determine further requirements for the day care area?

____

____

____

18. Is the means of exiting satisfactory from the retail sales "A" on the first floor?

______ Yes ______ No

Reference code section: ______________________________

19. What is the occupant load of the first floor of the building? ____________________

    Reference code section: ____

20. What is the exit capacity shown from the entire first floor area?

    ____

    What is the required total exit width for the occupant load of the entire first floor?

    ____

    Reference code section: ____

MODULE 5: HAZARDOUS MATERIALS AND PROCESSESS

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Activity 5.1

Characteristics of Hazardous Materials

Purpose:

This activity will point out that all hazardous characteristics cannot be found in one reference book. In order for you to complete this activity, you will have to use all available reference books in the class. In some cases where only a trade name has been given it will only be possible to find the flashpoint. In these cases the manufacturer of the chemical would have to be contacted to obtain more complete information.

Directions:

Below is a list of trade names, chemical names, and materials that are identified with a DOT label. Using available reference books, you are to determine, to the best of your ability, their hazardous characteristics.

Name	Flashpoint	Flammable Vapor Limit	Vapor Density	DOT #	NFPA 325M Classification
(1) Pentane					
(2) Acetylene					
(3) Styrene					
(4) Toluene					
(5) Gasoline					
(6) Vinyl Chloride					
(7) Butyl Alcohol					
(8) Formic Acid 90%					
(9) Coconut Oil					

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Activity 5.2

Hazard Class Introduction--Preparation

Purpose:

Enhance professionalism by improving communication skills as well as improving the foundation in knowledge of hazard classes.

Directions:

1. For your assigned hazard class discuss the contents of the Student Manual.

2. Outline a presentation for the class on the following:

   a. General problems.

   b. Principles for control.

   c. Prevention measures.

   You have 20 minutes to prepare.

3. Each member of your group must participate in the presentation.

4. The presentation should not be more than eight minutes. Remember this is an overview only.

5. Use the following pages of the Student Manual text section to find answers:

Group I	a.	Flammable Liquids	SM p. 5-11
	b.	Combustible Liquids	SM p. 5-12
Group II		Gases	SM p. 5-15
Group III		Chemicals	SM p. 5-18
Group IV		Explosives	SM p. 5-24

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Activity 5.3

Classifying Hazardous Materials

Purpose:

Determine into what groups hazardous materials fall.

Directions:

Below are listed the names of hazardous materials. You are to determine into what groups they fall. Example (flammable and combustible liquids, gas, chemicals, and explosives) and what the classification is in each group, using available reference books.

Name	Group	Classification
(1) Ammonia, Anhydrous		
(2) Acetylene		
(3) Potassium Nitrate		
(4) Smokeless Powder		
(5) Mineral Oil		
(6) Heptane		
(7) Cartridge Practice Ammonium		
(8) Styrene		

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Activity 5.4

Determining Code Requirements

Purpose:

To identify the appropriate sections of the various fire codes dealing with the incidental storage, handling, and use of flammable and combustible liquids, gases, and hazardous materials.

Directions:

Working in your table groups and using your fire codes, answer the following questions regarding the incidental storage, handling, and use of flammable and combustible liquids, gases, and hazardous materials.

1. You have just conducted an inspection of an automobile repair shop. During the inspection you determine that employees have been using gasoline to spot clean the floor. Is the use of gasoline for this purpose acceptable?

    a. Acceptable/Unacceptable: ____

    ____

    ____

    ____

    b. Code section: ____

    ____

    ____

    ____

2. During the inspection of a painting contractor's large warehouse, you find a 55-gallon drum of paint thinner (flashpoint of 104 °F, boiling point 300 °F). This drum is lying on its side in a metal cradle and is being dispensed into smaller containers by gravity. Is this type of dispensing acceptable?

   a. Acceptable/Unacceptable: ______________________________

   ____

   ____

   ____

   b. Code section: ______________________________

   ____

   ____

   ____

3. A general merchandise store has just received a shipment of white gasoline (lantern/stove fuel, flashpoint -45 °F). The fuel is displayed on a set of metal shelves 6 feet long and 3 feet wide, facing a 5-foot-wide aisle. The building is not protected by automatic sprinklers. What is the maximum quantity of fuel that can be displayed in this area?

   a. Quantity: ______________________________

   ____

   ____

   ____

   b. Code section: ______________________________

   ____

   ____

   ____

4. During the inspection of a newspaper office building you find a gallon container containing thinner for rubber cement (flashpoint 30 °F, boiling point 231 °F) stored in a general supply closet. Is this quantity of material acceptable in a general storage area?

   a. Maximum quantity that can be stored: ______________________

   ____

   ____

   ____

   b. Code section: ______________________

   ____

   ____

   ____

5. What is the maximum quantity of a Class 2 oxidizer material (solid) that can be displayed in an open array in a general merchandise sales area? The building is protected by automatic sprinklers.

   a. Quantity: ______________________

   ____

   ____

   ____

   b. Code section: ______________________

   ____

   ____

   ____

6. During the inspection of a dentist's office you find two cylinders of medical oxygen being stored in a general storage area ("E" cylinder, approximate capacity 25 cubic feet; "H" cylinder, approximate capacity 220 cubic feet). Caps are in place and cylinders are secured in the upright position by chains. Is this storage acceptable?

   a. Acceptable/Unacceptable: ____________________

   ____

   ____

   ____

   b. Code section: ____________________

   ____

   ____

   ____

7. How much of a highly toxic compressed gas can be kept before a permit is required?

   a. Quantity: ____________________

   ____

   ____

   ____

   b. Code section: ____________________

   ____

   ____

   ____

8. How much of a Class 2 solid oxidizer material can be kept before a permit is required?

   a. Quantity: ______________________________

   ____

   ____

   ____

   b. Code section: ______________________________

   ____

   ____

   ____

9. Can a Class I liquid be used for spot cleaning in a dry cleaning facility?

   a. Permitted use: ______________________________

   ____

   ____

   ____

   b. Code section: ______________________________

   ____

   ____

   ____

10. In a high school chemistry lab, what is the maximum quantity of flammable or combustible liquids that can be kept outside of safety cans?

    a. Quantity: ______________________________

    ____

    ____

    ____

    b. Code section: ______________________________

    ____

    ____

    ____

11. Is there any limit to the quantity of alcoholic beverages that can be kept in a retail sales area?

    a. Quantity: ______________________________

    ____

    ____

    ____

    b. Code section: ______________________________

    ____

    ____

    ____

12. During the inspection of a restaurant with a seating area for 300 persons you find 15 gallons of lamp oil (flashpoint 175 °F) in the original 1-gallon containers being stored in a closet. Is this acceptable?

    a. Acceptable/Unacceptable: ____________________

    ____

    ____

    ____

    b. Code section: ____________________

    ____

    ____

    ____

13. What is the maximum quantity of a flammable liquid that can be kept in any one listed storage cabinet?

    a. Quantity: ____________________

    ____

    ____

    ____

    b. Code section: ____________________

    ____

    ____

    ____

14. What is the maximum quantity of black powder that can be displayed in an indoor retail sales area?

    a. Quantity: ______________________________

    ____

    ____

    ____

    b. Code section: ______________________________

    ____

    ____

    ____

Activity 5.5

Code Requirements for Hazardous Materials

Scenario 1

Purpose:

Use local codes to determine requirements, given three scenarios.

Directions:

You have just completed an inspection of a wood frame building that is forty feet wide and eighty feet long. When the building was last inspected your records showed that it was used for the storage of auto parts. You now discover that the building is being used for the storage of 6,000 cubic feet of oxygen in cylinders, 6,000 cubic feet of chlorine in cylinders, and 4,000 cubic feet of acetylene in cylinders. The three types of gases are mixed together and not separated. There is no heat in the building and no automatic fire protection system. The building has one overhead door and one exit door located at one end of the building.

Using your local codes, what are the requirements that would address this situation?

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Activity 5.5 (cont'd)

Code Requirements for Hazardous Materials

Scenario 2

Directions:

You are inspecting a plastic manufacturing company. You find five 55-gallon drums of styrene stored inside a 1,000 square foot room of ordinary construction that has no fire resistive separation from the rest of the building and no automatic fire protection systems.

You also find that the same room is being used for the storage of two gasoline operated lift trucks. The styrene is being dispensed from the drums by use of a hand-crank pump. You note that styrene has been spilled on the floor from past dispensing operations. The date of your inspection is August 27, and the daily temperature has been over 90 °F for the last forty days.

Using your local codes, what are the requirements that would address this situation?

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Activity 5.5 (cont'd)

Code Requirements for Hazardous Materials

Scenario 3

Directions:

An out-of-state blasting firm has come to your community and wants to set up a local branch. Research and advise, in writing, your local requirements for blasting operations.

Using your local codes, what are the requirements that would address this situation:

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MODULE 6: SPECIAL HAZARDS

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Activity 6.1

Code Search: Electrical

Purpose:

This activity is designed to have you research your codes and become familiar with the electrical and/or fire code dealing with electrical problems encountered when inspecting.

Directions:

Using your electrical and/or fire codes, research the following questions with regard to electrical problems you may encounter.

There are three sets of questions. Use the one that is appropriate for your area.

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Activity 6.1 (cont'd)

Code Search: Electrical

NEC 70 Electrical Code Search

1. Is the interior of an exhaust duct in a dipping operation considered to be a Class I or Class II, Division 2, location?

2. Does an overcurrent device need to be enclosed in a cabinet or cut-out box?

3. Does NFPA 70 (National Electrical Code, 1987) cover electrical installations in aircraft?

4. How shall a lighting fixture exposed to physical damage in an agricultural building be protected?

5. What is the definition of an electrolytic cell?

6. Can a lighting fixture be installed in a duct or hood?

7. Must a conductor used for general wiring be marked for the maximum rated voltage?

8. May an industrial heating appliance have an overcurrent protection more than 50 amperes?

9. How shall temporary wiring be installed in an exhibition hall display booth?

10. Must a storable swimming pool be equipped with a ground-fault circuit-interrupter?

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Activity 6.1 (cont'd)

Code Search: Electrical

SFC/BOCA Electrical Code Search

1. Can the electrical connections and wiring be located within the spray enclosure for an automotive refinishing booth?

2. Where does the SFC/BOCA Fire Code refer to NFPA 70 (National Electrical Code, 1987), Division 2 locations?

3. Must electrical equipment and wiring conform to the requirements of NFPA 70 (National Electrical Code, 1987) in a decorative finish or industrial coating operation?

4. Is the floor area 21 feet outside a vapor area in a flammable dip-tank operation considered to be an NEC Class I, Division 2, hazardous location?

5. In a ripening process using ethylene gas to assist the process, how shall electrical wiring and equipment be installed?

6. May a 50-foot cut and frayed extension cord be used as wiring?

7. May artificial lighting be used in a pulverizing sugar operation?

8. What NFPA 70 (National Electrical Code, 1987) classification does magnesium fall into?

9. Must circulation fans be shut off during an insecticidal fogging operation?

10. Must explosion-proof wiring and equipment be used in a dip-tank operation?

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Activity 6.1 (cont'd)

Code Search: Electrical

UFC Fire Code Electrical Search

1. In a dip-tank operation (Class B Flammable), does the code allow the use of electrical equipment and wiring in the vicinity of the related drying operation?

2. Where does the UFC allow you to use and comply with the NFPA 70 (National Electrical Code, 1987)?

3. When using an extension cord for a portable appliance, can the current capacity of the extension cord be less than the rated capacity of the appliance?

4. Must electrical equipment be enclosed in a vapor-tight housing when used in an aircraft hanger?

5. How must all electrical installations be installed at a construction site?

6. What is the minimum clearance required for access to an electrical control panel?

7. When dispensing a Class I liquid outside of a building, must you provide for adequate bonding and grounding?

8. Must a container of ethylene be bonded or grounded?

9. May temporary wiring be attached to a structure?

10. How must artificial lighting be installed when used in an area that uses dust-agitating machinery?

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Activity 6.2

Code Search: Mechanical

Purpose:

This activity is designed to have you research your codes and become familiar with the code dealing with mechanical problems encountered during inspection.

Directions:

Each group will report on its findings to the class.

1. A masonry wall of a thickness of ______ is required for a low-heat appliance chimney.

   ANS ____

   Code Section ____

2. What are the requirements for installing a factory-built chimney?

   ANS ____

   Code Section ____

3. How can you determine what type of vent is being used? (ex. Type A, Type B).

   ANS ____

   Code Section ____

4. On a fuel-oil appliance, what type of vent is required?

   ANS ____

   Code Section ____

5. When or where can a BW type vent be used?

   ANS ____

   Code Section ____

6. What is the fire rating of a room in a place of assembly with a fuel-oil water heater having 150,000 btu/hr capacity?

ANS ____

Code Section ____

7. What is the largest tank for fuel-oil storage indoors with a fire separation?

ANS ____

Code Section ____

8. What are the requirements for a vent line from a storage tank?

ANS ____

Code Section ____

9. For return air in a commercial duct system, can a wood stud be used?

ANS ____

Code Section ____

10. What are the standards referenced by your code for the storage of flammable liquids and the installation of fuel-burning appliances?

ANS ____

Code Section ____

Activity 6.3

Code Search: Cooking Equipment/Hood System

Purpose:

This activity is designed so that you will have an understanding of where to find code requirements in your respective codes.

Directions:

Work in your code group to find the answers (BOCA, SBC, UBC, NFPA).

Scenario:

You have just made an inspection of a restaurant in a three-story brick building with wood floors and tar and gravel roof over wood.

The owner has had a local metal shop build the hood and duct system and install exhaust equipment, fans, and lights in the hood system. The owner bought a pre-engineered fire suppression system for the hood and duct system, and modified it to make it work in his hood system.

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Activity 6.3 (cont'd)

Code Search: Cooking Equipment/Hood System

Directions:

Answer the following questions using your codes, and compile the information into a formal letter for compliance.

What are the requirements for:

1. Height above roof?
2. Rating of shaft?
3. Clearance of the duct in the shaft enclosure from combustibles?
4. Thickness of duct material?
5. Thickness of hood material?
6. Length of hood over cooking equipment?
7. Type of fan?
8. Design of duct for air movement?
9. Type of light fixtures?
10. Type of joints and seams?
11. Type of filters?
12. Cleanout doors--size, how many?
13. What are the requirements for the fire suppression system?

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MODULE 7: FIRE PROTECTION SYSTEMS AND EQUIPMENT

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Activity 7.1

Fire Control and Extinguishing Agents

Purpose:

To demonstrate your ability to communicate concepts related to fire protection systems and equipment effectively.

Directions:

Your table group will be given this assignment by Friday (Day 5) of the first week in the course. Your group is to make a presentation to the class covering the subject matter noted in this activity. Your presentation should be 15 to 20 minutes in length, with the remaining time for class questions and discussion if needed. Research information and visual media are available in your Student Manual (SM), the classroom, or Learning Resource Center (LRC). It is highly suggested that visual media be used during your presentation. Any other requests for materials that your group may need shall be directed to your instructor. It is suggested that each member of the group take part in the class presentation.

Your group's assignment is to make a presentation on at least four different types of chemicals or agents used in fire suppression systems and portable equipment. Your presentation shall at a minimum include the following:

- Primary method of fire control or suppression for each chemical or agent related to the fire triangle or fire tetrahedron.
- Characteristics or composition of each specific fire extinguishing agent or chemical.
- The application/use of each chemical or agent in fixed or portable equipment.
- Strengths and limitations of each agent or chemical type on different fire classes.

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Activity 7.2

Sprinkler Systems

Purpose:

To demonstrate your ability to communicate concepts related to the types of sprinkler systems effectively.

Directions:

Your table group will be given this assignment by Friday (Day 5) of the first week in the course. Your group is to make a presentation to the class covering the subject matter noted in this activity. Your presentation should be 15 to 20 minutes in length, with the remaining time for class questions and discussion if needed. Research information and visual media are available in your SM, the classroom, or LRC. It is highly suggested that visual media be used during your presentation. Any other requests for materials that your group may need shall be directed to your instructor. It is suggested that each member of the group take part in the class presentation.

Your group assignment is to make a presentation on the six types of sprinkler systems. Your presentation shall also include as a minimum:

1. Major system components.

2. Examples of when and where each system might be used.

The six types of systems to cover are

- Wet pipe.
- Dry pipe.
- Preaction.
- Deluge.
- Combined dry pipe and preaction.
- Antifreeze.

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Activity 7.3

Water Supply Analysis

Purpose:

To demonstrate your ability to review water supply data and recognize deficiencies.

Directions:

Review water supply data for various sprinkler systems and determine if the water supply is adequate.

Scenario 1

You are surveying a former office building that has been converted to a used clothing and housewares store. You notice that the sprinkler system was hydraulically calculated. The hydraulic nameplate on the sprinkler riser indicates that the system has been designed for .10 gpm over 1,500 square feet and the required flow is 270 gpm at 30 psi.

You review the last 3 years' test reports, and observe that the main drain test pressures have been 28 psi, 28 psi, and 30 psi, respectively. Is there anything about this information that is a concern to you? If so, what?

Scenario 2

A one-story office building that is 14 feet tall has a pipe schedule system. You have reviewed the 2-inch drain test results for the past 6 years. The test results are as follows:

	Static Pressure (psi)	**Residual Pressure (psi)**
2001	70	55
2002	68	54
2003	65	53
2004	63	50
2005	60	40
2006	68	44

Does this information cause you any concerns? If so, what are they?

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Activity 7.4

Sprinkler Impairments

Purpose:

To identify sprinkler impairments.

Directions:

Your instructor will review several slides indicating various impairments to sprinkler systems' effectiveness in operation. As you review each slide, write down what appears to be wrong. Each group, as time allows, will present its findings.

Slide	**Conditions**
Slide 7-83	
Slide 7-84	
Slide 7-85	
Slide 7-86	
Slide 7-87	
Slide 7-88	
Slide 7-89	

Slide 7-90

Slide 7-91

Slide 7-92

Slide 7-93

Slide 7-94

Slide 7-95

Slide 7-96

Slide 7-97

Slide 7-98

Slide 7-99

Slide 7-100

Activity 7.5

Sprinkler System Tests

Purpose:

Describe sprinkler system tests and state the purpose of each test for wet- and dry-pipe systems.

Directions:

Your table group will be given this assignment by Friday (Day 5) of the first week in the course. Your group is to make a presentation to the class covering the subject matter noted in this activity. Your presentation should be 15 to 20 minutes in length, with the remaining time for class questions and discussion if needed. Research information and visual media are available in your SM, the classroom, or LRC. It is highly suggested that visual media be used during your presentation. Any other requests for materials that your group may need shall be directed to your instructor. It is suggested that each member of the group take part in the class presentation.

Your group's assignment is to make a presentation identifying the following sprinkler component tests required for existing wet- and dry-pipe systems: a **description** of the tests, the **frequency of the tests**, and the **purpose** of **each test**. Your presentation should include as a minimum:

1. Inspector's test and alarm devices.

2. Main drain test.

3. Air and water pressure gauges.

4. Valve trip test for dry pipe.

5. Antifreeze solution.

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Activity 7.6

Fire Alarm/Detection System Impairments

Purpose:

To identify fire alarm/detection system impairments.

Directions:

Your instructor will show several slides indicating various impairments to fire alarm/detection systems. As you review each slide, write down what appears to be wrong. Each group, as time allows, will present its findings.

Slide	**Conditions**
Slide 7-139	
Slide 7-140	
Slide 7-141	
Slide 7-142	
Slide 7-143	
Slide 7-144	
Slide 7-145	

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Activity 7.7

Fire Alarm Inspection Procedures

Purpose:

To demonstrate your ability to communicate procedures for inspecting existing fire alarm systems effectively.

Directions:

Your table group will be given this assignment by Friday (Day 5) of the first week in the course. Your group is to make a presentation to the class covering the subject matter noted in this activity. Your presentation should be 15 to 20 minutes in length, with the remaining time for class questions and discussion if needed. Research information and visual media are available in your SM, the classroom, or LRC. It is strongly suggested that visual media be used during your presentation. Any other requests for materials that your group may need shall be directed to your instructor. It is suggested that each member of the group take part in the class presentation.

Your group's assignment is to present material on fire alarm system inspections by fire service personnel. You should develop a procedure for inspecting a fire alarm system to determine if it is in operational condition, has any impairments, and describes what periodic tests are required.

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Activity 7.8

Wet Chemical System Inspections

Purpose:

To develop an inspection protocol for one type of fire protection system.

Directions:

Your table group will be given this assignment by Friday (Day 5) of the first week in the course. Your group is to make a presentation to the class covering the subject matter noted in this activity. Your presentation should be 15 to 20 minutes in length, with the remaining time for class questions and discussion if needed. Research information and visual media are available in your SM, the classroom, or LRC. It is strongly suggested that visual media be used during your presentation. Any other requests for materials that your group may need should be directed to your instructor. It is suggested that each member of the group take part in the class presentation.

Your group assignment is to make a presentation on the inspection of an existing wet chemical extinguishing system that is protecting a typical kitchen cooking area and grease removal system.

Areas to be covered are

- A description of the critical components of the wet chemical system.
- Items that are to be inspected every 6 months.
- Items that are to be inspected annually and tested by operation.

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Appendix

APPENDIX
EVALUATION PLAN AND ASSESSMENT

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ATTACHMENT 1

Letter Grade	Point Range	Student Performance Criteria
A	90-100	• Demonstrates ability to interpret, integrate, and apply learning outcomes beyond the context of the course through application of critical and creative thinking skills. • Completes work assignments that consistently exceed requirements and that interprets and applies objectives in new, unique, or creative ways.
B	80-89	• Completes work assignments that consistently meet most requirements. • Contributes regularly to class participation activities.
C	70-79	• Demonstrates a satisfactory level of competence in learning outcomes for the course. • Completes work assignments that satisfy minimum requirements for the course. • Satisfies minimum requirements for class participation activities.
D	60-69	• Completes work assignments that usually meet minimum requirements. • Contributes inconsistently or infrequently to class participation activities.
F	59 and below	• Cannot demonstrate competence in many fundamental outcomes for the course. • Submits work assignments that frequently do not meet minimum requirements, or do not complete the assigned work. • Does not satisfy minimum requirements for attendance or contribution to class activities.
I	—	• Satisfactorily completed most of the required work for the course, but due to medical reasons or other extenuating circumstances, is unable to complete the work by the end of the next semester. • Fails to request a deadline extension from the Training Specialist.

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ATTACHMENT 2

GRADING METHODOLOGY

Individual Project

The individual projects required midterm of the course are scored as follows:

1. The format and content of the project includes all of the elements listed in the objectives for the assignment in accordance with the learning outcomes.

2. Instructors will document the evaluation of students' presentations on the Individual Project Grading Sheet. Any corrective and/or diagnostic comments about the students' project should also be written on the form.

3. Instructors will record the appropriate grade for each student on Master Grade Sheet.

4. Instructors will share grade sheets, including any comments/recommendations with the student after completion of the presentation and grading.

5. Individual Project will constitute 20 percent of final grade for each student.

Midterm Exam

Each student will be given a midterm exam consisting of 35 multiple-choice questions. The exam will constitute 30 percent of the final grade.

Final Exam

Each student will be given a final exam consisting of 40 multiple-choice questions. The exam will constitute 30 percent of the final grade.

Final Course Grade

- attendance = 10 percent;
- student activities = 10 percent;
- individual project = 20 percent;
- midterm exam = 30 percent; and
- final exam = 30 percent.

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ATTACHMENT 3

INDIVIDUAL PROJECT RUBRIC

	4 points	3 points	2 points	1 point	Score
Information	Gathers an extensive amount of relevant, accurate information	Gathers sufficient relevant, accurate information	Gathers limited relevant, accurate information	Fails to gather relevant, accurate information	
Curricular Content	Shows thorough understanding of curricular content	Shows adequate understanding of curricular content	Shows partial understanding of curricular content	Shows little to no understanding of curricular content	
Creativity	Exhibits outstanding insight and creativity	Exhibits reasonable insight and creativity	Exhibits limited insight and creativity	Does not exhibit insight or creativity	
Ideas	Communicates ideas clearly and effectively	Communicates most ideas clearly and effectively	Communicates few ideas clearly and effectively	Has difficulty communicating ideas clearly and effectively	
Criteria Card	Meets all requirements on project criteria card	Meets most requirements on project criteria cards	Meets some requirements on project criteria card	Meets few to no requirements on project criteria card	
Points Earned					

Total Points: ______________________________ **Overall Project Score:** _________________________

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