Fire Protection Systems for Emergency Operations

FPSEO-Student Manual

3rd Edition, 7th Printing-January 2014



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FEMA

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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.

The goal of this course, *Fire Protection Systems for Emergency Operations* (FPSEO), is to provide Incident Commanders (IC's) with an understanding of the fire protection systems that are installed in buildings, how these systems work, and how their proper use will assist IC's in dealing with building fires effectively. Another goal is to provide fire officers with an understanding of how this information is acquired through effective preincident planning and how to relay this knowledge to other firefighters who must respond and function effectively, using these systems under emergency conditions.

The course culminates with a group presentation of a preincident plan for a hypothetical target hazard. The simulated training presentation will afford fire officers the opportunity to take this information, organize it into a training module, and then present the plan as if they were conducting a multicompany or in-station training class.

This course will cover the fundamental procedures for gathering and using information related to fire protection systems that an IC may need during a fire or related emergency. The course includes the basic concepts of preincident planning, and how an officer might share this information with other responders. This course provides a comprehensive review of the preplanning process found in the NFPA 1620, *Recommended Practice for Pre-Incident Planning.*

The course describes the components of sprinkler systems, stationary fire pumps, standpipe systems, fire alarm systems, smoke management systems, and specialty fire protection systems (e.g., Halon™ suppression systems, hood-range systems, water mist systems).

The course will help fire officers to develop Incident Objectives, Strategies, and Tactics* (OST's) related to these systems. This information will assist the IC in developing some initial OST's during infrastructure protection intelligence gathering. This preplanned information will lead to more effective fireground command, and better overall outcomes with firefighting operations.*

* As taught in other National Fire Academy (NFA) courses in the Incident Management Curriculum.

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"Fire Department Operations at Sprinklered Properties"
"How Reliable are Private Fire Hydrants?"

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COURSE SCHEDULE

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Unit 1:	Purpose of Fire Protection Systems
Unit 2:	Decisionmaking
Unit 3:	Preincident Planning Benefits
Unit 4:	Passive Fire Protection Features
Unit 5:	Fire Alarm Systems
Unit 6:	Water-Based Fire Protection Systems
Unit 7:	Smoke Management Systems
Unit 8:	Specialty Systems
Unit 9:	Integrated Systems and Performance
Unit 10:	Final Project

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SCHEDULE

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
AM	Unit 0: Introduction Unit 1: Purpose of Fire Protection Systems	Unit 3: Preincident Planning Benefits	Unit 5: Fire Alarm Systems Target hazards for final project due from all groups.	Unit 6: Water-Based Fire Protection Systems	Unit 7: Smoke Management Systems	Final Exam Unit 10: Final Project (cont'd) Graduation
PM	Unit 2: Decision-making Read: Units 3 and 4 in the Student Manual Target hazards for final project due from all groups at the start of Day Three.	Unit 4: Passive Fire Protection Features Read: Unit 5 in the Student Manual	Unit 5: Fire Alarm Systems (cont'd) Read: Unit 6 in the Student Manual	Unit 6: Water-Based Fire Protection Systems (cont'd) Read: Units 7 to 9 in the Student Manual	Unit 8: Specialty Systems Unit 9: Integrated Systems and Performance Unit 10: Final Project Final Exam review	
Reading	Units 1 through 4 in the Student Manual	Unit 5 in the Student Manual	Unit 6 in the Student Manual	Units 7 through 9 in the Student Manual		

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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

Say What You Mean ...



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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UNIT 0: INTRODUCTION

TERMINAL OBJECTIVE

Given an overview of the course agenda and requirements, the students will be able to describe the course goals and the rationale for the training.

ENABLING OBJECTIVES

The students will:

1. *List and share their biographical information, including their experience with fire protection systems and preincident planning.*

2. *List and share their expectations for the course.*

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COURSE OVERVIEW

The goal of this course, *Fire Protection Systems for Emergency Operations* (FPSEO), is to provide ***Incident Commanders*** (IC's) with an understanding of the ***fire protection systems**** that are installed in ***buildings*** and ***structures***, how these systems work, and how their proper use will assist the in dealing effectively with building fires. Another goal is to provide IC's with an understanding of how this information is acquired--through formal and informal ***preincident planning***, and how to relay this knowledge to other firefighters who must respond and function effectively using these systems under emergency conditions.

Who is the Incident Commander?

It is important to remember that in the National Incident Management system (NIMS), anyone may be thrust into the role of an Incident Commander. The first qualified person from an organized agency who arrives on the scene of an emergency is the IC until he/she transfers command or is relieved. This may be you, an acting officer, the apparatus driver, a senior officer, or even a firefighter responding to the scene in his/her own personal vehicle.

The Incident Commander's decisions in the first few moments may spell the difference between a successful incident outcome and a disaster. Having useful, current, and reliable information increases the chances of success.

The course will culminate with group presentations of a preincident plan for a ***target hazard***. One of the course goals is to create an awareness in fire officers of the importance of not only acquiring this information in the preplan process, but of the critical value of sharing the information with the response units that may have to deal with a fire or other emergency in a particular building. The simulated training presentation will afford fire officers the opportunity to take this information, organize it into a training module, and then present the plan as if they were conducting a multi-company or in-station training class.

* Words that are in ***bold italic*** are defined in the Glossary at the back of this manual. Only the first use of the word is in ***bold italic***.

Course Schedule

This 6-day course will cover the fundamental procedures for gathering and using information related to fire protection systems that an Incident Commander may need during a fire or related emergency. The course will discuss the basic concepts of preincident planning and how an officer might share this information with other responders. The course also provides a comprehensive review of the preplanning process like that found in NFPA 1620, *Recommended Practice for Pre-Incident Planning.*

The course will introduce fire officers to the components of ***fire sprinkler systems; stationary fire pumps; standpipe systems; fire alarm systems; smoke management systems;*** and ***specialty fire protection systems,*** e.g., ***Halon™ clean agent suppression systems, hood-range systems, water-mist systems***, etc.

The course also will help fire officers to develop incident objectives, strategies, and tactics (OST's) related to these systems. This information will assist the Incident Commander in developing some initial OST's during preincident planning. This preplanned information will lead to more effective fireground command and better overall outcomes with firefighting operations.

Course Requirements

Your success in this course is related directly to your participation and contributions. You are asked to participate in all individual and group activities, and share your ideas and experiences (good and bad).

There will be a final written exam on the last day of class. It will be based on materials presented in class as well as materials found in the Student Manual (SM).

All Incident Commander's need to become familiar with and maintain their knowledge of the systems found in the critical or target hazard structures located in their response areas. The recommended method for gaining this knowledge is through the preincident planning process. Your final group project is to present a simulated multicompany or in-station training session on the preincident plan your team develops.

Course Topics/Units

The course units will cover these topics/units:

- Unit 1: Purpose of Fire Protection Systems;
- Unit 2: Decisionmaking;
- Unit 3: Preincident Planning Benefits;
- Unit 4: ***Passive Fire Protection Features***;
- Unit 5: Fire Alarm Systems;

- Unit 6: Water-Based Fire Protection Systems:
  - sprinkler systems,
  - stationary fire pumps,
  - standpipe systems, and
  - foam systems;
- Unit 7: Smoke Management Systems;
- Unit 8: Specialty Systems;
- Unit 9: Integrated Systems and Performance; and
- Unit 10: Final Project.

This course is not designed to teach fire officers everything they might need to know about these systems. Rather, the objective of this course is to make fire officers more familiar with the types of systems found in target hazards and to provide information on how to enhance their understanding of the various systems by working with building owners, maintenance and safety personnel, and contractors who own or service these systems. Through this process, fire officers will gain greater knowledge of how these systems are integrated into their buildings and how they contribute to effective firefighting operations and lead to better outcomes under adverse fire or other emergency conditions.

Glossary

Each unit of this manual includes a Bibliography, and at the back of the manual is a Glossary of common fire protection systems terms.

Special Needs

If you have special needs or require some additional assistance in learning the material, please contact your instructors right away. Their job is to help you achieve an enjoyable and successful learning experience.

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Activity 0.1

Student Introductions

Purpose

To introduce you to each other and to the instructors.

Directions

1. Take a minute to complete these items.

   a. Name. _____

   b. Title/Rank. _____

   c. Department/Community character (urban, rural, industrial, residential, etc.). _____

   _____

   _____

   _____

   d. Your responsibilities or assignments. _____

   _____

   _____

   _____

   e. Your experience with fire protection systems. _____

   _____

   _____

   _____

   f. Your experience with preincident planning. _____

   _____

   _____

   _____

g. Your expectations for this course. _____

_____

_____

_____

h. Briefly describe the preincident plan you brought to share in class. _____

_____

_____

_____

i. Your experience creating PowerPoint™ presentations. _____

_____

_____

_____

2. You will be asked to share your responses with the class.

3. This sheet will be collected by the instructors at the end of the Activity.

UNIT 1: PURPOSE OF FIRE PROTECTION SYSTEMS

TERMINAL OBJECTIVE

The students will be able to recognize the value to the Incident Commander (IC) of prior knowledge of the fire protection systems in a building.

ENABLING OBJECTIVES

The students will:

1. *Identify components of common fire protection systems.*

2. *Identify 10 reasons for the use of fire protection systems.*

3. *List "indirect costs" that may result from a lawsuit against the fire department.*

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FIRE PROTECTION SYSTEMS

Fire service professionals need to embrace the importance of being as prepared as possible to deal with fires and other emergencies that may occur in buildings and facilities they are responsible for protecting. This can be accomplished through a well-developed preincident planning process that helps develop and maintain current knowledge of the systems that are installed in buildings to help firefighters better deal with these emergencies.

Fire protection systems may be useful in other emergencies, too. For example, a smoke management system may be an effective tool to remove toxic fumes released during a terrorist attack. A ***total flooding*** carbon dioxide system might be used to render inert an environment containing a mixture of ***pyrophoric*** chemicals before they burst into flame. A ***water spray system*** may make an effective emergency decontamination device.

PURPOSE OF FIRE PROTECTION SYSTEMS

What is the purpose of built-in fire protection systems? While the obvious answer may seem to be, "they are provided to detect or control a fire to protect life and property," there is much more that should be considered. Fire protection systems are only one means to achieve the strategic goal of protecting lives and property.

As you will learn in this course, large numbers of fire protection systems are employed today. They range from simple ***residential sprinklers*** to highly sophisticated integrated detection, suppression, and smoke control systems. This course will focus on those most important to the Incident Commander (IC) to achieve strategic and tactical success at an event.

Fire protection systems provide substantial value in the community's overall fire protection scheme that includes fire prevention, code enforcement, fire suppression operations, and public fire safety education.

The following sections are just some of the purposes related to fire protection systems:

Life Safety

Fire protection systems enhance the chance that a person will survive a fire in a building. The advent of the home smoke alarm, although not truly a "system," has reduced the number of residential fire deaths and injuries dramatically in just one generation.

Fire protection systems help safeguard those who can't protect themselves: persons who are institutionalized or can't escape a fire on their own. Consider the fire protection requirements for hospitals, nursing homes, prisons, reformatories, nurseries, and similar occupancy uses. They are designed and installed to "defend in place" because the infirm, the very old, the very young, and those who are incarcerated may not be capable of self-preservation. Unlike us, they cannot just get up and leave the building when it's on fire.

Risk Mitigation

All communities have target hazards in their built environments. Whether it's a large manufacturing facility, a hazardous materials rail transfer yard, a ***highrise*** apartment, or even a remotely located neighborhood of single-family dwellings, these target hazards provide a challenge to the local fire forces. Fire protection systems can provide a level of immediate protection that even the best staffed and equipped fire department cannot.

Firefighter Safety

When designed, installed, and maintained properly, fire protection systems enhance firefighter safety. Whether it's early notification during the incipient stages of a fire, or fire control through automatic suppression equipment, fire protection systems add another safety margin for those who put their lives at risk entering buildings that are on fire.

Design Latitude

Architects, builders, and owners are always looking for ways to achieve cost-effective construction and design latitude. Fire protection systems can do that.

For example, in the ***model building codes***, a building's allowable size (based on use and type of construction) can be tripled if an automatic sprinkler system is installed. Likewise, in some occupancies, corridor walls, ceilings, and doors don't have to meet ***fire-resistive ratings*** if the building is sprinklered. An otherwise noncombustible building can be reclassified by the building official as "1-hour fire resistive" by the installation of a sprinkler system.

All of these options can reduce costs and increase design latitude for the owner.

Conflagration Control

Historically, building codes were adopted to prevent conflagrations in cities where closely spaced buildings created a threat from exposure fires and burning embers. Fire protection systems help confine fires to the room or building of origin, thus minimizing the likelihood of a major fire spreading from building to building.

Firefighter Efficiency

Many fire protection systems are installed to improve firefighter efficiency and effectiveness. Standpipe systems, for example, transport water to the upper stories of buildings so firefighters don't have to stretch long hose lays. Fire department connections to sprinklers and standpipes provide a convenient method for the firefighter to supplement water pressure and volume.

Stationary fire pumps can be used strategically as an additional water supply, almost like adding another pumper to the fire scene.

Community Economic Health

Those communities that have suffered a major fire in their primary industrial or retail core, with the correlating loss of jobs, business, and tax revenues, know the value of fire protection systems. Keeping businesses viable and operational 24 hours a day is an essential part of the community's overall economic health and vitality.

For example, in the 1980's, two major hotel fires in Las Vegas, Nevada, caused a significant drop in tourist and casino revenues. The Nevada State legislature adopted a comprehensive, mandatory sprinkler retrofit law as a result of the fires, hoping to attract tourism back to the area. Now, no casinos or hotels are built without substantial fire protection features.

Cost Sharing

Many communities are faced with increased costs for municipal services. Law enforcement, garbage collection, water and sewer fees, and fire suppression costs continue to rise as equipment, fuel, and other consumables, and labor costs rise as well.

Built-in fire protection systems can be a cost-effective hedge against increased municipal costs. Many of the cities that have adopted mandatory sprinkler ordinances realize that as new construction arrives, it brings additional risks. Building owners and occupants should be responsible for sharing the costs of protecting that risk.

Durable Built Infrastructure

How many buildings constructed during the late 1800's and early 1900's survive today? In older communities, what is the leading threat to these structures? Fire.

As communities recognize the value of these older structures, and the importance of protecting new ones, built-in fire protection systems give them yet another tool to protect these buildings. Drive through any older city's downtown core, and you can see parking lots where buildings once stood. Look closely at the adjacent buildings, and often you can see smoke stains and fire damage on the exterior: lasting marks of the fire that destroyed the building where the parking lot now stands.

Communities recognize that rehabilitated structures, new buildings, and those under construction have more value than paved parking lots.

Historic and Cultural Resources

Not many people remember that in the late 1940's a basement fire in the White House in Washington, DC, forced President Harry S Truman and his family out of the building while significant repairs were made. One item was added during the repairs: an automatic sprinkler system.

America is blessed with significant historic, cultural, and social resources that define our Nation. Losing these to a fire can have long-lasting cultural implications.

Even structures that may not be historically significant but are destroyed by fire can affect a community's well-being. Look at the impact on a rural area if the region's only high school burns to the ground. Talk to churchgoers who have lost their houses of worship, and ask them how the incident affected them.

Crime Control

While the benefit of fire protection systems to deter or control arson fires is obvious, there is another, less apparent benefit. Buildings that have been damaged severely by fires often become havens for criminals: drug dealers, prostitutes, gang members, and others congregate in abandoned buildings out of the community's view. While the crimes that may occur here are considered social problems, they are related indirectly to the result of the fire: a crumbling built environment that could have been better protected from fire.

Less obvious, but certainly of contemporary concern, is the usefulness of built-in fire protection as a terrorism deterrent or mitigating factor. Given a choice between attacking an occupied structure without any fire protection, and one that is thoroughly protected with detection, suppression, and control features, a terrorist is likely to select the former because he or she will see more significant damage to achieve his/her political aims.

Environmental Hazard Control

Every day, more and more hazardous materials are developed, manufactured, and introduced into our environment. Unfortunately, during fires, some of these environmental threats escape, causing air, water, and ground pollution.

Adequate fire protection, in conjunction with appropriate hazardous materials mitigation measures, can minimize the likelihood of unwanted environmental contamination.

Acceptable Level of Risk

Municipal governments must assess ***risk*** on a daily basis. As risks increase, more and more resources are diverted in response.

Local governments can minimize risk and mitigate its consequences by requiring built-in fire protection. By mandating early detection and automatic suppression, municipal leaders are saying they are not willing to accept the risk of major fires with the correlated risk to people, property, jobs, tax base, the environment, and the infrastructure.

Development Disincentives

Unfortunately, some jurisdictions mandate fire protection equipment as a disincentive to development. The argument is that if the city or county forces additional costs onto a developer or builder, the project proponent will get discouraged and take the proposed development elsewhere.

Eliminate Human Error

There is an old saying in the fire protection field that the three leading causes of fires are men, women, and children. While intended to be humorous, the statement illustrates the fact that as humans interact with their environment, the fire risks increase. This is true in the home, at work, or outdoors.

A properly designed and well-maintained fire protection system may eliminate--or mitigate--the impact of that human error.

DIRECT AND INDIRECT LOSSES

Historically, the fire service has tracked life and property losses attributed directly to fires. Lives lost, injuries sustained, and property that has been damaged or destroyed (structures and contents) are common factors reported in local or ***National Fire Incident Reporting System (NFIRS)*** data categories.

These data quantify America's fire problem, and provide impetus for change. Fire officials and others strive to reduce the number of fire deaths, injuries, and property damage totals that occur locally and across the country.

Indirect Losses

Although direct losses provide a yardstick for measuring the scope of the work ahead, **indirect** losses also measure fire's impact on a community. Indirect losses are those social and economic costs that may not appear on a tally sheet or NFIRS report.

The list of indirect losses may be long depending upon the nature and extent of a fire, but here are just a few:

Property Insurance Costs

Anyone who has suffered more than one motor vehicle accident in a short time period knows what happens to personal insurance rates: They rise. The same is true for fire insurance rates. However, not only will an individual's property insurance rates rise due to continued losses, a community's overall insurance rating will be affected too. Insurance companies may be reluctant to write policies in communities that suffer a number of fires--especially large commercial losses--and may increase premium costs to protect their risk.

Medical and Funeral Costs

Special medical care provided for fire victims can easily cost hundreds of thousands of dollars. Emergency room treatments and specialized on-going care in hyperbaric facilities or burn units is expensive. Patients treated at that level of care often take months or years to recover from the physical injuries they suffer.

Likewise, funeral costs for those who expire from fire-related injuries may cost tens of thousands of dollars. These are "costs" that don't appear in the direct fire loss statistics.

Public Safety Tax Costs

Although jurisdictions normally budget and may tax for their overall fire protection service costs (personnel, apparatus, tools and equipment, supplies, etc.), there are times when the predicted expenditures are exceeded. If a fire apparatus is destroyed by a falling wall or radiant heat, is its replacement price added to the fire loss statistics? Are overtime costs included for large fire responses? Do we include the cost of response from mutual- or automatic-aid companies? How about the amount of water that is used to suppress the fire, or even the wear and tear on public streets as we respond to the incident?

All of these items have a "cost" associated with them that seldom, if ever, is included in the direct fire loss statistics.

Lost Tax and Business Revenue

Many communities in America are "company towns" that rely on one or more large companies to sustain the local income. If a significant business is destroyed, the tax revenue that the community collected is gone too. The result may be severe cutbacks in community services, or increased taxes distributed across other sectors of the jurisdiction to make up for the lost revenue.

Business income, the lifeblood of any enterprise, disappears when the business operation is out of service. Many companies that suffer fires never recover and go bankrupt or simply close their doors forever.

Lost Business Opportunities and Jobs

Devastating fires in commercial occupancies, no matter how small the business, often have significant impacts on the business. Employees who report to work find they have nowhere to go, and may have to apply for unemployment benefits. Skilled laborers may be lost to other companies. Suppliers lose a customer in the form of the business that burned, and--if the damaged business supplied others--it, in turn, may permanently lose a client.

Psychosocial Impacts

There are some indirect losses that can't be calculated on a ledger sheet. When a community loses a school, church, historic building, or other cultural significant artifact, the social impact can be devastating. When a family or large number of people dies in a single fire, the emotional effect ripples through a community.

Environmental Damage

Smoke contributes to air pollution, and fire control runoff may contaminate ground water or nearby waterways. Despite our best efforts to control pollutants resulting from an unwanted fire, there always will be some environmental damage. The scope and cost of this damage may not be evident for years, and seldom is included in the fire loss data that is accumulated shortly after an incident.

Lawsuits Arising From Losses

More and more, property insurance companies and other "injured" parties want to recover the money they pay for insurance claims or related damages. Negotiated settlements and lawsuits occur every day to restore money lost from a fire.

Historically, fire departments were "off limits" from lawsuits: They were protected by either law or courtesy. In recent years, however, fire departments and municipalities are viewed as "deep pockets" in lawsuits. If an aggrieved person or company can recover damages from the jurisdiction, the settlement must be paid by the taxpayers. Lawsuits usually do not involve a building's potential for fire or building code violations; instead they are more likely to involve fire department operations at an incident.

POTENTIAL FIRE DEPARTMENT LIABILITIES

There are many potential legal issues related to the fire department and IC's knowledge and use of fire protection systems during an emergency.

The IC should know that people always will "second-guess" command decisions made under the duress of an emergency. Was the IC aware of the fire protection system? Did he or she use it effectively and in accordance with national standards and practices? Did the system operate as designed? Did the decision to ignore or use it affect the incident outcome? Was the loss less or greater due to the fire department's use of the fire protection features? Sometimes, this second-guessing evolves into litigation that involves the local fire services.

As illustrated in the following article, the Montreal, Canada, Fire Department was held partially liable for a substantial fire loss in a highrise building.

Appeals Court Upholds $58-million Award for High-rise Fire

A Quebec (Canada) appeals court upheld a multi-million dollar trial court verdict that a building owner and city firefighters must share the blame for a huge fire in a Montreal high-rise office tower.

The October 1986 fire at the Alexis Nihon Plaza was the most serious fire ever in Canada. Insurance companies who wanted to recover some of the claims they paid out launched the $32.2-million lawsuit.

The fire, which broke out on Sunday evening, raged for thirteen hours because firefighters were unable to get enough water up to the tenth floor of the building. They couldn't find the outside connection to the standpipe system, which was incorrectly labeled "sprinkler system." Unable to find the right pipe, firefighters put so much pressure on another connection that it broke, according to a lawyer involved in the case. The upper floors from 10 to 16 were burning, while stores in the retail concourse were being flooded.

The trial court ruled that Alexis Nihon Plaza should have remedied the problem and should have routinely checked the system. Accordingly, the building owner was held liable for 75 percent of the damages.

But because the City of Montreal's fire department had known for more than three years that the sprinkler connection was mislabeled, they were held liable for 25 percent of the damages.

The trial court fixed damages to the building and its occupants at $22.2 million. The appeals court found no fault with the ruling of the trial court judge and upheld the findings of the lower court. With legal bills and 16 years of pre- and post-judgment interest, damages now exceed $58 million.

As more and more structures are outfitted with fire protection systems--some of which may be very complex--the fire department must increase its knowledge of these systems to use them for effective incident outcomes.

TYPES OF FIRE PROTECTION SYSTEMS

Two types of fire protection systems are installed in buildings, based on the codes adopted by the local community. These sometimes are referred to as being either ***Active Systems*** or ***Passive Features***.

Active Systems

Active systems generally are considered to be those that a fire company will use during a fire emergency. A wide variety of systems and designs usually are matched to specific hazards. As you can see from the following list of terms, there is a lot to know about the number and types of systems, how they operate, and their capabilities and limitations. It takes many years of study and experience to be proficient with all aspects of active fire protection systems. They include

- fire sprinkler systems:
  - ***wet pipe***:
    - -- ***alarm check valve***, and
    - -- ***shotgun risers***;
  - ***dry pipe***:
    - -- ***accelerator***, and
    - -- ***exhauster***;
  - ***preaction***:
    - -- ***single interlock***, and
    - -- ***dual interlock***;
  - ***deluge***;
  - ***foam***: ***water***:
    - -- high, medium, and low expansion; and
    - -- antifreeze;
- standpipe systems:
  - ***automatic standpipe***,
  - ***semiautomatic standpipe***,
  - ***manual standpipe***,
  - ***Class I***,
  - ***Class II***,
  - ***Class III***,
  - ***single zone***, and
  - ***multiple zone***;

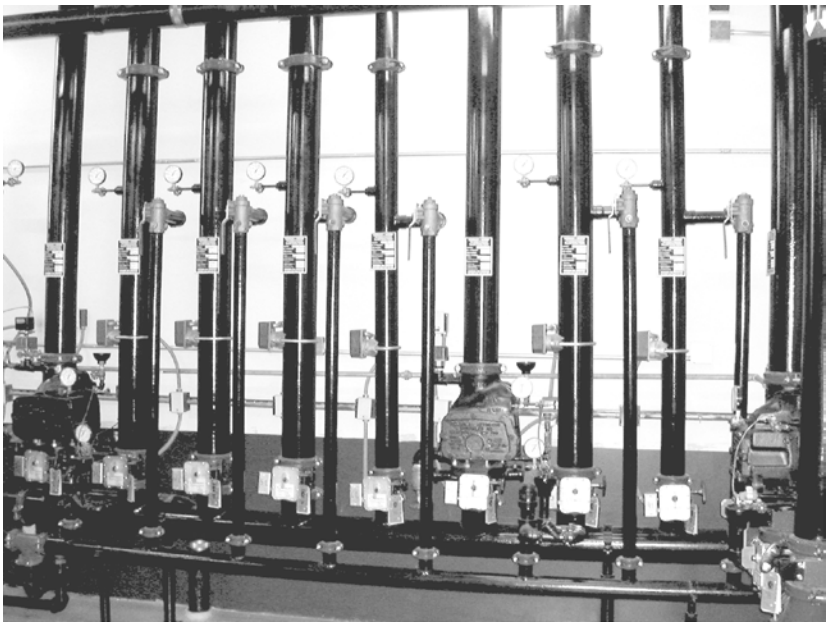


Figure 1-1
Sprinkler risers in the Venetian Hotel, Las Vegas, are an example of active fire protection systems.

- ***stationary fire pumps***:
  - ***single stage***,
  - ***multistage***,
  - ***electric drive***,
  - ***diesel drive***,
  - ***steam drive***, and
  - ***controllers***;
- ***fire alarm systems***:
  - ***manual***,
  - ***automatic***,
  - ***zoned***, and
  - ***addressable***;
- ***smoke management systems***:
  - ***dedicated***,
  - ***nondedicated***,
  - ***pressure method***, and
  - ***exhaust method***;
- ***specialty fire protection systems***:
  - ***spot applications***,
  - ***total flooding***,
  - ***Halon™***,
  - ***clean agents***,
  - ***Inergen®***, ***FM 200®***,

- ***carbon dioxide***,
- ***high or low pressure***,
- ***hand-held hose***,
- ***dry chemical***,
- ***sodium bicarbonate, potassium bicarbonate***,
- ***wet chemical***,
- ***potassium carbonate***, ***potassium acetate***, and
- ***high- or low-pressure water mist***.

It is important for IC's to understand that many automatic fire protection systems are engineered and installed to suppress a fire effectively without human intervention. This means the IC should be thoroughly familiar with the systems (and let them do their jobs as designed) before employing traditional manual suppression strategies and tactics.

Passive Systems or Features

Passive systems or features are structural elements that, when properly installed and maintained, assist in the control of fire and smoke movement in a building and contribute to the structural stability of a building under fire conditions. These systems include, but are not limited to:

- ***firewalls***;
- fire-rated ***floor and ceiling assemblies***;
- other fire assemblies (e.g., ***fire doors***, ***fire dampers***, rated exit corridors); and
- ***firestopping***, ***draft stops***, ***draft curtains***, and ***fire safing***.

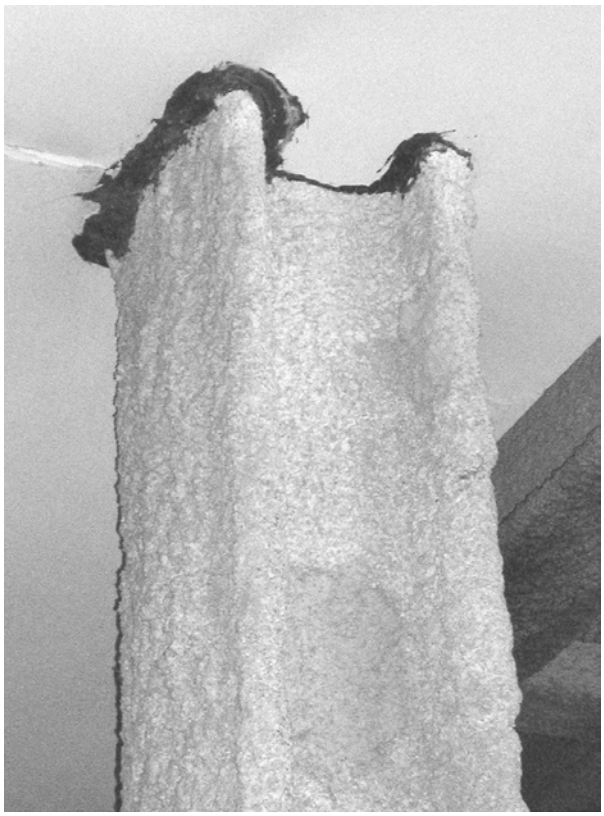


Figure 1-2
Spray-on fireproofing and smoke-seal caulking are two examples of *passive* fire protection.

SUMMARY

The purpose of this course is to provide IC's with fundamental information on fire protection systems and construction features, their components, and how they function to mitigate or control a fire or other emergency. The foundation for identifying and documenting this information is the PIP process. This is where we will start our journey to understand the capabilities and limitations of fire protection systems.

Activity 1.1

Purpose of Fire Protection Systems and Equipment

Purpose

To have you realize that, to be effective Incident Commanders, you must have an appreciation for the reasons fire protection systems are installed in buildings and facilities.

Directions

1. You will be working in small groups.

2. In your assigned groups, identify and write on an easel pad a list of at least 10 purposes for which fire protection systems are installed in buildings and facilities.

3. Select a spokesperson to report, and be prepared to discuss your answers with the rest of the class.

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Activity 1.2

Indirect Costs of Fire Department Lawsuits

Purpose

To understand the connection between having good information and the impact of lawsuits on a fire department, and to understand that there are more "costs" than just the money.

Directions

1. You will be working in small groups.

2. In your assigned groups, you will have 10 minutes to identify and write on an easel pad a list of "indirect costs" that may result from lawsuits against the fire department.

3. Select a spokesperson to report, and be prepared to discuss your answers with the rest of the class.

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Activity 1.3

Identifying Fire Protection Systems and Equipment

Purpose

To develop the ability to identify various pieces of fire protection system equipment, and to encourage you to look carefully at details in the built environment.

Directions

1. The instructor will show slides of several fire protection systems and components.

2. Use the Worksheet to identify the fire protection system or component, and describe its function briefly.

3. Be prepared to discuss your answers with the rest of the class.

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Activity 1.3 (cont'd)

Fire Protection Systems and Equipment Worksheet

Slide	Item	Function
1-15		
1-16		
1-17		
1-18		
1-19		
1-20		
1-21		
1-22		
1-23		
1-24		
1-25		
1-26		
1-27		
1-28		
1-29		

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UNIT 2: DECISIONMAKING

TERMINAL OBJECTIVE

The students will be able to recognize the importance of preincident planning in making appropriate decisions in specific emergency situations.

ENABLING OBJECTIVES

The students will:

1. Distinguish between classical and naturalistic decisionmaking.

2. Determine when to use each approach.

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INTRODUCTION

Decisionmaking is an integral part of every Incident Commander's (IC's) responsibilities. The process each IC goes through has been studied and evaluated, and research has shown that what the IC decides to do is based on knowledge gathered from training, experience, case studies, conversations with officers who have had relevant experiences, and pre-incident planning, which is the focus of this course. We use a cue-based decisionmaking process that employs the ***Primary Factors Chart*** (discussed in Unit 3: Benefits of Preincident Planning).

Two primary methods are used by incident scene decisionmakers to reach conclusions, determine results, and initiate actions. They are the classical method and the Naturalistic Decisionmaking Method (NDM).

CLASSICAL DECISIONMAKING

The classical decisionmaking method is a time-consuming process where the decisionmaker:

- gathers information;
- analyzes the information;
- determines the problems that are present, and selects and prioritizes those problems in order of importance;
- identifies and prioritizes the possible solutions;
- selects tactics from one or more possible options; and
- issues directives to have the tactics implemented.

The Command Sequence

Over time, the use of this system--called the **command sequence**--becomes a habit. When this happens, the Company Officer (CO) tends to use the technique under unfamiliar emergency conditions, thus structuring the decisionmaking process and reducing stress.

Using the command sequence also helps the CO stay proactive. The IC may use the steps to anticipate upcoming or urgent needs.

Using the Classical Method in Training

Decisionmakers need the classical method when they are in the training mode. In the training mode, they will be taught to look for cues, draw conclusions, consider results, and take action for an incident type not previously learned, or learned incorrectly.

Whether the cues, conclusions, results, and actions are learned must be tested in an application format. Such a format can be an exercise or simulation, provided by an expert in the specific

incident type. For example, an urban or city fire officer would learn wildland firefighting techniques from a wildland expert.

Using the Classical Method in Evaluation and Planning

The classical decisionmaking method also is used for evaluating and planning when time is not a factor.

Decisionmakers need to use the classical method when they are evaluating and comparing the critical cues used, conclusions and results determined, and actions taken by other decisionmakers.

This form of training typically employs case studies. Here, the student uses a case study to examine the obvious and subtle cue differences. The examination provides optional conclusions, results, and actions based on the cue differences. By using a case study and the classical method, students are able to evaluate whether or not the cues match the conclusions and actions of the decisionmaker at the actual scene. If they do not, then students will learn specific actions to avoid.

Using the Classical Method at an Emergency

It is appropriate to use the classical decisionmaking method at an actual incident scene where there has been little or no previous experience or training with this specific incident type, or with the variables that are present at an incident. The decisionmaker must formulate a basic plan before directing tactical actions. A process that does not include an evaluation of the incident information, a risk/benefit analysis, and appropriate strategies and tactics is not a plan--it is a design for disaster.

Base the plan on incident information (critical cues), real problems, and appropriate broad solutions (strategies). Choose the best solutions (tactics) from several options.

NATURALISTIC DECISIONMAKING

The NDM is a more rapid and intuitive process in which the decisionmaker very quickly:

- looks for certain critical cues (visual, audio, touch, smell);
- conducts a sizeup;
- relates the critical cues to previous similar situations (from experience or training);
- recalls the previous conclusion, results, and actions that most fit the new situation; and
- issues directives to have the tactics implemented.

Obviously, basing decisions on the understanding gained from previous experience can produce results much faster than following the step-by-step classical process.

The Role of Experience in NDM

The more experience the fire officer has had on similar types of incidents, the greater his or her ability will be to read the subtle differences at the incident, draw refined conclusions, and direct the most appropriate actions to provide a solution.

Also, the more familiar an IC is with a building, the better able he or she will be to make appropriate decisions at a fire event involving the building. Using preincident plan information and having a working knowledge of the building's fire protection systems will help the IC to make better decisions. Preincident planning is an important part of NDM.

When to Use NDM

An IC will use NDM when he or she has adequate experience or training on the incident type, or on the variables within the incident type. This method relies on an almost instantaneous recall of previously learned conclusions, results, and actions. It includes the interrelationships of specific information with conclusions, results, and actions based on whether or not they worked before. Therefore, it provides a direct, lightning-fast transition from what the IC sees, hears, feels, and smells to conclusions and resulting actions.

Time-Sensitive Nature of Decisionmaking

Because of the time-sensitive nature of emergency-scene decisionmaking, the choice between naturalistic and classical will not be conscious. The decisionmaker's brain will attempt NDM first. This is the way the brain operates, even though the decisionmaker is not aware of it.

The decisionmaker must recognize when he/she possesses insufficient information to use this method. Some cues for this recognition are

- It is obvious to the decisionmaker that there has been little or no experience or training on the specific incident type.
- The decisionmaker recognizes that the incident cues are very unfamiliar and do not immediately result in appropriate action decisions.
- The decisionmaker feels lost or overwhelmed, cannot think, or is in a panic. In these cases, the classical method is the appropriate response.

By recognizing these cues, the decisionmaker can determine that he or she needs to convert to a different decisionmaking method. That is the classical method. If this conversion is not done, the decisionmaker often is left with what has sometimes been called "brain-lock."

Continuing Sizeup

If NDM was used on the incident scene, the decisionmaker still will use the classical method to evaluate the actions taken using NDM, to ensure that what is being done is achieving the desired result. This is called **continuing sizeup**.

The IC asks such questions as:

- Is what I have directed to be accomplished actually solving the problems?

- Is the information I am receiving from other officers consistent with what I know, and what the preplan says about this building?

SUMMARY

Classical decisionmaking requires time and is best used in training, post-event evaluation, and preincident planning. It is used at a fire scene only if necessary knowledge and experience are lacking. However, the knowledge and experience acquired in preincident planning and training are keys to being able to make critical decisions using NDM at a fire.

Activity 2.1

Decisionmaking Models

Purpose

To identify when an IC is using the NDM and when the classical decisonmaking approach is used.

Directions

1. In your table group, take 10 minutes to read over the scenario below.

2. Decide when the fire officer is using classical decisionmaking, and when you think she is using the NDM.

3. For each example identified, ask yourself: "Was this type of decisionmaking appropriate?"

4. Identify the preincident planning knowledge that made the NDM possible, and the chief's preplanning activities that gave her the knowledge to use NDM.

5. Select a spokesperson to report to the class your findings and the rationale for your opinions.

Scenario

A 40-story mixed-use office, retail, and parking building is being constructed in the area of responsibility of the Anytown Fire Department. The battalion chief recognizes that this building will be a target hazard.

She obtains the building plans from the building department and fire marshal's offices. She documents information about the building and determines the type of construction, the intended building occupancies and uses, and the types of tenant spaces anticipated. She analyzes this information and uses it to begin a preincident plan for the building.

She then notes the scheduled date for the completion of the building, decides on the best time to visit the site, identifies the appropriate point of contact, and schedules a visit. At the site, she locates the firewalls, sprinklers, and other protection elements and notes them on the building plan. She then files a preincident plan data collection sheet on the building. The fire department planning unit refines the material into a formal preincident plan.

Two weeks after the building opens, the building engineer reports to the fire marshal's office that the fire pump located in the basement has failed, and will be out of service for at least 1 month while parts are being delivered. The fire marshal's office reports this to the operations division, and the IC attaches a highlighted note to the preincident plan.

Three weeks later, in the early morning, the fire department is dispatched to an automatic smoke detector alarm in one of the dwelling spaces on the sixth floor of the building. A standard building alarm assignment of one engine, one truck, one rescue, and the battalion chief is dispatched.

While en route, the IC gets a report from the fire dispatcher that a telephone call from an occupant on the 14th floor reports smoke in the corridor. The IC requests that a second engine and ladder truck be dispatched.

At the fire scene, the IC discovers that there is a fire on the 10th floor with flames and smoke pouring out of broken windows. The IC immediately requests a second and third alarm, and gives specific directions that will enable firefighters to confine the fire to the dwelling unit and protect the rest of the building from fire spread. She bases her strategy and tactics on her knowledge of the building and its protection systems.

As the firefighters are entering the building, the IC sees several persons at the window of the ninth floor of the building. The IC immediately directs the firefighters to bring hoses to the stairs, go up to the room, and bring down these persons.

The firefighters discover there is not enough pressure in their hoses to properly discharge hose streams on the 10th floor, so the IC orders that an engine supplement the standpipe fire department connection.

After the fire, the IC critiques the event with her team. They review what was done and consider whether they could have taken any different actions that would have resulted in a faster rescue or extinguished the fire more quickly. Based on this experience, they also consider what other problems could have arisen in this fire, and discuss how they could have resolved them.

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UNIT 3: PREINCIDENT PLANNING BENEFITS

TERMINAL OBJECTIVE

The students will be able to describe the benefits of preincident planning and the relationship between these activities and the effective use of fire protection systems.

ENABLING OBJECTIVES

The students will:

1. *Describe the key factors evaluated in a preincident plan.*
2. *Describe how preincident plans are used before, during, and after a fire.*
3. *Identify a list of information sources for completing preincident plans.*

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PREINCIDENT PLANNING

Noted fire protection specialist and author Francis Brannigan often repeats the quote "The building is your enemy. Know your enemy! Know your building!" This phrase is his way of warning fire service personnel of the importance of gathering good information before an event ends in disaster.

Clyde Pfisterer, a 46-year veteran of the Indianapolis Fire Department, reminds firefighters that if "you don't control the building, the building will control you."

Collecting information about your enemy is known as "intelligence gathering." In this era of terrorist threats from chemical, biological, nuclear, and explosive or incendiary hazards, the fire service must be vigilant about intelligence gathering. "Infrastructure protection" refers to guarding the essential functions and built environment that sustain our way of life and economy. Thus, preincident planning describes the means of infrastructure protection intelligence gathering: the process of information collection, sorting, evaluation, and dissemination of facts, probabilities, and mitigating factors relating to all hazard emergencies in buildings or facilities.

Effective fireground operations depend on the Incident Commander (IC) developing good objectives, strategies, and tactics (OST's). IC's develop OST's for virtually every incident to which they respond. Sometimes we don't realize we are doing this, but it is a mental process that is inherent in essentially all fireground commanders, whether they are chief officers, Company Officers (CO's), or acting CO's.

A quality preincident planning process will greatly assist a fire officer/IC in developing good OST's. Using established preincident planning forms to document important information on a particular target hazard lays the foundation for developing quality OST's. The next step is to capture this information in a format that will be readily available to the IC, prior to and on arrival at a fire in a particular building or hazard.

Two National Fire Protection Association (NFPA) Standards, 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments;* and NFPA 1720, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments* strongly emphasize the need for formal **preincident planning** efforts.

As IC's we must continuously reflect on the importance of the role we play in successful incident outcomes. Therefore, we must ask ourselves:

- Why is it important to have an IC for an emergency?
- Have you ever had a fire where quicker, more effective use of the building's fire protection system would have aided in the outcome?
- Where do **you** get your information on a building's fire protection systems, and how is this information kept for future reference?

- What are some the building fire protection systems that IC's likely would use during a fire?

- What are the benefits of preincident knowledge on fire protection system locations, what they do, how they operate, and what limitations they pose when managing a fire?

- Where do preincident planning and fire protection systems knowledge merge?

- Do you, as a potential fireground commander, have a method to identify control OST's for use at incidents involving target hazards?

- How and where do you document your preincident plan information?

VALUE OF PREINCIDENT PLANNING

Most fire departments conduct some form of preincident planning or hazard assessment. The question one must ask is "How well do we (my agency, my company) conduct this planning process?"--and, more importantly, "How effective are we at using this information in emergency situations?"

IDENTIFYING TARGET HAZARDS

Although familiarity with all structures in a district is important, an emphasis on target hazards should be the top priority. In the National Fire Academy (NFA) course *Command and Control of Fire Department Operations at Target Hazards*, a target hazard is defined as:

> Any building or potential incident site (e.g., outside hazardous materials storage site, bulk fuel storage facility) that has the potential for significant life loss, high property dollar loss, and/or the ability to overwhelm local resources.

Some examples of target hazards identified in the NFA course are nursing homes/convalescent homes/human care facilities, educational institutions (including colleges and universities), penal institutions, bulk storage facilities, grain elevators, large public assembly occupancies (churches, theaters, airport, bus and train terminals), buildings under construction, large mercantile occupancies (malls), highrise and midrise buildings, and large manufacturing and storage facilities (e.g., mill buildings).

Buildings or facilities need not be large to overwhelm an agency's resources. This definition makes every department in the country responsible for some type of target hazard. A fire in a midrise building (three to six stories) might not tax the resources of the Fire Department of New York City, but a small community in a rural area with two three-person engines and a two-person truck--and outside help 20 to 30 minutes away--likely would find a fire in this type of facility tremendously taxing.

The fire service needs to embrace the importance of becoming familiar with target hazard occupancies in response areas. There are documented fires where a lack of knowledge regarding fire protection systems, or a failure to properly use them resulted in fires getting out of control and seriously damaging or destroying buildings.

Preincident preparation will not eliminate the challenges presented by target hazards, but it will set the stage for how an officer--as IC--will prioritize fireground operations at all three incident management levels: **setting incident objectives, prioritizing incident strategies,** and **developing and implementing incident tactical operations**.



Figure 3-1(a)
For a Small Community, a Target Hazard may be a Historic Building



Figure 3-1(b)
A Hazardous Materials Tank Farm Nearly Always is a Target Hazard



Figure 3-1(c)
Highrise Buildings Are a Challenge for Any Agency

The preincident planning process is critical to successful outcomes in a challenging situation. Fire officers always must remember that they start out working behind, because the incident has already started and gained headway prior to being reported.

The methods officers can use to help catch up are quality preparation, pre-identification of the challenges a building presents, and a working knowledge of the support systems it contains that can help manage the control process.

DATA GATHERING FOR THE PREINCIDENT PLAN

Knowledge of a building's fire protection systems will aid in the decision-making process, provide a safer climate for firefighters to work in, and ultimately should lead to better outcomes. It is the goal of every firefighter when he or she responds to a fire emergency to prevent loss of life, minimize property damage, and assist the building owner in resuming normal operations as soon as possible after the fire. Knowing a building's fire protection systems, how they operate, their operational readiness, and how to secure them and then placing them back in service are all keys to these better outcomes. It is part of our responsibility, and we must become more proficient in this area.

THE PREINCIDENT PLANNING PROCESS

The Formal Process: Completing Forms

Preincident planning takes on essentially two different forms. The first is the more formal process, which involves the use of forms developed for this purpose (those found in NFPA 1620, *Recommended Practices for Pre-Incident Planning*, the NFA Quick Action Prefire Plan (QAP) Form, or other forms adopted by your organization). This method involves the documentation of critical information related to a building's occupancy and use, construction, systems, utilities, access, and other information vital to effective emergency operations.

The Informal Process: The Walkthrough

The second form of preincident planning is less formal, but very important. It involves a crew walking through a building, reviewing the documented preincident planning information for changes or alterations, and noting these changes. This process allows a company to maintain its knowledge of a building, and to look for and identify any deficiencies in the building's fire protection systems that may have happened since the last walkthrough.

Another valuable use of and reinforcement of the information gathered during preincident planning is to conduct drills at these critical facilities. This allows emergency responders to apply the knowledge they have obtained during the building preincident planning visit and to test their knowledge of the systems, their locations, and how they fit into the overall emergency operations plan.

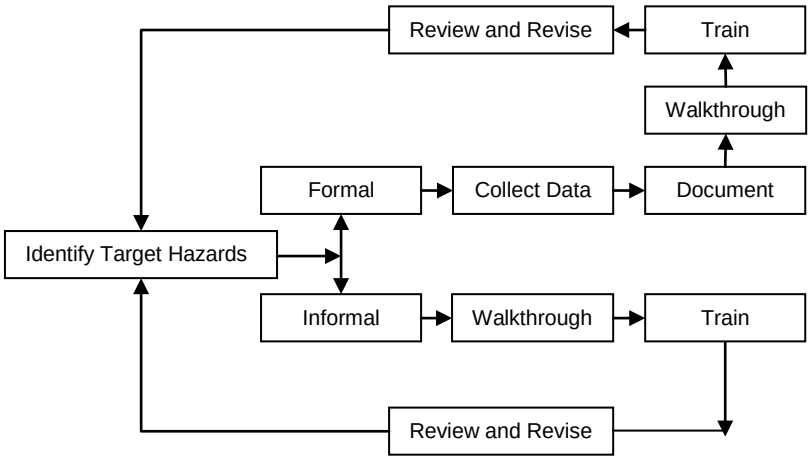


Figure 3-2
The Preincident Planning Process

LOCATION OF THE PREINCIDENT PLAN

In general terms, the fire service has established that preincident planning is a normal function for emergency response units. Engine and truck companies go through an information gathering process and develop these plans, most often in written form, and they are carried on engines and trucks for use during a fire. Some departments have gone so far as to put these plans in a database that can be accessed through a unit's mobile data terminal. This is generally where the process ends.

Technology is available for the drawing, storage, and retrieval of preincident plan information. Although somewhat costly, these programs, working in conjunction with apparatus mobile data terminals (MDT's), have proven very valuable in many communities. Since many communities already have the data available, it is a matter of developing, formatting, and programming the information into a computerized database that can be retrieved using MDT's in the field.

Some of these electronic programs include

- Microsoft Visio®;
- CAD Zone Fire Zone® or First Look PRO®;
- Pictometry Visual Intelligence®;
- ESRI Arcview®; and
- Mapping Solutions FireBase®.

It must be clearly understood that multiple units respond to these same buildings on the same or different shifts, or even from other jurisdictions. The officers and personnel on these crews need to be familiar with the fire protection components of these buildings. One cannot assume that the same units or the same personnel will always be at the fire when it occurs. Sharing the preincident information and having periodic drills at the more critical buildings are two keys to effective outcomes when fires happen in these buildings.

Fire departments should consider their particular needs when purchasing computerized preincident planning tools, but not forget they should consider the potential need to share this information with neighboring agencies.

Departments also must consider how they expect to share preincident plans with incoming apparatus and mutual-aid companies during an emergency. Is there an adequate number of current paper copies available for all key personnel? If stored electronically, how can they be retrieved and shared? Are all companies working on like radio frequencies (a key to interoperability) that can transmit or receive data? Are fax machines or other printing devices ready to download plans? Is there an adequate supply of paper and printing cartridges? These and similar contingencies should be resolved before an incident, not while the IC is standing in front of a burning structure asking for help.

PREINCIDENT PLANNING TOOLS

The preincident planning process is outlined in the nationally recognized document NFPA 1620. It is strongly recommended that it be used as the basis for preincident planning.

The major factors that should be evaluated during preincident planning as listed in NFPA 1620 are

- construction;
- occupant characteristics;
- protection systems;
- capability of public or industrial response personnel;
- availability of mutual aid;
- water supply; and
- exposure factors.

As of the writing of this course, the NFPA committee on NFPA 1620 has recommended moving this document from a ***Recommended Practice***, to a ***Standard***. The committee is attempting to make the change outside of the normal 3-year cycle (within the next 3 years), but has not completed the draft document as of the development of this course.

If the committee moves forward with this recommendation and it is approved on the floor during NFPA's hearings, the new Standard will require that those jurisdictions that adopt 1620 either by reference or specific reference during the code adoption process will be required to follow this Standard, or be exposed to significant legal liability for failure to do so.

As demonstrated in the Appeals Court ruling in Canada for the Montreal, Quebec, Alexis Nihon Plaza highrise fire, fire departments are being held to a higher standard than ever before for knowing how to properly use fire protection systems in buildings. Because local jurisdictions require these systems to be installed as part of the construction process, and then to be properly maintained for use under fire conditions, it is imperative that fire departments throughout this

country evaluate the readiness of these systems and know in advance of a fire how to properly use them.

Proper preincident planning will greatly assist departments in adhering to these expectations and help avoid the liability that might arise if a department has difficulty with system components during a fire emergency.

The plan should be developed in consultation with other professionals involved in the site or facility development, such as fire protection engineers, sprinkler contractors, building architects or engineers, water authorities, and insurance professionals, as well as by conducting site surveys. Other sources such as governmental agencies should be consulted for existing emergency plans they might require.

Historical information on similar occupancies involved in emergencies should be reviewed for issues that could cause problems in the structure being surveyed. The information should be recorded based on what information is needed and how it is to be used.

NFPA 1620 Recommendations

NFPA 1620 also says, "The preincident plan should be coordinated with an incident management system," which is also an essential element of this course. NFPA 1620 also recommends that the preincident planning process should begin before construction and actual occupancy of the building. The use of training for developing familiarity with the plan, with an emphasis on those portions of the plan that involve unique or unusual evolutions or operations, also is highlighted.

NFPA 1620 recommends that "The preincident plan should be the foundation for decision-making during an emergency situation and provide important data that will assist the incident commander in developing appropriate strategies and tactics for managing the incident. The preincident plan should help responding personnel identify critical factors that will affect the ultimate outcome of the incident, including personnel safety."

Primary Factors Chart

The NFA has developed a form called the Primary Factors Chart, for use by fireground commanders in developing their OST's. The Primary Factors Chart is a quick reference guide for managing a fire incident. When used in conjunction with, and completed during preincident planning, it becomes an even more meaningful tool.
A second version of the Primary Factors Chart has been developed for incidents involving hazardous materials or hazardous materials sites. The appropriate form to use should be based on what hazardous conditions will confront the IC. Both charts are shown in Appendix B to this unit.

How the Primary Factors Chart is Used

The Primary Factors Chart is a tool that can be used by command officers to help organize and manage an emergency incident, and some of this work can be done before the incident, or during the preincident planning process. When used as a preincident planning tool, the Primary Factors Chart gives the IC the foundation for dealing with the incident, without having to process a significant amount of information under very trying and hectic circumstances.

The Primary Factors Chart is divided into four areas. The first, or column #1, lists the **Pertinent Factors** about a building or hazard area, and includes consideration for life safety, building properties and exposures, auxiliary appliances (fire protection systems), and weather.

Column #2 is set aside for establishing **Incident Objectives** and, although final objectives cannot be developed until the real incident occurs, objectives based on critical pertinent factors, such as supplying sprinkler and standpipe connections and knowing the location of fire alarm ***annunciator*** panels, can be critical to effective early emergency operations.

Column #3 is dedicated to **Strategies**; planning these strategies based on the **Pertinent Factors** listed in Column #1 will assist in managing the flow of the incident to a successful conclusion.

Column #4 is set aside to remind the IC to evaluate the effectiveness of his or her strategies continually in meeting overall incident objectives.

Types of Issues that Can be Evaluated

Many building features and concerns can be surveyed. As an example, when dealing with a large public assembly occupancy, life safety is a pertinent factor. Fire protection systems are an essential component for protecting the lives of the occupants of the public assembly. Making sure these systems are operating properly and supported should be a primary strategy in carrying out the incident objective of the **safe removal of all occupants** from the building.

A secondary issue, and one of the unrecognized, but extremely important fire protection systems in these buildings, is the exiting features. Although not a principal element of this course, exiting features (corridors, fire door assemblies, ***exit passageways***, etc.) play a significant role in the **safe removal of all occupants**, as well as serving as access for firefighting personnel.

Knowing how the exiting systems are configured, the principal routes building occupants will use, and how to best use them for emergency personnel without creating a conflict with evacuation, is an essential part of the preincident planning process. Knowing which stairwells in a high-rise building are pressurized or designed to maintain a tenable environment for occupant evacuation is critical to overall effective management of a fire emergency in the building.

The Primary Factors Chart also helps establish in advance of the fire the amount and types of resources that might be needed to combat a fire in the particular building. You can plan alarm levels (resources) that may be required based on level of fire involvement.

Knowing what systems the building does and does not have will help in allocating and assigning available resources, based on the priorities established during the development of your incident objectives. For example, if the building has a fire sprinkler system, it may be more effective to have a limited staff company--two or three personnel--supply the sprinkler system, rather than attempting to lay and supply a 2-1/2-inch hoseline for initial fire attack. Immediately checking the fire alarm annunciator panel for fire location (when no fire is initially showing) will expedite routing of resources to the location of the fire.

Making notes, identifying specific **Pertinent Factors** on the Primary Factors Chart, and developing some basic **incident objectives** and **strategies** during the preincident planning process will begin laying out an IC's action plan for managing a fire emergency in the building. If this documentation is kept with the preincident planning information, the responding officer can use it to begin developing the overall Incident Action Plan (IAP) prior to arrival at the incident.

This process also allows the fireground commander the opportunity to identify specific hazards areas, exposure problems, and areas where structural integrity may be in question. The process helps IC's to identify methods to reduce firefighter exposure to heat, smoke, fatigue, fire, and other hazards. Ultimately, this should contribute to a reduction in the potential for both fire and property loss.

Other Data Sources

It must be emphasized that the formal preincident planning process is extremely important. However, the formal process is just one element of quality preincident preparation, and the formal documentation and building familiarization visit is not the only source of information that needs to be collected for a building, particularly on its target hazards.

Other sources include the building's architect, the owner, engineers, safety director, and the maintenance supervisor, as well as the insurance carrier/underwriter/risk manager or loss control specialist.

It is important for fire officers to review building plans submitted during construction, and then periodically check the plans normally kept in the building department's records to determine whether changes or modifications to the building have been made, by checking on permits that have been issued by the building or fire department, hazardous material operations permits, and Material Safety Data Sheets (MSDS) records, and county or jurisdictional records collected by the zoning and/or planning departments.

A fire agency's relationship with its fire code enforcement organization is an important one. Independent fire companies may have to work with a building department or fire marshal's office that is not legally bound to consider the suppression personnel's needs. In those cases, the fire department may need to work hard to build a close working relationship, but the efforts could be well rewarded. Code enforcement officials have the authority to make decisions that can make the IC's life easier. They enforce rules and regulations on water supplies for fire protection, fire

apparatus access roads, and built-in fire protection systems. Likewise, their permanent records and reports may provide a wealth of information for the IC: building and fire protection system plans and specifications, site plans, construction details, and inventories of hazardous materials or operations.

Preincident Planning Stages

The preincident process planning should not begin after a building is constructed and occupied. It should begin when the concept of the facility is proposed and needs the input of the fire department. Responding companies should be involved with the building during the conceptual or planning stage, and all the way through the construction phase. (Fires do occur in buildings under construction.) It should continue as the building is being occupied (and modified for the occupants) and then be an on-going process after the certificate of occupancy is issued and full operations are up and running.

Preincident planning lasts over the lifetime of a building, because as long as it is standing, the fire department must be prepared to deal with a fire or other emergency that may occur in the building.

Testing

Part of the preincident planning process should be verification that regular testing of all systems is being conducted in accordance with applicable adopted codes for your area. If this information is not available, or the building owner/manager cannot produce it, the reasons why these tests are not being conducted or documented should be requested. If there is reluctance on the part of the building representative to provide this information, the problem should be forwarded to your code enforcement official for corrective action.



Figure 3-3
Regular Inspection and Testing Should Correct Conditions Like This

According to the national fire codes and standards, most fire protection systems need to be inspected, tested, and maintained on a regular schedule, some as often as quarterly. These tests can identify significant deficiencies that should be corrected in a timely fashion.

These tests and records also can be used to identify trends that might not otherwise be obvious. For example, one regularly required test of automatic sprinkler systems, called a "main drain test," monitors the conditions of a neighborhood's water supply. If regular tests reveal a continual decline in water pressure or volume, this information should be identified on the preincident plan and reported to the water purveyor to make needed improvements. (The "improvement" may be as simple as checking the status of all street valves to ensure they are fully opened, to something as complex as re-engineering and installing new water storage facilities and mains.)

ACTIONS TO BE TAKEN BEFORE, DURING, AND AFTER THE INCIDENT

NFPA 1620 recommends a process for the development, use, and maintenance of a preincident plan. The process covers the time periods before the incident, during the incident, and after the incident**.**

Before the Incident

Before the incident, determine the following:

- the risks associated with the property, and what data should be collected for the preincident plan;
- what strategies might be employed for this property; develop a range of options;
- what to do with the information;
- what training is needed to assure all personnel are familiar with the plan; and
- what steps are needed to update and revise the plan.

Keep each plan simple enough to remain useful. Copies of the plan should be distributed to the appropriate potential responding units. The plan should be tested and practiced periodically, to provide an opportunity to review the data and refine the plan.

The preincident planning process should include a provision for training in those portions of the plan that involve unique or unusual evolutions or operations. Training should be used to communicate the preincident plan expectations to individuals or agencies included in the plan that do not normally work together.

During the Incident

The IC should

- establish an incident Command Post (CP);
- develop OST's;
- retrieve data from preincident plan; and
- make arrangements to share the information with responding companies.

During the incident, the preincident plan should be the foundation for decisionmaking and provide important data that will assist the IC in developing appropriate strategies and tactics for managing the incident. The plan should help responding personnel to identify critical factors that will affect the ultimate outcome of the incident, including personnel safety.

The plan should provide information on available facility personnel and how to contact them, to advise responding personnel of current conditions. The IC should use the information contained in the plan to anticipate likely scenarios. The IC also should review the plan continually throughout the incident, to remain aware of factors that might affect the success of the operation for strategic or tactical adjustments.

After the Incident

The IC should

- review the incident;
- critique the outcome;
- evaluate the plan effectiveness, and the overall program effectiveness; and
- modify the plan as appropriate.

After the incident, the effectiveness of the plan should be re-evaluated. The incident should be analyzed and the performance of responding personnel, facility owners, and occupants evaluated for their effectiveness in relation to the plan. The plan then should be modified based on this evaluation.

The preincident plan also may be useful as a postincident investigation tool. Fire investigators; insurance investigators; and other local, State, or private entities may find the information useful for a "virtual reconstruction" of the occupancy and conditions that existed before the incident.

Relating the Plan to Incident Management

Preincident planning gives the IC and other personnel the opportunity to assess risks and develop strategies under non-emergency conditions. It's often stressful when the alarm sounds and emergency personnel must make critical decisions in only a matter of minutes or even seconds.

One tool the fire service has embraced--which now is endorsed by the Department of Homeland Security (DHS)--is the National Incident Management System (NIMS). The Incident Command System (ICS) is an integral part of NIMS and, when successfully employed, increases fireground safety, accountability, and efficiency.

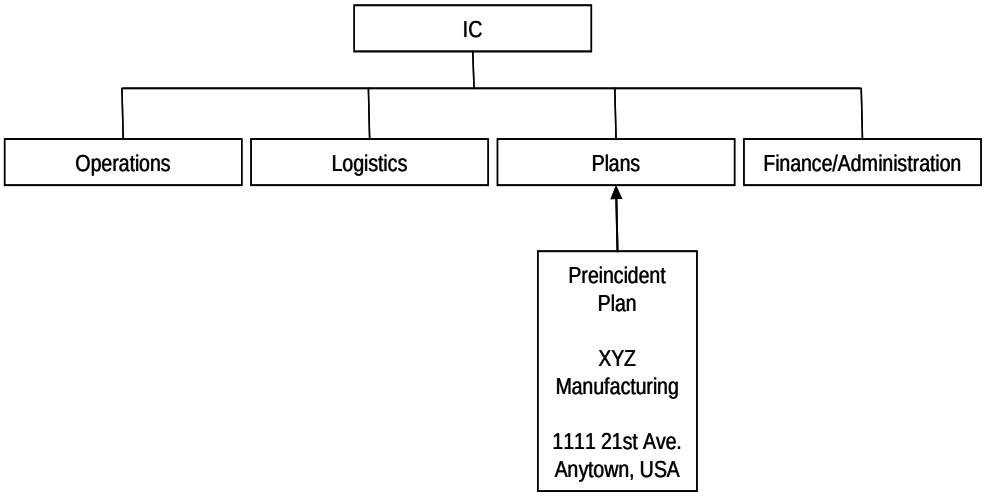


Figure 3-4
Preincident Planning/NIMS Relationship

Traditional preincident plans typically summarize a building or facility's hazards and the resources that may be necessary to control them. Why not "preplan" the ICS as well? The IC who anticipates the staff, groups, divisions, and resources he or she may need to control a target hazard event is better prepared to handle an emergency in a disciplined manner. This does not mean that every block on an ICS chart must be completed beforehand with names and radio identifiers, but wouldn't it make life easier if the IC expected he or she might need a Plans Chief, Foam Group Leader, or some other specialty resource person who specifically could help control the incident?

If they are not already, State and local fire officials and emergency first responders need to become familiar with NIMS and its elements. Many Federal programs and funding will be contingent on those agencies adopting and employing NIMS in their day-to-day operations. Additional information, and a copy of the NIMS plan, can be downloaded from http://www.dhs.gov/interweb/assetlibrary/NIMS-90-web.pdf

Preincident planning and NIMS go hand-in-hand. Agencies should train regularly with both tools.

Elements to be Considered Before the Incident

The following are just some of the elements that should be considered before an incident.

- the physical elements of the site and specific site considerations including access and road widths;
- construction type;
- capability of the public and industrial response personnel;
- fire hydrants and their locations;
- occupant considerations;
- fire protection systems and water supply, including needed fire flow for both sprinkler systems and handlines;
- fire department connections and their locations;
- fire sprinkler systems, type, number, and location of riser room, areas served by each riser, extent of sprinkler coverage;
- fire pumps (where required);
- fire alarm systems, type, location of annuciator panel, type of detectors, area of coverage (***addressable***, ***zoned*** or not);
- standpipe systems, type, intake, and outlet locations;
- pressure restricting devices and pressure-reducing valves;
- special hazard considerations;
- emergency operations considerations;
- exposures;
- special or unusual characteristics of common occupancy;
- transient conditions (things that may change on a regular basis);
- building services, (heating, ventilating, and air conditioning (***HVAC***), elevators, moving stairs (escalators), conveyors, boilers, chillers;
- utilities and their importance to supporting other fire protection systems;
- emergency and standby power;
- compressed and liquefied gases; and
- communication systems.

Having this information available will answer many of the questions that routinely arise during fire emergencies. It also will assist in identifying the number of resources that must be called, the type and capacity of the equipment needed, specialty equipment needed, where to position this equipment most effectively at the emergency scene, and essential actions that must be taken very

early in the incident (e.g., Who will hook up to the sprinkler or standpipe system? Who will go to the fire control or building engineer's room?).



Figure 3-5
Knowing the Hazards Prior to an Event is Critical for the IC

Identifying Points of Contact

The plan also must detail and maintain current information on points of contact such as:

- owner or operator;
- maintenance personnel or building engineer;
- facility fire brigade personnel;
- facility risk manager or safety director;
- alarm company contact;
- sprinkler system maintenance contact;
- elevator/escalator maintenance contact; and
- specialty contact (e.g., hood-range systems, Halon™ or clean agent systems).

STRUCTURE OF NFPA 1620

The preincident planning forms recommended by NFPA 1620 are structured so that information is listed in an organized manner for ready reference by an IC. Appendix C to this unit contains sample formats and hypothetical examples.

Quick Access Prefire Plan

The QAP is intended to provide a simple data collection and display tool for emergency responders. It is arranged so that responding companies can perform a quick check of the building layout, fire protection features, hazards, and required fire flow. For many occupancies, it may be all the detail needed to provide preincident plans.

The first page of the document lists information on a building using this format:

- plan number (assigned by the local agency);
- address;
- name (of occupancy or business);
- response district (e.g., Battalion 1);
- emergency contacts;
- construction type;
- fire protection (systems, features);
- water supplies available;
- water supply needed (based on fire involvement);
- initial dispatch (units on the first dispatch assignment);
- special resources that might be needed (foam, air units);
- exposures;
- strategies; and
- comments.

Page two of the QAP form is for a diagram of the building or complex layout. This page also lists the address, name, preplan number, and district.

A typical diagram would show hydrant locations, main sizes, and access points; separation distances between buildings; locations of sprinkler/standpipe system connections; ***fire alarm control panel*** location; a brief construction description of both the buildings and their roofs; building use (e.g., warehouse, apartments); and size of each building.

The Preincident Plan Data Collection Sheet

Another form that can be of great benefit to an officer in gathering preincident planning information is the *Preincident Plan Data Collection Sheet*, which is shown with a hypothetical example in Appendix D. This form can be used in the field to collect preincident plan data about a property. It is much more detailed than the QAP.

Data Collected on the Preincident Planning Data Sheet

This form gathers data related to:

- fire company district;

- date (of preplan);
- preplan number;
- occupancy location:
  - address,
  - building name, and
  - telephone number;
- operating information and access:
  - emergency contacts and titles,
  - operating hours,
  - primary access:
    -- what side would be designated Side A (for fireground operations purposes?),
  - key box location and contents,
  - exterior access concerns:
    -- obstructions to aerial operations, and
    -- exterior door concerns;
  - interior roof access;
- occupancy--information on the overall occupancy:
  - high fire load locations,
  - life safety concerns, and
  - evacuations assembly plan--assembly point location;
- hazards:
  - trash and waste hazards:
    -- (if an) incinerator or compactor inside,
  - locations:
    -- incinerator or compactor chutes,
  - (are) chutes sprinklered,
  - outside compactors or dumpsters:
    -- locations: compactors or dumpsters attached or exposed to interior,
  - hazardous materials present:
    -- location of MSDS sheets,
    -- hazardous material inventory attached, and
    -- location for use in an emergency,
  - materials reactive with air; water; or other materials present,
  - type of materials; typical locations,
  - reactive materials present; typical locations, and
  - process hazards present; typical locations;
- construction:
  - number of stories,
  - number of basements; full or partial,
  - average square footage per story,
  - penthouse; occupancy,
  - roof construction; trusses,
  - deck material; covering,
  - floor construction; trusses,
  - wall construction,
  - combustible concealed spaces; location:

-- attic,
-- cockloft, or
-- crawl space,
- interior fire barriers and walls; locations,
- wall penetrations:
-- locations, and
-- openings protected by doors, shutters, sprinklers, nothing,
- interior stairs:
-- number, and
-- location,
- obstruction to stairways,
- elevators:
-- number,
-- location,
-- area served, full/partial,
-- fire service mode,
-- elevator key location, and
-- elevator controls location,
- unprotected vertical openings; type and locations;

- water supply:
- primary water supply:
-- test results,
-- location, and
-- date,
- static pressure/residual pressure/flow rate,
- alternative supplies private supply, type:
-- gravity tank,
-- other tank,
-- cistern,
-- process system,
-- reservoir, and
-- other,
- fire pump,
- supplied by:
-- public supply, or
-- private supply,
- start-up; automatic/manual,
- number of pumps; location,
- onsite hydrants,
- location of hydrants,
- supplied by public/private,
- size of outlets and threads,
- which system supplies what protection system,
- nearest large volume water supply greater than 2,000 gallons per minute (gpm),
- needed fire flow calculations and factors, and
- largest single fire area;

The United States Fire Administration (USFA's) NFA has an online self-study course called "Testing and Evaluation of Water Supplies for Fire Protection." It can be found at: http://training.fema.gov/

The course explains water supply calculations for fire protection, how to perform a water supply test, and rural and urban water supply systems. Students who successfully complete the 6-hour course can obtain a certificate from the NFA.

- protection systems:
  - fire alarm system,
    - -- panel location, and
    - -- annunciator location,
  - types of alarms,
  - extent of coverage,
  - monitored system,
  - fire alarm company,
  - sprinkler system,
  - location of fire department connection; size of threads,
  - type of system,
  - extent of coverage--full or partial: areas protected (if partial),
  - location of main valves,
  - system coverage plan at valve,
  - standpipe and inside hoses,
  - combined with sprinkler system,
    - -- fire department connection (FDC) same as for sprinkler system,
    - -- location of FDC, and
    - -- size of FDC threads,
  - type of standpipes:
    - -- extent of coverage--full or partial,
    - -- outlet locations; stairway, open floor, other, and
    - -- outlet size and type,
  - special; protection systems,
    - -- type of systems,
    - -- locations, and
    - -- extent of coverage, full or partial;



Figure 3-6
Preincident Planning Fire Department Connections Eliminate Confusion

- utilities:
  - water, gas, storm and sanitary sewer, telephone, data communications;
- exposures:
  - distance, construction type, occupancy type, openings;
- special resource considerations:
  - special apparatus, equipment or personnel that might be needed;
- technical rescue exposures:
  - high-angle, confined space, swift water, ice; and
- remarks.

The Preincident Plan Form

In addition to the first two pages of the preincident plan, there is a **Preincident Plan Form** that lists information in more detail. This form is structured so that important information is immediately available to the IC:

A copy of the Preincident Planning Form and a hypothetical example is included in Appendix D. This form lists the types of information that could be provided in a preincident plan.

Site Access and Restrictions

- fences: (height and construction);
- security: (guard services);
- guard house location: (number on duty, knowledge, areas where guards do not have access);
- guard dogs;
- lockbox;
- fire command center;
- emergency operations center;
- remote annunciator: (location); and
- fire alarm panel.

Life Safety and Occupant Considerations

- hours of operation;
- number of occupants: days (8-4), evenings (4-12), nights (12-8);
- handicapped/special needs;
- areas of refuge: (defend in place strategy);
- emergency contacts: name, title, telephone;
- site emergency response plan; and
- emergency coordinator.

Occupancy or Special Hazards

- type of hazard and location;
- special shutdown procedures: (complex or extended operations); and
- controlled environments (clean rooms, hyperbaric chambers, etc.).

Building Construction

- building access: doorways, locking devices, accessible windows, fire escapes, tunnels, breachable walls;
- length, width, height, number of stories;
- walls: interior finish materials;
- floors: (raised floors);
- ceilings: (multiple/suspended ceilings);
- roof and roof coverings: (concealed spaces/multiple levels);
- vertical and horizontal openings: large, undivided areas, unprotected openings between floors, stairwells, elevator shafts, utility shafts, escalators, type of fire doors;
- smoke and heat venting or smoke management: (manual or automatic), control locations; and

- atriums: location in the building, number of stories connected, number of stories open to atrium.

Building Utilities

- electricity: enters property, (overhead or underground) at, disconnects located at, transformers: (PCB);
- emergency power supplies;
- natural gas: for (building heat) (processes), shutoff located at;
- Liquefied petroleum gas (LPG): for (building heat) (processes), storage tank(s) located at, shutoff located at;
- domestic water;
- steam;
- elevators: number, floors served, type, restrictions and location, fire service override, locations of keys; and
- compressed air.

Exposures

- north;
- south;
- east;
- west; and
- environmental concerns.

Protection Systems

- automatic sprinklers: ceiling/roof systems, in-rack systems, other systems, system demand (gpm @ pounds per square inch (psi));
- water supplies: type of supply, fire pump (diesel) (electric), rating (gpm @ psi);
- available flow: static, residual, flow available (gpm @ psi), residual;
- required fire flow;
- hydrants;
- FDC: location, FDC supplies;
- standpipe and inside hose connections: type of system, hose outlets, pressure available, control and sectional valves, FDC, risers;
- fire extinguishers; and
- special protection features: type of system, (CO_2, Halon™, gaseous extinguishing agents, foam-water, dry chemical, and wet chemical); hazard or area protected by the system; location of control panels; location of all protective agent supply and reserve containers; activation method; personnel hazards of protective agent.

Fire Alarm and Communication Systems

- detection systems: method of system activation (manual, automatic); area of coverage; fire alarm control panel and remote annunciator panels; type of automatic detectors provided (smoke, heat, other); off-site alarm transmission; name of, and contact number for, off-site monitoring agency;
- occupant notification: voice alarm or public address system, method and extent of occupant notification;
- onsite communications system: stairway telephone system; radios; and
- contact person or company responsible for system maintenance: telephone number.

The Preincident Plan Walkthrough

As the preincident plan walkthrough is being conducted, you should capture this important information, using the forms referenced above or those used by your department.

Once the information has been gathered, a plan should be developed and it should be updated for currency on a regular or planned schedule. Deficiencies or problems identified (even though this is not a formal code enforcement inspection) must be noted and referred for corrective action. These deficiencies, if not corrected, could hamper the fire department's ability to properly deal with a fire when one starts.

It may involve only bringing the problem to the attention of the safety or risk manager, or it may appropriately be referred to your fire marshal or to the fire prevention division or other code enforcement official for further corrective action.

Best Practices

A system must be in place so that, not only is corrective action taken, but also you are notified when the corrections are completed, so that your preincident planning information will reflect this. A system of "Best Practices" notification should be established for your jurisdiction so that proper referral, action, and followup notifications take place, so that corrections are made and responders are advised that these corrections have been completed.

Activity 3.1

Value of Preincident Planning

Purpose

To provide an example of a real incident, where some aspects of preplanning helped in the overall management of the incident, and an ongoing preplanning process could have altered the ultimate fire outcome.

Directions

1. After viewing the video on the Builders' Square fire in Palm Beach County, Florida, in your assigned groups, discuss the questions listed below and have someone write your responses on an easel pad.

    a. What preincident planning had been done on this building?

    b. How recent was the preincident planning information?

    c. What preplanning information did the IC use in managing this fire?

    d. What might have been different if preplanning had been conducted at this **target hazard** on a more frequent basis? (Yes, we are Monday morning quarterbacking!)

    e. What were the benefits of the Palm Beach County Fire Department's knowledge of this facility and the surrounding area?

    f. What fire protection systems were in place in this facility, and what was their impact on this fire?

    g. Would more recent preplanning at this facility have resulted in different outcomes from this fire?

2. Select a spokesperson to share your findings with the rest of the class.

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Activity 3.2

Preincident Planning Documents

Purpose

To evaluate the target hazard plans you brought from your own jurisdiction and to identify any deficiencies in your own plans, using Job Aids 3.1 and 3.2.

Directions

1. Using Job Aid 3.1 "Target Hazard Assessment," evaluate the target hazard plan you brought to assign a level of risk: low, medium, or high.

2. Once you have completed the "Target Hazard Assessment," conduct a gap analysis on the same plan, using Job Aid 3.2 "Preincident Plan Gap Analysis."

3. Be prepared to describe your results tomorrow morning.

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Activity 3.3 (Optional)

To Report…or Not?

Purpose

To reflect upon and discuss ethical and legal issues pertaining to preincident planning.

Directions

1. You will be working in small groups.

2. In your assigned groups, identify and write on an easel pad a list of responses to the scenario.

3. Select a spokesperson from the group to report, and be prepared to discuss your answers with the rest of the class.

Scenario

You are a training officer for a small fire department that relies heavily on community donations for operating funds and equipment. A good public image and public relations are critical to your department's success.

During your weekly evening training exercise, you drill the firefighters on updating some preincident plans.

Lt. Smith and her crew go to Sisters of Mercy Community Hospital to review the facility's plan. When they arrive, Lt. Smith tells the apprehensive hospital administrator, "Don't worry, this isn't a code enforcement inspection; it's only for us to become familiar with the hospital in case there's a fire.

"Oh, and by the way, we hear the hospital is planning to give us a $75,000 donation to help us buy a new aid car. Thank you."

During the walk around the facility, Lt. Smith and her crew find

- several stairway fire doors propped open;
- two cylinders of ethylene oxide for the gas sterilizer sitting in a dirty linen room; and
- ceiling tiles removed from the drop-in grid ceiling in the accounting office.

Lt. Smith adds the ethylene oxide to the "special hazards" portions of the preincident plan, but isn't certain what to do about the other items.

Question: What should she do?

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Activity 3.4

Preincident Plan Data Sources

Purpose

To identify the variety of data sources for information included in preincident plans.

Directions

1. You will be working in your small table groups.

2. Review a list of 10 items that may be included on a preincident plan, and provide suggested sources where that information can be obtained **without physically visiting the facility for which the plan is being developed.**

3. Enter your responses on the following Worksheet.

4. Select a spokesperson from the group to report, and be prepared to discuss your answers with the rest of the class.

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Activity 3.4 (cont'd)

Preincident Plan Data Sources

Item		Information Sources
1	Roof structure construction	
2	Site security features	
3	Fire alarm annunciator location	
4	Standpipe hose outlet size and type	
5	Main electrical shutoff location	
6	Firewall locations	
7	Interior decorations flame-spread ratings	
8	Storm drain inlets/outlets for runoff control	

	Item	Information Sources
9	Elevator operating controls	
10	Post indicator valve locations	

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APPENDIX A

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Job Aid 3.1

Target Hazard Assessment

This Job Aid is intended to give IC's and firefighters a simple tool for assessing buildings and facilities to determine if they are target hazards needing additional, detailed evaluation and preincident planning. It also can be used to prioritize preincident planning activities.

A target hazard is any building or potential incident site (e.g., outside hazardous materials storage site, bulk fuels storage facility) that has the potential for significant life loss, high property dollar loss, and/or the ability to overwhelm local resources.

Following the Job Aid, you will find "Points to Consider" when completing the form. This is not an exhaustive list, and you must remember that all the factors should be considered in total: one point alone may not be more important than another.

Review each target hazard factor, and assign a score based on your subjective assessment.

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TARGET HAZARD ASSESSMENT

Address: _____ Occupancy Name: _____

Assessment Date: _____ Assessed by: _____

Review each target hazard factor, and circle the number to assign a score based on your subjective assessment.

Target Hazard Factor	Low			Medium				High		
1. Structural Hazards The possibility of full involvement or structural collapse is:	1	2	3	4	5	6	7	8	9	10
2. Occupant Characteristics The possibility of occupants needing assistance or rescue is:	1	2	3	4	5	6	7	8	9	10
3. Content Characteristics The possibility of explosion, full involvement, or toxic release is:	1	2	3	4	5	6	7	8	9	10
4. Protection Systems The possibility of fire protection systems not controlling the event is:	1	2	3	4	5	6	7	8	9	10
5. Fire Service or Brigade Capacity The possibility of needing additional resources to control the event is:	1	2	3	4	5	6	7	8	9	10
6. Water Supply The possibility that additional water supplies are needed is:	1	2	3	4	5	6	7	8	9	10
7. Exposure Factors The possibility an event here will spread beyond the boundaries is:	1	2	3	4	5	6	7	8	9	10
8. Community Value The economic, cultural, or social value of this property is:	1	2	3	4	5	6	7	8	9	10

Total Score _____

Scoring: 8 to 24 = Low Hazard
25 to 56 = Medium Hazard
57 to 80 = High Hazard

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Points to Consider

1. Structural Hazards

- Is the building construction exposed wood frame, protected wood frame, heavy timber, exposed steel, protected steel, or fire resistive?
- Does the building have concealed spaces such as attics, cocklofts, balloon construction, or shafts/chases?
- Are there obvious structural weaknesses, such as sagging walls, roofs, or attached features?
- Are there extra live or dead loads, such as signs, roof-top air handling, water tanks, cantilevered canopies, or fire escapes?
- Does the building contain one or more types of trusses in the floor, ceiling, or roof assemblies?
- Does the building have limited interior access or egress?
- Is the interior space divided into small or complicated compartments?
- Are there unprotected vertical openings, such as lightwells, stairways, shafts, or elevator or utility shafts?

2. Occupant Characteristics

- What action and resources are needed to ensure that all occupants can escape safely or can be rescued?
- Are the occupants awake, alert, oriented, and capable of self-preservation?
- Are the occupants infirm, nonambulatory, incarcerated, restrained, medicated, or otherwise incapable of self-preservation?
- Does the means of egress system allow for quick exit, or is it potentially congested?
- Are there areas of refuge where building occupants can await rescue?

3. Content Characteristics

- Are the contents nonflammable or noncombustible?
- Are the contents moderately or highly flammable or combustible?
- Are the contents explosive, toxic, or otherwise dangerous to life, health, or the environment?
- Are the contents arranged so they are easily accessible for fire control and suppression?
- Are the contents secret or of very high value?

4. Protection Systems

- Does the building or facility have automatic fire suppression equipment throughout?
- Does the building or facility have partial automatic fire suppression equipment?
- Does the building or facility have automatic or manual fire alarms?
- Are the specialty fire suppression systems for small target hazard areas?

5. Fire Service/Brigade Capacity

- Is there an onsite fire brigade with the capability to control the fire until your arrival?
- Does your organization possess adequate 24-hour staffing to respond in an emergency?
- Is automatic or mutual aid needed to help control an incident?
- Are there special resources (apparatus, equipment, or personnel) needed to control an incident?
- Is the fire brigade equipment compatible with the fire department?

6. Water Supply

- Is there an onsite water supply adequate for incident control?
- Do you need to bring additional water supplies and, if so, how long will it take?
- Do you have adequate pumping capacity to deliver the required fire flow?
- Where is the nearest secondary water supply and how will you get in?
- Are special extinguishing agents required, such as Class A or B foam, clean agent, Class D extinguishing agent, dry chemical, or carbon dioxide?

7. Exposure Factors

- Are there adjacent exposures? How near are they?
- Are the exposures combustible or noncombustible? Do they have protected or unprotected openings? Are they sprinklered?
- Do the exposures constitute a life hazard or fire hazard?
- What action and resources are needed to protect exposures?

8. Community Value

- Does the building or facility have significant cultural, economic, social, or religious value?
- Is the building or facility easily replaceable?
- Will a loss in this building or facility significantly affect the entire community?

Job Aid 3.2

Preincident Plan Gap Analysis

Gap analysis is a tool commonly used in business and industries that strive to achieve International Standards Organization (ISO) 9000 series quality management and performance certification. It is a formal means to identify gaps between desired and actual performance levels. Once the gaps are identified, priorities and responsibilities can be assigned to close them.

Job Aid 3.2 was developed to provide a simple gap analysis tool for evaluating existing preincident plans, and comparing them to a known industry practice: NFPA 1620.

In the gap analysis form, the check boxes identify the following categories:

- **Not applicable**. The information does not apply to that particular preincident plan.
- **Not known.** The person conducting the gap analysis does not know if the condition or feature occurs at the building or site.
- **Documented but Not Current.** The reviewer knows or suspects there has been a change in the condition or feature from when the plan was created or last updated.
- **Documented but Not Accurate.** The reviewer knows there is an error in the condition or feature that has not been changed on the plan.

You are encouraged to use this tool to evaluate your own preincident plans and to develop an improvement strategy. You may want to use it as a model, and customize it to your needs.

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Job Aid 3.2 (cont'd)

PREINCIDENT PLAN GAP ANALYSIS

Occupancy:_____

Address:_____

Preincident Plan No.:_____ Gap Analysis Date:_____

Gap Analysis Conducted by:_____

	Physical Elements and Site Considerations	Not Applicable	Not Known	Documented but Not Current	Documented but Not Accurate
1.	Does the plan show building height in feet, number of stories, area in square feet?				
2.	Does the plan show all access points and floor designations?				
3.	Does the plan identify fire spread potential via exterior or voids in curtain walls?				
4.	Does the plan show potential for falling glass, curtain wall, parapets, overhangs?				
5.	Does the plan show important building details? (i.e., unsupported exterior walls, masonry walls)				
6.	Does the plan show important *roof* details? (i.e., structure, deck, covering, dead loads, drainage)				
7.	Does the plan show important *floor* details? (i.e., structure, construction, drainage)				
8.	Does the plan show interior wall construction and finishes?				
9.	Does the plan identify concealed or confined spaces?				
10.	Does the plan identify ceiling finishes or structure? (i.e., suspended grids)				
11.	Does the plan identify fire protection ratings and protection of structural members?				
12.	Does the plan identify doors and locking mechanisms?				
13.	Does the plan show large undivided areas?				
14.	Does the plan identify unprotected openings between floors? (i.e., stairs, shafts, escalators)				
15.	Does the plan identify the type, location and controls for building utilities?				

Occupancy:_____

Address:_____

Preincident Plan No.:_____ Gap Analysis Date:_____

Gap Analysis Conducted by:_____

		Not Applicable	Not Known	Documented but Not Current	Documented but Not Accurate
16.	Does the plan identify conditions that might hamper access to the site? (i.e., bridges, tunnels)				
17.	Does the plan identify site security constraints? (i.e., animals, fences, gates, guards)				
18.	Does the plan identify all exposures? (i.e., adjacent buildings, tank farms, rail yards)				
19.	Does the plan address environmental concerns? (i.e., drainage, runoff, sewers, wind direction)				
20.	Does the plan address emergency scene communications problems? (i.e., interference, coverage)				
	Occupant Considerations				
1.	Does the plan address life safety considerations? (i.e., mobility, population, cognizance)				
2.	Does the plan list likely hours of operation when the building will be occupied?				
3.	Does the plan identify the likely number of occupants?				
4.	Does the plan identify the likely location of occupants and their means of egress?				
5.	Does the plan identify occupants with special needs who must be evacuated or defended in place?				
6.	Does the plan include an evacuation and relocation plan?				
7.	Does the plan integrate with the site's existing emergency organization and action plan?				
8.	Does the plan identify special onsite assistance? (i.e., safety, fire, haz mat coordinator)				
	Protection Systems and Water Supplies				
1.	Does the plan show all features of the water supply? (i.e., hydrant locations, fire flow, other sources)				

Job Aid 3.2 (cont'd)

Occupancy:_____

Address:_____

Preincident Plan No.:_____ Gap Analysis Date:_____

Gap Analysis Conducted by:_____

		Not Applicable	Not Known	Documented but Not Current	Documented but Not Accurate
2.	Does the plan show the location of fire department connections for sprinklers and standpipes?				
3.	Does the plan identify all features of fire pump installations? (i.e., location, start instructions)				
4.	Does the plan show information regarding automatic sprinklers? (i.e., coverage, type, valve locations)				
5.	Does the plan show information regarding standpipes? (i.e., class, valves, outlet locations and type)				
6.	Does the plan show information regarding fire alarm systems? (i.e., control panel, annunciator location)				
7.	Does the plan show types and locations of special suppression systems? (i.e., range hood, CO_2)				
8.	Does the plan show types and locations of portable fire extinguishers?				
9.	Does the plan provide information on smoke management systems? (i.e., controls, coverage, capacity)				
	Special Hazard Considerations				
1.	Does the plan identify special hazards that are unique or uncommon for this type of occupancy?				
2.	Does the plan list "transient conditions" that may change responses? (i.e., periodic production runs)				
3.	Does the plan address the type, location, quantity, and use of hazardous materials or chemicals?				
4.	Does the plan address special hazards to responders? (i.e., inert atmospheres, confined spaces, high angle)				

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Job Aid 3.3

Sample Preincident Planning Policy and Procedure

Standard Operating Procedures (SOP's), policies, or guides are a common tool employed in the fire service to establish and maintain minimum standards of care and performance.

The following sample policy and procedure for preincident planning can be adopted for use by any fire department.

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Job Aid 3.3 (cont'd)

Fire Department

SOP No. _____

PREINCIDENT PLANNING

Effective Date: _____ Reference: _____
Supersedes: _____ Author: _____

1.0 PURPOSE

Preincident planning is an important tool to collect information that can improve firefighter efficiency and safety at an emergency.

Preincident planning provides essential fire protection and safety information, such as, but not limited to: facility arrangement and apparatus access, building contents, water supply, construction details, and types and locations of built-in fire protection systems. It includes all pertinent information that affects the Incident Commander's (IC's) control objectives, strategies, and tactics employed during an emergency.

Preincident planning should be a joint venture among emergency personnel; code enforcement authorities; and the property owners, occupants, and risk managers.

This policy and procedure identifies the roles and responsibilities for fire companies, fire battalion/district chief officers, code enforcement officials, and the Training and Planning Divisions in preincident planning for emergencies.

2.0 POLICY

It shall be the policy of the _____ Fire Department to perform regular target hazard preincident planning, to conduct frequent training with these plans, and to assure a high degree of reliability and currency with the preincident planning information.

3.0 DEFINITIONS

"Code enforcement authorities" shall mean the _____ building official, building inspector, plans examiner, planning director, zoning technician, fire marshal, fire inspector, and/or their designees.

"Preincident plan" shall mean the standard _____ Fire Department paper-based or electronic reporting means adopted by the Incident Operations Committee.

"Tactically significant occupancy" shall mean any building or facility that does not meet the definition of "target hazard," but may provide one or more challenges to first responders, such as facility arrangement and apparatus access, unusual building contents, water supply, construction details, or types and locations of built-in fire protection systems.

"Target hazard" shall mean any building or potential incident site (e.g., outdoor hazardous materials transfer site, bulk fuel storage facility) that has the potential for significant life loss, high property dollar loss, and/or the ability to overwhelm the _____ _____ Fire Department resources.

4.0 PROCEDURES

4.1 Fire Company Officers

4.1.1 Each calendar quarter, Company Officers (CO's) shall select a target hazard or tactically significant occupancy to preplan for emergency incidents in their first-due area. CO's may choose to use the Target Hazard Assessment form (Form No. __) to prioritize their efforts. The selected property shall be approved by the officer's immediate supervisor.

4.1.2 When the CO has selected an appropriate site for a preplan, he/she should meet the owner/occupant at the selected site and, together with the owner/ occupant, complete the preincident plan data collection form (Form No. _____). Companies are encouraged to make drawings or record other information that may be useful in a response book carried on the apparatus.

4.1.3 The CO shall make every preincident plan survey a training opportunity. Preincident plan data collection forms shall be posted in the station in a conspicuous location for review and comment for not less than 30 days. Training records shall be forwarded to the Battalion/District Chief.

4.1.4 At the end of the posting period, the preincident plan data collection form shall be sent to the Planning Division.

4.2 Battalion/District Chiefs

4.2.1 Battalion/District Chiefs shall review their CO's recommended preincident plans and approve or revise as necessary.

4.2.2 Battalion/District Chiefs shall conduct an annual gap analysis of existing preincident plans, prioritize updates, and assign projects at their discretion. A copy of the gap analysis report shall be sent to the Planning Division.

4.2.3 Battalion/District Chiefs shall conduct at least one multiple company drill each quarter employing the preincident plans for target hazards or tactically significant occupancies. Training records shall be forwarded to the Training Division.

4.3 Planning Division

4.3.1 The Planning Division shall receive all preincident planning data collection forms and prepare them in final paper-based or electronic versions using the _____ Fire Department approved software.

4.3.2 The Planning Division shall distribute copies of final preincident plans to all CO's, battalion/district chiefs, and the communications center.

4.4 Training Division

4.4.1 The Training Division shall schedule not less than two all-company drills annually using preincident plans for target hazards or tactically significant occupancies.

4.4.2 The Training Division shall maintain records of all training conducted with preincident plans for target hazards or tactically significant occupancies.

4.5 Code Enforcement

4.5.1 During permit plan review and inspection, code enforcement authorities shall identify new or existing occupancies that are potential target hazards or tactically significant occupancies. This information shall be transmitted to the CO in the appropriate response area.

4.5.2 Code enforcement authorities shall share with the fire CO's all publicly available information pertinent to preincident planning.

5.0 FORMS

5.1.1 Form No. ____, *Preincident Plan Data Collection*
5.1.2 Form No. ____, *Target Hazard Assessment*
5.1.3 Form No. ____, *Preincident Plan Gap Analysis*

By order of the Fire Chief _____

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APPENDIX B

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Primary Factors Size-Up Chart

Column #1 Primary Factor Size-Up Chart			Column #2 Incident Objectives Attainable/ Measurable/ Flexible	Column #3 Strategies	Column #4 Evaluate Effect of Strategies Every 10 Minutes	
Pertinent Factors (P)	(Check appropriate boxes) P				Effective	Ineffective
Life Hazard	Occupants		Examples of Incident Objectives:	[R] **Rescue** • Interior/Exterior/Both		
	Firefighters		• Remove all civilians from danger. • Contain and Control Fire. • Remove smoke from the building. • Care for any injured civilians or FF's.			
Location/Fire	Where and how big Exposures on Arrival			[E] **Exposure Protection** • Exposure lines		
	After Arrival – Burn Time					
	Radiation/Conduction/Convection			[C] **Confinement** • Hoseline Placement – six sides		
Construction	F/R, NC, HT, ORD., WF					
	Fire Bldg./Exposures		List Incident Objectives:	[E] **Extinguishment** • Hoseline Placement		
Occupancy (Contents)	Fire Building			[O] **Overhaul** • Expose Hidden Fire		
	Exposures		1. _____			
Height	Fire Building (Front/Rear)			[V] **Ventilation** • Removal of smoke/toxic gases • Fire Control		
	Exposures (Front/Rear)		2. _____			
Area	Fire Building/Configuration					
	Proximity of Exposures /Config.		3. _____	[S] **Salvage** • Water – Run-Off • Apply Covers		
Exposures	Fire Building		4. _____			
	Structural Collapse					
	Collapse Zone		5. _____			
	Apparatus Placement			List Incident Strategies / Assigned To:	Identify alternative strategies for firefighter safety when occupant safety has been determined not to be a Primary Factor.	
Weather	Visibility		6. _____	1.	• _____	
	Temperature/Humidity			2.		
	Wind – Direction/Velocity		7. _____	3.	• _____	
Apparatus/ Personnel	Special Equipment - RIC			4.		
	Sufficient Companies/Personnel		8. _____	5.	• _____	
Auxiliary Appliances	Fire Building Supplied			6.		
	Exposures Supplied		9. _____	7.	• _____	
Special Matters	HazMats, Open shafts, etc.			8.		
			10. _____		• _____	
Water	Available/Needed			9.		
					• _____	
Time	Duration of Operations (Rest-Rehab) Time of Day Time of Alarm			10.		

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APPENDIX C

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Quick Access Prefire Plan

Building Address:

Building Description:

Roof Construction:

Floor Construction:

Occupancy Type:	**Initial Resources Required:**

Hazards to Personnel:

Location of Water Supply:	**Available Flow:**

	Estimated Fire Flow			
Level of Involvement				
Estimated Fire Flow				

Fire Behavior Prediction:

Predicted Strategies:

Problems Anticipated:

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

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Quick Access Prefire Plan Example

Building Address:
1234 Fairchild Street

Building Description:
One-story, exterior masonry walls

Roof Construction:
Plywood panels on wood trusses, hot mop finish

Floor Construction:
Concrete slab

Occupancy Type:	**Initial Resources Required:**
Mixed production, office, warehouse	*4 Engines, 2 Trucks, 1 Tender, 1 EMS, 1 Chief*

Hazards to Personnel:
1. *Woodworking: dust and power equipment.*
2. *Flammable liquid storage and painting.*

Location of Water Supply:	**Available Flow:**
Hydrants on all corners of site.	*1,175 gpm*

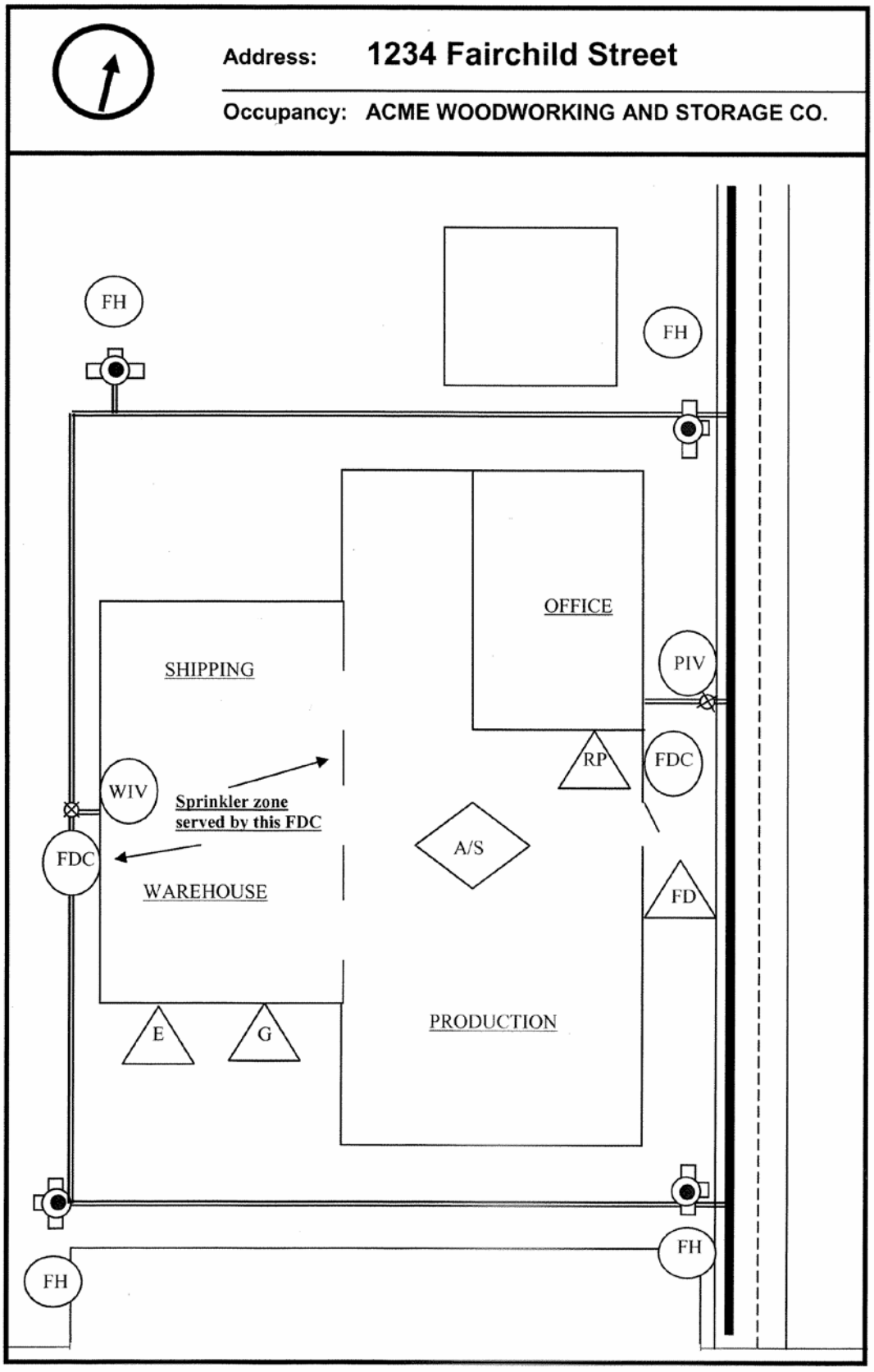
	Estimated Fire Flow			
Level of Involvement	*25%*	*50%*	*75%*	*100%*
Estimated Fire Flow	500	1,000	1,500	2,000

Fire Behavior Prediction:
Rapid, due to extensive combustible load

Predicted Strategies:
1. *Assist daytime staff with immediate rescue*
2. *Support automatic sprinkler system*
3. *Protect exposures*

Problems Anticipated:
Potential for low water volume at onsite hydrants

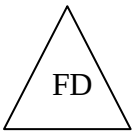
☐ **Standpipe:** *No*	☒ **Sprinklers:** *Wet pipe throughout*	☐ **Fire Detection:** *No*


Address: 1234 Fairchild Street
Occupancy: ACME WOODWORKING AND STORAGE CO.
FH
FH
OFFICE
SHIPPING
PIV
RP
FDC
WIV
Sprinkler zone
served by this FDC
A/S
FDC
WAREHOUSE
FD
PRODUCTION
E
G
FH
FH

NFPA 170, *Standard For Fire Safety Symbols*

The following symbols are from NFPA 170, *Standard for Fire Safety Symbols*. They are the recommended symbols for preincident plans.

1. Fire department access point



2. Wall

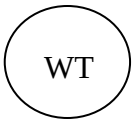
3. Door



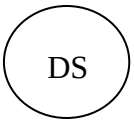
4. Opening (Window)

5. Water sources

Tank



Drafting site



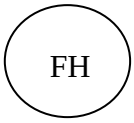
6. Water main

Public

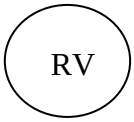
Private



7. Fire hydrant

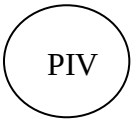


8. Riser, fire sprinkler system



9. Valves

Post indicator



Outside stem and yoke



Wall indicator

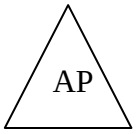


10. Fire department connection



11. Fire alarm panel

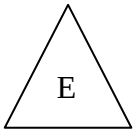
Annunciator



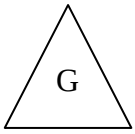
Reset



12. Electrical shutoff



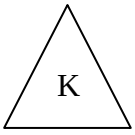
13. Gas shutoff



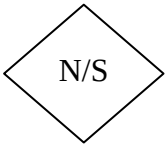
14. Domestic water shutoff



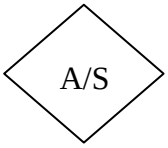
15. Key box



16. Building area not sprinklered



17. Building area sprinklered



18. Fire pump room



APPENDIX D

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Preincident Planning Data Collection Sheet

This form was developed to serve as an information-gathering tool for formulating a preincident plan. As much information as possible has been identified on this form, but it is not intended to imply that it is all-inclusive. There may be other elements of a building that do not fit exactly into one of the fields on this form. Therefore, it is incumbent on the officer directing the preplan data collection process to ensure that this information is documented and then included using the final preplan storage and retrieval system (computer system, paper system, GIS, etc.).

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Preincident Planning Data

Fire Company/District: _____ Date: _____ Preplan #: _____

Preincident Plan Data Collection Team: _____

_____

Normal Response Assignment: _____

Mutual-Aid/Automatic-Aid Response Units: _____

_____

Special Need Apparatus or Equipment: _____

Facility Information

Address: _____

Facility/Building Name: _____

Telephone Number: _____

Operations and Access Information

Operating Hours: Normal/Open: _____ Closed: _____

Likely Number of Occupants:

Day (1st) Shift	
Swing (2nd) Shift	
Night (3rd) Shift	

Physically Challenged or Special Needs Occupants: Yes ☐ No ☐ Locations: _____

_____

Primary Access: _____

Exterior Site Access Issues: Yes ☐ No ☐ Locations: _____

_____

Side A for Command Purposes: _____

Recommended Locations for
Primary Staging: _____

Secondary Staging: _____
Base: _____

Lock Box: Yes ☐ No ☐ Location/Contents: _____

Guard Animals: Yes ☐ No ☐ Type/Location: _____

Fire Command Center: Yes ☐ No ☐ Location/Contents: _____

Emergency Operations Center: Yes ☐ No ☐ Location/Contents: _____

Exterior Door Access Concerns: Yes ☐ No ☐ Locations: _____

Interior Roof Access: Yes ☐ No ☐ Locations: _____

Obstructions to Elevated Equipment (silos, cyclones, tanks, towers): Yes ☐ No ☐

Locations: _____

Occupancy Type/Use

Principal Use: _____

High Fire Load: Yes ☐ No ☐ Locations: _____

Life Safety Concerns: Yes ☐ No ☐ Locations: _____

Evacuation Plan: Yes ☐ No ☐ Assembly Point Location: _____

Construction

Number of Stories: _____ Number of Basements (full or partial): _____

Average Square Footage per Story: _____

Penthouse: Yes ☐ No ☐ Occupancy/Use: _____

Roof Structure Construction: _____

Trusses: Yes ☐ No ☐ Type: _____

Roof Deck Material: _____

Roof Covering Material: _____

Floor Construction: _____

Trusses: Yes ☐ No ☐ Type: _____

Wall Construction: _____

_____

Blast- or Explosion-Resistant Walls or Windows: Yes ☐ No ☐ Location(s): _____

_____

Combustible Concealed Spaces: Yes ☐ No ☐

Locations: ☐ Attic ☐ Cockloft ☐ Crawl Space ☐ Other: _____

Interior Fire Barriers and Walls: Yes ☐ No ☐ Locations: _____

_____

Wall Penetrations: Yes ☐ No ☐ Locations: _____

_____

Openings Protected by: ☐ Doors ☐ Shutters ☐ Sprinklers ☐ Not Protected

Interior Stairs: Number: _____ Location: _____

_____

Stairway Obstructions: Yes ☐ No ☐ Locations: _____

_____

Elevators: Number: _____ Location: _____

_____

Area Served--Full or Partial: _____

Fire Service Mode: Yes ☐ No ☐ Elevator Key Location: _____

_____

Elevator Controls Location: _____

Unprotected Vertical Openings: Yes ☐ No ☐ Type/Location: _____

_____

Hazards

Trash and Waste Hazards: _____

Incinerator or Compactor: Yes ☐ No ☐ Locations: _____

_____

Incinerator or Compactor Chutes: Yes ☐ No ☐ Locations: _____

Incinerator or Compactor Chutes Sprinklered: Yes ☐ No ☐

Outside Compactors or Dumpsters: Yes ☐ No ☐ Locations: _____

_____

Compactors or Dumpsters Exposed or Attached to Exterior: Yes ☐ No ☐ Locations: _____

_____

Hazardous Materials Present: Yes ☐ No ☐ Locations: _____

_____

Location of MSDS Sheets: _____

_____

Hazardous Materials Inventory Attached: Yes ☐ No ☐

Location for Emergency Use: _____

Reactive Materials (with air, water) or other materials present: Yes ☐ No ☐

Type/Location: _____

_____

Radioactive Materials Present: Yes ☐ No ☐ Locations: _____

Process Hazards Present: Yes ☐ No ☐ Locations: _____

Water Supply

Primary Water Supply: _____

Flow Readings: _____

Test Location: _____ Flow Test Date: _____

Static Pressure: _____ Residual Pressure: _____ Flow Rate: _____

Alternative Sources: _____

_____

Private Supply: Yes ☐ No ☐ Type: ☐ Gravity Tank ☐ Other Tank ☐ Cistern ☐ Other:

_____

Process System: ☐ Reservoir ☐ Other: _____

Fire Pump: ☐ Yes ☐ No ☐ Supplied by: ☐ Public Water ☐ Private Water

Start-up: ☐ Automatic ☐ Manual

Shut down: ☐ Automatic ☐ Manual

Automatic Transfer Switch? ☐ Yes ☐ No

Number of Pumps: _____

Pump Locations: _____

Onsite Hydrants: Yes ☐ No ☐ Supplied by: ☐ Public ☐ Private

Size of Outlets and Threads: _____

Hydrant Locations : _____

_____

Hydrant Gate Valves? ☐ Yes ☐ No

Hydrant Gate Valve Locations: _____

Which System Supplies Which Protection Systems: _____

_____

Nearest Large-Volume Water Supply Greater than 2,000 gpm: _____

_____

Fire Flow Calculations: (See Appendix F.)

Largest Single Fire Area: _____

Fire Protection Systems

Fire Alarm System: Yes ☐ No ☐ Panel Location: _____

Annunciator Location(s): _____

Type of Alarms: _____

Extent of Coverage: _____

Monitored Systems: Yes ☐ No ☐

Fire Alarm Monitoring Company: _____

Telephone: _____

Sprinkler Systems: Yes ☐ No ☐ Location of FDC: _____

_____

Number of FDC Hose Inlets: _____

Thread Design, if not National Standard: _____

Size of FDC Threads: ☐ 2-1/2-inch ☐ 4-inch ☐ 5-inch ☐ Other: _____

Type of Systems: ☐ Wet ☐ Dry ☐ Preaction ☐ Deluge ☐ Other (Describe): _____

_____

Extent of Coverage (full or limited area): _____

Areas Protected (if limited area): _____

_____

Main Control Valve(s) Location(s): _____

Sectional Control Valve(s) Location(s): _____

System Coverage Plan at Valves: Yes ☐ No ☐

Standpipe and Inside Hoses: Yes ☐ No ☐

Standpipe Class(es): ☐ Class I ☐ Class II ☐ Class III

Combined with Sprinkler System: Yes ☐ No ☐

FDC Same as for Sprinkler System: Yes ☐ No ☐

Location of FDC: _____

Number of FDC Hose Inlets: _____

Thread Design, if not National Standard: _____

Size of FDC Threads: ☐ 2-1/2-inch ☐ 4-inch ☐ 5-inch ☐ Other: _____

Outlet Locations: ☐ Stairway ☐ Open Floor ☐ Other

Outlet Type: ☐ Nonpressure Regulating ☐ Pressure Regulating

Outlet Size(s): _____

Occupant Use Hose: Yes ☐ No ☐

Special Protection Systems: Yes ☐ No ☐

Type of Systems: _____

Locations: _____

Extent of Coverage--Full or Partial: _____

Utilities

Y	N	Service	Shutoff Location	Service Provider
		Natural Gas		
		LP Gas		
		Fuel Oil		
		Electric		
		Emergency Power		
		Heating		
		Water		
		Hot Water		
		Steam		
		A/C and Ventilation		
		Specialty Gas*		
		Specialty Liquid*		

*Record type of gas or liquid

Exposures

Exposure	Separation	Life Hazard	Fire Load	Construction	Sprinklered		Priority
					Y	**N**	

Legend:	**Description**	**Sample Entry**
Exposure	Nearest important building or structure	A, B, C, D or 1, 2, 3, 4 Tank farm, office building
Separation	Distance in feet	Self-explanatory
Life Hazard	Occupants not capable of self-preservation	High, medium, low
Fire Load	Combustibility of contents	High, medium, low
Construction	Combustible or Noncombustible	Combustible or Noncombustible
Sprinklered	Full sprinkler protection	Yes/No
Priority	Importance for protection	1 to 5, High = 1, Low = 5

Other Exposure Concerns: _____

Special Resource Considerations: _____

Technical Rescue Exposures

High Angle: Yes ☐ No ☐ Locations: _____

Confined Space: Yes ☐ No ☐ Locations: _____

Remarks

Contact Information

Name	Title	Telephone	Emergency	Mobile	E-mail
	Primary Contact				
	Owner				
	Manager				
	Fire/Safety Director				
	Emergency Director				
	Maintenance Director				
	Haz Mat Coordinator				
	Medical Director				
	Occupant(s)				
	Other(s)				

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Sample

Preincident Planning Data

Fire Company/District: *Engine 3-A* Date: *8-4-04* Preplan #: *04-17*

Preincident Plan Data Collection Team: *Lt. Catellano, Smith, Vander Heiden*

Normal Response Assignment: *Engines 1-3-4-11, Truck 2, Medic 19, Air Unit 1, Chief 2, Chief 5*

Mutual-Aid/Automatic-Aid Response Units: *Mutual Aid: Cedarville Truck 3; Tenders 4, 11, 17; Belvedere Engines 6 and 27; Merrydale Ambulance 1 and 2*

Special Need Apparatus or Equipment: *Cedarburg Air Unit 202*

Facility Information

Address: *2719 Southeast Powell Avenue*

Facility/Building Name: *Winchester Consolidated High School*

Telephone Number: *555-433-1212*

Operations and Access Information

Operating Hours: Normal/Open: *0630 to 1730* Closed: *1730 to 0630; although there may be special evening events in the cafeteria, auditorium, or library.*

Likely Number of Occupants:

Day (1st) Shift	*1,150 (School year only)*
Swing (2nd) Shift	*3-5 custodial staff*
Night (3rd) Shift	*1-3*

Physically Challenged or Special Needs Occupants: Yes ☒ No ☐ Locations: *Severely disabled students in wheelchairs and motorized carts in special education wing, and infants in Room 19 day care center.*

Primary Access: *From Interstate 21 to main parking lot at intersection of Southeast Powell Avenue and 27th Street*

Exterior Site Access Issues: Yes ☒ No ☐ Locations: *At night, chain-link fence gate is closed and locked around running track. This blocks access to east end of gymnasium.*

Side A for Command Purposes: *Principal's office nearest parking lot off Southeast Powell Avenue*

Recommended Locations for:

Primary Staging: *Teacher's parking lot*

Secondary Staging: *Student parking lot*

Base: *Safeway parking lot*

Lock Box: Yes ☒ No ☐ Location/Contents: *Next to main entrance by Principal's office. Will need attic ladder to reach as it is located above the door frame to the left. Contains master key for all spaces and key to dust collection silo trap door.*

Guard Animals: Yes ☐ No ☒ Type/Location:

Fire Command Center: Yes ☐ No ☒ Location/Contents: *N/A*

Emergency Operations Center: Yes ☐ No ☒ Location/Contents: *Not on site, see School District Headquarters*

Exterior Door Access Concerns: Yes ☒ No ☐ Locations: *At night, when school is not occupied, all exterior exit doors with panic hardware are chained shut to prevent break-ins.*

Interior Roof Access: Yes ☒ No ☐ Locations: *Two locations: 1) East wing, head custodian's office/work area. 2) In back of cafeteria kitchen next to walk-in closet.*

Obstructions to Elevated Equipment (silos, cyclones, tanks, towers): Yes ☐ No ☒ Locations: *Dust collection system at woodshop has an exterior ladder to the top. The trap door at the top is locked. The key for the padlock is in the key box near the Principal's office.*

Occupancy Type/Use

Principal Use: *High School*

High Fire Load: Yes ☐ No ☒ Locations: _____

Life Safety Concerns: Yes ☒ No ☐ Locations: *Severely disabled students in wheelchairs and motorized carts in special education wing, and infants in Room 19 day care center.*

Evacuation Plan: Yes ☒ No ☐ Assembly Point Location: *Football field and running track at south side of campus.*

Construction

Number of Stories: *1* Number of Basements (full or partial): *Small partial basement beneath boiler room*

Average Square Footage per Story: *187,000*

Penthouse: Yes ☐ No ☒ Occupancy/Use: _____

Roof Structure Construction: *Wooden plywood panels on wood-aluminum tube trusses*

Trusses: Yes ☒ No ☐ Type: *Wood-aluminum tube*

Roof Deck Material: *Wooden plywood panels with hot mot asphalt and pea gravel*

Roof Covering Material: *Hot mot asphalt and pea gravel*

Floor Construction: *Concrete slab*

Trusses: Yes ☐ No ☒ Type: *N/A*

Wall Construction: *Concrete masonry units (CMU), poured-in place tilt-up and brick veneer; gypsum wallboard interior finishes*

Blast- or Explosion-Resistant Walls or Windows: Yes ☐ No ☒ Location(s): *N/A*

Combustible Concealed Spaces: Yes ☐ No ☒

Locations: ☐ Attic ☐ Cockloft ☐ Crawl Space ☐ Other: _____

Interior Fire Barriers and Walls: Yes ☒ No ☐ Locations: 2-hour fire wall cuts building almost in half; one-hour fire walls around boiler room, auditorium, cafeteria, and library

Wall Penetrations: Yes ☒ No ☐ Locations: Numerous doors with self-closures in fire walls; doors are supposed to close automatically when the fire alarm system goes off.

Openings Protected by: ☒ Doors ☐ Shutters ☒ Sprinklers ☐ Not Protected

Interior Stairs: Number: None Location: _____

Stairway Obstructions: Yes ☐ No ☒ Locations: None

Elevators: Number: None Location: _____

Area Served--Full or Partial: N/A

Fire Service Mode: Yes ☐ No ☐ Elevator Key Location: N/A

Elevator Controls Location: N/A

Unprotected Vertical Openings: Yes ☐ No ☒ Type/Location: _____

Hazards

Trash and Waste Hazards: Each classroom has a cardboard barrel for paper recycling.

Incinerator or Compactor: Yes ☒ No ☐ Locations: Incinerator is next to custodian's office in main boiler room. Trash compactor is outdoors under canopy next to cafeteria.

Incinerator or Compactor Chutes: Yes ☐ No ☒ Locations: _____

Incinerator or Compactor Chutes Sprinklered: Yes ☐ No ☒

Outside Compactors or Dumpsters: Yes ☒ No ☐ Locations: *Trash compactor is outdoors under canopy next to cafeteria.*

Compactors or Dumpsters Exposed or Attached to Exterior: Yes ☒ No ☐ Locations: *Trash compactor is outdoors under canopy next to cafeteria.*

Hazardous Materials Present: Yes ☒ No ☐ Locations: *Small amounts of flammable liquids and gases in Chemistry Lab, Room 122*

Location of MSDS Sheets: *3-ring binder on shelf behind teacher's desk Chemistry Lab, Room 122*

Hazardous Materials Inventory Attached: Yes ☐ No ☒

Location for Emergency Use: _____

Reactive Materials (with air, water) or other materials present: Yes ☐ No ☒

Type/Location: *Ethyl alcohol, propane, compressed air, ether, silicon dioxide, reagents, calcium hypochlorite, sodium hydroxide, sodium chloride, carbon tetrachloride. Cans or glass bottles on shelf in Chemistry Lab Storage Room*

Radioactive Materials Present: Yes ☐ No ☒ Locations: _____

Typical Locations: _____

Process Hazards Present: Yes ☐ No ☒ Locations: _____

Water Supply

Primary Water Supply: *South Winchester County Water and Sewer Authority*

Flow Readings: _____

Test Location: *Fire hydrant in parking lot in front of school* Flow Test Date: *6-15-03*

Static Pressure: *65* Residual Pressure: *42* Flow Rate: *1275 gpm*

Alternative Sources: _____

Private Supply: Yes ☐ No ☒ Type: ☐ Gravity Tank ☐ Other Tank ☐ Cistern ☐ Other:

Process System: ☐ Reservoir ☐ Other: N/A

Fire Pump: ☒ Yes ☐ No ☐ Supplied by: ☒ Public Water ☐ Private Water

Start-up: ☒ Automatic ☐ Manual--Number of Pumps: 1

Shut down ☒ Automatic ☐ Manual

Automatic Transfer Switch ☒ Yes ☐ No

Pump Locations: Sprinkler riser room on southeast corner of main building.

Onsite Hydrants: Yes ☒ No ☐ Supplied by: ☒ Public ☐ Private

Size of Outlets and Threads: 2-2 1/2 and one 5-inch on each hydrant

Hydrant Locations : Main parking lot, teachers' parking lot, south side of gymnasium, north side of cafeteria (by loading dock), entrance to football stadium.

Which System Supplies Which Protection Systems: Sprinkler riser room on southeast corner of main building has four systems. System No. 1 (wet) protects classrooms and administrative offices System No. 2 (wet) protects auditorium, cafeteria and gym. System No. 3 (wet) covers rest of school except under football Stadium. System No. 4 (dry) protects boiler roof, loading dock and storage/restroom areas under football stadium.

Nearest Large-Volume Water Supply Greater than 2,000 gpm: 16-inch water main supplies hydrants at corner of 14th Avenue and Southeast Powell.

Fire Flow Calculations:

Largest Single Fire Area: Auditorium and stage

Fire Protection Systems

Fire Alarm System: Yes ☒ No ☐ Panel Location: *Main panel is in custodian's area in main electrical room*

Annunciator Location(s): *Wall-mounted next to main entrance; custodian's office*

Type of Alarms: *Smoke detectors, pull stations, and water flow switches*

Extent of Coverage: *No automatic detection in gym other than sprinkler water flow. All other areas covered by smoke detectors. Pull stations next to each exit and one in sprinkler riser room and at office secretary's PBX.*

Monitored Systems: Yes ☒ No ☐

Fire Alarm Monitoring Company: *Winchester County Emergency Communications Center*

Telephone: *555-444-1111*

Sprinkler Systems: Yes ☒ No ☐ Location of FDC: *On wall next to sprinkler valve room*

Number of FDC Hose Inlets: *3*

Thread Design, if not National Standard: *None, it's NST*

Size of FDC Threads: ☒ 2-1/2-inch ☐ 4-inch ☐ 5-inch ☐ Other:

Type of Systems: ☒ Wet ☒ Dry ☐ Preaction ☐ Deluge ☐ Other (Describe):

Extent of Coverage (full or limited area): *Full*

Areas Protected (if limited area):

Main Control Valve(s) Location(s): *Sprinkler riser room (OS &Y)*

Sectional Control Valve(s) Location(s): *Painting room in auto shop has one small isolation valve.*

System Coverage Plan at Valves: Yes ☒ No ☐

Standpipe and Inside Hoses: Yes ☐ No ☒

Standpipe Class(es): ☐ Class I ☐ Class II ☐ Class III

Combined with Sprinkler System: Yes ☐ No ☒ N/A

FDC Same as for Sprinkler System: Yes ☐ No ☒ N/A

Location of FDC: N/A

Number of FDC Hose Inlets: N/A

Thread Design, if not National Standard: N/A

Size of FDC Threads: ☐ 2-1/2-inch ☐ 4-inch ☐ 5-inch ☐ Other: _____

Outlet Locations: ☐ Stairway ☐ Open Floor ☐ Other

Outlet Type: ☐ Nonpressure Regulating ☐ Pressure Regulating

Outlet Size(s): N/A

Occupant Use Hose: Yes ☐ No ☐

Special Protection Systems: Yes ☒ No ☐

Type of Systems: Wet chemical system in cafeteria kitchen hood-and-duct exhaust.

Locations: Cafeteria kitchen hood and duct exhaust.

Extent of Coverage--Full or Partial: Cafeteria kitchen hood-and-duct exhaust.

Utilities

Y	N	Service	Shutoff Location
X		Natural Gas	Gas meter outside boiler room
		LP Gas	
		Fuel Oil	

X		Electric	Main meter outside boiler room; subpanels in each wing
		Emergency Power	
X		Heating	Rooftop units
X		Water	Foot valve outside sprinkler riser room
		Hot Water	
		Steam	
X		A/C and Ventilation	Rooftop units
X		Specialty Gas* (Natural Gas)	Main Bunsen burner valve outside Chemistry Room 122
		Specialty Liquid*	

*Record type of gas or liquid

Exposures

Exposure	Separation	Life Hazard	Fire Load	Construction	Sprinklered		Priority
					Y	**N**	

Legend:	**Description**	**Sample Entry**
Exposure	Nearest important building or structure	A, B, C, D or 1, 2, 3, 4 Tank farm, office building
Separation	Distance in feet	Self-explanatory
Life Hazard	Occupants not capable of self-preservation	High, medium, low
Fire Load	Combustibility of contents	High, medium, low
Construction	Combustible or Noncombustible	Combustible or Noncombustible
Sprinklered	Full sprinkler protection	Yes/No
Priority	Importance for protection	1 to 5, High = 1, Low = 5

Other Exposure Concerns: _____

Special Resource Considerations: _____

Technical Rescue Exposures

High Angle: Yes ☐ No ☒ Locations: _____

Confined Space: Yes ☒ No ☐ Locations: *Small work and access area beneath main boiler.*
Permitted confined space; permits and plan posted on door into confined space.

Remarks

Contact Information

Name	Title	Telephone	Emergency	Mobile	E-mail
Audrey Summers	Primary Contact	555-491-6875	555-491-6875		
Principal					
	Owner				
Audrey Summers	Manager				
Lois Henderson	Fire/Safety Director	555-718-9080	555-718-9080		
	Emergency Director				
	Maintenance Director				
	Haz Mat Coordinator				
	Medical Director				
	Occupant(s)				
Errol Anthony	Other(s)	555-482-1111	555-482-1111		
Head Custodian					

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APPENDIX E

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Preincident Plan Form

This form was developed to capture the important details that were collected by the preincident plan data collection or survey team, and condense the information into a useable format. This is only one example of how information may be carried on fire apparatus. Fire officers are encouraged to develop similar forms that may serve their agency's unique needs or style.

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Expiration Date:

Preincident Plan

Fire Company District: **Date**: **Preplan#**:

Street Address:

Facility Name: **Telephone:**

Normal Response Assignment:

Mutual-Aid/Automatic-Aid Response Units:

Site Access and Restrictions:

Fences:

Security Office Location:

Guard Animals:

Lockbox Location:

Fire Command Center:

Emergency Operations Center:

Remote Annunciator:

Fire Alarm Panel:

Life Safety and Occupant Considerations

Operating Hours: Normal/Open: **Closed:**

Number of Occupants: Daytime: **Evenings:** **Nights:**

Physically Challenged/Special Needs:

Areas of Refuge:

Emergency Contacts:

Site Emergency Response Plan

Emergency Coordinator:

Primary Staging Area:

Secondary Staging Area:

Occupancy or Special Hazards

Type of Hazard and Location:

Special Shutdown Procedures:

Controlled Environments:

Building Construction

Building Access:

Length: **Width:** **Height:** **Number of Stories:**

Walls:

Vertical and Horizontal Openings:

Smoke and Heat Venting or Smoke Management:

Control Locations:

Building Utilities

Electricity:

Emergency Power Supplies:

Natural Gas:

LP-Gas:

Domestic Water:

Steam:

Elevators:

Exposures

North:

South:

East:

West:

Environmental Concerns:

Protection Systems

Automatic Sprinklers:

Water Supplies:

Available Flow:

Required Fire Flow:

Hydrants:

Fire Department Connection:

Standpipe and Inside Hose Connections:

Fire Extinguishers:

Special Protection Systems:

Fire Alarm and Communication Systems

Detection System:

Occupant Notification:

Onsite Communications System:

Contact Person or Company Responsible for System Maintenance:

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Sample

Expiration Date: December 31, 2005

Preincident Plan

Fire Company District: Engine 3-A **Date:** August 4, 2004 **Preplan#:** 04-17

Street Address: 2719 Southeast Powell Avenue

Facility Name: Winchester Consolidated High School **Telephone:** 555-433-1212

Normal Response Assignment: E-1, 3, 4, 11, T-2; M-19; AU 1; C-2, C-5

Mutual-Aid/Automatic-Aid Response Units: Cedarville T-3, Te-4, 11, 17; Belvedere E-6 and 27; Merrydale A-1 and 2

Site Access and Restrictions: From Interstate 21 to main parking lot at intersection of Southeast Powell Avenue and 27th Street.

Fences: 8-foot chain-link fence around running track and football stadium.

Security: None

Security Office Location: None

Guard Dogs: None

Lockbox Location: Next to main entrance by Principal's office. Need attic ladder to access.

Fire Command Center: None

Emergency Operations Center: None

Remote Annunciator: Mounted on wall next to main entrance.

Fire Alarm Panel: Simplex Model 2001 located in main electrical room next to custodian's office.

Life Safety and Occupant Considerations

Operating Hours: Normal/Open: 0630 to 1730 **Closed:** 1730 to 0630

Number of Occupants: Daytime: 1,150 **Evenings:** Variable **Nights:** Three

Physically Challenged/Special Needs: Severely disabled students in wheelchairs and motorized carts in Special Education wing. Infants in Room 19 day care center.

Areas of Refuge: (Defend-In-Place Strategy) None

Emergency Contacts: (Name, Title, Telephone)

- Principal: Audrey Summers (555-491-6875)
- Head Custodian: Errol Anthony (555-482-1111)
- School District Safety Manager: Lois Henderson (555-718-9080)

Note: these are all 24-hour contact numbers.

Site Emergency Response Plan

Emergency Coordinator: Principal: Audrey Summers (555-491-6875)

Primary Staging Area: School main parking lot at 27th Street and Southeast Powell Avenue

Secondary Staging Area: Wal-Mart parking lot, 26th Street and Southeast Powell Avenue

Occupancy or Special Hazards

Type of Hazard and Location: Nothing unusual for high school-type occupancy

Special Shutdown Procedures: (complex or extended operations): None

Controlled Environments: None

Building Construction

Building Access: At night, when the school is not occupied, all exterior exit doors with panic hardware are chained shut to prevent break-ins.

Length: 1,950 ft. **Width:**96 ft. **Height:**12 ft. **Number of Stories:** One

Walls: Concrete masonry units (CMU), poured-in place tilt-up and brick veneer; gypsum wallboard interior finishes.

Vertical and Horizontal Openings: None.

Smoke and Heat Venting or Smoke Management: None **Control Locations:** N/A

Atriums: None

Building Utilities

Electricity: Underground entry to main transformer outside boiler room on north side of site.

Emergency Power Supplies: Emergency lighting units in hallways, auditorium, cafeteria, and gym.

Natural Gas: Main shutoff at meter next to boiler room.

LP-Gas: None

Domestic Water: Foot valve in sidewalk outside of sprinkler riser room.

Steam: None

Elevators: None

Compressed Air: Small cylinders stored in Chemistry Room 112.

Exposures

North: None

South: None

East: None

West: None

Environmental Concerns: Parking lot storm drains run into Winchester Creek.

Protection Systems

Automatic Sprinklers: Buildings protected throughout with wet and dry pipe sprinklers.

Water Supplies: Water district hydrants on all corners of site.

Available Flow: Static: 65 psi, Residual 42 psi; Flow = 1275

Required Fire Flow: 1,150 gpm

Hydrants: Main parking lot, teachers' parking lot, south side of gymnasium, north side of cafeteria (by loading dock), entrance to football stadium.

Fire Department Connection: On wall next to sprinkler valve room.

Standpipe and Inside Hose Connections: None.

Fire Extinguishers: PW portables in all hallways; 20#ABC in custodian's room; 20#BC and K-1 in cafeteria kitchen.

Special Protection Systems: Wet chemical kitchen hood-and-duct suppression system in cafeteria kitchen.

Fire Alarm and Communication Systems

Detection System: Smoke detectors, pull stations, and water flow alarms. (No smoke detectors in gymnasium.) Smoke detectors in HVAC systems automatically shutdown HVAC, but do not report fire conditions until a room detector operates.

Occupant Notification: Klaxon and strobe lights.

Onsite Communications System: School public address system in principal's office. (Power switch is located on lower left side of main panel.)

Contact Person or Company Responsible for System Maintenance: Head Custodian: Errol Anthony (555-482-1111)

APPENDIX F

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Fire Flow Calculations

There is no single "correct" method for establishing fire flow: the Incident Commander's (IC's) overall objective is to provide enough water effectively at the right place to suppress the heat energy released by the fire. The availability of the water system and the fire department's capacity to deliver flow may be the limiting factors.

Several mathematical formulas exist to determine water supply requirements. Some of these formulas are intended to be applied during building construction, and others are intended to be quick references for an IC confronted with an emergency.

When determining the required fire flow values for your preincident plan, you may want to consider the factors described in this Appendix.

Features Influencing Required Fire Flow

When a fire protection engineer, inspector, IC, insurance representative, or contractor discusses fire flow, six significant features must be considered:

1. Building construction type.
2. Occupancy type.
3. Building size.
4. Exposures.
5. Percentage of involvement.
6. Automatic fire protection.

Taken together, these elements are evaluated to establish how much water is needed to control and suppress a fire.

Building Construction Type

Do the building materials used in construction contribute to the fuel load? Wood, plastics, and other combustible materials provide fuel. Steel, concrete, and gypsum wallboard do not increase the fuel load of a structure.

Occupancy Type

A structure's use, or **occupancy**, is a major factor in evaluating water supply requirements. A mercantile occupancy likely has a heavier fuel load than an office use; a rack storage warehouse generally has more potential fuel than a dwelling.

Building Size

Generally, the larger the building, the more water will be needed to control a fire in it. A 100,000-square-foot building, for example, will require a higher flow rate than a 28,000- square-foot building, because the larger building can contain more fuel. Likewise, a tall or multiple-story building may include more fuel, so the structure's volume may be a consideration.

Exposures

An important part of fire strategy is to prevent fire from spreading from the burning building to adjacent structures or exposures. Master streams or handlines often are used to protect exposures, and an adequate water supply must be calculated for them. Usually, the closer that exposures are located to one another, the greater the water damage.

Percentage of Involvement

Part of an effective sizeup includes determining how much of a building is burning. If the fire has gained headway when the fire suppression forces arrive, it will take a greater amount of water to control and, eventually, to suppress the fire.

Automatic Fire Protection

If installed and operating properly, automatic sprinklers will confine a fire and keep water demands low. Effective sprinkler protection also minimizes the water needs for handlines.

Some jurisdictions reduce fire flow calculations if the building is protected by a complete smoke detection system that reports to the fire department. Their justification is that if the fire suppression forces get early notification and respond, the fire will be small upon their arrival and less water will be needed.

Fire Flow Formulas

There are at least five recognized fire flow calculation formulas in use today. Some are intended for preincident assessment of a community's flow rate; others are quick calculations for IC's who are faced with an emergency. The "community flow rate" calculations generally are meant for conflagration control, rather than a single room-and-contents fire or building.

Iowa State University Method

The Iowa State University (ISU) method was created in the 1950's after a series of studies of fire in enclosed spaces. The ISU "Ideal Rate of Flow" formula:

Required fire flow (gpm) = V ÷ 100

Where V = the volume of the space is on fire.

Example:

An IC arrives at a burning noncombustible mercantile occupancy that measures 50 feet by 75 feet and is one story (12 feet) tall. The IC quickly determines that the volume of the structure is 45,000 cubic feet. Using this number and the ISU formula, the required fire flow for this structure would be 450 gallons per minute (45,000 ÷ 100 = 450).

National Fire Academy Formula

The National Fire Academy (NFA) formula, taught in the *Managing Company Tactical Operations* (MCTO) classes, is similar to the ISU method, but employs different values.

The NFA fire flow formula:

Required fire flow (gpm) = (Length x Width) ÷ 3

Example:

Using the same example, an IC arrives at a burning mercantile occupancy that measures 50 feet by 75 feet and is one story (12 feet) tall. The IC quickly determines that the area of the structure is 3,750 square feet. Using this number and the NFA formula, the required fire flow for this structure would be 1,250 gallons per minute (3,750 ÷ 3 = 1,250).

Insurance Service Office

The Insurance Services Office (ISO) "Guide for the Determination of Required Fire Flow" has been a recommended practice for calculating fire flow for many years. It is more complicated than the ISU or NFA methods, but usually is employed when the fire department is establishing minimum flows for new construction, rather than for emergency operations. It also is an important consideration in a jurisdiction's overall fire defense rating for insurance rates.

The ISO guide employs several steps in the calculations, but the fundamental fire flow formula is

$$NFF = (C)\ (O)\ [1 + (X + P)]$$

Where:

NFF = Needed Fire Flow
(C) = Construction factor, including effective area
(O) = Occupancy factor
(X + P) = Exposures and communication (openings) factor

In order to solve this equation, the fire protection person must know how ISO establishes these "factors."

First, another equation is needed to solve for C. That formula is

$$C = 18F\sqrt{A}$$

Where:

F = the coefficient related to the construction type
A = the effective building area

The construction type coefficient comes from the following table:

Description	Coefficient
Wood frame	1.5
Joisted masonry	1.0
Noncombustible/masonry noncombustible	0.8
Fire resistive or modified fire resistive	0.6

Example:

Using the same example, let's solve for C assuming a noncombustible building.

The building measures 50 feet by 75 feet giving us an area of 3,750 square feet. Inserting this value into the formula gives us:

$$C = 18\ (0.8)\ \sqrt{3,750}$$

$$C = 18 \cdot (0.8) \cdot 61.23$$

Thus, C = 881.712 (Round up to 882)

The minimum value for C is always 500 gallons per minute.

Occupancy Factors

The next step in the ISO formula is determining the occupancy factor (O). This also is accomplished by referring to a table:

Occupancy Combustibility Class	Construction Type	Factor (O)	Samples*
C-1	Noncombustible	0.75	Steel or concrete products storage
C-2	Limited combustible	0.85	Apartments, hospitals, hotels, metal product fabrication, parking garages, schools
C-3	Combustible	1.00	Bakeries, dairy processing, mercantile, motion picture theaters, repair or service shops
C-4	Free burning	1.15	Aircraft hangars, food processing, furniture stores, warehouses, rubber product manufacturing
C-5	Rapid burning	1.25	Flour mills, chemical manufacturing, distilleries, paint sales and storage, textile manufacturing

* This is **not** the complete list from the ISO Guide.

Example:

With this information, we can insert the combustibility class factor of our sample structure into the equation:

$$NFF = 882 \cdot 1.00(X + P)$$

Exposure and Communication

The last portion of the ISO formula is to determine the likelihood a fire might spread due to exposures or interior openings. To obtain this information, use the formula:

$$(X + P) = 1 + \sum_{i=l}^{n} X + P$$

Where *n* = number of sides of subject building, and (X + P) has a maximum value of 1.75.

Value for both X and P come from other tables found in the ISO "Guide for the Determination of Required Fire Flow."

Example:

To keep our example simple, we will presume this mercantile occupancy is located where exposures are not a consideration, and the values for (X + P) equal zero.

Our final fire flow formula using the ISO method:

$$NFF = (C)\,(O)\,[1 + (X+P)]$$

$$NFF = (882) \cdot (1.00) \cdot [1 + 0]$$

$$NFF = 882 \text{ gallons per minute}$$

ISO does not compute Needed Fire Flow for sprinklered buildings because it is presumed the calculated flow for the sprinklers and **hose stream allowance** is sufficient for the property. (See Chapter 6 "Water-Based Fire Protection Systems.")

NFPA Standard 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*

The NFPA 1142 fire flow calculation method is intended to be used in those area where water systems are not readily available, and fire protection water must be retrieved from tanks, ponds, cisterns, and other sources.

The NFPA 1142 method uses the volumetric capacity of specific structure to compute the "minimum water supply." The NFPA 1142 fire flow formula is

Minimum water supply (MWS) = (Total structure volume) ÷ (Occupancy hazard classification number) · Construction classification number

Where:

Total structure volume = the product of length · width · height
Occupancy hazard classification number is obtained from a chart (see below)
Construction classification number is obtained from a chart (see below)

Occupancy hazard classification	Samples*
3	Flammable liquid spraying, plywood and particle board manufacturing, sawmills, upholstering with plastic foams
4	Barns and stables, mercantile, paper and pulp mills, repair garages, piers and wharves, department stores
5	Amusement occupancies, cold storage warehouses, machine shops, libraries, restaurants, unoccupied buildings
6	Bakeries, barber or beauty shops, canneries, cement plants, post offices, gasoline services stations, electronics plants
7	Apartments, colleges and universities, museums, hotels and motels, schools, theaters without stages, hospitals

*This is **not** the complete list from NFPA 1142.

The construction classification value comes from the following table:

Description	Classification Value
Wood frame	1.5
Heavy Timber	0.75
Masonry (Ordinary)	1.0
Noncombustible	0.75
Fire-resistive	0.5

Example:

Using our example of the 3,750 square feet, noncombustible mercantile occupancy with a 12-foot ceiling, our formula for minimum water supply would be:

$$MWS = 45{,}000 \text{ cu.ft.} \div (4 \cdot 0.75)$$
$$MWS = 45{,}000 \div 3$$
$$MWS = 15{,}000 \text{ gallons}^*$$

*Note that NFPA 1142 requires a minimum water supply of 2,000 gallons regardless of the results of the formula.

If the structure being evaluated has exposures within 50 feet, the resulting MWS must be increased by 50 percent, and the minimum supply increases.

Many jurisdictions must provide mobile water supplies in the form of tender shuttles or strike teams to sustain fire flow. Annex C of NFPA 1142 provides IC's a formula for calculating the amount of time it takes to sustain a specific flow using mobile apparatus.

The formula is

$$Q = V/[A + (T_1 + T_2) + B] \cdot 0.9$$

Where:

- Q = **maximum** continuous flow capability
- V = mobile water supply capacity
- A = time for the mobile supplies to drive 200 feet, dump water into a drop tank, and return 200 feet to a starting point
- T_1 = time in minutes for the mobile water supply to travel from the fire to the water source
- T_2 = time in minutes for the same mobile water supply to travel from the water source to the fire
- B = time for the mobile supplies to drive 200 feet, fill mobile water supply at the water source, and return 200 feet to a starting point
- 0.9 = amount of water supply considered unavailable due to spillage, underfilling, and incomplete unloading

The annex also address means to compute how safe travel times influence water delivery. It would be a good preincident planning activity to compute and drill on the amount of apparatus and time it would take to sustain a minimum fire flow for a target hazard.

International Fire Code

IFC Appendix B provides another method for computing the required fire flow for buildings.

The IFC method employs a table that lists the minimum flow based on the construction type and size of the structure or what is called the "fire flow calculation area". The "fire flow calculation area" is the sum of all floor area between firewalls with no openings (see Chapter 4 for a discussion of firewalls), or, in fire resistive construction, the sum of the area of the three largest successive floors.

Fire Flow Samples*

Construction Type	I-A/I-B	IIA/IIIA	IV/V-A	IIB/IIIB	V-B	Fire Flow (gpm)	Duration (Hours)
Fire Area (Sq. Ft.)	0 - 22,700	0 - 12,700	0 - 8,200	0 - 5,900	0 - 3,600	1,500	2
	30,201 - 38,700	17,001 - 21,800	10,901 - 12,900	7,901 - 9,800	4,801 - 6,200	2,000	2
	128,701 - 145,900	72,401 - 82,100	46,401 - 52,500	33,501 - 37,900	20,602 - 23,300	4,000	4

*This is **not** a complete list from IFC Appendix B.

Example:

In the example of the 3,750 square foot noncombustible mercantile occupancy, we find noncombustible construction (IIA) column on the table, read down to the corresponding area (3,750 square feet) and determine that the required flow is 1,500 gallons per minute for two hours.

Construction Type	I-A/I-B	IIA/IIIA	IV/V-A	IIB/IIIB	V-B	Fire Flow (gpm)	Duration (Hours)
Fire Area (Sq. Ft.)	0 - 22,700	0 - 12,700	0 - 8,200	0 - 5,900	0 - 3,600	1,500	2
	30,201 - 38,700	17,001 - 21,800	10,901 - 12,900	7,901 - 9,800	4,801 - 6,200	2,000	2

The IFC also address fire flow in one- and two-family dwellings. Dwellings with fire areas less than 3,600 square feet may have a fire flow of 1,000 gpm. Dwellings with larger fire areas must use the flow information from the table.

IFC Appendix B also allows fire flow reductions between 50 percent and 75 percent if the structure is protected by automatic sprinklers and is a light hazard occupancy classification as determined by NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Illinois Institute of Technology Method

The Illinois Institute of Technology (IIT) studied 134 fires in the Chicago area, and developed the following fire flow formula for nonresidential occupancies. The results of the survey were used with regression analysis to develop flow requirements based on building area:

$$\text{Fire flow} = -1.3 \cdot 10^{-5} A^2 + 42 \cdot 10^{-2} A$$

Where A = the area of the fire in square feet.

Example:

Using the mercantile example, and assuming that the building is fully involved, the fire flow figure would be

$$\text{Fire flow} = -1.3 \cdot 10^{-5}(3{,}750^2) + 42 \cdot 10^{-2}\ (3{,}750)$$

$$\text{Fire flow} = -1.3 \cdot 10^{-5}\ (14{,}062{,}500) + 42 \cdot 10^{-2}\ (3{,}750)$$

$$\text{Fire flow} + -1.3 \cdot (1 \div 10{,}000) \cdot\ (14{,}062{,}500) + 42 \cdot (1 \div 100)(3{,}750)$$

$$\text{Fire flow} = -1.3\ (0.00001) \cdot (14{,}062{,}500) + 42 \cdot (0.01)(3{,}750)$$

$$\text{Fire flow} = -182.825 + 42 \cdot (37.5)$$

$$\text{Fire flow} = -182.825 + 1575$$

$$\text{Fire flow} = 1{,}392.175 \text{ gallons per minute}$$

Summary

There is a variety of methods to establish required fire flow for fire protection. All are based on mathematical formulas, and range from simple to sophisticated. There is no single "correct" formula or method for fire flow calculations.

Here are the fire flow calculations results for our hypothetical noncombustible mercantile occupancy that measures 50 feet by 75 feet and is one story (12 feet) tall.

Fire Flow Calculation Method	Required Fire Flow
Iowa State University	450 gpm
National Fire Academy	1,250 gpm
Insurance Services Office	882 gpm
NFPA 1142	15,000 total gallons
International Fire Code	1,500 gpm
Illinois Institute of Technology	1,393 gmp

IC's should meet with their fire protection personnel (fire marshal, inspectors, insurance underwriters, plant managers, building/facility engineers, etc.) to identify fire flow needs, and establish contingency plans for developing satisfactory flows during an emergency.

UNIT 4:
PASSIVE FIRE PROTECTION FEATURES

TERMINAL OBJECTIVE

The students will be able to identify the value and performance capabilities of many of the passive fire protection features installed in buildings and facilities.

ENABLING OBJECTIVES

The students will identify the types of protection provided by:

1. *Property line setbacks.*
2. *Firewalls.*
3. *Rated assemblies.*
4. *Fire-resistive materials.*

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PASSIVE FIRE PROTECTION FEATURES

Passive fire protection features are nothing new to building construction or to the fire service. These features are required by the model building codes and have been around for many, many years. Building codes were developed with the goal of stopping the problem of fire spread and conflagrations and, at the time, passive fire protection features were the best technological solution. Most firefighters do not realize that nearly 70 percent of what is written in the building codes includes fire safety requirements employing passive fire protection features.

For the purpose of this course, **passive** fire protection is defined as:

> Structural and construction elements designed, installed, and maintained to control fire and smoke spread in a building and contribute to its structural stability. It includes, but is not limited to, ***firewalls***, ***fire barriers***, ***fire partitions***, spray-on or otherwise applied fire proofing, and ***fire resistive assemblies***.

Ask yourself: Where do the requirements for firewalls, fire-rated exit corridors, and exiting (a fire safety issue) originate? The answer: your locally adopted building code. Many fire officers and Incident Commanders (IC's) do not realize this, and yet when the fire starts it is these same fire officers who must command fireground operations in coordination with these features.

Many firefighters have created preincident plans that include a number of these passive fire protection features without even realizing it. Interior and exterior wall arrangements, stairway enclosures, and exit corridors are drawn on the plans to show building, hallway, and room configurations, and the access points to them. Often, these features are an important part of the building's fire resistance, and not just spatial arrangement.

Passive fire protection features, if properly designed, installed, and maintained, can help contain smoke and fire and contribute to structural stability.

PASSIVE FEATURES

Types of Passive Features

Building codes, architects, and code enforcement officials use specific terminology to describe specific fire protection features. For example, while most people may use the phrase "firewall" to describe a solid barrier between two spaces, in code enforcement "firewall" means some very specific things: it has to have a 2- or 4-hour fire resistance rating, it can have only a small number and size of openings (windows/doors), the openings have to be "protected" with fire assemblies (fire shutters, fire curtains, or fire doors), and the wall may have to be constructed with a ***parapet***.

While it is essential the fire and building code official understand the details of these terms--and how they apply within the building or fire code--IC's should have a fundamental understanding of how these features may help or hinder their fire control efforts.

Some of the passive features we will discuss include

- setbacks from property lines;
- firewalls;
- fire-rated floor and ceiling assemblies, including:
  - fire barriers, and
  - fire partitions;
- ***smoke barriers***;
- other fire assemblies:
  - fire doors, and
  - fire and smoke dampers;
- structural fire protection:
  - encasement, and
  - spray-on; and
- firestopping, ***draft stops***, and ***draft curtains***.

We'll discuss some of the principal features of these construction elements that are pertinent to preincident planning and effective strategic and tactical applications. Remember, these may be generic descriptions of the rules and regulations pertaining to building construction. They may vary based on occupancy and local conditions. You should refer to your local building code and building department for specific rules in your jurisdiction.

PROPERTY LINE SETBACKS

In many communities, local zoning regulations establish "setback" distances, the amount of space required between the outer edge of a building and the nearest property line. Often, the purpose of these rules is to provide a built environment that is visually appealing, allowing open space and landscaping to "soften" the impact of construction on the environment.

In the building codes, however, there are no requirements to construct a building that is set back from the property line or adjacent structures. The phrase "zero lot lines" means a property owner could erect a structure on his or her property line.

Since building codes are intended to protect property and help in conflagration control, two key concerns must be addressed: the likelihood of igniting adjacent structures from radiant heat waves, and the risk of roof fires from flying brands. As one builds closer to a neighbor's property (or even other structures on one's own property) the fire resistance of the exterior walls and roof must be increased.

As an example, Building Owner A wants to erect a manufacturing plant in the community of Anytown, USA. There are no setback regulations in Anytown, but the owner must provide adequate parking for two shifts of employees. This means he will have to locate the building as close to one property line as possible to accommodate the parking rules.

A quick review of Anytown's building code shows that if the exterior wall is more than 20 feet from a property line, it does not have to have any fire resistance. If the building is 10 feet from the property line, it must have a 1-hour fire-resistive exterior wall, and may have nonopening windows outfitted with fire-resistive or wired glass. If the building is less than 5 feet from the property line, it must have a solid exterior wall that has a fire resistance rating of 4 hours, and no windows or doors.

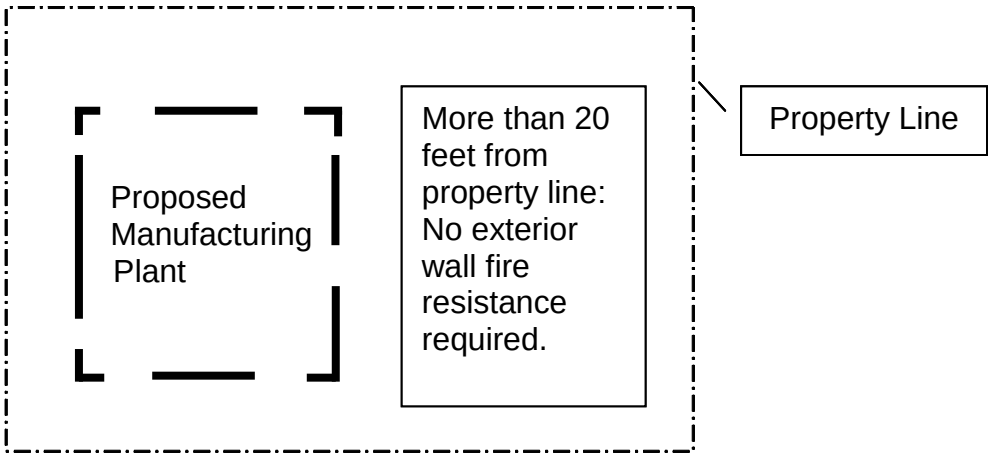


Figure 4-1(a)
Example of Setback Influence on Fire Resistance (structure more than 20 feet from property line)

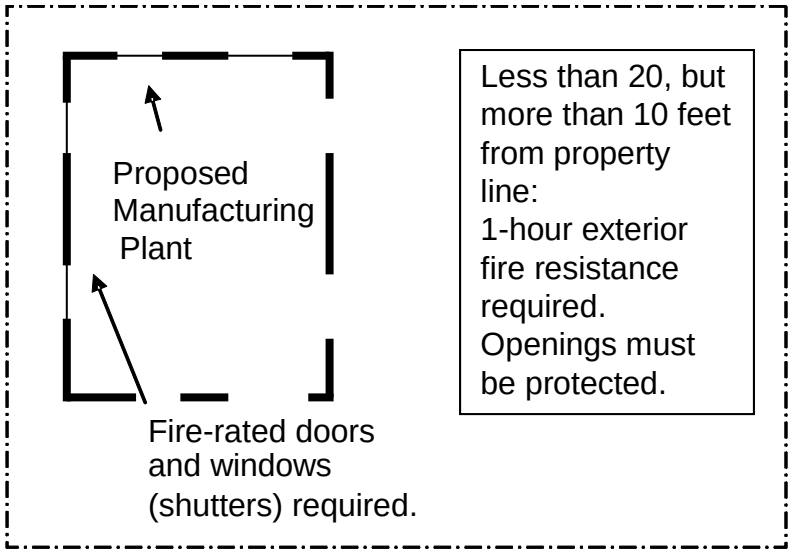


Figure 4-1(b)
Example of Setback Influence on Fire Resistance (structure more than 10, but less than 20 feet from property line)

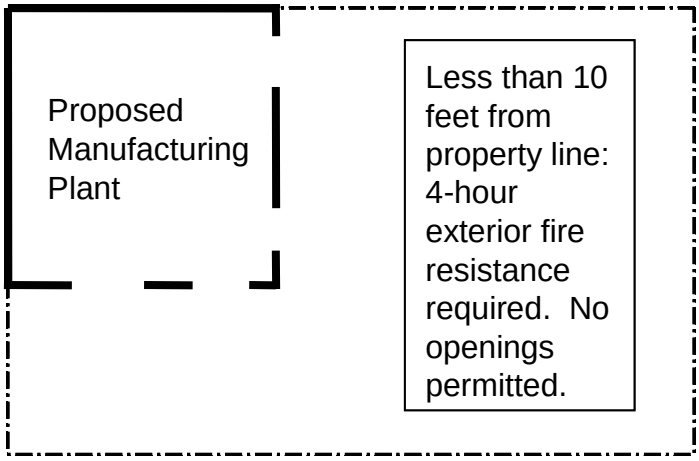


Figure 4-1(c)
Example of Setback Influence on Fire Resistance (structure less than 10 feet from property line)

In this case, as the structure is located closer to the adjacent property, its exterior wall fire resistance must increase. Conversely, as the structure is located away from the property line, the fire resistance requirement may drop to "zero." (There are additional code requirements that influence how this sample structure might be constructed. This illustration is used solely to show the influence of setbacks on exterior fire resistance ratings.)

When buildings are located close together, the fire resistance rating of exterior walls is an important piece of information for the IC. This information should be included on preincident plans. Given the data, he or she may choose to assign resources to protect exposures rather than concentrate on initial fire attack at a large incident.

ASSEMBLY AS IT RELATES TO PASSIVE FEATURES

The word "assembly" is used frequently when discussing passive fire protection features. What does it mean?

The term "assembly" is used to describe the combination of equipment, structural, and architectural elements designed, constructed, and maintained to resist fire and heat. It includes firewalls, fire doors, fire dampers, floor/ceiling assemblies, roof/ceiling assemblies, fire barriers, and fire partitions. (See the Fire Protection Glossary following Unit 10: Final Project for a description of these terms.)

Most construction materials are not inherently fire resistive. Wood will burn and steel will melt even though it is noncombustible. Additional materials, such as gypsum wallboard, may have to be applied to construction materials to give them fire resistance. Furthermore, they may have to be applied in a very specific manner to achieve a fire resistance rating.

A Typical Wall Assembly

There are many, many ways to construct fire-resistant barriers. Here, for example, is the material and construction description for a typical 1-hour fire-resistive wall assembly:

> 0.018 (No. 25 carbon sheet steel gage) channel-shaped studs 24" on center with one full-length layer of 5/8" Type X gypsum wallboard applied vertically to each side attached with 1" long No. 6 drywall screws to each stud.
>
> Screws are 8" on center around the perimeter and 12" on center on the intermediate stud.
>
> The wallboard may be applied horizontally when attached to 35/8" studs and the horizontal joints are staggered with those on the opposite side.
>
> Screws for the horizontal application shall be 8" on center at vertical edges and 12" on center on the intermediate stud. Figure 4-2 is a drawing of this assembly.

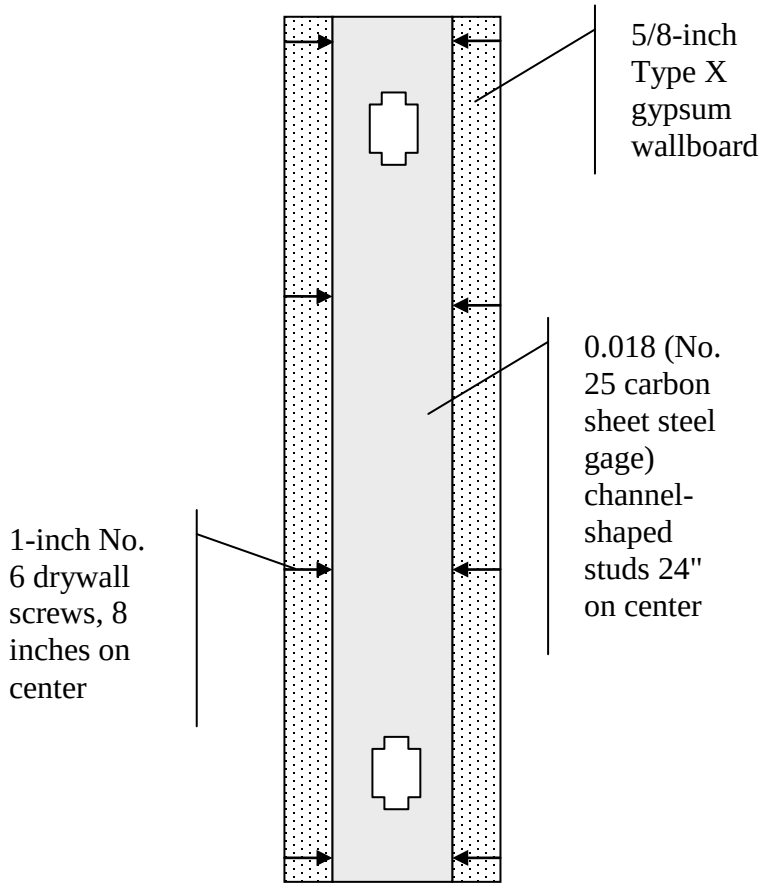


Figure 4-2
Typical 1-Hour Rated Assembly

Note that part of the fire resistance comes from the insulating value of the air space between the wallboard because air is not a good heat conductor.

Architects and code officials use a variety of resource directories to verify the construction details for fire resistance. An important part of the building inspector's job is to assure all of the details are met.

Firefighter Rescue: Impact-Resistant Wallboard

IC's should be aware of construction materials that may affect firefighter safety.

Trapped firefighter survival tactics include breaking through gypsum wallboard to a safer environment, but a construction product may make that technique impossible.

Manufactured for wall assemblies where surface durability and impact or penetration resistance are major concerns, Hi-Impact® BRAND gypsum wallboard contains a Lexan® substrate embedded to strengthen the wallboard. This product easily could be found in ceilings and walls of gymnasiums, institutions, school corridors, or any other high traffic area. It looks no different from ordinary wallboard.

The material is manufactured with four different Lexan® thicknesses ranging from 0.010- to 0.080-inch. Based on laboratory tests, a 5/8-inch sheet of this wallboard with the thickest-available Lexan® will resist an impact of more than 2,188 ft. lbs. By comparison, standard 5/8-inch gypsum wallboard has an impact resistance of 24 ft. lbs.

The Roberts Park, IL, Fire Protection District conducted a series of tests to determine what it would take for a firefighter to breach a single layer of Hi-Impact® BRAND gypsum wallboard on a wood stud wall. Table 4-1 summarizes their results:

Table 4-1
Roberts Park, IL, Test Results

Tool	Times Struck	Results
8 lb. maul (striking end)	14	No penetration
12 lb. sledgehammer	14	No penetration, broken wall stud
8 lb. pickhead axe (blade)	38	Penetrated wall on sixth swing, able to create larger hole for firefighter
Halligan bar	30	Penetrated wall on fourth swing, able to create larger hole for firefighter

8 lb. pickhead axe (striking end)	18	No penetration
8 lb. maul (cutting end)	19	Penetrated wall and broke one stud

The test results suggest that these handtools may not be adequate to breach these walls easily. Remember, these tests were performed on a single sheet of Hi-Impact® BRAND gypsum wallboard; a fire-rated assembly would have at least two sides that would have to be penetrated. (For a complete copy of the test results, visit www.robertsparkfpd.org)

By visiting a building during construction to identify this type of product, and noting this information on a preincident plan, the IC adds another piece of valuable data. This is the type of information that could make firefighters' jobs easier and save lives.

FIRE RESISTANCE RATINGS

Building officials and fire inspectors use the phrase "fire resistance ratings" to describe the fire protection requirements for a building or structural elements. One-hour, two-hour, three-hour, and four-hour ratings are "shorthand" that they use to communicate the relative fire resistance of materials.

Fire resistance ratings for various materials and construction techniques are achieved under **closely monitored** laboratory testing procedures and **do not** reflect "real world" conditions.

While an assembly tested in the laboratory may obtain a 3-hour fire resistance rating, there is no guarantee it will withstand a fire's assault for 3 hours. Depending upon fire load and condition of the assembly, it may fail in minutes or survive a long time.

IC's should consider fire resistance ratings only for comparison purposes: a 3-hour-rated assembly should survive longer than a 2-hour, 1-hour or, 45-minute assembly. Assemblies that have been compromised by damage (holes punched for wires, for example) or neglect (fire doors propped open) should be considered to have no fire resistance rating.

"***Compartmentalization***" or "compartmentation" are other terms fire protection and building professionals use to explain passive fire protection features. By constructing the building in such a way that it creates a "box" or compartment around a fire area, the fire may be confined by the fire-resistive construction. This is an important consideration for separating hazardous uses from one another. Active fire protection systems (sprinklers, fire alarms, specialty systems) enhance the fire control and early notification functions.

FIREWALLS

The building codes limit how large a structure may be, based on use and construction type. Generally, the more fire resistive it is, the larger it can be. These limits are based on the largest

fire a reasonably outfitted and capable fire department could control. The area may be called the "maximum allowable area," or in the insurance industry, the "***maximum foreseeable loss***" area.

There are times, however, when an owner needs a space larger than the building code permits. Storage and industrial operations are two obvious examples, but even schools, hospitals, and hotels may need to be larger than the local building code allows.

In these circumstances, the architect or owner may choose to install a **firewall** to divide the structure into smaller units. While the exterior footprint of the structure may seem huge (imagine an automobile assembly plant), it may be subdivided into smaller areas by firewalls.

In the building codes, firewalls define separate **buildings**. If a structure under a single roof is divided by a firewall, the building code considers it to be two separate buildings for the purposes of applying rules relating to construction, occupancy, egress, utilities, etc.

Fire Resistance Rating for Firewalls

To satisfy the building codes, firewalls must have a 2- or 4-hour fire resistance rating (2-hour for wood frame and some steel buildings, 4-hour for concrete and some steel buildings). Firewalls must be designed to remain standing even if the building on one side or the other of it collapses. Firewalls historically have required a parapet that extends above the roof, but the building codes now allow alternate designs. Likewise, parapets may be installed solely for aesthetic reasons.

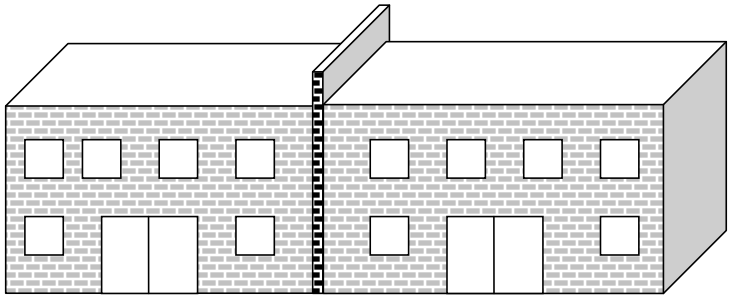


Figure 4-3
Typical Firewall Application

As shown in Figure 4-3, the parapet prevents a roof fire from traveling horizontally beyond the firewall. It also gives the IC an exterior visual clue of the location of the firewall.

Openings in Firewalls

Firewalls are allowed to have openings in them to allow the passage of people and products. The amount of openings is limited by the building codes, and the openings must be provided with "***opening protectives***" such as fire doors and dampers. Since these openings are the weak spot in

the firewall assembly, if damaged or neglected, they should be checked and identified during preincident planning. Any damage or compromise should be reported to the owner and code enforcement authority.

Firewalls are significant barriers to fire spread, and should be identified clearly on preincident plans.

FIRE BARRIERS

Often, two or more distinct "uses" occupy the same building. A modern high school, for example, may include classrooms, laboratory spaces, theaters, offices, kitchens, gymnasiums, industrial shops, day care centers and other uses. In order to protect a less hazardous use from a more hazardous one, the building codes require the construction and maintenance of ***fire barriers***.

Building codes contain tables that prescribe the required fire-rated separations between uses or "occupancies." A nursing home, for example, must be separated from a parking garage beneath it by a 3-hour fire barrier.

Fire barriers can be vertical (walls) or horizontal (floors and ceilings), or both. They may have a fire resistance rating ranging from 1 to 4 hours. The fire barrier is intended only to separate different occupancies, so the outer boundaries of the fire barrier stop at the outer edge of the occupancy. (For example, no parapet would be required between a side-by-side classroom and chemical storeroom, as long as the fire barrier extended from floor to roof.)

Fire barriers up to 3-hour rated may have openings, as long as they are protected by equivalently rated opening protectives.

Thus, openings in a 1-hour fire barrier must be protected by 1-hour fire doors or dampers, and a 3-hour barrier by 3-hour doors or dampers. A 4-hour fire barrier--because it generally separates the most hazardous occupancies--may not have any openings into another occupancy. Figure 4-4 shows a typical fire barrier arrangement.

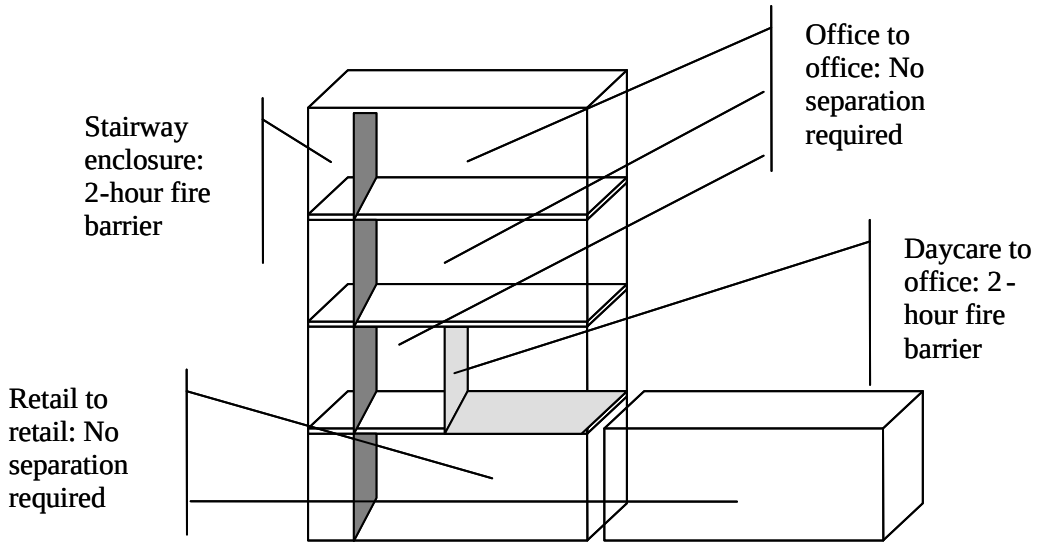


Figure 4-4
Typical Fire Barrier Arrangement

Fire Barriers in Multistory Buildings

In multistory buildings, fire barriers often are created between floors to prevent vertical fire spread. In fact, the building codes specifically require that not more than two adjacent floors may share the same atmosphere unless the building has been constructed with an atrium, and all the special fire protection features that go along with atrium design.

Floor/Ceiling Assemblies

The fire barriers between floors are called "floor/ceiling assemblies," and may consist of a complicated arrangement of the floor construction of the story above, and the ceiling construction of the story on which one is standing. Floor/Ceiling assemblies often require the components of the lay-in grid ceiling commonly seen in office buildings. Removing a ceiling tile may compromise the integrity of the fire-resistive barrier, so pre-incident planners should be on the lookout for those conditions.

Floor/Ceiling assemblies (and roof/ceiling assemblies, if required) may be difficult to identify. If you have questions about the requirements for fire barriers, you should consult your local code enforcement official for assistance.

STAIRWAY ENCLOSURES

Another important fire barrier, especially for the IC and fire attack teams, is the stairway "enclosure" (see Figure 4-5). Buildings three or more stories tall must have their egress stairs

enclosed by fire-resistive construction of at least 1 hour, and 2 hours for buildings four or more stories.



Figure 4-5
Stair Enclosure

These enclosures provide an area for staging and fire attack--as well as retreat--for multistory buildings. The enclosures must be outfitted with fire-rated door assemblies, and the doors must remain closed at all times or close automatically in the event of a fire to protect the enclosure from smoke and heat. The standpipe system for fire attack normally is located in the stair enclosure (see Unit 6: Water-Based Fire Protection Systems). IC's should have a contingency plan to assure all doors are closed during an emergency.

FIRE PARTITIONS

Fire partitions may be installed when a lesser standard of fire protection is required. Fire partitions have a 1-hour fire resistance rating, and are used to separate dwelling units in apartments, separate guest rooms in hotels, create corridors, and separate tenant spaces in covered mall buildings.

Partitions may be identified on preincident plans to orient responders to the layout of the structure, but generally are not considered significant fire separations.

SMOKE BARRIERS

In those occupancies where "defend in place" or "shelter in place" strategies are employed (hospitals, nursing homes, penitentiaries, etc.) and those where smoke management/control systems are installed, **smoke barriers** are built to withstand the passage of toxic products from one area to another. They must be tightly sealed at all joints and openings.

Smoke barriers may be difficult to identify without a complete set of construction drawings, but "cross corridor" door sets provide one clue to identify their locations. Think about the last time you visited a hospital wing and observed a pair of automatic closing doors dividing the floor area. These assemblies often occur at smoke barriers, and provide an area for nursing staff to relocate nonambulatory patients while they await rescue or fire control.

OTHER FIRE ASSEMBLIES

Except in some extreme cases (such as where 4-hour fire barriers are required), the building codes allow openings in firewalls, barriers, and partitions. These openings must have fully operating "opening protectives" that close in the event of a fire to maintain the integrity of the compartment wall, floor, or ceiling.

Fire Door Assemblies

Most firefighters are familiar with fire door assemblies: they're the ones propped open! Fire door maintenance is an ongoing problem that fire inspectors and IC's face daily. If the fire door fails to close, there might as well be no fire door in the opening because heat, smoke, and flames will travel through without resistance.

Fire door assemblies consist of more than the door leaf. They include the frame and its anchors, the closing hardware, the hinges, the latches, and glazing, if any. Fire doors must be self-closing or automatic closing in the event of a fire.

- **Self-closing** fire door assemblies close by themselves every time a person passes through. These are the style that often gets wedged in the "open" position because it is inconvenient for the users to open and close the door every time they go through.
- **Automatic-closing** fire door assemblies have mechanisms that hold them in the "open" position, and automatically close them upon the operation of a smoke detector, glass bulb, or other similar device. Some automatic closing doors are arranged to close automatically when there is a power failure.

Since fire doors are installed in firewalls, barriers, and partitions, their locations should be clearly identified on preincident plans. When arriving on the scene of a fire, the IC should assign a team to assure all fire door assemblies are closed, if it is safe to do so.

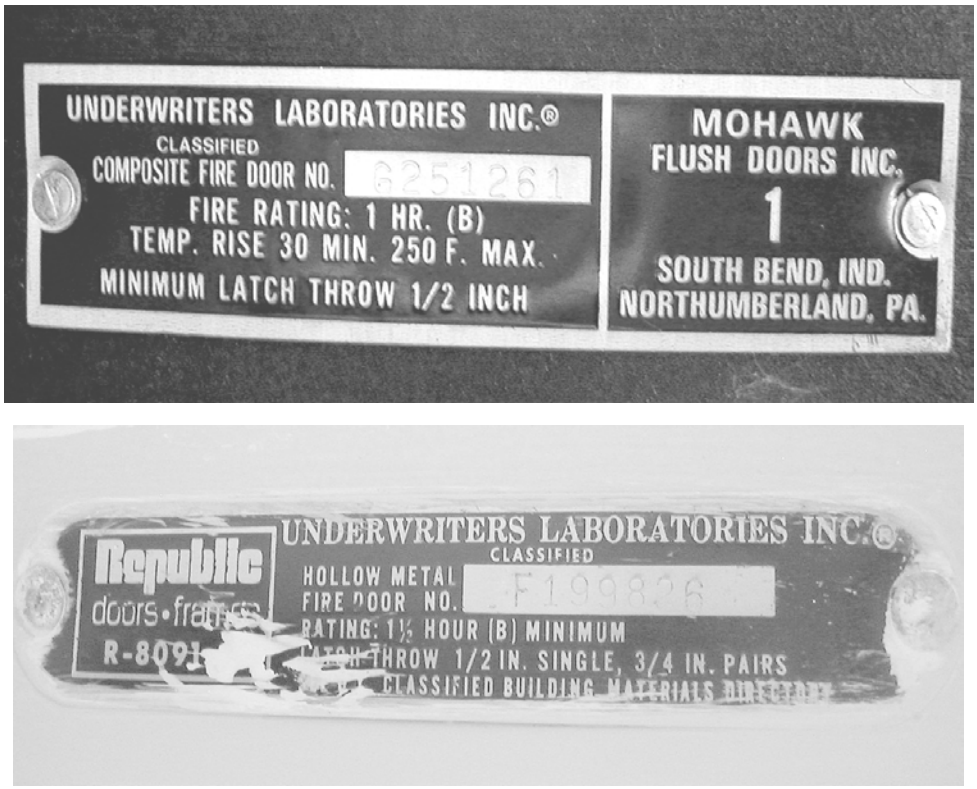


Figure 4-6
Fire Door Labels

Generally, swinging-type (side-hinged) doors are installed where people or only small products must move through a fire rated barrier. Overhead coiling steel doors are installed to protect larger openings (such as in warehouse operations) where forklift trucks and other vehicles must pass through on a regular basis.

Regardless of where they are installed, overhead coiling steel doors create a potential safety hazard for building occupants and firefighters. When properly installed, the overhead doors are equipped with a governor that regulates their descent speed. If the governor is faulty, the door speed is controlled only by gravity forces and may descend with serious consequences. These doors are nicknamed "guillotine" doors because of the potential for them to fall at an uncontrolled rate.

Fire attack crews should be careful whenever they cross a fire barrier that has overhead coiling steel doors. If the door descends after the team has passed through it, the weight of the door may make it impossible to lift by hand, and may even act as a hose clamp that restricts the flow of water.

Fire Door Assembly Ratings

Fire doors are required to have a label that provides important information about the assembly. The label also can provide a clue to the fire resistance rating of the wall where the assembly is installed.

Generally, the local building code will establish the requirement for the fire door assembly rating. Table 4-2 provides a summary of the typical fire door rating requirements based on location.

Table 4-2
Typical Fire Door Ratings (In Hours)

Location	Wall or Partition Rating	Fire Door Assembly Rating
Shafts	2	1-1/2
	1	1
Firewalls and barriers	4	3*
	3	3
	2	1-1/2
	1	3/4
Corridors	1	1/3
Smoke barriers	1	1/3

*Firewalls that separate buildings must have two 3-hour assemblies (one on each side of the wall), a fire **barrier** may get by with one.

Interpreting Fire Door Labels

What does a fire door assembly label tell you? In addition to the manufacturer's name, you will find the name of the independent testing laboratory that evaluated it for fire resistance performance. Usually, this is Underwriters Laboratories, Inc. or Warnock Hersey, but it may be any recognized third-party testing service.

The label should tell you the door is "classified," which means that an identical assembly has been tested under specific laboratory conditions to satisfy the fire-rating requirements.

Look at Figure 4-6: Fire Door Labels. You will see one is for a hollow metal door leaf, the other a composite material. One has a fire resistance rating of 1-1/2-hours, the other only 1-hour. Both fire ratings are followed by the letter "B," even though they have different fire protection ratings. The letter designation is intended to identify the "opening" for which the door is intended. Table 4-3 provides a summary of the letter designations.

Table 4-3
Fire Door Assembly Letter Designations

Class	Recommended for Openings Located in:
A	Firewalls and walls that divide a single building into fire areas.
B	Shafts and vertical enclosures, and 2-hour-rated partitions.
C	Walls or partitions between rooms and corridors.
D	Exterior walls likely to suffer **severe** fire exposure.
E	Exterior walls likely to suffer **moderate** fire exposure.
F	Exterior walls likely to suffer **light** fire exposure.

This alphabetic method of labeling has been de-emphasized in recent years because of the potential confusion between the required door rating and the opening location identifier. Once, it was common to call a 1-1/2-hour door a "Class B door," but as shown in Figure 4-6, it could also be rated only 1-hour. Today's preferred identification method is to rely on the hourly fire protection rating.

The next line on the upper label in Figure 4-6, "Temp. Rise 30 Min. 250 F. Max." means that when the door was tested in a furnace, the side away from the flames rose not more than 250 °F (121 °C) above ambient after 30 minutes of fire exposure. If there is no temperature reported, it means the temperature on the side away from the flames rose more than 650 °F (343 °C). Fire door assemblies with the 250 °F temperature rise limitation typically are required in stair enclosures and other means of egress to protect humans in the exit system.

The final line, "Minimum Latch Throw," is the minimum distance the latch must extend beyond the faceplate in order to assure the door latches properly.

FIRE AND SMOKE DAMPERS

Fire Dampers

When heating, ventilating, and air-conditioning (HVAC) ducts penetrate fire-rated walls, barriers, and partitions, a fire damper usually must be inserted in the plane of the wall where the duct goes through.

Fire dampers employ fusible link elements to close automatically in the event of a fire and prevent flame transmission through the wall. ***Listed*** fire dampers have a rating of 90 minutes or 3 hours.

Smoke Dampers

Smoke dampers, on the other hand, are placed in HVAC systems where that equipment penetrates smoke barriers. These dampers are electrically operated and controlled by smoke detectors. They are designed to minimize the amount of smoke and toxic gases that pass through

a smoke barrier. The locations of smoke dampers are important to the IC because they may be key components of the building's smoke management/smoke control system, which is discussed in Unit 9: Integrated Systems and Performance.

Some smoke dampers are listed for both **fire resistance** and **leakage rating** (the term used for smoke control).

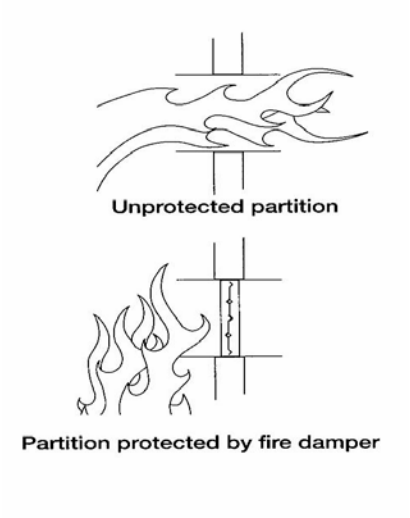


Figure 4-7
Fire Damper Protection



Figure 4-8
Typical Fire Damper



Figure 4-9
Closed Smoke Damper

STRUCTURAL PROTECTION

Since not all construction components are inherently fire resistant, in some cases the building codes require additional materials be added to provide protection. This is done through **encasement** or **spray-on**.

Encasement

Encasement involves the direct application of some fire-resistive medium: Gypsum wallboard and concrete are two of the most common. In Figure 4-10, for example, the noncombustible steel will begin to fail when it is heated, so the concrete is applied to the lower portion of the column to absorb heat and prevent the steel from weakening early in a fire. Steel columns and other structural elements may be encased with one or more layers of wallboard, and specific thickness of concrete to provide fire protection. In Figure 4-10, the column is in a parking garage, so the concrete also helps protect it from collisions.

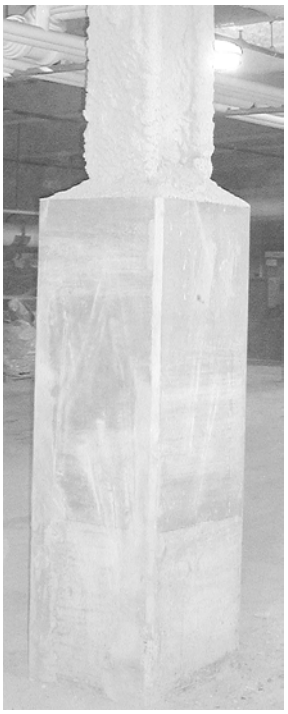


Figure 4-10
Concrete-Encased Steel Column

Spray-on Fireproofing

Spray-on fireproofing is a material that is applied wet, and dries to a hard finish. It looks like cotton or cellulose, and many people mistake it for sound deadening rather than its primary purpose of fire protection. (In Figure 4-10, the upper portion of the column is protected using this method.) Spray-on fireproofing is commonly applied to open web steel trusses and steel columns. It also may be applied to the exposed side of metal-pan floor/ceiling assemblies to provide additional heat resistance.

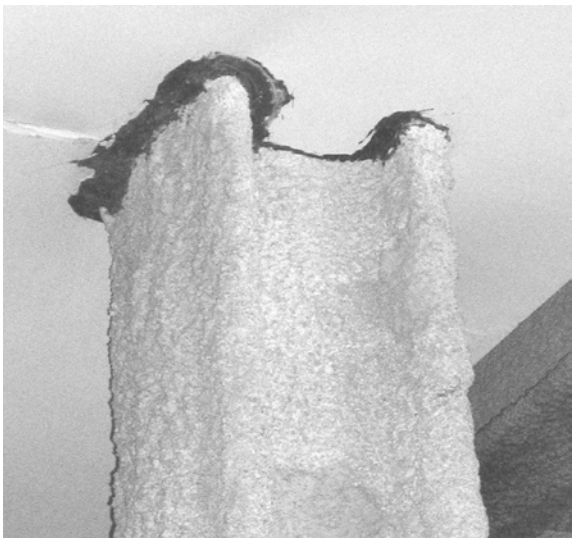


Figure 4-11
Steel Column: Spray-on Fireproofing

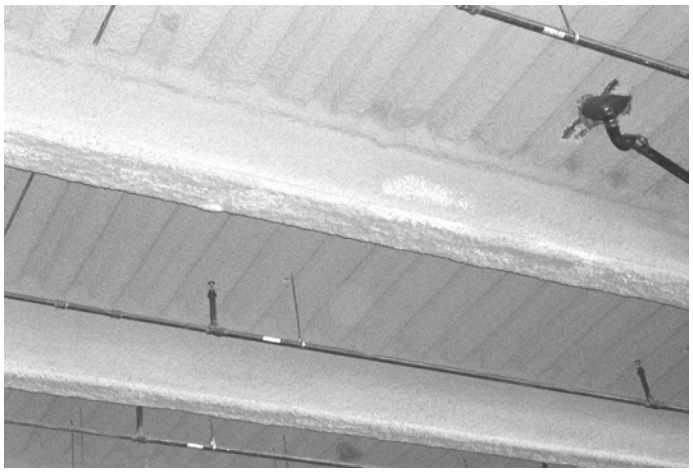


Figure 4-12
Metal Deck: Spray-on Fireproofing

Spray-on fireproofing is an essential element of the structural fire protection. If it is damaged, removed, or otherwise compromised, the structural integrity of the building during a fire is endangered. Damaged or missing spray-on fireproofing identified during preincident planning or code enforcement inspections should be reported to the building owner and code enforcement official (see Figure 4-13).



Figure 4-13
Inadequate Column Protection

FIRESTOPPING, DRAFT STOPS, AND CURTAIN BOARDS

Firestopping

The fire-resistive integrity of passive fire protection works only if it is fully enclosed. Penetrations for communications equipment, electrical cables, plumbing and gas lines, sprinkler pipe, and other utilities may result in holes that allow heat, fire, and toxic gases to escape an enclosure.

Where these penetrations are identified in a firewall, barrier, or partition, they must be sealed with **firestop** materials that have a fire resistance rating at least equivalent to the construction. This can be accomplished with fire-resistive or ***intumescent*** mastics, caulking, or pillows--special products that are manufactured to provide passive fire protection in these openings.

Fire Blocks

Fire can travel inside concealed spaces of walls and floors. Anyone who has experienced a fire in a balloon-frame construction building knows the challenges this presents.

Modern building codes require the installation of fire blocks or "fireblocking" in combustible walls, floors, stairs, between floors, and in other areas to slow fire spread in these enclosed spaces.

Draft Stops

In combustible concealed spaces (attics, between floors, etc.), natural air currents and those caused by convection from a fire may spread a fire quickly beyond its area of origin, especially since fire attack in these areas may be delayed because of other priorities.

The building codes require the installation of **draft stops** to slow these air currents. Draft stops are not necessarily fire resistant, since their only function is to slow air movement in the concealed area. Penetrations around draft stops should be sealed to slow air movement.

Draft stops can be found in crawl spaces, floor/ceiling assemblies, roof/ceiling assemblies, and attics of combustible construction.



Figure 4-14
Horizontal Fire Blocks



Figure 4-15
Attic Draft Stop

Curtain Boards

Draft curtains typically are installed in factory and industrial buildings, warehouses, and other large open spaces where it is important to slow air currents along the underside of the ceiling. Draft curtains must be made from noncombustible materials, be sealed around the penetrations, and hang between 4 feet and 8 feet from the ceiling. On your next visit, look at the ceiling of your local Home Depot store to get a sense of how draft curtains are installed.



Figure 4-16
Curtain Board

PASSIVE FIRE PROTECTION FEATURES MAINTENANCE

Passive fire protection is an important element of a structure's overall fire resistance. In fact, for many occupancies, it may be the only fire protection within the building.

To be viable, however, passive fire protection features must be maintained as they were designed and installed. Firewalls that are compromised by holes or other damage must be repaired with equivalent fire-rated construction. Fire door assemblies must not be propped open or otherwise rendered out of service. Fire protection achieved through encasement or spray-on application must be replaced if it is missing or damaged.

While it is predominantly the fire inspector's role to identify and arrange the correction of these deficiencies, every firefighter and IC has an obligation to become familiar with passive fire protection features and how they can be exploited to strategic and tactical advantage.

Walls, floors, and ceilings do more than define the spaces in which we work and live. They may provide a life-saving barrier between you and the fire, but they will work only if properly maintained. If you identify a problem with a passive fire protection feature, identify it on the preincident plan, and notify the owner and code enforcement official that repairs, or corrective action must be taken.

PASSIVE FEATURES' STRATEGIC CONSIDERATIONS

Passive fire protection features are installed to create "compartments" or "boxes," separating one space from another. The space may be small, such as a clothes closet, or large, such as an industrial plant or warehouse. One side of the barrier may contain a highly hazardous occupancy, and the other may have no hazards at all. In any case, the IC must have an understanding of--and appreciation for--how passive fire protection features work in a building.

When developing fire control strategies, the IC should keep in mind why the passive fire protection features were installed in the first place.

The primary function of passive fire protection features is to help confine spread of fire, heat, and products of combustion horizontally or vertically. This is accomplished by the installation and maintenance of fire-rated walls, ceilings, roofs, and other vertical or horizontal separations.

Passive fire protection also may have been selected by the owner or occupant as a means of avoiding code requirements for other fire protection features, especially sprinklers. The report below describes an event where the owner and architect chose this option.

When Code Alternatives Don't Work

In 1992, a Bellingham, Washington, developer erected a one-story 24,000 square foot tilt-up concrete building to attract an international furniture retailer. The local building code in force at the time required all retail occupancies "more than" 12,000 square foot to be outfitted with an automatic sprinkler system.

To avoid the cost of the sprinklers, the developer arranged to have the retail space divided almost in half by a four-hour firewall, creating two "buildings" under the same roof. In fact, the thickness of the wall alone was enough to reduce floor space on both sides of the wall to a few square inches less than 12,000 square foot In order to move people and products from one side of the store to the other, the developer installed a three-hour fire door assembly designed to close automatically upon operation of a smoke detector.

About three years after the store's grand opening, an overheated fluorescent light ballast dripped flaming, molten insulation onto a polyurethane foam sofa that was sitting directly beneath the light fixture. The sofa fire spread to adjacent furniture, and, due to delayed reporting, the fire grew into a multiple alarm event.

The three-hour fire door assembly had been propped open by bed frames, so it failed to close when the smoke detector operated and the fire spread through the opening to the opposite side of the firewall.

The fire eventually was extinguished with master stream and large diameter hand lines. The direct fire loss was estimated at the time at nearly $1 million.

When the developer rebuilt, he did not add sprinklers.

The IC should consider the following points during his or her strategic assessment of the incident:

- Passive fire protection features establish the perimeter of specific spaces, enabling the IC to identify potential lines of defense. These perimeters may be horizontal (floors and ceilings) or vertical (walls).

- Parapets, when used, usually align with the firewall beneath them. Conversely, not all firewalls are identified by parapets above the roof because of construction alternatives. Good preincident planning will identify where these critical fire protection features are located.

- Passive fire protection features may identify the boundaries of large open areas that may have large amounts of combustibles in the form of storage or furnishings.

- Passive fire protection features can assist with "defend in place" strategies in high life-risk occupancies.

- Passive fire protection can be employed for directed control of fire, heat, and products of combustion. Opening/Closing fire doors and other opening protectives can be used to direct the fire.

Positive pressure ventilation with mobile, powered fans is an example of using fixed barriers and openings to channel smoke out of a building. Opening rooftop heat and smoke vents can improve interior visibility.

By confining fire spread, passive fire protection features provide time for emergency forces to conduct sizeup, search and rescue, and make tactical attack decisions.

PASSIVE FEATURES' TACTICAL CONSIDERATIONS

Passive fire protection features work only when they are maintained properly. If they are compromised, they lose their effectiveness at resisting fire, heat, and products of combustion.

If passive fire protection features are compromised during an event, the IC should

- Assign one or more persons to close all fire doors.

- Assign one or more persons to close all stair and elevator enclosure doors.

- Assign one or more persons to close all fire shutters or curtains.

- Protect hoselines from overhead coiling steel doors.

- Protect openings in firewalls and barriers with hose streams.

  - If openings are protected with deluge systems or water curtains, check operational condition and prepare to use them.

- Protect adjacent exposures with hose streams.

- Avoid additional compromise except for rescue or overhaul (i.e., don't cut roofs across parapets).

If rooftop smoke and heat vents are not operating, size up the situation and open them with handtools if recommended. Shrink- or melt-out vents can be cut with a power saw, or the corner lifted with a pick-headed axe. Spring-loaded vents may have rooftop or interior pull handles to release the vent.

FIRE PROTECTION: THE BASICS

Community fire protection is a complicated mix of manual suppression, built-in detection and suppression, building construction limitations, water supply, access roads, weather conditions, and human behavior. There is no single solution to a community's fire challenge.

IC's and firefighters can perform their jobs more efficiently and safely if they understand the varied components of the built environment: passive and active fire-protection features. These complementary parts should be included on preincident plans so the fire department can provide the best level of service within the resources it has.

Activity 4.1

Fun with Erfi (Fire)

Purpose

To learn the variety of terminology used to describe passive fire protection features, and to help the instructor assess your familiarity with these terms.

Directions

1. You will be playing an anagram game where the letters of familiar words are jumbled. The words all describe some passive fire protection feature that may be found in a building.

2. You will be shown a series of 13 pairs of slides with descriptive clues, and the answer jumbled at the bottom.

   Example: a device used to add strings of numbers--lalacrotuc.
   (The correct answer is "calculator.")

3. Once you rearrange the letters into the correct word, call out your answer in class.

4. The instructor will display the correct answer on the screen.

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Activity 4.2

Passive Fire Protection Systems

Purpose

To identify some of the maintenance issues related to passive fire protection features.

Directions

1. Work in table groups to identify the ways that the fire protection of the passive fire protection systems listed in the left column of the Worksheet may be compromised, and the impact of a fire if these systems are not properly installed and maintained.

2. List your group's findings on an easel pad and select a spokesperson from the group to report the findings.

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Activity 4.2 (cont'd)

Passive Fire Protection Systems Worksheet

Passive Fire Protection System	Potential Problems
Property line setbacks	
Fire doors	
Firewalls	
Protected steel	
Vertical openings (chases)	
Smoke barriers	
Fire barriers	
Stairway enclosures	
Draft curtains	

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Activity 4.3

Strategic and Tactical Considerations for Passive Fire Protection Features

Purpose

To employ passive fire protection features to achieve incident objectives, and to describe the strategy and tactics to achieve those objectives.

Directions

1. Working in table groups, review the following scenario. Identify and describe your incident objectives, explain your strategy to achieve those objectives, and describe the tactics you would employ to achieve successful results.

2. List your group's findings on an easel pad, and select a spokesperson from the group to report your recommendations.

Scenario

You are the acting lieutenant on a four-person ladder company. Your crew includes an experienced driver and two firefighters.

Late one winter afternoon, just as it's getting dark, you are returning from the apparatus maintenance shop when the radio and mobile data terminal alert you to a possible structure fire at the intersection of 6th and Main Street, the Anderson Transfer and Storage Building.

You realize that your company is only about eight blocks away, and could be the first-arriving unit. You acknowledge the alarm, and notify the fire dispatch center that you will respond as part of the normal alarm assignment. The next nearest company is at least 6 minutes away, if they are in quarters.

As the truck turns onto Main Street, in the street lights you can see low-lying smoke banking close to the sidewalk and almost completely obscuring the street. As you get closer, you look down the alley and can see an orange glow through the open steel door facing the east alley.

You are about to give your radio sizeup when a middle-aged man emerges from the smoke in front of the building, coughing and gagging. Between coughing fits, he tells you the company is having a holiday party on the third floor, and there may be 12 to 18 people trapped on the upper floors. He does not know how many people made it out of the building.

As IC, you must

1. Describe your objectives.

2. Explain your strategy to accomplish your objectives.

3. Describe your tactics.

4. Identify which passive fire protection features are compromised, and how you would overcome the impairments.

Activity 4.3 (cont'd)

Quick Access Prefire Plan

Building Address:
6th and Main Street (Anderson Transfer and Storage)

Building Description:
Four-story office with tall one-story warehouse. Ordinary construction.

Roof Construction:
Plywood roof deck with hot mop asphalt.

Floor Construction:
Heavy timber joists.

Occupancy Type:	**Initial Resources Required:**
Office and personal good storage.	*3E, 2T, 1 Squad, Deputy Chief*

Hazards to Personnel:
Warehouse contents stored in heavy packing/shipping boxes to 20 feet. Tank farm across alley to east.

Location of Water Supply:	**Available Flow:**
4th and Main Street	*1,875 gpm*

	Estimated Fire Flow			
Level of Involvement	*25%*	*50%*	*75%*	*100%*
Estimated Fire Flow	750	1,500	2,250	3,000

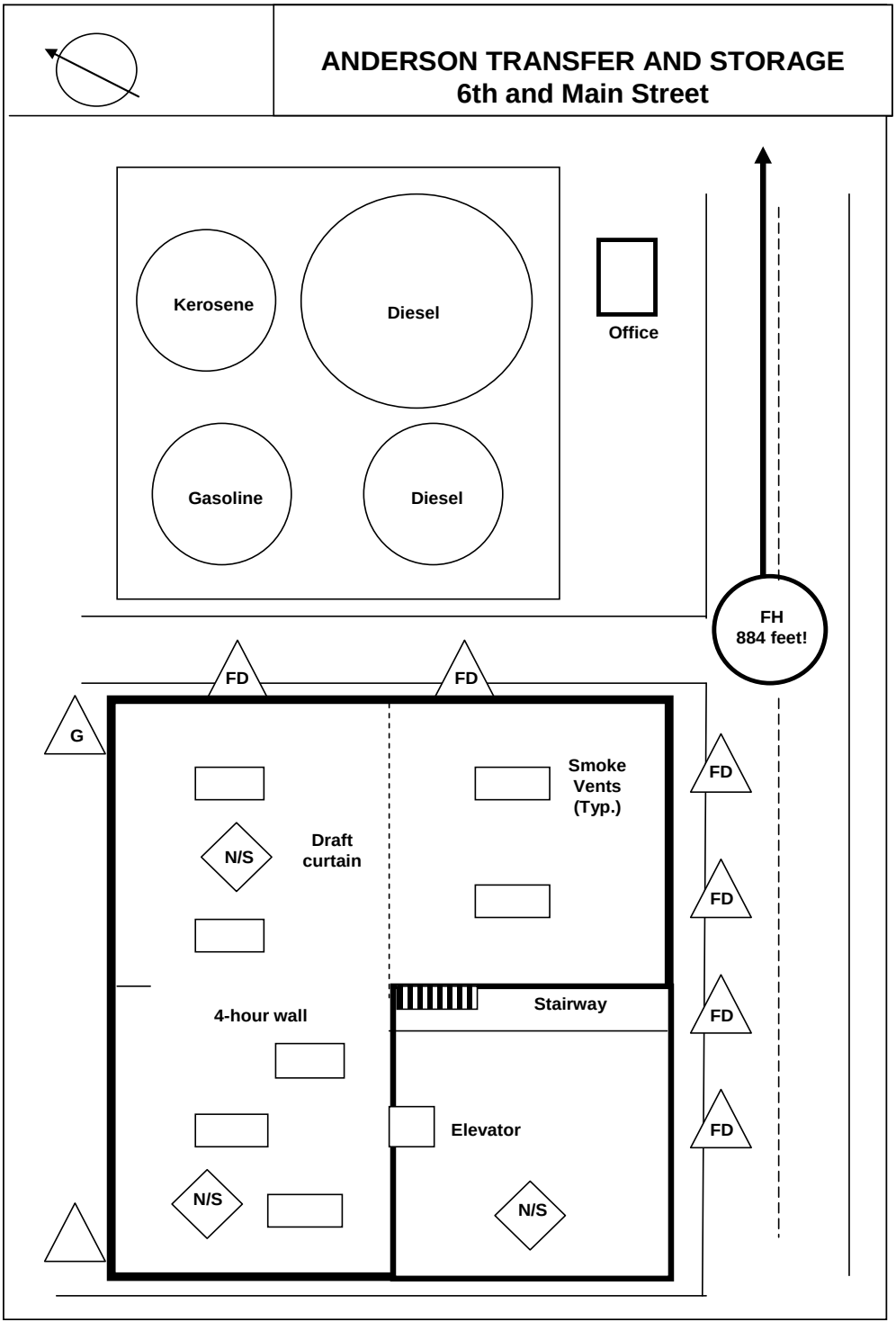
Fire Behavior Prediction:
Heavy fuel load in warehouse, light hazard in office, watch for vertical openings. Freight elevator is open to all floors.

Predicted Strategies:
Fast attack with large handlines or go to defensive mode.

Problems Anticipated:
Ordinary construction, heavy fuel load, inadequate water supply.

☒ **Standpipe:**	☐ **Sprinklers:**	☐ **Fire Detection:**
1-1/2-in. house line in stairway	*None*	*None*

Plot Plan

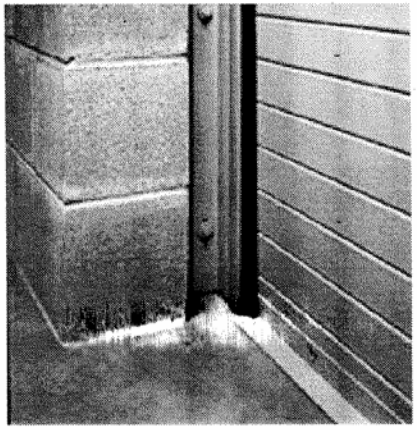

ANDERSON TRANSFER AND STORAGE
6th and Main Street
Kerosene
Diesel
Office
Gasoline
Diesel
FH
884 feet!
FD
FD
G
FD
Smoke
Vents
(Typ.)
N/S
Draft
curtain
FD
4-hour wall
Stairway
FD
Elevator
FD
N/S
N/S

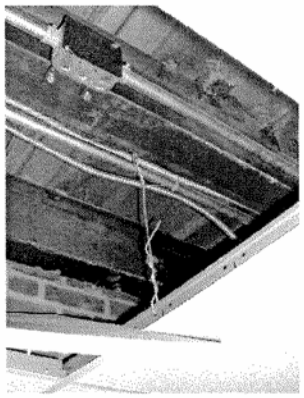
APPENDIX

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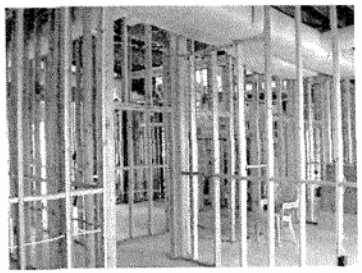
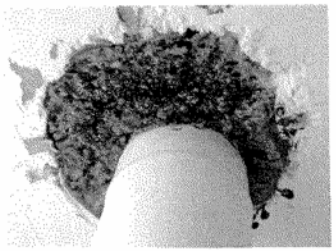
Job Aid 4.1
Passive Fire Protection Features

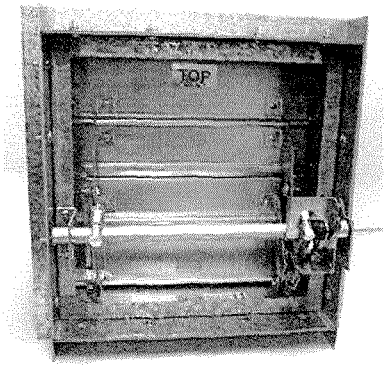
It is very difficult to identify passive fire protection features in buildings or structures once they are constructed. This job aid may help the IC or preincident planning team identify some of the more common passive fire protection features. The building department or fire marshal's office may have drawings or building plans that clearly show where these features are found on specific buildings.

	Feature	Description	Fire Resistance Ratings (Hours)	Where Found
	Firewall	A wall that restricts the spread of fire, and extends continuously from the foundation to or through the roof. All openings must be protected with fire doors or dampers. Firewalls have sufficient structural stability under fire conditions to allow structural collapse on either side without causing the wall to collapse. By code, firewalls create separate buildings.	2, 3, or 4	Separating large open spaces, separations between different occupancy types.

	Feature	Description	Fire Resistance Ratings (Hours)	Where Found
	Fire Barrier	A wall or floor/ceiling assembly, or combination of both designed to restrict fire spread. All openings must be protected with fire doors or dampers. Fire barriers can be vertical (walls) or horizontal (floor/ceilings) or both, and end at the outer edges of the spaces they create.	1, 2, 3 or 4	Occupancy separations, shaft enclosures, exit passageways, incidental use areas, horizontal exits.
	Fire Partition	A wall designed to restrict fire spread. The partitions end at the outer edges of the spaces they create.	1, 2, 3 or 4	Corridors, walls separating dwelling units, walls separating tenant spaces in a covered mall.

Feature	Description	Fire Resistance Ratings (Hours)	Where Found
Fire Door Assembly	Any combination of fire door, frame, hardware and other accessories that together provide a specific degree of fire protection rating	1/3, 1/2-, 1-, 1-1/2 - or 3	Any fire resistive rated wall assembly that has openings for moving people or goods.
Fire Damper	A device designed to close automatically upon detection of heat, interrupt migratory airflow and restrict flame passage.	1-1/2 - or 3	Ducts and air transfer openings
Draft Stop	Material, device or construction installed to restrict the movement of air within concealed spaces of combustible buildings	None	Crawl spaces, attics floor/ceiling assemblies, roof/ceiling assemblies

	Feature	Description	Fire Resistance Ratings (Hours)	Where Found
	Fireblocking	Building materials installed to resist the free passage of flame to other areas of the building through concealed spaces.	None	Walls, ceilings, and floors, stair stringers.
	Fire Stop	Specific materials or products (pillows, pads, caulk) that are designed, tested, and fire resistance rated to stop fire spread through rated walls or ceilings.	1 to 4	Pipe penetrations, cable penetrations, duct penetrations.
	Smoke Barrier	A continuous vertical or horizontal membrane that is designed and constructed to resist the passage of smoke.	None	Wall, floor, ceiling assembly, hospitals, nursing homes, jails.

	Feature	Description	Fire Resistance Ratings (Hours)	Where Found
	Smoke Damper	A device designed to close automatically upon the detection of smoke, and to resist the passage of air and smoke. Where required, is capable of being repositioned from a remote command station.	None, rated for air leakage	Ducts and air transfer openings.
	Combination Fire/Smoke Damper	A device designed to close automatically upon the detection of heat or smoke, and to resist the passage of air and smoke. Where required, is capable of being repositioned from a remote command station.	1-1/2 to 3 for fire damper, none for smoke damper (air leakage rated)	Ducts and air transfer openings.

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UNIT 5:
FIRE ALARM SYSTEMS

TERMINAL OBJECTIVE

The students will be able to describe the role of fire alarm systems in life safety, fire protection, and fire control.

ENABLING OBJECTIVES

The students will:

1. *Identify the types of alarm systems and their locations.*
2. *Explain how each type of alarm system works.*
3. *Recognize the types of impairments that can affect the effectiveness of fire alarm systems.*
4. *Describe strategies and tactics related to the effective use of fire alarm systems.*

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OVERVIEW

This unit summarizes fire alarm systems, describing the various types in use, the occupancies that they are used to protect, and providing an overview of how each functions. Systems may be as simple as a manual pull station type that sounds a building fire alarm, or as sophisticated as an automatic system that is capable of operating air-handling and ventilation systems in order to limit fire travel and the spread of combustion products.

You will find that all systems have specific limitations. These systems are used to alert occupants and emergency service personnel, but, to protect lives and property effectively, an alarm system should be used in conjunction with fire suppression systems. Most fire alarm systems do not initiate any direct firefighting appliances; however, there are exceptions, such as water spray, clean agent, or carbon dioxide systems.

This unit is intended to provide a brief overview for Incident Commanders (IC's). Students interested in learning more about the requirements and technical details of fire detection and alarm systems should consider enrolling in the National Fire Academy (NFA) class *Principles of Fire Protection: Structures and Systems.*

TYPES OF ALARM SYSTEMS

Automatic Systems

Automatic alarm systems will function, without the need for human intervention, to receive and sound an alarm. They depend upon the activation of a detection device, flow switch, tamper device, or other sensor that is interpreted at a central signal-processing unit, commonly called the fire alarm control panel. Depending on the type of installation, the central processor **may** notify the proper persons to respond. The central processor also will activate indicating devices such as annunciator lamps, audible devices, or signal devices that may be incorporated into the system.

Manual Systems

These systems require human interaction to begin the fire alarm transmitting process. By the activation of a pull station, or transmission from a central control point, the building occupants are notified and the emergency services may be summoned.

FIRE ALARM CONTROL PANEL

The heart of the fire alarm system, the fire alarm control panel, contains all the electronics, indicators, and terminal equipment for the entire alarm system. Depending upon the complexity of the system, the IC may be able to make selective public address announcements from this point, have telephone communication with various areas of the occupancy, or control a variety of fire protection features in the building.



Figure 5-1
Typical Fire Alarm Control Panel

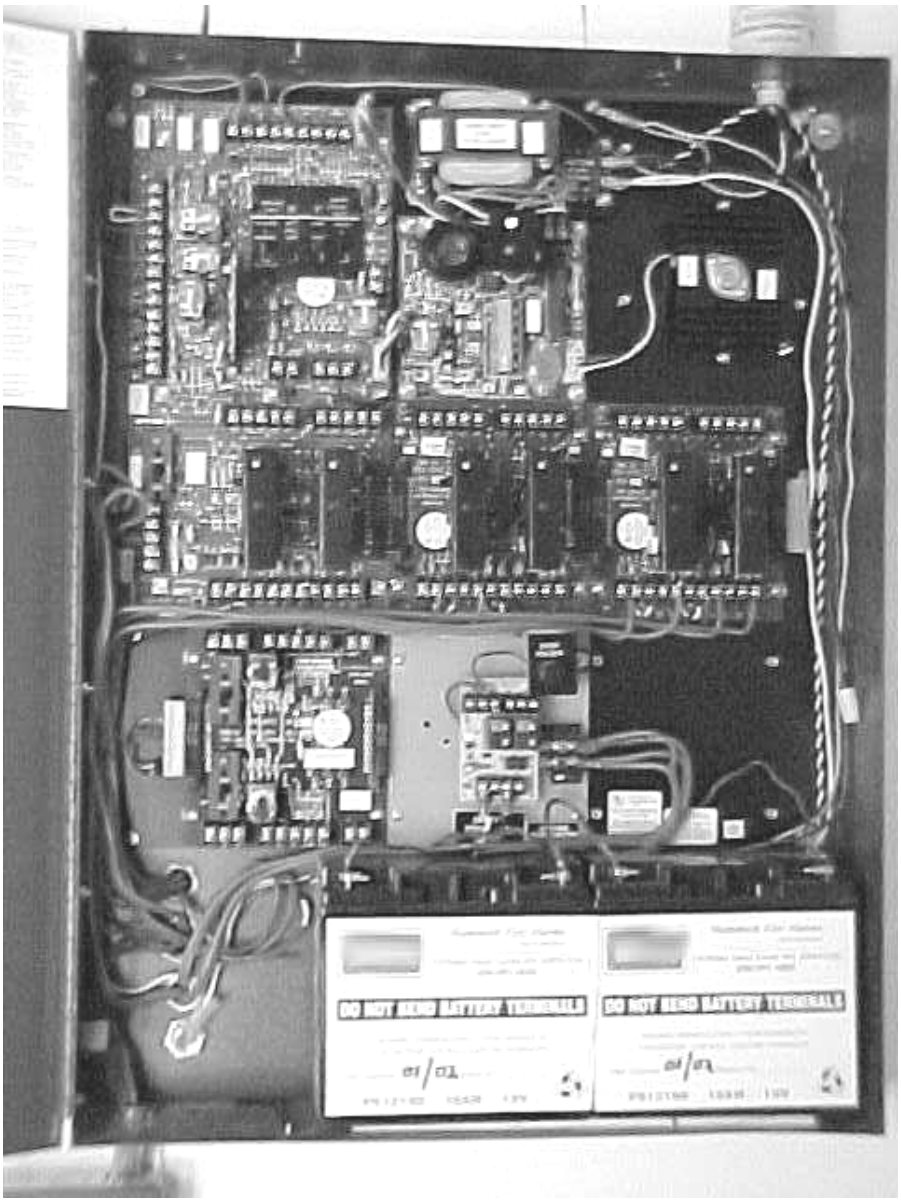


Figure 5-2
Typical Fire Alarm Control Panel (Interior)

By responding to and looking at the fire alarm control panel, the IC may determine the location of the alarm; whether it is fire, trouble, or supervisory; may silence audible devices; acknowledge the alarm; and reset the system. Depending upon the level of system sophistication, the IC also may be able to operate air-handling systems for the redirection or suppression of smoke, or operate other systems that will expedite fire suppression activities. Some systems will capture elevators and place them in the lobby for fire service use.

The alarm control panel may be located in an open area of a building, lobby of the occupancy, electrical or mechanical rooms, or in the case of a large complex, it may be housed in a separate

room. The local fire marshal is permitted to specify any location in the building where the fire alarm control panel should be located. This location will assist in selecting the location for the Command Post (CP) for any incident because the IC will want to be in constant communication with someone at the fire alarm control panel.

Signals

Fire alarm control panels are designed to receive and process a variety of signals. Interpreting these signals, especially in a distracting environment when the alarm is ringing and the strobes are flashing, can challenge even the most experienced IC. While most signals are presented on panels in only a few ways, it is important for the IC to become familiar with them before a problem occurs.

It's also important for the IC to remember that when it comes to fire alarm control panels, the word **signal** may apply to **visual** and **audible** signals that must be interpreted. Visual signals typically are green, yellow, or red lamps or light-emitting diodes (LED's). Audible signals at the fire alarm control panel can be buzzers, bells, or whistles.

Normal Status

When the fire alarm system is fully functional and ready to operate, the only signal the IC should see is a green lamp or LED that indicates the fire alarm control panel is receiving its regular power supply (usually 120-volt AC). Although this is no guarantee the system is fully operational, without a comprehensive electronics analysis, it is the best indicator to the IC that everything is "normal." If other lamps are illuminated (yellow or red) there is a problem with the system that must be addressed by a service technician. Not certain if the lights are working? There is a "lamp test" switch somewhere on the panel that can be toggled to check the status of all the LED's.

Fire or Emergency Alarms

Fire alarms or other emergency conditions usually are displayed with red lamps or LED's and also may be displayed on a screen or paper printout. The screen or printout may display the location of the specific device that is in alarm and indicate what the detector has sensed. As other devices operate, the screen or printout is updated with any successive information received by the central control unit. When the fire alarm control panel receives an emergency signal, the alarm in the panel will sound as well until it is silenced.

Trouble Signals

If something goes wrong electronically with the fire alarm system, the central control unit should display a ***trouble signal***: a yellow lamp or LED and an audible sound. Normally, the fire service

is not notified automatically of trouble conditions because they range from faulty detectors to any number of system malfunctions such as open circuits, failure of the primary or secondary power supply, ground faults, or disconnected devices. Usually, in the case of trouble alarms, a system technician or facility maintenance person familiar with the system will be notified to respond and rectify the situation.

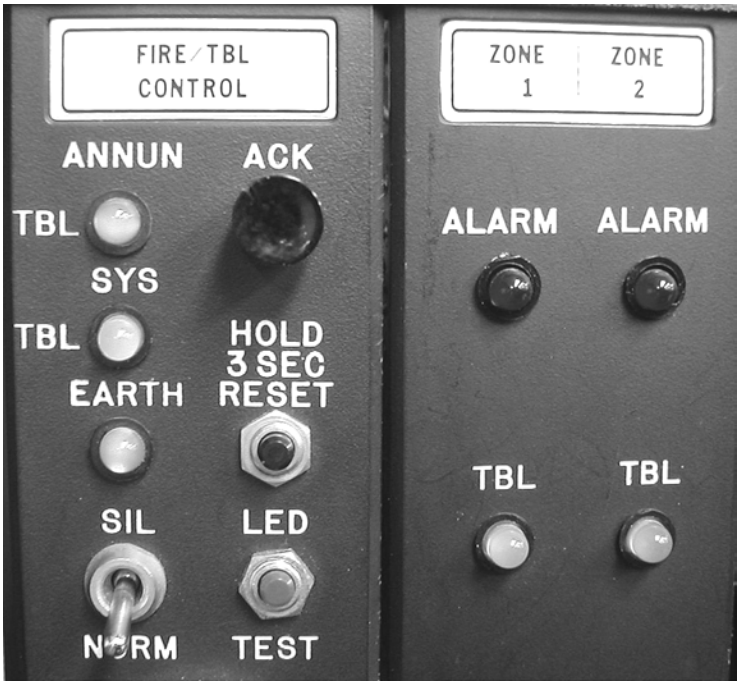


Figure 5-3
Simple Fire Alarm Control Panel Controls

The audible trouble signal at the panel may be silenced, but a visual signal must remain until the problem is fixed. Newer fire alarm control panels are arranged so the audible trouble signal sounds once every 24 hours as a reminder that technical repair service is needed. Should the IC find a fire alarm system with yellow lights showing during a preincident survey or inspection, this is a situation where the building owner and code enforcement official should be notified right away.

Tampers/Supervisory

A fire alarm control panel can be arranged to monitor or supervise the condition of a variety of fire protection features. Tamper switches may be placed on water supply control valves so if someone closes the valve, the fire alarm control panel receives a "tamper" alarm. Water pressure, air pressure, water temperature, fire pump status, and water levels are just a few of the many items that can be supervised.

When a ***supervisory signal*** is received at the fire alarm control panel, the typical response is for a yellow or red lamp or LED and an audible alarm to occur. This can be confusing to an untrained person who misinterprets a supervisory alarm for a trouble signal. They are not the same thing, and if the fire alarm system has been wired properly, they will report differently at the fire alarm control panel. Normally, the fire department is not summoned for a tamper or supervisory alarm. Remember, "trouble" is electronic; there is an electrical problem with the system. "Tamper" or supervisory is mechanical; someone is adjusting a valve or there is something wrong with a fire protection system that needs a technician's attention.

Power Supplies

Fire alarm control panels must be equipped with reliable power supplies. Most systems installed today receive their primary power from the local utility service, usually the same service that provides lights and power for the rest of the building.

In the event of a power failure, or serious voltage drop due to brown-out conditions, a fire alarm control panel must have a secondary power source. In most cases, this is a gel-cell battery, but the secondary power source may be a generator, uninterruptible power supply, or other arrangement that assures a secondary power source is available.

The secondary power for the fire alarm control panel must be adequate to power the system for at least 24 hours, and then have enough reserve to sound all alarm devices for at least 5 minutes. In those facilities equipped with voice command or public address systems, the secondary power must be capable of operating the communications equipment for at least 2 hours after the 24-hour secondary power period.
Electrical power terminology can be confusing. The following definitions may help:

Primary power is the regular, "day-to-day" power source for a building or equipment. Normally, it is provided by a utility company, but may be generated on site in the case of an industrial facility or similar occupancy.

Emergency power must operate automatically within 10 seconds, and last 90 minutes*. Emergency lighting units in exit paths are typical of this arrangement.

Standby power must operate within 60 seconds, and there is no specified duration*. Diesel- or gas-powered generators are usually used to accomplish this power supply.

Secondary power is a term applied only to fire alarm systems. It must operate within 30 seconds and power the system at least 24 hours with at least 5 minutes of alarm capacity at the end of that period*.

Backup power is not a defined term.

* Source: National Fire Protection Association (NFPA) Standard 70, *National Electrical Code*®.

DEVICE AND WIRING ARRANGEMENTS

Zoned Protection

The system may be divided into various protection zones. This is accomplished by the way the detection wiring circuits are arranged in the building. For example, all of the detection devices on one floor may be on one circuit, and those on another floor are on a different circuit. In this case, the building is said to be zoned "by floor." Similarly, the system could be arranged so all pull stations are on one circuit, water flow switches on another, smoke detectors on another, and so on. The number of zones is limited only by the capacity of the fire alarm control panel. The zone arrangement usually is approved by the local fire marshal or code enforcement authority.

The system may be noncoded or coded. In the case of noncoded systems, the zone must be identified at the fire alarm control panel. A coded system, on the other hand, will sound a sequence of three coded signals, indicating the location of the alarm, much the same as a municipal street box alarm system. This serves as an indicator not only to fire department response units, but also to facility safety personnel. Table 5-1 is an example of typical coding arrangements for signals.

Table 5-1
Sample Fire Alarm Coded Sequences

Location	Alarm Signal Sequence
Basement	1-1*
First floor	2-1
First floor pull station (east)	2-1-1
First floor pull station (west)	2-1-2
Second floor	2-2
Third floor	2-3
Attic	3-1

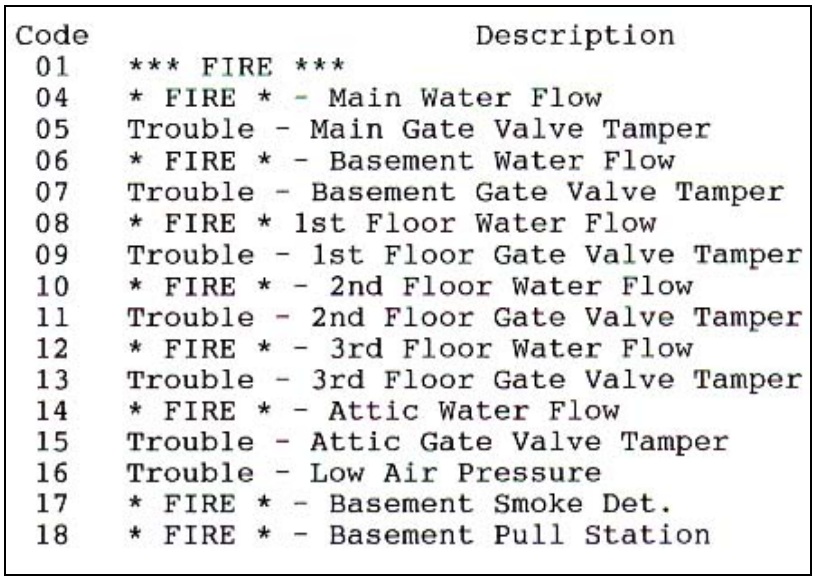
*One stroke or ring of a bell, followed by a half-second pause, then a second stroke. After a 1- to 2-second pause, the pattern repeats two more times. Following the third "round" there is a longer pause, and the cycle repeats until the system is reset.

Addressable Systems

The advent of digital technology has allowed greater flexibility and capability to be incorporated into fire alarm systems. In the addressable system each component of the system is provided with a multidigit or alphanumeric system "address." This allows the system to audit periodically all the components, such as smoke detectors, and test the operating condition of each unit. It also allows the central computer to compensate for such things as normal obscuration of light channels, and alerts system technicians to replace the unit when it is falling below required operating characteristics. In this respect, it lowers the rate of false alarm transmission.

Not only can the system perform periodic self-tests, but also in the event of activation it allows each element of the system to perform pre-programmed functions. As one example, if an in-duct smoke detector activates, not only will the alarm sequence be started, but part of the programmed function of that particular detector may be also to shut down fans, close dampers, or perform any number of other tasks assigned to it by a computerized fire alarm control panel. The fire alarm control panel identifies the specific device in alarm, thus greatly reducing the search time needed to find the problem.

Addressable systems allow individual tasks to be assigned to each detector. Normally the functions performed are indicated on the central control panel, either in the form of a printout or graphics, or both. When resetting these systems, the IC can follow the sequence of restart in the various controlled systems from the control panel.



Code	Description
01	*** FIRE ***
04	* FIRE * - Main Water Flow
05	Trouble - Main Gate Valve Tamper
06	* FIRE * - Basement Water Flow
07	Trouble - Basement Gate Valve Tamper
08	* FIRE * 1st Floor Water Flow
09	Trouble - 1st Floor Gate Valve Tamper
10	* FIRE * - 2nd Floor Water Flow
11	Trouble - 2nd Floor Gate Valve Tamper
12	* FIRE * - 3rd Floor Water Flow
13	Trouble - 3rd Floor Gate Valve Tamper
14	* FIRE * - Attic Water Flow
15	Trouble - Attic Gate Valve Tamper
16	Trouble - Low Air Pressure
17	* FIRE * - Basement Smoke Det.
18	* FIRE * - Basement Pull Station

Figure 5-4
Example of Addressable Programming

Digital systems normally are found in larger occupancies, and it is advisable to have one or more representatives from facility maintenance and engineering present to ensure that proper procedures are followed and that the system is completely functional prior to leaving the scene.

Alarm Verification

Digital communications also have allowed the creation of a fire alarm feature called ***alarm verification***. The purpose of this feature is to reduce substantially the number of inadvertent or false fire alarms to which the fire service responds.

Although each manufacturer achieves it with a different technology, essentially alarm verification consists of the following steps:

- The detection device (usually a smoke detector) senses something that would cause it to go into alarm.

- The device transmits a signal to the fire alarm control panel to "stand by" while the device continues to test the atmosphere around it.

- If, after approximately 30 seconds, the detector reports "all clear," the fire alarm control panel resets itself and no alarm is transmitted.

- If, however, the smoke or other product in the detector remains after about 30 seconds, the fire alarm control panel interprets this as a "verified" alarm and sounds an emergency signal.

Unfortunately, alarm verification is a feature that cannot be retrofitted onto many existing systems that continue to transmit unwanted or nuisance alarms.

FIRE ALARM SYSTEM INITIATING DEVICES

Initiating devices activate alarm signals and supervisory systems. Examples of initiating devices are manual pull stations, smoke and heat detectors, and water flow switches. Supervisory devices are tamper and temperature switches.

Pull Stations

Pull stations are found in a number of shapes and sizes. They normally will have operating instructions in raised lettering on the face of the station. Placed so that they are clearly visible to occupants, there usually will be at least one station per floor. Pull stations normally will be found near exits and stairway doors so that occupants may activate them as they exit the building. Pull stations also are referred to in NFPA 72, *National Fire Alarm Code*®, as "manual fire alarm boxes."



Figure 5-5
Manual Pull Station

Noncoded Pull Stations

This type of station sends a continuous signal that will sound the alarm system warning devices until the station and system are reset. Opening the station and allowing the switch to return to the off position is generally the most common means to reset this type of pull station. While most stations may be opened with a small screwdriver, some require a hexagonal wrench to open the station to reset it.

Noncoded stations do not indicate where they are located in the building and require fire companies to walk the occupancy to find the activated station.

Coded Pull Stations

Coded pull stations, when activated, send an intermittent signal to the central control unit. This signal is an indication of the position of the station in the building (refer to Table 5-1). The coded station simplifies deployment of company members to the area, which results in saving time in getting to the exact area of the fire.

Coded stations are reset in the same manner as noncoded. The only difference between the two may be that the coded station will have a plate attached to the face, indicating the number of the station.

Single-Action Stations

As the name implies, this type of station requires only one motion or action on the part of the user to activate the system. The single-action station is normally the type that breaks a small glass or plastic rod when the lever is pulled. A single-action station that has been activated will always appear with the activating lever protruding from the front of the station, or in the case of a slide-type lever, it will be protruding below the face of the station. When resetting this type of station, it is necessary to replace the glass rod in order to place the lever back into the operating position.

Double-Action Stations

This type of station requires that the person operating it perform two steps to activate the station. Normally, it requires that a door or cover first be opened to gain access to the activating switch.

In unusual situations, such as penitentiaries, pull stations require a guard or other responsible person to have a key to operate it. This is intended to prevent malicious or disruptive false alarms.

Reset Keys

Each manufacturer of alarm systems normally uses a proprietary locking mechanism common to its fire alarm control panel, annunciator panels, pull stations, and other associated equipment. In many cases, the pull stations may be reset simply by opening the cover of the box with this common key and allowing the spring-loaded switch to return to the "off" position.

The fire department may obtain these keys from the manufacturer so they may be distributed to Company Officers (CO's) or stored in a premises' key box. This will assist companies in the restoration of service when such keys are available.

DETECTION DEVICES

State-of-the-art detection systems may use one or a variety of the many detection modes on the market today. A diverse number of units are available to the design engineer to tailor a system to the needs of the occupancy.

A detector must be able to determine a fire condition and transform this response into a visual/audible signal to alert building occupants. Automatic detectors fall into one of six basic categories: heat, smoke, combination, fire gases, industrial gases, and flame.

Detector design and technology can be very complex, and the installation "rules" (established by codes and standards) are very demanding. Not all automatic detectors are suitable for all locations, so it is incumbent upon the designer and owner to derive the most suitable arrangement to protect life and property.

Three common terms used in conjunction with automatic detector design are "spot," "line," and "beam." These words are used to describe detector placement and operating method. A "spot type" detector is one that is placed on a single "spot" within the protected area, and provides detection response based on an area of coverage. Your home smoke alarm is an example of a spot type detector.

A "line type" detector is a continuous wire or cable strung through a protected area. The cable itself is the detection device. A "beam type" detector uses a visible or invisible light source either inside the detector or projected across an open space to provide detection.

Your local fire marshal or code enforcement authority should be consulted for guidance on these devices.

HEAT DETECTORS

In the category of heat detectors, there are **restorable** and **nonrestorable** detector features. While this is not a significant issue for the IC who is responding to an alarm, it may help explain why a fire alarm system cannot be reset in a timely fashion.

Restorable detectors respond to an increase in heat in the room or space where they are installed. Once the room temperature drops back to within "normal" range, the detector may reset itself and be ready to operate again. In this circumstance, it may be difficult for the IC to determine which specific detector operated to signal the alarm.

Nonrestorable detectors, on the other hand, are single use. Once they reach their design temperature and operate, they are "destroyed" and must be replaced by a qualified person. In this case, the fire alarm system cannot be reset, and the IC must leave the premises with a fire watch or other responsible party because at least part of the facility's fire protection is out of service at this point.

Fixed Temperature Heat Detectors

These spot type detectors normally are found in the highest part of the space they are protecting. They are the most basic type of automatic detector commonly in use and depend upon the action of heat expansion of a material, melting action, or a thermoelectric property to function. Fixed temperature detectors operate at a specific temperature determined at the time of manufacture, usually between 135 °F (57 °C) and 500 °F (260 °C), although higher operating temperatures may be made for special applications. While they are the least prone to false activation, they are also among the slowest acting type of automatic detector.



Figure 5-6
Fixed Temperature Heat Detector

Fusible Link and Glass Bulb Type

Nearly identical to sprinkler heads, the links and bulbs are used to hold electrical contacts apart until they fail at their predetermined temperature. The failure of the link or bulb allows the contacts to close and transmit an alarm to the central control unit. It is necessary to replace the fused unit to restore the system to operating condition.

Continuous Line or Thermistor Type

This line type detector will cover a wide area of a room or building according to their specifications. They often are used in large open spaces like warehouses (where they are laid across the truss chords), in cable trays, or even outdoors on conveyor systems of bulk storage tanks.

The continuous line detector is constructed in the same fashion as a rigid coaxial cable. It has an inner conductor and an outside cover of stainless steel. Between the two conductors is a semiconducting insulator. When the temperature rises, it changes the electrical resistance characteristic of the insulator, allowing more current to flow in the cable, and sends a signal to the central control unit. An advantage of this device is that it is self-restoring when the temperature is reduced (see Figure 5-7).

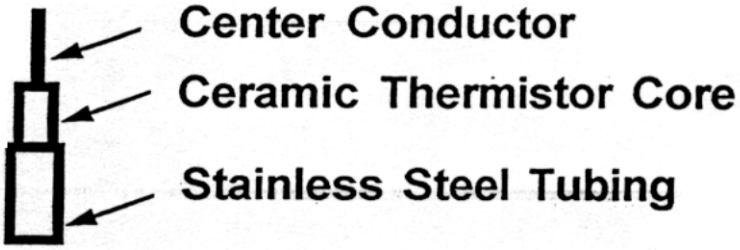


Figure 5-7
Typical Line Detector--Inner Core Cable
Sheathed with Stainless Steel



Figure 5-8
Typical Line Detector--Two Wires

A second type continuous line detector (Figure 5-8) uses a twisted pair of wires that are insulated and covered with an outer sheath. When the predetermined melting point of the insulation is reached, it fails, allowing the conductors to come into contact with one another. This contact--essentially a short circuit--transmits the signal to the central control unit and activates the alarm system. To restore this type it is necessary to replace the failed wire or segment.

Rate-of-Rise Detectors

Fire causes rapid rise in ambient temperature in a given area. This type detector will sense the rapid increase at lower ranges than fixed temperature detectors. Normally they will activate on a 10º to 15 ºF (-12º to -9 ºC) increase over a span of 1 minute. This range is used because room temperatures are not normally expected to increase with such rapidity. Rate-of-rise detectors would be prone to false trips if placed in an area near a door to the outside or similar situation where large temperature fluctuations would occur such as in a skylight or near a unit heater.

Rate-of-rise detectors look very similar to fixed temperature devices, and it may be impossible to tell the difference from a distance.

A combination rate-of-rise/fixed temperature detector incorporates the use of an air chamber, diaphragm, pressure contacts, and a vent. These detectors often use ***eutectic*** solder, which melts at a specified temperature that enables the contacts to shut.

Air in the chamber expands more rapidly than it can escape from the vent. The pressure increase causes the diaphragm to be displaced toward the electrical contact, which closes the circuit and sounds an alarm. Usually, the rate-of-rise feature in this type of detector will automatically restore itself when the temperature returns to normal.

The fixed temperature portion of the detector operates when heat melts the fusible link/eutectic solder, causing a spring to release. This results in the diaphragm depressing against the electrical contact. Since this operation causes the fusible link/eutectic solder to melt, the entire detector must be replaced.

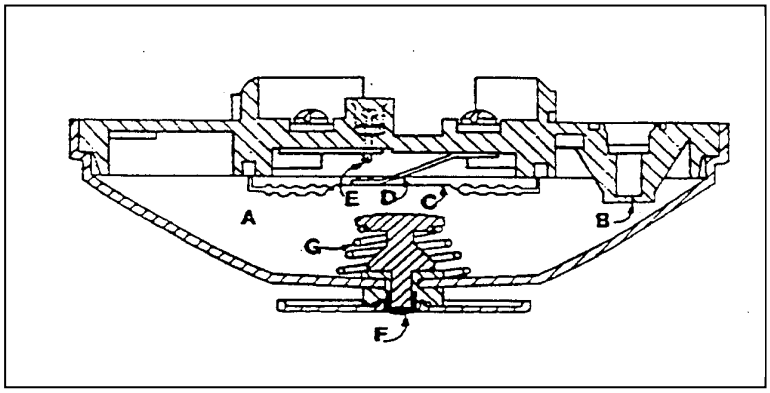


Figure 5-9
Combination Spot Type Rate-of-Rise
and Fixed Temperature Detector

As shown in the diagram above:

- Air in the chamber (A) expands more rapidly than it can escape from the compensated vent (B).
- This pressure increase causes the diaphragm (C) to be displaced toward the electrical contact (D), which closes the circuit at (E) and sounds an alarm.
- The rate-of-rise feature will restore itself automatically when the temperature returns to normal.

For fixed temperature operation:

- Heat causes the fusible link (F) to melt.
- Spring (G) is released, which depresses the diaphragm (C) against the electrical contact (D).
- When the fusible alloy has melted, the entire detector must be replaced.

Bimetallic Detector

Just as in a home heating thermostat, this unit operates on the principle that differing metals have differing expansion rates. The metals are bonded together in thin strips that are calculated to have a known response to a given temperature. These strips will bend and when the preset temperature has been reached, will either open or close a contact and activate the alarm system. They are self-restoring but should be checked by an alarm technician to be certain that they have not been damaged during operation.

Pneumatic Type Detectors

Pneumatic spot and line detectors are available. The spot type of detector is the most commonly used. It consists of an air-filled chamber with a flexible diaphragm in the bottom. As temperature increases, the diaphragm is forced outward, until it closes an electrical contact and transmits an alarm to the central control unit. The chamber is protected from a false trip by a vent hole that will compensate for normal air pressure changes, but will not vent so quickly that the detector will not operate as designed. The spot type detector is also known as a "heat-actuated device" or HAD (see Figure 5-10).

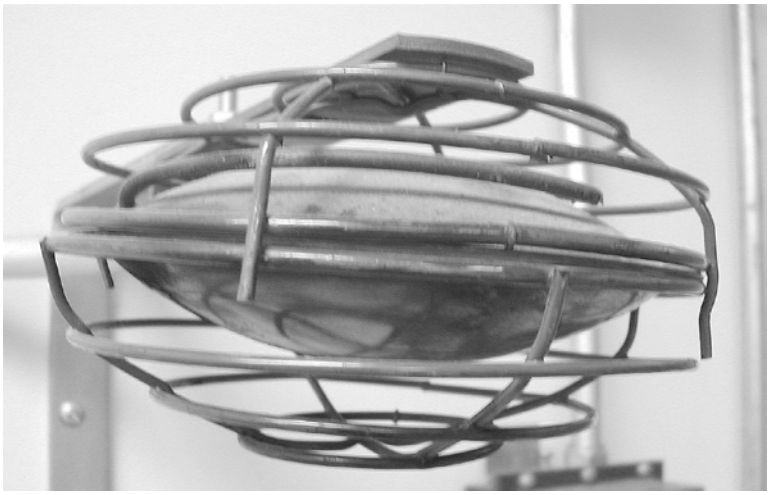


Figure 5-10
Pneumatic Heat-Actuated Device (HAD)

The line detector, like the line fixed temperature type, is designed to provide wide area coverage. It functions in the same way as the spot type, in that the tubing acts as the chamber and will cause the vented diaphragm to operate in the same manner. According to specifications the tubing is normally limited to 1,000 feet in length, and is arranged in rows not more than 30 feet apart, and at least 15 feet from any wall.

Rate-Compensating Detectors

These are designed for use in areas that are subject to regular changes in ambient temperature, such as outdoors, or in commercial kitchen hood-and-duct systems. Such changes would be slower than those encountered in fire conditions. This type of detector contains an outer bimetallic sleeve that contains an inner set of bowed struts that make up the electrical contact. The struts expand at a slower rate than the outer sleeve. A gradual rise in temperature will allow both devices to remain synchronized, while a rapid rise will force the struts together and activate the detector.



Figure 5-11
Rate-Compensating Detector (left) Used with Smoke Detector for Elevator Recall



Figure 5-12
Cutaway of Rate-Compensating Detector
to Display Electrical Contacts

SMOKE DETECTORS

The two fundamental smoke detector sensing method types are **photoelectric** and **ionization**. They react more rapidly than heat detectors and are the preferred devices in use today for life safety applications.

Photoelectric

This type of detector uses an internal light source that is coupled to a photocell; it uses both direct light beam and refraction to detect smoke. A beam of light across the sampling area onto the photocell maintains an electric current in the system. When sufficient smoke enters the sampling area and obscures the light beam, the current drops, and the alarm is activated.

In the refractory type, the light beam does not strike the photocell and no current is present in the detector. When smoke enters the sampling area, the light from the source is refracted by the smoke particles, causing the scattered light to strike the photocell and activate the alarm (see Figure 5-13).



Figure 5-13
Photoelectric Smoke Detector

This type of detector will work for all types of fires and normally will respond faster to smoldering fires than will the ionization detector discussed below. An advantage of photoelectric detectors is that they are self-restoring when any smoke has been cleared from the sampling area.

Another type of photoelectric detector is the **projected beam**. Used in large open areas like atriums, churches, theaters, warehouses, concert halls, and any facility with tall ceilings, a projected beam detector employs an invisible infrared beam that is "shot" from a transmitter to a receiver. If smoke breaks the beam, the detector will go into alarm (see Figure 5-14).

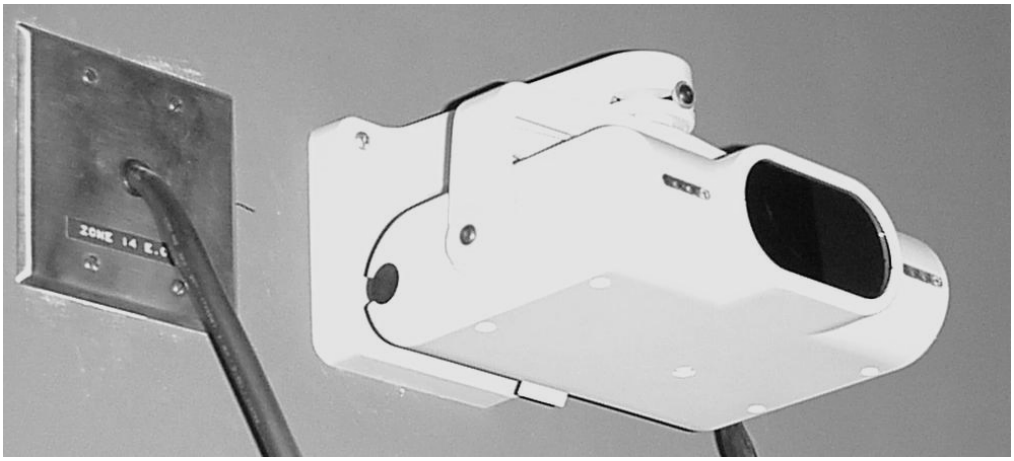


Figure 5-14
Sample Projected Beam Transmitter

Ionization Detectors

The ionization detector uses the fact that molecules involved in the combustion process become ionized, or electrically unbalanced, by picking up free electrons that are released during burning of a fuel.

The heart of the detector is the sensing chamber, which contains a small radioactive source and two plates, one positive and the other negative. Under normal conditions, a small electrical current flow is maintained by this relationship (see Figure 5-15). The products of combustion entering the chamber and attaching the free electrons before they can reach the positive plate unbalance the chamber. The resulting imbalance causes the current to cease flowing and trip the alarm (see Figure 5-16).

These detectors respond more quickly to flaming fires and, like the photoelectric type, are self-restoring when smoke is cleared from the chamber. Dual-chamber type detectors have the ability to use photoelectric as well as ionization detection.

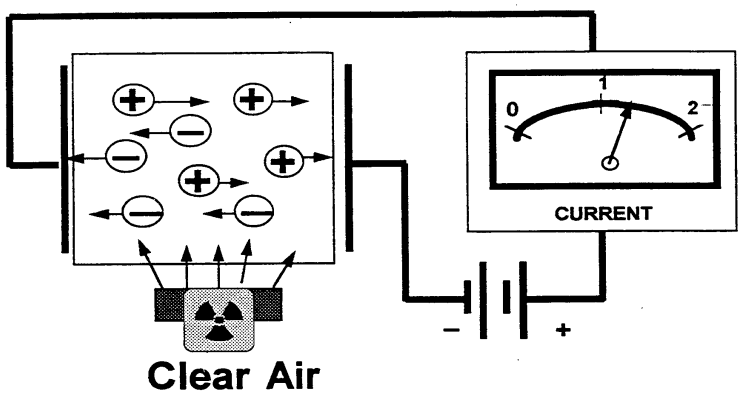


Figure 5-15
Ionization Chamber Principle (Clear)

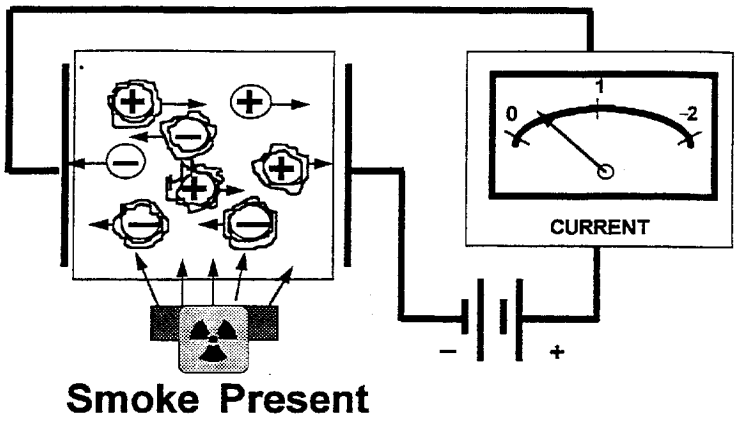


Figure 5-16
Ionization Chamber Principle (Particulates)

Combination Detectors

A variety of manufacturers produce **combination** detectors that offer the features of both smoke and heat detectors. These provide a property owner with an added degree of early detection and notification. In Figure 5-17, a "snap disk" heat detector is attached to the lower, outside portion of the smoke detector housing.



Figure 5-17
Combination Smoke and Heat Detector

Duct Detectors

Duct smoke detectors are installed to minimize smoke spread through heating, ventilating, and air-conditioning (HVAC) systems, or are used as part of a mechanical smoke management system.

Duct detectors may be installed inside the duct itself, or mounted on the outside of the duct with an air pick-up and discharge tube inserted into the duct.



Figure 5-18
Smoke Detector (right) with Upper Pick-up Tube and Lower Discharge Tube

As air flows through the HVAC system, it passes across the pick-up tube. Any particles or products of combustion are drawn by ***venturi*** action into the smoke detector sensing chamber. Depending upon the design plan, the HVAC system either shuts down, stopping all air flow, or goes to a high velocity as part of a smoke management system. (Smoke control is discussed in greater detail in Unit 7: Smoke Management Systems.)

If the duct detectors are not immediately visible (such as when they are located above a ceiling grid), NFPA 72 requires the installation of a remote indicating lamp (usually a red LED) in an obvious location.

Many fire departments specify that the operation of a duct detector sound a supervisory signal rather than a fire signal because of the frequency of dust-caused unwanted alarms in the HVAC system. You should check with your local code enforcement authority to determine how duct detectors report in your jurisdiction.

CONDITIONS THAT CAUSE NUISANCE ALARMS

Detection Placement Problems

Detector installations always should be in accordance with their listings since these are the conditions under which the equipment was tested to perform. If the listing installation instructions are silent, or an unusual circumstance occurs, the guidance established in NFPA 72 for detector placement should be used for reference.

The following conditions could cause repeated nuisance alarms, or worse, unintentionally disable the system so that it is unable to operate.

The IC should be prepared to help the property owner or occupant identify these problem areas and find solutions to prevent nuisance or unwanted alarms.

Recess Mounting

Detectors are tested in a smooth ceiling configuration, and if installed in a recessed area or pocket, they may not respond as quickly as required.

Detectors should not be mounted in recessed areas, such as narrow beam pockets, unless specifically listed for that application.

Air Movement

Smoke detectors are listed for a specific range of air velocity, and open area detectors should not be installed where air flows exceed those rates.

Air movement can have a number of undesirable effects on spot type smoke detectors:

- by creating a pressure barrier between the fire and detector;
- by diluting smoke before it reaches a detector;
- by cooling smoke to prevent its buoyancy to reach the detector; and
- by causing the smoke to migrate to another zone, thereby resulting in a misleading detector operation.

Spot type smoke detectors should be installed at least 3 feet from air diffusers.

Mounting Security

All spot type detectors (heat or smoke) consist of a detection element connected to a permanent base. The base is intended to be mounted to the ceiling, wall, or other fixed structural element. Ideally, the base should be connected to an approved electrical junction box.

Fluorescent Light Fixtures

Electrical noise from fluorescent light ballasts and fixtures can cause false alarms, so smoke detectors should be located at least 6 feet from fluorescent fixtures.

Heating Equipment/Internal Combustion Engines

Open flame or electrical resistance heating systems, solid fuel appliances, and internal combustion engines all may produce dust, smoke, exhaust particulates, carbon monoxide gas, and other emissions that may cause false fire alarms.

Age/Sensitivity

As detectors age, their sensitivity increases, thus the likelihood of unwanted alarms increases. Sensitivity ranges are required to be checked every other year by a qualified technician (or by the computer-operated fire alarm control panel), but this may not occur on schedule.

Altitude

Although not a common problem in most of the United States, detectors installed at elevations more than 3,000 feet above sea level can have unwanted performance problems. Only detectors listed for these high altitudes should be installed.

Industrial Processes and Fumes

When specifying or inspecting smoke detection systems, the installer must take particular care in surveying the potential ambient atmosphere. Any of the following processes or equipment have high potential for false alarms:

- industrial machining;
- spray painting (aerosol or electrostatic);
- baking and curing ovens;
- dryers;
- fireplaces;
- cooking equipment;
- chemical fumes/dip tanks/process vessels;
- sawing, drilling, and grinding;
- exhaust or fume hoods;
- cutting, welding, and brazing; and
- moisture sources:
  - live steam,
  - steamtables,
  - showers,
  - humidifiers,

- cleaning sinks,
- humid air, and
- water spray.

Detectors are listed to perform within specific environmental ranges, and damp or humid areas cause particular problems. Ambient relative humidity should be below 85 percent. Increases in water vapor in the air can cause water droplets to form in the detector sensing chamber. Humidity exceeding 93 percent can cause light refraction (bending) in photoelectric detectors and/or a loss of current flow that can lead to false alarms.

Dusty and Dirty Environments

Perhaps the most common false alarm problem involving smoke detectors is dust accumulation occurring either during system installation or due to inadequate maintenance and cleaning.

Dust can accumulate in the sensing chamber of a smoke detector, making it overly sensitive.

During new construction, the fire inspector may be asked to allow installation of the smoke detectors before the building is ready for the certificate of occupancy. This should be discouraged whenever possible because of the activities that tend to occur at this phase of construction. Gypsum wallboard dust, paint spray, carpet adhesive fumes, and fine wood dusts may affect detector performance and likely will lead to future problems.

Some manufacturers ship their detectors with brightly colored dust covers (usually orange plastic) that minimize some of the invasive dust, but do not prevent it entirely. If dust covers are used, the contractor must be reminded to remove them before occupancy.

Insect Infestations

The presence of small insects in the smoke detector's sensing chamber can mimic the conditions of a fire. This is more problematic in photoelectric rather than ionization type detectors. Most manufacturers produce bug screens for their detectors, but small organisms still may be able to squeeze through into the devices.

One solution may be to install an insecticide strip near the detector, but that also may emit vapors that can cause the detector to operate. Checking with the detector manufacturer for solutions to insect infestation is a good first step.

Incompatible Devices

Fire alarm system components manufactured by different companies may not be compatible with each other. Just like automobiles, different fire alarm system manufacturers offer different "base" models and optional upgrades. If an owner or technician tried to substitute one manufacturer's product for another (for example, a Pyrotechnics™ smoke detector connected to an Edwards™ fire alarm control panel), the devices may be "incompatible" and the result may be

false or nuisance alarms. The service technicians and manufacturers can provide lists of compatible devices that may be integrated into an operational system.

GAS DETECTORS

Fire Gas Detectors

Fire gas detectors are not commonly used devices. They respond at a speed between that of the rate-of-rise detector and the smoke detector. The principle of operation is based on the fact that all combustible materials will emit water vapor, carbon dioxide, or carbon monoxide when burned. The fire gas detector uses catalytic or semiconducting elements to detect changes in the levels of these fire gases from ambient conditions.

Industrial Gas Detectors

Gas detectors may be employed to detect either fire gases or so-called "industrial" or "process" gases.

Process gases (butane, propane, heptane, silane, chlorine, etc.) may be used in an industrial application where early detection of a leak is essential to life safety or property protection.

Likewise, during combustion, higher than normal levels of carbon monoxide, carbon dioxide, hydrogen chloride, hydrogen fluoride, hydrogen sulfide, and hydrogen cyanide may be produced. These gases may be sensed by special detectors designed and manufactured specifically for them.

Gas-sensing fire detectors usually operate with simple sensors such as a semiconductor or catalytic element.

Detectors that employ a semiconductor respond to either oxidizing or reducing gases by creating electrical changes on the semiconductor. In catalytic detectors, the detector contains a material that remains unchanged, but accelerates the oxidation of the combustible gas. The resulting temperature increase causes a change in the element's resistance, which then initiates the alarm.

FLAME DETECTORS

These are the fastest response detectors, but they are quick to transmit nuisance alarms because of stray light tripping the units. They must have an unobstructed view of the area to be protected or they will not function as designed.

Some flame detectors respond to ultraviolet light, and can be tripped by welding arcs or sunlight. Others respond to infrared light and depend upon the flickering of a flame to activate them; normally they will not respond to a steady infrared source.

Like the smoke detector, these units also are available in the dual-purpose type that react to both ultraviolet and infrared light emissions (see Figure 5-19).

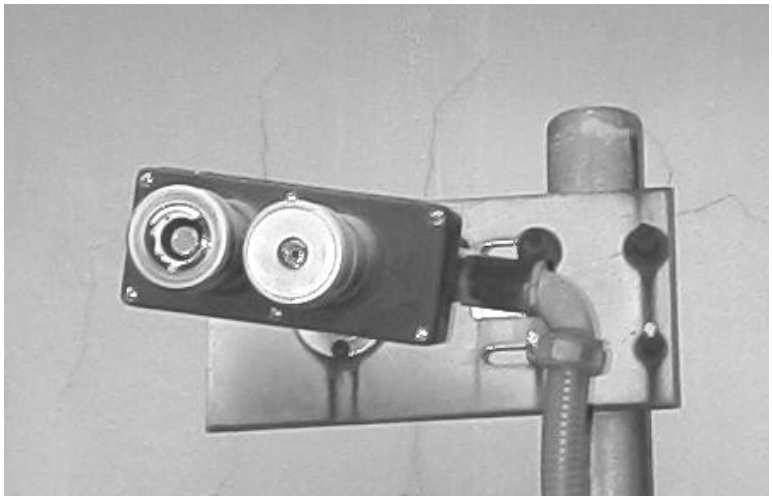


Figure 5-19
Typical Infrared and Ultraviolet Flame Detector
Outdoor Installation

WATER-BASED FLOW/PRESSURE SWITCHES

Monitoring Devices

Although these do not directly detect heat or smoke, pressure and flow switches respond to water movement in sprinkler systems, and automatically transmit an alarm to the fire alarm control panel. These devices may be used within the piping of water-based fire protection systems to detect the movement of water, a drop in pressure, or a differential in pressure caused by sprinkler opening. The movement of water due to any of the above reasons will cause the flow switch to close the circuit and transmit an alarm. It is required that any flow switch be further protected by a tamper alarm switch, so that a warning is given should the system be shut down or rendered inoperable.

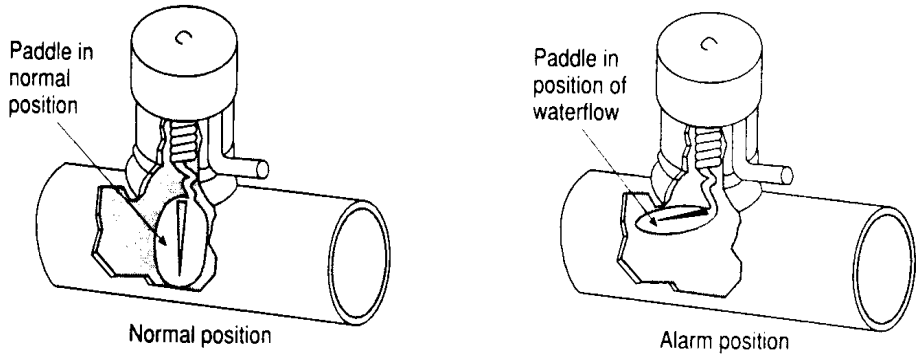


Figure 5-20
Vane or Paddle Type Water Flow Switch

Vane Type Water Flow Switch

This type of switch consists of a vane or paddle that protrudes into the sprinkler pipe. Vanes are constructed of thin, flexible plastic or metal connected to the alarm switch that is mounted on the outside of the pipe. Water flow will cause the vane to move and close the contacts, thereby transmitting an alarm. The material of the vane is flexible, so that it will not interfere with water flow should a large number of heads open to suppress a fire.

Vane type switches are usually equipped with a time delay so that false alarms will not be transmitted during pressure surges or short-duration water movement within the system.

This type of switch is not used in dry pipe, deluge, or preaction systems because the large flows found in the risers may damage the vane. They may be used in branch lines as floor indicators or section indicators to assist in locating the area of water flow.

SUMMARY--DETECTORS

This is a general overview of commonly used detection devices. Detailed specifications are available from alarm system manufacturers and the many fire service or alarm industry publications that are available. For the IC or CO, it is important to understand the basic function, limitations, and restorability of the various detectors in order to maintain unbroken protection in occupancy.

NOTIFICATION APPLIANCES

Notification appliances, also known as signaling devices, may be anything from water motor-operated gongs to electric bells, klaxons, sirens, or horns. Strobes or other highly visible lights

back up the audible devices. In some specialty applications, notification may occur by tactile (touch or vibration) or even olfactory (odor) means.

Notification appliances normally are found both inside and on the exterior of the occupancy. Interior audible devices must conform to various standards for sound levels, while visible indicators are rated for candlepower. They must be sufficiently loud to overcome ambient sounds and bright enough to be seen in smoke conditions.

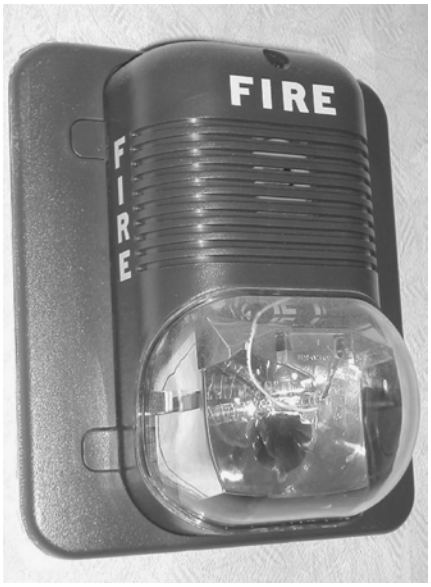


Figure 5-21
Typical Wall-Mount Audible and Visual Notification Appliance

REMOTE ANNUNCIATORS

Locations

An alarm system may have the central controls housed in a room separate from the entryway. In such cases, remote annunciators are provided. These may be located near one or more main entrances; in a central lobby; or in the case of a multistructure occupancy, one may be located in each building within the complex. They also may be located in a guard shack or security building. The location should be marked on the preincident plan since this will be a common location to which the fire companies will respond.

Graphics

Remote annunciators may be provided with a graphic layout of the structure and contain visual indicators of the device that has been activated. They may also have a screen or paper printout device as well.

Interpretation

Some remote annunciators, as well as the central control panel, may use colored lamps or LED's to indicate the type of alarm being registered. In such cases, the color red is reserved for fire, amber for trouble or supervisory, and green would indicate normal system operation.

OFF-PREMISES REPORTING

In the past, many facility fire alarms were connected to the municipal fire alarm system by the use of an auxiliary that released and pulled the hook of a street box when the fire alarm in the occupancy was activated. Many cities have eliminated the municipal systems due to maintenance costs, liabilities, and increases in false alarms over the years. The majority of automatic alarm systems report by digital information transmitted over telephone lines to a central alarm-processing center.

Many people are surprised to learn there is no nationally mandated law, code, or standard that specifies how quickly an alarm-processing center must notify the local fire department when the center receives an alarm.

NFPA 72 requires alarms be sent to the fire department "without unreasonable delay." Although explanatory material included in NFPA 72 encourages that the alarms be sent to the fire department within 90 seconds of receiving them, there is no legal mandate to do so. Some jurisdictions have adopted local laws and standards specifying a maximum reporting time.

Why are alarm-processing centers allowed such nonspecific criteria? Many alarm-processing centers serve hundreds, if not thousands, of cities and fire districts, and may have hundreds of thousands of clients sending them alarm signals. Imagine an electrical storm moving through a community that might cause hundreds of simultaneous power surges that could result in inadvertent fire alarm signals being transmitted to the alarm-processing center. It would be physically impossible for the center to notify the local fire department of all those alarms within 90 seconds.

Alarm Retransmission Delays

Depending upon protocols set by a subscriber and the fire alarm company, interruptions in the communication of the alarm may result. If this does occur, the fire alarm is delayed and this delays the municipal dispatch center, thus causing a delay in the fire department response.

Although this is a poor practice, some alarm companies will, upon receipt of a fire alarm, attempt to call back to the facility to verify the alarm prior to passing it to the local fire department*. There are many cases where this practice has led to sufficient delay in response to have resulted in a major loss that could have been prevented if the alarm had been immediately directed to the fire service. It is almost a certainty that every fire officer can cite at least one fire that need not have reached the magnitude it did, had the alarm not been delayed in processing.

COMMUNICATIONS FEATURES

Fire detection and alarm systems must be tailored to local codes or the requirements of the specific occupancy use. One communications feature that varies from occupancy to occupancy is how the building tenants will be notified of an alarm.

The most common method of warning is **immediate notification**. As soon as a manual station is activated, or an automatic detector operates, the fire alarm system sounds throughout the building. Occupants are expected to notice the alarm and take appropriate action: escape, relocation, fire control, etc.

While it may seem desirable to notify all occupants simultaneously, there are times when **selective notification** is more appropriate. This method is common in extremely large or highrise buildings. When an alarm sounds, only those most threatened by a fire are notified. In a highrise building, this usually includes the alarm initiation floor and two floors above and below. While controversial, the reason for this method is to avoid overloading the egress system with persons evacuating the building.

Another occupant communications method is called **presignal**. Here, the fire detection system reports to an onsite location, such as a guard shack, building engineer's station, or other constantly attended location, and the person there must investigate the alarm source. If the person investigating the alarm discovers a problem, he or she has the means to operate the general evacuation alarm. If a second initiating device operates in the meantime, the fire alarm system will sound a general evacuation alarm. Meanwhile, if there is off-premises reporting, the fire department is notified as soon as the first initiation device operates.

The drawback to presignal features is that they rely on human intervention--someone must respond to the alarm, identify a dangerous condition, and then notify occupants. If this person fails any part of this effort--or is overcome by the fire--building occupants are at risk of a delayed notification. For this reason, many fire marshals do not permit the installation of presignal systems. Presignal systems may be found in jails, health-care facilities, or large assembly occupancies.

A similar notification arrangement is called **positive alarm sequence**. Also commonly found in highrise buildings, jails, schools, and large places of assembly, these likewise report to a central onsite location. In this case, though, if the investigating person does not acknowledge the alarm within 15 seconds, a second initiating device operates, or if the fire alarm system is not reset within 180 seconds, occupants are notified automatically. If off-premises reporting exists, the fire department is notified as soon as the first device operates.

Fire Service Communications

Some fire alarm systems provide additional communications features for fire service use. The two most common are public address systems and firefighters' phones.

The local building or fire code specifies where these features are required, but generally they are installed where "selective relocation" of occupants is desirable over mass evacuation. This includes highrise buildings, institutions (hospitals and nursing homes), and even covered shopping malls.

Public Address/Voice Communications in Buildings

Most often found in highrise and other large structures, these systems allow the IC to make announcements selectively in the areas affected by the alarm. Located in the central control cabinets, these systems allow the IC to silence any prerecorded messages and select the public address function on a floor-by-floor or building-by-building basis. The system also may be used as emergency one-way communication to companies operating in an area that may need to be evacuated.

Speakers are used as alarm notification appliances, instead of horns or bells, so that voice messages containing information and instructions related to a fire emergency can be transmitted to the building occupants.

During a fire emergency in a building, after activation of the alarm system, evacuation may be impractical or impeded. Messages, either prerecorded or live, can be transmitted within the entire building or in selected areas, to ensure occupants have a safe area of egress out of the building or to a safe area within the building.

Devices, such as recorded public address announcements, may sound only on the floor of the alarm activation, may sound on the floors above and below, or may sound throughout the occupancy; however, in some instances these devices may not be installed on rooftops. Each system is tailored to the requirements of local codes or the occupant of the facility.

When responding to an automatic fire alarm, it can be an advantage to silence indicating devices to control the situation and speed the restoration of the system.

In investigating the source of the alarm, the devices activating can make this difficult and hamper communications between the IC and the companies operating at the scene of the alarm. The ability to silence horns and bells selectively greatly assists in quick restoration of occupancy protection.

*If the alarm-processing center is an Underwriters Laboratories (UL)-listed "central station," this procedure is a violation of their listing. They are required to notify the fire department first. The alarm-processing center could lose its listing if it is learned they are calling the protected premises before the fire department.

In highrise buildings, for example, the typical fire alarm protocol is to automatically notify up to five floors of occupants of a potential emergency. Generally, this means when a fire alarm operates, the following occupants are notified immediately by audible and visual devices: those on the fire floor and those on the two adjacent floors above and below the "fire floor." If the building owner has provided an effective fire evacuation plan, and occupants comply with it, not more than five adjacent floors of occupants should begin to leave the building. (Total simultaneous evacuation of all building occupants before an emergency is confirmed may overtax the egress system.)

Usually in these circumstances, the fire alarm signal consists of a pre-recorded voice message (in some cases a bilingual voice message) that provides occupants generic instructions to evacuate the building.



Figure 5-22
Typical Fire Alarm Public Address Microphone

Upon arrival, the IC can assess the conditions and use the fire alarm and public address system to order a complete, partial, or sequential evacuation, if necessary. Operation of the public address system microphone overrides any prerecorded messages.

If installed correctly, the public address system provides separate communication zones for all floors, elevators, and egress stair towers. By selecting the appropriate zone at the fire alarm control panel, and speaking clearly into the microphone, the IC can provide life-saving instructions to building occupants and firefighters who may be in the building.

The IC needs to preplan these systems to learn their controls and layout. Depending upon the manufacturer, some fire alarm control panels employ toggle switches or buttons that must be pressed to select a speaker zone even before the microphone button is pushed. The speaker zones should be identified on the fire alarm control panel or remote annunciator. However, it is always best for the IC to have tested the system beforehand, and make a list of the speaker zones that can be included on the preincident plan.

The IC also should think carefully about the text of the messages that will be provided. Public address announcements, since they are given without the chance for immediate feedback from the listener, should be delivered slowly with simple words and explanations. Most public address microphones require that the speaker put his or her mouth in close contact with the microphone. Generally, holding the microphone at a 45 degree angle from the speaker's mouth provides the clearest communication with the least distortion.

Firefighter Phones

Also known as "firemen's phones" or "fire warden phones," these devices are provided to improve emergency communications between the IC and attack crews. Portable radio communications in large steel and concrete buildings often are ineffective, so the phone system provides another tool for the emergency responders.

Although these are not telephones in the traditional sense, firefighter phones provide a hardwire connection between the fire alarm control panel and wall-mounted phone jacks distributed throughout the building. The wall jacks normally are located

- in elevators and elevator lobbies;
- in each exit stair at each floor-level landing and area of refuge;
- in emergency and standby power rooms; and
- in fire pump rooms.

The handsets for these phones normally are stored in the central control panels and must be issued to the companies as they report for assignment at an incident. The phones have the advantage of being a direct communication from the IC to the CO. These can prove to be invaluable on a busy fireground when radio channels are tied up with other communications. During an incident of any consequence, it may be advisable to assign at least one person to operate the firefighter phone system (see Figure 5-23).



Figure 5-23
Firefighter Phones and Wall Jack

According to NFPA 72, the fire phone system must be capable of conducting not less than five simultaneous conversations with the fire alarm control panel. This gives the IC the opportunity to disperse personnel to various portions of the building to provide ongoing sizeups and communications.

Once the fire phone handsets are plugged into the wall, they are designed to ring or buzz the fire alarm control panel automatically to notify the IC that someone is calling. The IC may have to operate a button or toggle to respond to that particular phone jack location. Most fire phone handsets require the user to push a button or switch to talk, and as long as the button is pushed, they can conduct two-way conversations (see Figure 5-24).



Figure 5-24
Firefighter's Phone at Fire Alarm Control Panel

Handsets normally are stored near the fire alarm control panel. Fire crews should get in the habit of stopping by the handset supply to take one with them before they attack the fire. This way, they will have a backup communication system if their portable radios are ineffective.

Just like using the public address function, the fire department should spend time before an incident to train with these devices to learn their strengths and limitations.

STRATEGIC PERSPECTIVE RELATED TO FIRE ALARM SYSTEMS

Occupant/Fire Service Notification

Notification of building occupants and emergency responders should be as close to simultaneous as possible. Any delay in notification of the fire service could result in life or property losses. The local jurisdiction should work closely with any occupancy having an alarm system to plan operations in the event of fire.

Fire Department Response

Each municipality will have its own guidelines concerning response to automatic fire alarms. Depending upon hazards to life and property, response should be sufficient to provide maximum

capability for quick and positive action upon arrival. What often may be regarded as just another automatic alarm response may be the beginning of a long and dangerous assignment, with potential loss of life and property. Building surveys will allow the fire department to be aware of potentials within occupancy and plan strategies in advance.

Relocation/Evacuation/Defend in Place

During the survey process it must be considered what life protection steps will be taken during an emergency in the occupancy. The preincident planning form provides a field where responding personnel can assess the potential number and special needs of occupants they might find upon arrival.

Questions to Consider

- Does the occupancy have safe havens, also known as "areas of refuge," where persons may be awaiting rescue?
- Are some occupants medically or physically restrained so they cannot escape?
- Are there adequate means of egress (doors, stairs, corridors, passageways, etc.)?
- Will these means of egress be compromised by responding firefighters and their equipment entering the structure?
- Is the occupancy equipped with smoke control devices, a means to pressurize stairwells, or a means to vent smoke and gases automatically to atmosphere?
- What other fire protection features exist to protect occupants while they await evacuation or rescue?

The local jurisdiction must be able to determine at what point to direct persons to areas of safety within the occupancy or remove them to a point distant from it. If a large-scale evacuation becomes necessary, planning for sufficient support personnel also must be considered in the survey.

TACTICAL CONSIDERATIONS RELATED TO FIRE ALARM SYSTEMS

Translating Strategy into Practice

Fire alarm system response protocols vary with each department and, sometimes, with each occupancy type. In any case, first-arriving units should have a clearly defined role upon arrival. Whether it's a one-story elementary school or a highrise hospital, each responding company should have an expectation of its assignment.

Fire departments should be consistent in their responses. Whether you call them "box alarms," "alarm activations," "AFA's (automatic fire alarms)," or some other name, your responses to them should be considered training for the real thing. You must be prepared for any contingency when you arrive. Not all fire alarms are reporting fires. The alarm may be caused by a toxic gas release, a broken water line, a frightened person's response to a bomb scare, or even a request for medical aid.

Response Tactics

IC's, from the CO "in the right-hand seat" to a chief having his or her own chauffer, have many things to think about in those first few minutes between dispatch and arrival. What are the conditions? What are the probabilities? What are my resources? The list goes on and on.

Following are just a few additional tactics to consider when responding to buildings or facilities that are equipped with fire alarm systems:

- Consider calling the occupancy while en route. Many apparatus are equipped with cellular telephones. A quick call to the occupancy during your emergency response may provide more information about the source of the alarm.

- Evaluate additional clues you obtain during the response. Has the dispatcher told you additional telephone calls are being received? Do they have telephone confirmation of the alarm problem?

"Completing the Circuit"

Firefighters and IC's can get frustrated quickly if they have to respond to multiple false or inadvertent alarms at the same occupancy. Often, there is a temptation to respond more slowly or even cancel while en route because, "After all, it's probably just a false alarm." When the dispatcher reports, "We got a call from the premises and everything's okay," the fire companies may want to return to quarters.

This is a dangerous practice that could have disastrous results. All alarms should be treated seriously until proven otherwise **by firefighters who have arrived at the scene**.

In those events where someone calls the dispatch center to say "there's no problem," the fire department still should send at least one person or company to complete the circuit of communications and assure there is no fire or other emergency. The responder may want to downgrade from an emergency response to normal traffic speed, but should never leave an alarm unanswered.

When you arrive

- One company or the IC should report to the fire alarm control panel, fire control room (command center), or remote annunciator to establish the location and extent of the alarm.

- The IC should announce, as part of the sizeup, the conditions reported at the panel or annunciator. The type of alarm should be identified based on interpreting signals at the panel.

  - Is it a fire alarm, a trouble signal, or supervisory signal?

  - Has only a single device operated? Has an automatic detection device alarm been followed by a manual pull station? This might suggest that someone has observed a fire and wants to ensure that evacuation or relocation has been initiated.

  - If multiple automatic detection devices have operated, where are they? Are they all on the same floor? Are they operating from adjacent floors or spaces? Multiple signals may mean the fire is spreading.

- Request additional resources, if needed.

- Verify that building evacuation has begun, if appropriate. A better tactic, depending upon the circumstances and the prefire assessment in your preincident plan, may suggest that selective relocation or a shelter-in-place technique is preferred.

- The IC or another designated person should communicate desired occupant instructions via the public address system, if one is present. Tell the occupants to "stay put," begin their evacuation, select a specific egress stair tower, or similar instructions.

- Communicate with building security or maintenance personnel to obtain assistance with the fire alarm control panel and auxiliary features, such as elevator recall, fire pump status, egress door unlocking systems, or smoke management system operation.

- The building owner/management may have a policy that security or maintenance reports to the panel or main entry to meet you.

- Establish a CP and lobby control in a location that provides easy two-way communications to fire protection and communications equipment.

- Consider silencing audible alarms to improve communications if you are certain all occupants have evacuated. However, do not silence evacuation alarms prematurely.

- Consider assigning one person to monitor the fire alarm control panel signals and report changes to the IC.

- Depending upon fire conditions, if audible evacuation signals are not sounding, the IC should consider operating the alarm (with a pull station or control switch in the panel) to initiate building evacuation while fire companies search for the source of the alarm.

- Due to the types of occupancies where **presignal** systems are employed, this may be a critical life-saving action. The building person charged with investigating the source of the alarm may not have found the fire and returned to operate the system, or, worse, may have become a fire victim during the search.

- With public address-capable systems, the IC may choose selective evacuation in the area of the alarm.

- If the audible alarms fail to work, firefighter teams should begin evacuations by face-to-face notifications, using the facility telephone or public address system, or other means.

- Initiate a search of the structure to identify the source of the alarm. Newer, addressable alarm systems may provide the location of the specific detection device that is operating, but that information should be evaluated carefully. Improper installation, changes, or inadequate maintenance may provide misleading signals.

- Building searches should occur only in teams of two or more persons. Search teams should be in radio communications with the CP. Search teams should employ a coordinated plan based on preincident information or the IC's specific instructions.

- Quickly review the building's emergency action plan, if it has one, with security or maintenance personnel. It may be posted in the fire command center, next to the fire alarm control panel or remote annunciator.

- Review your fire department preincident plan to identify pertinent information, and take appropriate strategic and tactical action as needed.

- If they have one, verify that facility personnel have initiated their employee/occupant accountability plan.

- When using public address or voice command systems, remember to keep evacuation or relocation instructions simple. Consider developing prescribed "scripts" and have them posted at or near the public address system controls. Take command of the evacuation with a calm, direct manner. Hold the microphone close to your mouth, and speak slowly and clearly. Be careful not to create feedback with portable radios.

- With firefighter telephone systems, assure that CO's, and group or division supervisors going to other locations take at least one telephone with each crew.

- Do not authorize evacuated building occupants to return until you have assured the situation is resolved and have obtained approval from the IC.

- Assure that the fire alarm system is left in the ready mode, a technician has been summoned, and/or a fire watch posted before you leave the scene.

- Document any communications with the alarm technician or building owner/manager regarding the condition of the fire alarm or detection system upon your departure.

RESET PROCEDURES AND PROTOCOLS

Putting the Alarm Back in Service

Standard Operating Procedures (SOP's) should be established for placing an automatic alarm system back in service, once the cause of the alarm has been determined.

Each alarm system will have specific functions in a specific series of steps that must be performed in order to place the system in service. Reset instructions should be posted somewhere near or in the fire alarm control panel.

Contact technical representatives of the companies in your jurisdiction, or contact the responsible facility personnel, to determine what steps must be followed in order to reset the system successfully.

Don't Leave the Building in Alarm or Trouble Mode

An occupancy never should be in either of these modes when the fire department leaves the scene, because doing so may prevent any other alarms being transmitted from the facility.

Contact Technical Specialist

Contact the appropriate technical specialist or facility personnel to respond to the scene, and have a representative of the department remain until the responsible party arrives. In most cases, the alarm company will notify a representative from the occupancy automatically upon receipt of an alarm.

Reset System

If the alarm system cannot be reset, be certain that someone is responding to take care of the situation.

Many jurisdictions do not allow fire department personnel to touch or reset fire alarm control panels due to fear of legal liabilities. Check with your agency risk manager or legal counsel before initiating any fire alarm reset efforts in your community.

Fire Watch

Arrange to have a fire watch established while the system is out of service. Onsite security persons or members of the department may be assigned to this duty while the system is out of service. Onsite workers may be used for the same purpose, but it is necessary to be sure that someone is aware of the situation and on guard against any other incident. (See Job Aid 5.1 in the Appendix for a sample fire watch notification form.)

SUMMARY--ALARM SYSTEMS

This is only a brief overview of alarm system capabilities. It is important that IC's be familiar with all of the systems to be found in their districts. Each system is different, and custom tailored to the needs of the occupant. Contacting the various manufacturers and referring to NFPA 72 will provide indepth information concerning the many types of systems and components to be found in the marketplace.

Activity 5.1

Fire Alarm System Actions

Purpose

To identify potential fire alarm system signals and recognize the appropriate onscene actions to take, depending on what alarm is activated.

Directions

1. Work in table groups to recognize and define the significance of each of the different types of alarm system components listed on the Worksheet.

2. Brainstorm potential alarm condition causes and tactical actions that may be necessary for each device, and record them on the Worksheet.

3. List the group's findings on an easel pad.

4. Select a spokesperson to share your group's findings with the class.

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Activity 5.1 (cont'd)

Fire Alarm System Actions Worksheet

Alarm Condition	Potential Cause	Recommended Action
Alarm sounding		
Manual pull station activation		
Smoke detector activation		
Heat detector activation		
Duct detector activation		
Water flow alarm		
Supervisory alarm activation		
Trouble alarm activation		

Alarm Condition	Potential Cause	Recommended Action
Alarm sounding		
Multiple device activations		

Activity 5.2

Fire Alarm System Components

Purpose

To decide what components of a fire alarm system are most important to an IC and why.

Directions

1. You are the IC first arriving at a fire scene. Individually, take 5 minutes to prioritize the components of a fire alarm system according to their benefit to you as IC for decisionmaking and tactical use during an alarm. You may assume the building has all of the devices listed on the Worksheet.

2. List your responses in the matrix, with the column marked 1 being "most important," and 5 being "least important." If you decide there are items of equal importance, list them in the rows.

3. Then, in your table groups, discuss and reach consensus on your responses.

4. List your group's findings on an easel pad.

5. Select a spokesperson to share the group's findings with the class. Be prepared during the discussion to justify your rankings.

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Activity 5.2 (cont'd)

Fire Alarm Systems Components Worksheet

Firefighter phones
Remote annunciator
Smoke detector
Elevator recall controls
Trouble signals
Public address system
Water flow alarm
Manual pull station
Duct smoke detector
Digital communicator
Heat/Flame detector
Notification appliance
Fire alarm control panel
Continuous line detector
Fire alarm box
Supervisory device (tamper)

Most Important				Least Important
1	2	3	4	5

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Activity 5.3

Strategic and Tactical Considerations for Fire Alarm and Detection Systems

Purpose

To employ fire alarm systems and equipment to achieve incident objectives, and to describe the strategy and tactics to achieve those objectives.

Directions

1. Working in table groups, review the following scenario. Identify and describe your incident objectives, explain your strategy to achieve those objectives, and describe the tactics you would employ to achieve successful results.

2. List your group's findings on an easel pad and select a spokesperson from the group to report your recommendations.

Scenario

The Traveler's Holiday Sunset Inn is a relatively new, three-story, 85-room motel on the retail strip. It is constructed as a wood-frame building with all guest rooms opening onto a central corridor with exits at both ends and one approximately in the center of the building. One of the architectural features is a two-story atrium-like solarium starting on the floor above the lobby, that is open between the second and third floors; it has a glass ceiling open to the sky.

In addition to the 1-hour fire-resistive construction, fire protection consists of a partial sprinkler system (in the guest rooms and corridors only), smoke detection in the corridors, and single-station smoke alarms in the guest rooms.

There are no sprinklers in the attic, but it is protected by a line-type heat detection cable. The fire alarm system is relatively modern, and includes voice command as well as a secure cache of five fire phones for the fire department. The fire alarm control panel is located behind the lobby front desk, and there is no remote annunciator.

Tonight, at about 0138, the local alarm company calls your fire dispatch center to report the alarm company has received several trouble signals from the motel. The alarm company called the motel, but got no answer, so your local protocol calls for sending a single engine company to investigate.

Upon your arrival, there are no interior or exterior alarms sounding, and nothing seems to be out of the ordinary from the outside. The lobby front door is locked from the outside, so you open the key box to gain access to the building.

You discover no one is at the front desk, and the fire alarm control panel is emitting a loud piezo horn signal.

As you look at the fire alarm control panel, you see red light-emitting diodes on the following zones:

- attic;
- solarium smoke;
- third floor corridor; and
- elevator recall.

You also observe yellow light-emitting diodes on these zones:

- sprinkler riser tamper switch;
- notification appliance circuit;
- secondary power circuit;
- attic duct detector (west);
- attic duct detector (center);
- key box security system; and
- city box disconnect.

As IC, you must:

1. Describe your objectives.

_____

_____

_____

2. Explain your strategy to accomplish your objectives.

_____

_____

_____

3. Describe your tactics.

4. Identify which elements of fire alarm system you would employ to aid your efforts and how you would accomplish this.

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Activity 5.3 (cont'd)

Quick Access Prefire Plan

Building Address:
17945 21st Century Way

Building Description:
Three-story hotel, wood frame, 1-hour construction.

Roof Construction:
Lightweight wood trusses, plywood deck, three-tab shingles.

Floor Construction:
TJI's

Occupancy Type:	**Initial Resources Required:**
85-room motel	*2 E, 1 T, Aid 23, Aid 21, Medic 2*

Hazards to Personnel:
None significant, there is a solarium between the second and third floors.

Location of Water Supply:	**Available Flow:**
On site	*2,700 gpm*

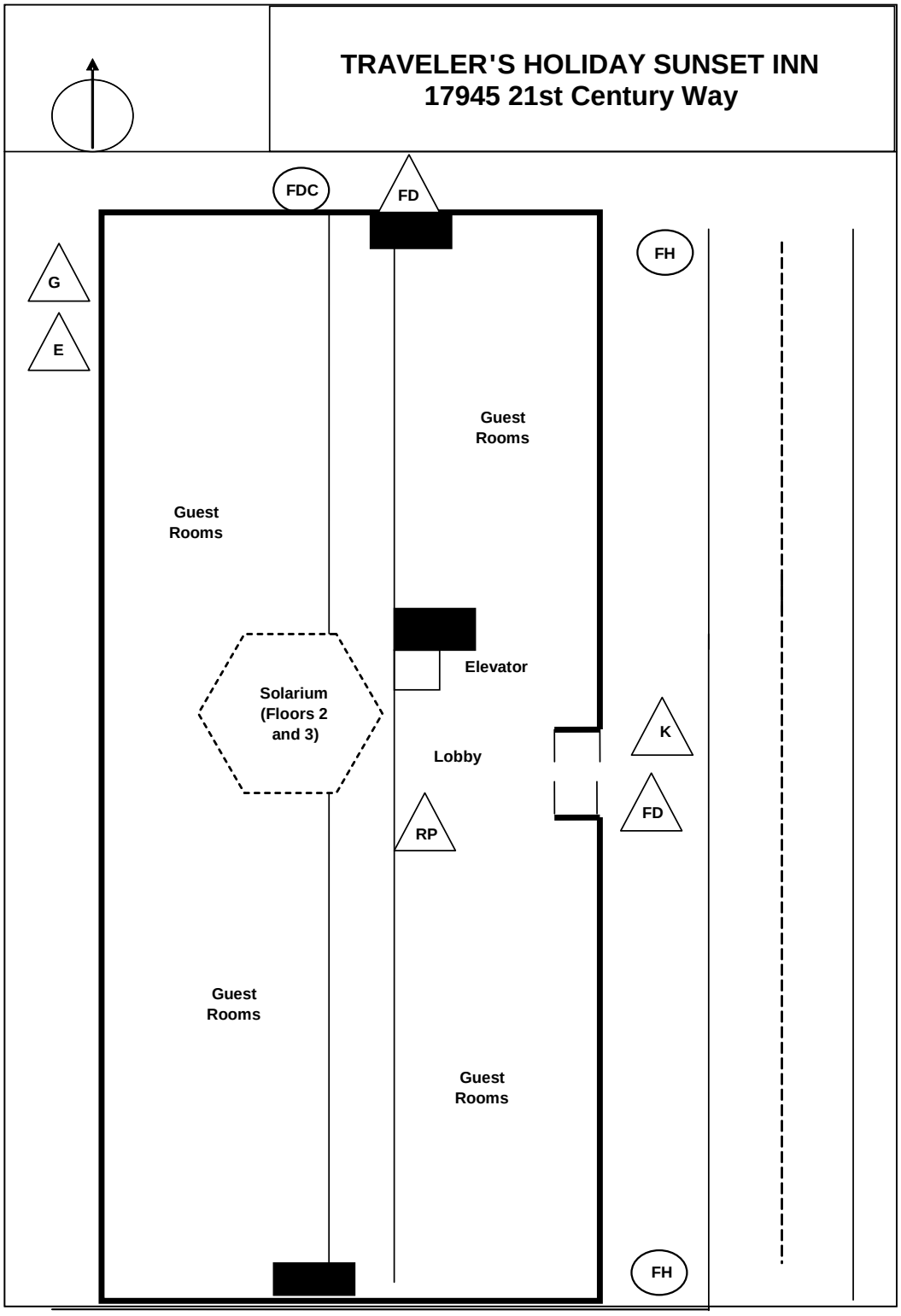
	Estimated Fire Flow			
Level of Involvement	*25%*	*50%*	*75%*	*100%*
Estimated Fire Flow	500	1,000	1,500	2,000

Fire Behavior Prediction:
Lightweight construction, solarium between floors 2 and 3 allows fire spread.

Predicted Strategies:
Lightweight construction, preconnected hoselines will not reach third floor or attic.

Problems Anticipated:
Light weight construction, pre-connected hose lines will not reach third floor or attic.

☐ **Standpipe:**	☒ **Sprinklers:**	☒ **Fire Detection:**


TRAVELER'S HOLIDAY SUNSET INN
17945 21st Century Way
FDC
FD
FH
G
E
Guest Rooms
Guest Rooms
Elevator
Solarium (Floors 2 and 3)
K
Lobby
FD
RP
Guest Rooms
Guest Rooms
FH

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APPENDIX

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Job Aid 5.1

Sample Fire Watch Notice

From time to time, it may be necessary to leave a fire protection system out of service because it cannot be repaired or restored in a timely fashion. In those cases, the IC should establish a fire watch while the system is out of service. Onsite security persons, or members of the department, may be assigned to this duty while the system is out of service. Onsite workers may be used for the same purpose, but it is necessary to be sure that someone is aware of the situation and on guard against any other incident.

The following sample form can be adapted for use in your local jurisdiction. It is suggested you contact your agency risk manager or legal counsel regarding fire watch policies before using this or a similar form.

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Job Aid 5.1 (cont'd)

FIRE WATCH NOTICE	
Date:	Time:
Address:	
Issued to:	Title:
Type of system out of service: [ ] Fire alarm [ ] Standpipes [ ] Smoke management	 [ ] Fire sprinklers [ ] Fire pump [ ] Specialty system:
[ ] Other (Describe)	

Due to the fact a required fire protection system is out of service, you are hereby notified that you must provide a fire watch guard service to patrol the premises until such time as the fire protection system is restored to its normal operating condition.

WHERE REQUIRED

24-hour-a-day fire watch guard service is required in the following occupancies (check one that applies):

[ ] Residential or institutional locations such as apartments, hospitals, nursing homes, dormitories, alcohol or drug treatment facilities, assisted living facilities, board and care facilities.
[ ] Places of public assembly that are open and in operation.
[ ] Facilities where employees are engaged in 24-hour production or operations.
[ ] Facilities where there may be risk of vandalism, mischief, sabotage, or arson.

Fire watch guard service shall be provided in one of the following ways:

- Contract with fire department-approved security firm.
- Arrange with _____ Fire Department to hire off-duty firefighters.
- Provide a responsible employee whose sole responsibility is fire watch guard service as specified below.

FIRE WATCH GUARD SERVICE

The role of the fire watch is to patrol the premises on a regularly scheduled basis, and in the event of a fire or other emergency, notify emergency personnel and occupants.

The fire watch shall:

- Have no duties other than patrolling the premises as a fire watch.

- Make rounds of the premises not less than _____ minutes apart, and in such a fashion as to cover all portions of the premises, including outdoor yards and storage areas.
- Maintain a written log of the rounds indicating beginning and end times, and any deficiencies discovered.
- Make sure all exits are free of obstructions, and functional fire protection equipment is accessible.
- In the event of a fire,
    - Report the incident without delay to the fire department using a telephone (dial 9-1-1), radio, or fire alarm box.
    - Take steps to notify occupants of the premises of any emergency conditions using public address systems, fire alarm systems, or other means.

Received by _____ Witness _____

Distribution: Original: occupant Copy: NFIRS Incident Report

Job Aid 5.2

Preplanning Fire Alarm and Detection Systems

The preincident planning data collection form and preincident plans presented in Unit 3: Preincident Planning Benefits are comprehensive in their own right, but do not include the important elements related to fire alarm and detection systems.

Job Aid 5.2 can be used as a supplement for the preincident planning team to identify important details regarding fire alarm and detection systems for inclusion in the formal preincident plan.

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Job Aid 5.2 (cont'd)

FIRE ALARM AND DETECTION SYSTEMS

Address: _____ Date: _____ Preplan # _____

Facility/Building name: _____

Fire alarm control panel location: _____

Remote annunciator location: _____

Primary power supply shutoff location:

Room: _____

Circuit breaker panel: _____ Circuit: _____

System reset instructions posted at: _____

System Operation

	Yes	No
Manual operation only (pull stations)		
Automatic operation only (smoke/heat detection)		
Automatic and manual operation		

Features

	Yes	No
Occupant notification only (noncoded local alarm, bell, or horn only)		
Off-premises reporting (monitored)		
Water-based fire protection systems reporting		
Water flow		
Tamper		
Fire pump running		
Fire pump power loss (phase loss)		
Fire pump phase reversal		
Low air pressure		
High air pressure		
Low water temperature		
High water temperature		
Other: (specify)		
Elevator service: Recall to homing floor		
Elevator service: Recall to **alternate** floor		
Occupant notification (prerecorded voice message)		

	Yes	No
Occupant notification (public address system)		
Firefighter phone system		
Hazardous materials storage and use supervision		
Low product temperature		
High product temperature		
Low product tank level		
High product tank level		
Other: (specify)		

Public Address System

Microphone location: _____

Speaker zones:	Yes	No
Each occupied floor		
Normally unoccupied areas (mechanical/electrical rooms)		
Exit stair enclosures		
Elevator cars		
Other: (specify)		

Microphone operating instructions: _____

Firefighter Phones

Handset cache location: _____
Number of available handsets: _____

Phone jack locations:	Yes	No
Each occupied floor		
Normally unoccupied areas (mechanical/electrical rooms)		
Exit stair enclosures landings		
Elevator cars		
Other: (specify)		

Firefighter phone operating instructions: _____

UNIT 6: WATER-BASED FIRE PROTECTION SYSTEMS

TERMINAL OBJECTIVE

The students will be able to describe the strategic and tactical roles of water-based systems in fire control and suppression.

ENABLING OBJECTIVES

The students will:

1. *Describe the role of sprinklers in fire protection.*
2. *Describe the role of standpipe systems in fire protection.*
3. *Describe the role of fire pumps in fire protection.*

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SPRINKLER SYSTEMS

This section of Unit 6: Water-Based Fire Protection Systems provides information on automatic sprinkler systems and how the Incident Commander (IC) can effectively apply this information as a firefighting tool to aid in the prevention of loss of life and property.

National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, is the nationally accepted standard for the installation of automatic sprinkler systems. It defines an automatic sprinkler system as "an integrated system of underground and overhead piping, valves, and sprinklers designed in accordance with fire protection engineering standards."

This is a technical definition; however, a sprinkler system also can be defined as a system that consists of a configuration of piping that distributes water to release mechanisms (sprinkler heads) and, when activated, supplies extinguishment in a form of a spray pattern to extinguish a fire. Sprinkler systems are located to protect specific hazards.

Elements of Effective Automatic Sprinkler Systems

The most widely used method of automatically controlling a fire is an automatic sprinkler system. Three important elements enable automatic sprinkler systems to be effective:

1. Presence of a sprinkler system in a building or structure.
2. The system's reliability due to inspection, testing, maintenance, and adequacy of the water supply.
3. Design and extinguishment effectiveness to protect the hazard.

The first element is obvious: Either an automatic sprinkler system is installed in an occupancy, or it is not. Fire officers with almost any amount of experience have fought fires in one or more buildings not protected by automatic sprinkler systems.

The second element, reliability, depends upon the components and maintenance that will be discussed in this unit. They include types of sprinkler systems, extent of coverage, operation of the different types of systems, where different systems are installed, sprinklers, valves, piping, and common impairments that render systems ineffective.

The third element that is considered vital in the operation of automatic sprinkler systems is the proper design of the system and how quickly the system responds in the event of fire. The fire service plays an important role in this third element.

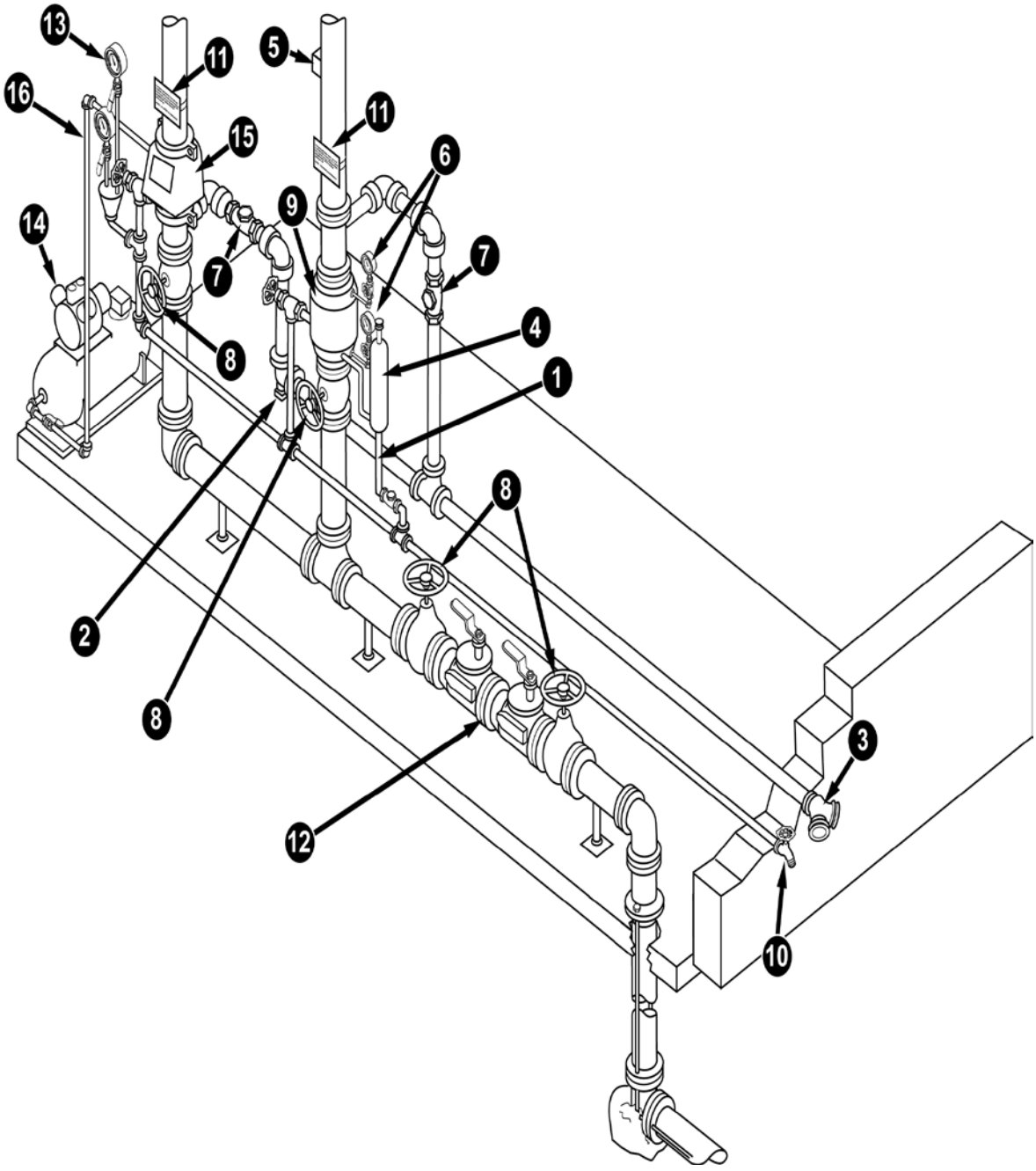


Figure 6-1
Sprinkler System Details

Figure 6-1 shows a typical sprinkler system in detail. The numbered elements are

1. **Retarding chamber drain**. This small-diameter pipe (usually 1/2-inch) drains the retard chamber.

2. **Ball drip**. Also known as an "automatic drain," the ball drip has a hollow brass ball inside. When the fire department connection (FDC) pipe is pressurized by hoselines, the ball is pushed against the drain opening, closing the hole. When the pressure is released, the ball floats to the surface and allows drainage.

   Ball or automatic drains are provided on pipes that may be exposed to cold weather, where frozen water would be a problem.

3. **FDC**. The FDC is used to supplement the pressure and volume of the operating sprinkler system.

   Notice that on the wet pipe alarm valve (9), the FDC enters the riser above the valve. This enables the fire department to pump into the sprinklers, even if the wet pipe valve is damaged or the main control valve(s) (8) are closed.

   On the dry system, the FDC line enters below the dry pipe valve (15). There are two reasons for this. First, if it were on the air side of the dry pipe valve, there is a chance the air would escape, causing the riser to fill with water. Unless there is a fire, this typically is an undesirable condition.

   Second, when a dry pipe valve opens, the internal clapper must latch in the fully open position to permit maximum water flow. When an engine pumps into the FDC on a dry pipe system, the incoming water pressure helps push the clapper to the latched position.

4. **Retarding chamber**. Installed only on wet pipe systems, retarding chambers are provided to prevent inadvertent water flow alarms resulting from pressure surges in the supply.

   When an incoming surge occurs, a small amount of water is routed to the retarding chamber rather than through the wet pipe valve and into the sprinkler pipe where it could cause the water flow alarm to sound, thereby calling the fire department.

   When the surge stops, the water drains harmlessly from the retarding chamber to the drain line.

   Occasionally, the retarding chamber will be outfitted with a "pressure flow switch" on its top. In this case, when the incoming surge fills the chamber and pushes against the switch, the alarm will sound.

   In the event of a sprinkler opening, the water flow to it also will fill the retarding chamber and continue to flow (sounding the alarm) until the water is shut off.

   One potential problem with retard chambers outfitted with flow switches is that there may be a manual isolation valve to the retard chamber. (See Figure 6-1.) If this valve were closed, water could not get to the retard chamber nor to the water flow pressure switch. This is not the preferred method of installation under current standards.

5. **Flow switch interconnect with fire alarm system**. Flow switches have a small paddle that is inserted in the sprinkler pipe. When water flows, the paddle moves a lever that closes electronic contacts. Flow switches are adjustable so that they can be delayed up to 90 seconds once the water flows. This is another means of minimizing inadvertent alarms due to pressure surges.

6. **Water pressure gauge**. On a wet pipe system, the lower gauge displays the incoming water pressure, and the upper gauge displays the water pressure on the sprinkler system side of the wet pipe valve. (See Job Aid 6.2 in Appendix A for an explanation of gauge pressures.)

   On some wet pipe systems, called "shotgun risers," there may be only one gauge to display the water pressure.

7. **Check valve**. Check valves are installed in water systems to permit water to flow in one direction only. Check valve housings have an arrow embossed on them that indicates the direction of water flow.

8. **Outside stem and yoke** (**OS&Y) control valve with tamper switch**. Outside stem and yoke (or "outside screw and yoke") valves are "indicating" valves. An IC can determine if an indicating valve is open or closed without even touching it. An OS&Y valve is fully open when the stem is fully visible above the wheeled handle. (The valves in this drawing are open.)

   Any valve on a water **supply** to a sprinkler system (or other water-based fire protection system) must be an indicating valve.

   Electronic tamper switches are provided to report changes in the valve status. If someone moves the control valve handle from its normal position, a "supervisory" tamper signal is reported to the fire alarm system. Control valves also may be equipped with chains and locks to prevent their unwanted closure.

9. **Wet pipe alarm valve**. Also known as an "alarm check valve," the valve contains a clapper that prevents water in the sprinkler system from flowing back into the supply. When a sprinkler opens, the clapper pivots out of the way.

   The primary purpose for a wet pipe alarm valve is to provide a means to channel water to the retarding chamber, or a water motor gong (not shown) that is a mechanical alternative to an electronic flow switch. It also may act as a check valve to prevent water form flowing back into the supply when the fire department connection is pressurized.

   Although not entirely obsolete, many modern installations avoid the water motor gong in favor of a flow switch. A common wet pipe system installation today is the "shotgun riser" that consists solely of an indicating control valve, a water pressure gauge, and a flow switch.

10. **Two-inch main drain**. Installed primarily to drain the sprinkler system so work can be performed, the 2-inch main drain also is used by inspectors to conduct periodic water supply tests.

11. **Hydraulic design data nameplate**. Sprinkler design information used to assess the sprinkler system's performance.

12. **Double detector check valve assembly**. Also known as "backflow prevention devices," these valves are required by many water purveyors to isolate the sprinkler system from the potable water source. Not all sprinkler systems have them, especially older systems or those connected to private fire protection water supplies.

    The stagnant water inside sprinkler pipes may contain ferrous oxide (rust), heavy metals, cutting oil, and other contaminants, so the backflow prevention device keeps this water from coming into contact with drinking water supplies.

13. **Air pressure gauge**. Installed on the system side of a dry pipe valve (15) to measure the air pressure that is holding back the incoming water supply.

14. **Air compressor**. This device is used to automatically maintain air pressure on the dry pipe sprinkler system, and is sized to restore full system pressure within 30 minutes after the sprinkler system operations.

15. **Dry pipe valve**. Dry pipe sprinkler systems are installed in areas subject to freezing. The sprinkler pipe above the clapper in the dry pipe valve is filled with air or nitrogen under pressure. When the valve opens, water fills the empty pipe.

16. **Water pressure gauge**. Installed on the water supply side of the dry pipe valve to measure incoming water pressure.

The designer must know whether the building will be of combustible or noncombustible construction because it is one factor influencing how and where individual sprinklers are installed. Finally, the capacity (pressure and volume) of the water supply is a significant factor in the system design because it establishes whether additional water supplies and stationary fire pumps are needed.

IC's must never assume that a sprinkler system installed for one occupancy hazard class is adequate for another. That analysis is best left to engineering or fire protection professionals. For example, a sprinkler system installed to protect a mercantile occupancy with moderate storage heights (like a K-Mart, Wal-Mart, or neighborhood supermarket) is intended to protect the moderate range of combustibles found in these types of stores. If that retailer closes shop, and the space is occupied by a tire retailer, the sprinkler system should be analyzed to see if it still is adequate. Otherwise, if a fire occurred, it likely could overpower the sprinklers. Firefighters or IC's who identify changes like that should report them to the owner, fire code enforcement officer, or insurance company.

Purpose of Automatic Sprinkler Systems

The purpose of automatic sprinkler system is to detect, report, confine, control, and extinguish a fire. Detection of a fire occurs when a sprinkler is operated by the element located in the center of the sprinkler.

Sprinkler System Challenges

Example 1:
Why Didn't the Sprinklers Suppress the Fire?

In 2004, Montgomery County, Maryland (a suburb of Washington, DC), sustained its second significant fire in a property sprinklered in accordance with NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*. After the fire, the Fire Code Enforcement Office was asked, "How can a building with sprinklers have such a large fire?"

The answer:

Residential structures like those involved in this fire have sprinkler systems installed according to the requirements of NFPA 13R. This code does not require the installation of sprinklers in bathrooms that are less than 55 square feet, closets less than 24 square feet, or attics that contain no gas, electric appliances, or storage.

This fire started in a void space near the unsprinklered attic, then traveled into and across the attic, burning the roof off the structure. The fire also weakened the truss supports that held the sprinkler system protecting the top-floor living units. Once the pipe broke, the building became, in essence, a nonsprinklered combustible structure.

The lesson:

Sprinkler systems that are designed for residential properties, as opposed to those in commercial structures, are designed as **life safety** systems, not property protection. Since no one perished in this fire, the sprinkler system could be said to have accomplished its role.

The IC needs to be aware that any building can burn, and if a firefighter steps onto the roof of a building protected by sprinklers for **life safety**, the attic under his or her feet is not protected, even though other parts of the building are sprinklered.

Example 2:
Improving the Fire Service's Image

A National Fire Academy (NFA) instructor was traveling a few years ago and decided to spend the night in a well-known hotel in an east coast city. He went out for dinner and, while enjoying his meal, heard and saw fire apparatus responding in the direction of his hotel, but thought nothing of it.

After about 45 minutes, he returned to the hotel and discovered that the fire units had responded to the place where he was staying. He went into the hotel and found water flowing through the first floor ceiling in one of the wings. Being curious, as most of us would be, he walked down the hall and spoke to some of the firefighters. He discovered that a guest had hung something on one of the sidewall sprinklers in his room, breaking the glass bulb and causing the water flow. The fire department could not figure out how to shut the system down. They could not find the valves in the riser room and did not know where the floor control valve was located.

In the stairwell, the NFA instructor ran into a fire department officer and a firefighter. He was on the stairwell landing of the floor where the sprinkler was still flowing. The fire department had tried to shut off the flow using a redwood plug, but the sprinkler was a recessed type and they had damaged the sprinkler, rather than shutting the water off.

The instructor pointed to a sectional control valve and told the officer that if he closed that valve, he would stop the water flow. The officer was hesitant because he was concerned it would disable the standpipe system and asked the instructor who he was. He said he was in fire protection and assured him that if they closed the valve, it would solve their immediate problem. At that point, the firefighter reached up, closed the valve and sure enough water flow ceased shortly thereafter.

This is a classic case of not knowing a building's fire protection systems. We need fire sprinklers to help protect lives and property, but we also have an obligation to know how they operate and how to shut them down when they are not needed. And we need to know this before the event happens. The public depends on us to know how to handle these situations, and this is a classic case where good pre-planning and related documentation would have led to an early shut down of the system, stopping unnecessary water damage and presenting the most positive of image for all of us in the fire service.

Unfortunately, this did not happen in this instance!

Example 3:
Water, Water Everywhere

A New Jersey firefighter sent this true story:

"It was a dark and stormy night, and very cold. We got a fire alarm call to Continental Insurance, a five-story office building out near the New Jersey Turnpike. I missed the first truck, but made the second truck about five minutes later.

"When I arrived on scene, the crew from the first truck was trying to open a door in a closet on the outside wall of the building. Water was seeping under the door onto the loading dock. The door opened to the inside and could not be forced by three firefighters leaning on it. There was literally a wall of water up against the door on the inside.

"I went to the sprinkler valve room area and found all valves open and the 1500-gpm [gallons per minute] fire pump still running. No one on the first truck, including one of the assistant chiefs, had taken steps to stop the water flow.

"There were no indications of a fire in any part of the building. Since there were no other smoke or fire alarms going off in the building, and there was no indication of a fire, I turned off the pump and began draining down the system through the 2-inch drains.

"After a while, enough water drained out of the piping in the building to stop the flow to the line that broke. Soon thereafter, enough water drained out of the room under the door to allow us to open the door and replace the head.

"The high-water mark on the wall was 20 feet off the floor. The masonry walls of the room kept the water in the room with very little drainage.

"The following week, I did a training session for our department on the basics of sprinkler systems, fire pumps, and standpipes!"

Sprinkler systems, when designed and installed in the proper occupancies, have proved that the chances of dying in a fire, and the average property loss per fire are both cut by 1/2 to 2/3, compared to fires where sprinklers are not present, according to Rohr (2001).

Unfortunately, many people do not realize that there are significant differences among sprinkler systems. Even the NFPA *Professional Qualifications* standards for firefighters and officers do not place much emphasis on understanding sprinkler design and how it relates to fire protection.

Sprinkler systems designed and installed to protect one type of fire hazard may be woefully ineffective for another. IC's need to be able to identify how sprinkler designs may affect the outcome of an incident.

Property Protection Versus Life Safety

Historically, fire sprinkler systems were installed primarily to protect buildings and their contents. It has only been in recent generations that there is an increased emphasis on sprinkler design for life safety. There are significant differences between the two. Property protection sprinkler systems are designed and installed to detect a fire (by the heat-responsive sprinkler element), report a fire (through local or off-premises alarms), and confine the fire until the fire suppression forces arrive to extinguish it. Only in recent sprinkler design--and then only in special storage occupancies--are the engineers considering actual fire **extinguishment** rather than control.

While sprinkler systems designed for property protection have been effective at protecting lives, systems installed for life safety are not intended to protect property at all. Any fire control or suppression from a life safety system is a happy coincidence.

Sprinkler system design is a daunting responsibility. NFPA 13 provides design and installation guidance. A sprinkler engineer or designer must consider many variables when creating a system for property protection. He or she must evaluate the likely fire load in the building (how much fuel), the potential rate of heat release (how rapidly it might burn), and the contents' configuration (e.g., high-piled rack storage, palletized storage, cardboard or wooden boxes, etc.). The fire load and its arrangement enable the designer to match the sprinkler performance to a **hazard class**. (See Appendix A, Job Aid 6.1, for a brief description of the hazard classes.)

Life Safety Systems

In the early 1970's, fire professionals realized the enviable life safety record for sprinkler protection could result in a technology transfer to make sprinkler systems more affordable and available.

As a result, two new NFPA sprinkler design and installation standards were developed--13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, and 13R. Systems installed to these standards have important consequences for IC's.

First, because these systems are for life safety and not property protection, the standards allow sprinklers to be omitted from some spaces in a building: unused attics, small bathrooms and

closets, garages, and exterior exit pathways. Thus, a fire starting in one of those areas could easily overpower the rest of the sprinkler system before it would be able to operate. This also implies potential firefighter safety concerns. Since unused attics are not required to be sprinklered--and many roofs above them are supported by lightweight wooden/metal plate truss assemblies--firefighters venturing onto a roof for vertical ventilation must be made aware they are stepping over a space that has no sprinkler protection.

Second, since residential systems are designed for life safety only, there may be only enough water supply to operate the system long enough for occupants to escape the building. The two NFPA standards require sprinkler system water supplies to last only 10 minutes for one- and two-family dwellings and mobile homes, and 30 minutes for the four-story residential properties. Therefore, part of the preincident planning (PIP) should include the identification of water supplies and alternate sources to support the systems.

Overcoming Sprinkler Myths

Have you ever seen the elegant Hollywood television star languidly lighting a cigarette, only to be doused seconds later by a deluge of water from the fire protection system? While these images provide comic relief to television viewers, unfortunately that is the only image some persons have regarding sprinkler systems: "If one goes off, they all go off."

Fire protection professionals for years have fought to dispel many of the myths regarding sprinklers. Some of the common ones found in a search of the World Wide Web are included in Appendix B to this unit.

Sprinkler Details

Sprinkler technology and design are undergoing dramatic changes. There is an ever-increasing number of sprinklers that are designed to protect specific hazards and, consequently, may not be substituted for installation in different occupancies.

Residential sprinklers, for example, are designed for extremely quick operation and water discharge in a pattern intended to prevent flashover. They are designed to protect lives, not property. Therefore, residential sprinklers would not be appropriate in an office building.

In a warehouse, on the other hand, the sprinklers may have to be matched to the particular hazard of the contents and storage array. The installation may require extra large orifice (ELO), large drop, or Early Suppression Fast Response (ESFR) sprinklers to protect the risk adequately. Figures 6-2 to 6-4 show examples of common sprinkler types.

Matching sprinklers to the potential fire risk is a complex engineering decision that should be accomplished by persons knowledgeable in the field. IC's and fire inspectors can obtain advice on this topic from fire protection and insurance professionals.



Figure 6-2
Upright Spray Sprinkler with
Chemical Pellet Operating Element



Figure 6-3
Sidewall Sprinkler with Glass Bulb Operating Element



Figure 6-4
Pendent Sprinkler with Link and Lever Operating Element

What is a Hydraulically Calculated Sprinkler System?

Most sprinkler systems installed today are professionally designed using an engineering principle called "hydraulic calculation." Although the design methods are mathematically complex, the basic principle is simple: provide enough water to the sprinklers to control or suppress a fire while overcoming friction and elevation pressure losses in the pipe.

Once the designer identifies the occupancy's fire hazard potential (see the first page of Job Aid 6.1 in Appendix A) and evaluates the water pressure and volume available for fire protection, he or she programs that information into a computer that determines the volume and pressure needed to supply the sprinkler system when it is discharging water.

The engineer must prove that the design is adequate to control or suppress a fire in the "hydraulic remote area," a portion of the structure that is most challenging for the pipe network to supply adequately. The size of the remote area, and the specific number of sprinklers in it, varies upon the occupancy type, fire hazard, and available water supply. Engineering guidance is established by nationally recognized fire protection standards.

Hydraulically calculated sprinkler systems must be identified by the installation of a hydraulic nameplate at the sprinkler riser. The nameplate includes important system design and performance information. Normally, it has white or silver letters on a red background, but that color combination is not required.

The IC can learn a lot about the sprinkler system by interpreting the information on the nameplate. A typical hydraulic nameplate might read like this:

Hydraulic System

This building is protected by a hydraulically designed automatic sprinkler system.

Location: 1817 Franklin Street

No. of Sprinklers: 426
Basis of Design:
1. Density: 0.10 gpm/sq. ft.
2. Designated Area of Discharge: 1500 sq. ft.

System Demand:
1. Water Flow Rate: 302 gpm
2. Residual Pressure: 46 psi

- The **location** represents the building address, or, it may read something like "Fourth Floor, East Wing," "Warehouse Rack Storage Area," or "Retail Sales: North."

- The **number of sprinklers** is the total number of sprinklers served by that riser.

- **Density** is expressed in **tenths of a gallon per minute per square foot**, and describes the rate of water flow needed to control a fire in the hydraulic remote area. Typically, density figures range from 0.10 to 0.40, but may vary depending upon the system requirements.

- The **designated area of discharge** is also known as the **remote area**, the **area of application**, or the **hydraulically remote area**. Usually, these values will range from 1500 to 4000 square feet, but may vary depending upon the system requirements.

The IC can use this information to get an idea of how much water may be necessary for fire control in this building. When multiplying the **density** times the **area of discharge** (in this case, 0.10 gpm times 1500 square feet), the product is a rough approximation of the amount of water estimated to be needed for fire control: 150 gpm. The sprinkler designer has engineered the system to deliver this amount of water in case all of the remote area sprinklers are flowing simultaneously. The actual flow will differ due to friction and elevation influences.

- The **water flow rate** is the amount of water needed to supply the remote area, plus water for fire department hose streams.

- **Hose stream allowance** is an amount of water estimated to be necessary for fire department handlines eventually to extinguish the fire. Water flow rate and hose stream allowances are added together to establish the total flow rate for the property.

- **Residual pressure** is the water pressure needed at the base of the riser (where the sprinkler system enters the building) to overcome pressure losses due to elevation and friction, and adequately supply the remote area.

Interpreting hydraulic calculations can be a daunting task. Numerous courses are available for fire protection personnel to learn to read and understand them. For the IC, the important thing is to know when conditions may have changed in the building, which could render the sprinkler system ineffective (see Job Aid 6.1).

HOW SPRINKLER SYSTEMS WORK

Sprinklers confine a fire by allowing the flow of water to a particular area and protecting other areas from becoming involved, and by providing extinguishment. The sprinkler system reports or identifies where the fire is occurring by means of local alarms or offsite monitoring stations.

When an automatic sprinkler system is installed in an occupancy, for instance, a warehouse building, and a fire occurs somewhere in the warehouse, the products of combustion (heat from the fire) cause the actuating device to open the sprinkler head and enable the flow of water onto the fire, thus preventing fire spread and effectively providing the fire department with advanced support before arrival on the fire scene.

Different sprinkler systems may activate using different methods, but all the systems operate to perform one end result: provide the necessary water to the sprinkler head to effectively control or extinguish a fire before the fire destroys the occupancy.

TYPES OF SPRINKLER SYSTEMS

There are five types of automatic sprinkler systems that an IC may encounter when responding to sprinklered occupancies:

1. Wet pipe sprinkler systems.

2. Dry pipe sprinkler systems.

3. Preaction sprinkler systems.

4. Deluge sprinkler systems.

5. Foam sprinkler systems.

These different types of systems operate differently, and the systems are activated in different ways. The activation of these different types of systems will be explained, but there is one similarity among all sprinkler systems: They are designed to provide extinguishment.

Wet Pipe Systems

As shown in Figure 6-5, typical wet pipe sprinkler systems are systems that contain an arrangement of piping, filled with water under pressure, that provides an instantaneous flow of water to the activated sprinkler head to successfully confine and extinguish a fire.

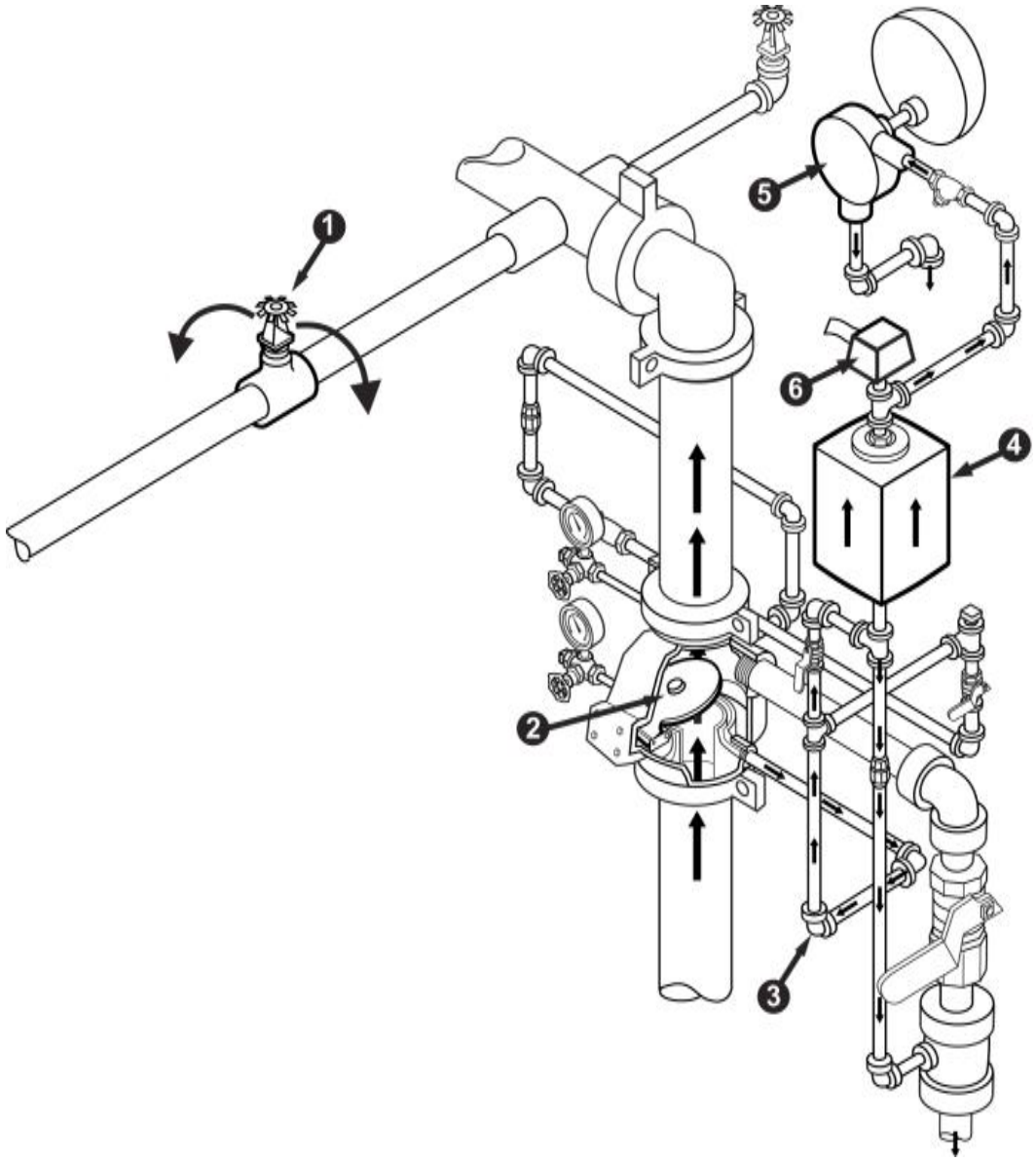


Figure 6-5
Typical Wet Pipe System

When a sprinkler (1) opens, the discharging water lifts the alarm valve clapper (2) and flows to the open sprinkler (1). Simultaneously, water flows through the alarm line (3) to the retard chamber (4). When the retard chamber is filled, water flows to the water motor alarm (5) and/or optional pressure switch (6), which signals an electric alarm bell.

In lieu of the optional pressure switch (6), the system may be equipped with a paddle-type flow switch installed directly on the riser. When the paddle switch electrical contacts close, the flow switch signals an electric alarm bell or the fire alarm control panel. The paddle-type flow switch is preferred over the pressure switch because of the potential for closing the alarm line to the retard chamber.

In the event of a water pressure surge without a sprinkler opening, the alarm line (3) carries the excess water to the retard chamber (6) where it may drain off without sounding an alarm.

Wet Systems Locations

Wet pipe sprinkler systems are commonly found in areas that are heated at all times, or areas that are not subjected to freezing conditions. As previously stated, wet pipe sprinkler systems contain water in the piping arrangement under pressure at **all times**. If a wet pipe sprinkler system were located in an outside area, under a loading dock or in a cold climate area, the water would freeze inside the piping, rendering the system inoperable.

Wet pipe sprinkler systems can be found in such areas as shopping malls, churches, hotels, public buildings, office buildings, and schools. Residential sprinkler systems in hotels, motels, apartments, boarding homes, and single-family dwellings must be wet pipe systems.

Unless there is a specific reason for **not** employing a wet pipe system, the national installation standards require sprinkler systems to have water in them at all times.

Alarm Check Valve

The term "alarm check valve" is synonymous with a wet pipe sprinkler system. The fusing of a sprinkler allows water to flow within the system, and the incoming pressure lifts the main clapper valve. A small portion of the water is directed to a pressure switch by way of the retarding chamber (see Figure 6-5). The time required to fill the retarding chamber equals the delay in transmitting the alarm. The purpose of the retarding chamber is to lower incidence of false alarm transmission due to momentary surges in pressure that may occur from time to time.

The retarding chamber is equipped with a normally open drain that allows water from a pressure surge to drain before the chamber is filled to the point that will allow alarm transmission. A constant flow of water in the piping will cause the chamber to fill and activate the switch, whereas a momentary pressure surge will drain from the chamber without causing a false trip of the alarm.

Antifreeze Systems

Often, where there is a small portion of a building or structure that is susceptible to freezing, the owner will choose to install an antifreeze system. These systems are found in loading, cold storage warehouses, exposure protection systems, and similar applications.

Antifreeze systems are wet pipe sprinkler systems with a proportion of nonflammable ethylene glycol or similar antifreeze solution mixed in the water. They require additional check valves to prevent the antifreeze from entering the potable water supply.

Antifreeze systems are "maintenance intensive." The antifreeze solution must be tested on a regular basis to assure it remains viable.

Dry Pipe Systems

Dry pipe sprinkler systems, as shown in Figure 6-6, **do not** contain water under pressure within the system, as found in wet sprinkler systems. Dry sprinkler systems have an arrangement of piping that contains either air or nitrogen under pressure in the piping arrangement, instead of water. A sprinkler head activates (releases the pressure of either air or nitrogen), enabling the water pressure to open the valve, permit the flow of water into the piping, and release the water through the activated sprinkler.

Dry Systems Locations

Dry pipe sprinkler systems are generally installed in areas in which a wet system cannot be installed--areas that are subjected to freezing condition--because these types of systems employ the use of air or nitrogen in the piping.

Some areas that would be effectively protected by this type of system may be storage loading docks attached to a warehouse, attic areas in buildings, freezer areas in food storage plants, etc.

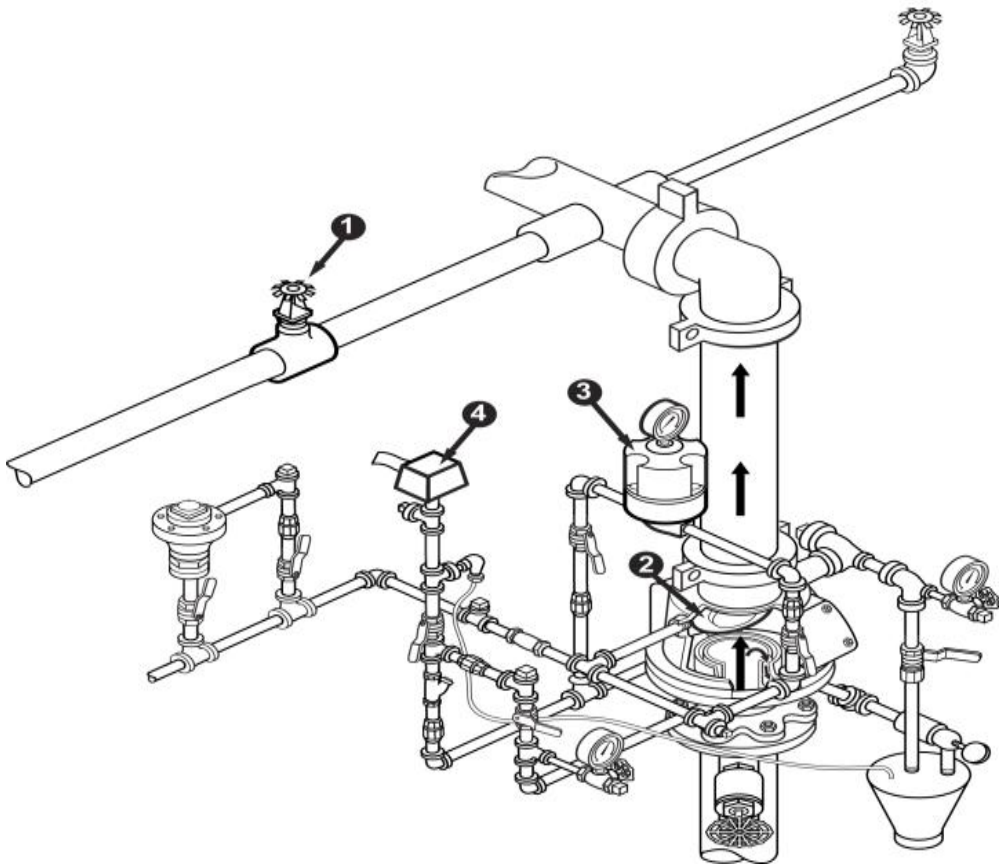


Figure 6-6
Typical Dry Pipe System

How Dry Pipe Systems Work

When a sprinkler (1) opens, loss of air pressure in the system allows the dry valve clapper (2) to open, filling the system with water. To speed the opening of the dry valve in large systems, an accelerator (3) can be added. Water flow from the intermediate chamber of the dry valve can cause a pressure switch (4) to activate an electric alarm and/or operate a mechanical water motor alarm.

The Differential Principle: Physics at Work

Air and water pressure gauges on dry pipe valves at first may appear illogical. In a normal condition, the upper gauge (air pressure) usually displays less pressure than the lower gauge (water supply). How can this be? Why doesn't the higher water pressure push the valve open and fill the sprinkler pipe?

The answer lies in an elementary physical concept known as the "differential principle." The movable clapper in a dry pipe valve is designed with two different surface areas: the one in contact with the air can be up to six times larger than the side in touch with the water supply. Due to the larger surface area, this differential enables the lower air pressure to hold back the higher water pressure. For example, in a differential dry pipe valve with this 6:1 ratio, 10 pounds per square inch (psi) of air will hold back 60 psi of water.

Sprinkler technicians usually will add a few extra pounds of air pressure on the dry side to prevent accidental dry pipe valve trips. Therefore, in the previous example, the air gauge may read 25 psi, and the water supply gauge may read 60 psi. (See Job Aid 6.2 for an explanation of interpreting gauge pressures.)

Quick Opening Devices

Quick opening devices often are installed to speed the operation of a dry pipe valve. The predominant types of quick opening devices are accelerators and exhausters. Both devices are intended to lower air pressure on the system side of the dry pipe valve to allow the water to reach sprinklers more quickly.

An **accelerator** reroutes the air from the system side of the dry pipe valve to the intermediate chamber and helps the incoming water "push" the heavy dry pipe clapper to the fully open position. An **exhauster** removes air from the system side of the dry pipe valve and discharges it through the large diameter main drain, "exhausting" it to the outdoors.

Preaction Systems

Preaction sprinkler systems, as shown in Figure 6-7, require the use of a combination of sprinklers and a supplemental detection system to initiate the flow of water. The supplemental detection devices that may be used in this type of sprinkler system are

- smoke detectors;

- heat detectors;
- infrared detectors (IR);
- ultraviolet detectors (UV); and
- wet or dry pilot lines.

In essence, preaction sprinkler systems have another fire detection component that operates before activating the flow of water to sprinklers. In preaction systems, only **one** or **a few** sprinklers will open. Generally, these systems are slightly pressurized using air and/or nitrogen as in dry pipe sprinkler systems.

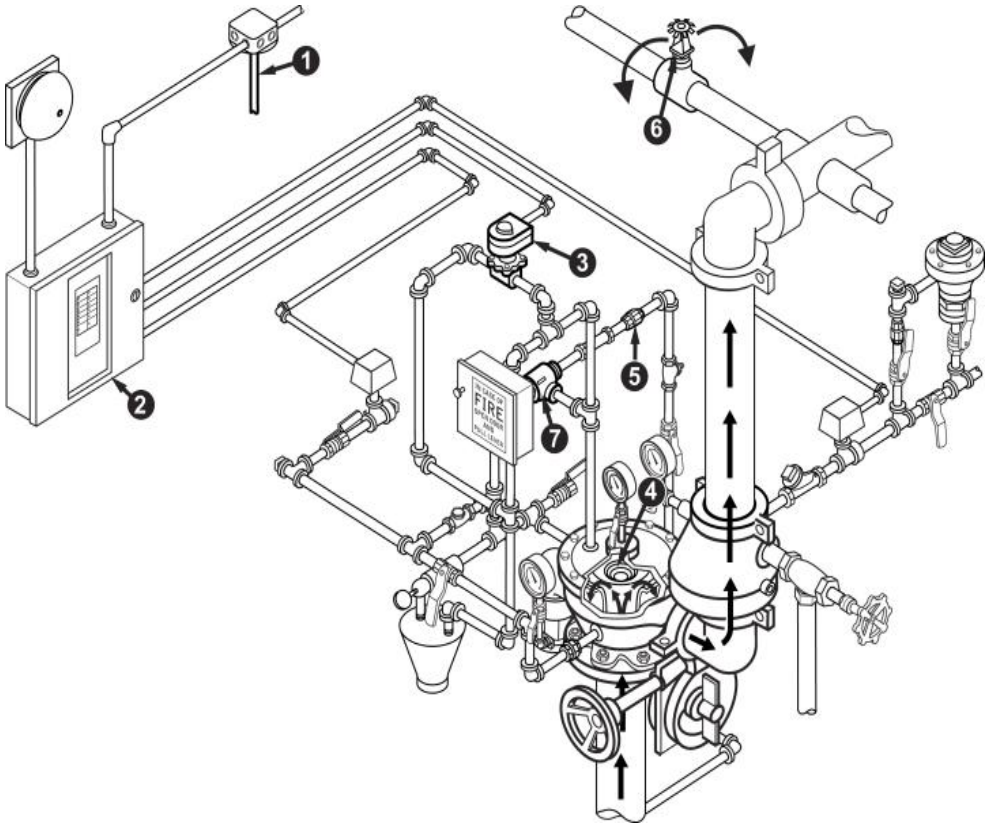


Figure 6-7
Typical Preaction System

How Preaction Systems Work

When the detector (1) is activated by fire, a signal is sent to the release control panel (2). The panel sends appropriate alarm and trouble signals and, at the same time, signals the release of a solenoid valve (3). The deluge valve priming chamber (4) is vented faster than water is supplied through the restricted orifice (5), allowing the deluge valve to open. The water enters the system piping, but until a sprinkler (6) activates, no water is discharged. When the deluge valve

operates, pressure closes the pressure-sensing operating valve (7), cutting off the supply of water to the priming chamber, latching the deluge valve in the open position.

Preaction Systems Locations

Preaction sprinkler systems are installed in areas where an inadvertent discharge could cause serious damage to equipment and hinder operations: in other words, areas in which serious water damage would be detrimental to an occupancy's ability to function. These systems might be installed in such areas as a computer mainframe room of a large computer operations company that is located in a highrise building. The flow of water onto a mainframe computer system would definitely shut down operations and office personnel could not work without the operating system.

On the other hand, preaction systems are more costly to install and maintain, and tend to be less reliable than wet pipe systems. Because of these factors, and experience showing that inadvertent discharge from a wet pipe system is not so big a problem as previously thought, many computer rooms are protected by wet pipe systems. FM Global, the worldwide fire research and insurance consultant, does not recommend preaction systems in computer rooms.

Deluge Systems

Deluge sprinkler systems are similar to wet and dry sprinkler systems; however, they operate using a combination of two methods previously mentioned. Deluge sprinkler systems have standard **open** sprinklers installed in the system. Open sprinklers contain no fusible element. The operation of this type of system requires a supplemental detection system to initiate the flow of water to the open sprinklers. Deluge systems are used when a large volume of water will be needed instantaneously.

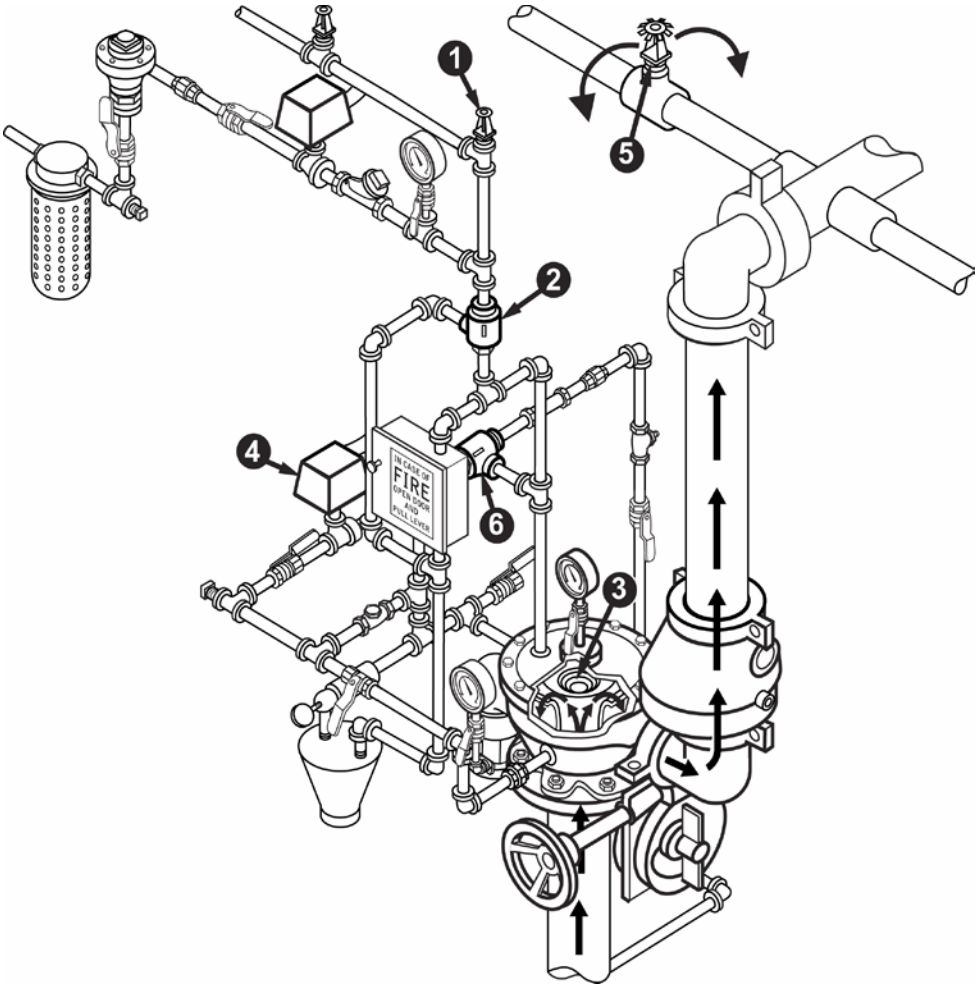


Figure 6-8
Typical Deluge System

How Deluge Systems Work

When a fixed temperature release (1) is activated by fire, pressure in the release system escapes from the open device, allowing the pneumatic actuator (2) to open. This releases pressure from the priming chamber (3) of the deluge valve, allowing the valve to open. Water flows into the system piping and to the alarm devices, causing the pressure switch (4) to activate and electric alarm and/or operating a mechanical water motor alarm. Water flows from all open sprinklers or nozzles (5). When the deluge operates, pressure closes the pressure sensing operating valve (6), cutting off the water supply to the priming chamber, latching the deluge valve in the open position.

Deluge Systems Locations

Deluge sprinkler systems are found in areas that require a **large** volume of water almost instantaneously. Deluge systems can be located in areas that contain a rather high volume of flammable or combustible liquids. Areas where these systems may be found include aircraft hangars[1], which may contain a large amount of jet fuel or ordnance with large combustible potential. These systems deliver water quickly in very high volumes.

Foam Systems

Foam sprinkler systems, as shown in Figure 6-9, are similar to deluge sprinkler systems, except that they discharge foam from special open sprinklers that aspirate the foam solution to produce a foam blanket. A foam proportioning system is used to inject the foam concentrate into the water supply.

Aqueous-film-forming foam (AFFF), and film-forming fluoroprotein (FFFP) agents can be used in foam sprinkler systems; generally however, standard sprinklers are used with these agents. AFFF and FFFP **do not** require the aspiration of air to form the bubbles, as the mechanical foam requires.

Foam sprinkler systems are designed to deliver foam for a specified period of time. When the supply of foam concentrate runs out, the system will discharge water only. The quantity of foam concentrate, and therefore the length of time the system will discharge foam, is determined by the severity of the hazard located in the occupied building and/or area.

[1] NFPA 409, *Standard on Aircraft Hangars*, has been amended to allow closed-head sprinkler systems.

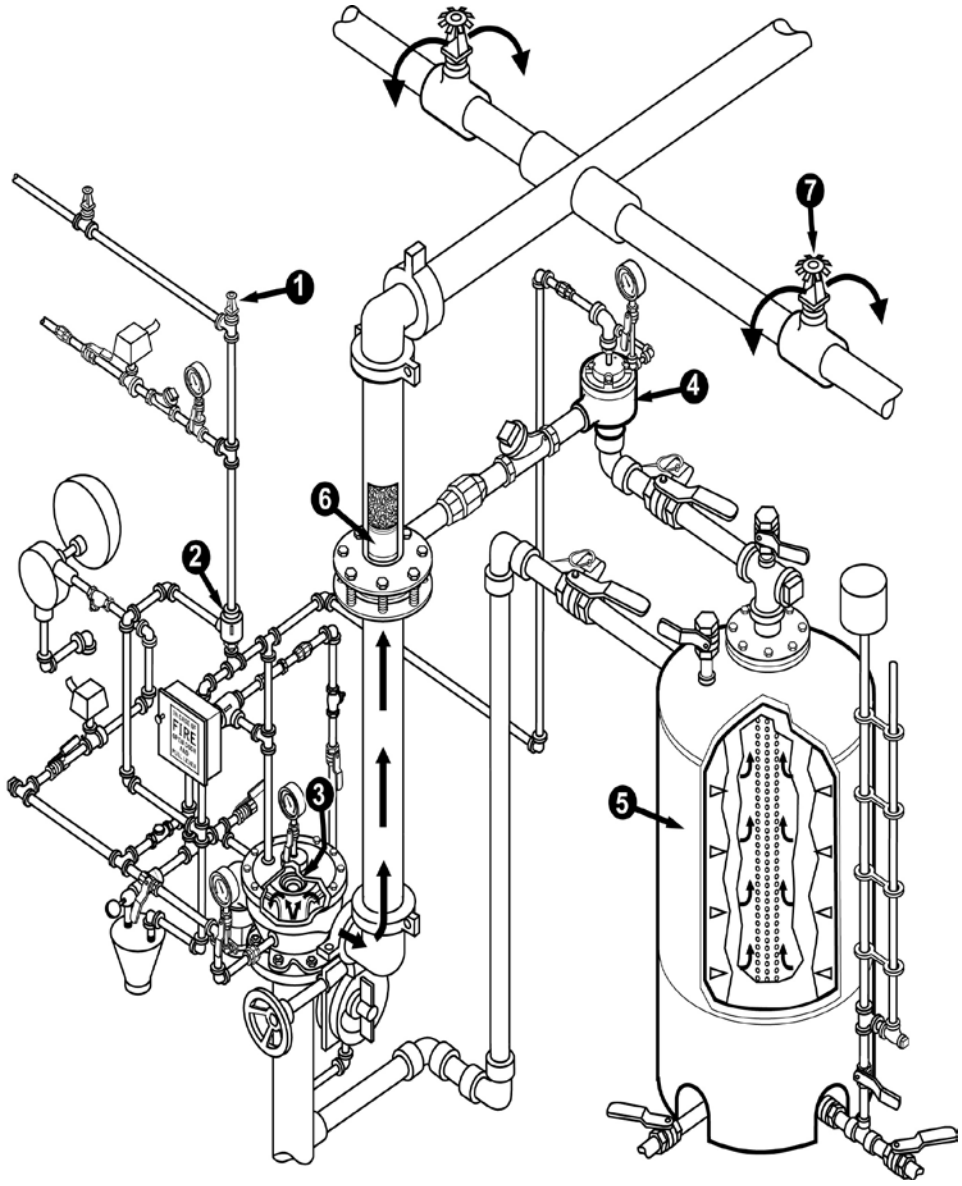


Figure 6-9
Foam Systems

How Foam Systems Work

When the pilot line in this example (1) is activated by fire, pressure in the release system escapes, allowing the pneumatic actuator (2) to open. This releases pressure from the priming chamber (3), which allows the deluge valve to open. Piping tied into the priming chamber of the concentrate control valve (4) allows the valve to open at approximately the same time, opening the foam concentrate line to the sprinkler system. The outer shell of the bladder tank (5), pressurized by system water, squeezes foam concentrate out to the proportioner (6). As water flows through the venturi area of the proportioner, a metered pressure drop draws foam concentrate into the system water, creating a foam solution mixed into the appropriate ratios.

This solution then flows through the sprinkler piping and out to the open sprinklers or nozzles (7).

Foam system operations may be initiated by flame detectors, heat detectors, smoke detectors, or any other initiating device that is suitable for the target hazard.

Foam System Locations

Foam sprinkler systems are used principally for protecting flammable liquid hazards, such as at petroleum storage and dispensing facilities, and aircraft hangars.

SPRINKLER SYSTEM COMPONENTS

Different types of automatic sprinkler systems are actuated differently and have differing components that enable them to work. Seven components that will be discussed in this course are

1. Piping.
2. Valving.
3. Tampers.
4. Flows.
5. Gauges.
6. Accelerators/Exhausters.
7. Compressors.

These mechanisms are vital to the operation of an automatic sprinkler system; however, the components mentioned may be on all systems, but some may not be needed on some systems. See Job Aid 6.3 for pictures and descriptions of common sprinkler system components.

Turning Sprinkler Systems Off

The preplan also should identify the location of main sprinkler shutoff and sectional control valves (see Figure 6-10). One of the anecdotes at the beginning this unit describes the damage that can result, even if there is no fire, if firefighters do not know how to turn off sprinkler systems.

Sectional Control Valves

Fire sprinkler systems often have small segments of pipe separated from the rest of the system by sectional control valves.

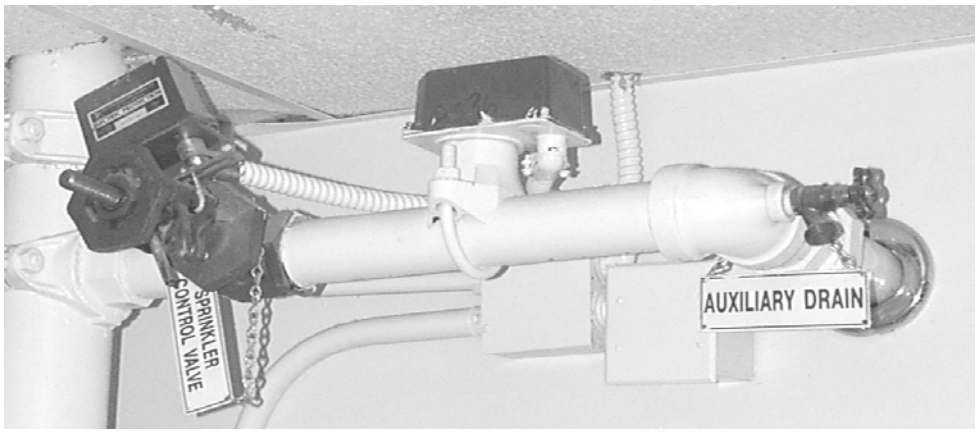
Also known as "isolation" or "cutoff" valves, sectional controls are installed to allow small portions of the system to be turned off for service or repair without compromising the fire protection in the entire structure.

Sectional valves may be found supplying sprinklers at loading docks, spray booths, rack storage arrays, elevator shafts and machine rooms, canopies, freezers, small rooms, or even areas where frequent fires are expected, such as inside industrial baking and drying ovens. They are often used to isolate individual floors of multistory buildings.

Using a sectional control valve, fire officers may be able to shut off a small portion of an operating sprinkler system without having to close the main supply valves. That portion of the system can be drained and restored while the rest of the fire protection remains in service.

Sectional valves must be "indicating" valves and should be electronically monitored or chained in the "open" position to enhance their reliability.

Sectional control valves should be identified on preincident plans so they can be found and operated quickly.



(from L to R: OS&Y control valve with tamper switch, flow switch, and auxiliary drain)

Figure 6-10
Typical Sectional Control Valve Arrangement

WATER SUPPLY SOURCES

An adequate and readily available water supply is vital to efficiency and success in the operation of an automatic sprinkler system. NFPA 13 specifies what is adequate and how an engineer designs an automatic sprinkler system using different available water supply sources.

Water Demand

The water supply requirements vary based on the hazard being protected. Generally, for property protection sprinkler systems, the water supply must be capable of supplying the design demand of the sprinkler system and **hose stream allowances** for a minimum 2-hour duration. An extra hazard occupancy needs more water than a light hazard occupancy. (See Job Aid 6.1 for an occupancy description.) The hose stream allowance is the amount of water (in gallons per minute) that is expected to be needed to suppress the fire while the sprinkler system is controlling it.

Extra Hazard, Group II Water Demand

The local auto body shop wants to expand and provide complete automatic sprinkler protection to satisfy the building and fire codes.

The sprinkler designer determines that the fire protection system needs a flow of 1,787 gallons per minute (gpm) to meet design standards, plus 500 gpm for hose streams. What is the total required water demand for this system?

Sprinkler demand = 1,787 gpm +
Hose stream demand = 500 gpm
Total water demand = 2,287 gpm

According to NFPA 13, the water supply at this rate must last 2 hours (120 minutes), so the 2,287 gpm is multiplied by 120 minutes to obtain the total water demand:

2,287 x 120 = 274,440 total gallons needed

For life safety systems. The water supply duration is intended only for the sprinkler system, and to last long enough only to get occupants out of the building.

Residential Sprinkler Water Demand

A two-story condominium is required to have a residential sprinkler system to satisfy the life safety provisions of the local building code.

The sprinkler designer determines that the fire protection system needs a flow of 56 gallons per minute (gpm) to meet design standards, and there is no hose stream requirement since it is a life safety system. What is the total required water demand for this system?

Sprinkler demand = 56 gpm
Total water demand = 56 gpm

According to NFPA 13R, the water supply at this rate must last 30 minutes, so the 56 gpm is multiplied by 30 minutes to obtain the total water demand:

56 x 30 = 1,680 total gallons needed

In some instances, there may be a need for a combination of different water supply sources that should be available to support an automatic sprinkler system. Take, for instance, an automatic sprinkler system that is maintained by only one water supply source, such as a municipal city water main. If the water main breaks, the water supply needs to be shut off to enable the city water department to perform necessary repairs on the system. The automatic sprinkler system that receives water from this source is rendered useless unless another source can be an adequate substitute. This is why different systems may use a combination of sources that allow the water supply to support or feed the automatic sprinkler system continually **without** interruption.

A number of water sources can be used to operate a sprinkler system:

- municipal water supply;
- mobile water supply;
- onsite water supply; and
- backup water supply.

Municipal Water Supply

A municipal water supply generally consists of a connection to a reliable public water works system that supplies adequate pressure to the automatic sprinkler system and is the primary source of water to the system.



Figure 6-11
Municipal Water Supply Features

Mobile Water Supply

A mobile water supply consists of fire equipment such as pumpers and tenders that may supplement the automatic sprinkler system in the event of a fire and the activation of the system.



Figure 6-12
Mobile Water Supply

Onsite Water Supply

An onsite water supply is a source of water located near the sprinklered structure. Some onsite water supplies could be ponds, cisterns, swimming pools, or elevated or pressurized water tanks that could supplement or be a "backup" to the municipal water supply if it were to become impaired. Occasionally, the onsite supply is the only water source for the sprinklers, so monitoring and maintaining its condition is critical.

Any sprinkler system is only as good as its water supply. It is incumbent on the IC to identify water supply sources, inventory their capabilities and limitations, and plan for contingencies in case of emergency.

SUMMARY--SPRINKLER SYSTEMS

Sprinkler systems need a reliable water supply, which should be identified in the preincident plan. The IC should also plan for contingencies that may arise as a fire event. Job Aid 6.4 provides a sprinkler operation data collection form that an IC can use to collect information at incidents where sprinklers are involved.

STANDPIPE SYSTEMS

Standpipe systems are installed in buildings to deliver water volumes for hose streams in otherwise inaccessible locations for firefighters and occupants.

Definition

NFPA 14, *Standard for the Installation of Standpipe, Private Hydrants, and Hose Systems,* defines a standpipe system as:

> An arrangement of piping, valves, hose connections, and allied equipment installed in a building or structure, with the hose connections located in such a manner that water can be discharged in streams or spray patterns through attached hose and nozzles, for the purpose of extinguishing a fire, thereby protecting a building or structure and its contents in addition to protecting the occupants. This is accomplished by means of pumps, tanks, and other equipment necessary to provide an adequate supply of water to the hose connections.

Much of the terminology related to standpipe system components (e.g., valves, pipe, fittings, gauges) is identical to that used in sprinkler systems. Refer to the previous section for a description of these terms.

Where Standpipe Systems Are Found

Standpipes generally are required in highrise buildings by all of the model codes, with some exceptions. Standpipes also can be found in other large-area buildings, such as hospitals, terminals, warehouses, industrial buildings, enclosed shopping malls, theaters, stadiums and arenas, parking garages, bridges and tunnels, piers and wharves, and limited access highways, to name a few. Even buildings under construction may be required to have temporary standpipes for fire service use.

As a fire officer and IC, it is important for you to be aware of where these systems are located in your response area, and what their limitations are (e.g., dry, manual dry, manual wet, automatic dry, automatic wet, or a semiautomatic dry system). Knowing this information in advance of a fire will allow the preplanning of system supply priority and procedures, and will greatly assist in the overall management of a fire incident.

Standpipe System Classes

NFPA defines three classes of standpipes:

Class I Systems

Class I systems provide 2-1/2-inch hose outlet connections to supply water for **use by fire departments and those trained in handling heavy fire streams**. The systems must be designed to deliver a flow of not less than 500 gpm at 100 psi at the topmost **hose outlet**. Pre-1980's systems may be designed to deliver 500 gpm at only 65 psi outlet pressure. (Note that the design criteria are based on the hose **outlet** location, and do not include calculations for friction loss in hose and nozzles that the fire department might attach.)

In buildings where Class I systems are installed, there must be at least one standpipe riser in every required exit stairway. NFPA 14 requirements specify that the water supply must deliver 500 gpm to the "first" standpipe, and 250 gpm to all other standpipes with a maximum water supply requirement of 1,250 gpm. Thus, if a structure has three exit stairways, the total water supply required would be 1,000 gpm: 500 for the first standpipe, and 250 gpm for each of the other two. This does not mean only one of the three standpipe risers will deliver 500 gpm; in fact any one of the three could do so. This volume requirement pertains only to the minimum required water supply.

Class II Systems

Class II systems provide 1-1/2-inch hose stations to supply water for **use primarily by the building occupants**, or by the fire department during initial response or mop up. Class II systems--which often are connected to the building's potable water supply--must be designed to deliver 100 gpm at 65 psi at the outlet. Class II systems normally are not equipped with a FDC to supplement the flow and pressure.

Class III Systems

Class III systems employ the features of both Class I and II. They provide 1-1/2-inch hose stations to supply water for use by building occupants, and 2-1/2-inch hose connections to supply a larger volume of water for use by fire departments and those trained in handling heavy fire streams. The systems must be designed to deliver a flow of not less than 500 gpm at 100 psi at the topmost hose outlet.

NFPA 14 and locally adopted fire codes require that hose installed on Class II and III be regularly inspected and tested. However, it is strongly recommended that fire departments **do not use** firehose installed for occupant use because it is often poorly maintained and cannot withstand the normal pressure necessary for effective fire department hose streams.

Zoned Systems

Highrise buildings (having occupied floors more than 75 feet above the lowest point of fire department access) provide special water delivery challenges for the fire service. Automotive pumping apparatus may not be capable of providing the "lift" needed to move large water volumes many stories in the air.

Historically, NFPA 14 required highrise buildings greater than 275 feet to have multiple "zones" for high and low elevations. This specific elevation requirement is gone from the standard, but IC's still will find zoned systems in new and existing highrise buildings because they are the most efficient way to deliver water to the top of tall structures. System designs now are based on engineering calculations that determine pressure needed to get the minimum required flow to the various elevations.

Two-Zone Systems

A typical two-zone system employs two stationary fire pumps in series. The first pump in line takes water from the supply and pumps it to the low zone and/or the second fire pump in line. The sum of the two pressures is enough to push the water to the upper zone (see Figure 6-14). The upper zone also may be served from a tank located in the upper elevations of the building.

Multizone Systems

In those circumstances where the structure is so tall that two pumps aren't adequate to boost the water pressure, a third pump may be installed in the upper floors of the building to increase the water pressure to an adequate operating range. This third pump also may take water from a stationary tank in the building (see Figure 6-15).

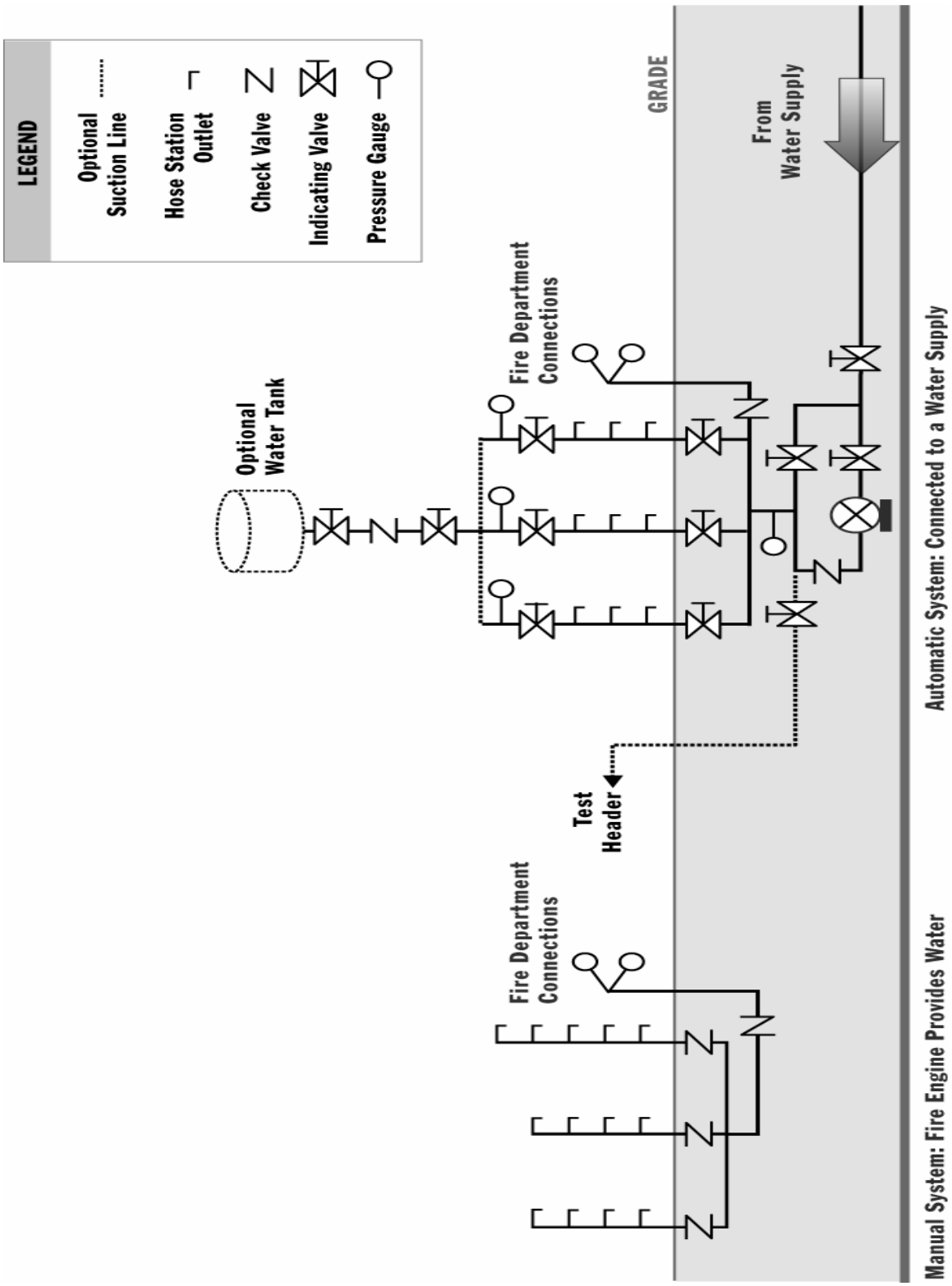


Figure 6-13
Single-Zone System

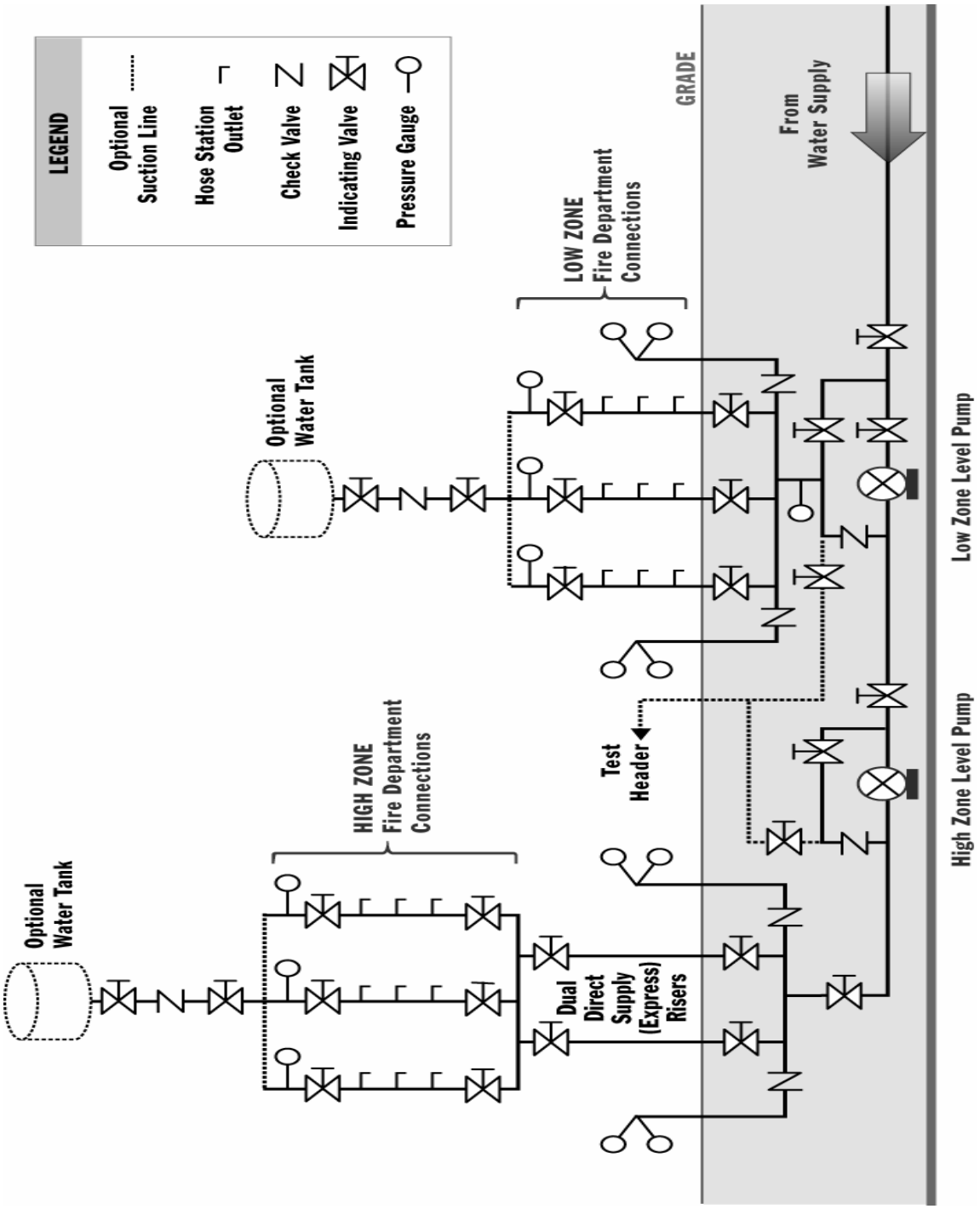


Figure 6-14
Typical Two-Zone System

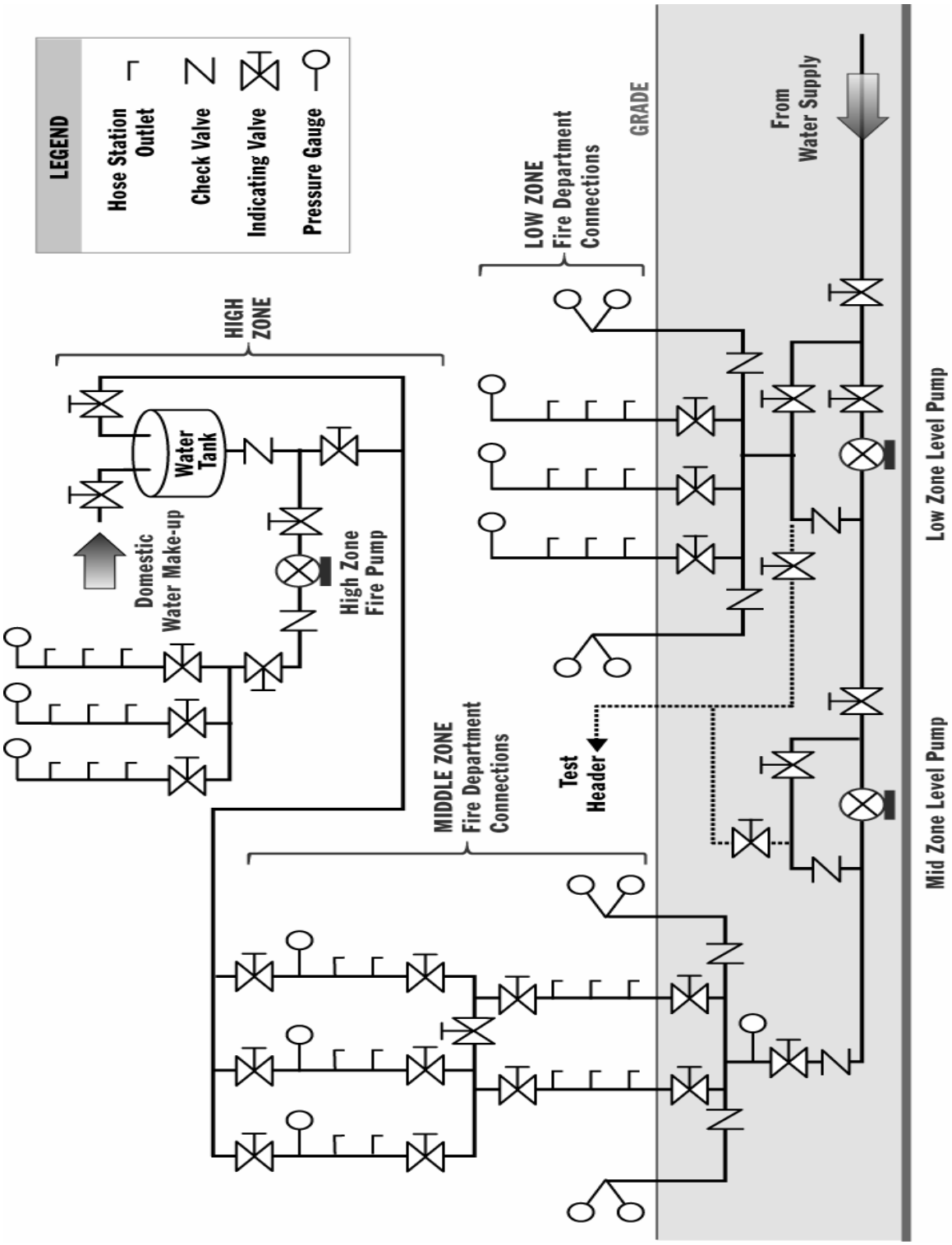


Figure 6-15
Typical Multizone System

Water Supplies

Standpipe systems must be provided with an adequate water supply for effective fire control and suppression. The water supply may be provided by the fire department transferring water from nearby hydrants, or it may be part of a system already built into the structure.

Standpipe systems are supplied with water by either manual or automatic means.

Manual Systems

Manual systems are not connected to a water supply, or are connected to a small priming water supply that is not capable of delivering the system demand, and require water from a fire department pumping apparatus to supply the system demand. Priming water may be provided solely to reduce the time required to deliver water to the hose outlets.

It is imperative that for manual systems the necessary pump pressure calculations are made prior to a fire to obtain effective flows at the point of discharge. These calculations should be recorded on the pre-incident plan.

The pump operator must know what pressure needs to be supplied to the system in advance of the emergency, so that an adequate firefighting flow is available once hookups have been made to the system discharge valves. It is a common practice for pump operators to supply a system at 150 psi until the calculations for the system have been completed. But knowing in advance the proper system supply pressure will assist in assuring that an adequate water supply and pressure are available to suppression forces once they commence fire attack.

Manual Dry Systems

The manual dry system does not have a permanent water supply attached to the system, and must be supplied through a fire department pumping apparatus to meet system demand.

As part of the preplanning process, fire officers should verify the water source, hydrant locations, and type and size of fitting for connecting to the system.

Although most are standard 2-1/2-inch connections, some departments are requiring specialized large diameter hose fittings, such as a Stortz connection. When these large-diameter hose connections are found, there should also be 2-1/2-inch connections adjacent to or in close proximity to the larger diameter hose connection.

Manual Wet Systems

Manual wet systems are connected to a small water supply that is not capable of supplying system demand. These systems must be supplied by a fire department pumping apparatus.

Manual standpipes should not be installed for use as Class II or Class III systems, where a constant water supply is required.

Wet or Automatic Systems

Automatic and semiautomatic standpipe systems require a minimum of one preconnected water supply that is capable of supplying the standpipe system's hydraulic demand for the minimum required duration. Several types of water supply may be acceptable. These include

- public waterworks system, with a booster pump when higher pressures are required;
- fire pumps connected to a reliable water source;
- pressure tanks; and
- gravity tanks.

In addition to the primary water supply on an automatic or semiautomatic standpipe system, one or more FDC's with a reliable water source accessible nearby are required.

For those buildings that are not considered highrise structures, but may be required to have standpipes, the water supply does not have to meet the **pressure** demand for the standpipe system if the building is fully sprinklered and the arrangement is approved by the Authority Having Jurisdiction (AHJ). In these cases the standpipe system is treated as a manual system, and the water supply must be supplied from a fire department pumping apparatus.

Wet or automatic systems are connected to a water supply that is capable of supplying system demand (adequate volume and pressure for firefighting purposes).

Wet Systems

Automatic wet systems are systems that are capable of supplying system demand automatically. They are supported by a water supply capable of meeting the firefighting water supply demand for a particular building or area. The water supply may be the municipal system, private water system, or one or more storage tanks in the building.

Automatic Dry Systems

Normally automatic dry systems are filled with pressurized air, using a dry valve that admits water into the system when a hose valve is opened. The air normally is discharged through the hoseline so there will be a delay in receiving water in the line, not unlike water being supplied from a fire department pumper. Firefighters must be aware of this delay and not make an attack on the fire until they have a working hose stream. These systems must be capable of supplying system demand. Normally they are installed where the piping is subject to freezing.

Semiautomatic Dry Systems

The semiautomatic dry system is a dry system that uses a deluge valve or other device that admits water into the system upon activation of a remote control device located at a hose connection. A remote control device must be located at each hose connection. The water supply for these systems must be capable of supplying system demand.

Connection Locations

Many fire departments are now requiring that FDC's be located at a corner of the building away from the potential wall collapse area. This creates a safe zone for the apparatus and apparatus operator, in the event the building does collapse. A fire hydrant usually is installed within less than 100 feet of the connection, and out of the potential collapse zone, for ease of hookup and pumping operations.

Highrise Buildings

For highrise buildings, two remotely located FDC's are required for each zone within the pumping range of fire apparatus, in addition to the automatic water supply. Two FDC's reduce the possibility of having falling glass cut all supply hoses and interrupt the secondary water supply during a fire.

Multiple Standpipe Systems

Buildings that require more than one standpipe system are required to connect them at the bottom of the system. This requirement gives greater reliability to the system.

Standpipe Fire Department Connection Markings

Each fire department connection for a standpipe system should be marked with letters in a cast plate or on a fitting that reads

"STANDPIPE"

For systems where the fire department connections serve both fire sprinklers and standpipe systems, signage should be installed at the connections that read either:

"STANDPIPE AND AUTOSPRKR"

or

"AUTOSPRKR AND STANDPIPE"

This signage usually is found on an embossed metal plate around the FDC supply pipe or in the brass FDC fitting itself.

As part of the PIP process, the firefighters and IC should closely study the embossed plate around the FDC for additional information.

At the 110-story, 1,450-foot tall Sears Tower in Chicago, Illinois, for example, the FDC metal plates explain which floors and features they support. (Note: "LL" means Lower Level.")

One FDC is labeled "Zone 1 Sprinklers LL 3-16, Fire Standpipe 3-10," while the adjacent is labeled "Zone II Fire Standpipe 11-28, "Sprinklers 17-28, 31st Floor Tank Fill." (See Figure 6-16.)

Connecting to the wrong FDC could delay support for firefighters attacking the fire.



Figure 6-16
Fire Department Connection Cast Plate

Locations of Hose Outlet Connections

Hose connections for fire department use are to be located as follows:

Class I Systems

For Class I systems, hose connections must be located

- At each intermediate floor landing, and supplied with a 2-1/2-inch connection. When approved by the AHJ, they may be located at the main floor landings of exit stairways.

- Where horizontal exits are found, e.g., in hospitals and highrise buildings, connections are to be installed on each side of the wall, adjacent to the exit opening.

- In each exit passageway at the entrance from the building areas into the passageway. (Note that "exit passageway" has a specific building code definition, and is not simply a path of travel.)

- In covered mall buildings, at the entrance to each exit passageway or exit corridor, and at each exterior public entrance to the mall.

- At the highest landing of stairways with stairway access to a roof and on the roof if the roof has a slope of less than 4:12. Where stairways do not access the roof, an additional 2-1/2-inch hose connection shall be provided at the hydraulically most remote riser, to facilitate testing the system.

- Additional hose connections are required in buildings where the reach for the most remote point in the building exceeds 150 feet in nonsprinklered buildings, and 200 feet in sprinklered buildings.

For Class I manual systems, each hose station outlet should be marked with a conspicuous sign reading

"**MANUAL STANDPIPE FOR FIRE DEPARTMENT USE ONLY.**"

Class II Systems

Class II systems must be provided with 1-1/2-inch hose stations, so that all portions of each floor level of the building are within 130 feet of a hose connection provided with 1-1/2-inch hose, or within 120 feet of a hose connection provided with smaller than 1-1/2-inch hose. Distances are measured along a path of travel originating at the hose connection.

Class III Systems

Class III systems shall be provided with hose connections, as required for both Class I and Class II systems.

Cabinets and Hose Reels

Hose outlet connections for all standpipe classes may be found in wall-mounted or recessed cabinets with steel or glass doors. It is common to find Class II hose stations with the 1-1/2-inch hose on reels or racks. When using Class II stations, it is imperative that the hose be removed entirely from the rack or reel or water may not flow from it when the control valve is opened.

Standpipe Sizes

Separate standpipes shall be provided in each required exit stairway. Class I and Class III standpipes usually are at least 4 inches in size (diameter). Standpipes that are part of a combined (fire sprinkler and standpipe) system usually are at least 6 inches in size.

Standpipe System Pressure

Under current standards, the minimum residual pressure required for a standpipe system must be 100 psi at the **outlet** of the hydraulically most remote 2-1/2-inch hose connection, and 65 psi at the outlet of the hydraulically most remote 1-1/2-inch hose station. It is important to note that the minimum pressure at the **outlet** is required to be 100 psi and is not the pressure at the **nozzle**. This requirement may not apply to older systems.

"Hydraulically most remote" may not be the same as the physically most remote point from where the standpipe water supply enters the building. The hydraulically most remote location is determined by pressure losses due to friction and elevation, and is calculated during system design.

Many jurisdictions are requiring pressure at the outlet above the minimum, to coincide with the type of hose and nozzle that will be attached to the connection. These calculations are based on supplying 100 psi at the nozzle for variable fog nozzles, and 65 psi at the nozzle for smooth bore nozzles.

It is important to calculate the actual nozzle pressure based on friction loss that will occur as water flows through your hoseline. Calculating the friction loss for the hose you use in these situations, whether it be 1-1/2-inch, 1-3/4-inch, or 2-1/2-inch, will give you a reading for the actual pressure at the nozzle, depending on hose length, and will give a good indication of the firefighting stream that will be available. Because the variables may be complicated, it is essential to perform the calculations beforehand and include them on the preincident plan. Job Aid 6.6 provides guidance for manual standpipe system hose outlet calculations.

Disagreements Regarding Correct Pressure

There remains a great deal of disagreement over what the correct pressure should be in standpipe systems at the hose connections for firefighter hose lines.

In 1993, after the One Meridian Plaza Fire in Philadelphia, Pennsylvania, where three firefighters died, NFPA amended its Standard 14 to require a pressure of 100 psi at the outlet of the hydraulically most remote 2-1/2-inch hose connection. This must be controlled by **pressure-regulating devices**--also called **pressure-reducing valves** (PRV's)--in buildings where head pressure may cause a greater, unmanageable pressure in the line, such as in a highrise building.

The controversy still exists because some departments still use smooth-bore tips on their hose packs used to connect to standpipe system outlets. These smooth-bore nozzles do not require the higher pressure to maintain an adequate firefighting stream, thus the previous NFPA 14 specified only 65 psi at the connection. There are also many departments that use variable fog nozzles on their hose packs, and these nozzles generally specify 100 psi as the working pressure.

Fire officers need to evaluate their standpipe systems based on the hose and nozzles they will connect to these systems, and develop their strategies and tactics based on their local situations.

Pressure-Regulating Devices

NFPA 14 allows the **maximum** operating pressure on a standpipe system to be 350 psi, far in excess of what is safe to handle at the end of a hoseline. Thus, in some circumstances, these high pressures must be reduced to safe, workable levels while maintaining effective fire streams.

One very important component of a standpipe system is valves categorized as **pressure-regulating devices**. This type of valve may be called a **pressure control valve** (PCV), PRV, or **pressure-restricting device** (PRD). (See Figure 6-17.)

PCV's and PRV's are designed with the same purpose in mind: to reduce the downstream water pressure under both flowing (residual) and nonflowing (static) conditions.

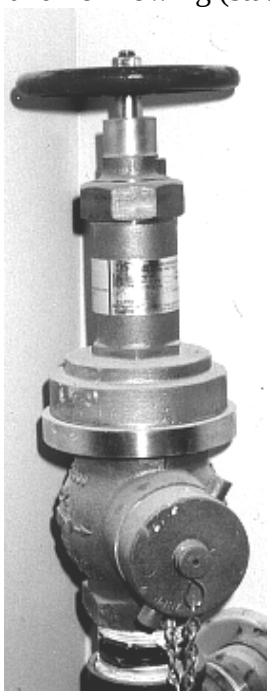


Figure 6-17
Typical Standpipe Pressure-Regulating Outlet

PRD's only reduce the downstream water pressure under flowing (residual) conditions.

All PRD's are installed to allow proper flow pressures at the outlets on a system. They must be properly set and installed so that the proper pressure is maintained at the outlet valve so that adequate firefighting streams are available. When valves are improperly set and installed, this can result in inadequate streams, as happened in the One Meridian Plaza fire, or this could cause an uncontrollable amount of pressure. For example, in a highrise building with the fire on the 10th floor of a 50-story building, if a PRD is not installed, the head pressure developed from the water on the upper 40 floors could cause a fire- fighting hose to be unmanageable.

Two methods of setting PRD outlet pressures exist: **field set** and **factory set**. Field-set devices are designed and manufactured so their pressure settings can be adjusted after the device is installed on the standpipe riser. This gives the installer the greatest amount of flexibility to install PRD's at any location and adjust them later. Factory-set devices have the calculated outlet pressure set at the manufacturing facility, and it cannot be adjusted in the field. Therefore, it is essential that the installer match the preset PRD to the floor level that corresponds to its calculated pressure. Failure to do so may result in the wrong outlet installed at the wrong floor level, with potentially disastrous results. Fire officials must verify **before an incident** that PRD's are properly installed and adjusted.

PREINCIDENT PLANNING WALKTHROUGH

When conducting a preincident walkthrough of a building, it is essential that all components of a standpipe system be evaluated. Evaluation should start with verification of the water supply source to ensure its adequacy, including checking the **post indicator valve** (PIV) or **wall indicator valve** (WIV) on fire protection systems to ensure they are in the open position, inspecting the fire department connections to check for damage to the threads or obstructions in the opening, and inspecting valves at each level to confirm they are fully operational. This is an important part of preincident planning.

Verifying the Origin of the Water Supply

Fire officers need to be very familiar with where the water supply for a standpipe system originates. Wet standpipe systems may be supplied by the municipal water system, local storage tanks, or underground cisterns. Advance knowledge of how much water is available and what pressures are supplied by these systems will assist in developing fireground objectives, strategies, and tactics. Verifying the available water supply from the hydrant supply in ground systems is an important part of the pre-planning process. If the system is part of the fire sprinkler system, or is attached to a permanent water supply, make sure the PIV or WIV is in the open position, and that the PIV is locked to prevent tampering or inadvertent closing. Also, check to make sure the OS&Y valves for the system are in the open and chained position, and that the shutoff valves for the system are chained and locked in the open position. Newer installations likely will have electronic tamper switches as well.

Verifying Fire Department Connection Locations

Once the water supply has been verified, fire officers need to check for the location and condition of fire department connections (FDC). FDC's are usually located on the exterior of a building, or at a remote location adjacent to a fire hydrant. Verifying that the connections are in good condition, threads are not damaged, and there are no obstructions in the water way is a proper preplan check. Contingencies need to be established in advance, in case the FDC is damaged or unusable. If a normal hookup cannot be made, a common alternative is to connect to an outlet on the first floor to supply the system. It is essential that as part of the preincident survey, IC's identify which FDC supplies which standpipe riser. It's only been since the early 1980's that the model building codes required all standpipes to be interconnected, so it may not be unusual to find a FDC for each riser in a structure with multiple risers.

Recent building code changes--as well as requirements in NFPA 14--require multiple FDC's on highrise buildings. Often, these are located on opposite sides of the building.

SUMMARY--STANDPIPE SYSTEMS

Standpipe systems provide an opportunity for fire departments to maximize their capabilities under fire conditions. Dependence on these systems without a working knowledge of all of their components, i.e., water supply, FDC's and what they serve, connection locations, and proper supply pressure, can impact the outcome of a fire incident.

Also, confirming operational readiness is critical to effective standpipe operations. Preplanning for all of these issues and determining proper connection and hose layout procedures in advance of an incident will have a significant impact on how effective standpipe systems operations will be, and should result in more positive outcomes in firefighting operations.

STATIONARY FIRE PUMPS

Fire pumps are needed whenever fire protection system demands exceed the capabilities of the available water supply. Fire pumps may be either "booster" pumps that increase pressure from a water source such as an aboveground tank or public water main, or "suction" pumps that draw water from a static source (pond, lake, underground tank) and send it to the fire protection system.

Fire Pump Locations

In many cases, the fire pump may be situated in the main riser room of the automatic sprinkler system or in an adjacent fire pump room. For larger complexes, such as large manufacturing plants, the fire pump may be located in a separate building that houses the fire pump(s), and the building also may have a water storage tank attached to support the sprinkler system.

Temperature Concerns

Fire pumps should be located in areas or buildings where heating is readily available, and the temperature in the area does not fall below 40 °F (4 °C). NFPA recommends that a room that houses a diesel fire pump should be heated to at least 70 °F (21 °C).

Components

Fire pump assembly components are pumps, drivers, controllers, test headers, bypass, and jockey pumps.

Types of Fire Pumps

Two types of pumps typically are used: centrifugal or "booster" fire pumps, where water is available under pressure (city water supply/city water main/elevated tank); and vertical turbine pumps, where the available water supply is in a static state, for example in a pond or reservoir.

Centrifugal Pumps

Water in centrifugal pumps enters the suction inlet and passes to the center of an impeller. The impeller rotates and drives the water by centrifugal force to the rim, where the water is discharged. Their operation is similar to the centrifugal fire pumps installed on fire apparatus.



Figure 6-18
Typical Centrifugal Fire Pump Assembly

Vertical Turbine Pumps

A internal combustion vertical turbine pump usually has a right-angle gear to drive with impellers connected to the pump head by a vertical shaft. Electric motors are mounted in line with the pump, and don't need angle valves. As the pump operates, the water is passed from one impeller to another, gaining additional force along the way, until it passes through the pump outlet.

Single-Stage Versus Multistage Pumps

Most centrifugal pumps contain a single impeller and are called single-stage pumps. If a fire protection system calls for high-pressure demands, such as in a large manufacturing plant that contains different systems and a large area, multistage pumps are needed.

Electric drive pumps are provided with circulation relief valves to discharge water when the pump is being run with no water discharge. This valve is provided because, without it, the temperature of the water trapped in the pump casing would increase due to centrifugal force created by the pump. The high temperature may increase vapor space and result in "cavitation" that can permanently damage a pump.

Fire Pump Drivers

A fire pump driver rotates the pump impeller(s). An IC may find different fire pump drivers. The most common drivers are electric and diesel; however, in older installations (late 19th and early 20th centuries) a steam-powered fire pump may be used.

Drivers used to operate a fire pump can be electric, diesel, and, in some cases, steam. Rated pump sizes range from 25 gpm to 5,000 gpm.

Electric

Electric motors often have the advantage of being less costly, quieter, and have lower maintenance costs than other drivers. In most cases, unless exempted by the AHJ, an electrically driven fire pump requires a "backup" or second source of power. In the event of a total power failure, an electric fire pump would be rendered useless. It is for this reason that many times an electric fire pump requires a backup or second power to ensure operability.

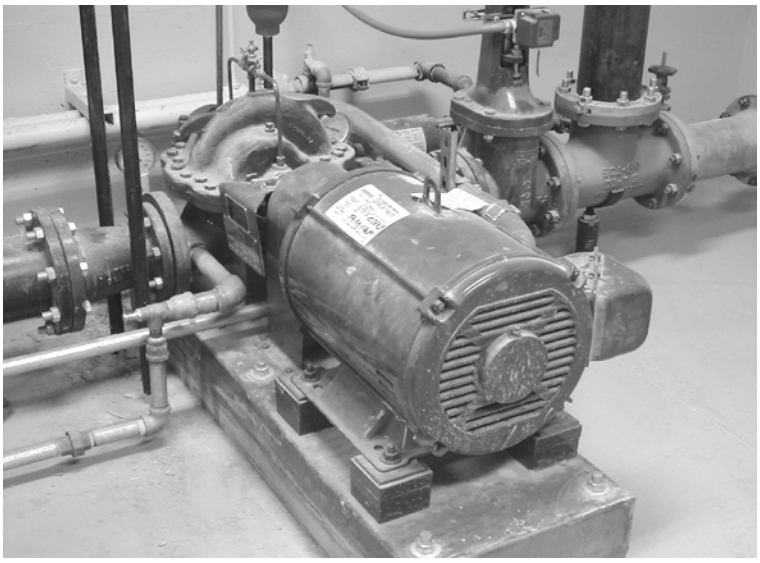


Figure 6-19
Electric Motor Drive

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, mentions the following to serve as backup or second power:

- storage battery (although an unlikely source because of insufficient capacity at a reasonable cost);
- generator;
- uninterruptible power supply (combination of battery and generator);
- separate electrical service (often from a nearby building)*; and
- connection ahead of service disconnecting means (main power service).

In many instances, fire pumps are wired so they receive power ahead of the main power service disconnect coming into a building, so this would not come into play as an emergency power source. Batteries generally are not powerful enough to handle a fire pump, so these are not used. More often than not, diesel, liquefied petroleum, or natural gas generators are used to support or back up an electrically driven fire pump.

Diesel

If adequately maintained, diesel engines are highly reliable power sources for a fire pump operation. These engines are started by battery-powered sets that are charged like a car or truck. Diesel engines are a great deal louder than electric motors (see Figure 6-20).

*The preincident plan should identify when this option is used so the IC doesn't request an "area-wide" power disconnect that would de-energize the electric driver.

The installation requires that special design features be provided in their placement in the area that will contain them. A fire pump room housing a diesel fire pump requires ventilation and exhaust (from the diesel fumes). Diesel engines are commonly used because they are more reliable than the other engine motors discussed previously and can operate when all power is lost. Gasoline-powered engines are not permitted.

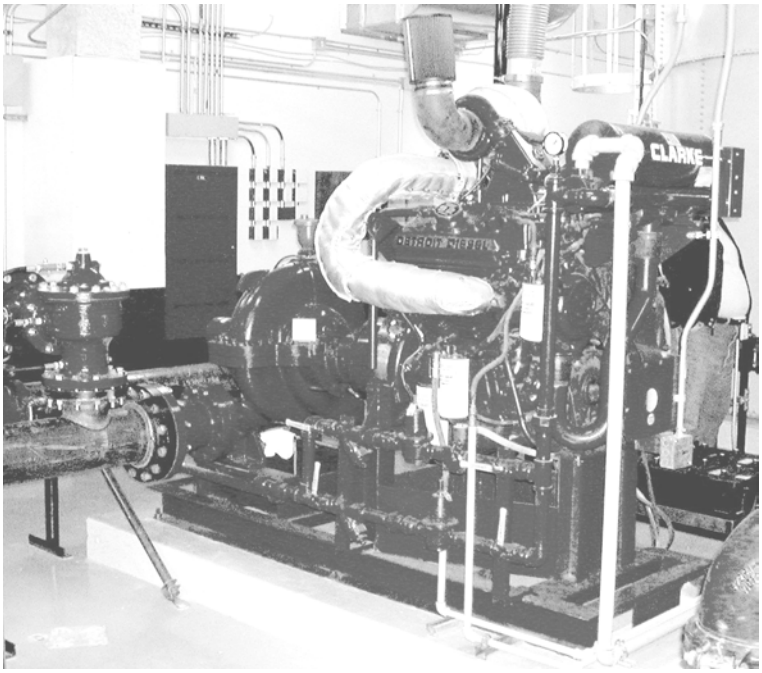


Figure 6-20
Diesel Fire Pump

Steam

Steam-driven turbines once were used and considered acceptable for driving fire pumps, generally in power plants that used steam in their processes and for associated purposes. The use of steam turbines has decreased significantly in recent years; however older areas of the country may still have these turbines installed.

Fire Pump Controllers

Pumps are started and stopped by controllers. A fire pump may be started manually, but usually is arranged to start automatically upon a drop in the system pressure or the activation of the fire protection system. Automatic starting requires a controller.

Controllers for Electric Motor-Driven Pumps

The primary role of the controller is to start or stop the motor that drives the fire pump. Primarily, this is done through the use of a water pressure switch, which is connected by 1/2-inch sensing pipe to the system. During sprinkler activation, water pressure drops and starts the pump. However, there are times when the drop in water pressure may not be enough to start the pump.

There are also times when it would be beneficial for the pump to start before the water begins to flow (depending upon the actual system). Under these conditions, the pump can be started by a signal from the detectors, or an air pressure sensor in the case of a dry pipe system.

High-voltage controllers (ones operating at greater than 600 volts) must meet the same requirements as electrical controllers. In addition, a step- down transformer needs to be installed for the alarm signal circuit. Finally, these controllers need to be built so that individuals are protected from contact with high voltage.

There are a number of basic components that should be considered and installed on a system when an electric motor is used to operate a fire pump. These components are

- isolation switch;
- circuit breaker;
- automatic transfer switch (optional);
- alarm and signal devices;
- manual start or stop buttons; and
- high-voltage controllers.

Figure 6-21 shows the basic components of a fire pump controller.

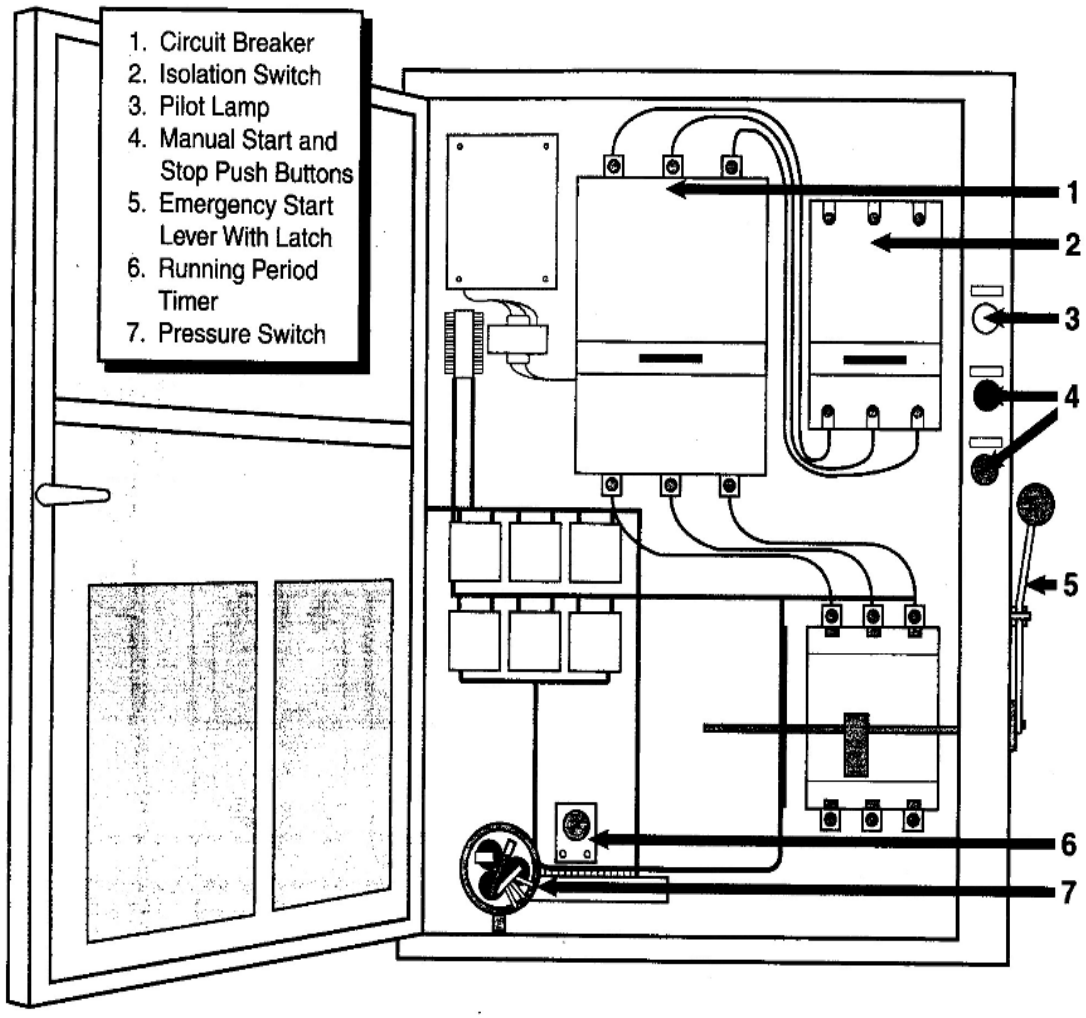


Figure 6-21
Typical Fire Pump Controller*

*Reprinted from *Private Fire Protection and Detection*, 2nd ed., FFP/IFSTA.

Isolation Switch

The first part of the controller (as the power comes in) is where an isolation switch is placed on the system. The isolation switch is provided for the service technician to "de-energize" the fire pump driver while still being able to work on the electric controller.

The isolation switch **must** be operable from the outside of the controller. This switch **should not** be opened or closed when the circuit breaker is in the **closed** position. This warning should be printed next to the switch to prevent electrocution (see Figure 6-21).

Circuit Breaker

The circuit breaker is located directly after the isolation switch. When a fire pump driver needs to be shut down, or the controller needs to be repaired, the circuit breaker must be opened first. Why? The circuit breaker is a disconnecting means and allows the isolation switch to be opened and then electrically isolate the fire pump. The circuit breaker is designed to protect the fire pump driver from electrical overcurrent.

Automatic Transfer Switch (Optional)

In those cases where the second power source is required to come on automatically when the primary power is lost, an automatic transfer switch is used. Once it senses the loss or significant reduction of primary power, it switches the controller to the second power source--generator, separate service, etc.

Signaling Devices

When something does affect the operation of a fire pump, someone should be notified that something is wrong. NFPA 20 requires that two signaling devices be used: a **power-available** indicator and a **phase-reversal** indicator.

Power-Available Indicator

The power-available indicator identifies the operating voltage that is available at the pump motor. This indicator is **required** to be visible. If a pilot light is used, then it must be accessible to maintenance for necessary repairs.

Phase-Reversal Indicator

The phase-reversal indicator is located on the controller to tell two things: If the light on the phase-reversal indicator is off, then the pump is wired correctly. If this light is indicated, or is on, then the pump is wired incorrectly and, if activated, the pump will operate backwards, rendering the fire pump useless and ineffective.

Monitoring Signals

NFPA 20 requires that three signals be sent to a constantly attended location, if someone does not constantly monitor the pump. These three signals are

1. Pump running alarm.

2. Loss of phase alarm.

3. Phase reversal alarm.

These alarms can be audible or visual, and the electricity used to support these signals must come from a separate source of power that is **supervised**, meaning the source of power for the signals cannot come off the main electrical supply running the fire pump.

Manual Pump Starts

Most fire pump assemblies are arranged to start the pump automatically when there is a measured pressure drop in the fire protection system, such as that caused by sprinklers or standpipe valves being opened.

In those cases where the pump fails to start automatically or is not equipped with automatic start, someone should be assigned early in the incident to confirm the fire pump is running. If it is not, that information should be relayed to the IC and a decision made to start the pump.

Starting a properly working fire pump is easy: Find the controller and look for the "Start" button or buttons, which normally are colored green. A manual start feature bypasses all of the automatic start procedures. If there are multiple start buttons, press them simultaneously. If the pump does not start right away, try a second time.

Some controllers also have a manual lever that can be moved to start the pump. Move the lever to the "On" position, and latch it there. It should be moved from the "Off" position to the "On" position in as quick a motion as possible to prevent burning electrical contacts.

If there is no response after a second try or manipulation of the manual start lever, there may be an additional failure that needs to be addressed. **Do not try to open the fire pump controller door or operate any of the electrical components because of potentially high voltages.** Advise the IC right away of the circumstances, and make arrangements to have the building engineer or maintenance person respond to the fire pump controller.

Stopping the Pump Manually

All controllers should have a manual way of stopping the running of the pump. On most systems a push button is located on the outside panel of the controller. In most instances, this manual push button is the only means available to shut off a running pump.

If the controller is equipped with a manual lever, shutdown should be accomplished by a person with knowledge of the equipment. In that case, the circuit breaker should be tripped to disconnect the circuit before moving the lever.

If you cannot shut off an electric drive pump, there is danger that the pump will overheat and damage itself beyond repair, especially if the circulation relief valve fails. In that case, it is important to flow water to keep the pump cool.

There are several options to accomplish this: open one or more valves on the test header or flow meter, flow one or more hoselines from a standpipe outlet, or open the fire sprinkler system main drain valve. In any case, check the water discharge location so you don't create additional property damage.



Figure 6-22
Manual Start

Controllers for Diesel Engine Pumps

Diesel engine pump controllers are required to be located in or around visual range of the pump. These controllers must follow NFPA 70, *National Electrical Code*®, wiring installation specifications. Alarm and signaling devices should be visible and allow an individual to determine that the pump is set to run automatically.

Generally, the diesel engine controllers also have a light indication, as used in the electric controllers previously mentioned. There are a number of conditions listed in the National Fire Sprinkler Association (NFSA) *Fire Pump Handbook* that would activate an audible alarm (see Isman, 1994, p. 50).

Alarms

When a fire pump room is not attended constantly, the fire pump is required to have installed either an audible or visual alarm for the following three conditions:

1. The pump begins running.

2. The controller is set to either manual or off, instead of in the automatic position it should be in.

3. Trouble signal, which occurs when one of the two conditions above is indicated.

For diesel-drive pumps, the following alarms also are required

- low oil pressure;
- high engine temperature;
- overspeed;
- failure to start;
- battery failure; and
- primary power (AC) failure.

How Diesel Pumps Start Automatically

Diesel pumps start automatically by using one of two methods: electric or air. Electric uses the batteries that are installed on the system. Generally, there are two different sets of batteries on each system. Each set should be able to allow the pump to operate. Battery chargers are used in these instances and must follow NFPA requirements.

Air may be used to activate a pump. In this instance, air is kept under pressure (similar to the dry pipe sprinkler systems discussed earlier), and when a drop in the pressure occurs, the air allows the engine to start and activate the workings of the fire pump.

Test Headers and Flow Meters

Like mobile fire apparatus, stationary fire pumps must be tested periodically to verify they are performing at peak capacity. This is accomplished through annual testing using a **test header** or **flow meter**.

Test headers (see Figure 6-23) are pipes equipped with gated outlet valves. Usually, there is one test outlet for each 250 gallons of rated pump capacity. During testing, the service technician or property manager connects 2-1/2-inch hoselines to each test outlet and performs a full flow test. Meanwhile, the technician is monitoring pump performance with suction and discharge pressure, pump temperature and revolutions per minute (rpm's). This is similar to the annual service test performed on fire apparatus.

In recent years, installers are choosing flow meters in place of test headers. A flow meter accurately measures the pump output volume so the technician does not have to perform Pitot gauge readings and mathematically convert the pressure to volume.

Fire Pump Test Headers

A caution to all fire officers when evaluating these hookups: Do not confuse fire pump test headers with FDC's. (See Figure 6-23.) Test headers are identified by the nonindicating gate valve and the male threaded connections. They are used for the fire pump's annual performance test.

Test headers often are placed in close proximity to the FDC. Test headers should be properly identified as such, but often these markings are missing or have been removed. Therefore, check and verify what connections are FDC's, and make sure they are clearly identified.

A test header located on an adjacent or nearby building could be used as an alternate water supply.

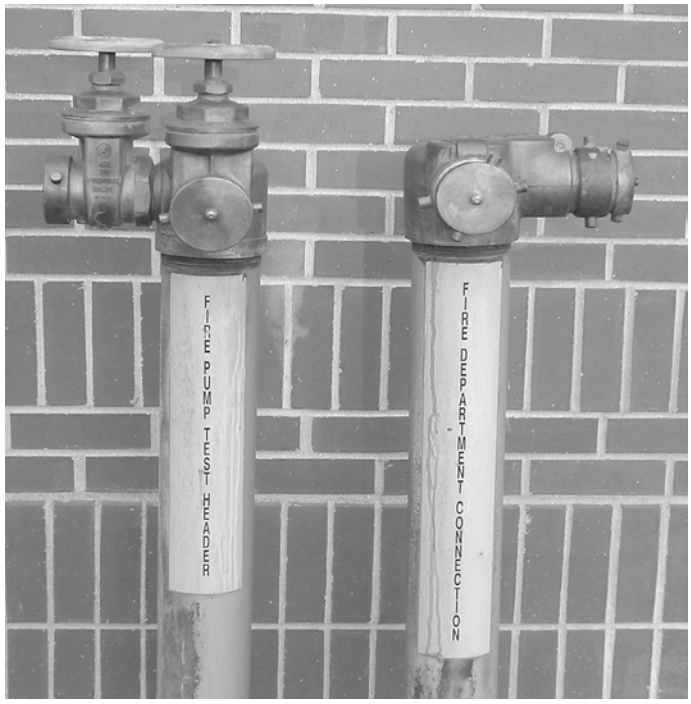


Figure 6-23
Adjacent Pump Test Header (L) and FDC

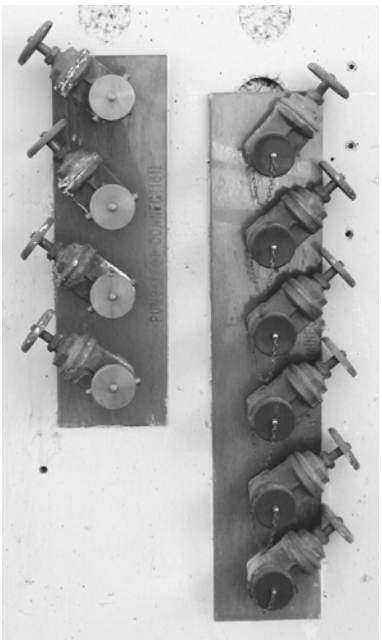


Figure 6-24
Test Header

Fire Pump Bypass

NFPA 20 requires some fire pump assemblies to be outfitted with a pump **bypass**. The purpose of the bypass is to allow water from the source (tank, pond, reservoir, municipal system, etc.) to supply the fire protection system even if the pump fails to operate. It also allows the property owner to isolate the pump for service (by closing valves on the intake and discharge sides of the bypass), while leaving the rest of the fire protection system in service. The water supply pressure won't be as high as if it were boosted by the fire pump, but there still will be water for fire protection.

The control valves on the pump bypass normally are left in the "open" position, and closed only for fire pump service. During an incident, someone should be assigned to check the status of these valves to assure they are open.

Bypassing the Fire Pump

The fire department does not normally pump directly into a fire pump for firefighting operations within a sprinklered building. Fire pumps are set up to act as independent units; however, bypass valves are located on fire pumps in case the sprinkler system needs to be supplemented (additional water is needed), or if the fire pump is working from a limited water supply source, such as a water storage tank.

Fire pumps generally supply closed loop systems within a sprinklered facility. This means that the water comes in from a supply to the fire pump, which then supplies the automatic sprinkler system. In this case, the fire department usually provides water to the system from a municipal water hydrant or another offsite water source (pond or lake, etc.) in order not to interfere with the fire pump and automatic sprinkler system.

The only time an IC would disable a fire pump would be in the event the automatic sprinkler system is compromised by collapse or other failure and is not helping to extinguish the fire. In this instance, the IC would use fire department apparatus to supply water as the "sole" source for extinguishing the fire.

For example, if a fire department responds to a fire in an occupied structure that is sprinklered, and finds the sprinkler system is not being supplied the necessary water because the 8-inch sprinkler riser that supplies the sprinkler system has been broken off by debris from a collapsing wall unit. The system is rendered useless in this instance, and the fire pump would be wasting water.

Jockey Pumps

Most fire pumps are arranged to start automatically when a sensing device detects a pressure drop on the fire protection system, such as when one or more sprinklers open. To avoid false pump starts due to normal pressure fluctuations, jockey pumps are installed on many fire protection systems to maintain pressure to the system **without** having the fire pump "kick on" or power on the pump. Jockey pumps are not listed fire pumps.

Generally, if a fire pump is supplied water through a city or public water main system, pressure fluctuations or drops in the pressure may occur to the system. These fluctuations are minor, so generally the fire protection system will not operate. This type of pump is used so that it will power on **before** the fire pump and pressure the system to its minimum pressure level.

Another important feature for jockey pumps is their ability to minimize the water surge or water hammer when the main fire pump starts. If the fire protection system is maintained near its normally operating pressure, there is little surge when the fire pump starts.

When the automatic sprinkler system operates and a jockey pump is installed, this pump will operate first. The jockey pump will not be able to keep up with the flow demand; therefore, pressure will continue to drop, and in turn, activate the fire pump.



Figure 6-25
Jockey Pump

Maintenance Records for Fire Pumps

A number of testing procedures must be conducted on fire pumps to ensure their efficiency and proper operation. These procedures consist of weekly inspections, monthly inspections, quarterly inspections, and annual inspections. Generally, in the insurance industry for larger manufacturing or occupied highrises, an insurance engineer reviews these inspections to ensure that the proper maintenance and repairs are conducted on the system.

The fire pump maintenance schedule can be found in NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

In most cases, a reputable fire protection contractor, insurance adjuster, or even the fire department conducts annual fire pump flow or performance tests. This annual test on a fire pump reveals whether or not the fire pump is operating according to manufacturer guidelines and is able to support the design requirements of the automatic sprinkler system.

SUMMARY--FIRE PUMPS

Just like the mobile fire pumps that arrive when the fire department shows up, stationary fire pumps are an integral part of a community's fire protection. Their reliability and capability must be considered during the preincident planning process.

Fire departments should inventory the types and ratings of pumps installed within their response areas. They should become familiar with start and stop procedures, power sources (primary and secondary), and FDC's that supplement the pumps' operation.

Whenever possible, the IC should work closely with facility management and the code enforcement authority to assure that pumps are inspected, tested, and maintained on a regular basis.

RESTORATION PROCEDURES/PROTOCOLS

Fire departments and IC's always should ensure that the fire protection systems are functional, even if they cannot be reset. Sometimes, it is possible to isolate a part of the sprinkler system and allow the rest of the system to operate.

Fire department personnel should remain on the scene to arrange a fire watch in the event that an area of the sprinkler system needs to be isolated. A maintenance person or sprinkler contracting company should be notified of the problem immediately. Generally this can be done by the maintenance person or building representative. In some instances, the fire protection contractor that installed the system has an emergency phone number, usually located on the riser above the alarm valve. In the event a building representative or maintenance person is unavailable, fire department personnel could make this call.

System Impairments

Any fire protection system is only as effective and reliable as its care and maintenance. This is particularly true for water-based systems that may sit in a ready condition for long periods of time before they needed to detect or control a fire, or to be used by the fire protection services to suppress a fire.

Fire protection codes and standards require periodic inspections, maintenance and testing of water-based systems to enhance the likelihood they will work during an emergency. However, compliance with these requirements is only as effective as the code enforcement authority or the owner's commitment to get work done.

Many things may affect the performance of a water-based fire protection system: inadequate water pressure or volume, content (fuel) changes, closed valves, freezing conditions, physical damage, etc. (See Job Aid 6.1 "Factors Influencing Fire Sprinkler Performance.") These factors are called "impairments."

While identifying and correcting impairments is the property owner's responsibility, who may be helped by fire code or insurance inspectors, a knowledgeable Incident Commander (IC) can mitigate potential problems if he or she can identify them before an incident occurs. This chapter has summarized briefly how water-based fire protection systems should be installed to meet nationally recognized standards and enhance their reliability during a fire. An IC who would like to know more about system impairments--and how they may affect incident outcomes--is encouraged to meet with fire code or insurance inspectors, or take additional courses specifically on water-based fire protection systems.

STRATEGIC AND TACTICAL CONSIDERATIONS FOR WATER-BASED FIRE PROTECTION SYSTEMS

Water-based fire protection systems are only as good as their design, maintenance, and use, especially by responding firefighters. While the IC can perform lots of preincident research to understand the design and maintenance, it's primarily in the strategic and tactical use of these systems where the IC can be successful.

An important concept for the IC to understand is that most automatic sprinkler systems installed for property protection are not intended to **extinguish** the fire. (ESFR is an exception, but it is limited primarily to high challenge rack storage warehouses.) Sprinkler systems for property protection are intended to **detect** the fire by operation of a heat-sensitive sprinkler, **report** the fire by an alarm, and **control** the fire until the suppression forces arrive.

Residential systems, installed primarily for life safety rather than property protection, also have some limitations regarding fire **extinguishment**.

While these are subtle differences, they are important to the IC, who must understand the capabilities and limitations of all the systems within his or her response area. It means the IC must know the appropriate strategy and tactics to employ to use the fire protection system effectively, control the fire, and, ultimately, arrange to have the fire extinguished with handheld hose streams.

Strategic Considerations

- Life safety is always the IC's priority objective. He or she should employ the water-based fire protection systems to that advantage.

- Water-based fire suppression systems should be considered a primary fire control tool, not an adjunct to manual hose streams.

- Water-based fire suppression systems must be identified beforehand to determine if they are designed and installed primarily for property protection or for life safety. These differences should be emphasized on a preincident plan, especially as they may affect firefighter safety.

- Water-based fire suppression systems have the advantage of being "on duty" 24 hours a day, seven days a week, 365 days a year. They likely will be the "first responder" to the fire and probably will be operational even before the fire department arrives.

- Water-based fire protection systems (especially sprinklers) may be used to hold a fire in check while the IC establishes a command structure and assesses incoming resources. This provides the IC a broader range of options in the first few minutes of an operation.

- Water-based fire protection systems (especially standpipes) can be used to move large water volumes long distances without extending long hoselines, thus reducing attack time and firefighter fatigue.

- Water-based fire suppression systems (especially fire pumps) can act as an adjunct to or replacement for the mobile fire apparatus that has arrived on scene.

- Water-based fire suppression systems are effective, but they must have an adequate and reliable source of water. The IC must arrange to establish a reliable water supply as one of his or her control objectives early in the incident. Preferably, this has been identified and addressed during the PIP process.

- Water-based fire protection systems employing foam or other additives must have an adequate supply of product preplanned and arranged for delivery at the time of the incident.

- Property protection must be a high priority for the IC, including adequate ventilation and salvage operations.

Tactical Considerations

NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, since 1933 has served as a guide for fire departments who want to improve their tactical responses at buildings and facilities outfitted with these water-based fire protection systems. It provides a basic list of information that an IC should know, as well as specific steps that should be taken to increase the fire protection systems' effectiveness during a fire.

NFPA 13E prescribes an important responsibility for the fire department and IC:

> It is most important that each fire department responding to properties protected by automatic sprinkler systems have standard operating procedures [SOP's] developed for handling fires in sprinklered buildings. It is the duty of the officer in charge at the fire to see that these procedures are carried out as promptly and efficiently as possible.

Sample SOP's are provided in the supplementary readings section of this manual, and additional examples can be found on the World Wide Web using any search engine.

These are just some of the tactical considerations to be considered in SOP and fireground actions:

- An accurate sizeup of the seriousness of the situation can be hindered by low visibility from cooled smoke due to operating sprinklers.

  - Shutting the sprinkler system "off" prematurely to let the smoke clear may be disastrous as it is likely that the fire will continue to grow.

- The IC should provide a complete sizeup, establish the Incident Command System (ICS), broadcast the location of the Command Post (CP), and assess and request additional resources, if needed.

  - The IC should confirm that adequate communications are provided among all persons on the fireground, especially attack crews who may enter the building.

- The SOP or IC should arrange to have at least one engine (pumper) take prompt action to supply the sprinkler or standpipe system.

  - Where possible, at least one hoseline should be connected to the FDC and pumped according to fire conditions.

    -- For sprinklers, the system should be pumped at 150 psi at the FDC, unless the system is posted to pump at a different pressure.

    -- For standpipe systems, the pump operator should refer to the preincident to determine the pump pressure needed for the elevation of the fire, hose length, and nozzle configuration. Pump discharge pressures should not exceed 200 psi.

    --If manual hose streams are employed to supplement foam suppression systems, application rates and needed concentrate quantities should be planned before the incident.

  - If there are multiple FDC's for sprinklers or standpipes, all connections should be provided with hoselines.

    -- For standpipe systems, all FDC's should be charged.

    --Once all connections are made, the IC or Company Officer (CO) should confirm that water is flowing into the sprinkler system.

  - Main control valves (OS&Y, PIV, and WIV) should be checked to verify they are in the fully opened position.

    --If a valve is closed, the IC should be notified immediately, and the valve opened unless it is tagged "Closed for Repairs" or similar language.

    --Valves found closed should be reported to the fire investigator after the incident.

  - Sectional or floor control valves also should be checked to assure they are open as necessary.

- Assign a responsible person with a portable radio or two-way communication to the CP to stand by the main control valve(s).

  - These valve(s) should not be shut until the IC has confirmed the fire is extinguished, not just controlled.

- If all aboveground valves have been checked, and the water supply still does not appear to be reaching the fire protection system, check the status of roadway box valves to confirm they are fully open.

  - Roadway box valves may require the use of a special T-shaped wrench commonly called a "hydrant key."

- If the system is supplied or supplemented by a stationary fire pump, it should be checked to confirm is it operating.

  - Don't rely solely on the indicator lights on a fire alarm control panel to report the fire pump status.

  - If the fire pump is not operating, the IC should be notified immediately, and the pump started unless it is tagged "Out of Service for Repairs" or similar language.

  - If the pump fails to start or obviously is out of service, the fire pump bypass should be checked to verify all of its control valves are open.

  - If the pump is running, do not shut it off. Even if the fire engine takes over system supply by pumping into the FDC, it will not hurt the fire pump to operate at "churn," the condition where the pump is running but no water is flowing. If you are concerned about overheating the stationary fire pump, have someone slightly open a test header outlet to flow water.

- If possible, before extending handlines for control or suppression, identify and obtain a second water supply for pumping apparatus so as not to take water from the fire protection systems.

  - When attack crews proceed up stairways equipped with standpipe systems, they should check all hose outlet valves in lower floors to assure they are closed.

- The IC should evaluate the effectiveness of the water spray pattern on fire control and suppression efforts, and make strategic and tactical adjustments if necessary.

  - If an explosion or other major event has damaged the sprinkler system, or the fire obviously is overrunning the fire protection system, it may be advisable to close the main control valve to direct fire protection water to hose streams. However, this is not a preferred tactic unless all other tactics have failed.

- The IC should evaluate the likelihood the fire will spread beyond its current area, and take steps to protect exposures, including supplementing adjacent fire protection systems.

- The unit assigned to ventilation should be prepared to act as assigned, and have ventilation accomplished before hose teams enter the building.

- The unit assigned to property protection should be prepared to

  - Conduct basic salvage operations with protective tarps or covers.

  - Remove or protect products, machines, and merchandise that may be susceptible to water damage.

  - Evaluate fireground water runoff to assure no environmental damage is expected.

OPERATIONS USING STANDPIPE SYSTEMS

Training

Training personnel on proper procedures for connecting to, supplying, and fighting fire using standpipe systems is critical to effective fireground operations. Part of that training takes place during preplanning. Firefighters need to become familiar with the locations of all components that support standpipe operations including hydrants, FDC's, water supply valves, pumps, tanks, and hose connections.

Hose Packs

Fire officers need to confirm that the hose packs carried on their apparatus are of sufficient length to combat a fire on any floor served by the standpipe system. Hose packs will vary in length from 100 to 200 feet of hose, based on local practices. The size of hose may vary from 1-1/2 inches to 1-3/4 inches to 2-1/2 inches. Many jurisdictions carry a gated wye with their hose pack so that an additional line can be connected if deemed necessary. (If the hose outlet connection is in a cabinet, confirm that the gated wye will fit with adequate clearance around it so a second hoseline can be connected and the gate valve handle operated. Some fire agencies add a 6- to 8-foot piece of 2-1/2 inch hose to their hose packs so they can connect the 2-1/2 hose to the outlet and lay the gated wye on the floor.)

Hoseline Connections

Determining where the hoseline is to be connected should be done in advance of the fire. Most departments connect at the outlet on the landing just below the fire floor, and play the line down the stairs for advancement. This should be done before the line is charged. Fire officers must realize that connecting below the fire floor will necessitate additional hose to make up for the line left in the stairwell, so hose packs need to be set up with this in mind. It may very well mean adding an additional 50 feet of hose to have a line that will reach all portions of the floor.

In covered mall buildings, standpipe hose pack connections are to be located in exit hallways or corridors. This allows the connection to be made prior to firefighters' entering the fire area.

Highrise Standpipe Operations

The variables and complexities built into highrise buildings may be compounded by the fire location and fire load within the floor's tenant space. Due to this fact, pairing of engine companies should be considered. Companies operating in tandem will facilitate hose stretching and relief for personnel operating hoselines.

Many fires will be within easy reach of hose streams operating from the immediate stairway enclosure area. Other fires may require extending hoselines, using rolled-up lengths, and using personnel from more than one company in order to advance the first hoseline.

When firefighters are able to determine the particular section of a floor where the fire is located, they should attack the fire from the unburned side. The fire should be pushed toward the side that has already burned. Stretch a hoseline from the standpipe outlet on the floor below the fire.

Severe fire and heat conditions may stop the advance of a single handline. When two handlines operating from the same stairwell are necessary, the second line should hook up to the outlet on the fire floor.

When unable to determine the fire section on a floor, ascertain if the building has more than one standpipe riser. Buildings with two or more standpipe risers increase operational capabilities and provide additional security for operating forces and occupants. The initial commitment of engine companies in two separate standpipe-equipped stairwells will allow

- the engine company in the best position to commence aggressive fire attack;
- two handlines to be operated;
- increased stream coverage on the fire floor;
- prevention of the fire wrapping around the core;
- the ability to maintain the integrity of both stairwells (to protect companies operating above the fire);
- firefighters to assist occupants (if the assigned stairwell is an evacuation stair) and ensure that the stairwell door remains closed;
- increased fire attack options and flanking movements; and
- the availability of standby line (to attack fire extension on the floor above).

Coordination of handlines is critical if a two-pronged attack is necessary. Care must be taken to prevent an opposing or "dueling handline" scenario where each crew is working against the other. This situation is counter-productive and dangerous. **Operating lines must never oppose each other.**

The high pressure required to supply water to the upper floors of a highrise building limits the amount of water that a fire department pumper can supply. A good "rule of thumb" is to have a separate pumper supply the standpipe system for each handline in operation.

SUMMARY

Water-based fire protection systems are the predominant tool IC's can find in many buildings and structures to achieve successful fire control. The IC needs to know where sprinkler, standpipe, and fire pump systems are located, how they operate, and how they should be maintained to assure a high degree of reliability. This information should be part of the preplan for target hazards in the community.

The IC and others who may be called to respond to "protected" facilities must remember that just because a building has an automatic sprinkler system, there is no guarantee it will control or suppress the fire. Many factors influence the successful outcome of a fire in a sprinklered property; the fire department is there to assure the system performs as well as can be anticipated given the conditions found upon arrival and extent of automatic protection provided in the facility.

There are many additional sources of information and training on fire protection systems and equipment: local community college classes; manufacturers; insurance companies; Federal, State, and local training academies; and on the World Wide Web. A competent IC will learn all he or she can about water-based fire protection systems to be more efficient on the next incident that occurs in a building protected by automatic or manual systems.

Activity 6.1

Strategic and Tactical Considerations for Standpipe Systems

Purpose

To provide examples of strategic and tactical considerations for use under emergency conditions in buildings that contain this fire protection system.

Directions

1. You will be working in small groups.

2. Given the following control objectives, develop and write on an easel pad a short Standard Operating Guideline/Procedure (SOG/SOP) for standpipe use in a four-story college dormitory.

Control Objectives

1. Using the features of the Class I, II, and III standpipe systems, describe in the SOG/SOP how to:

   a. Contain the fire to the area or floor of origin.

   b. Provide for the safe evacuation of all building occupants.

2. Using the features of the Class I, II, and III standpipe systems, list in the SOG/SOP the basic water supply and alternative water supply sources, who will hook up to the exterior system connections, procedures for connecting hose to the interior standpipe outlets, and location where hookups will be made (e.g., floor below the fire floor, landing below the fire). You also should specify the equipment that needs to be taken into the building for firefighting purposes, such as packs, size of hose, or nozzle type, all of which will contribute to successful fire attack and extinguishment.

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Activity 6.2

Fire Protection System Impairments

Purpose

To identify obvious impairments to water-based fire protection systems, and to identify how those impairments may affect system performance.

Directions

1. You will be shown slides of 20 impairments to fire protection systems.

2. On the Worksheet, next to the number of each slide, write the impairment shown and, in the next column, briefly describe how it may affect the system performance.

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Activity 6.2 (cont'd)

Fire Protection System Impairments Worksheet

Slide	Impairment	Potential Effect
6-133		
6-134		
6-135		
6-136		
6-137		
6-138		
6-139		
6-140		
6-141		
6-142		
6-143		
6-144		
6-145		
6-146		
6-147		
6-148		
6-149		
6-150		
6-151		
6-152		

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Activity 6.3

Alternative Solutions to Deal with System Impairments

Purpose

To plan alternate solutions when fire protection systems are out of order.

Directions

1. Read the following scenario and work together for 10 minutes to identify one or more solutions to the problem.

2. You should select a member from your group to report your findings and recommendations.

Scenario

The local auto assembly plant, your community's biggest employer, is a 1,600,000 square feet noncombustible, fully sprinklered building. The site is surrounded by a private 8-inch water main that supplies yard hydrants and sprinkler systems. The municipal water supply is a 12-inch looped main, with 1,400 feet of a 10-inch pipe connecting the two. The building is protected by two diesel-driven fire pumps, each capable of delivering 2,500 gpm at 150 psi. There is no onsite water storage capacity. There is a municipal fire hydrant on the 12-inch line at the connection to the 10-inch. Domestic/Sanitary service is on a separate supply.

In addition to automobile assembly, the plant operates a continuous automobile paint spray operation, a conveyor system for dipping frames in heated combustible liquid undercoating, welding and cutting operations, and industrial drying ovens that emit flammable vapors.

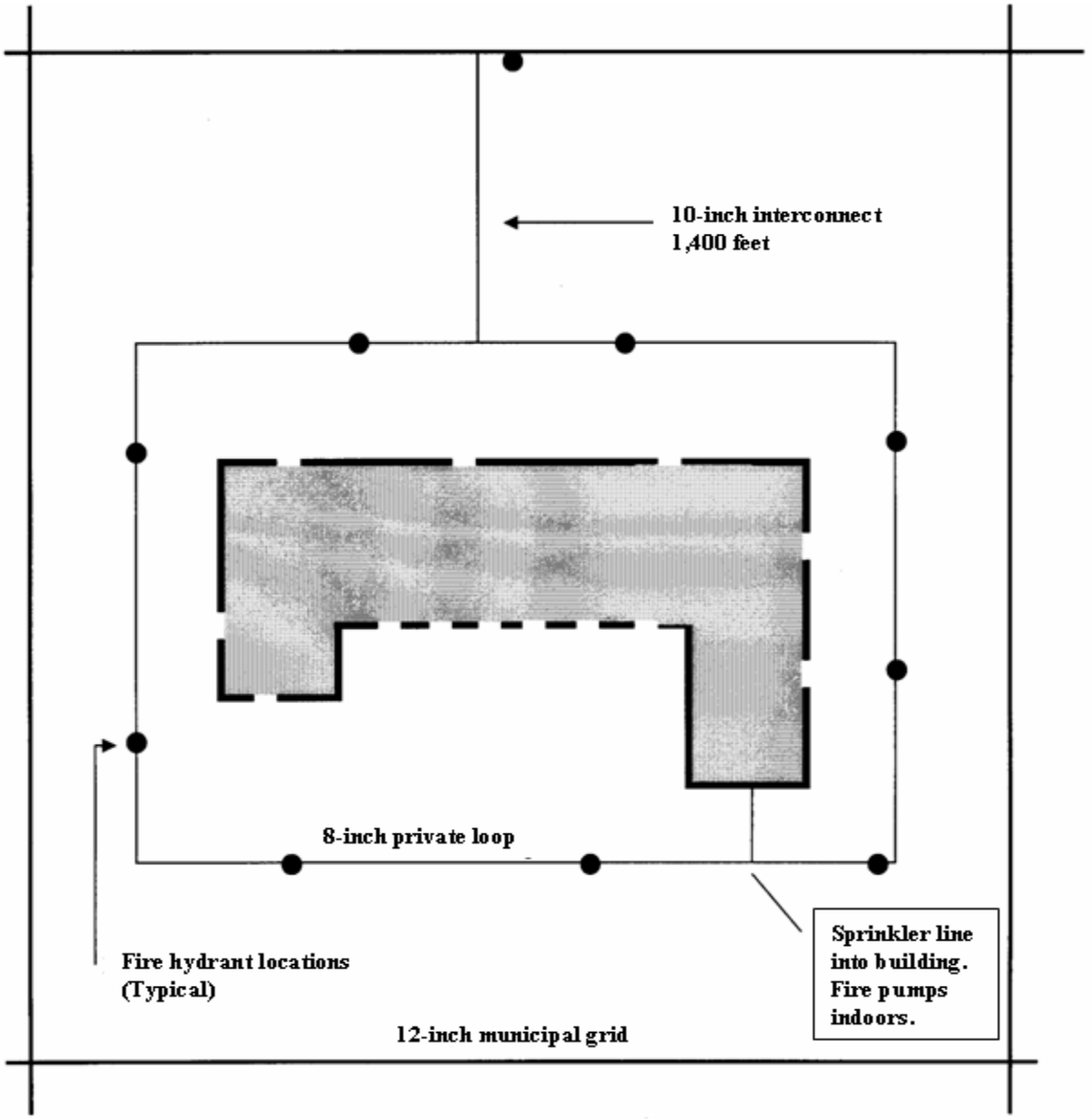
The water purveyor has demanded that a backflow prevention device be installed to isolate the public water supply from the private service. The work is estimated to take 7 hours during which the plant will be without fire protection. Freezing conditions are not an issue. The city manager has given you the responsibility to ensure the plant remains operational and the fire protection is uninterrupted. Employing only "fire watches" is not acceptable to the plant's risk management or to the city manager.

As IC, what are your principal objectives, strategies, and tactics to keep the plant fully operational with no acceptable losses in this scenario?

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Activity 6.3 (cont'd)

Plot Plan



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Activity 6.4

Unplanned Impairments

Purpose

To develop strategies and tactics to handle an emergency when there is a catastrophic failure of a fire protection system.

Directions

1. Read the following scenario and work together to identify one or more solutions to the unplanned impairment.

2. You should select a member from your group to report your findings and recommendations.

Scenario

You are notified of a water flow alarm at Hangar No. 4 at the airport. As you and your crew (one driver and one firefighter) are getting on the apparatus to leave the station, dispatch informs you it has received several telephone reports of a large fire inside a Boeing 737-100 that is in the hangar for repairs. You are the Incident Commander (IC). Dispatch has upgraded the alarm assignment from a single company to a full first-alarm assignment of three additional engines, two ladder trucks, the air unit, and the district chief. The airport aircraft rescue and firefighting apparatus is out of service for repairs following failure of its annual pump test.

You recently conducted a walkthrough of the hangar and know that the 450,000 square feet noncombustible building is protected by twelve 8-inch dry pipe sprinkler risers connected to a single 12-inch manifold. Each riser has an exterior WIV. The site is served by fire hydrants on all four corners of the building, and the tested fire flow is 5,200 gpm. There is an exposure to the south that consists of a bulk fuel farm containing aircraft fuel.

As you arrive, you notice a tug operator has tried to pull the aircraft through the hangar doors, but the opening is not wide enough to accommodate the wings. There is a large volume of water flowing out the hangar doors, and the rear of the aircraft is well involved.

The tug operator tells you that when she tried to move the aircraft, the port side wing collided with one of the dry pipe risers and broke it off about 20 feet above the floor. She said there is a "geyser" of water shooting toward the hangar's steel truss roof. The aircraft wing is leaking fuel, and the aircraft nose is protruding outside the hangar door. You know from training that the 737 is capable of holding up to 7,000 gallons of fuel.

Due to the thick black smoke that has accumulated at the ceiling, you cannot determine visually if other sprinkler systems are operating. All building occupants have escaped and are accounted for.

As IC, what are your incident strategies and tactics to minimize property loss in this scenario?

Activity 6.4 (cont'd)

Quick Access Prefire Plan

Building Address:
Hangar No. 4 off Runway 27R

Building Description:
300' x 1,500' foot aircraft storage and repair hanger; lightweight steel walls with glass panels

Roof Construction:
Open web steel truss; height to roof deck: 115'

Floor Construction:
Concrete slab, smooth finish

Occupancy Type:	**Initial Resources Required:**
Airplane storage and repair hangar	*ARFF-1; E-1, -3, and -9; T-1 and -2; Air One; Chief 3*

Hazards to Personnel:
Lightweight steel construction, combustible metals, flammable liquids, rotating jet engines

Location of Water Supply:	**Available Flow:**
Hydrants on all sides of the building	*5,200 gpm*

	Estimated Fire Flow			
Level of Involvement	*25%*	*50%*	*75%*	*100%*
Estimated Fire Flow	1,000	2,000	3,000	4,000

Fire Behavior Prediction:
Wide open area, no firewalls, may spread from building to aircraft or vice versa

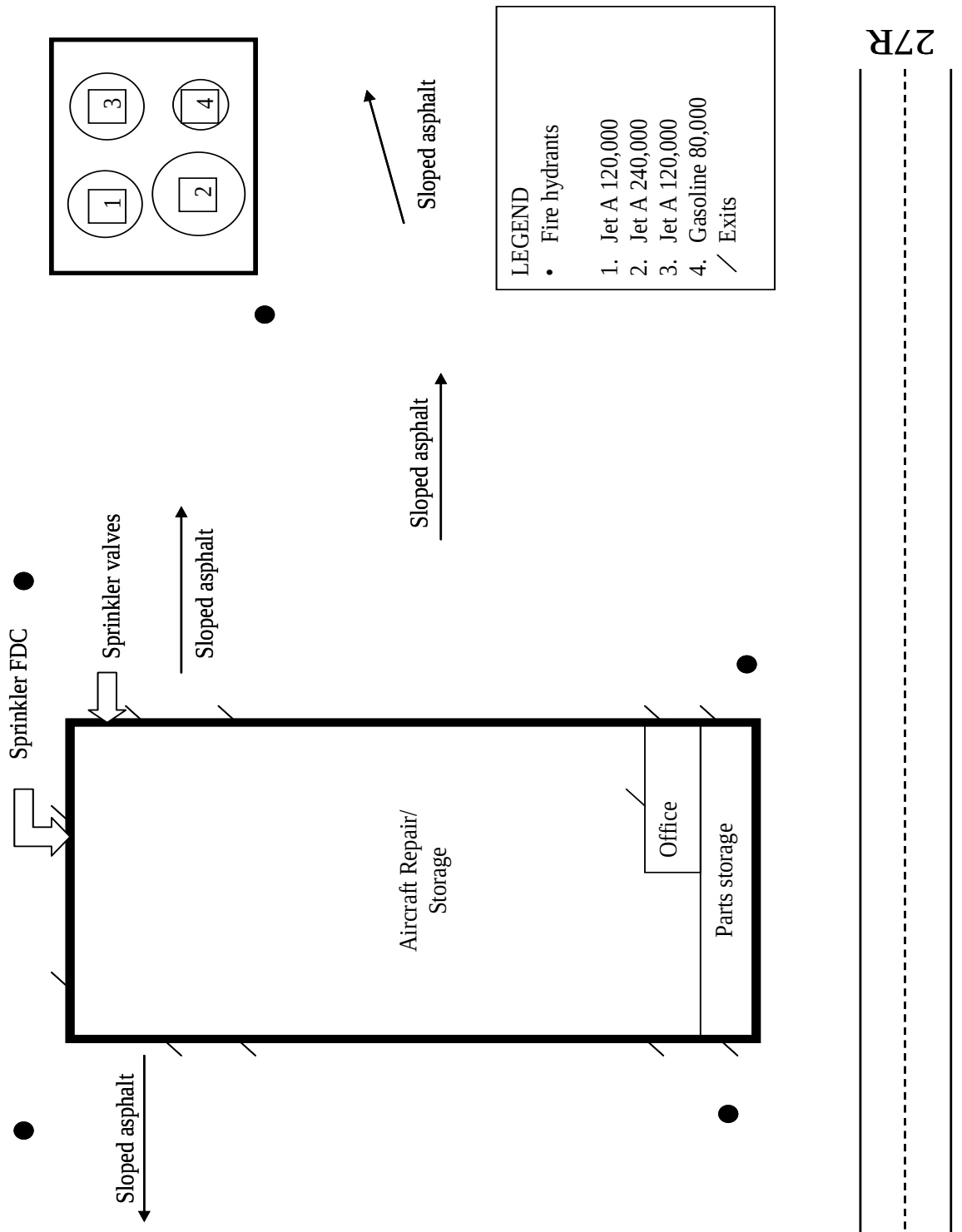
Predicted Strategies:
Exposure protection, confine and extinguish, prevent environmental damage

Problems Anticipated:
Flammable liquids drainage toward tank farm, combustible metals, welding gas cylinders

☐ **Standpipe:**	☒ **Sprinklers:**	☐ **Fire Detection:**

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Activity 6.4 (cont'd)



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Activity 6.5

Strategic and Tactical Considerations for Water-Based Fire Protection Systems

Purpose

To employ water-based fire protection systems and equipment to achieve incident objectives, and to describe the strategy and tactics used to achieve those objectives.

Directions

1. Working in table groups, review the following scenario. After you have read the scenario, you will be shown a single photograph of the incident.

2. Identify and describe your incident objectives, explain your strategy to achieve those objectives, and describe the tactics you would employ to achieve successful results.

3. List your group's findings on an easel pad, and select a spokesperson from the group to report your recommendations.

Scenario

Your historic downtown has undergone substantial renovation and rehabilitation in the last few years. Buildings that sat abandoned for many years are being brought back life as chic nightspots, restaurants, boutiques, and condominiums.

Many of these buildings were erected in the late 1800's and early 1900's. Most are ordinary construction with unreinforced masonry, but the structural frames have been evaluated and enhanced for seismic protection. There are common basements shared among the buildings, and the basements extend about 4 feet under the public sidewalk.

Your jurisdiction had the foresight to adopt an aggressive building rehabilitation code, so all of these structures are outfitted with automatic sprinklers and, if they are more than three stories, standpipes for fire department use. Due to your community's level terrain, all water-based fire protection systems need booster pumps to enhance water pressure.

You are a battalion chief running errands between stations one afternoon when you encounter the situation shown in the slide. Your first-due companies are 3 to 5 minutes away.

As IC, you must

1. Describe your objectives.

2. Explain your strategy to accomplish your objectives.

3. Describe your tactics and make assignments to responding units.

4. Identify which built-in water-based fire protection systems you would employ to aid your efforts, and how you would employ them.

Activity 6.5 (cont'd)

Quick Access Prefire Plan

Building Address:
14 East Adams Street

Building Description:
Three-story mixed use, ordinary construction

Roof Construction:
Heavy-timber with built-up asphalt roof

Floor Construction:
Heavy timber with plank deck

Occupancy Type:	**Initial Resources Required:**
Lunch room and condos	*2 E, 1 T, 1 BC, 1 Tender*

Hazards to Personnel:

Location of Water Supply:	**Available Flow:**
Hydrant at 1st and Adams	*3,000 gpm*

	Estimated Fire Flow			
Level of Involvement	*25%*	*50%*	*75%*	*100%*
Estimated Fire Flow	500	1,000	1,500	2,000

Fire Behavior Prediction:
Old, ordinary construction, open stair from first to third floors

Predicted Strategies:
Evacuate occupants, supply sprinklers, call for help

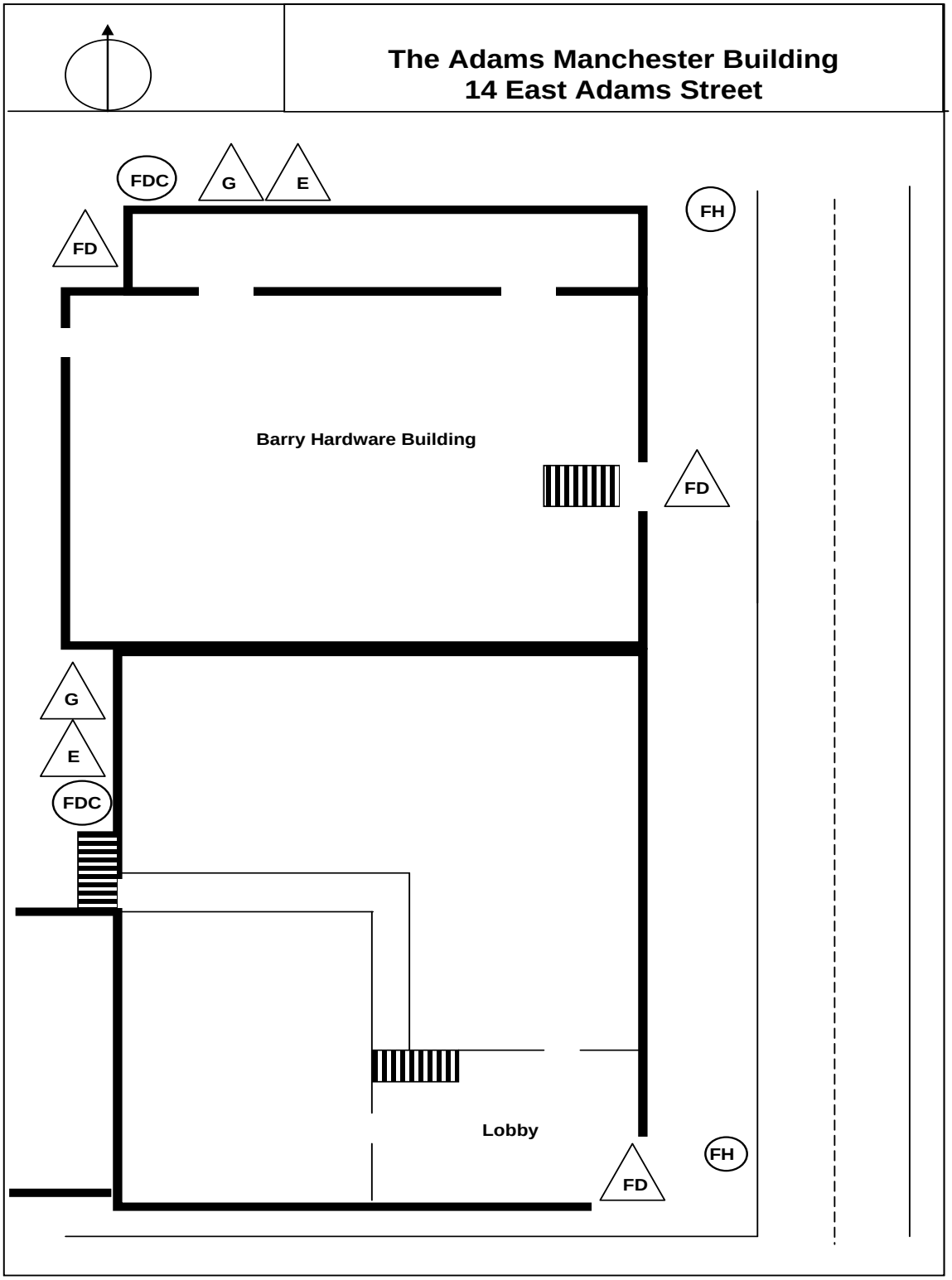
Problems Anticipated:

☐ **Standpipe:**	☒ **Sprinklers:**	☒ **Fire Detection:**
None	*Full*	*Water flow only*

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Activity 6.5 (cont'd)

Plot Plan



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APPENDIX A

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Job Aid 6.1

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 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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Job Aid 6.1 (cont'd)

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 6.2

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.

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Job Aid 6.2 (cont'd)

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.

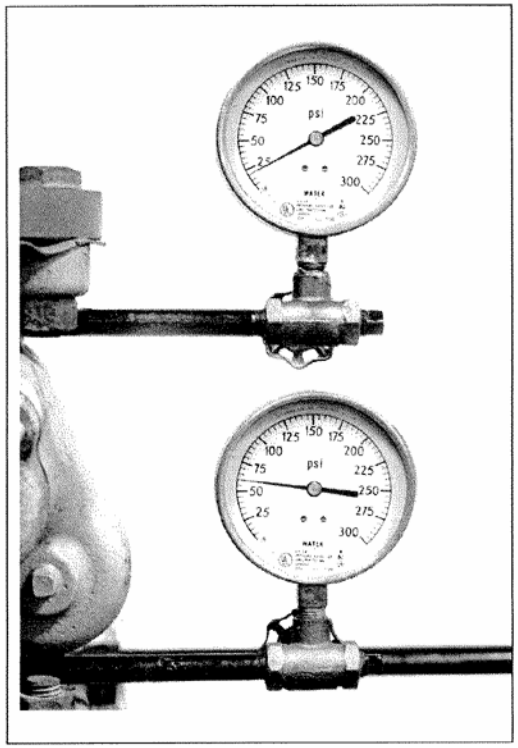
Since water is (for all practical purposes) incompressible, the excess pressure from the surge must be transferred somewhere on the system side. In this case, it appears on the system side gauge.

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.

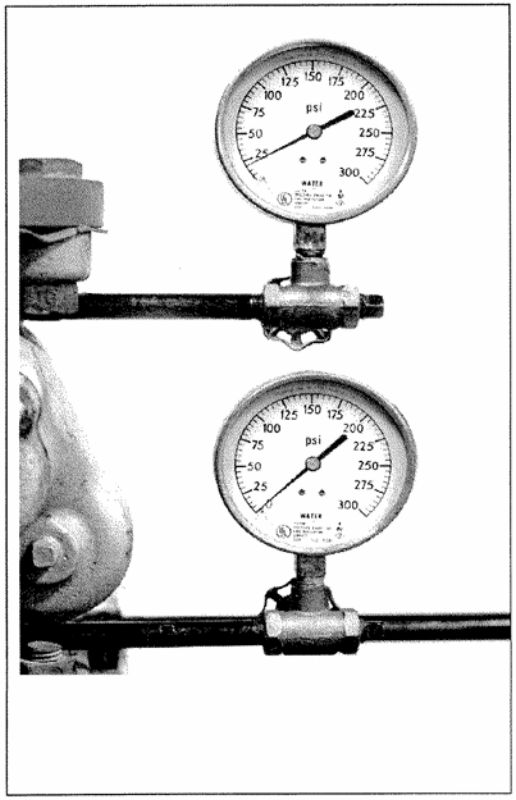
This is a serious condition that needs immediate technical service because this sprinkler system is inoperable. Even if a sprinkler would fuse from a fire, or be broken off due to mechanical damage, the slight amount of pressure on the system side (20 psi) probably would not control a fire.

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.

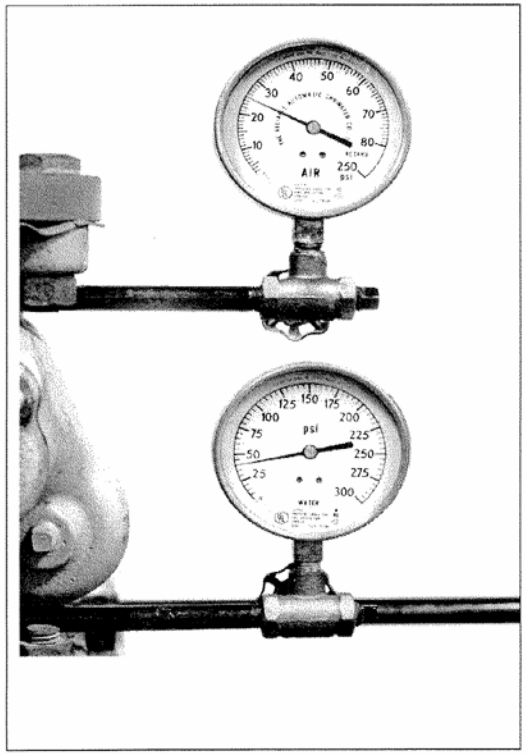
This is a serious condition that needs immediate technical service because this sprinkler system is inoperable. The "fix" may be as simple as checking all the supply control valves to assure they are fully open.

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.

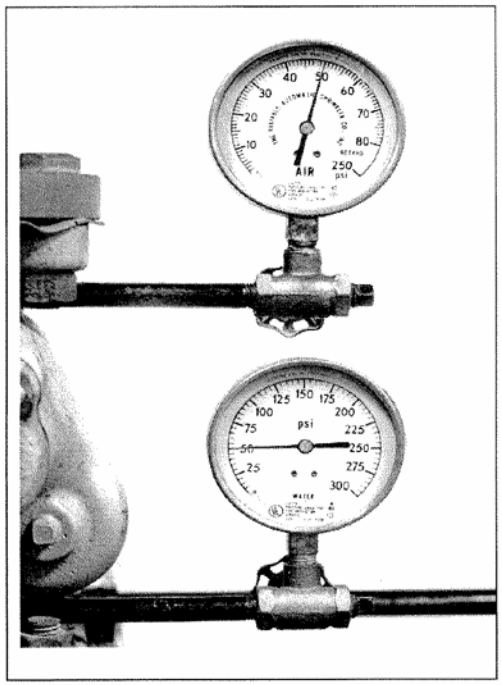
Usually, this amounts to an additional 10 to 20 psi over the amount needed to restrain the d pipe valve.

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.

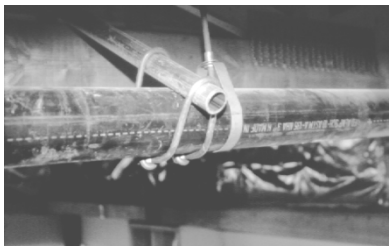
Job Aid 6.3

Common Fire Sprinkler System Components

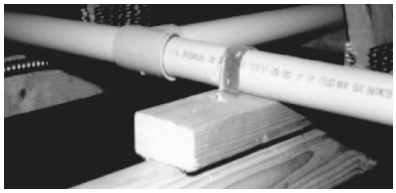
Automatic sprinkler systems are an interconnected network of valves, fittings, and sprinklers that, at first glance, can be confusing. Job Aid 6.3 provides a sample of some common components that the IC may see in the field. Remember, designs and components will vary by manufacturer and age of the equipment.

Sprinkler Piping

In most commercial applications, fire sprinkler piping will be made of steel, although in some circumstances (particularly residential and light hazard occupancies) plastic or copper tube may be used.



Black iron or steel



Listed plastic tube



Type K, L, M copper

Valves

Valves controlling water supplies must be "indicating" valves. Valves for drains, gauges, and testing apparatus can be "nonindicating."

Indicating Valves



Outside Stem and Yoke with Tamper and Chain



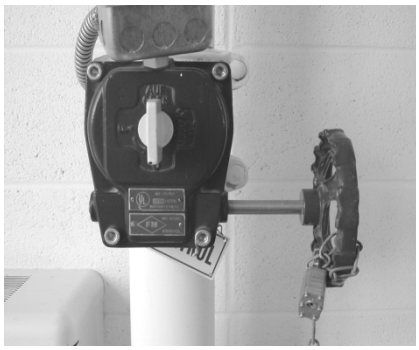
Post Indicator Valve



Wall Indicator Valve with Tamper and Seals

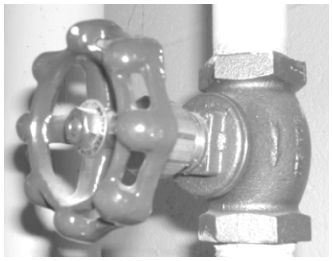


Quarter-Turn

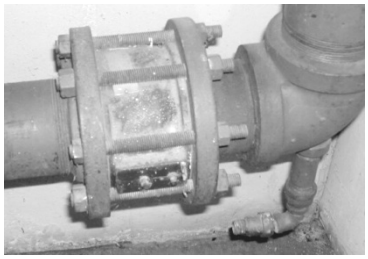


Butterfly

Nonindicating Valves



Globe or Ball



In-line Check



Spring-loaded Check

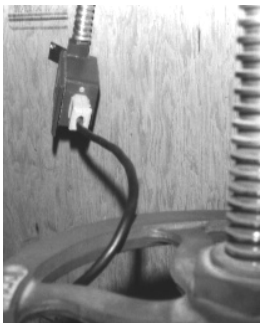


Gate or Roadway Box

Tamper Switches

Tamper switches are supervisory devices intended to notify a responsible person that one or more control valves is closed. The fire department normally is not notified automatically when a tamper switch is activated. It is up to the property owner or operator to investigate the cause of the tamper alarm and seek corrective action.

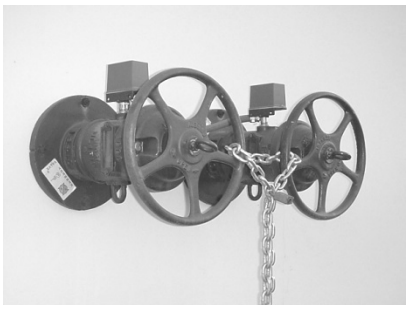
Tamper Switches



Low voltage cable



Valve seals



Heavy-duty chain

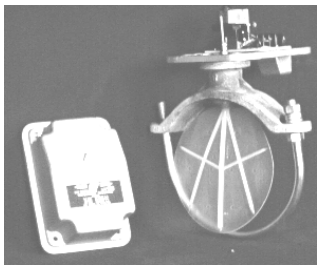


Electronic tamper switch

Flow Switches and Alarms

Water flow switches and alarms are designed to report water flow, and thus signal either a fire-caused sprinkler operation or water flow from damaged pipes. Water flow alarms should be treated as emergency responses until confirmed otherwise.

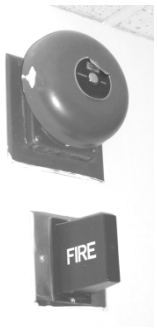
Flow Switches/Alarms



Paddle-style flow switch



Water motor gong



Electric bell

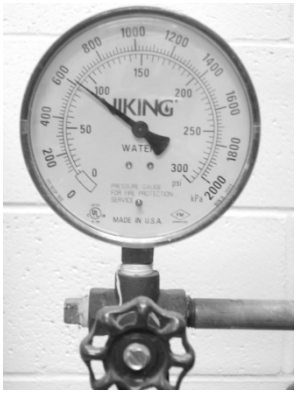
Pressure Gauges

Pressure gauges are used to visually monitor a variety of conditions on a sprinkler system:

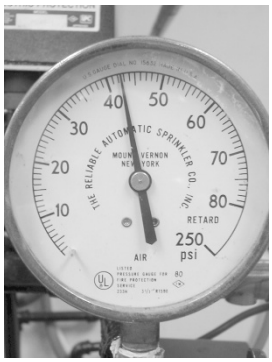
- water flow;
- air pressure on dry pipe systems;
- water pressure on supply and system side of valves;
- suction and discharge pressure on fire pumps; and
- air and operating pressures on accelerators and exhaustors.

Firefighters should take care to read the gauges carefully; some indicate water pressure only, some are for air pressure only, and some gauges are listed to measure water or air pressure. The gauge should be labeled on its face to identify what it is measuring.

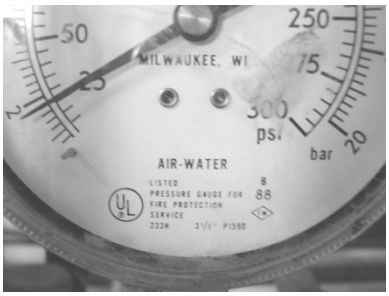
Air/Water Gauges



Water pressure gauge



Air pressure gauge



Combination Air/Water

Quick-Opening Devices

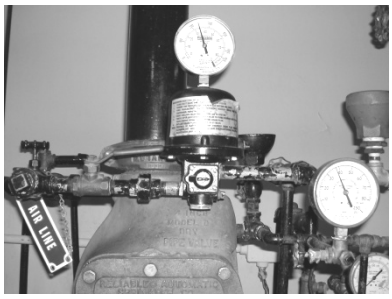
Quick-opening devices are used on dry pipe systems to shorten the amount of time it takes to get water from the main control valve to the remote part of the sprinkler system.

Accelerators operate by transferring air that was stored in the sprinkler piping to the intermediate chamber of the dry pipe valve, thus accelerating its opening.

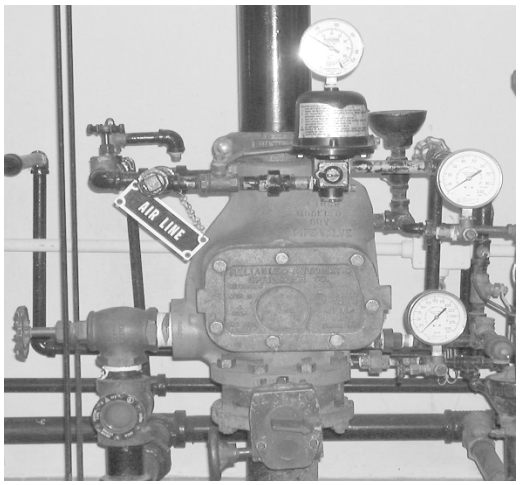
Exhaustors discharge the air that was stored in the sprinkler piping to the main drain, thus releasing the air to the atmosphere to assist the opening of the valve.

In extreme cases, an accelerator and exhaustor may be used in combination to speed water flow to a large sprinkler system.

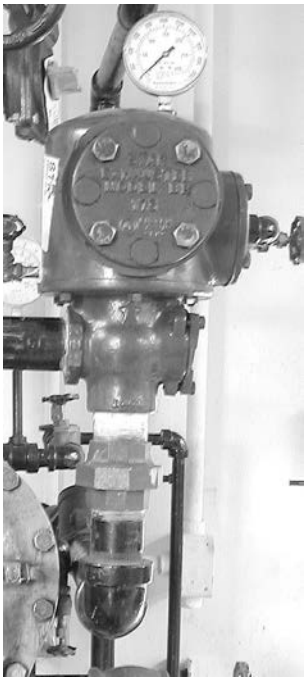
Quick-Opening Devices



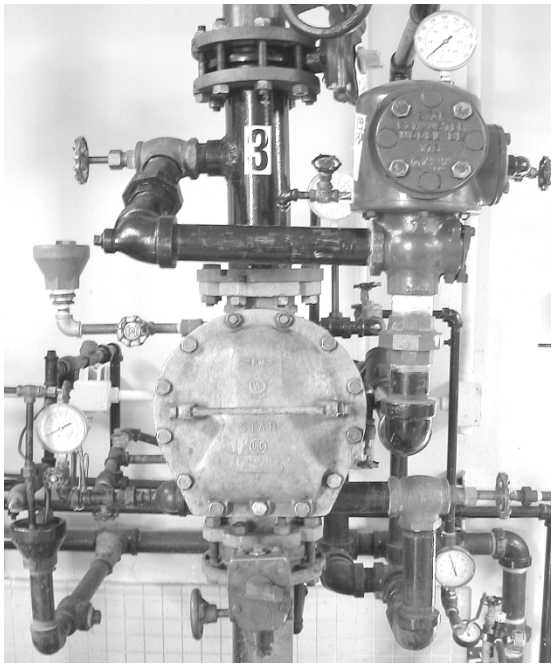
Accelerator



Accelerator on Dry Pipe Riser



Exhaustor



Exhaustor on Dry Pipe Valve

Compressors

Air compressors are needed to maintain air pressure on dry pipe systems (unless they use stored nitrogen) to hold the dry pipe valve closed until a sprinkler opens. Compressors may be mounted on the wall, the floor, or on the dry pipe riser itself. Compressors must be capable of refilling the entire dry pipe system within 30 minutes.

Compressors



Riser-mounted compressor



Floor-mounted compressor

Job Aid 6.4

Sample Sprinkler Operation Performance Report

An essential part of any successful fire event is the postincident analysis, often called a "post-fire critique" or "debriefing." The lessons learned from fire department performance can be translated into action for training, changes in operations, building and fire code improvements, and modernization of fire protection equipment.

In order for that information to be useful, it must be captured in a meaningful way for evaluation. The sample "Sprinkler Operation Performance Report" on the following page can be a tool for the IC to collect information from incidents where a sprinkler system is involved.

This information should be attached to the incident report (National Fire Incident Reporting System (NFIRS) Version 5.0), and routed to the members of the organization who can use it in their areas of expertise. This may include the Training Division and Fire Prevention Bureau, among others. Fire insurance loss control personnel also have an interest in this information.

A note on the report section marked "Hydraulic Design":

Most sprinkler systems installed since the late 1970's employ something called hydraulic calculations or hydraulic design for matching the sprinkler system to the fire risk. These systems should have a hydraulic nameplate attached somewhere on the riser (see photograph next page) that gives design information. If the nameplate exists, that information can be transferred to this report.

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Job Aid 6.4 (cont'd)

Typical Hydraulic Nameplate



Building address

Total number of building sprinklers

Density, expressed in *tenths of gpm*, such as 0.10 or 0.25.

Area of application, also known as the *remote area* or *design area*, expressed in square feet. Usually not less than 1500 nor more than 4000 sq. ft.

System demand, the minimum amount of water in gpm needed to adequately supply the *remote area.*

System design pressure, the minimum water pressure in pounds per square inch needed to adequately operate sprinklers in the *remote area.*

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Job Aid 6.4 (cont'd)

Sprinkler Operation Performance Report	
Date:	**Time:**
Address:	
Occupancy:	

Type of sprinkler system: **[ ] Wet pipe [ ] Deluge** **[ ] Dry pipe [ ] Foam:Water** **[ ] Pre-action [ ] Other**	**Hydraulic Design (if any):** **._____ gpm at _____ sq. ft.**
Location of operating sprinklers:	**Number of operating sprinklers:**
Result of sprinkler operation: **[ ] Fire suppressed** **] Fire controlled, manual suppression needed** **[ ] Fire not controlled** **[ ] Life safety system only**	**Reasons for unsatisfactory performance:**
Did private water supply operate satisfactorily? **[ ] Yes** **[ ] No** **[ ] Not applicable**	**If not, why?**
Main control valve status: **[ ] Fully open** **[ ] Partially open** **[ ] Closed**	**Who was assigned to check control valve status?**
Did fire department connect to fire department connection? **[ ] Yes** **[ ] No**	**Engine/Pumper company number or name:**
If not, why?	
Was water pumped into system? **[ ] Yes** **[ ] No**	**Number of hoselines used:**
Was main control valve closed after fire? **[ ] Yes** **[ ] No**	**Who ordered it closed?**
Number of sprinklers replaced by fire department:	
Type of sprinklers replaced by fire department:	
Was sprinkler service fully restored? **[ ] Yes** **[ ] No**	**By whom?**
Actions taken to restore service:	

Was management representative notified? **[ ] Yes** **[ ] No**	**By whom?**
What went well?	
Where could improvements be made?	
Comments:	

Reported by _____

Job Aid 6.5

Sprinkler/Standpipe Status Survey

Occupancy: _____ Date: _____

Address: _____ Contact person: _____

Instructions

Visually inspect each location, component, or element described in this checklist. Place a check mark in the box "OK" or "Not OK" depending upon your findings. Upon completion of this report, transfer information regarding any noted impairs to your Quick Look Plan, notify the owner/occupant of any impairments, and route a copy of the report to the Fire Prevention Bureau.

Building Exterior

OK	Not OK	N/A	ITEM
			FDC is visible.
			FDC shows no damage/obstructions.
			FDC threads match company hoselines.
			FDC caps and plugs in place.
			FDC check valve is operational.
			PIV or WIV is visible.
			PIV or WIV is secure (chain/lock/tamper switch).
			PIV or WIV is open.

Building Interior

OK	Not OK	N/A	ITEM
			Main control valve is accessible.
			Main control valve is open and secured.
			Pressure gauges indicate water pressure on system.
			Spare sprinklers and wrench are in cabinet.
			System shows current service/inspection tag (≤1 year).
			Sectional control valves open and secure.
			Storage/operations unchanged since last visit.
			Storage at least 18 inches below sprinklers.
			Standpipe hose outlets accessible/threads okay.

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Job Aid 6.6

Manual Standpipe System Hose Outlet Calculations

Manual standpipe systems for fire department use are not connected to a water supply. They require water from a fire department pumping apparatus to supply the system demand.

It is imperative that for manual systems the necessary pump discharge pressure calculations are made prior to a fire to obtain effective flows at the point of discharge. These calculations should be recorded on the preincident plan. The worksheet in Job Aid 6.6 enables the fire department to maintain a record of those recommended pump discharge pressures.

When calculating the pressure for the nozzles listed in the Job Aid, do not forget:

- the estimated hose size and length between the pumping apparatus and the FDC;
- the estimated friction loss due to the fire department connection;
- the estimated fire attack hose size and type connected to the hose outlet; and
- the estimated friction loss due to fittings or appliances attached at the hose outlet (e.g., gated wye).

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Job Aid 6.6 (cont'd)

Address: _____ Date: _____ Preplan # _____

Facility/Building Name: _____

Standpipe Riser Location: _____

House Outlet Location: _____

Calculations based on hose size and type:

[ ] 1-/2-inch unlined [ ] 1-1/2-inch lined [ ] 1-3/4-inch lined [ ] 2-1/2-inch lined

[ ] Other: _____

Recommended Pump Discharge Pressure

	Smooth Bore Nozzle			Variable Tip Nozzle		
Floor	100 ft.	150 ft.	200 ft.	100 ft.	150 ft.	200 ft.

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APPENDIX B

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Myth	Fact
"Water damage from a sprinkler system will be more extensive than fire damage."	Water damage from a sprinkler system will be much less severe than the damage caused by water from firefighting hose-lines or smoke and fire damage if the fire goes unabated. Quick response sprinklers release 8 to 24 gallons of water per minute compared to 50 to 125 gallons per minute released by a firehose. Sprinklers are highly reliable devices that are activated by heat. They will only go off if there is a fire which increases the heat beyond the sprinkler trigger point (typically 135 to 165 °F (57.2 to 73.9 °C)). Preaction systems employ additional safety features. Research has demonstrated that only 1 in 16 million heads ever activates by accident. Sprinkler systems can be connected to an alarm monitoring company or an external alarm that will notify neighbors or passersby of a water flow. This will facilitate the prompt notification of the fire department and will minimize that amount of water damage.
"When a fire occurs, every sprinkler head goes off."	Sprinkler heads are individually activated by fire. Residential fires are usually controlled with one sprinkler head, and 90 percent of all fires are controlled with six or fewer heads. A study conducted in Australia and New Zealand covering 82 years of automatic sprinkler use found that 82 percent of the fires that occurred were controlled by two or fewer sprinklers.
"Sprinklers steal water from the fire department hoselines."	A properly designed sprinkler system (for commercial structures) includes water supplies for the system **and** fire department hose streams.

Myth	Fact
"A smoke detector provides enough protection."	Smoke detectors save lives by providing a warning system but can do nothing to extinguish a growing fire or protect those physically unable to escape on their own, such as the elderly or small children. Too often, battery-operated smoke detectors fail to function because the batteries are dead or have been removed. As the percent of homes in America that were "protected" with smoke detectors increased from zero to more than 70 percent, the number of fire deaths in homes did not significantly decrease.
"Sprinklers are designed to protect property, but are not effective for life safety."	Sprinklers provide a high level of life safety. Statistics demonstrate that there has never been any multiple loss of life in a fully sprinklered building. Property losses are 85 percent less in residences with fire sprinklers compared to those without sprinklers. The combination of automatic sprinklers and early warning systems in all buildings and residences could reduce overall injuries, loss of life, and property damage by at least 50 percent.
"The added cost of sprinklers will make housing unaffordable to first-time buyers."	A sprinkler system costs one to two percent of the total construction costs. The cost of a sprinkler system is comparable to what many people pay for carpet upgrades, a paving stone driveway, or a whirlpool bath. In many U.S. communities where sprinkler systems are available, consumers are requesting this feature and houses with sprinkler systems are selling faster than those without.

Myth	Fact
"It is unfair to target new construction because new buildings are safer than older buildings."	There are more fires in older buildings because older buildings comprise a larger portion of the country's structural inventory. There are more deaths and injuries in older dwellings because demographically identifiable groups who are more susceptible to fire, such as the elderly and people of low socioeconomic status, tend to live in older homes. Modern construction techniques such as webbed truss construction, vented soffits, and human-made composite materials, make newer houses far more susceptible to serious damage from fire. New structures built today will be older structures tomorrow; it makes sense to start now and use the technology that is available in order to build safer communities. Fire is the leading threat to seriously damage or destroy structures; earthquakes, flooding, and other natural disasters lag far behind.
"Sprinklers are ugly, I don't want them in my space."	Residential and commercial sprinkler heads come in a variety of unobtrusive styles and models and in designer colors. Some can be mounted flush with the ceiling line, and concealed behind protective covers.
"Sprinkler systems are not practical in cold climates, the pipes will freeze and cause water damage."	In commercial applications, dry pipe and preaction sprinklers provide an alternative to water-filled pipes. Anchorage, Alaska, has had a residential sprinkler ordinance in place for more than 10 years and residents have not experienced a single sprinkler system freeze-up.

Myth	Fact
	Specially molded insulation is available to ensure that piping in unheated attics is properly insulated and protected from freezing. A variety of sidewall sprinkler heads are available. Sidewall sprinkler piping is placed in the interior walls to prevent exposure to cold attics, and eliminating the concern for freezing. Residential sprinkler systems use plastic and copper piping similar to that used for domestic water systems. If the heat in a house drops to a level where the sprinkler system will freeze, it is likely that the domestic system will also freeze. There is no unique danger of freezing with sprinkler systems that does not already exist with domestic water systems.
"Smoke alarms set fire sprinklers off."	Fire sprinklers and smoke alarm systems are designed to activate according to different conditions. Sprinkler heads are individually heat activated, usually at 165 °F. Smoke alarms, when activated, give only an audible warning sound; they do not cause fire sprinklers to flow water. In commercial applications where flooding volumes are needed to control hazardous areas, preaction and deluge systems may use smoke detection for early notification and operation.
"Smoke alarms will put the fire out!"	This is a dangerous and misleading statement that is many times made on the basis that smoke alarms will alert the occupants who will then get a fire extinguisher to put out the fire.

Myth	Fact
	Untrained persons should only use fire extinguishers to fight small incipient fires. The number-one priority when you hear a smoke alarm or a fire alarm is to get everyone out of the building.
"Fire sprinkler systems are not reliable."	Laboratory testing and a 50-year installation/ activation history clearly shows that fire sprinkler systems exceed a 95 percent "fail-safe" status.
"Property will have to pay an expensive yearly testing fee."	Like any piece of mechanical equipment, sprinkler systems must be inspected, tested, and maintained to ensure a high degree of reliability. No one would buy a car and then never bother to change the oil, tires, or get a tune-up. Testing fees will be directly related to the market demand.
"Insurance costs will go up due to fire sprinkler system ruptures and leaks."	Consider these facts: a) Sprinkler head failure rate is one in 16 million. b) Domestic plumbing ruptures and leaks are over a 1000 to 1 ratio compared to sprinkler system ruptures and leaks. c) If an insurance company wants to place a surcharge on your policy because you have a sprinkler system, there are other insurance companies that value the reliability and effectiveness of fire sprinkler systems and will reduce your policy premiums if you have fire sprinkler protection, especially in rural or "unprotected areas" in our country. d) Some insurance companies are the leading advocates for fire sprinkler systems to protect the risks they must underwrite.

Myth	Fact
"Fire sprinkler systems cause taxes to go up."	Not when local government practices fiscal diligence. While the overall **property value** increases in sprinklered buildings, the fire protection costs may go down, especially in communities that can maximize all the benefits afforded by using fire sprinkler protection. Reductions in water service sizes, hydrant spacing, fire service costs, and damage repair can be reduced. Some progressive local governments offer tax incentives to encourage homeowners to install fire sprinkler systems in their dwellings.
"People will install fire sprinkler systems on a non-mandatory basis."	A 200-year history clearly shows that safety equipment and safety systems are rarely installed when left to good intentions. Getting fire sprinklers installed in a community so that all of the "trade-up" advantages can be maximized usually requires mandated legislation or local ordinances. A spotty, hit-and-miss application of fire sprinkler system installation is not the most cost-effective way of achieving all of the benefits afforded from fire sprinklers. From a life safety, property conservation point of view, there will be no significant change in these horrendous statistics until fire sprinklers are required by law to protect those who cannot adequately protect themselves.

APPENDIX C

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LOS ANGELES CITY FIRE DEPARTMENT
Training Bulletin #12

J.C. GERARD, Chief Engineer and General Manager

10-69

TRAINING BULLETIN #12
AUTOMATIC SPRINKLER SYSTEMS

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"The automatic sprinkler is by far the most important of all fire protection devices". . . . . NFPA.

Early detection of fire and effective application of the available water supply are fundamental to minimizing most fire losses. A very reliable method of obtaining this detection and application is a properly installed and maintained automatic sprinkler system. Records show that 96% of all fires in sprinklered buildings are extinguished or satisfactorily held in check by the sprinkler system.

There have, however, been fires in which large losses have occurred because fire departments did not effectively utilize this valuable fire fighting tool. It is for this reason that companies "shall hook up and pump into sprinkler systems as soon as the need is evident." (Manual of Operations, Article 20. A visible fire in a sprinkler-protected building should be sufficient evidence to require this action. NBFU Bulletin No. 270 suggests that "one of the first fire alarm engine companies responding….. should lay two 2 ½ " lines into the fire department connection." Pump operators should then deliver 100 p.s.i. to the inlet if no fire is showing. If it is obvious that a fire is in progress and a number of heads have opened, pump pressure should be increased to 150 p.s.i.

Officers must be thoroughly familiar with the arrangement of sprinklers and other private fire protection. They must know the amount of water available so that unwise use of hose lines will not take water away from sprinkler systems. (This can only be determined by pre-fire inspection.) Even using a strong city main. Normally, one and one-half inch lines are sufficient in sprinklered buildings.

In order to properly utilize the potential of sprinklers in the area, it is suggested that companies maintain a list of sprinklered buildings in their district. (This information can be obtained from the F-316s, which are filed behind the F-173s in the company files. Pre-fire planning drills should be held with this list as a basis, utilizing sketches and "on-the-scene" inspections to reaffirm the location of fire department connections and control valves. Threads and caps should be checked at this time to see that they are in good working order and that valves are <u>turned on.</u>

Extreme caution must be exercised by officers when ordering systems turned off after a fire. A shut off should be made only after a thorough check reveals that the fire is out. The amount of water discharged by sprinklers is small compared to that from hose streams which may be needed in case of a rekindle. The fireman who is ordered to close the control valve must remain at the valve, so that it can be reopened without delay if needed. He should remain there until the system is put back into service. There is grave danger of prematurely shutting down the system even though hose lines have been laid. Officers must also impress responsible persons in sprinklered buildings not to turn the system off before the fire department arrives in the event of a fire.

Some officers treat a sprinkler system as a first aid device to be used only until the fire department arrives. Officers who think in this manner are forgetting that sprinklers delivering water directly over the seat of a fire generally use far less water while doing a better job of cooling and extinguishing than hose lines. In many instances, sprinklers are the <u>only</u> means of delivering water to the seat of a fire where conditions of dense smoke make it impossible to tell

whether a hose stream is being used effectively. Intense heat may even prevent hose men from reaching the fire at all.

JUNIOR SYSTEMS

"Junior systems" may be encountered from time to time which are designed to provide simple, inexpensive protection for light hazard occupancies where not over three or four sprinklers are likely to operate. The system is connected directly to the service water supply through a one-inch brass pipe and electric water flow alarm. There is no fire department connection or drain valve. The system itself is a loop of three-fourths of an inch or one inch of copper tubing fitted with small orifice (one-fourth of an inch or three-eighths of an inch) sprinklers They will discharge about one-half as much water as the standard one-half inch sprinkler, and are distinguished by a pintle extending beyond the center of the deflector. (For identification purposes only.)

CHECK LIST FOR OFFICERS

1. Have a list of all sprinklered buildings in the area with sketches showing connection locations and main sizes.
2. Be aware of water supply and auxiliary sources in the area.
3. Inspect fire department connection and control valves periodically.
4. Hook up and pump into sprinklers whenever the need is evident.
5. Exercise extreme caution when shutting down systems.
6. Be sure that all auxiliary fire fighting equipment is restored to service before leaving.
7. Hold periodic drills on all of the above.

Further information on this subject can be found in NBFU Special Interest Bulletin No. 270; National Fire Code, Volume IV, Chapters 13, 13A and 13L; and NFPA Handbook of Fire Protection, Chapters 51 to 60.

APPENDIX D

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Los Angeles City Fire Department

Training Bulletin #62
VI.

Date of Issue **1-93** *Revision Date*

2-INCH HIGH-RISE HOSE SYSTEMS

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January, 1993
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This Training Bulletin will familiarize and instruct members in the use of the 2-Inch High-Rise Hose System, including methods to make up the hose packs and pigtail assembly, high-rise water system review, standpipe hose lays, extending hose lines, and maintenance of the hose.

I. SPECIFICATIONS

This hose is of a single jacket construction utilizing nitrile rubber impregnated synthetic yarn as the cord material. It comes in 50 foot lengths with 1-1/2" couplings and is ribbed to reduce wear and increase grip. The shoulder of the couplings are tapered to reduce snagging on furniture, door frames, and other obstacles. The hose is blue in color, which will aid in identification. It is more susceptible to damage than double jacketed hose as it has a tendency to incur very small punctures when used around broken glass and sharp objects; however, these punctures will not tear or increase in size even under extreme pressure. Use of this hose for purposes other than hose packs should be avoided. A benefit of this hose, especially when working in the confined spaces of stairwells and interior hallways, is its ability to resist kinks. Under pressure, the hose can be bent to within 12 inches before it will kink. Additionally, it drags more easily than the 2-1/2"
Dacron/polyester jacketed hose in present use.

When supplying the standard 75 psi nozzle pressure to the 1-1/2" 200 gpm Elkhart (yellow bumper) nozzle, your flow will be 200 gpm with a friction loss of 35 psi per 100 feet of 2" hose.

II. HOSE PACK COMPONENTS

A Company's complement will consist of two complete 100-foot hose packs and one pigtail assembly. This will provide the Company the option of laying a single line of uniform size 200-feet in length delivering 200 gpm or two lines 100-feet in length delivering a total of 400 gpm. Officers should keep in mind that the primary objective of a Company assigned to attack the fire is to get one line into operation.

Each hose pack consists of:

l. Two 50' sections of lightweight blue hose
2. One 1-1/2" complete 200 gpm spray nozzle
3. One 2-1/2" X 1-1/2" reducer
4. Five 2' ladder straps

The pigtail assembly consists of:

l. One 8' section of lightweight 2-1/2" hose
2. One 2-1/2" to 1-1/2" gated wye
3. One lightweight folding spanner
4. Two ladder straps
5. One 2-1/2" 60 degree elbow

III. ASSEMBLING THE PACK

The high-rise hose, unlike many lightweight hoses, has a dull-looking adhering surface that holds together very well in a pack. It takes five ladder straps, each two-feet in length, to effectively hold the pack together. If the straps are too long, cut off the excess and burn the bitter end to prevent fraying. You can begin making your pack with either the hose rolled, or stretched out straight.

The hose packs are fashioned using a 30 minute air bottle to form a "U" shaped single layer or double layer pack.

Considerations for using either the single layer or double layer can be based on compartment space and Company preference. The single layer method produces a pack eight-inches taller than the double layer method.

The pack can be made without using an air bottle; however, using the bottle will insure the pack is ideally fitted to be carried over the breathing apparatus. Listed below is the procedure to assemble a hose pack:

l. Place a 30 minute bottle on the floor.

2. Place the female coupling of the first section of hose about ten-inches below the gauge of the bottle. Attach the reducer to the female coupling.

3. Begin wrapping the hose around the bottle folding it alternately against itself continuing the folds about ten-inches below the gauge of the bottle. There is no need to wrap the hose tightly around the bottle. Keep it loose enough so that the hose forms nicely into the horseshoe shape.

4. Attach the second section of hose:

A. For a single layer hose pack, continue folding it alternately against itself.

B. For a double layer hose pack, bring the second section on top of the first and continue the horseshoe folds until the second section is completed on top of the first.

1. When you reach the male coupling of the second section, attach the nozzle and position it at the base of the pack on the same side as the female coupling you began the pack with.

2. To secure the hose pack, place a strap about eight-inches above the bottom of the pack on each side. One side will incorporate the nozzle, coupling, and reducer. Placing the straps eight-inches or so above the folds will help prevent permanent kinks in the hose. Place the third strap at the very top, or middle, of the pack. The fourth and fifth straps will be placed at convenient locations to hold the pack together. Utilizing five straps will insure the integrity of the pack.

When complete, the packs will weigh 38 pounds compared to 64 pounds for 100-feet of the old 2-1/2" lightweight hose. The approximate dimensions will be 40" tall by 22" wide for the single layer pack and 32" tall by 16" wide for the double layer pack.

IV. ASSEMBLING THE PIGTAIL

The pigtail assembly weighs ten pounds and is made by rolling the gated wye inside the hose and elbow. Listed below is the procedure to assemble the pigtail:

1 Attach the eight-foot section of the 2-1/2" lightweight hose to the 2-1/2" to 1-1/2" gated wye.

2. Wrap the hose tightly around the wye.

3. Attach the 2-1/2" elbow to the female coupling of the 2-1/2" lightweight hose.

4. Secure it with a short strap also capturing the lightweight spanner.

5. Attach a longer strap to the pigtail to use as a carrying handle.

V. WATER SYSTEM REVIEW

There are three basic types of systems that you will encounter based upon the year the building was built:

A. Buildings built prior to 1960 were limited to 150-feet in height and were required to have only a Dry Standpipe (Class I) System for our use.

B. Buildings built between 1960 and 1974 were required to have a Combination (Class III) Standpipe System. Combination means that the 1-1/2" interior wet standpipes for use by the occupants is supplied by the same riser as the 2-1/2" outlet for our use. Pressure is supplied by an on-site fire pump. This system may also have 2-1/2" hose with a 1" straight tip attached to it. These will be found in hose cabinets located in the stairwells above the fourth floor, and are intended for Fire Department use. However, this hose should not be used due to its unreliability. This system is the primary reason for carrying the eight-foot 2-1/2" hose in the pigtail. The pigtail allows you to connect to the outlet, which is located in a recessed cabinet, and then operate two lines off the gated wye in order to maximize the available water from the outlet.

C. The third type of Standpipe System you will encounter is a Combined Standpipe Sprinkler System required in buildings built since 1974. A Combined System use the same riser to supply Fire Department outlets and the sprinkler system.

Keep in mind that any of these buildings may have an upgraded system. The only way to know for sure which system you will encounter is to pre-fire plan the occupancies in your first alarm district.

VI. STANDPIPE HOSE LAYS

A. The Dry Standpipe (Class I) System is found in buildings built prior to 1960. The outlet is adjacent to the fire escape, usually directly above the inlets at street level. However, if the building has been upgraded to meet seismic criteria, you may find that the outlets have been moved inside to a new enclosed stairwell.

Very often, the best way to get a line on a fire in one of these buildings is to drop bag a 1-3/4" or 1-1/2" hand line directly from your apparatus. Keep in mind that your 2" hose pack has the same 200 gpm nozzle that the 1-3/4" line does. If you need to extend off one of these lines with a 2" hose pack, your friction loss will be 50 psi per each 100-feet of 1-3/4". If you attempt to supply the hose pack from a 1-1/2" line, the friction loss in 100-feet of 1-1/2" alone would be approximately 130 psi, which would be prohibitively high.

If the outlet is adjacent to the fire escape, the eight-foot section of pigtail hose can be used to bring the gated wye around so the 1-1/2" outlets are pointed in or at the window, and then use one of the straps to secure it to the balcony. If the dry standpipe is in a stairwell, attach the elbow and gated wye directly to the outlet. Using the elbow will get the hose coming off the outlet/gated wye down onto the landing instead of sticking out blocking the landing.

B. Combination Standpipe Systems

Outlets on the Combination Standpipe (Class III) System, above the fourth floor, will have 100-feet of 2-1/2" with a 1" straight tip attached and located in a cabinet. A dripcock is attached to the outlet to prevent any water that might leak from the valve from getting into the hose while it is stored on the rack.

This system has orifice plates specifically engineered to reduce the flow of water supplied from a particular outlet. The size of the orifice plate is determined by the static pressure on the supply side of an outlet. The higher the pressure in the system, the smaller the inside diameter of the orifice plate will be. Due to gravity's effect on the water (head), the higher pressures will be found on the lower floors of a building. It is important to remember that the orifice plate does not regulate pressure, it restricts flow. The orifice plate can be found at one of the following locations:

· Soldered to the outlet itself

· Behind the gasket on the dripcock

· Soldered to the male end of the dripcock

· Behind the gasket on the 2-1/2" hose

Removal of the orifice plate is recommended in order to get the maximum flow from the outlet. Failure to do so will restrict the flow from the outlet to 200 gpm at a minimum of 50 psi residual pressure. Obviously, leaving the orifice plate in place will prevent you from getting the required 75 psi nozzle pressure and will not enable you to supply any additional lines. This is the outlet the pigtail hose was designed for. It allows you to attach your lines to the gated wye outside the cabinet.

The orifice plate is removed by either removing the gasket, removing the orifice plate, and replacing the gasket; or, if it is soldered into place, by using a slotted screwdriver or your channel locks, and using them as a pry bar to break the plate off of the opening. Be careful not to damage the threads on the outlet.

To initiate the hose lay, place the pack on the landing and remove the straps. Secure the 2-1/2" X 1-1/2" reducer in a safe location.

One Firefighter takes the coupling that connects the two sections of hose together from the center of the pack and carefully flakes it out up the stairwell.

Once it is flaked out up the stairwell, the other Firefighter places the nozzle in front of the door and attaches the pigtail assembly, without the elbow, to the outlet and then the female hose coupling to the wye.

Open the outlet slowly allowing the hose to be loaded. If the orifice plate has not been removed, open the valve fully. If the orifice plate has been removed, the outlet should be opened one and one-half turns, then adjusted from there. Have a member assigned to stay at the gate valve throughout the firefighting operation to insure no one accidentally adjusts your outlet.

Have the Firefighter who took the coupling up the stairwell remain there until the hose is completely loaded. After climbing 20, 40, or 60 floors, is no time to get in a hurry and end up with a giant pile of spaghetti that you cannot untangle on the fire floor landing. The Firefighter should make sure the hose is flaked out neatly and that the first section through the stairwell door is laying on top of the section connected to the outlet. This will allow the hose to slide down the stairs and into the hallway with a minimum of effort. When properly laid out, this hose works very well and requires minimal effort to drag it down hallways and around corners.

The nozzle person should open the nozzle, adjust the nozzle pressure and pattern prior to entering the hallway. Removing the orifice plate will allow the gate valve to be used as an adjustable orifice plate.

If conditions in the stairwell will not allow you to connect to the standpipe on the fire floor, you can connect on the floor below and easily pull this hose up the stairwell. Ideally, you want to flake the hose up the stairs from the fire floor.

C. Combined Standpipe Sprinkler System

The Combined Standpipe Sprinkler System is found in buildings built since 1974 that are more than 75 feet in height. These high-rise buildings are required to be fully sprinklered and also have a standpipe for our use. The sprinkler system and Fire Department outlets are fed by a common or "combined" riser.

The hose lays will be the same as with a Combination Standpipe Sprinkler System with the difference being the outlet valve.

This system utilizes a Pressure Reducing Valve (PRV) when the pressure at the outlet exceeds 150 psi. Therefore, it is possible in new construction to encounter orifice plates on the upper floors where the system pressure falls below 150 psi. This will typically be the top six to eight floors. Usually the "PRV's" are very obvious; however, some of them are very similar in appearance to the gate valve, which re-enforces the need to pre-fire plan the buildings in your area.

When making connections to the Combined Standpipe Sprinkler System connect the elbow and gated wye directly to the outlet, and when ready, open the PRV fully. Failure to open the PRV fully will result in severely reduced flow.

VII. EXTENDING HOSE LINES

Two different methods of extending your hose lines will be discussed. Both methods allow for extending from the nozzle in order to maintain control of your water supply. By utilizing complete hose packs to extend the original line, the need for additional fittings will not be necessary.

The first method involves laying out the pack you are going to extend with in the stairwell in the same manner you would the initial firefighting line.

Take the nozzle and female coupling of the dry line down the hall to the nozzle. This should leave your extension line flaked out behind you.

Shut the nozzle down and remove the tip. Attach and load the extension line, strapping the shut off butt on the original line open, and continue firefighting operations.

The second method will require leaving the hose pack that is not connected to the outlet, on the back of the Firefighter backing up the nozzle person. Remove the reducer and two of the hose straps while still in the stairshaft. This will simplify the operation at the nozzle.

Remove the remainder of the straps and stretch the hose out behind you, as mentioned above. Shut off the nozzle on the wet line and remove the tip. Attach and load the dry line, and strap the shut off butt on the original line in the open position. Advance the line.

Having a nozzle on each pack will allow you to shut the first line down, remove the tip, attach the second pack or a single section, and advance your line. This, of course, is not that easy when visibility is reduced due to smoke and loss of light. However, your routine practice of recognizing couplings while blindfolded during search and rescue drills will pay off. Shutting down the nozzle will not create a problem when opening it back up under the static pressure built up due to the new design of the nozzles.

VIII. MAINTENANCE

Due to the construction of this hose (synthetic nitrile rubber) a thorough drying after use is not necessary. After each use, scrub the outer jacket to free it of dirt and fire debris. Drain excess water from interior of hose jacket, then form a pack as described earlier. The annual service test will be performed as per the instruction for hose testing in Volume 3 6/11-25.96. The service test pressure for this hose is 300 psi.

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APPENDIX E

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Los Angeles City Fire Department
Training Bulletin #63
VII.

Date of Issue **5-90** *Revision Date*

PROCEDURES FOR SUPPLEMENTING HIGH RISE FIRE PUMPS

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July 1990
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Page 1

PROCEDURES FOR SUPPLEMENTING HIGH RISE FIRE PUMPS

The purpose of this training bulletin is to outline the Departments high-rise pumping procedures and to identify buildings where the procedures would be applied. In addition, safety considerations and obstacles that could be encountered will be discussed.

The high-rise pumping procedures will be implemented on buildings with a building fire pump supplying the standpipe systems. These buildings are existing high-rise buildings (built between 1960 and 1974) higher than 150 feet, existing high rise buildings between 75 and 150 feet that have been retrofitted to include a fire pump, and new high-rise (built after 1974) buildings.

The procedures are designed as a back up to a building's fire pump. In the event that the building's fire pump fails, Fire Department apparatus will be required to assume the building fire pump's function of maintaining the system pressure. The system pressure equals head pressure plus friction loss in the standpipe inlets plus pressure required at the highest outlet.

There are a variety of ways to identify the system pressure. The quickest and most reliable way is to locate the Fire Department Connection (FDC) sign, a plaque mounted near the fire department connection inlets. Minimally, the FDC sign provides the system pressure, and may also include additional information such as area of building served and address of building. An alternate method to determine the system pressure, would be to consult the building engineer, or to view the discharge gauge of the building's fire pump while the pump is running. The latter two, of course, would not be practical during an emergency and would best be accomplished during a pre-fire inspection. At an emergency, and a FDC system pressure sign is not provided, an estimate of the building's system pressure can be calculated by multiplying the number of floors by five (5), then adding the constant of 150 psi. The sum will be the approximate system pressure. This constant of 150 psi is a figure derived by adding the average pressure required at the roof outlet (125 psi) and the friction loss in the standpipe inlet (25 psi).

Example: 20 story high-rise:

20 (number of floors)
x 5 (amount of head per floor) 100
+ 150 (constant)
250 psi

For a 20 story high-rise, the approximate system pressure would be 250 psi.

PROCEDURES

RESPONSIBILITY

The member responsible for supplying the water system will be the first arriving 200 series engineer, or in the event that the first two arriving companies on scene are single engines, the second arriving engineer will supply the system. The engineer supplying the water system will:

1. Lay hydrant to fire.

2. Spot the apparatus at the Fire Department Connections (FDC's) with the pump panel away from the building. Spot so as to lay the 2 1/2" lines as free from kinks and sharp bends as possible, especially at the discharge gates and 2 1/2" FDC inlets.

3. Remove all plugs from the 2 1/2" FDC inlets to prevent back pressure from leaking past the clapper valves and "locking" them on.

4. Connect two 2 1/2" lines from the apparatus to the FDC's, utilizing the discharge gates on the building side of the apparatus. Each line shall be a maximum of 100 feet. If pumping over 300 psi, strap the lines together using ladder straps on each side of each coupling and midway between each coupling. Load the 2 1/2" lines before strapping.

5. If the high rise is over 20 stories or the system pressure at the FDC is over 250 psi, another apparatus shall spot to the hydrant/4-way and pump half the system pressure to the apparatus supplying the FDC's.

6. If there is a fire, pump into the system 100 PSI BELOW THE SYSTEM PRESSURE as shown on FDC sign or on the calculated estimate. This should be below the ON/OFF pressure settings of the building fire pump. This will allow the building fire pump to perform its designed function of supplying the system.

INITIAL PRESSURE TO PUMP

Example: 20 story building –

System Pressure = 250 psi.
Less = 100 psi.
Pump = 150 psi.

If you are not flowing water, monitor the pump temperature. Use the pavement cooler to alleviate water in the pump heating up.

7. *Once the Engineer is hooked up and pumping, determine if the water is flowing or not and notify the Incident Commander to this fact. An expedient way to determine if water is flowing is to feather the discharge gate. If the gate resists closing and/or there is a drop on the discharge gauge, water is flowing. If the water is static, the closing of the gate is easily accomplished and the pressure. trapped in the discharge line will register on the discharge gauge. Monitor gauges to determine if and when you start flowing water, this will be indicated by a drop in discharge pressure and verified by, feathering the gate. Once water is flowing, throttle up to the system pressure and notify the Incident Commander.*

8. If there is an actual fire, whether the Engineer(s) is (are) supplying the FDC with one apparatus, or two apparatus pumping in series, request additional engines from the Incident Commander and have them duplicate the operation into the other two inlets of the FDC utilizing a separate source of water, if possible, for the supply lines. This will provide additional GPM and increased reliability in supplying the system.

SAFETY CONSIDERATIONS:

At the scene of a high rise fire, danger from falling glass and debris is a genuine concern. Due to the engineer's exposed position and proximity to the building, precautions shall be taken to guard against the hazards of falling debris. The engineer can protect himself by one of more of the following:

1. Donning all safety clothing

2. Having a truck company spot their aerial so as to cover both the panel and the FDC's. Once spotted, lay salvage covers, folded to a quarter of their width, on the rungs from the pedestal to the top of the aerial.

3. Spotting a second apparatus next to your engine and using a pike pole and salvage cover, create a roof over the panel.

4. Creating a lean-to over the panel out of pike poles, rubbish hooks and salvage covers.

5. Draping rubbish carriers, salvage covers or other such suitable barriers over the offside running board to the ground to protect the legs from the horizontal spread of flying glass shards.

   Protection for the 2 1/2" can be accomplished by using ladders, salvage covers, seat cushions, compartment or hose bed liners (wood slats). The means of protection is limited only by the operators ingenuity and the materials on hand.

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UNIT 7: SMOKE MANAGEMENT SYSTEMS

TERMINAL OBJECTIVE

The students will be able to identify the types of smoke management systems, their locations in buildings, how they operate, and their roles in strategic and tactical efforts.

ENABLING OBJECTIVES

The students will:

1. *Identify the types of smoke management features and their locations in buildings.*
2. *Describe the operation of each type of smoke management feature or system.*
3. *Recognize the need to incorporate smoke management systems into preincident plans.*

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SMOKE MANAGEMENT

Fire protection professionals know that smoke is the leading cause of fire deaths. In addition to the risk to civilians, firefighters exposed to smoke and its toxic constituents face challenges during rescue, fire control, overhaul, and postincident investigations. Even when working in full self-contained breathing apparatus (SCBA) with thermal imaging equipment, firefighters may have a difficult time finding their way through dark, hot atmospheres. One of the keys to successful incident outcomes is smoke management.

For the purposes of this unit, the terms smoke "control" and smoke "management" are synonymous; they will represent one or more methods to remove smoke from confinement to enhance emergency operations.

Smoke management features and systems can be found in a wide variety of buildings to provide a more tenable environment and facilitate entry and fire suppression. They may be as fundamental as rooftop vents with both manual and automatic release mechanisms, or as complex as systems integrated into the environmental control components of a building that functions to maintain a temperature-controlled environment for its occupants. Many of these systems are designed and can be used to control the movement of smoke and toxic gases under fire conditions.

The key is for the fire officer/Incident Commander (IC) to know in advance what kind of smoke management features are in the building, how they operate, and what their capabilities are in relation to managing, controlling, and moving smoke during or after a fire.

HEATING, VENTILATING, AND AIR-CONDITIONING SYSTEMS

A basic understanding of environmental air controls is essential to comprehend the use of mechanical smoke management systems. Heating, ventilating, and air-conditioning (HVAC) systems are designed to process and treat air. The HVAC system simultaneously controls the air's temperature, humidity, and cleanliness, and distributes it to meet the requirements of the conditioned spaces. Another function is to collect the air from the conditioned spaces and return it for reprocessing and reuse.

HVAC systems found in buildings fall into two categories: 1) central air-conditioning systems (where the processing equipment supplies air to more than one floor), and 2) noncentral air-conditioning systems (that supply air only to the floor on which the processing equipment is located).

Central air-conditioning systems are most common and create the most problems during a fire.

The IC must understand the components (and configuration of the components) that make up the HVAC system and become familiar with all building systems and controls. HVAC systems are divided into three subsystems:

1. The processing system.

2. The supply (or distribution) system.

3. The return system.

The Processing System

The processing system usually is installed on the floors of the building where the mechanical equipment rooms (MER's) are located. The following equipment for the processing of the air should be found in the MER:

- outside air-supply dampers;
- equipment for the heating, cooling, filtering, and humidifying of the air;
- supply air fans;
- smoke and/or heat detectors within ductwork or plenum;
- ductwork to the supply airshaft;
- ductwork from the return airshaft;
- return air fans;
- exhaust air dampers; and
- mixing dampers.

The mechanical equipment draws in outside, unconditioned air and processes it to adjust humidity and temperature to within tolerable limits for the occupants and equipment inside the building.

Figure 7-1 illustrates these items. Starting at the lower left of the drawing, outside air (OAS) is brought into the building, and contaminants are removed by the filters. The "maxi-"or "mini-dampers" are used depending upon the system demand.

Once the air is conditioned, it is distributed through the building by the supply air fan (SAF) through the supply air shaft (SAS.) It returns to the MER through the return air shaft and fan where it is further conditioned. Smoke detectors (S/D) installed in the ducts will stop the air flow if they detect smoke or other particulates, especially dust. Smoke detectors are required only when the air handling capacity of the system is 2,000 cubic feet per minute (cfm) or more.

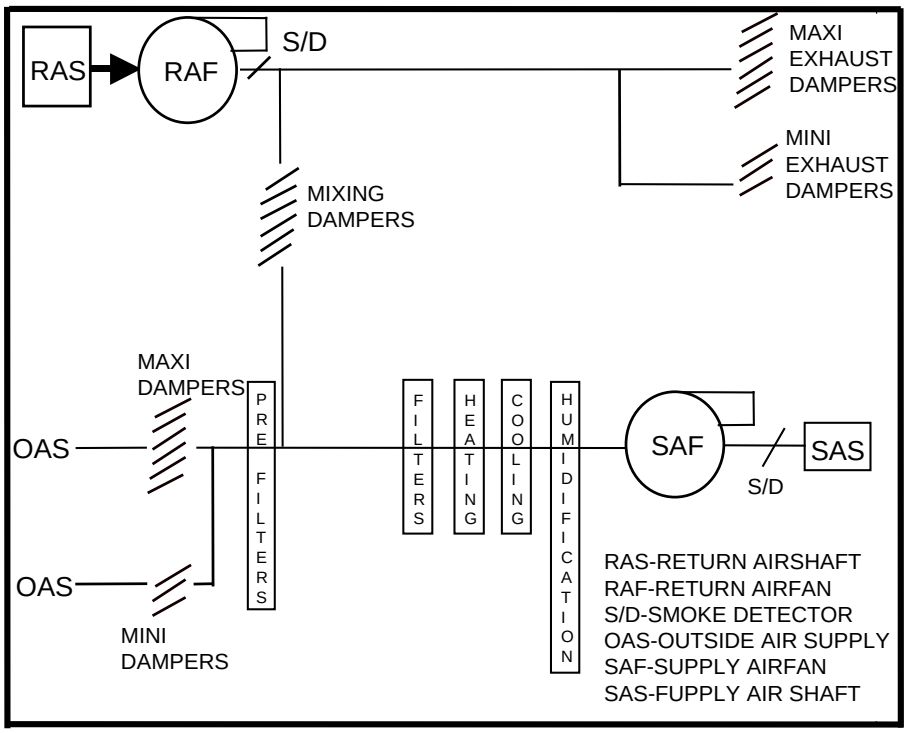


Figure 7-1
MER Air-Processing System Components

The Supply (Distribution) System

Supply system components consist of:

- a supply airshaft;
- fire, smoke, or combination dampers;
- supply air ducts; and
- air diffusers.

Figure 7-2, Typical HVAC System, may be used to trace the path of air through the system.

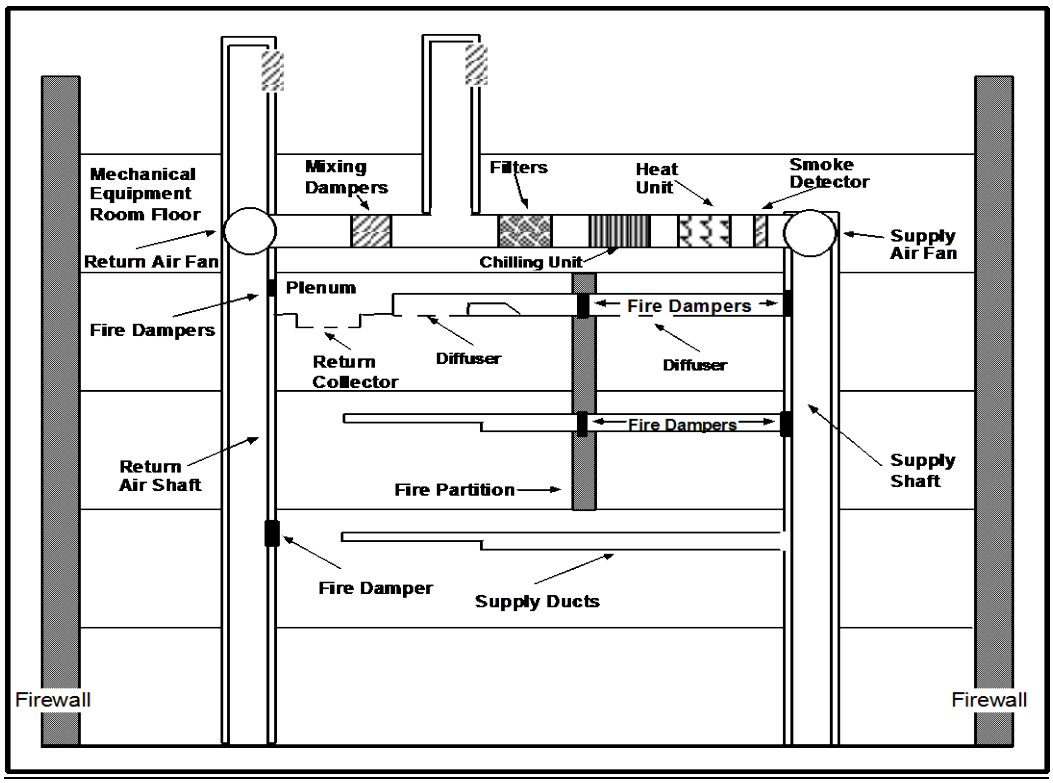


Figure 7-2
Typical HVAC System

Fire Dampers

Fire dampers are installed in air-distribution systems in order to maintain the required integrity of a fire-resistive assembly when ducts penetrate fire-rated wall partitions or floors. They are manufactured with a fusible link to close automatically on detection of heat to restrict the passage of flame and heat.

Smoke Dampers

Smoke dampers (called "leakage-rated" dampers) are installed in air-distribution systems to control the movement of smoke. They usually are found only where duct systems penetrate smoke barriers, such as in hospitals, nursing homes, prisons, or other such occupancies. They are controlled by an automatic alarm device (usually smoke detectors) and also may be opened manually from a fire command station.

Combination Fire/Smoke Damper

These are designed to perform both functions of a fire and smoke damper when the location lends itself to multiple required functions. Example--a smoke control system that is part of a building HVAC system that connects to a 2-hour rated mechanical shaft.

The Return System

Figure 7-2 also can be used to trace the path of return air from the floors to the MER. The return air system components consist of:

- Return air ductwork and inlets.
- Return air plenums. (A plenum is an air compartment or chamber to which one or more ducts are connected to form a part of an air distribution system. In noncombustible buildings, the space between the suspended ceiling and the underside of the floor above may be used as a plenum for the collection of the return air back to a mechanical air-handling shaft.)
- Fire, smoke, or combination dampers.
- Smoke detectors located in the air-handling ductwork to shut down the HVAC unit automatically, or activate a smoke control system.
- Return airshaft.

In a typical central air-conditioned building, the large volume of air required precludes the use of a single HVAC system. A number of HVAC systems usually exist--each supplying a number of floors. The groups are referred to as HVAC system supply zones. Figure 7-3, HVAC Zones, illustrates a typical zoned system.

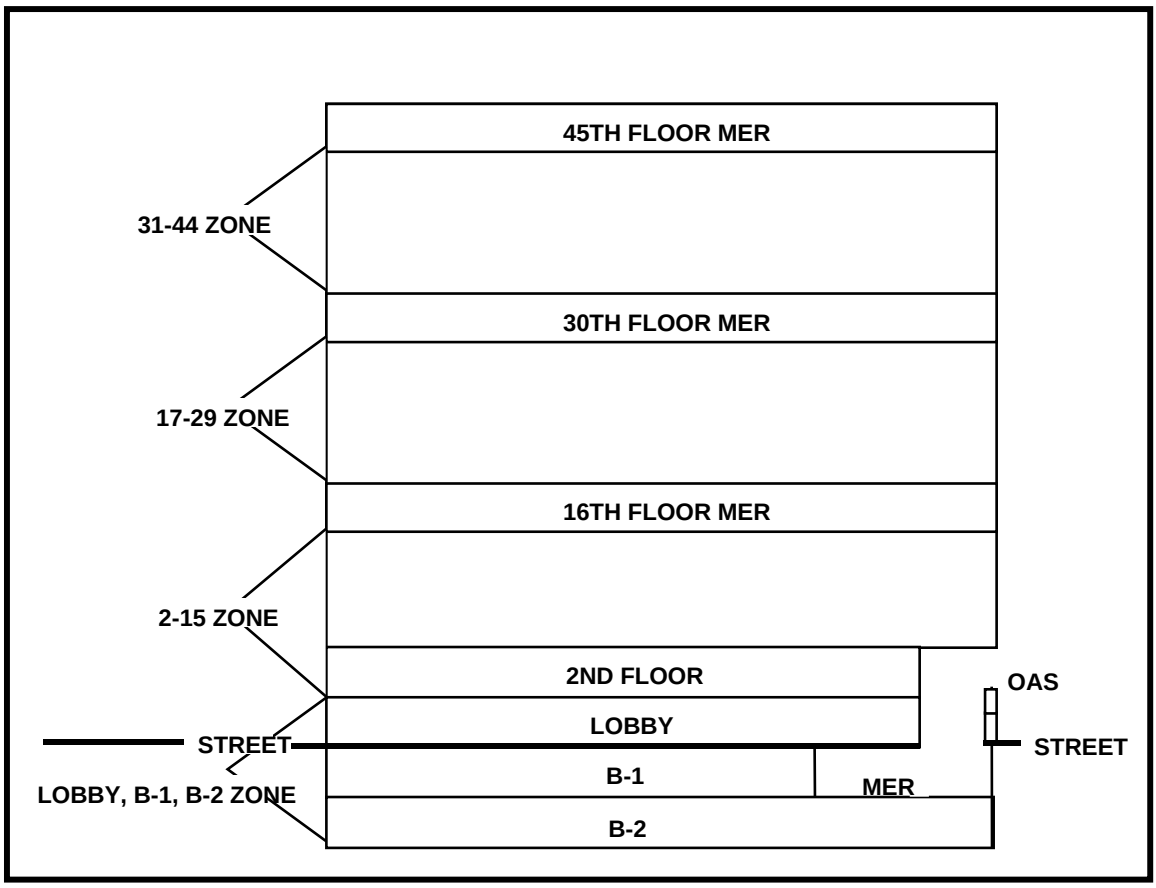


Figure 7-3
HVAC Zones

HVAC System Air Flow

Normal airflow through an HVAC system follows certain, predetermined steps. The following detailed review of the airflow process takes you through these steps.

Air Flow Through Processing Equipment

(Refer to Figure 7-4, Six HVAC Zones.)

1. Air is returned from the occupancy areas of the building for reprocessing via the return airshaft.

2. The return air fan is used to assist movement of air in the return airshaft to the MER.

3. Air from the return air fan then flows through the mixing dampers.

4. The air then is mixed with a set percentage of outside air. The amount depends on outside air temperature and humidity. This can be controlled manually (by the engineer on duty) or automatically (by local or computerized controls).

5. The mixed air then is processed by flowing through filters, heating/cooling equipment, and (optional) humidification apparatus.

6. The supply air fan assists the movement of air into and through the supply air shaft to the occupancy areas.

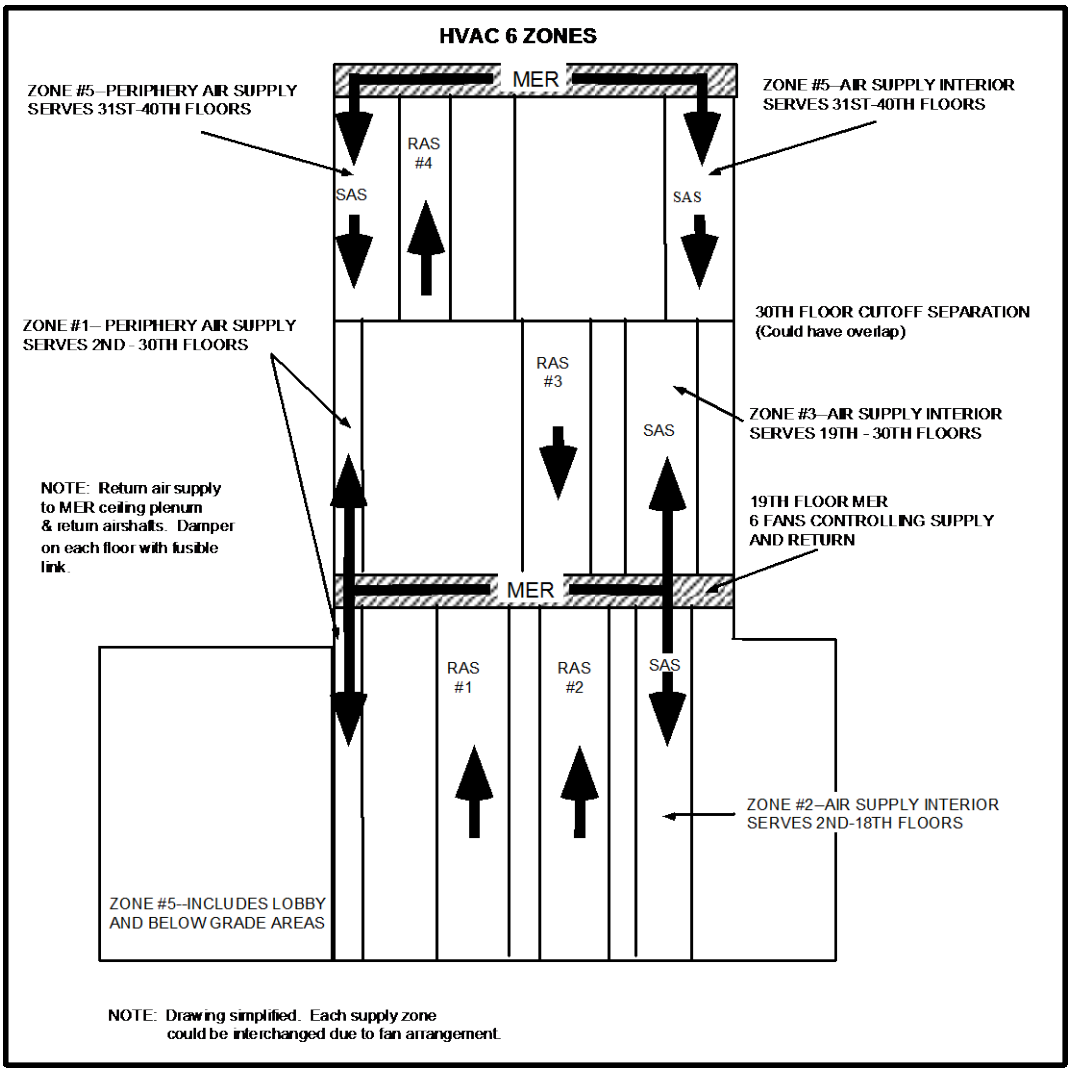


Figure 7-4
Six HVAC Zones

Air Flow Through the Supply System

(Refer to Figure 7-2, Typical HVAC System.)

1. Air is distributed to all floors via the supply airshaft.

2. Air from the supply airshaft is distributed throughout the floor by ducts. The ducts are located in the plenum.

3. Fire dampers will be found where ducts meet the supply airshaft and, in most instances, wherever ducts pass through a rated fire partition.

4. Air from the supply ducts is distributed to the occupied areas by air diffusers mounted in the ceiling or by air grills located in the walls.

Air Flow Through the Return System

(Refer to Figure 7-2, Typical HVAC System.)

1. Air from the occupied areas flows through the return collectors into the plenum or ductwork.

2. The air flows through the plenum or ductwork to the return airshaft. (The return air may or may not be ducted.)

3. Fire dampers will be found where the air enters the return airshaft and wherever the air flows through a fire-rated partition. If the building has a smoke control system, smoke or combination dampers will be found.

4. The air then is returned to the processing equipment via the return airshaft.

NONCENTRAL AIR-CONDITIONING EQUIPMENT

In some buildings, such as supermarkets, single-story offices, warehouses, and similar occupancies, rooftop units (RTU's) provide the heating and air-conditioning. Rather than use a series of interconnected ducts, this equipment takes outside air, conditions it, and disperses it into the room or area beneath it.

To prevent these devices from spreading smoke or adding outside air to a fire, those delivering 2,000 cfm or more are equipped with smoke detectors for automatic shutdown.

OTHER CONSIDERATIONS

There are a number of methods to shut down the HVAC system automatically in the event that fire conditions are present. The system is shut down upon detection of a fire by some type of smoke- or heat-actuated detection device. These devices include smoke detectors or other approved heat-activated devices, usually an interconnection with a water-flow alarm on the sprinkler system. These devices are located where they will be affected readily by smoke or an abnormal rise in the temperature in the duct.

Activation of any of the devices stops the supply air into, and the return air from, the affected floor. Manual operation may be accomplished either by shutting down the supply fans and the return fans serving the affected floor, or by activating approved remote-controlled reversible smoke dampers on the fire floor.

Fusible links commonly are used to close fire dampers. Once a fire damper has closed, it must be opened manually before any air can pass through the opening it is protecting. Supply and return fans that have been shut down by the activation of a smoke detector cannot be reactivated until the smoke detector has been cleared or bypassed.

Many buildings may be equipped with a smoke control system that incorporates the components of the building HVAC system. These types of systems are designed to operate automatically in the control of the spread of smoke in the building. When these systems are installed, they use automatic smoke dampers that are interconnected with the building smoke detection system. An operating manual for the smoke control system should be kept within the building fire command center. These controls require a high degree of knowledge and understanding before anyone should attempt to use them in other than the automatic mode of operation.

Temperature variations that occur in the periphery of the building, due to weather changes and movement of the sun, require supplementary treatment of the air.

- Air supply may be from the main supply shaft, from a separate periphery supply shaft, or from the floor in the vicinity of the periphery of the building.

- Air supply to the periphery is treated locally or centrally to suit the needs of the periphery. Piping containing heated or chilled water is used sometimes to treat this air locally (as in the case of a fan coil or an induction system). The air then is discharged into the periphery of the building.

- Air that is supplied to the periphery from the main supply shaft is ducted through the plenum of the floor below. This air then travels, via bonfire-rated flexible connectors, from the ducts to the air treatment equipment on the floor that is being served. Fire experience has shown that fire entering the plenum can extend from one floor to another via failure of these flexible connectors or, if these connectors are not properly fire-stopped, via the space that was left around them.

- Peripheral air is returned to the MER via the normal air return system.

Due to the many variations that may be found in HVAC systems, fire officers should consult with the building engineer during the preparation of the preincident plan for the building. They should gather information as described above, and conduct simulations of fire problems to preplan the handling of the HVAC system. This procedure not only will familiarize the building engineer with the functions that would be required during a fire, but also will allow fire officers the opportunity to become familiar with the configurations, abilities, and limitations of the HVAC systems in their response district. The IC needs to visit buildings under construction during the installation of the HVAC system and during operational acceptance tests of the mechanical system.

Smoke Management: Building Code Concepts

The requirements for the installation of smoke management features and systems are generally found in a jurisdiction's adopted building code. These systems are both active and passive.

Passive Methods

Passive methods include walls and floors, which act as barriers to slow smoke's migration through a structure. Passive methods also may include architectural designs that allow smoke to accumulate at the ceiling, high above the level of human occupancy (this feature is known as a smoke "sink" or "reservoir"). For the purpose of this course, rooftop smoke vents (operated by fusible links, or shrink-out plastic) are considered passive devices.

Active Systems

Active systems include integrated automatic fire sprinklers, fire detection systems, and air handling equipment. These systems must work together to achieve a consolidated/coordinated approach to fire protection. The IC must know how these systems function together to make fireground command decisions effectively.

Some definitions that will assist the IC are shown in the Fire Protection Glossary at the end of this Student Manual (SM).

Smoke Management Requirements

In the National Fire Protection Association (NFPA) and International Codes Council (ICC) model building codes, smoke control is required in buildings with atriums, in covered mall buildings, highrise buildings, and for theatrical stages and underground or windowless buildings. Large industrial buildings, or even small warehouses, also may have some requirements for smoke management. Buildings constructed before 2002, or those covered by other model codes, may have other specific requirements. It is important for the IC to consult with his or her fire marshal, building official, and mechanical inspectors to determine which buildings in their response district meet this requirement.

Some buildings have a fire command center designed into them that serves as a central command and control point for managing the systems contained within these buildings. (See Unit 9: Integrated Systems and Performance for additional information.) They are principally found in highrise buildings, but there have been instances where fire command centers have been installed in extremely large storage, underground, and warehouse facilities. These are generally referred to as highrise buildings "lying on their sides."

In highrise buildings the HVAC system may close system dampers automatically, which will limit the movement of heat, smoke, and gases to other parts of the building. These systems may be designed to pressurize the floors above and below the fire floor containing the fire products. These same systems may be designed to exhaust the fire products directly to the outside.

Whether it is a large industrial building with melt-away roof vents or a highrise building with HVAC systems, smoke management systems play an integral role in the safety of the building occupants and firefighters.

FUNDAMENTALS OF SMOKE AND HEAT VENTS

Venting Procedures

The most fundamental venting procedure used by fire departments today involves opening a roof, using conventional power and handtools (chain saws, reciprocating saws, axes, etc.) carried on fire apparatus. This procedure includes inherent risks and should be avoided whenever possible. Lightweight construction roofs or roof structures that have been exposed to heat for some time may fail catastrophically, injuring and killing firefighters.

In large flat-roof industrial and warehouse buildings, it is not unusual to find an arrangement of rooftop vents designed to release smoke and other products of combustion in the event of a fire to help to maintain a tenable environment for a longer period of time. This will assist building occupants in their evacuation of the building and provide a more manageable environment for firefighter entry.

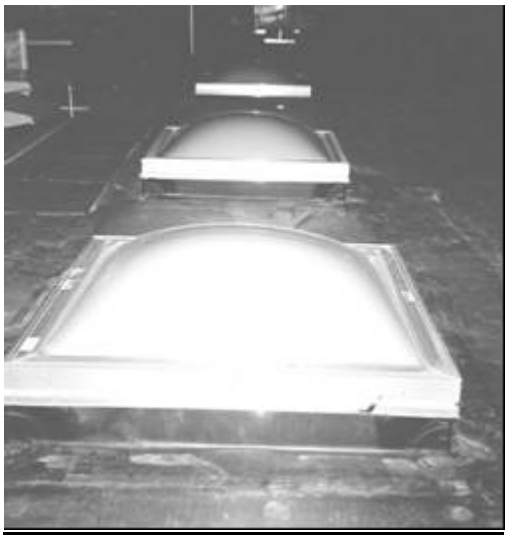


Figure 7-5
Melt-Away Plastic Roof Vents (Roof-top View)

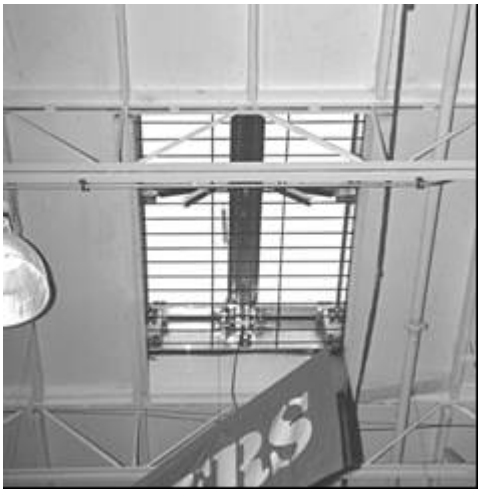


Figure 7-6
Roof Vent with Automatic/Manual Release Mechanisms
(Note the security bars to prevent unauthorized entry.)



Figure 7-7
Plastic Roof Vent in Warehouse

The model building and fire codes specify where roof vents are required and the ratio of roof-to-floor area of coverage that must be met in order to satisfy code requirements. IC's don't necessarily need to understand the ratios for coverage, but they must be aware of the buildings where they are installed, how they operate, what the melt-away temperature is, and whether or not they have a remote manual release feature.

Smoke and heat vents generally are required in industrial buildings and warehouses more than 50,000 square feet, in hazardous occupancies, and in any occupancy where high-piled combustible stock or rack storage is provided (more than 12 feet above the floor). An exception is given for storage occupancies exclusively for bulk frozen food storage where the building is protected by a fully automatic fire sprinkler system.

Located in the roof, smoke and heat vents (also called "gravity" vents) operate automatically to release smoke and hot gases. They rely on the smoke's buoyancy to escape the structure. Two major methods of rooftop venting are employed: spring-loaded mechanical or shrink-out plastic. Spring-loaded vents are designed with a fusible link that activates the opening of the vent when the temperature reaches a certain degree under fire conditions. The vent cover may be metal or plastic. Shrink-out plastic vents simply melt and fall to the floor, leaving the vent hole open to the atmosphere. Firefighters assigned to rooftop operations should never stand on either of these vent types.

The code requires that smoke and heat vents be approved, labeled, and capable of manual and automatic operation. Manual operation of spring-loaded vents often includes a rooftop D-ring mechanism that can be pulled, and a similar arrangement on the interior--often including a long

metal cable so firefighters can reach the D-ring. Manual operation of the shrink-out vents consists of cutting them with power equipment or prying them from their rooftop curbs.

When a building is equipped with an automatic fire sprinkler system, it is important that the smoke and heat vents not operate automatically prior to activation of the sprinkler system. This sequence likely will cause the introduction of outside air that will feed the fire and cause it to spread. In this case, rapid-fire attack is of the utmost importance. Fire and building inspectors are expected to assure that the vent operating temperature is higher than the sprinkler operating range.

Specifications

The dimensions specified for smoke and heat vents require that the cross-sectional area be 16 square feet, with a minimum dimension of 4 feet. The code allows projections such as ribs and rain gutters to project into the required 4 feet, as long as the total width for all projections does not exceed 6 inches.

Smoke and heat vents are required to be a minimum of 20 feet from adjacent property lines to reduce fire exposure to other buildings. They also must be at least 10 feet from property separation walls separating other high-piled storage areas.

Curtain Boards (Draft Curtains)

Curtain boards (draft curtains) are used in conjunction with smoke and heat vents. They must be constructed so that heat and smoke will not pass through them; thus, they generally are made of sheet metal, lath and plaster, gypsum wallboard, or another approved material that prevents the passage of smoke. They usually project between 4 and 8 feet from the ceiling.

Curtain boards are installed to contain smoke and heat, therefore creating heat buildup that will result in the activation or opening of the vents to allow these products of combustion to escape. They also are used in conjunction with fire sprinklers, so that temperatures will build, activating the sprinklers. If curtain boards were not installed, the heat and gases might travel some distance along the ceiling before activating both the vents and sprinklers, resulting in a more significant fire.



Figure 7-8
Curtain Boards

Controversy Regarding Curtain Boards (Draft Curtains)

There is some controversy over the effectiveness of curtain boards subsequent to a 1998 fire in a Home Depot store in Tempe, Arizona. In this fire, the draft curtains supposedly impaired sprinkler system operation, because the draft curtains impeded heat flow from one area to another, causing intermittent sprinkler activation.

From the NFPA Fire Investigation report summary:

> According to eyewitness testimony, when the fire was first observed it was located approximately chest height on one side of a 12 ft. (3.7 m)-high double-row rack. There was an additional 3 ft (0.9 m) of storage on the top level that created a total height of 15 ft (4.6 m). The size of the fire was characterized as being as big as a computer monitor. Within a very short time, the fire had extended vertically along both the outside face of the rack and within the flue longitudinal space the full height of the rack.
>
> …The first company to arrive was Phoenix Engine 38, which was located 1.2 miles (1.9 km) away. As soon as they left the station they could see a large column of smoke coming from the area. Upon arrival, they immediately made entry in through the northeast door, advancing a handline. They reported that smoke had filled the building from floor to ceiling and that visibility was zero.

> The sprinklers had activated by this time, and the firefighters were inundated with water as they made entry, advancing with a 1-3/4-in. hoseline. . . .
>
> …A ladder company was assigned to ventilate the roof. When they reached the area over the fire, they reported one skylight had burned through and that three automatic roof vents had opened. They proceeded to open 42 more, either by popping them open with an axe or sawing through the fiberglass panels. . . .
>
> …Eventually, 66 sprinklers were activated over an area of 5,082 ft^2 (472 m^2). Fire damage from flame impingement was limited to 1,500 ft^2 (139 m^2). The fire destroyed product in the rack of origin for a length of 32 ft (10 m) and for the full height of the rack.
>
> …A series of draft curtains were located throughout the building. They were constructed of sheet metal and measured 78 in. (2,000 mm) in depth. One draft curtain was located directly over the aisle where the fire occurred.
>
> …the fire was fueled by conventional fuel loads, and overwhelmed the inadequately designed sprinkler systems, destroying 96 linear ft (29 m) of product [other racks were affected], and causing six million dollars in damage (NFPA 1998).

There is movement among some fire protection proponents to eliminate draft curtains, or use them on a very limited basis in sprinklered buildings. Check with your fire marshal or building official to determine whether this applies to your jurisdiction. This would only apply to very recent new construction, and would not normally affect existing occupancies.

MECHANICAL SMOKE CONTROL SYSTEMS

Some modern buildings are required to have some form of smoke control/smoke management system. With the introduction of atriums, underground buildings, and large covered shopping mall buildings, the need for creating a tenable environment in institutional occupancies, and the fire service experience with highrise and large retail warehouse facilities, the model codes have, since the mid-1980's, begun to mandate smoke control systems.

What is an "Atrium" and Why is it a Problem?

The ancient Romans designed their homes with a center courtyard, often covered by a roof to keep out the elements. This became the "heart" or "atrium" of their living space.

When this architectural feature re-emerged in modern building construction, hotel and office designers embraced the idea. They could create an inner courtyard, and control the area's environment to make it a pleasant meeting space. Windows from adjacent rooms could face this dramatic element.



Figure 7-9
Atrium in a Luxury Hotel

Building and fire code officials realized the inherent dangers: a fire in one or more of the rooms facing the atrium could not vent to the outside like a "normal" building fire. Furthermore, firefighting access would be limited to the tenant corridor side only.

In the building codes, atriums are large spaces where two or more adjacent floors share a common atmosphere and they are covered at the top. Atriums generally require additional fire protection features including sprinklers, smoke management, and special egress requirements.

The principal purpose of mechanical smoke management systems is the maintenance of a tenable environment for as long as possible for the safe evacuation of the building and for re-entry by firefighters to combat the fire. Occupant safety is the number-one priority. A side benefit that must be managed is the movement of smoke, heat, and gases, which will allow for faster, more direct entry and fire attack by suppression forces.

Smoke control systems using the buildings HVAC system must meet minimum requirements under most model codes. All parts of these systems, whether active or passive, must be capable of continued operation for not less than 20 minutes after detection of a fire event.

Dedicated or Nondedicated Systems

Depending upon the design selected by the engineer, smoke management systems may be **dedicated** or **nondedicated** to smoke management.

A dedicated system is one that is designed and installed solely for the purpose of smoke management. It has separate fans, electronics, and manual controls. It is designed to operate only in the event of a fire.

A nondedicated smoke management system is integrated with the building's regular HVAC systems. In the event of a fire, the HVAC reverses its normal functions, and works as smoke control.

Dedicated systems tend to be easier to design and operate because they do not have the sophisticated engineering controls needed to manage day-to-day comfort as well as fire conditions.

As part of a preincident plan effort, the IC should identify which of the two systems is employed, and learn how the controls for each are operated. The building management or engineer is crucial to help this effort.

In either design, it is important for the IC to have access to operating instructions (manuals) during an emergency. Operating plans should be maintained in the building's fire command center.

Smoke Control Methods

There are two predominant methods of mechanical smoke control in buildings: pressurization and exhaust. A third method, smoke reservoir, is used occasionally.

Pressurization Method

The preferred method of controlling smoke is the positive pressurization method. This is accomplished by creating pressure differences across smoke barriers. By creating a higher pressure outside of the zone of fire involvement, smoke, heat, gases, and other products of combustion are impeded from moving from the fire area into the areas not involved.

The pressure differential can be maintained between floors, between corridors and exit stairs, and, in the case of covered mall buildings, even between smoke zones that have no permanent physical barriers. The pressure differential should not impede the opening and closing of exit doorways. The fire, building, or mechanical inspector should have verified this important safety consideration when the building was first occupied.

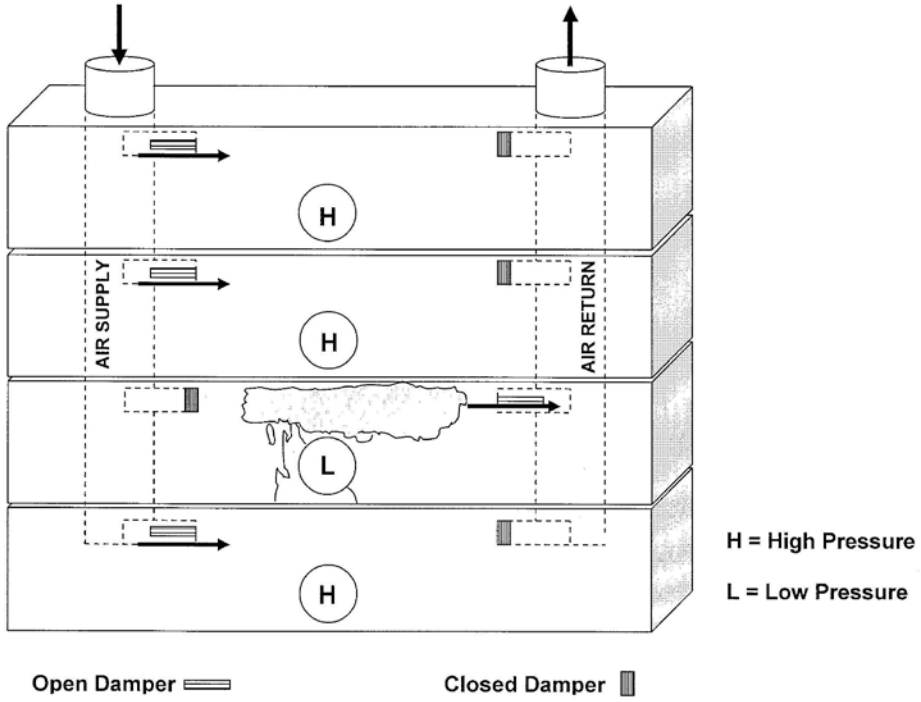


Figure 7-10
Typical Pressurization Method

The pressure differences are achieved by starting and stopping specific air handling equipment, and/or opening or closing smoke dampers, louvered devices installed in air ducts that can close automatically to block air flow.

Sandwich Effect

When used between floors, pressurization is commonly called the **sandwich effect**. Here, the air pressure on the floors above and below the fire floor is greater than the floor of fire involvement. This allows for containment of the fire to the floor of origin for a period of time. This does not eliminate the need for rapid fire attack and extinguishment, but with a properly operating system, it does afford the IC a period of time when the fire is somewhat contained and the stairwells used for both access and egress of occupants are maintained at a level of tenability.

Stairwell and Elevator Shaft Pressurization

Stairwell and elevator shaft pressurization is commonly used in highrise buildings. Shaft pressurization is accomplished through the use of fresh air introduced mechanically into the shaft at a pressure that is higher than that found on the floor of fire involvement (see Figure 7-11). The engineering concept causes the shaft pressure to hold back the smoke, heat gases, and products of combustion from entering the stairs or elevator shaft.

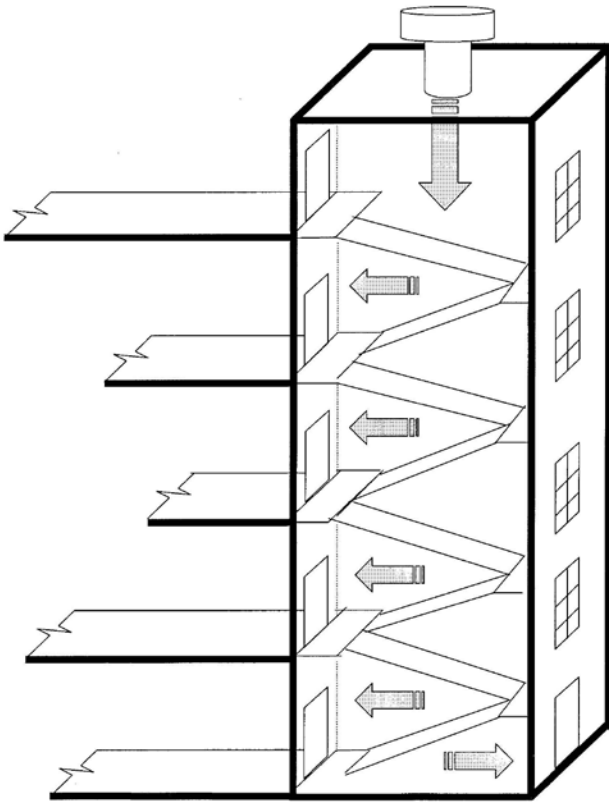


Figure 7-11
Single-Point Stair Pressurization

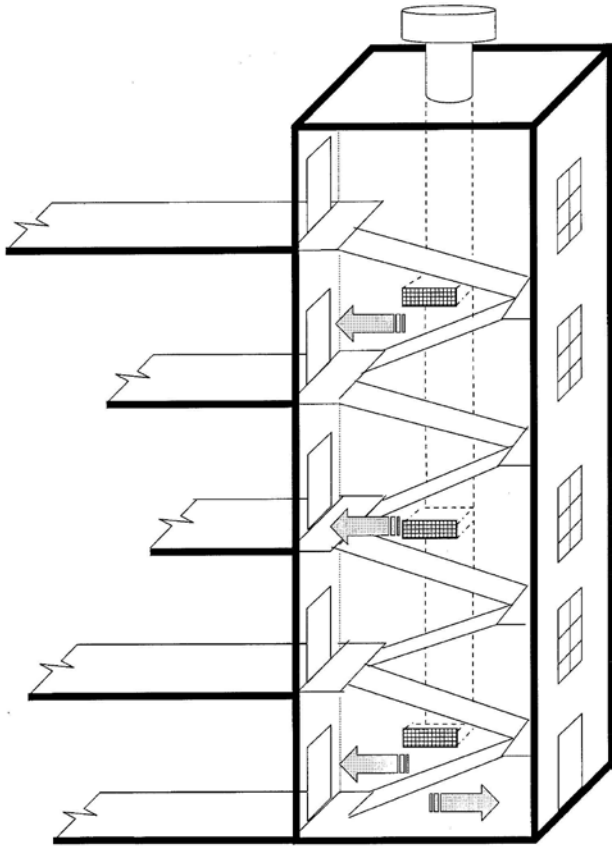


Figure 7-12
Multipoint Stair Pressurization

The pressurized air may be introduced at the top or bottom of the enclosure, or even in one or more locations simultaneously. Elevator lobbies may be pressurized to keep smoke out of adjacent stair and elevator shafts.

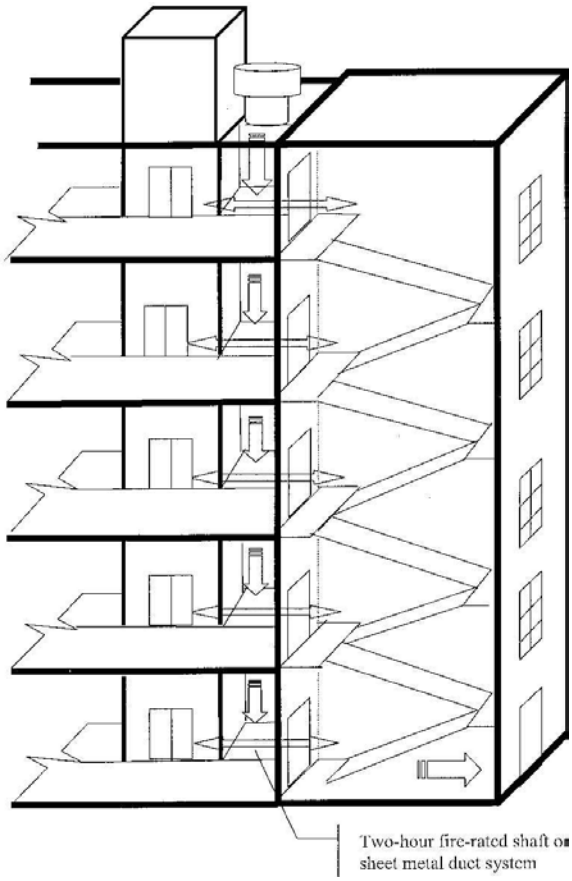


Figure 7-13
Elevator/Stair Pressurization

Covered Mall Buildings

Another example where pressure differentials are designed into the buildings' systems is modern covered mall buildings. Covered mall buildings employ sophisticated smoke management systems because an estimated one-half of the structure's required egress capacity passes through the covered pedestrian way in the mall. Imagine putting a roof over all the stores along Main Street, and you can understand why smoke management is so important.

In covered mall buildings, if the fire starts in a tenant space, the HVAC system for the tenant space will automatically (or can be manually) shut down. The remainder of the mall will continue to be supplied by the HVAC system, thereby creating a higher pressure differential and helping keep the fire, smoke, and gases inside the tenant space (see Figure 7-14).

Notice that in the main pedestrian walkway of the covered mall building, smoke zones are created without physical barriers such as walls. The higher pressures from the adjacent fans are all that are employed to force air back into the tenant space.

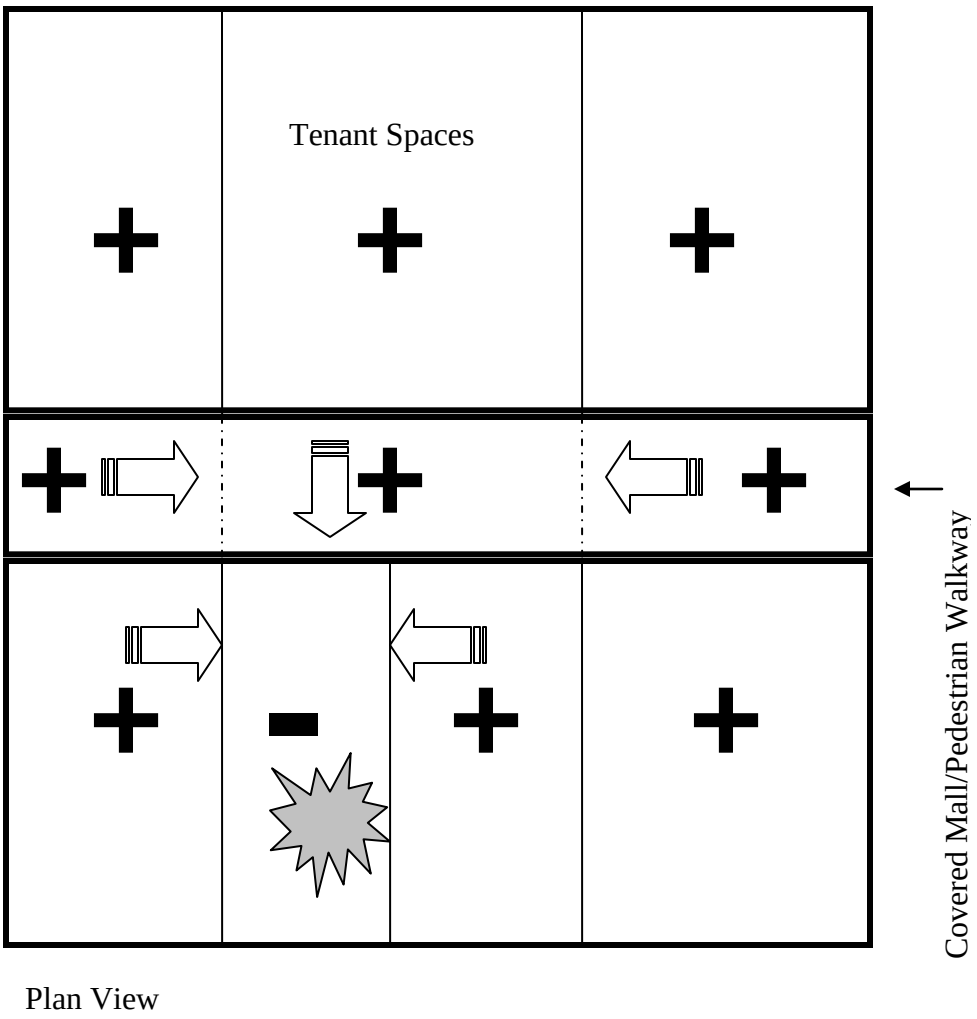


Figure 7-14
Covered Mall: Fire in Tenant Space

Conversely, if the fire is in the open area walkway of the mall, the HVAC components serving this area can shut down or be turned off, causing a lower pressure differential than the tenant spaces and helping maintain tenability in the tenant spaces (see Figure 7-15). Automatic shutdown normally occurs upon sprinkler system water flow or from duct smoke detectors installed on the return side of the HVAC system, which closes these dampers and may cause shut down of the exhaust fans serving this area.

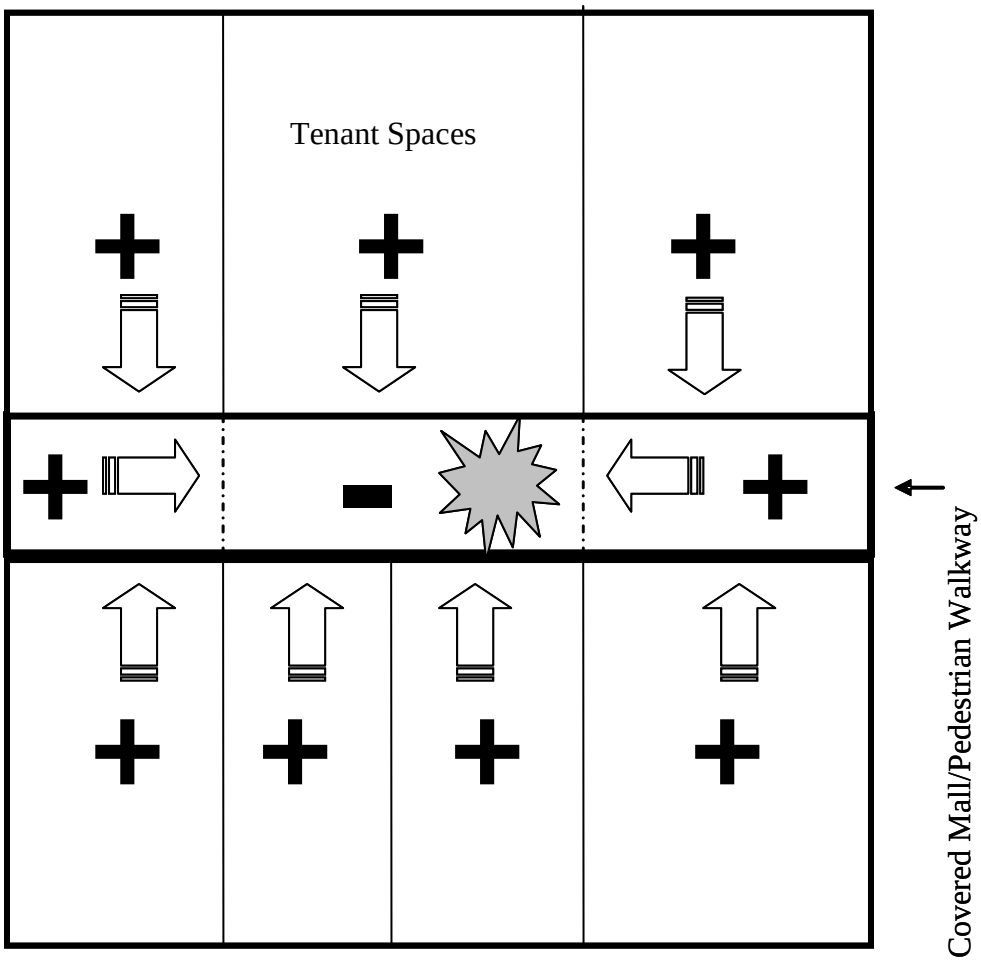


Figure 7-15
Covered Mall: Fire in Mall

To provide a sense of the sophisticated equipment and controls needed to automatically operate smoke management systems, look at Figure 7-16. If a fire spread from one smoke zone to another, the smoke management system controls must adapt automatically. In this example, the fire has spread from the covered mall space into a tenant space, so the tenant space fan that was pressurizing the mall now must shut down on its own. If the fire continues to grow and cross numerous smoke zones, the smoke management system is programmed to respond.

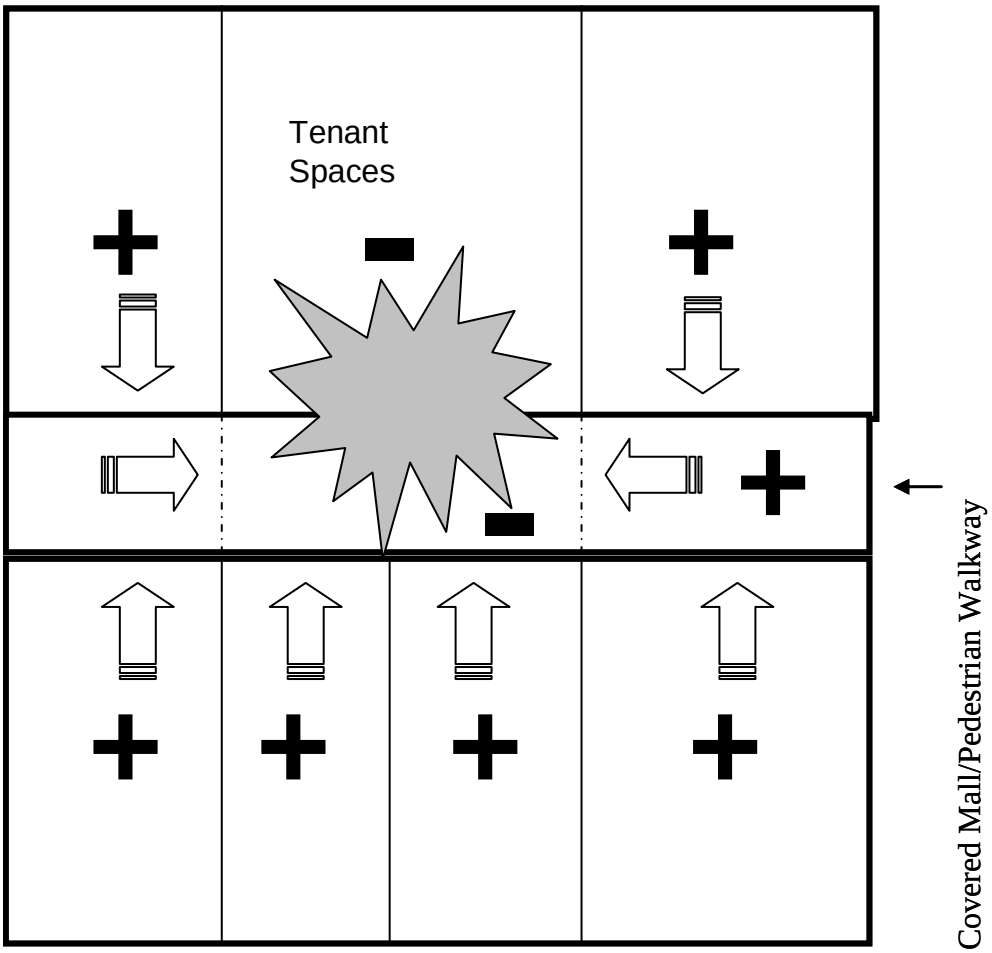


Figure 7-16
Covered Mall: Spreading Fire

Likewise, the smoke management system can be controlled manually by the IC or a building engineer most familiar with the system. Improper operations can result in spreading the smoke and fire through the building, creating greater risk to escaping occupants, firefighters, and property.

Good preplanning of these systems and buildings will allow fire officers to have the knowledge and understanding of how these systems work in individual buildings before a fire starts.

Smoke Zones

The concepts discussed above are closely aligned and often are developed in conjunction with smoke zones. Smoke zones are created in buildings requiring smoke control to impede smoke and fire movement from one zone to another.

Smoke Barriers

Smoke zones are developed using construction materials that create an airtight smoke barrier. Smoke barriers are required to be constructed and sealed to limit leakage areas exclusive of protected openings. Smoke zones in the pedestrian walkway portion of a covered mall building are an exception to this rule. These smoke zones are created by pressurizing the adjacent mall spaces.

Openings in smoke barriers are required to be protected by automatic-closing leakage-rated dampers actuated by the required controls for the mechanical smoke control system. This may be accomplished by smoke detectors or manual controls.

Exhaust Method

In some applications such as atriums or high-piled storage warehouses, the **exhaust method** may be used. Here, provisions are made for the introduction of outside air, or air from adjacent zones, to make up for the exhaust air. The exhausted air must flow through an exhaust opening that is at least 10 feet above any walking surface that forms a portion of a required egress system with the smoke zone.

The exhaust method is not nearly so effective at smoke management or removal as the pressurization method, so design engineers prefer to avoid this when possible. IC's may find exhaust-only systems in older buildings, constructed when the techniques of mechanical smoke management still were not well understood.

Smoke Reservoir or Sink

Some architects and engineers are experimenting with another concept called the smoke "reservoir" or "sink." This technique has been employed in several covered shopping malls as part of a performance-based design option.

In this case, the designer and code officials established an agreed-upon performance standard that in the event of a fire in the mall or tenant space, smoke production would not affect specific egress components for a 20-minute period. Given that design requirement, fire protection engineers computed the volume of smoke likely to be generated by a fire. With that information, the architect increased the design height of the roof so smoke would accumulate at higher elevations without banking down to where it would affect people leaving or firefighters entering the building within that 20-minute period.

The ceiling space is outfitted with small, manually operated exhaust fans to purge smoke from this "reservoir" after a fire has been extinguished.

It must be noted that performance-based design is a complex and sophisticated process, and there were additional life safety and fire protection features included in this covered mall project.

SYSTEM OPERATION

Mechanical smoke control system design is an engineering challenge best left to experienced professionals. There are many variables in design due to the type of occupancy, fuel loads, building architectural features, and changing weather conditions. We rely on the fire, building, and mechanical inspectors to verify that these systems will work as they are intended.

The IC's primary responsibility is to learn the mechanics of system operation so he or she can employ the smoke management to his or her strategic and tactical advantage.

Automatic Operation

To be effective, smoke management systems are arranged to operate automatically upon smoke detection within the area where the fire begins. This is accomplished during the design and installation phases by the strategic placement of smoke detectors throughout the building, and coordinating their operation with the HVAC system serving each zone. In a covered mall building, for example, the smoke detectors in the tenant spaces are served by different circuits from those in the pedestrian mall. This coordination is accomplished with computerized controls having programs to evaluate the sequence of device operation and control HVAC equipment as needed.

Smoke management systems also are operated automatically by water flow alarms from the sprinkler system in the smoke zone. This means the fire sprinkler system layout must closely align with the smoke control zones.

Manual Operation

Smoke management systems can be operated manually as well. This is where the IC must obtain detailed knowledge about the system operation, and include it on the preincident plan. A good time to do this is before the building is granted its Certificate of Occupancy.

Manual controls normally are found within or near the fire alarm control panel, and sometimes are located in a separate room called a fire command center (see Unit 9). The space should include an operations manual for the system, as well as clearly reproduced graphics that represent the smoke management system layout, and correlate that layout to the manual controls (see Figure 7-17).

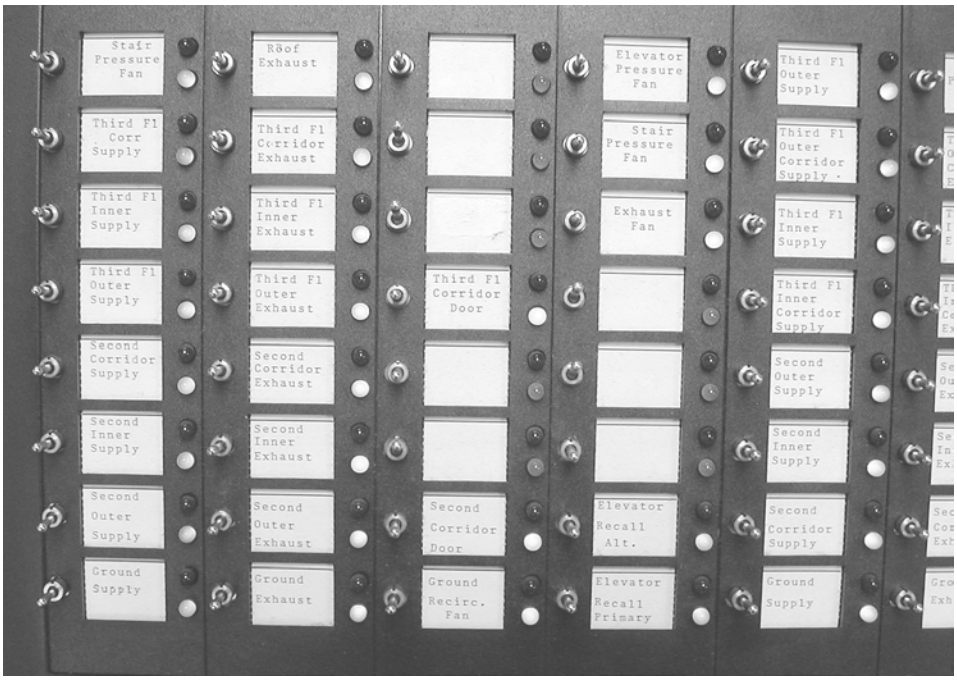


Figure 7-17
Typical Smoke Controls at Fire Command Center

According to NFPA 92A, *Recommended Practice for Smoke-Control Systems*, the smoke management system should include the following manual controls:

- ON-AUTO-OFF control over each piece of smoke-control equipment that can also be controlled from other sources within the building. This includes all stairway pressurization fans; smoke exhaust fans; HVAC supply, return, and exhaust fans in excess of 2,000 cfm (57 m^3/min); elevator shaft fans; atrium supply and exhaust fans; and any other operating equipment used or intended for smoke-control purposes.

- ON-OFF of OPEN-CLOSE control over all smoke control and other critical equipment associated with a fire or smoke emergency and then be controlled only from the fire command center.

- OPEN-AUTO-CLOSE control over all individual dampers relating to smoke control and that are also controlled from other sources within the building.

Manual controls may be two- or three-position toggle switches or "on-off" push buttons. The controls are accompanied by lamps or light-emitting diodes (LED's) that provide status indication of the various components. If, for example, the IC wants to operate a smoke fan at the top of an atrium, the status indicator lamp should illuminate to tell him or her that fan is in service. (The indicator light is not a guarantee the fan is working properly; that can be assessed only by evaluating system performance.)

Current codes require the status lights or LED's as follows:

- Fans, dampers, and other operating equipment in **normal** status: WHITE.
- Fans, dampers, and other operating equipment in **off** or **closed** status: RED.
- Fans, dampers, and other operating equipment in **on** or **open** status: GREEN.
- Fans, dampers, and other operating equipment in **fault** status: YELLOW/AMBER.

The status indicator lights will illuminate when the system operates automatically as well, so a responding IC might be confronted with a fire alarm or smoke management control panel that's lit up like a holiday tree. That is not the time to learn how to use the system.

SPECIAL CONDITIONS

Smoke Detectors for HVAC Systems

Even though a building may not be outfitted with a sophisticated smoke management system, the model building codes still require some HVAC installations to shut down automatically in the event of a fire to prevent smoke migration.

Smoke detectors for HVAC systems are installed in the return-air systems with a design capacity of greater than 2,000 cubic feet per minute in the return air duct or plenum, upstream of any filters, exhaust air connections, outdoor air connections, or decontamination equipment and appliances. In essence, this requirement places the detection devices in areas where early detection of the fire will occur and system shut down will happen in the most effective manner.

Duct Smoke Detectors

HVAC shutdown is accomplished by **duct smoke detectors**, which are connected to the building's fire alarm control panel when a fire alarm system is provided (see Figure 7-18). Activation of a duct smoke detector initiates a visible and audible supervisory signal at a constantly attended location. They may not serve as a substitute for required open-area detection. The supervisory signal at a constantly attended location is not required where duct smoke detectors activate the building's alarm notification devices.



Figure 7-18
Sampling Tube Duct Detector

If the building has no fire alarm control panel, the duct detector must have a signal (audible and visual) at its location within the HVAC system.

POWER SOURCES FOR SMOKE CONTROL SYSTEMS

Power for smoke management systems must include both a primary and a backup, or standby, power source. The model codes require that the primary source be the building's normal building power systems. The secondary power source and its transfer switches must be in a separate room from the normal power transformers and switch gear, and must be in an enclosed room, constructed of not less than 1-hour fire-resistive-rated fire barriers, ventilated directly to and from the exterior. Transfer to full standby power should be automatic, within 60 seconds of failure of the primary power.

TEMPORARY FACTORS THAT AFFECT SMOKE CONTROL OPERATIONS

Like sprinklers**,** smoke management systems are designed for a specific set of conditions that were anticipated at the time the building was constructed. As fire officers know, however, over time conditions in a building or facility will change, often having a negative effect on the potential performance of a fire protection system. Smoke control systems suffer the same potential problems.

Fuel Influences

When the smoke control system is designed, the engineer bases the design and capacity on the type, amount, and configuration of fuel loads that will be expected in the structure.

When a fire occurs, the severity with which it burns is known as the "heat release rate." All combustible fuels have measurable heat release rates, and they vary with the type and

configuration of fuel. Wood and ordinary combustibles for example, generally have lesser rates of heat release than similar amounts of plastics.

A smoke management system designed to work in an environment where ordinary combustibles were common may be woefully inadequate to handle heat and toxic gases from plastics.

The IC should be aware that content changes within a building may have a serious effect on the smoke control and be prepared to respond to those changes. If he or she identifies these potentially significant changes during a preincident plan or familiarization walkthrough, that information should be relayed to the building owner and code enforcement official.

Sprinkler Influences

Firefighters know that heated smoke rises, so the common expectation is that smoke from burning materials should reach the smoke control equipment. In the early stages of a fire this may be true, but once the automatic sprinkler system operates, the smoke will be cooled and tend to settle in lower areas, challenging the smoke management system to remove it. The IC may have to consider supplementing the built-in system with portable ventilation fans.

Weather Influences (Indoors and Outdoors)

When rising smoke loses its buoyancy, it settles and spreads horizontally. This is called the "stack effect" and can be observed in tall buildings, particularly in atriums.

The weather conditions outside the building can influence stack effect (as does the fire's rate of heat release) so that smoke control performance on a cold, dry day is different from a hot, humid day. An IC needs to observe the weather conditions during an incident and be prepared to adjust strategy and tactics if he or she is fighting both the fire and the elements.

Ventilation

Mechanical smoke control systems are designed under optimal conditions: only a limited number of windows or doors are open, HVAC systems are in their normal operating modes, and the smoke management system is fully functional.

Opening and closing doors and windows, as occupants leave the building and fire suppression crews enter, will affect the smoke control system's ability to manage the smoke. The piston-effect of elevators traveling up and down (though they are not supposed to be used during an evacuation) will create pressure differentials that affect smoke control.

Fire Operations Decisions

The IC's decisions to use the smoke management system or to otherwise ventilate the structure will affect the smoke control system's operational effectiveness.

If the IC puts efforts into rescue and suppression while the smoke management system is operating, the outcome may be different from the IC choosing to emphasize ventilation as a strategic and tactical plan.

Unfortunately, because all fires behave differently, IC's don't have the luxury of repeated practice on buildings under smoky conditions to evaluate the outcome of their decisions.

STRATEGIC APPLICATIONS OF SMOKE MANAGEMENT

Smoke management systems are not intended to maintain a pristine atmosphere during a fire. They are designed to provide moderately tenable environments for occupant escape, firefighter operations, and property conservation.

The IC must assess the overall performance of the smoke management features in relation to his or her strategic objectives. A few minutes spent with the building engineer to ensure that the smoke management equipment is operating effectively may be time well spent. Likewise, with limited resources, the IC may rely on the system to perform as it was designed, and focus on other priorities such as rescue or fire attack. In a building outfitted with rooftop vents, it may be wise to ensure that they are open as needed before initiating interior fire attack.

As a strategic asset, the IC can employ smoke management systems to work in concert with other built-in fire protection features (automatic sprinklers, automatic fire detection, manual standpipes) so he or she can make the best use of the resources the fire department brings: people and apparatus. Smoke management provides one more tool for the IC to achieve a successful fire outcome.

TACTICAL CONSIDERATIONS RELATED TO SMOKE CONTROL

The following are just a few of the tactical considerations that may be employed when using smoke management features or systems:

Initiation

Where smoke control systems are provided, best practices recommend that they be operated early in the fire (usually this is done automatically) and remain operational until the building is fully evacuated. If the system is not operating when the fire department arrives, the IC should make a thorough assessment of fire and smoke conditions, and order the system turned on if appropriate.

Establish Good Reconnaissance and Communications

The IC may have the Command Post (CP) located away from the fire structure, or inside a fire command center, where it is impossible to monitor conditions visually.

The IC should assign reliable observers with two-way communications (portable radios, telephones, or fire phones) to report the smoke control system's effectiveness. Communications must be clear among all parties so operating the smoke control system does not cause conditions to deteriorate in the original or adjacent smoke zones.

The IC also should assign a competent person to monitor conditions at the fire alarm control panel. By interpreting incoming fire alarm and damper position signals, the fire and smoke path can be plotted against the preincident plan.

Let the System Work

Let the smoke management system perform the job it was intended to do: maintain tenable environments for egress, rescue, firefighting, and property protection. If the system needs support with portable power ventilation equipment, make sure it is positioned in such a way that the portable fans supplement, rather than oppose, the building equipment.

Be Patient

It may take several minutes or more for the smoke management system to perform in an optimal manner as fans stop and start, dampers open or close, and pressures adjust in the smoke zones. Don't expect instant miracles.

Plan Ahead

Employ sound incident action planning practices. Identify where the problem exists, and based on facts and preplanned knowledge, where it's likely to go. It's fairly unlikely the smoke will pass adjacent smoke zones without causing them to operate, so you can anticipate fire growth and direction.

Don't Just Flip Switches or Push Buttons

The first few minutes of any incident can be chaotic while the IC assesses the incident, assigns resources, and develops an action plan. This initial contact can be even more overwhelming when the IC is at the fire alarm control panel confronted by flashing lights, buzzers, and other loud distractions.

The first instinct often is to do something, even if it's wrong. Flipping switches or pushing buttons may silence the noise temporarily, but with smoke management systems, this action can have a disastrous effect. The smoke control system will respond to manual overrides from the fire alarm control panel, and you may put smoke and other toxic products in places where you don't want them. Likewise, careless operations may add air to the fire, increasing the rate of combustion, potentially opening more sprinklers, and making a bad situation worse.

Remember, be patient, be calm, and refer to the preincident plan for guidance.

Maintain Smoke Zone Barriers

The smoke control systems are designed to move specific volumes of air within the smoke zones or compartments. The IC should do everything possible to assure the smoke barriers are not compromised:

- Assign a crew to check fire doors to make certain they are closed. Even closing nonrated doors can be of value.
- Turn OFF the HVAC supply in the affected fire zones, and OPEN return air dampers to vent the smoke to the outdoors.
- Turn ON the HVAC supply in the adjacent smoke zones, unless this action creates worsening fire conditions.
- Check smoke barriers for penetrations that can be repaired quickly with salvage covers or tarps. Small holes in walls and floors can be plugged with readily available materials, or sealed with duct tape.
- Try to keep curious onlookers and firefighters from opening doors or windows.

The IC should strive to maintain the integrity of the smoke barriers until the fire attack crews are ready to enter to conduct rescue or firefighting operations.

SUMMARY

The key to all of these smoke control/smoke management systems is knowing in advance how they operate, what their capabilities are, what impact they will have on fire control or fire spread, and what steps the IC must take to best use these systems. The buildings we are challenged to protect each will have its own unique features.

As the officer in charge, you should work with and coordinate with building maintenance or risk management personnel so that when a fire occurs, you will be able to operate these systems to maximize their capabilities in limiting the spread of fire, smoke, heat, and gases in the building.

Activity 7.1

Where are Smoke Management Systems Found?

Purpose

To identify the types of buildings/occupancies where smoke management/smoke control systems may be found.

Directions

1. Working in your table groups, develop a list of buildings that may be required to have some form of smoke management/smoke control system installed.

2. Write your list on an easel pad and have a spokesperson report your findings to the class.

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Activity 7.2

Smoke Management/Smoke Control

Purpose

To provide examples of strategies and tactics for use under emergency conditions in buildings that contain this fire protection system.

Directions

1. You will be divided into small groups.

2. Read the scenario and identify, with your group, the strategies and tactics to deal with the circumstances described.

3. Remember to employ the RECEO-VS hierarchy of command: rescue, exposure protection, confinement, extinguishment, overhaul--ventilation and salvage.

4. Each group will report on its work to the rest of the class and discuss how effective and workable each strategy or tactic would be for fireground operations.

Scenario

The past few years have seen an explosive growth in digital processing operations. Everything from payroll reporting to photographic imaging has become digital, forcing an incredible dependence on computers and peripherals.

Your community was selected for a huge, secure facility that is the communications center for a multinational corporation that conducts highly sensitive business with government and industry.

Fifteen years ago, the company obtained permits from the municipality to build a massive structure that houses super computers, uninterruptible power supplies, lead-acid wet-cell batteries, diesel-powered generators, and a host of electronic switching gear. The company's call center, which employs about 250 people per shift, operates around the clock.

What makes this building so challenging is that more than 65 percent of the operations are located underground, at least 30 feet below grade. The rest is three stories above grade. Other than a small, glass-front administrative area, all of the building is windowless. The total building area exceeds 4 million square feet.

Fire protection systems in the building include mechanical smoke management that is initiated by smoke detectors spaced throughout the building. The building is protected by a number of wet, dry, and preaction automatic sprinkler systems.

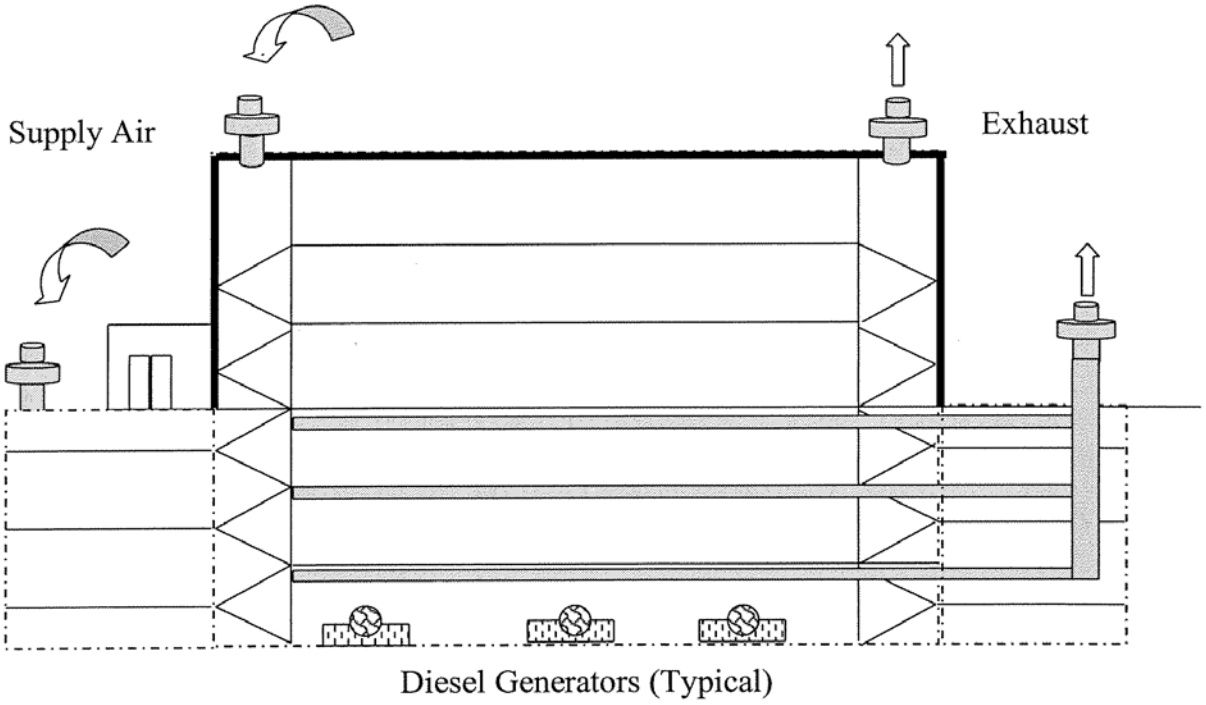
This morning, your communications center received a telephone report that some of the electrolyte from the battery storage room has leaked onto the floor, and the onsite hazardous materials response team is responding to clean it up. In accordance with agency protocols, one engine company from your organization is dispatched to stand by.

When the engine company is a few blocks from the scene, the officer reports a large column of thick black smoke coming from the vicinity of this facility. Within seconds, the dispatcher receives another telephone call from the site reporting that one of the diesel standby generators in the basement started and, when the starter engaged, the electrical spark ignited the hydrogen gas in the battery room. The fire has spread into the generator area and is threatening the diesel fuel tanks, but they are not yet on fire.

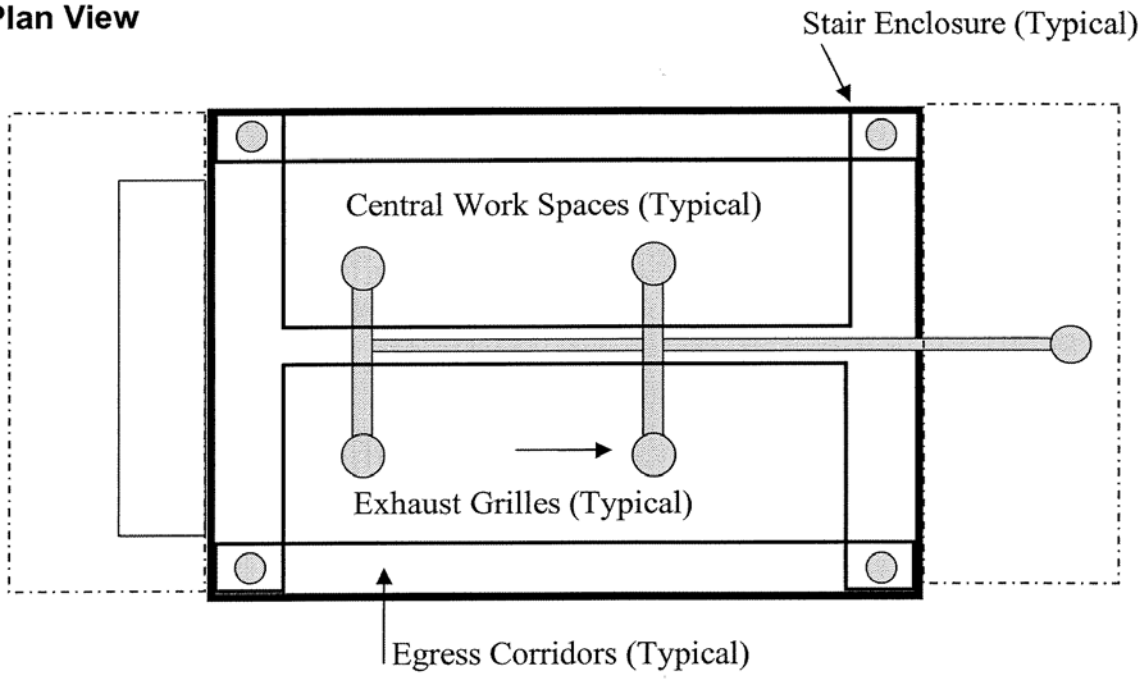
You are to identify objectives, strategies, and tactics to control this event. Refer to the simple sketch on the next page for orientation.

Activity 7.2 (cont'd)

Elevation View



Plan View



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APPENDIX

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Job Aid 7.1

Preplanning Smoke Management Systems

The preincident plan data collection form and preincident plans presented in Unit 3: Preincident Planning Benefits are comprehensive in their own right, but do not include the important elements related to smoke management/smoke control systems.

Job Aid 7.1 can be used as a supplement for the data collection team to identify important details regarding smoke control systems for inclusion in the formal preincident plan.

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Job Aid 7.1 (cont'd)

Smoke Management/Smoke Control

Address: _____ Date: _____ Preplan # _____

Facility/Building name: _____

Prevailing winds/Potential downwind (leeward) exposures: _____

_____

_____

Roof Vents

	Yes	No
Total rooftop coverage		
Special locations		
• Hazardous materials storage areas		
• High-piled storage areas		
Shrink-out plastic		
Fusible link operated		
Manual remote release		

Number of vents _____

Mechanical release methods

- Rooftop _____
- Interior _____
  - Pike pole length needed to reach release _____
- Manual release location(s): _____

  _____

Smoke Control Systems

Fire control room location: _____

_____

Room key located at: _____

Lock box provided: Yes ☐ No ☐

Location: _____

Smoke zone plans provided: Yes ☐ No ☐

Plans stored in: _____

Dedicated ☐ Nondedicated ☐

Pressurization		Yes	No
	Stairs		
	Elevator shafts		
	Elevator lobbies		
	Floor-to-floor (zones)		
	Fire separation to separation (smoke zones)		
	Other (specify)		

Exhaust		Yes	No
	Atrium		
	Warehouse/Storage		
	Other (specify)		

Combination		Yes	No
	Atrium		
	Warehouse/Storage		
	Other (specify)		

Automatic Controls

System initiated by		Yes	No
	Smoke detection		
	Water flow		
	Other (specify)		

Manual Controls

Smoke control: ON-AUTO-OFF

	Yes	No
Stairway pressurization		
Smoke exhaust fans		
Supply fans		
Return fans		
Exhaust fans		
Elevator shaft fans		
Other equipment used for smoke control: (specify)		

Damper control: OPEN-AUTO-CLOSE

Smoke Barrier Locations	Yes	No

Other controls accessible only from fire command center:
ON-OFF or OPEN-CLOSED

	Yes	No

Status Indicator Lights

Status	Preferred Color	Actual Color
Normal status	White	
Off/Closed	Red	
On/Open	Green	
Fault Condition	Yellow/Amber	

Special conditions or comments: _____

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UNIT 8: SPECIALTY SYSTEMS

TERMINAL OBJECTIVE

The students will be able to recognize the role of specialty systems in fire protection.

ENABLING OBJECTIVES

The students will:

1. *Identify five types of specialty fire protection systems.*
2. *Describe where they are likely to be found and how to operate them.*
3. *Describe the types of impairments to the systems that may impede their effectiveness.*

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TYPES OF SPECIALTY SYSTEMS

This unit describes several types of specialty systems, how they work, and where they are found.

Specialty systems may be installed to protect specific areas of a building, or may be located to protect "special" hazards such as dip tanks, paint booths, computer rooms, cooking facilities, or industrial equipment.

Usually, specialty systems are intended to control or suppress a fire in its incipient stage, well before the fire reaches the building's fire sprinklers. Sometimes, specialty systems are used as a substitute for the building's sprinklers, so their reliability and performance is essential to prevent a fire from spreading.

Specialty systems usually are custom-configured to the hazard they protect, and alterations to the system or hazard may render the fire protection useless. For example, in a commercial kitchen, specific nozzles are located to protect specific hazards: deep fryers, grilles, woks, and chain broilers. If a new chef rearranged the cooking line for his or her convenience and did not have the fire protection system rearranged with it, the fire system would be useless. If--while gathering infrastructure protection intelligence--the Incident Commander (IC) or firefighter suspects something has been rearranged, that information should be reported to the building owner and code enforcement official.

Specialty systems also may be arranged to perform additional functions beyond suppression. When commercial kitchen systems operate, for example, they must disconnect all electrical power and shut off fuel gases to all the cooking appliances. Gaseous systems may interconnect with the heating, ventilating, and air-conditioning (HVAC) equipment to stop fans and close dampers. Gaseous systems also may close doors and other partitions automatically to confine system agent.

The IC should be familiar with the performance and operating characteristics of these systems. Gaseous systems, for example, may require the room or space where they discharge to remain tightly closed for some period of time to allow the agent to "soak" the enclosure. Opening a door or window prematurely would cause the agent to escape and, if manual firefighting forces are not prepared, the fire could get out of control.

There also are a number of health and safety concerns with specialty systems, ranging from potential asphyxiation to cardiac irritation. Firefighters and IC's should be familiar with predischarge alarm signals where they are used. In carbon dioxide (CO_2) systems that discharge automatically into an enclosed space, for example, the system must give a 60-second predischarge alarm to allow occupants to escape. When the system is discharged manually, there is no alarm, although the CO_2 may be scented with wintergreen oil to act as an olfactory warning. IC's must insist personnel wear full protective clothing and self-contained breathing apparatus (SCBA) before entering these potentially deadly atmospheres.

Total Flooding and Local Applications

When selecting a specialty fire suppression system, the designer must understand the hazard that is being protected. Generally, specialty systems are divided into two categories: total flooding and local application.

A total flooding application is one in which an entire space must be filled with fire suppression agent. Automotive spray booths, computer and electronic rooms, paint lockers, mixing rooms, and similar three-dimensional hazards are typical total flooding applications. When the fire suppression agent is discharged, it fills the entire space until the fire is extinguished or controlled.

Local applications are limited in scope and often considered "two-dimensional" hazards such as flammable liquid dip tanks, commercial kitchen cooking appliances, part washing machines, conveyors, and printing presses.

In either application, the specialty fire suppression may be the only automatic fire protection available. IC's should be familiar with the operation of this equipment and be prepared to use it as an alternative to traditional manual firefighting techniques.

Halon™/Clean Agent

Halon™ and Halon™ replacement agents are used in the protection of computer centers, archives, aircraft facilities, and other installations where normal firefighting agents would result in more damage than that caused by the fire itself. Halon™ interrupts the flame feedback reaction and interrupts the fire triangle (depletes oxygen) to smother the fire, including the chemical chain reaction. Halon™ agents are used in 3 to 5 percent concentrations, and these concentrations are sufficient to lower oxygen levels to the point where a firefighter breathing apparatus is essential.

The agents normally used in these systems are Halon™ 1211 and 1301, the latter primarily found in total flooding systems. In recent years other inert gas agents that are various combinations of nitrogen, carbon dioxide, and argon have replaced the halogenated agents. The replacements are a result of concern for ecology.

After years of study, in 1989 scientists and governments adopted the "Montreal Protocol" that banned the production and use of chlorinated fluorocarbons (CFC's) because of the potential environmental damage to the Earth's ozone layer. Halogenated fire extinguishing agents are a member of the CFC family, so their production was halted, and their ongoing use was limited to very special applications where Halon™ alternatives were not available.



Figure 8-1
Halon™ Cylinders



Figure 8-2
Halon™ System Discharge Nozzle

Halons™ are most effective on Class B and C fires, but have limited effect on Class A combustibles. There is no specific size for Halon™ cylinders, and they may be from 5 to 600 pounds each. There is also no standard color for these containers. Depending upon the size of the system, the cylinders may be banked together. They are pressurized with nitrogen, and the only effective means of telling whether they are full is by their weight.

The cylinders are equipped with one or more release valves. The valves may be activated hydraulically, pneumatically, mechanically, or electrically. Most are electrically activated in response to smoke or heat detectors. These detectors are usually cross-zoned or addressable, and the system requires a response by more than one detector to reduce the chance that the agent will

be released accidentally. The master panel for the system should be located in an area separate from the system itself.

Halon™ systems also are equipped with manual release controls located near exits to the area under protection. Some systems may be equipped with abort switches; however, these are not recommended. (An abort switch gives a human observer the opportunity to stop the system's automatic operation.)

Before release of the agent, the system is required to give a prerelease warning by means of audible alarm and visual signal. The prerelease alarm is intended to warn occupants that they should leave the space before the agent is discharged. The alarm warning indicates a 15- to 20-second delay before the system is activated.

Clean Agents

Fire protection engineers and product manufacturers have been searching for a "drop in" Halon™ replacement, one in which they can replace the agent tanks but keep the Halon™ discharge pipe and nozzles. So far, the industry has not succeeded in that effort but has developed alternate fire protection chemicals called "clean agents."

There are a variety of products on the market, but among the most common are Halotron®, FM 200®, and Inergen®. A chemical "cocktail" (one agent is made from heptafluoropropane, and another is a mixture of nitrogen, argon, and carbon dioxide), clean agents are electrically non-conductive, leave no residue, and have health effects similar to the halogenated agents.



Figure 8-3
Clean Agent Storage Tank



Figure 8-4
Clean Agent Release and Abort Switches



Figure 8-5
Clean Agent Distribution Nozzle

The fire suppression is performed by lowering the oxygen content of the protected area to a point sufficient to sustain human life but insufficient to support combustion. Typical applications for clean agents are computer centers, tape storage centers, telephone exchanges, remote cellular sites, process control rooms, medical diagnostic rooms, and magnetic resonance imaging (MRI) scanners, plus many others.

When properly designed, clean agent systems will extinguish surface burning fires in Class A, B, and C hazards by lowering the oxygen content below the level that supports combustion. One product, Inergen®, also has been tested by Factory Mutual Research Corporation (FM) for its ability to create inert atmospheres in the presence of hazardous materials. Those tests have shown that the agent, at design concentrations between 40 percent and 50 percent, has successfully rendered inert mixtures of propane/air and methane/air.

The systems can be actuated by detection and control equipment for automatic system operation along with providing local and remote manual operation as needed. Accessories are used to provide alarms, ventilation control, door closures, or other auxiliary shutdown or functions. When the agent is discharged into a room, it introduces the proper mixture of gases that will allow a person to breathe in a reduced oxygen atmosphere.

Carbon Dioxide

CO_2 has a long record of successful fire control. These systems are found in kitchens, printing presses, marine environments, and areas similar to those where Halon™ or clean agent systems

might be found. CO_2 is used as a smothering agent. It is effective on Class B and C fires. These systems also can be found as total flooding types, but are more likely to be encountered as local application systems.



Figure 8-6
Warning Signs for CO_2 Discharge

The detection system used with carbon dioxide may be either rate-of-rise or fixed temperature type detectors, although in certain applications other types of detectors may be used.



Figure 8-7
Carbon Dioxide Nozzle

The systems may be operated automatically, manually, or have available an emergency operating mechanism, should the other two devices fail to operate. CO_2 systems also must employ a predischarge warning alarm because the gas displaces the oxygen in the atmosphere, making the

environment unable to support life. The manual emergency operating system, though, does not give advance warning to those in the protected spaces prior to activation.

Dry Chemical

Useful in combating Class A, B, and C fires, these systems normally are used in industrial applications. Quench tank or dip tank applications, spray paint areas, and hood-and-duct assemblies in commercial kitchens are the most predominant areas where dry chemical systems will be encountered. They may be local application or total flooding systems. The local application system would be designed to apply the agent to a specific surface area. They present cleanup and residue problems when discharged.

The dry chemical system may be small or large, depending upon the design specifics for the area to be protected. They may be released by fusible links or a detection system. Dry chemical systems also are equipped with manual release devices. Like any other specialized system, a prerelease warning allows persons in the area to evacuate before the agent is applied to the area.



Figure 8-8
Dry Chemical Nozzle Clogged with Agent

For years, dry chemical was the agent of choice in commercial kitchens. However, in recent years, fire protection professionals have identified two changes that are of concern: the dietary switch from lard to vegetable oils for cooking, and improvements in deep fryers that retain heat longer. Research shows the vegetable oils have a higher flashpoint than animal fats, and dry chemical agents (usually sodium bicarbonate) may not control a fire in them.

Dry chemical systems are no longer approved for commercial cooking equipment that uses vegetable oils, but firefighters may find them still used in older installations. If the IC or firefighter suspects cooking media have been converted to vegetable oils, and the facility still employs a dry chemical suppression system, that information should be reported to the building owner and code enforcement official.

Wet Chemical

To overcome the problems identified with dry chemical systems in commercial cooking installations, wet chemical systems often are employed. The liquid in the wet chemical absorbs heat, and the resulting foam smothers heated fuel vapors. Wet chemical systems excel at extinguishing fires in commercial cooking hoods and the associated ductwork. When discharged, they are extremely messy and require extensive cleanup before the area is usable again.

The agents used are normally a solution of water and potassium carbonate or potassium acetate. The agent is applied in a spray pattern and forms a soap when it reacts with the animal or vegetable oils used in cooking. The process is referred to as **saponification**.



Figure 8-9
Wet Chemical Nozzle with Protective Plastic Cover

Wet chemical systems are activated either by manual release, fusible links, or heat or rate-of-rise detection devices. In commercial kitchens where wet chemical systems are installed, the IC likely will find an unusually shaped portable fire extinguisher that looks like a bug sprayer with a wand. This is a "K-rated" extinguisher to be used to fill in gaps that may occur in the soapy foam blanket.

Although not common in smaller applications, automatic sprinklers also can be installed in commercial cooking facilities. There are specially designed sprinklers to prevent excess splashing of the hot cooking oils and grease.

Automatic suppression systems in commercial cooking applications are more and more frequently required to interconnect with the building fire alarm system, if it has one, so the fire department may get earlier notification of a kitchen fire.

If a wet or dry chemical suppression system operates in a commercial or institutional kitchen, the local health authority should be notified. Some agents are incompatible with food products, so the kitchen inventory may have to be discarded.

Water Mist Systems

Relatively new to firefighting, water mist systems were developed as a possible alternative to sprinklers and gaseous agents. Water mist systems use finely divided water particles to absorb heat and control a fire. The microscopic-sized water droplets are effective because they have a relatively large surface area that easily converts to steam and quickly absorbs heat.

There are both high- and low-pressure systems (ranging from 70 to 4,000 pounds per square inch (psi)) in the marketplace; both operate on the same principle as preaction or deluge systems and use the same detection systems to activate them. Heat, smoke, or, in some cases, flame detection devices may be used to operate the systems.

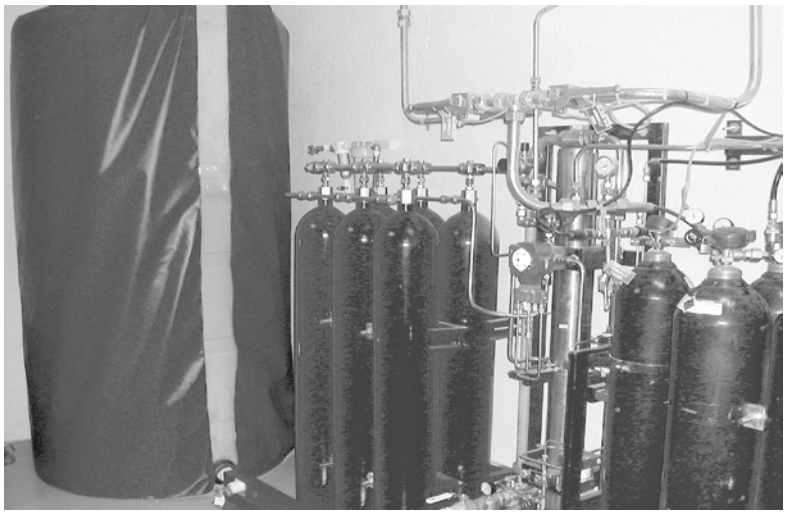


Figure 8-10
High-Pressure Water Mist System with Back-up Supply Tank

Since water is the agent used by mist systems, they are installed for all classes of fire, and can be used where humans are present, without undue danger of asphyxiation or poisoning, which is not the case with chemical agents. Mist systems can be used around energized electrical components, such as transformer bays, electrical service rooms, and computer data centers. They are finding applications aboard ships and aircraft, and their uses in residential and commercial applications are being explored. One leading hotel chain is researching the use of

high-pressure water mist in residential applications, and also has installed one system in a Jefferson, Maryland, fire station as a prototype project.



Figure 8-11
High-Pressure Water Mist Discharge Nozzles

Refer to NFPA 750, *Standard on Water Mist Fire Protection Systems,* and the *NFPA Fire Protection Handbook* for indepth information concerning mist systems. It is likely that the fire service will encounter many more of these in new construction, as well as retrofits replacing other systems. The design and installation of these systems is very sophisticated, so the fire service should spend time with installers and service technicians to learn more about them. Furthermore, NFPA 750 requires low-pressure water mist systems (less than 175 psi) be outfitted with fire department connections to serve as an adjunct water supply, so the IC will need to identify those connections and any special operating pressures associated with them on the preincident plan.

IMPAIRMENTS/OPERATIONAL READINESS

Once they have been activated, none of the systems described above is restorable by fire service personnel. Systems must be recharged and restored by technicians from the manufacturer or authorized agent. The dry and wet chemical systems require specialized cleanup contractors to remove the agent once it has been discharged. Any time a specialty fire suppression system operates, the IC should notify the building owner and code enforcement official.

Pull Stations

Pull stations should be free of obstructions, well marked, and easily reachable in the event the system must be activated by human intervention. Pull stations should be located in such a

manner that the person activating them will not be exposed to the agent, or have the means of egress from the space either too far or filled with agent before exit can be made.

Owners and operators of commercial kitchens often tell their employees to "never touch" the manual release, so staff may be reluctant to do so for fear of the resulting mess. If the fire cannot be controlled by portable extinguishers, the manual release should be the next course of action. (The manual release requires up to 40 pounds of pressure to operate it, and the operating cable may be as long as 14 inches, so don't hesitate to give the manual release a good yank.)

Nozzle Clearances/Obstructions

Firefighting systems are impaired or rendered useless if the nozzles are obstructed or damaged in any manner. Design specifications for the system will include required clearances for any discharge orifices, as well as the area covered by each nozzle. There are too many nozzle styles to cover indepth and each is designed to distribute agent in a different manner.

Rearrangement of the Hazard

In most cases, objects impeding the operation of fire protection systems may be moved easily to provide proper operation of the system. These things should be considered during facility surveys or onsite inspections. Nozzles that are too close to tanks or the surface they are protecting may cause problems due to the pressure at which the agent is delivered to the nozzle. Proper clearance and sufficient open area around the nozzles is vital to the operation of the protection system.

DANGERS AND PROBLEMS ASSOCIATED WITH SPECIALTY SYSTEMS

Specialty firefighting systems, because of the materials they use, may create potentially dangerous problems for firefighters if they are not made aware of them before they encounter such systems.

Wet chemical systems may create hazardous footing because the materials are soapy and result in slippery conditions on floors. Dry chemicals may cause inhalation problems, and the various chemicals used could have different effects on anyone who may ingest or inhale the agents. Halons™ reduce oxygen content in the areas in which they are released; in some cases the heat of the fire and the chemical reaction of the agents with the burning materials may break down the agents or combine chemically with the fuel, releasing products like chlorine gas. CO_2 and Halon™ replacements also reduce the oxygen content of areas in which they are used. Firefighters should be made aware of these possible dangers and act accordingly.

STRATEGIC APPLICATIONS RELATED TO SPECIALTY SYSTEMS

Specialty systems can be a significant aid to the IC, but they do have strategic and tactical limitations that should be considered.

Since specialty systems are employed to protect specific hazards, the preincident planning effort should identify these conditions clearly (see Job Aid 8.1). The survey team should establish the nature and extent of hazard (e.g., flammable liquid dispensing, spray booth, dip tank) and the type of protection that is provided. This may very well be the most hazardous operation within the building or facility.

Specialty systems typically are installed to protect only a limited area, and not designed to provide suppression throughout an entire building. Specialty systems--especially Halon™ and clean agents--may be installed to protect highly valuable materials such as data processing or records. These spaces may be more valuable to the property owner or occupant than is the rest of the building. The preincident plan should describe clearly the extent of protection provided by the specialty system.

Most specialty systems provide "one shot" at fire suppression. Once their agent is discharged, there may be no backup equipment or agent to continue fire control until the fire forces arrive. In other cases, depending upon the value of the hazard being protected, special hazard systems may have redundant agent supplies or be backed up by automatic sprinkler systems. Both of these conditions should be identified on a preincident plan, and the IC should prepare to deal with either contingency: a fire that isn't controlled by the fire suppression equipment or a sprinkler system that must be supported.

TACTICAL APPLICATIONS RELATED TO SPECIALTY SYSTEMS

When responding to a fire involving a specialty system, sizeup is an important consideration. The fire suppression system may or may not have operated by the time the fire department arrives. The IC should have all the facts regarding the equipment before a decision is made to attack the fire manually, or try to use the built-in fire protection system as a first choice. Don't hesitate to let the system work as designed.

Manual Operations

Once the decision is made to use the fire protection system, the IC or firefighter assigned to operate it must understand how to effect manual operation. This may be accomplished by a push button or pull cable. Push button releases normally will be colored red. If the system operates with a pull cable (like a commercial kitchen range hood system) don't hesitate to give it a strong pull. Most are designed to operate with a pull of at least 40 psi, and the operating cable may be as long as 14 inches from the wall.

Halon™, clean agent, other gaseous systems may have an **abort** switch located near the manual release. This should not be used unless the fire has been confirmed to be extinguished.

Total Flooding Applications

For total flooding applications, be sure to maintain the integrity of the enclosure, especially for gaseous extinguishing agents. Make certain HVAC equipment to the space is turned off, and doors, windows, shutters and other openings are closed to confine the extinguishing agent. One exception is those systems (like commercial cooking or spray booths) where the extinguishing agent must be drawn up into or through a long run of duct by the exhaust fan. Do not enter spaces where extinguishing agent has discharged until you are prepared to attack the fire or confirm it is extinguished.

Be prepared with adequately sized handlines to attack the fire in case the specialty system does not extinguish the fire. Portable fire extinguishers also may be an option to consider, depending upon the nature of the hazard. If the specialty protection is provided by a water mist system, be sure to hook to the fire department connection to support the system.

Firefighter Risk

Always wear full protective clothing, including SCBA. Specialty systems have inherent risks, including oxygen depletion, cardiac irritation, fine particulates, and toxicity.

Verify that utility service--natural gas, propane, or electricity--is disconnected from the hazard that is protected. These utilities may cause flammable vapors to reignite.

Restoring the System

After the fire is extinguished and satisfactory overhaul is performed, notify the building owner and occupant that the fire protection system has operated and that a service technician will be needed to restore service. Be sure to notify the appropriate code enforcement official so he or she can schedule a followup inspection.

SUMMARY

Specialty fire protection systems play an important role in fire protection. They may control or suppress a fire in its incipient stage, or keep it from spreading to the point where the building's sprinkler system operates. Knowing their abilities and limitations is an important addition to a pre-incident plan strategy.

Specialty systems are designed and engineered to protect specific hazards. If an IC or firefighter has questions about the system configuration or level of protection, he or she should consult a qualified fire protection technician or fire inspector to obtain additional information.

IC's should not hesitate to use specialty fire protection systems as a first line of defense, yet be prepared to back them up as needed to achieve fire control and suppression.

Activity 8.1

Operational Considerations for Commercial Kitchen Systems

Purpose

To employ specialty fire protection systems and equipment to achieve incident objectives, and to describe the strategies and tactics used to achieve those objectives.

Directions

1. Working in table groups, review the following scenario. After you have read it, discuss it with each other.

2. Identify and describe your incident objectives, explain your strategies to achieve those objectives, and describe the tactics you would employ to achieve successful results.

3. List your group's findings on an easel pad, and select a spokesperson from your group to report your recommendations.

Scenario

Bobbie's Bistro and Blues is a favorite local hangout, noted for its friendly atmosphere, cold drinks, and homestyle cooking. Bobbie's deep-fried chicken and home fries are famous in the region, and people come from miles around to enjoy the food.

Most of the locals call Bobbie's a "joint." Its old exposed wood-frame construction and run-down appearance are part of the image that Bobbie cultivates for her customers. The one-story, nearly square-shaped building measures about 4,200 square feet.

Bobbie always has been cooperative with the fire inspection division, making timely corrections to any code violations. The most recent inspection occurred 3 weeks ago, and the fire inspector noted the following items:

1. The wet chemical fire suppression system in the range hood was due for its 6-month service.

2. The hood-and-duct system was missing some of the grease collection filters.

3. The hood-and-duct system is due for a cleaning.

4. Two of the deep fryers have been moved from their original location and now are not protected by the fire suppression system nozzles.

The kitchen cooking line is more than 40 feet long, and includes two chain broilers, three griddles, eight deep fryers, four grilles, and two woks. Energy sources for the cooking equipment include liquefied petroleum gas (LPG) and electricity. The fire suppression agent cylinders and control for the wet chemical agent are mounted 8 feet above the floor on the wall next to the exhaust hood. The remote manual pull is on the wall adjacent to the kitchen service door. The Class K-rated extinguisher hangs on the wall next to the remote manual pull, and several 2A-20BC extinguishers are distributed throughout the restaurant. These are the only fire protection devices in the building.

At about 0830 this morning, Bobbie opened the restaurant to prepare for the lunch crowd. In the kitchen, she started turning the cooking appliances on to warm them before the rest of the staff arrived. She also switched power on to the exhaust system.

A few minutes later, the bread delivery truck arrived at the kitchen service door, and Bobbie went out to chat with the driver. When she returned, Bobbie saw a fire at one of the deep fryers. The fire was growing rapidly, climbing the wall behind the cooking line, and spreading into the exhaust duct. Bobbie immediately closed the service door, and she shouted to the delivery truck driver to call 9-1-1 on his cell phone.

You are the first-arriving engine company, and you observe heavy black smoke coming out of the exhaust duct on the roof. As you look inside the service door, you can see the fire is confined to the cooking equipment, the wall behind, and the exhaust hood, but it is continuing to grow.

As IC, you must

1. Describe your objectives.

2. Explain your strategy to accomplish your objectives.

3. Describe your tactics.

4. Identify which built-in fire protection systems you would employ to aid your efforts, and how you would employ them.

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Activity 8.2

Strategic and Tactical Considerations for Specialty Fire Protection Systems

Purpose

To employ specialty fire protection systems and equipment to achieve incident objectives, and to describe the strategies and tactics used to achieve those objectives.

Directions

1. Working in table groups, review the following scenario. After you have read it, discuss it with each other.

2. Identify and describe your incident objectives, explain your strategy to achieve those objectives, and describe the tactics you would employ to achieve successful results.

3. List your group's findings on an easel pad, and select a spokesperson from your group to report your recommendations.

Scenario

Nana's Snacks is the largest snack food producer in your State. Their main plant, which is located on the outskirts of your first response area, produces pretzels, potato chips, corn chips, pork rinds, and Nana's Famous Cheezee-Bites.

As Nana's success has grown, so has the plant. Originally constructed in 1947, the building has been expanded and remodeled more than four times. It now comprises a mix of construction types, production lines, and storage and distribution areas. Fire protection levels vary depending upon when each addition was constructed.

The original 1947 plant has been converted into corporate offices with a small retail outlet. Student groups visit from time to time to tour the plant to see how their favorite snacks are made. In 1953, the first plant expansion occurred: a monolithic concrete building that was built for storage and distribution, but now handles raw materials for the first stage of production.

Raw materials include wheat and potato flour, salt, flavorings, corn meal, and hydrogenated vegetable oils stored in 55-gallon plastic drums. There is no high-piled or rack storage in this building.

A major plant expansion occurred in 1976 with the addition of an ordinary construction building to house two high-volume potato and corn chip production lines, a 20,000-gallon open-top vat of liquefied vegetable oil, and work areas where raw materials are prepared for cooking. The

cooking lines, called "tunnels," and the surface of the vegetable oil tank are protected by an automatic carbon dioxide fire suppression system. Four low-pressure CO_2 tanks and the control mechanism are located along the west wall of the building. The tanks also have a manual release located in a cabinet on the outside wall.

Automatic or manual operation of the CO_2 system is designed to cause the production line to stop, all HVAC systems to shut down, and the overhead fire doors to close, confining the CO_2 to the 1976 building. However, there is no record of this equipment ever being tested to see if it really works.

The 1976 building also is equipped with a dry pipe sprinkler system. Likewise, there is no record of this equipment ever being tested to see if it really works.

The 1984 building is used as a mix of postproduction and storage. Once the cooked chips leave the tunnels, they are bagged and put into cardboard boxes. The bulk bags and flattened boxes are stored in the 1984 building. Once bagged and boxed, the chips are stacked on pallets, banded with plastic wrap, and taken by forklift to the 1998 building.

There is an open breezeway with a steel canopy over the doors between the 1984 and 1998 buildings. The newer building is used for product storage and distribution. It has a 26-foot-high ceiling, and there is rack storage of boxed chips to 22 feet. The building is protected by a wet pipe sprinkler system.

The total ground floor area of the combine structures is about 356,000 sq. ft. The building is approximately 100 feet wide on Williams Street, and extends about 350 feet deep from the street.

During the day shift, there are about 18 employees in the office and retail outlet. The rest of the facility employs 48 to 52 persons per shift, and the production lines run 24 hours a day.

Your dispatch center has received a telephone report that a high-pressure hydraulic-type line containing liquefied vegetable oil has ruptured near the south cooking tunnel. The caller describes "high-pressure jets of fire shooting" around the tunnels. The caller reports heavy black smoke rapidly filling the 1976 building, but then the telephone line is disconnected. The dispatch center also reports it is receiving numerous cell phone calls of heavy black smoke in the area of Nana's.

The communications center dispatches a first-alarm assignment in accordance with the preincident plan. You are the officer on the first unit that arrives 6 minutes after the alarm is dispatched.

As IC, you must

1. Describe your objectives.

2. Explain your strategy to accomplish your objectives.

3. Describe your tactics.

4. Identify which built-in fire protection systems you would employ to aid your efforts, and how you would employ them.

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Activity 8.2 (cont'd)

Quick Access Prefire Plan

Building Address:
2626 Williams Street

Building Description:
One-story, mixed construction

Roof Construction:
Mixed, most covered with asphalt and pebbles

Floor Construction:
Concrete slab

Occupancy Type:	**Initial Resources Required:**
Snack food production and storage	*3 E, 2 T, 1 BC, 1 Ambulance*

Hazards to Personnel:
High voltage electrical, high temperature cooking lines, pinch hazards

Location of Water Supply:	**Available Flow:**
Hydrants on all sides	*2,600 gpm*

	Estimated Fire Flow			
Level of Involvement	*25%*	*50%*	*75%*	*100%*
Estimated Fire Flow	750	1,500	2,250	3,000

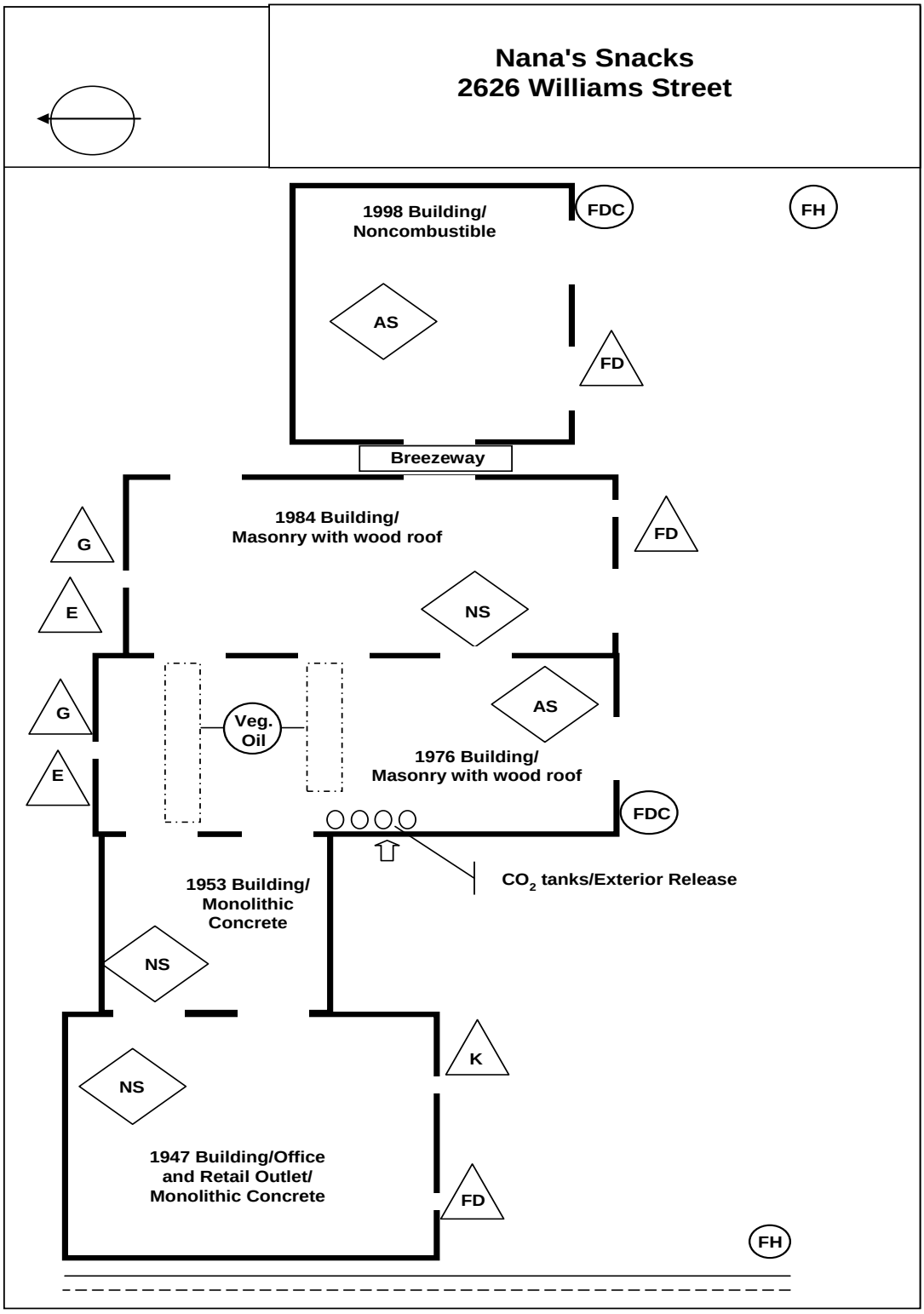
Fire Behavior Prediction:
Mixed construction types, partial sprinklers, lots of wall openings

Predicted Strategies:
Confine fire to area of origin with fire doors and hose streams

Problems Anticipated:

☐ **Standpipe:** *No*	☒ **Sprinklers:** *Partial*	☒ **Fire Detection:** *Water flow only*

Plot Plan


Nana's Snacks
2626 Williams Street
1998 Building/
Noncombustible
FDC
FH
AS
FD
Breezeway
1984 Building/
Masonry with wood roof
FD
G
E
NS
AS
G
Veg.
Oil
E
1976 Building/
Masonry with wood roof
FDC
CO2 tanks/Exterior Release
1953 Building/
Monolithic
Concrete
NS
K
NS
1947 Building/Office
and Retail Outlet/
Monolithic Concrete
FD
FH

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_____. *Fire Protection Handbook*. 19th ed. Quincy: Author, 2004.

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APPENDIX

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Job Aid 8.1

Preplanning Specialty Fire Protection Systems

The preincident data collection form and preincident plans presented in Unit 3: Preincident Planning Benefits are comprehensive in their own right, but do not include the important elements related to specialty fire protection systems.

Job Aid 8.1 can be used as a supplement for the preincident planning team to identify important details regarding specialty fire protection systems for inclusion in the formal preincident plan.

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Job Aid 8.1 (cont'd)

Specialty Fire Protection Systems

Address: _____ Date: _____ Preplan # _____

Facility/Building name: _____

Protected hazard: _____

Location: _____

Type of specialty system:

	Yes	No
Halon™		
Clean agent		
Dry chemical		
Wet chemical		
Carbon dioxide		
High/Low pressure water mist		
Other: (specify)		

Total flooding or spot application: _____

Operational features:

	Yes	No
Must the protected room or space remain closed?		
If yes, HVAC controls are at:		
Are safety warning signs posted?		
Does the system release automatically?		
Is there a manual release?		
If yes, location:		
Is there an abort switch?		
If yes, location:		
Does the specialty system have a backup supply of identical agent?		
If yes, does it operate automatically?		
Is the specialty system supplemented by automatic sprinklers?		
For **water mist** systems:		
Is there a fire department connection?		
If yes, location:		
Recommended pumping pressure at connection:		psi

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UNIT 9: INTEGRATED SYSTEMS AND PERFORMANCE

TERMINAL OBJECTIVE

The students will be able to explain how the systems described in previous units are integrated into interdependent systems.

ENABLING OBJECTIVES

The students will:

1. *Define integrated systems.*
2. *Describe the inputs and outputs of fire control system components and their activation sequence.*
3. *Describe how knowledge and use of fire protection systems relate to Homeland Security National Preparedness goals.*

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INTEGRATED SYSTEMS

It is becoming more commonplace to find that two or more systems within a facility are related directly to the fire alarm system. In fact, the model codes require such systems in some buildings. Upon activation of one fire protection system, the integrated systems will work together to assist in fire control or to enhance life safety.

Purpose of Integrated Systems

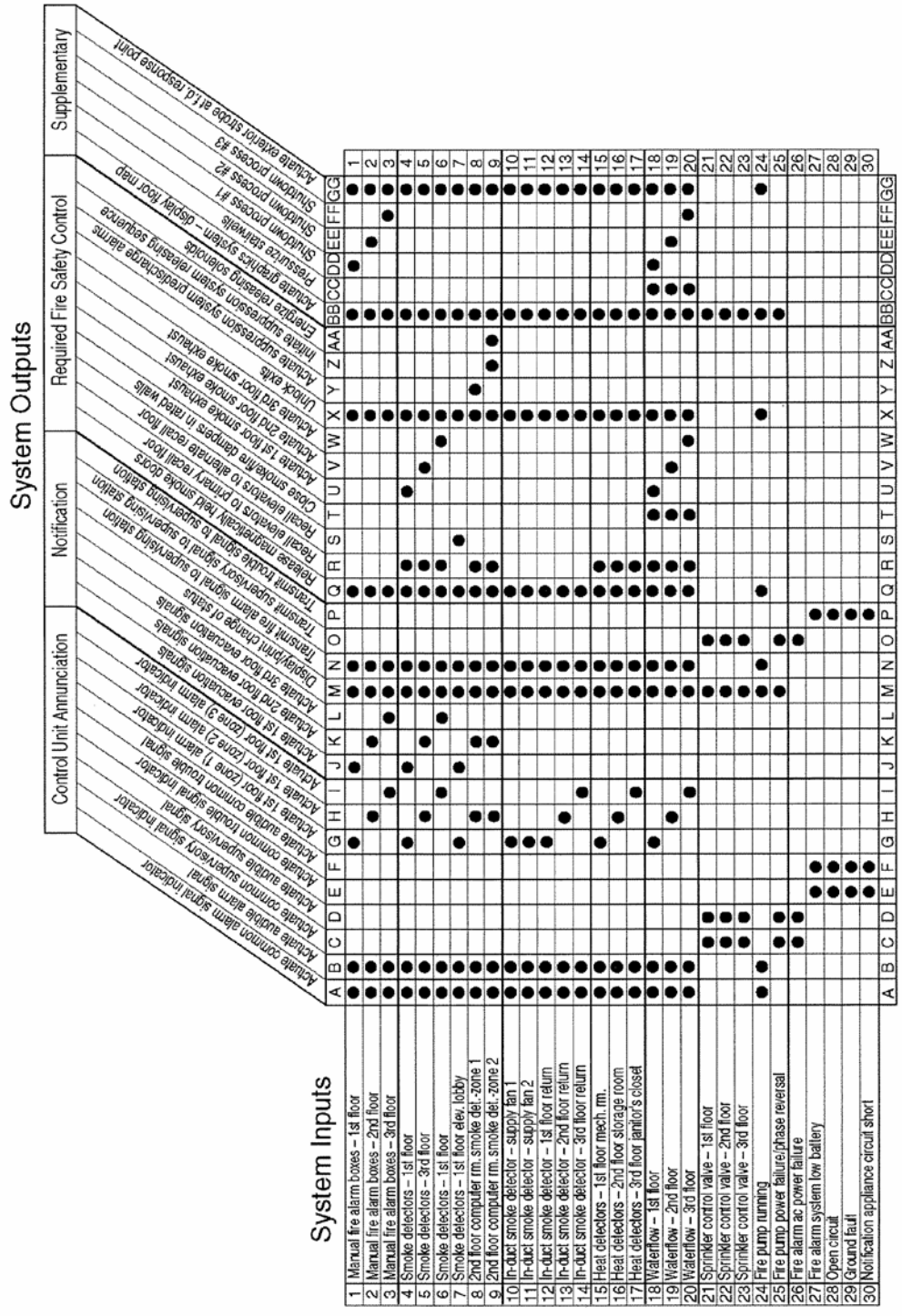
Integrated systems provide automatic operation and control of many of the fire and life safety components of a building, especially those that have been discussed in this course. The most prevalent application of this concept is found in highrise buildings and institutions.

Integrated systems can be highly sophisticated and require a significant level of attention to detail by the designer, installer, building owner or occupant, and the code enforcement official to ensure that they operate in the way they are intended. Once installed, they must be tested and maintained regularly to ensure that one or more components has not failed, resulting in ineffective operation of the life safety and fire protection features.

The fire protection features also may be integrated with the structure's security and environmental control, which add another level of complexity to the design and maintenance.

The fire alarm system operational matrix, also called an input-output matrix, is shown in Table 9-1. It provides an example of how complex these systems can be. The input-output matrix typically is used by the fire alarm system designer and code enforcement inspector to verify the system performs as designed.

Table 9-1
NFPA System Inputs and Outputs*



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For example, in this particular integrated system layout (Table 9-1), look at System Input No. 19 in the left-hand column. This is a second-floor water-flow detector for the sprinkler system. Reading across the matrix from left to right, you see that, when this device operates, the following integrated actions occur

- The common alarm signal is actuated.
- An audible alarm signal is actuated.
- A water flow alarm indicator (Zone 2) is reported to the first floor.
- The attached printer provides an output/status change report.
- The alarm signal is transmitted to the supervising station (central alarm receiving point).
- Magnetically held-open smoke doors are released.
- Elevators are recalled to the primary recall floor.
- Smoke/Fire dampers in rated walls close automatically.
- The second-floor smoke exhaust system is actuated.
- Exit doors are unlocked.
- The remote graphic annunciator panel is illuminated.
- Egress stairwells are pressurized.
- Industrial Process Number 2 is shut down.
- An exterior strobe light is illuminated.

This sample matrix from National Fire Protection Association (NFPA) 72, the *National Fire Alarm Code*®, represents a relatively simple project. You can imagine the complexity of integrating major systems in large buildings or facilities. Furthermore, minor modifications to a system over time, or failure of any of the components, may cause the integrated systems to fail to achieve their design objectives.

It is critically important that the Incident Commander (IC) knows about the integrated systems and how they work. This information must be collected beforehand, and added to the preincident plan in a way that is easily interpreted and used.

The key to understanding integrated systems is to contemplate their strategic design objective: Why were the systems connected together in the first place? Certainly, there are many buildings with independent fire protection systems such as separate fire alarm, standpipe, and specialty

systems. IC's should work closely with their local code enforcement officials to obtain background information. Is the design strategy to achieve life safety? Must the occupants be "defended in place" because they are incapable of self-preservation? Is property protection or continuity of operations the greatest concern?

Generally, when the life safety or property protection strategy is more complex, the integrated fire protection features will be more sophisticated and complex. Remember from Unit 1: Purpose of Fire Protection Systems that these devices may be installed for more than just fire suppression or detection.

FIRE COMMAND CENTERS/FIRE CONTROL ROOMS

Under the recent model codes, highrise buildings and some other large occupancies are required to have a **fire command center**, from which most of a building's systems can be managed and controlled. Fire command centers also may be known as **fire control rooms**.

Fire command centers can be, and have been, installed in other types of buildings, such as large underground buildings. Knowledge of these buildings and how these system components work together is an important infrastructure protection intelligence activity. Control rooms are becoming more common as new structures are being built, or as older structures are renovated. The fire control room may be integrated with the building security function and greatly enhances the operation of the fire department incident command structure.

By code, the fire command center must be separated from the remainder of the building by not less than a 1-hour fire-resistance-rated fire barrier. The room must be a minimum of 96 square feet, with a minimum dimension of 8 feet, and at least 3 feet of clearance in which the IC and Command Staff can move. In existing or renovated buildings, there may not be space for a room this size.

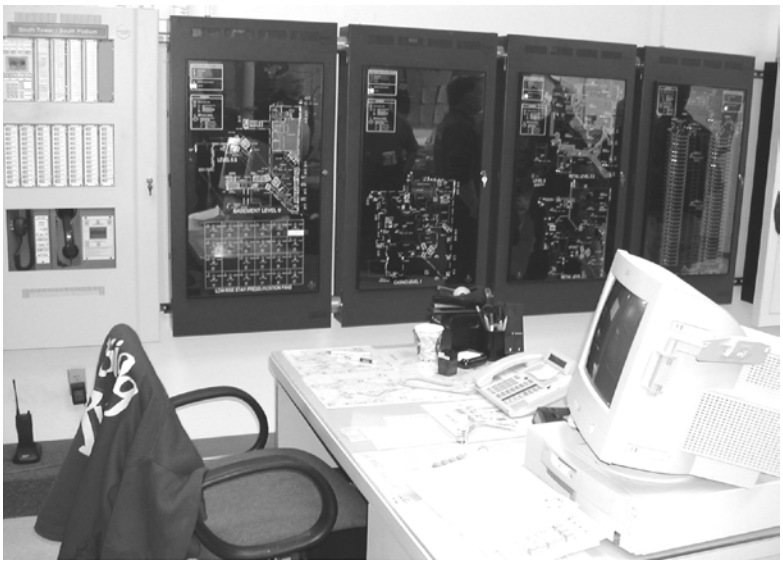


Figure 9-1
Fire Command Center for Highrise Hotel

The fire command center location within the building and the equipment arrangement inside is determined by the code enforcement official. IC's might want to meet with their code enforcement officials to develop a standardized layout for system controls in fire command centers. That way, no matter what the building or incident, the IC can find the controls quickly.

The fire command center must contain the following features:

- The emergency voice/alarm communications system unit, including the public address equipment.

- The fire department communications equipment (firefighters' phones).

- Fire detection and alarm system annunciator unit. The main fire alarm control panel may be located somewhere else, such as an electrical room.

- Annunciator unit visually indicating the location of the elevators and whether they are operational.

  Elevator capture and monitoring can be observed from the fire control room. Communication is available with individual cars. It is possible with some systems to override cars and place them where they are needed from the fire control point.

- Status indicators and controls for air-handling systems.

- The firefighters' control panel for smoke control systems installed in the building.

- Controls for unlocking stairway doors simultaneously.
- Sprinkler valve and water-flow detector display panels.
- Emergency and standby power status indicator.
- A public access telephone for fire department use, with controlled access to the public telephone system.
- Fire pump status indicators and, in many cases, the equipment may also be operated from this area.
- Schematic building plans indicating the typical floor plan and detailing the building core, means of egress, fire protection systems, firefighting equipment, and fire department access. This might be a good place to keep a copy of the facility preincident plan, as well.
- A worktable.
- Generator supervision devices; manual start and transfer features.
- Public address system, where specifically required.

A fire command center is where all the systems listed above can be monitored and managed. It is an essential part of a building's fire and life safety system, and IC's must become very familiar with the location, system components, and how to use these systems effectively.

SMOKE MANAGEMENT/SMOKE CONTROL

An essential fire management component in a building's fire command center is smoke management or smoke control. These buildings are usually zoned so that smoke movement using the heating, ventilating, and air-conditioning (HVAC) systems can be managed through the controls in the fire command center.

Stairwells

Control of pressurized stairwells also is maintained in the control room. By working with building management, engineering, or maintenance, fire officers can become knowledgeable about how these systems operate and how to use them most effectively under fire conditions.

Heating, Ventilating, and Air-Conditioning

The control room allows for the opening and closing of dampers, starting and stopping of HVAC units, and the management of air flow to help create a tenable environment for building occupants.

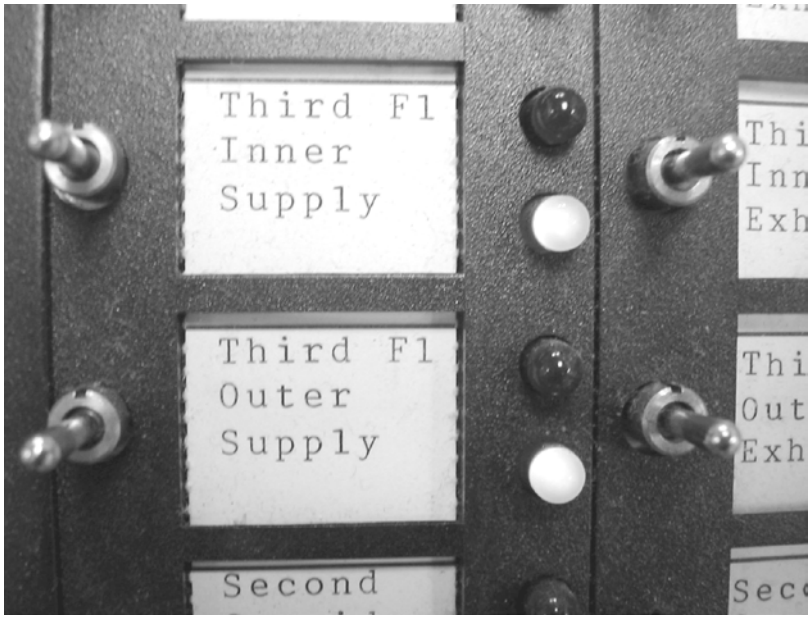


Figure 9-2
Toggle Switches for Smoke Management/Control

Computer Monitoring

These building systems usually are monitored using computer technology that will give ongoing updates on systems status, such as fire alarm activation location, operation of fire pumps and emergency generators, exit stairwell door status (open/closed), fire pump operation, and water flow from fire sprinkler systems.

Communications

These systems allow for voice announcements to be made to building occupants, advising them of the fire situation and whether to evacuate or stay in place for rescue. Because communications using portable radios often can be a challenge in these buildings due to the dense concrete and structural steel, buildings with fire command centers are required to be equipped with an internal telephone (communications) system for use by firefighters. This communication system allows firefighters to talk directly to command personnel in the fire command center, to stay current on building systems' status, and to communicate progress to the IC in firefighting efforts.

OTHER INTEGRATED SYSTEMS

Until recently, the most common application of system integration was the activation of the alarm system when there was water flow through sprinkler heads in a sprinkler system. This could result in an alarm being sounded locally, transmitted to a remote location, and/or to the fire department dispatch center.

Under the requirements of the model codes and NFPA 72, these systems working together have resulted in an early detection of fire, and notification and transmission of a fire alarm in a building protected by these systems.

In recent years, technology has developed the capability for other life safety and property protection actions to take place on the discovery of a fire through fire detection systems.

This may include the closing of dampers in the HVAC system, which will slow the spread of a fire through these systems. It also may include the closure of doors leading to exit stairwells and exit passageways, to provide a safer avenue of egress. It also may cause the smoke control zone concept to activate, to create positive and negative pressure differentials that slow or impede the movement of fire and its toxic products from one area or floor of a building to another.

It also may cause the opening of automatic rooftop vents to allow the movement of smoke, heat, and gases out of the building.

ELEVATORS

There is substantial controversy in the fire service regarding the reliability and tactical use of elevators during fires. To heighten the controversy, there is substantial public interest in using elevators to evacuate highrise buildings quickly, and several groups are researching that challenge to develop recommended safety improvements.

The decision to use elevators during an emergency is a matter for local policy. Elevator performance is discussed here because they are required by safety codes to be integrated with the rest of a building's fire protection features. Three major national standards influence elevator design and operation: American Society of Mechanical Engineers (ASME) A17.1, *Safety Standard for Elevators and Escalators*, NFPA 72, and NFPA 13, *Standard for the Installation of Sprinkler Systems*. The first establishes requirements for safety and operation of elevators, including recall and firefighter service, the second provides rules for integration with the fire alarm system, and NFPA 13 sets requirements for sprinklers in elevator shafts, hoistways, and equipment rooms. (It is important to remember that, as safety codes change, existing equipment may not be required to be modernized. Therefore, these requirements do not pertain to **all** elevators and hoistways. Each installation must be studied carefully and explained on the preincident plan.)

Hoistways are the vertical shafts in which elevator cars travel. In buildings with multiple elevators, all elevator cars in a bank are usually in a common hoistway. Some highrise buildings are

equipped with low-, medium-, and highrise bank elevators--also known as split bank. These are configured so that some elevators serve only lower floors of the building while others serve the upper floors. It is important to know whether or not the building has split-bank elevators and, if so, which floors the different banks serve. This information can be critical to deciding whether it is safe to use the elevator system.

The hoistway is separated from each floor by a hoistway door. This door is opened by movement of the elevator car door (once the car is level with the floor landing). Smoke and heat under pressure at the fire floor can enter the hoistway (even though the hoistway doors are closed) and travel up or down the shaft. If a large volume of fire enters the hoistway shaft, the shaft acts like a chimney and draws the fire upward where the heat may be sufficient to ignite materials on upper floors next to the hoistway. As heat and smoke rise within the hoistway, pressure will force it out the hoistway doors onto the upper floors.

Elevator cars will burn to the point where hoisting cables can fail and cause the car to fall down the shaft. If fire has penetrated an elevator car or the hoistway, it is important that personnel be assigned to floors above and below the fire floor (including the floor where the shaft terminates) to check for spread of fire or smoke.

Almost every highrise building is required to be equipped with elevator emergency service features that automatically move the elevator cars to specific locations under fire conditions. The feature also allows firefighting personnel to place the elevator cars in a "firefighter service" mode that provides specific safety features. Automatic recall may be initiated whenever an alarm device is activated. Manual recall can be done through recall switches located in a lobby control panel or in a fire control room. Automatic or manual recall of elevators (available through firefighter service mode) is important for a couple of reasons.

- It reduces the possibility of occupants being trapped in an elevator car.

- It provides fire department access to elevator cars (if the decision is made to use them).

ASME A17.1 now requires that modern elevators be equipped with "Phase I" and "Phase II" operational features. Phase I recall is arranged to return the elevator car to a designated "homing" floor when a smoke detector in the elevator shaft, lobby, or mechanical room operates. In the event the smoke detector on the homing floor operates, the elevator is sent to an alternate floor. In either case, when the elevator arrives at the specified destination, the elevator car doors open and the elevator cannot be operated without a special key.

Phase II service enables fire service or other emergency personnel to operate the elevators by using a key outside the elevator door and inside the elevator car. Firefighters may, when authorized by local policy, use the elevator to transport personnel and equipment to aid firefighting and rescue.

Phase I (Recall)

Elevator controls are integrated with the fire alarm system as required by NFPA 72 in the following ways:

- Smoke detectors must be installed in each elevator lobby, elevator hoistway, and machine room to initiate Phase I recall. These are the only detectors required to do so. If every smoke detector in a building caused the elevators to recall, all inadvertent fire alarm system activations would put the elevators out of service until they were reset.

- In buildings that don't have a fire alarm system, the detectors must be connected to a fire alarm system control unit specifically manufactured for elevator service. These are known as "elevator recall control and supervisory panels."

- When the elevator lobby, elevator hoistway, or elevator machine room smoke detectors operate, they must report an alarm signal on the building fire alarm system and visually indicate, at the main fire alarm control panel and remote annunciators, the alarm circuit or zone on which the alarm was detected. They do not necessarily sound the building evacuation signal.

- Elevator hoistway and/or elevator machine room smoke detectors must provide "separate and distinct" visible signals at the fire alarm or elevator control panel and annunciators to alert the firefighters and other emergency personnel that the elevators are no longer safe to use.

- Where heat detectors are used to shut down elevator power prior to sprinkler operation, the detector must have both a lower temperature rating and a higher sensitivity as compared to the sprinkler. A sprinkler head rated at 212 °F (100 °C) and a heat detector rated at 135 °F (57 °C) is recommended. These heat detectors must be located within 2 feet of each sprinkler installed in the elevator hoistway and/or elevator machine room.

- As an alternate, some installations use an arrangement called a **shunt trip** that is connected to a sprinkler water flow switch. When the sprinkler opens, the water flow switch signals the elevator controller to stop the elevator car.

- Control circuits to shut down elevator power must be monitored for their operating voltage. If the shutdown circuit loses power, there must be a supervisory signal at the fire alarm or elevator control unit and remote annunciators.

Elevator recall systems must be wired in a way that will optimize the recall performance, and minimize risk to responding fire service personnel. This is accomplished by wiring three separate circuits to the elevator controllers in the machine rooms:

1. In elevator lobbies, the first smoke detection circuit is arranged to keep the recalled elevator from going to the wrong homing floor.

2. The second circuit in the lobby is arranged for standard recall.

3. The third circuit is intended for firefighter safety. It is arranged to bring the elevator cars to the homing floor during Phase I recall, and notify firefighters of smoke in the hoistway or machine room during Phase II service. This third circuit will sound an alarm in the elevator car, warning firefighters to move to a known safe floor and leave the elevator.

NFPA 13 requires sprinklers to be installed at the top of combustible elevator shafts, and in the elevator pit if there is a chance that combustible debris may accumulate there. These sprinklers typically have separate control valves, with attached tamper switches, to stop water flow without shutting off the entire sprinkler system. The location of these valves, and the extent of area they control, should be identified on the preincident plan.

Phase II Operations

For Phase II operations, a relettered two-position keyed switch marked FIREFIGHTER'S SWITCH, OFF, and ON is provided in or adjacent to the operating panel in each elevator car.

Once the elevator is in Phase II operation:

- The elevator is operable only by the person in the elevator.
- The elevator does not respond to the smoke detection system that automatically recalls the car to homing or alternate floors.
- Continuous pressure is required on the **Door Open** button to open the doors. When the pressure is released, the doors will close immediately.
- When fully opened, the doors remain open until closed by pressure on the **Door Close** button or alternatively by pressure on the floor button in the car.
- Doors close and the car starts by selecting a floor call button in the car and pressure on the **Door Close** button, or alternatively by pressure on the floor button in car. The sequence is not important.
- The car will serve floors with floor-access control (such as a penthouse or mechanical floor that is "locked out" to the general public).

Regardless of your agency's policy for elevator use in fires, as an IC you must be familiar with how this important transportation system will--or is expected to--operate during an event. Noting the operations on a preincident plan, and training on them regularly, can prevent confusion and accident during an emergency.

Elevator Operations

Under normal conditions, elevators may be the only practical method of moving between floors in some buildings. Under fire conditions, elevator operation can become erratic and extremely dangerous. Many elevator system control components can be affected by smoke, moisture, and heat, all of which are present during a fire. Control components that can be affected include floor call buttons, electrical contacts located in shaftways, and electrical elements located at the bottom of the hoistway. Light-sensitive systems that keep doors from closing are affected by smoke. A flashlight may be a practical means of activating the door closure mechanism.

Safe use of elevators under fire conditions requires

- knowledge of how elevators work;
- knowledge of the maximum number of personnel to allow into each car (generally five to six people);
- an understanding of what malfunctions may occur (e.g., erratic movement, traveling to unselected floors, traveling to the fire floor, ceasing to operate, doors opening without use of "Open Door" button);
- familiarity with elevator preincident plans, agency Standard Operating Procedures (SOP's), and their use under emergency conditions; and
- a department-wide policy regarding the use of elevators during fire conditions should be developed and adhered to by all department personnel.

Firefighter Service During Fire Operations

Whenever possible, elevators equipped with firefighter service (Phase II) mode should be used for fire operations. The following guidelines should be followed when using these elevators.

- Assure that the elevators have been placed in the "firefighter service" mode.

- First-arriving units initially should avoid (if possible) a firefighter service-equipped elevator that is capable of stopping at all floors. Many converted service or freight elevators are arranged this way and therefore are capable of being affected by fire on any floor.

- Service elevators should be used only after the IC has determined that the fire is not adjacent to the shaft. Experience indicates that many building fires have been found in the service elevator lobby (in piles of collected rubbish). Heat and flame have affected the doors and control wiring of nearby service elevators.

- Personnel should never take an elevator that services all floors in order to travel to a floor above the fire. When assigned to go above the fire via an elevator, choose an elevator that has a blind shaft on the fire floor. A blind shaft goes through the floor, but does not open onto it. If there is no blind-shaft elevator to go above the fire, stair enclosures should be used.

- Remember, a firefighter-service-equipped elevator is not necessarily a "safe" elevator. It still can be affected by heat, smoke, or water entering the shaft.

The decision to use elevators during a fire is one that must be tempered with good judgment. While it is true that using elevators will speed up initial investigation and fire control efforts, a malfunction that causes response to a nonselected floor can result in firefighter deaths. Therefore, using stairs is the safest method of ascending to the fire floor.

The decision to use elevators should be based on assurances that the elevator lobby on any involved floor is safe and that the cars that are used are not physically capable of reaching the fire floor (they belong to a split bank). Fire personnel already on fire floors can confirm that the elevator lobbies on those floors are tenable.

Even when assurances are in place that elevators can be used safely, any additional safety features or procedures should be employed. These include the use of split-bank elevators that terminate at least five floors below the lowest reported fire floor. Only use cars that allow firefighter service. In addition, all personnel riding in elevator cars should wear full protective equipment and have forcible entry tools, a means of communication, an extinguisher, and a knowledgeable firefighter assigned to operate the car.

Even though the elevator may be capable of traveling directly to the fire floor, it is always recommended that all elevator travel cease five floors below the lowest fire floor. Initial fire attack team personnel traveling in elevator cars must be equipped with donned breathing apparatus and facepiece, portable radio, dry chemical extinguisher, forcible entry tools, and portable spotlight. The portable spotlight is to be used in case of lighting power failure. It also can be used to check the hoistway for smoke before use. **If even the slightest amount of smoke is in the hoistway, the elevator should not be used.**

If sound-powered phone jacks are available in the elevator car, they should be placed in service with a sound-powered phone/headset.

Departments that allow personnel to use elevators at emergency incidents should consider the following items as a minimum when developing policies and procedures:

- Only use an elevator car with the firefighter service feature that allows for emergency control of the elevator car. (Note: In older buildings, "firefighter service" is sometimes identified as "firemen service.")

- Consult with the company that installed the elevator. Ask about the machine's features and use.

- Follow all guidelines for split-bank elevators.

Pertinent General Information

- Take time to become familiar with specific elevators before leaving the lobby. Early staffing by one or more personnel who have become familiar with the elevators is important.

- Use stairs whenever possible, and limit elevator use to those in banks that cannot be affected by the fire.

- Consider calling in an elevator repair/service company that provides personnel on emergency duty. Many buildings have these personnel on 24-hour call. The telephone numbers must be posted in the elevator machinery room and often are posted in the vicinity of the elevator lobby.

- Conduct fire department operations using elevators that have been placed in "manual mode" if firefighter service-equipped elevators have not been installed in the building.

- Use all applicable sections of this procedures guide when using elevators in the "manual mode."

  All firefighting personnel should be well trained in the operation of firefighter service controls on elevator cars. The time to conduct this training or to develop department policies regarding emergency use of elevators is not on the day of the fire.

ACTIVATION SEQUENCE

The first link in the chain of integrated systems may be the smoke detection system. With the activation of a detector, an integrated system will transmit the alarm, either to the fire department or to a central receiving station; capture the elevators in a highrise building and return them to the lobby for fire service control; and possibly begin the shutdown of HVAC systems to limit smoke spread.

The second activation usually is sprinklers or other suppression systems as needed to begin the process of extinguishment.

The chain of integration can be as simple as two interconnected systems, or as complex as many systems all connected directly to the fire alarm. In any event, upon activation of the fire alarm system, it becomes the master system and directs the actions predesignated to all other systems connected to it.

LOBBY CONTROL AT THE FIRE SCENE

When the IC arrives on scene, the control panel annunciators will give the status of all systems and allow the IC the flexibility of changing the operation of any or all of them from one central control point.

Strategic and Tactical Considerations

While considering a strategy for fire control in a building that employs integrated systems, it is well for the IC to consider the original design strategy and purpose for the integration. Were the systems integrated to enhance "defend in place" strategies? Were the systems installed primarily to protect valuable property? How will these integrated systems best help the IC achieve his or her own control objectives? It makes sense to use the systems that are provided in the building rather than rely on traditional, labor-intensive fire suppression methods.

Perhaps the foremost successful tactic to be employed with integrated systems is good preincident planning. Knowing which systems exist and how they work together will enhance the IC's confidence in the equipment, and enable the IC to make best use of fire department personnel and equipment as they arrive.

Second, using the preincident plan is crucial to success. The complexity of integrated systems may require the IC to need special personnel or equipment to manage fire operations. The preincident plan should identify those persons or equipment, and prompt the IC to summon them early in the event.

While current practice discourages establishing a Command Post (CP) inside the building that is on fire--or otherwise threatened--it is important for the IC to have a direct and reliable communications link to the inside. That may be the building or campus engineer in conjunction with a knowledgeable person in the fire department. Competent persons should be assigned to the fire command center, the fire alarm control panel, the fire pump room, the elevator machine room, sprinkler risers, smoke control equipment, and any other critical location. Remember, with integrated systems, it is important that they work together.

It also is vitally important that the IC have clear and reliable communications from the fire to the CP. Where applicable, firefighters should be reminded to take firefighter telephones with them as a means of primary or backup communications.

Once the entry team reaches the fire, it should report conditions immediately so the IC can make the most efficient use of the built-in fire protection features.

NATIONAL PREPAREDNESS AND LOCAL PERFORMACE

The September 11, 2001, attacks on America opened an entirely new chapter in fire safe building design and fire protection features. Whether it was the collapse of the World Trade Center buildings due to impact or fire, or the severe damage to the Pentagon, people all over the country began to ask if we are building our structures "safe enough." Integrated fire protection systems and equipment have taken on a whole new importance for the public and IC's alike.

In order to assure America's preparedness and protection from all hazards disasters (natural and manmade), the President of the United States issued Homeland Security Presidential Directive 8

(HSPD-8): *National Preparedness.* The directive gives Federal, State, local, and tribal governments tools to measure if they are "prepared" for major emergencies.

HSPD-8 defines preparedness as "the existence plans, policies, training and equipment necessary at the Federal, State, and local level to maximize the ability to prevent, respond to and recover from major events. The term 'readiness' is used interchangeably with preparedness."

Three major components of HSPD-8 are National Planning Scenarios, Target Capabilities List, and National Priorities. The 15 National Planning Scenarios are hypothetical, yet plausible, disaster scenarios that could occur in any part of the country. Developed by the Department of Homeland Security Office of State and Local Government Coordination and Preparedness, the objective was to develop the minimum number of credible high consequence scenarios needed to identify a broad range of prevention and response requirements. These are not scenarios that might happen "somewhere else, not in my community." As IC's, you should be aware that some of the scenarios involve buildings or facilitates that are equipped with a variety of fire protection features that were discussed in this course. Your knowledge of these features can be applied to mitigate the consequences of these events.

The scenario titles include

- Improvised Nuclear Device;
- Biological: Disease Outbreak--Pandemic Influenza;
- Chemical: Attack Resulting in Explosion of Chlorine Tank;
- Biological Attack: Aerosol Anthrax;
- Chemical Attack: Nerve Agent;
- Biological Attack: Plague;
- Natural Disaster: Major Earthquake;
- Natural Disaster: Major Hurricane in a Port City;
- Radiological Attack: Radiological Dispersion Devices;
- Chemical Attack: Releasing Toxic Industrial Chemicals;
- Chemical Attack: Blister Agent;
- Explosives Attack: Bombing Using Impoved Explosive Device;
- Biological Attack: Foreign Animal Disease--Foot and Mouth Disease;
- Biological Attack: Food Contamination; and
- Cyber Attack.

Target Capabilities

In addition to the disaster scenarios, HSPD-8 describes a Target Capabilities List, a set of 36 essential capabilities that should be developed and maintained, in whole or in part, by various levels of government to prevent, protect against, respond to, and recover from terrorist attacks and major disasters. The list was identified using the Natural Planning Scenarios to identify the critical tasks that would need to be performed across the 15 scenarios.

While many of the 36 essential capabilities affect agencies other than the fire service, some examples related to this course include

- citizens protection: evacuation or in-place protection;
- critical infrastructure protection;
- firefighting operations and support;
- interoperable communications;
- public safety and security response;
- structural damage assessment and mitigation; and
- worker health and safety.

National Priorities

Recognizing that all these capabilities cannot be accomplished overnight, HSPD-8 established "national priorities" to guide the Nation's preparedness efforts to meet the most urgent needs. These national priorities are remarkably similar to the IC's objectives, strategies, and tactics discussed in this course to achieve successful incident outcomes.

The national priorities include

1. Implement National Incident Management System (NIMS) (including the Incident Command System (ICS)) and National Response Plan (NRP) to enhance coordinated efforts. (The NRP is the Federal government's plan on how its various agencies will respond to incidents of national significance.)

2. Expand regional collaboration through mutual-aid agreements and assistance compacts to meet target capability levels.

3. Implement a National Infrastructure Protection Plan.

4. Strengthen information sharing and collaboration.

5. Strengthen interoperable communications to enable personnel from different disciplines and jurisdictions to communicate effectively during major events.

6. Strengthen Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) detection, response, and decontamination capabilities.

The information you have obtained in this course will help you and your agency meet these national planning and preparedness goals.

The Executive Summaries of the National Planning Scenarios and Target Capabilities List can be viewed at https://odp.esportals.com or www.llis.gov

SUMMARY

Although these integrated systems may appear complex, through good preplanning and working with building maintenance, risk management, or safety personnel, fire officers can become familiar with which buildings have these capabilities, how they operate, and how to use them effectively during fire emergencies.

As with any fire protection system, knowledge of which buildings have these components, how they function for life safety and property protection, and how to best use them must be part of the preplanning process. If fire officers wait until the fire to find out how these integrated systems work, they will not use them properly, will have less successful outcomes, and will not have served their communities to the best of their ability.

Activity 9.1

Linking with Homeland Security Preparedness Goals

Purpose

To synthesize *Fire Protection Systems for Emergency Operations* (FPSEO) course content with HSPD-8.

Directions

1. In your table group, you will review a condensed version of one of four National Preparedness Scenarios.

2. You should discuss the following questions, which pertain to the situation as it relates to the content of this course, and write your responses on an easel pad. The answers will require you to recall knowledge from the entire course.

3. Select one person from your table group to act as a spokesperson and report the group's comments from discussion.

Scenario 1: Chemical: Attack in Explosion of Chlorine Tank

General Description

An industrial facility storing a large quantity of chlorine gas (liquefied under pressure) is infiltrated. Using a low order explosive, a storage tank is ruptured, releasing a large quantity of chlorine gas downwind of the site. Secondary devices are set to affect first responders.

Geographical Consideration/Description

The chlorine storage facility is on the outskirts of a city having a population of about 75,000. The site is flat, and at approximately the same elevation as the community. The site comprises 40 acres, and includes several storage tanks, transfer equipment (rail and truck), distribution piping, and several operational buildings. The largest store tank contains 120,000 gallons of liquefied chlorine. The compromised tank has a 90,000 gallon capacity. The site is surrounded by a 10-foot-high chain-link fence with emergency access gates on each side. There are no waterways in the vicinity.

Timeline/Event Dynamics

Except for very cold conditions, the release would be over in under an hour. The plume would travel downwind, and be dispersed below detectable amounts in 6 hours.

Secondary Hazards/Events

Once they grasp the situation, authorities will shelter in place a significant area downwind of the site. Numerous injuries will result from population panic once downwind casualties begin to occur and as many as 10 percent of the people will self-evacuate. Further injuries are likely, due to motor vehicle accidents in the surrounding roadways. Rule of thumb is 1 death per 10,000 evacuated.

The storage tank will be lost, along with some sensitive control systems damaged by the freezing liquefied gas. The secondary devices will cause damage to other plant facilities and equipment in a 20-meter radius of the blasts as well. There will be hundreds, if not thousands, of auto accidents during the evacuation. In areas of heavy chlorine exposure, there will also be heavy corrosion of metal objects.

Recovery/Remediation

Since chlorine is a gas, the extent of decontamination required will be minor, largely related to any releases generated by the secondary devices. Regardless, monitoring and sampling a large industrial facility will be a challenge. Actions of incident site personnel include decontamination of contaminated areas, disposal of decontamination wastes, environmental testing, repair of destroyed/damaged facilities, and public information.

There will be significant damage to the plant as a direct result of the attack. Environmental impact, especially public safety concerns, are likely to delay rebuilding efforts significantly.

Questions

1. Would this occupancy qualify for one needing preincident plans? Why or why not?

2. What fire protection systems or features might be found in these occupancies?

3. Which of these fire protection systems or features may be integrated so they operate together?

4. How might the IC use these systems to mitigate the event?

5. How might the event affect the fire protection features?

6. How might the fire protection features work **against** successful incident mitigation?

7. What contingencies might you consider to overcome problems?

Scenario 2: Chemical Attack: Nerve Agent

General Description

Sarin vapor is released into the ventilation systems of 3 large commercial office buildings (20-story) in a metropolitan area. The agent kills 95 percent of the people in the buildings, and kills or sickens many of the first responders. In addition, some of the agent exits the buildings through rooftop ventilation stacks, creating a downwind hazard.

Geographical Considerations/Description

The buildings have an occupancy of 2,000 personnel each (i.e., 20-story buildings with 100 occupants per floor), and the outdoor/subway population density of the surrounding areas is assumed to be 3,900 people per square mile (one-tenth of the total population density in the vicinity of Times Square, NY).

Timeline/Event Dynamics

The attack will require 6 months to plan, including putting the faux janitors in place, shipping the agent, and fabricating the spray devices. Once all is ready, the janitors will take less than 10 minutes to retrieve the sprayers from the courier vans, emplace them, and activate them. First responders should begin arriving at the facility within 10 to 15 minutes of the attack.

Secondary Hazards/Events

Numerous injuries will occur as a result of panic on the street, including falling and crushing injuries. Further injuries are likely to occur due to motor vehicle accidents in the surrounding roadways.

Property Damage

Little direct damage due to the attack except the building interiors and contents will be highly contaminated by agent condensing on surfaces. The three buildings and their contents will be a total loss due to decontamination measures and/or psychological impacts of future usability. Sarin is classified as a nonpersistent agent from a military viewpoint--not an environmental health viewpoint. If left in place the drywall and other porous substances would be leaching minute amounts of agent for years. Valuable and removable property and equipment could be removed from the building, bagged, and monitored, then released if no agent is detected at minimum monitoring levels. The buildings themselves will likely be demolished and thermally treated truckload by truckload in a car-bottom furnace. Airing and washing should decontaminate adjacent structures adequately, however. Some motor vehicles will be involved in accidents.

Recovery/Remediation

Anything exposed to a high vapor agent concentration will require decontamination, including bodies. Actions of incident site personnel include decontamination of building and other contaminated areas, disposal of decontamination wastes, environmental testing, and public information.

There will be little damage to the building as a direct result of the attack. However, decontamination of some materials may be difficult or impossible. Even if the structures and property could be technically decontaminated, the psychological impact on future usability would be significant.

Questions

1. Would this occupancy qualify for one needing preincident plans? Why or why not?

2. What fire protection systems or features might be found in these occupancies?

3. Which of these fire protection systems or features may be integrated so they operate together?

4. How might the IC use these systems to mitigate the event?

5. How might the event affect the fire protection features?

6. How might the fire protection features work **against** successful incident mitigation?

7. What contingencies might you consider to overcome problems?

Scenario 3: Natural Disaster: Major Earthquake

General Description

A 7.2 magnitude earthquake occurs along a fault zone near a city of about 280,000 persons. Modified Mercalli (MM) VIII or greater intensity ground shaking extends throughout the area. Ground shaking occurs for approximately 25 seconds. Soil liquefaction has occurred in some areas and has added to the destruction, since even earthquake-resistant buildings may fail when liquefaction occurs. The primary cause of damage was the resultant ground shaking from the fault rupture. Quicksand-like conditions in areas of liquefaction have contributed to the destabilization and collapse of buildings and utilities.

The greatest damage is in your first response area, in a one-story, noncombustible construction industrial plant that is about 800,000 square feet. The plant employs about 8,500 persons, equally divided among three around-the-clock shifts.

Geographical Considerations/Descriptions

This earthquake occurs in an area with a past history of earthquake activity. The highest points in the area are approximately 5,000 feet above sea level and the lowest land elevations are a few feet above sea level. Most of the built environment and the population are located in the lower elevations.

Timeline/Event Dynamics

Predisaster conditions: A large ice/snowstorm prompted emergency declarations for snow removal in four seismic zone States. Freezing and subfreezing temperatures are expected in the region for the next several days. While scientists have been predicting a moderate to catastrophic earthquake in the region sometime in the future, there were no specific indications that an earthquake was imminent in the days and weeks prior to this event.

Initial event: A 7.5 magnitude earthquake strikes along the seismic zone. Rapid horizontal movements associated with the earthquake shift buildings off their foundations caused some tall buildings to collapse or "pancake" as floors collapse down onto one another. Shaking is exaggerated in areas where the underlying sediment is weak or saturated with water. (Note: In the central and eastern United States, earthquake waves travel more efficiently than in the western United States. An earthquake of a given size in the central and eastern United States may cause damage over a much broader area than the same size earthquake in California.)

The building is well involved upon your arrival.

Aftershock(s): Several hours later, an aftershock of magnitude 8.0 occurs. Based on past events, additional aftershocks are possible. Sizeable aftershocks (7.0 to 8.0) may occur for months after the original jolt.

Secondary Hazards/Events

Natural gas and oil hazards: Onsite hazardous contamination impacts of concern include a natural gas compression station, a bulk chemical tank farm, and natural gas/crude oil pipelines.

Property Damage

More than 50 percent of the building is on fire, and controlling the fires is hampered by lack of water and disrupted roadways. The widespread debris has severely impeded access and heightened the risk of fire.

Ground shaking from the earthquake has generated massive amounts of debris from collapsed storage stacks near the plant.

There are numerous reports of toxic chemical fires, plumes with noxious fumes, and spills. Significant concern for spilled hazardous materials from storage, overturned railcars, and chemical stockpiles make progress very slow as triage is conducted.

Recovery/Remediation

Many areas will be contaminated by hazardous materials and decontamination, and site restoration will be a major challenge.

Questions

1. Would this occupancy qualify for one needing preincident plans? Why or why not?

2. What fire protection systems or features might be found in these occupancies?

3. Which of these fire protection systems or features may be integrated so they operate together?

4. How might the IC use these systems to mitigate the event?

5. How might the event affect the fire protection features?

6. How might the fire protection features work **against** successful incident mitigation?

7. What contingencies might you consider to overcome problems?

Scenario 4: Chemical Attack: Releasing Toxic Industrial Chemicals

General Description

Multiple railcars at a major rail transit facility explode with resulting fires. Two of the railcars contain flammable liquids or solids. The wind is headed to the north-northeast, and there is a large, heavy plume of smoke. The smoke is visible then drifting east into heavily populated areas.

Releases of cobalt, nickel, molybdenum, cadmium, mercury, vanadium, platinum, and other metals have occurred in the plumes. One of the burning railcars contains resins and coatings including isocyanates, nitriles, and epoxy resins. Some explosive devices (IED's) are set for delayed detonation. Casualties occur on site due to explosive blast and fragmentation, fire, and vapor/liquid exposure. Downwind casualties occur due to vapor exposure.

Geographical Considerations/Description

The large rail facility is located west of town, and serves two major rail lines that provide significant freight transportation services throughout the country. There are numerous trans-shipment warehouses scattered throughout the facility: they range in size from 50,000 to 750,000 square feet. They range from one to three stories, and several have large basements. The overall site is flat.

Timeline/Event Dynamics

Total time to plan and prepare for the attack would be on the order of 2 years, including reconnaissance, weapons training, and accumulation of weapons. Time to execute the attack would be several weeks to coordinate the shipping and coincident arrival of the railcars at the facility. Time between detonations would be 2 to 3 minutes at each site. Fires resulting from the attack would take many hours, possibly days, to extinguish.

Secondary Hazards/Events

Once they grasp the situation, authorities will evacuate or order shelter in place for a significant area downwind of the rail yard. Numerous injuries will occur as a result of population panic once downwind casualties begin to occur. Further injuries are likely to occur due to motor vehicle accidents surrounding roadways. Rule of thumb is 1 death per 10,000 evacuated.

Property Damage

Dozens of railcars are derailed and lying throughout the site. Depending on which chemicals are released, there may be significant property damage in the downwind area. This may occur either directly due to the corrosive effects of the chemicals, or the corrosive effects of any decontamination methods employed. There will be as many as 700 auto accidents during the evacuation. Upon your arrival, you count at least seven of the trans-shipment warehouses on fire.

Recovery/Remediation

The extent of decontamination required will depend on the chemicals. Regardless, monitoring and sampling a large industrial rail facility will be a challenge. Actions of incident site personnel include decontamination of contaminated areas, disposal of decontamination wastes, environmental testing, repair of destroyed/damaged facilities, and public information. A large number of trained and properly equipped workers will be needed to decontaminate the site. Decontamination of workers will also present logistical challenges.

There will be significant damage to the rail yard as a direct result of the attack and subsequent fires. Decontamination of some materials may be difficult or impossible. Environmental impact issues are likely to delay rebuilding efforts significantly.

Questions

1. Would this occupancy qualify for one needing preincident plans? Why or why not?

2. What fire protection systems or features might be found in these occupancies?

3. Which of these fire protection systems or features may be integrated so they operate together?

4. How might the IC use these systems to mitigate the event?

5. How might the event affect the fire protection features?

6. How might the fire protection features work **against** successful incident mitigation?

7. What contingencies might you consider to overcome problems?

Activity 9.2

Fire in a Covered Shopping Mall

Purpose

To practice commanding an incident in a large, complex structure with heavy life risk, using the fire protection systems and features available to assist in controlling the incident.

Directions

1. You will be shown a series of slides to help your group visualize the covered mall. You will also see a series of slides depicting a fire.

2. Use the Primary Factors Size-up Chart to list objectives, strategies, and tactics on your easel pad.

3. As a group, staff positions within the ICS of the fire department as needed for this exercise. Identify the ICS roles to be assigned in order to manage the mall incident effectively, and draw the organization tree on your easel pad.

4. List the fire protection systems for consideration at this mall store fire and explain the sequence of how your group used them on this incident.

5. Should each business in a multitenant structure have a preplan or is a preplan for the complex sufficient? List your arguments for and against on your easel pad.

6. At the conclusion of the simulation exercise, all groups will participate in a debriefing facilitated by the instructors. Be prepared to explain the reasons for your decisions.

Scenario

The Columbia Mall is a large, two-story structure with more than 2.1 million square feet of retail space under roof. Built in the 1980's, the mall includes five major department stores and more than 196 assorted specialty shops and restaurants.

Exterior wall construction is concrete block covered by a bar-joist, flat pan roof. Interior walls consist of steel studs covered by 1/2-inch gypsum wallboard. There is a Lexan™ panel skylight system providing natural light to the covered pedestrian mall.

The entire mall is sprinklered, with the sprinklers mounted below the dropped ceiling. The anchor stores are protected by separate sprinkler systems, which are not interconnected with the mall systems. There are no sprinklers in the concealed spaces above the ceiling tiles. Each of the exit passageways has a Class I automatic standpipe outlet where the passageway doors enter

the covered mall. The combined standpipe and sprinkler systems are supplied by the same water main, which has two 500-gpm electric fire pumps (one primary and one backup).

The covered pedestrian mall has a zoned smoke management system that is designed to confine smoke to the mall or tenant spaces (depending upon the fire location), or in one isolated space within the covered pedestrian mall. The smoke management system is designed to be automatic upon smoke detection or sprinkler flow within the zone where the fire occurs.

Essential life safety systems (fire pumps, smoke management, fire alarm with voice communications and emergency lighting) are supported by a diesel-powered standby power generator having a 6-hour standby fuel capacity. All of the fire control features are monitored in the fire command center on the same side of the building as the mall management office.

Facility access can be achieved from two roads (south and north) into the 7,500-car parking lot that surrounds the building. There are three parking garages, one on the north and two on the south sides of the complex. Fire apparatus cannot enter the raised portions of the parking garages.

This complex was preplanned by the other shift after the renovations were completed. The drawings were made and the photos were taken at that time. The Miaro Bistro became a tenant after the preplan was finished.

The alarm sounds just before 1400 hours on the Friday after Thanksgiving. The mall has been heavily patronized since it opened at 0900. All stores have been overstocked for the holiday shopping season. Virtually all parking places are occupied with some cars parked on grassy areas at the perimeters of the parking lot. Outside temperature is 31 °F (-.5 °C) with a south wind of 15 miles per hour (mph).

Mall maintenance and the Central City Gas Company have been working on a reported gas leak at Entrance 4 all morning. There is a report of an explosion in the egress corridor hallway of Entrance 4, lower level, south side of the complex. Multiple injuries and heavy fire are reported.

Activity 9.2 (cont'd)

Quick Access Prefire Plan

Building Address:
1000 Columbia Avenue (Route 50)

Building Description:
Shopping mall: 2.1 million square feet
Two and three stories, portions built in 1980's
Five major dept. stores, 196 shops and restaurants

Roof Construction:
Bar-joist flat pan--Lexan™ skylight length of center mall

Floor Construction:
Concrete, covered by ceramic tile/carpet

Occupancy Type:	**Initial Resources Required:**
Shopping center	*One commercial bldg. alarm*

Hazards to Personnel:
Ingress, egress, horizontal interior hose lays, maze-like interior

Location of Water Supply:	**Available Flow:**
Hydrants on site (10) 12-inch main	*1,600 gpm per hydrant*

	Estimated Fire Flow			
Level of Involvement	*1 store*	*3 to 5*	*Dept. Store*	*Wing*
Estimated Fire Flow	500 gpm	1,000 gpm	3,000 to 5,000 gpm	5,000 gpm

Fire Behavior Prediction:
Horizontal spread, common ceiling between stores

Predicted Strategies:
Rescue (primary search), confinement, ventilation

Problems Anticipated:
Access to fire, occupants, zoned sprinklers, and long hose lays

[X] **Standpipe:** *Horizontal at hallways*	[X] **Sprinklers**: *Zoned: 1 to 4*	[X] **Fire Detection:** *Smoke, water flow detection*

Incident Locator Preplan
Columbia Mall

Sprinkler Zone 1	Sprinkler Zone 2
1. Johnson's Fashions 2. Office Providers 3. Multiscreen Theaters 4. Bert's Drug store 5. Phil's Steak and Cheese 6. Doctor John Offices 7. Central Women's Store	1. Tri-City Toys 2. O'Neil's Gifts 3. Phelps Dollar Store
Sprinkler Zone 3	**Sprinkler Zone 4**
1. Gaines Electronics 2. Mall Conference Rooms 3. Maxine's Pets 4. Central Specialty Foods 5. Cooking Things	1. Shoe Family 2. Harrison's Restaurant 3. China Specialty Store 4. Dancing Dan's Furniture 5. The Arcade 6. Goode Hunting 7. Equipment 8. Boyd's School Supplies

Activity 9.2 (cont'd)

Columbia Mall Occupancies

Alphabetical List	Sprinkler Zone	Smoke Control Zone	Nearest Entrance
Bert's Drugstore	1	A	1
Boyd's School Supplies	4	D	4
Central Specialty Foods	3	C	2
Central Women's Store	1	A	3
China Specialty Store	4	D	4
Cooking Things	3	C	2
Dancing Dan's Furniture	4	D	4
Doctor John Offices	1	A	1
Gaines Electronics	3	C	2
Goode Hunting Equipment	4	D	4
Harrison's Restaurant	4	D	6
Johnson's Fashions	1	A	1
Mall Conference Rooms	3	C	2
Multiscreen Theaters	1	A	7
Office Providers	1	A	9
O'Neil's Gifts	2	B	3
Phelps Dollar Store	2	B	2
Phil's Steak and Cheese	1	A	9
Shoe Family	4	D	6
The Arcade	4	D	2
Tri-City Toys	2	B	3

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Activity 9.3

Assessing Fire Protection System Suitability for Terrorist Events

Purpose

To evaluate a proposed procedure for its suitability to terrorist events.

Directions

1. Working in table groups, review the following scenario. After you have read the scenario, discuss it in your group.

2. Given what you have learned about fire protection systems and equipment, identify and describe both the strengths and weaknesses of the proposed procedures.

3. You need only to focus on the procedures in Section VI.

4. List your group's findings on an easel pad, and select a spokesperson from the group to report your comments.

Scenario

The regional Emergency Preparedness Task Force (EPTF) has been assigned to write community-wide policies and procedures for emergency response to terrorist incidents ranging from dirty bombs to biohazard exposures. The EPTF consists of representatives from police, fire, Emergency Medical Services (EMS), Local Emergency Planning Committees (LEPC), Department of Emergency Management (DEM), public works, mental health services, and the American Red Cross.

The following page includes a draft policy and procedure for handling a specific type of terrorist incident in the regional hospital/trauma center. It is expected that the new policy will be implemented as soon as all agencies have had a chance to review it.

You and your group are to review the proposed policy and procedure, and prepare on behalf of the fire department a list of comments describing both the strengths and weaknesses of the emergency procedures.

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Activity 9.3 (cont'd)

Emergency Preparedness Task Force
Controlling Toxic Releases:
Southwest Regional Hospital And Trauma Center

I. Purpose

The purpose of this policy and procedure is to describe in detail the response steps necessary to control hazardous, toxic, highly toxic, or otherwise life-threatening terrorist chemical or biological releases occurring at Southwest Regional Hospital and Trauma Center.

II. Scope

This policy and procedure shall apply to all first responders and hospital personnel.

III. Authorities

a. The Homeland Security Act of 2002, codified in Title 6 USC.

b. Department of Homeland Security Management Directive MD-00032-Policy and Procedure Implementation.

c. International Building and Fire Codes, 2003 edition.

d. The Hazen-Williams Act of 1902, codified in Title 6 USC.

e. Emergency Preparedness Task Force Authorization Act of 2004.

f. The Interlocal Law Enforcement and Fire Services Emergency Response Act of 2001.

g. The State Department of Health and Mental Hygiene statutes and ordinances of 203, as amended.

IV. Policy

It shall be the policy of all first responders and hospital personnel to handle hazardous, toxic, highly toxic, or otherwise life-threatening terrorist chemical or biological releases in accordance with these procedures.

V. Definitions

The following definitions shall apply to this policy and procedure. Words not defined in this section shall have their commonly accepted definitions.

"EOC" shall mean Emergency Operations Center, a designated facility where unified command can be established.

"Event" shall mean the unanticipated release of hazardous, toxic, highly toxic, or otherwise life-threatening terrorist chemical or biological agents intended to harm persons or property, and which constitutes exigent or otherwise emergent conditions.

"Fire Responder (FR)" shall mean any hospital employee, firefighter, police officer, ambulance attendant, or other person authorized, deputized, or otherwise empowered to respond to an event.

"Hazardous, toxic, highly toxic, or otherwise life-threatening terrorist chemical or biological release (HTCBR)" shall mean any liquid, solid, gaseous, or particulate matter dispersed into the atmosphere from a container to endanger lives or property.

"Incident Commander (IC)" shall mean the person responsible for the command and control of an event.

"Life Safety and Fire Protection Features (LSFPF)" shall include, but not be limited to, automatic and manual fire detection and alarm, automatic sprinkler systems, fire standpipe systems, smoke management and control systems, specialty fire protection systems, and any other device, equipment, or system capable of protecting life and property, including fire- and smoke-resistant construction.

"Postevent" shall mean the time after the IC has declared the exigent conditions under control.

"Preevent" shall mean the time before a terrorist event is reported to the authorities.

"Protected Premises" shall mean the Southwest Regional Hospital and Trauma Center (SRHTC).

VI. Procedures

Section 1. Prevent

1. The fire department IC, in conjunction with the police department IC, shall periodically survey the protected premises to identify the life safety and fire protection features available to use during an event.

2. Results of these surveys shall be incorporated into a written report for dissemination to FR's.

    a. The written report(s) shall emphasize the importance of compartmentalization and patient isolation as first priority strategies to minimize the spread of HTCBR.

3. FR's shall conduct periodic training activities and exercises to familiarize themselves with LSFPF.

    a. Hospital personnel may familiarize themselves with LSFPF during normal daily duties.

4. Reports of simulated postincident analyses from the training activities and exercises shall be forwarded to the EPTF for review within ten (10) working days of the activity.

    a. Records of such training shall be maintained for a period of not less than three (3) years from the date of training.

Section 2. During an Event

1. The first-arriving FR shall conduct an initial sizeup, establish incident objectives, determine strategy and tactics, and communicate same to responding personnel.

    a. The FR shall establish a clearly identified Command Post (CP) adjacent to the fire alarm control panel (FACP) in the Fire Command Center (FCC).

    b. The first-responding IC shall review the hospital preincident plan to assure all contingencies are satisfied.

    c. The first-responding IC shall assign an Incident Safety Officer (ISO) and Public Information Officer.

    d. The first-responding IC shall consider summoning the Greater Metropolitan Area Hazardous Materials Response team, if warranted.

2. The second-arriving FR shall report to the fire pump control room to verify the operational status of the fire pump, and report same to the first- responding IC at the CP.

    a. If the fire pump bypass is closed, it shall be opened immediately.

    b. If the fire pump is not running, it shall be started immediately, unless otherwise directed by the first-responding IC.

3. The third-arriving FR shall report to the FCC and immediately establish a Systems Unit:

    a. Send the elevator cars to the floor where the incident is reported to initiate rescue of nonambulatory occupants.

    b. Start the atrium smoke control and stairway pressurizations systems to purge all HTCBR products to the outdoors.

    c. Establish a Lobby Control Group to shuttle equipment to the affected area.

4. The fourth-arriving FR shall operate the FACP voice command system, and transmit the following message:

    "Ladies and gentlemen, this is a terrorist emergency. This is not a drill. Please leave immediately by the nearest exit, stairway, or elevator to meet in the hospital cafeteria, where we can account for all occupants."

    The message shall be repeated at least three times.

5. All additional arriving Units shall report to Staging, which shall be located in the parking lot of the Safeway grocery store across the street from the Hospital.

    a. The Staging Manager is authorized to requisition food and drink up to $7.50 per person per 24-hour period on the incident scene for rest and rehabilitation purposes. Receipts of all transactions shall be retained.

6. Hospital security and maintenance personnel are to carpool to the Northeastern Regional Hospital, where they will establish a remote EOC.

7. Hospital administrative personnel are to report to their designated floors to verify that all cross corridor and stair enclosure doors are in the closed position.

    a. Once this assignment is completed, hospital administrative personnel shall report to the cafeteria, where a joint media information center shall be established.

8. Southwest County EMS shall be responsible for patient triage, treatment, and transport.

    a. The patient triage area shall be established adjacent to the FCC so the first responding IC can account for the number of patients treated and transported.

b. Class II standpipe hoselines may be used for patient decontamination. Only qualified fire personnel in full protective clothing may use standpipe hoselines.

9. The first-responding law enforcement officer shall take steps to minimize traffic impacts by closing nearby roads, hospital parking lot access, and building ingress/egress.

10. Once the incident is stabilized, the preaction sprinkler system shall be turned on to flush HTCBR to storm drains where they can be collected. It shall be the first-responding IC's decision to assign personnel to this task.

a. The preaction sprinkler system can be operated by the remote release handle located in the fire pump control room.

11. The first-responding IC may consider operating all cafeteria exhaust hoods at maximum exhaust speed to draw HTCBR from the cafeteria.

Section 3. Postevent

1. Once the event is declared under control, the first-responding IC shall conduct a postincident analysis.

a. The postincident analysis shall include an assessment of classical or naturalistic decisionmaking efforts that were employed during the emergency.

2. Written reports from the postincident analyses shall be forwarded to the EPTF for review within ten (10) working days of the event.

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APPENDIX

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Job Aid 9.1

Preincident Planning Integrated Systems Matrix

Now that the IC understands the complexity of built-in fire protection systems and their integrated relationships, it's time to collect that information for the preincident plan.

The matrix on the next page can serve as a simple method for identifying which systems in a building or facility work together.

Use it like the mileage chart on a road map. Find the system(s) in the left-hand column, and the integrated system along the top row. Where the two cells intersect, insert some sort of mark to identify their relationship.

EXAMPLE

Preincident Planning Integrated Systems Matrix	Sprinkler, wet pipe	Sprinkler, dry pipe	Sprinkler, preaction	Sprinkler, deluge	Sprinkler, foam	Standpipes	Fire alarm, automatic	Fire alarm, manual only
Sprinkler, wet pipe	■							
Sprinkler, dry pipe		■						
Sprinkler, preaction			■					
Sprinkler, deluge				■				
Sprinkler, foam					■			
Standpipes						■		
Fire alarm, automatic			●	●			■	
Fire alarm, manual only				●				■

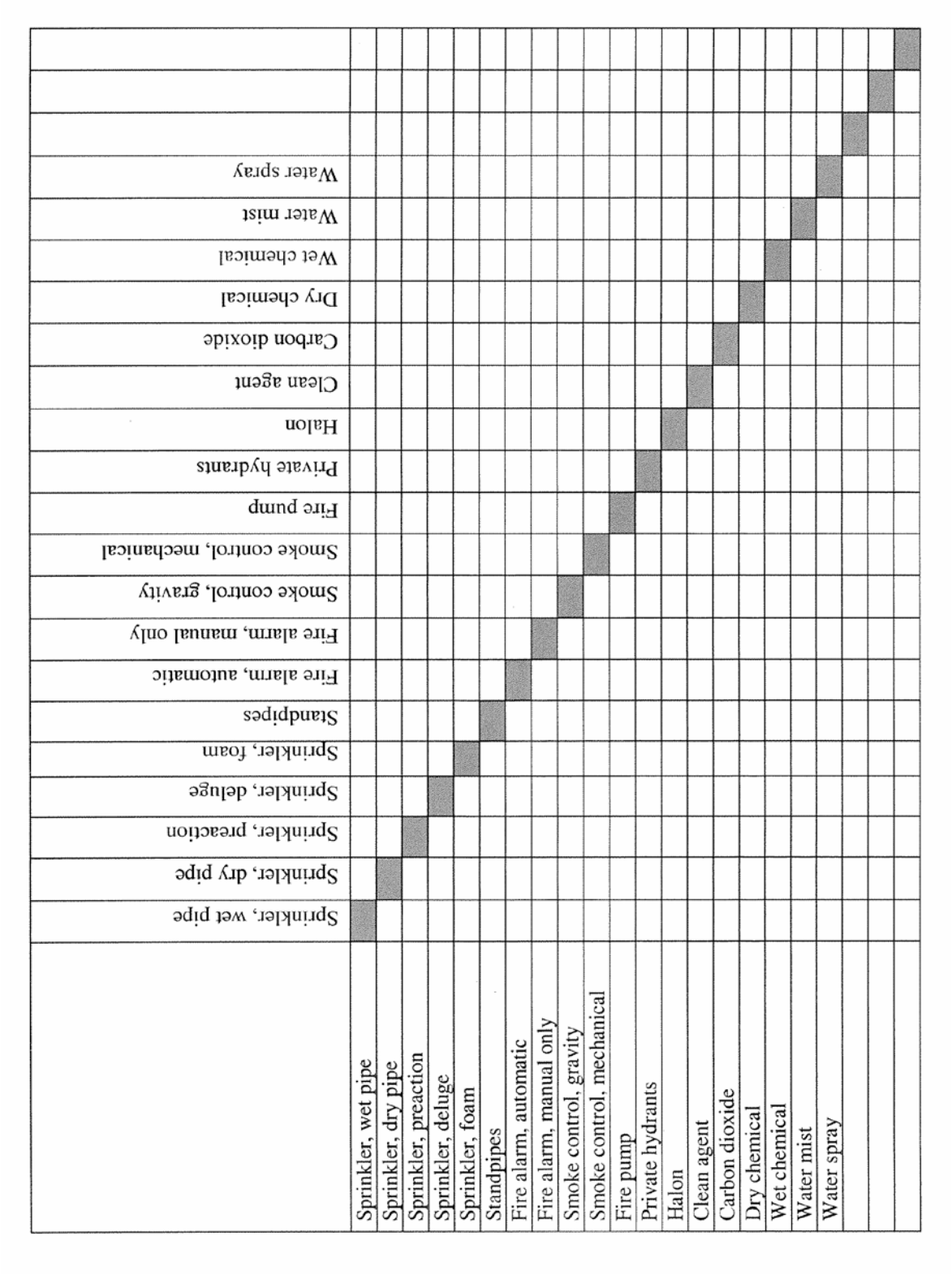
In this example, the preaction sprinkler system is integrated with the automatic fire alarm, and the deluge sprinkler system is integrated with the automatic and manual fire alarm systems.

This matrix can be used as a supplement for the preincident planning team to identify important details regarding integrated systems for inclusion in the formal preincident plan.

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Job Aid 9.1 (cont'd)

Preincident Integrated Systems Network



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Fire Protection System Safety Considerations

Any manual or automatic fire protection equipment system has some inherent safety hazards. Fire operations and maintenance personnel should be aware of these hazards so they may take suitable safety precautions such as respiratory, eye, skin, or fall protection.

Firefighters already are aware of some of the safety concerns related to their own equipment: every fire department should perform annual inspections and pressure tests on their firehoses to prevent catastrophic failures and avoid injuries.

Built-in fire protection systems are no different. While they offer superior fire protection in many circumstances, they are not without risks as well.

The following matrix summarizes some of the potential concerns with the various fire protection systems that we have discussed in other units. This matrix was developed by reviewing the NFPA Standards for the installation of these systems.

The extent or severity of each hazard is not described in the matrix. There is no identified difference, for example, between a minor or serious eye irritant that a product causes. If the NFPA Standards mentioned even the slightest hazard, it is included in the matrix.

For additional information, or more specific details, you are encouraged to contact product or system manufacturers. You also may want to obtain and review Material Safety Data Sheets (MSDS) on the extinguishing agents. MSDS can be obtained from the product manufacturer.

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Fire Protection System Safety Considerations (cont'd)

	Automatic Sprinklers	Wet pipe	Dry pipe	Deluge	Preaction	Foam/Water	Water spray	Standpipes	Class I	Class II	Class III	Fire Pumps	Electric drive	Diesel drive	Fire Alarm	Special Hazard Systems	Halon™	Carbon dioxide	Dry chemical	Wet chemical	Clean agent	High-pressure water mist
Noise														X	X		X	X				
Asphyxiation/Oxygen depletion/ Respiratory compromise																	X	X	X		X	X
Cardiac arrhythmia/ Sensitization																	X				X	
Particulate in suspension																		X	X			
Obscured vision		X	X	X	X	X	X										X	X	X	X	X	
Slippery surfaces		X	X	X	X	X	X		X	X	X		X	X						X		
Electrical conductivity (agent)		X	X	X	X	X	X		X	X	X											
Electrical conductivity (equipment)		X	X	X	X	X	X		X	X	X		X	X	X		X	X	X		X	
Pressure vessels																	X	X	X	X	X	X
Excessive operating pressures									X	X	X		X	X								
High voltage													X	X								
Agent toxicity															X		X				X	
Mechanical injury (pinch points, falls, turbulence, etc.)				X		X							X	X			X	X			X	
Stroboscopic effect															X							
Eye irritation																			X	X	X	X
Skin irritation																				X	X	
Dizziness/Impaired coordination																	X					
Cold																	X	X				
Toxic agent decomposition																	X				X	

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UNIT 10:
FINAL PROJECT

OBJECTIVE

The students, in groups, will be able to develop and present a simulated training exercise on infrastructure protection intelligence collection.

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Activity 10.1

Final Project

Purpose

To integrate the information presented in the course into a real-world infrastructure protection intelligence activity.

Directions

1. Select a target hazard from one of your group members' communities to develop a comprehensive preplanning training session that will simulate a multicompany drill, meeting, or battalion training session. The target hazard must be as complex as possible. For example, choose a hospital complex rather than a local supermarket.

2. The student whose target hazard is selected must provide to the instructor and students in his or her group a basic site plan, including the location of access roads around the building, fire hydrant locations, and a list of protection components in the building, **no later than the start of the third day of class**.

    a. The list must include the size of the building, both area and height, the location of the fire department connections (FDC's) (standpipe and sprinkler), the location of the riser room, and the location of the fire alarm panel.

    b. The list also must include other protection features, if available, such as smoke management systems; and specialized fire protection features, such as clean agent suppression systems, Halon™ systems, hood-range systems, etc.

3. The group is to develop objectives, strategies, and basic tactics related to the fire protection systems in the building, using the Primary Factors Chart.

    a. Each essential element of the building's fire protection systems should be covered, including water supply and alternatives, connection hook-up procedures, alarm panel coordination, smoke management coordination, and use of specialty systems.

    b. The training should be comprehensive enough to address all relevant points covered in the course.

4. Each member of the group must participate in the development and presentation of the training session. It must be a minimum of 20, but not more than 30 minutes in length, with 10 minutes for questions and feedback after the presentation is completed.

5. As each course unit is completed you should add the elements covered into your training package.

    a. You can use the infrastructure protection intelligence software provided on Day One to formulate your program.

    b. It may not be possible to incorporate photos into the presentation.

6. The goal of this activity is to give all students an opportunity to practice developing a training session that will provide attendees quality preplan information on a real target hazard.

    a. As part of this training each critical element of the building's fire protection systems should be covered.

    b. Some segments may have to be simulated if all information on the building is not available at the class location.

7. Another goal of this activity is to give each student a template from which to develop preincident plans in this format. It is our hope that you will see the benefits of this preplanning process and how it will assist Incident Commanders (IC's) in developing knowledge of and effectively using fire protection systems during fires and other emergencies.

8. Job Aid 10.1 is provided as a sample lesson plan to help focus the training on key principles of infrastructure protection intelligence.

APPENDIX

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Job Aid 10.1

Sample Lesson Outline

Training with preincident plans is an important element to achieve successful incident outcomes. Training should be conducted with adequate detail and frequency to ensure that those who need to use preincident plans will gain confidence in themselves and the information that is presented.

Preincident plan training should be organized and delivered to achieve maximum benefit so that all key points are covered. The following sample lesson can help the trainer focus his or her instruction on the significant factors related to fire protection features and infrastructure protection intelligence collection.

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Job Aid 10.1 (cont'd)

Fire Department
Training Division

I. Topic: Reviewing preincident plans

II. Time: ____ hours/minutes

III. Reading/Other Assignments:

- _____ Fire Department Standard Operating Procedure on Infrastructure Protection Intelligence
- NFPA 1620, *Recommended Practice for Preincident Planning*
- Infrastructure protection intelligence plan(s) for the following occupancies or addresses:

_____

_____

_____

IV. Learning/Teaching Aids: (Visual aids needed to deliver this lesson effectively.)

_____

_____

_____

_____

_____

V. Facilities: (Classroom, facility, or location needed to deliver this lesson effectively.)

_____

_____

_____

_____

_____

VI. Equipment: (Equipment or tools needed to deliver this lesson effectively.)

VII. Handouts: (Handouts, information sheets, or tests needed to deliver this lesson effectively.)

Job Aid 3.2 "Infrastructure Protection Intelligence Gap Analysis"

VIII. Behaviors to Foster:

- Fire loss and property damage can be reduced when the firefighters are prepared to use the infrastructure protection intelligence plan to their advantage during a fire.
- Property damage can be reduced when the firefighters are prepared to handle nonfire emergencies such as leaks, spills, or system failures.
- Regular review and training on preincident plan improves the chances the information will be timely and accurate.
- Public relations are enhanced when the fire service arrives prepared at an incident.
- Having comprehensive training makes the firefighters' job safer and easier.

IX. Standard(s)/Recommended Practices:

- NFPA 1001-3-3.13 and 1001-4-5.1
- NFPA 1620-2-2.6

X. Motivation: (Why should students be motivated to pay attention?)

_____

_____

_____

_____

XI. Student Performance Objectives:

Given a(n) _____ Fire Department infrastructure protection intelligence plan, the firefighter/officer shall be able to:

- identify the principal elements (site and access characteristics, occupancy, fire protection and water supply, and special hazards),
- describe how to use the plan during an incident,
- perform a site visit to verify the information on the plan is current and accurate.

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Job Aid 10.1 (cont'd)

Teaching Points		Instructor Notes/Actions
1. Purpose of the training		1. Distribute the preincident plan(s) that will be used in the session. 2. Use motivational ideas to encourage students to pay attention.
2. Primary Factors Chart(s) from National Fire Academy (NFA)		Show the NFA Primary Factors Chart and relate it to infrastructure protection intelligence plan(s).
3. Developing control objectives		1. Explain what is meant by control objectives. 2. List and discuss the potential control objectives for this specific infrastructure protection intelligence plan. 3. Ask, "What are the priorities?"
4. Developing control strategies		1. Explain what is meant by control strategies. 2. List and discuss the potential control strategies for this specific infrastructure protection intelligence plan. 3. Ask, "What are the priorities?"
5. Developing control tactics		1. Explain what is meant by control tactics. 2. List and discuss the potential control tactics for this specific infrastructure protection intelligence plan. 3. Ask, "What are the priorities?"
6. Physical elements and site considerations		(Use this portion to discuss the significant physical elements and site considerations addressed in the infrastructure protection intelligence plan.)
7. Occupant considerations		(Use this portion to discuss the significant occupant characteristics and site considerations addressed in the infrastructure protection intelligence plan.)

Teaching Points		Instructor Notes/Actions
8. Protection systems and water supplies		(Use this portion to discuss the significant passive and active fire protection features addressed in the infrastructure protection intelligence plan.) Ask, "Which fire protection systems can the IC use to bring this event to a successful conclusion?" "What dangers in this occupancy are increased, decreased, or affected by the fire protection systems? List and discuss.
9. Special hazards		(Use this portion to discuss the significant special hazards addressed in the infrastructure protection intelligence plan.)
10. Using the infrastructure protection intelligence plan a) Before an incident gap analysis b) During an incident c) After an incident		(Use this portion to discuss • How to perform a infrastructure protection intelligence plan gap analysis using Job Aid 3.2. • How to use the infrastructure protection intelligence plan during an incident. • What information to consider for postincident debriefing.) Ask, "If the structure is on fire upon arrival, which fire protection systems already are working? "How does that information affect incident command priorities?" List and discuss.
11. Review		
12. Posttest		(Use this to measure the students' comprehension of the material.)

GLOSSARY

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GLOSSARY

A-B

Active Fire Protection System(s) — Fire protection equipment and devices designed, installed, and maintained to function in the event of an emergency to detect, report, confine, control, or suppress a fire. Including, but not limited to, automatic sprinkler systems, automatic and manual fire detection and alarm systems, specialty fire suppression systems, and smoke management/smoke control. See "**Passive** Fire Protection Features."

Accelerator — A quick-opening device installed on a dry pipe sprinkler system. The accelerator transfers air under pressure from the sprinkler system pipe to the dry pipe valve to speed its operation.

Addressable — When used in conjunction with fire alarm systems, describes a method for installing programmable initiating devices so an alarm will correspond with the specific location and/or device (e.g., "Smoke detector Number 3, third-floor custodian's closet").

Alarm Check Valve — The main water control valve on a wet pipe sprinkler system consisting of a pivoted "clapper" that swings open when water flows through an open sprinkler or drain. Contains connections for a retarding chamber and pressure gauges.

Alarm Verification — A feature of automatic fire detection and alarm systems intended to reduce unwanted, inadvertent, or false alarms. When products of combustion are detected, the alarm system delays reporting for a given period of time until a second detect operates or the system confirms products of combustion are in a smoke detector sensing chamber.

Annunciator — An electronic device containing lamps or light-emitting diodes (LED's), graphic displays, and/or alphanumeric characters to provide fire alarm status information, usually at a location remote from the main fire alarm control panel.

ANSI — American National Standards Institute, a professional association that evaluates design and performance standards for consistency.

Approved — Acceptable to the code enforcement official or authority having jurisdiction (AHJ).

Area of Refuge — An area where persons unable to use stairways can remain temporarily to await instructions or assistance during emergency evacuation. These areas usually are separated from the rest of the building by fire-resistive construction and have two-way communication to a central location in the building, such as a fire alarm control panel.

Assembly, Fire-Resistive — A combination of equipment, structural, and architectural elements designed, constructed, and maintained to resist fire and heat. Examples include firewalls, fire doors, fire dampers, floor/ceiling assemblies, roof/ceiling assemblies, fire barriers, and fire partitions.

ASTM — American Society for Testing and Materials, a professional organization that develops consensus standards. Noted for developing replicable fire testing standards such as those for measuring fire resistance or flame spread.

Atrium — As defined in the building codes, a large open vertical space among two or more adjacent floors that share the same atmosphere. Commonly found in hotels, offices, and multistory covered shopping malls.

Authority Having Jurisdiction (AHJ) — In National Fire Protection Association (NFPA) codes and standards, a term used to identify the person or agency responsible for making project decisions regarding life safety and fire protection. It may include the fire chief, fire marshal, building official, electrical inspector, insurance inspection bureau, property owner, or designee. Normally, in code enforcement, the AHJ is the building or fire official.

Automatic — As applied to fire protection devices, equipment, and systems, is a feature that provides the emergency functions without the necessity of human interventions, and is activated as a result of a response to temperature increase, rate of temperature increase, or products of combustion.

Building — Any structure used or intended for supporting or sheltering any use or occupancy.

Building, Highrise — A building having occupied floors located more than 75 feet above the lowest level of fire department vehicle access.

Building, Lowrise — Used in reference to evaluating structural stability. An enclosed or partially enclosed building in which the mean roof height is less than or equal to 60 feet, and does not exceed the building's smaller horizontal dimension.

Thus, a structure that measures 60 feet by 30 feet with a 30-foot high roof would qualify as a lowrise building.

Building, Windowless — A structure that measures at least 1,500 square feet and is not provided with doors or windows for ventilation or rescue sized and spaced in accordance with the building code. Generally, openings must be at least 30 inches wide, have 20 square feet of net clearance, be openable from the outside, and be located not more than 75 feet from the opposite wall.

Buoyancy — The physical characteristic of a heated fluid or gas to rise, such as smoke rising from above flames.

C

Chase — An enclosed space extending horizontally through one story of a building, connecting openings on the same floor, or floors and ceiling space. See "Shaft."

Churn — A condition in which a stationary fire pump is rotating (running) but is not discharging water. This condition may result in the fire pump overheating.

Clapper — Slang term for the portion of a check valve that pivots on a stem to prevent water from flowing through an orifice. Commonly found in fire department connections and fire sprinkler alarm check valves.

Clean Agent — Electrically nonconducting, volatile or gaseous fire extinguishing agent that leaves no residue when it evaporates.

Cockloft — A shallow space, usually without draft stops or other fire barriers, between the ceiling of the top floor of a building and the underside of the roof deck. In older construction, a cockloft may span several occupancies and may be separated by fire partitions.

Commodity — Combination of products, packing material, and container holding the product, including conventional wood or steel pallets.

Combination Fire/ Smoke Damper

A listed device installed in ducts and air transfer openings designed to close automatically upon the detection of heat and also to resist the passage of air and smoke. The device is installed to operate automatically, controlled by a smoke-detection system, and, where required, is capable of being positioned from a remote command station.

Combination Systems

Generally refers to combined sprinkler and standpipe systems. Combination systems are automatic sprinkler systems with standpipe hose outlets. Depending upon the application, the hose outlets might be Class I for fire department use or Class II for occupant use. (This second application is called "small hose connections" in the sprinkler installation standards. They are employed mostly in warehouse and storage applications.)

Combustible Liquid

A liquid that has a flashpoint of 100 °F (37.8 °C) or more under controlled laboratory test conditions.

Compartmental-ization (Passive)

One of the oldest and most fundamental principles of fire protection. Buildings are segregated, or broken up, into multiple fire/smoke compartments and separated from adjacent fire/smoke compartments by fire-resistive construction that also is intended to restrict smoke migration.

Conduction

Transfer of heat within solids or between solids in contact with each other.

Controller, Fire Pump

Electrical equipment arranged to manually or automatically start (and, sometimes, stop) a station fire pump assembly. Automatic starting usually is accomplished through the installation of a pressure-sensing switch that responds to a pressure decrease on the fire protection system that the pump supplies.

Convection

Transfer of heat energy by the movement of heated liquids or gases.

Cross-Zoning

Usually installed to control specialty system releasing devices, an arrangement of automatic detectors installed so two or more devices must operate before the agent is released. The first detector to operate will sound an alarm; when the second device operates the fire suppression agent will discharge.

D

Deflagration Propagation of a combustion zone at a velocity that is less than the speed of sound in an unrestricted medium.

Deluge Sprinkler System A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers.

Detonation Propagation of a combustion zone at a velocity that is greater than the speed of sound in an unrestricted medium.

Draft Stop A material, device, or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor/ceiling assemblies, roof/ceiling assemblies, and attics.

Driver, Fire Pump The electric motor or internal combustion engine that operates a stationary fire pump. In older systems, steam may provide the power to drive the fire pump.

Dry Chemical Extinguishing Agent A powder composed of small particles (usually sodium bicarbonate, potassium bicarbonate, urea-potassium-based bicarbonate, potassium chloride, or monoammonium phosphate used as a fire extinguishing medium).

Dry Pipe Sprinkler System A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers.

E

Early Suppression Fast Response A sprinkler design criteria that acts more quickly than a standard sprinkler to deliver large quantities of water to suppress a fire. Usually used in "high challenge" environments such as rack storage warehouses. Also known as ESFR.

Eutectic A metal alloy blended to have a specific melting temperature. Most often used in heat detectors or the fusible links of automatic sprinklers.

Exhauster — A quick-opening device attached to a dry pipe sprinkler system that releases air from the sprinkler system through the main drain pipe. Exhausting the air to the atmosphere helps the dry pipe valve operate more quickly.

Exit System — All elements of the means of egress from a building or facility to a public street, sidewalk, or place. Includes doors, hallways, corridors, aisles, exit passageways, stairs, and stair enclosures.

The exit system consists of the:

- exit access: the space between any point of an occupied building and the exit;
- exit: the space that is separated from all other spaces in a building by fire-resistive construction or fire protection systems; and
- exit discharge: the space between the termination of the exit and the public way.

Exit Passageway — An exit component that is separated from all other interior spaces of a building or structure by fire-resistive construction and opening protectives, and provides for a protected path of horizontal egress travel to the exit discharge or public way.

Explosive — Any chemical compound, mixture, or device that has the purpose of bursting or rupturing an enclosure or container due to the development of internal pressure from a deflagration.

Explosive Range or Limits — The upper and lower limits in which the ratio of flammable vapor to air will support combustion. See also "Flammable Limits or Range."

Extinguishment — Extinguishment occurs when a fire is reduced to a heat release rate of zero. The only way to guarantee a fire has been extinguished is when a firefighter verifies the fire is out.

F-G

Facility — A building or use in a fixed location including exterior storage yards for flammable and combustible substances and hazardous materials, piers, wharves, tank farms, and similar uses. The term includes recreational vehicle, mobile home, and manufactured housing parks, sales, and storage lots.

Fire Barrier	A fire-resistance-rated vertical or horizontal (wall or floor-ceiling) assembly of materials designed to restrict fire spread. Openings in the fire barrier are protected by fire-rated assemblies (fire doors and dampers). Fire barriers must be 1-, 2-, 3- or 4-hour rated, depending upon their application.
Fire Command Center	Also known as a fire control room, the location in a building where fire protection systems and equipment can be monitored and controlled.
Fire Control or Fire Control Mode	When applied to sprinkler systems, fire control is achieved by pre-wetting combustibles surrounding the fire area and by cooling hot gases at the ceiling. In an actual warehouse fire, 20 or more control-mode sprinklers may be required for control.
Fire Partition	A vertical assembly (wall) of materials designed to restrict the spread of fire. Openings in the fire partition are protected by fire-rated assemblies (fire doors and dampers). Fire partitions have a 1-hour fire-resistance rating.
Fire Protection Systems	Approved devices, equipment, and systems or combinations of systems used to detect a fire, activate an alarm, extinguish or control a fire, control or manage smoke and products of a fire, or a combination thereof.
Fire Resistance Rating	A value (commonly ranging from 20 minutes to 4 hours) assigned to an assembly of materials that has been subjected to standard, laboratory-controlled fire tests.
Fire Safety Functions	Building and fire control functions that are intended to increase the level of life safety for occupants or to control the spread of harmful effects of fire.
Fire Safing	A method or material--such as caulk, bags, or pillows--installed to resist the passage of flame and heat through openings in a fire-rated partition, barrier, or wall to accommodate cables, cable trays, conduit, tubes, pipes, or similar items. Also known as "Firestop" or "Firestopping."
Firestop	A material--such as caulk, bags or pillows--installed to resist the passage of flame and heat through openings in a fire-rated partition, barrier, or wall to accommodate cables, cable trays, conduit, tubes, pipes, or similar items.

Firewall — A fire-resistance-rated wall having protected openings, which restricts the spread of fire and extends continuously from the foundation through or to the roof, with sufficient structural stability under fire conditions to allow collapse of construction on either side without causing the wall to collapse. Firewalls have 2-, 3- or 4-hour fire-resistance ratings, depending on where they are used.

Flammable Liquid — A liquid that has a flashpoint of less than 100 °F under controlled laboratory test conditions.

Flammable Range or Limits — The range in which the ratio of flammable vapor to air will support combustion. See also "Explosive range or limits."

Flashover — The point at which room temperature at the ceiling of a compartment reaches 1,100 °F (593 °C) or higher and all combustible materials within the compartment ignite almost simultaneously.

Flashpoint — The temperature at which a liquid fuel--when ignited--will flash momentarily, but not sustain combustion.

Foam Sprinkler System — A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers, and equipped with special sprinklers that aerate a mixed foam/water solution at the point of discharge.

Fully Developed Fire — Steady or postflashover fire at peak heat release rate.

Gravity Vent — See "Smoke and Heat Vents."

H

Halogenated Extinguishing Agent (Halon™) — A fire extinguishing medium using one or more of the atoms of an element from the halogen chemical family (iodine, bromine, fluorine, chlorine) to interrupt a fire's chemical chain reaction.

Hazard — Chemical or physical condition that has the potential for causing damage to people, property, or the environment.

Heat of Combustion — Energy produced when a unit of fuel is completely burned with pure oxygen.

Heat Release Rate — Mass heat loss rate times the heat of combustion and combustion efficiency (portion of the mass actually converted to energy).

High Challenge Occupancy — A facility or building that, due to the nature, type, or array of contents or operations, creates a unique challenge for the fire protection system(s) to protect.

Highrise Building — A building having occupied floors located more than 75 feet above the lowest level of fire department vehicle access.

Horizontal Exit — A fire-resistive barrier--having a minimum 2-hour rating--that effectively divides an occupied space in half. According to the model building codes, once an occupant passes through the horizontal exit, he or she is presumed to be in a "separate building" even though they may still be within the same structure.

Hose Stream Allowance — The amount of water (in gallons per minute) needed for manual fire fighting in sprinklered buildings. The hose stream allowance is added to the fire sprinkler system water demand to determine the total water supplies needed for a sprinklered building.

HPR — Highly Protected Rate (or Risk). An insurance policy rate that provides a cost incentive based on the degree of fire protection available.

HVAC — Industry abbreviation for heating, ventilating, and air-conditioning systems and equipment.

I

Incident Commander (IC) — The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and releasing of resources. The IC has overall authority and responsibility for conducting incident operations and is responsible for the management of all incident operations at the incident site.

Ignition Temperature — The minimum temperature to which a substance must be heated to ignite and sustain combustion.

Indicating Appliance — Also known as a "notification appliance." An audible, visual, tactical, textual, or olfactory device intended to alert building occupants to an emergency condition.

Initiating Device — A system component that originates transmission of a change-of-state condition, such as in a smoke detector, manual fire alarm box, or supervisory switch.

Inspection — In relation to fire protection systems and equipment, a visual check of the equipment or system to ensure that all components are in place, all operating functions are in a ready position, all gauges show appropriate pressures, and similar surveys.

Intumescent — A product such as paint, mastic, or caulking that contains entrained carbon dioxide gas. When the material is heated, the gas expands to form a thick, marshmallow-like coating over the surface of the coated item to provide fire resistance.

J-K-L

Jockey Pump — A small, nonrated pump assembly designed to maintain pressure on a fire protection system so the main fire pump does not operate prematurely.

Labeled — Equipment or material to which has been attached a label, symbol, or other identifying mark of a nationally recognized testing agency. See "Listed."

Listed — Equipment, materials, or services that have been evaluated by an independent, third-party agency to verify they perform as intended. The most common listing agencies are Underwriters Laboratories (UL) and FM Global (FM), formerly Factory Mutual. See "Labeled."

Lowrise Building — Used in reference to evaluating structural stability. An enclosed or partially enclosed building in which the mean roof height is less than or equal to 60 feet, and does not exceed the building's smaller horizontal dimension.

Thus, a structure that measures 60 feet by 30 feet with a 30-foot high roof would qualify as a lowrise building.

M

Maintenance — In relation to fire protection systems and equipment, regular service as specified by the manufacturer.

Maximum Foreseeable Loss Wall — Insurance industry term for a firewall designed to stop the spread of an uncontrolled fire when there is an impairment to the property's fire protection system **and** manual firefighting is limited or delayed. The phrase is not used in model building codes.

Model Building Code — A building safety regulatory document prepared by interested persons that can be legally adopted with or without amendments by local jurisdictions. The current model building codes include the *International Building Code* published by the International Codes Council, Inc., and NFPA 5000, *Building Construction and Safety Code.*

Model Fire Code — A fire safety regulatory document prepared by interested persons that can be legally adopted with or without amendments by local jurisdictions. The current model fire codes include the *International Fire Code* published by the International Codes Council, Inc., and NFPA 1, *Uniform Fire Code*®.

N-O

National Fire Incident Reporting System (NFIRS) — A standard national reporting system used by U.S. fire departments to report fires and other incidents to which they respond and to maintain records of these incidents in a uniform manner.

Notification Appliances — Any equipment that is part of a fire alarm system and intended to notify building occupants of an emergency. Includes bells, horns, buzzers, klaxons, sirens, strobe lights, vibrating alerts (tactile), or smell alerts (olfactory). Also known as an "indicating appliance."

Nuisance Alarm — An alarm caused by mechanical failure, malfunction, improper installation, or lack of proper maintenance, or an alarm activated by a cause that cannot be determined.

Opening Protective — An assembly of components installed in the opening of a fire- or smoke-resistive barrier, partition, or wall designed to close the opening during a fire. Examples include fire doors, fire dampers, smoke dampers, fire shutters, fire curtains, etc.

P-Q-R

Parapet

In building construction, a portion of a firewall that extends above the roof, in the same plane as the wall.

Passive Fire Protection Features

Structural and construction elements designed, installed, and maintained to control fire and smoke spread in a building and contribute to its structural stability. Includes, but is not limited to, firewalls, fire barriers, fire partitions, spray-on or otherwise applied fire-proofing, fire-resistive assemblies. See "**Active** Fire Protection Systems."

Pilot Line, Dry or Wet

A detection system employed with preaction sprinkler systems that uses air under pressure (dry) or water under pressure (wet) in a small-diameter pipe equipped with small-diameter sprinklers in the same space as the fire control sprinklers.

Preaction Sprinkler System

A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure, with a supplemental detection system installed in the same area as the sprinklers.

- Single interlock: Air in the pipe is not under pressure. Once the detection device senses a fire, the main sprinkler control valve opens and the pipe fills with water.
- Dual interlock: Air in the pipe is under pressure. Both the supplemental detection system **and** a sprinkler must operate to release air from the system and open the preaction valve to enable water to flow.

Preincident Planning

A process of information collection, sorting, evaluation, and dissemination of facts, probabilities, and mitigating factors relating to emergencies in buildings or facilities.

Pressurization, Smoke Management/ Control (Active)

The creation and maintenance of pressure levels in zones of a building including elevator shafts and stairwells that are higher than the pressure level at the smoke source, such pressure levels being produced by positive pressure of a supply of uncontaminated air, by exhausting air and smoke at the smoke source, or by a combination of these methods.

Note: Exhausting the zone of origin may be all that is necessary to achieve a fully compliant smoke control system.

Primary Factors Chart

A tool that can be used by Command Officers to organize and manage an emergency incident. The Primary Factors Chart identifies

- pertinent factors about a building or hazard area;
- incident objectives;
- strategies to achieve incident objectives; and
- reminders to evaluate the effectiveness of the selected strategies continually.

Protected Opening

A penetration through a wall, floor, ceiling, or other fire-resistive barrier that is equipped with a device (fire door, fire damper, etc.) designed to close automatically and protect the integrity of the barrier.

Pump, Jockey

A small, nonrated pump assembly designed to maintain pressure on a fire protection system so the main fire pump does not operate prematurely.

Pyrophoric

A chemical with an autoignition temperature in air, at or below a temperature of 130 °F (54.4 °C).

Quick-Opening Device

Equipment attached to a dry pipe sprinkler valve to aid the removal of air in the sprinkler system and speed the operation of the dry pipe valve. Quick-opening devices most commonly are exhausters or accelerators.

Radiation

Transfer of heat energy from a hot surface to a cooler surface by electromagnetic waves.

Radiation Feedback

The condition of electromagnetic waves reflected from one heated surface to another.

Recommended Practice

With NFPA, a document that is similar in content to a Code or Standard, but that contains only nonmandatory provisions using the word "should" to indicate recommendations.

Residential Sprinkler System

A sprinkler system installed in living spaces and adjacent corridors designed to control an incipient fire for the purpose of life safety. This is accomplished by wetting walls and the ceiling to prevent flashover in the room where the fire begins. Residential sprinkler systems are not designed for property protection, therefore sprinkler protection may not be included in all parts of a structure.

Retard Chamber — A small vessel connected to an alarm check valve to collect water and regulate pressure from water surges to prevent unwanted water flow alarms. Also called a "retarding chamber."

Risk — Mathematical probability that an event or sequence of events involving hazards will result in varying degrees of damage to people, property, or the environment.

S

Saponification — The result of adding water and alkali to animal fats to create a soap-like product.

Sectional Control Valve — An indicating control valve used to isolate one or more portions of a water-based fire suppression system. Sectional control usually is arranged to disable one portion of a system (such as an individual floor) while the rest of the system remains in service.

Shaft — An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and roof. See "Chase."

Shotgun Riser — Industry term for a wet pipe sprinkler riser that consists solely of a control valve, pressure gauge, main drain, and flow switch.

Smoke — The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, including the quantity of air that is entrained or otherwise mixed into the mass.

Smoke Compartment — A space within a building enclosed by smoke barriers on all sides, including the top and bottom. Smoke compartments are frequently called smoke zones and these terms are used interchangeably.

Smoke and Heat Vents — Passive devices installed to permit smoke and heat to escape from a building. Normally installed on roofs, these devices may be melt-out material operated by fusible link, manually operated, or a combination of these methods.

Smoke Control Mode	A predefined operational configuration of a system or device for the purpose of smoke control. Synonymous with smoke "management."
Smoke Control System, Gravity	A method of smoke control that relies on natural ventilation forces to control or remove smoke. Usually used in reference to rooftop smoke and heat vents.
Smoke Control System, Dedicated	A "stand alone" smoke control system where fans, controls, and alarm features are independent of the building's HVAC system.
Smoke Control System, Nondedicated	A "combined" smoke control system where fans, controls, and alarm features are integrated with the building's HVAC system.
Smoke Control System, Mechanical	An engineered system that uses mechanical fans to produce pressure differences across smoke barriers or establish airflows to limit and direct smoke movement.
Smoke Control System, Passive	A system of smoke barriers arranged to limit the migration of smoke.
Smoke Damper	A listed device installed in ducts that is designed to resist the passage of air and smoke. The device is installed to operate automatically, controlled by a smoke detection system, and, where required, is capable of being positioned from a remote command station.
Smoke Detector, Ionization Principle	A smoke detection device that employs a small radioactive electron source. When small particles enter the smoke chamber, the particles are ionized. The ionized particles affect the electrical current flow in the sensing chamber, sounding an alarm.
Smoke Detector, Photoelectric Principle	A smoke detection device that employs a light source and light-sensitive target. When smoke interrupts or alters the light-beam, an alarm is sounded. Photoelectric detectors may include light-beam interruption (obscuration) or bending (refraction).
Smoke Exhaust System	A mechanical or gravity system intended to move smoke from the smoke zone to the exterior of the building. It includes smoke removal, purging, and venting systems, as well as exhaust fans used to reduce the pressure in the smoke zone. An approved gravity system may be automatically or manually operated smoke vents.

Smoke-Proof Enclosure	An exit stairway designed and constructed so that the movement of the products of combustion produced by a fire occurring in any part of the building into the enclosure is limited.
Smoke Zones	A space within a building enclosed by smoke barriers on all sides, including the top and bottom. Smoke zones frequently are called smoke compartments, and these terms are used interchangeably. In rare cases, such as covered shopping malls, smoke zones may have no physical barriers other than the mall floor and ceiling.
Specialty Fire Protection Systems	Fixed fire protection systems employing special extinguishing agents or application techniques. Includes halogenated agents, halogen replacements (clean agent), dry and wet chemical, carbon dioxide, and water mist.
Sprinkler System, Automatic	An integrated system of underground and overhead piping, valves, and sprinklers designed in accordance with fire protection engineering standards.
Sprinkler System, Deluge	A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers.
Sprinkler System, Dry Pipe	A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers.
Sprinkler System, Foam	A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers, and equipped with special sprinklers that aerate a mixed foam/water solution at the point of discharge.
Sprinkler System, Pre-action	A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure, with a supplemental detection system installed in the same area as the sprinklers.

Sprinkler System, Residential Design

A sprinkler system installed in living spaces and adjacent corridors designed to control an incipient fire for the purpose of life safety. This is accomplished by wetting walls and the ceiling to prevent flashover in the room where the fire begins. Residential sprinkler systems are not designed for property protection, therefore sprinkler protection may not be included in all parts of a structure.

Sprinkler System, Wet Pipe

A sprinkler system employing automatic sprinklers connected to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire.

Spot Application

Used in relationship to specialty fire protection systems to describe a system that discharges to protect a two-dimensional hazard such as a printing press, a dip tank surface, or commercial cooking surfaces.

Standpipe System

An arrangement of piping, valves, hose connections, and allied equipment installed in a building or structure, with the hose connections located in such a manner that water can be discharged in streams or spray patterns through attached hose and nozzles, for the purpose of extinguishing a fire, thereby protecting a building or structure and its contents in addition to protecting the occupants. This is accomplished by means of pumps, tanks, and other equipment necessary to provide an adequate supply of water to the hose connections.

- **Class I**

  Class I systems provide 2-1/2-inch hose outlet connections to supply water for use by fire departments and those trained in handling heavy fire streams. The systems must be designed to deliver a flow of not less than 500 gallons per minute (gpm) at 100 pounds per square inch (psi) at the topmost hose outlet.

- **Class II**

  Class II systems provide 1-1/2-inch hose stations to supply water for use primarily by the building occupants, or by the fire department during initial response or mop up. Class II systems--which often are connected to the building's potable water supply--must be designed to deliver 100 gpm at 65 psi at the outlet. Class II systems normally are not equipped with a fire department connection to supplement the flow and pressure.

- **Class III** — Class III systems employ the features of both Class I and II. They provide 1-1/2-inch hose stations to supply water for use by building occupants; and 2-1/2-inch hose connections to supply a larger volume of water for use by fire departments and those trained in handling heavy fire streams. The systems must be designed to deliver a flow of not less than 500 gpm at 100 psi at the topmost hose outlet.

Standpipe, Automatic (Dry) — Automatic dry systems normally are filled with pressurized air, using a dry pipe valve that admits water into the system when a hose valve is opened. The air normally is discharged through the hoseline so there will be a delay in receiving water in the line, not unlike water being supplied from a fire department pumper. They normally are installed where the piping is subject to freezing.

Standpipe, Automatic (Wet) — Automatic wet systems are systems that are capable of supplying system demand automatically. They are supported by a water supply capable of meeting the firefighting water supply demand for a particular building or area. The water supply may be the municipal system, private water system, or one or more storage tanks in the building.

Standpipe, Manual — A standpipe system that is not connected to a water supply, or has only a small priming water supply that is not capable of delivering the system demand and requires water from a fire department pumping apparatus to supply the system demand.

Standpipe, Semi-Automatic (Dry) — A dry system that uses a deluge valve or other device that admits water into the system upon activation of a remote control device located at a hose connection. A remote control device must be located at each hose connection.

Standard — A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements, and which is in a form generally suited for mandatory reference by another standard or code for adoption into law.

Structure — That which is built or constructed.

Supervisory Signal — Used in conjunction with fire protection systems to identify "normal" and "off-normal" conditions, such as valve closure, high or low air pressure, high or low water temperature, or security features on a system. A supervisory signal is **not** a trouble signal.

Suppression Mode — When applied to sprinkler systems, describes automatic sprinklers, such as Early Suppression Fast Response, that are designed to suppress the fire to the point where there is no active combustion. See "Fire Control Mode."

T

Target Hazard — Any building or potential incident site (e.g., outside hazardous materials storage site, bulk fuels storage facility) that has the potential for significant life loss, high property dollar loss, and/or the ability to overwhelm local resources.

Test Header, Fire Pump — Equipment containing one or more 2-1/2-inch outlets with gate valves used to perform periodic performance testing on the fire pump. May be used in lieu of a flow meter.

Testing — In relation to fire protection systems and equipment, a performance check, where the system or equipment is exercised in compliance with the testing criteria outlined in the NFPA codes and standards or manufacturer's requirements.

Thermistor — Thermally sensitive resistors that have, according to type, a negative (NTC), or positive (PTC) resistance/temperature coefficient. Manufactured from the oxides of the transition metals--manganese, cobalt, copper, and nickel, NTC thermistors are temperature dependant semiconductor resistors.

Total Flooding — Used in relationship to specialty fire protection systems to describe a system that discharges to protect a three-dimensional hazard such as a spray booth or computer room.

Trouble Signal — An alarm signal from a fire alarm control panel indicating an electronic failure of some kind: i.e., loss of main power, circuit interruption, disconnected device, or ground fault. A trouble signal is not a **supervisory** signal.

Truss — A framed structural unit made up of a group of triangles arranged in a single plane in such a manner that, if the loads are applied at the points of intersection of the truss members, only compressive or tensile (nonbending) forces will result in the members.

U-V-W

Valve, Indicating — A water control valve that can be identified as "open" or "closed" without touching the valve. Usually used on water supplies to fire protection systems. Includes post indicators, wall indicators, quarter turn, and butterfly valves.

Valve, Nonindicating — A water control valve that must be manipulated to determine its "open" or "closed" status. Usually used on fire protection systems for test or drain connections that are not critical to system operation. Includes globe, ball, check, and gate valves.

Venturi — A short tube with a tapering constriction in the middle that increases the velocity of the fluid flow and results in a corresponding downstream decrease in fluid pressure. Commonly used in the fire service for foam eduction.

Water Spray System — Similar to a deluge system, a water spray system employs normally open nozzles, but discharges water in a fine mist. Usually used for exterior exposure protection such as for aboveground tanks or oil-filled electrical transformers.

Wet Chemical Extinguishing Agent — A fire extinguishing agent made from a solution of water and potassium-carbonate-based chemical, potassium-acetate chemical, or a combination of both.

Wet Pipe Sprinkler System — An automatic sprinkler system employing automatic sprinklers connected to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire.

Windowless Building — A structure that measures at least 1,500 square feet and is not provided with doors or windows for ventilation or rescue sized and spaced in accordance with the building code. Generally, openings must be at least 30 inches wide, have 20 square feet of net clearance, be openable from the outside, and be located not more than 75 feet from the opposite wall.

X-Y-Z

Zoned — When used in conjunction with fire alarm systems, describes a method for installing initiating devices and circuits so an alarm will correspond with the general location and/or devices (i.e., "Second floor, gymnasium, smoke detectors, pull stations, etc.") See "Addressable."

SUPPLEMENTARY READINGS

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PERFORMANCE KEYS TO SUCCESSFUL FIRE OUTCOMES

Reprinted from *Fire Engineering* magazine, January 2003.

By James G. Munger, Ph.D., MIFireE, CFPS, and Robert A. Neale

An emerging new philosophy in modern building designs may mean big changes are in store for fire suppression personnel. For many years, fire officials have performed pre-incident surveys and developed strategic and tactical plans to identify and mitigate hazards in buildings and facilities constructed under "prescriptive" building and fire codes. Now, architects, engineers, fire marshals, and building officials are exploring new ways to construct buildings that employ modern materials, nontraditional construction methods, alternative fire protection systems, and creative new designs. This new approach is known as performance-based designs.

Performance-based designs employed in sophisticated and challenging construction projects may not adhere to traditional building codes, and the fire protection features on which we have learned to rely may not exist. Consequently, comprehensive pre-incident planning and regular inspection are imperative to ensure fire departments protect lives and property--including their own.

Firefighters may discover that the fire protection features with which they have been familiar--such as fire separation walls and smoke management systems--don't exist in these new buildings. Many incident commanders have made successful defensive stands at four-hour-rated firewalls, and if those walls don't exist, alternate plans must be made.

Prescriptive Codes and Performance Designs

Fire suppression personnel should not suspect that buildings are becoming less safe with these new designs. In fact, the opposite may be true.

Many local, state, and national building codes have evolved in the past century based on observed events and public demand for improvement. When 492 people died in Boston's Cocoanut Grove, building codes changed to require that doors swing in the direction of exit. Fire codes addressed combustible interior decorations. After 64 people died in the Hotel LaSalle in Chicago and another 119 died in Atlanta's Winecoff Hotel, the codes addressed the issues of enclosing vertical openings to minimize fire and smoke spread.

Other recent changes have been based on hazardous-materials regulations, improvements in fire detection and protection systems, and an overall better understanding of fires and how they perform in buildings. However, not all of these code changes have been based on scientific or engineering principles. Many of these code changes have resulted in what are called "prescriptive" requirements. The building and fire codes prescribe exactly what fire protection or life safety strategy must be employed to meet the intent of the code.

For example, most building codes require two- or four-hour-rated area separation or fire walls to divide the floor area of buildings into spaces where the fire department can be expected to control a fire. Some structures, based on their size or use, require the installation of fire sprinklers. Others, because of their height, require standpipe systems to make the firefighters' job easier by not having to string fire hose up stairways.

Over time, firefighters learn to rely on these features and include them in their pre-incident plans. Look at the pre-incident plans in your station. Not only do they include the access roads, building footprint, and fire hydrants, but they probably include fire wall and door locations, fire department sprinkler and standpipe connections, smoke management system controls, and known locations of hazardous materials and processes.

Some plans even might include pre-incident strategic and tactical instructions. In one case, the strategy might be to confine a fire to one-quarter of the building, while the tactics to be employed include supplementing the sprinklers, establishing secondary water supplies, starting fire pumps, and setting up defensive master streams.

A common tactic in high-rise firefighting is to connect hoselines to a standpipe system in a fire-rated stair enclosure before entering the floor to attack the fire.

These tactics have become common because of the consistency among building and fire code requirements for structures based on their size and use. With prescriptive building codes, fire departments operating in any state or territory can predict how a building will be erected and outfitted for fire protection.

Traditional code requirements may be tossed aside, however, where performance-based designs and codes are employed. Rather than using prescriptive lists of requirements, performance designs apply scientific data on fire and smoke spread, combustion principles, and human behavior to building designs and construction. Firefighters should not expect to find all of the same fire protection features to which they are accustomed in these buildings, but alternate methods likely are provided. Essentially, designers may be creating their own building code for each unique structure.

For example, as part of a performance design, the architect and engineer may be able to show that all occupants can be evacuated within a specific period of time, thereby eliminating the need for fire resistive exit enclosures. Or, more commonly, they may show through fire testing that sprinklers would not be effective in an extremely tall ceiling configuration and therefore could be omitted.

Before a performance design is implemented, those persons interested in the successful outcome get together to discuss their goals and objectives for the project. These participants are called stakeholders and should include the local fire officials (prevention, engineering, and suppression), emergency medical services, hazardous-materials emergency response teams, and pre-incident planning specialists.

This is an important time for fire suppression personnel to look at the proposal and offer their comments. Address significant fire suppression concerns (water supply, access roads, hydrant placement, and fire suppression equipment) early in the discussion so they can become part of the pre-incident plan.

The Importance of Preincident Plans

All fire officials know it is better to be prepared than to be sorry. Information gathered and evaluated before an incident can be the difference between a successful and unsuccessful outcome.

An important part of pre-incident planning when dealing with performance-based designs is to visit the property regularly and update the plan as needed. To assist the fire department as well as the owners and occupants of buildings, the National Fire Protection Association developed NFPA 1620, *Recommended Practice for Pre-incident Planning*. This document was first published in 1993 as NFPA 1420, *Pre-incident Planning for Warehouse Occupancies*. Since its original issue, the document has been expanded to cover all types of occupancies. It is anticipated that in the near future this document will be revised from a "recommended practice" to a "standard."

As NFPA 1620 points out, a pre-incident plan is one of the most valuable tools available for aiding emergency responders in effectively controlling an emergency. A pre-incident plan should not be confused with inspections, which are intended to identify fire hazards and monitor code compliance. Proper planning involves evaluating the protection systems, building construction, contents, and operating procedures that can impact emergency operations. Unlike fire prevention or fire safety inspections, a pre-incident plan assumes that some type of incident will occur.

Performance-based designs often are based on scientific or engineering studies and computerized fire modeling programs that predict what should happen in the event of a fire. To ensure the models are valid and the project stays within safe limits, these designs incorporate "bounding conditions." A bounding condition is one that, if changed, would result in a significantly different outcome.

As a hypothetical example, the bounding conditions on a high school chemistry lab design might include the fact that no more than two gallons of denatured alcohol are stored in the room. The fire protection system then would be designed to control a fire in that space with that amount of fuel. If 20 gallons of alcohol are brought into the room, the fuel load is increased substantially. This situation would exceed the bounding conditions and perhaps result in a fire protection system failure.

Pre-incident plans should identify the bounding conditions, and fire personnel should have a method to identify and report changes to get them corrected.

Infrastructure Protection Intelligence Considerations

Key considerations for pre-incident planning of performance designs include many of the factors already identified in NFPA 1620.

- Physical elements and site considerations. There are three major factors identified in physical elements and site considerations: building construction, building services, and external conditions. Building construction includes not only the critical structural elements, combustibility, and size but also window and door access, roof construction, opening protection (fire doors), and significant design features such as atria that may allow smoke and fire to spread vertically through many stories. Building services include water (fire protection and domestic), sewer, electric, gas, steam, liquid fuels, emergency power, and elevators. Site considerations include exposures, road and bridge access, slopes, security features, and potential environmental impact of an incident and how it might be mitigated.

- Occupant considerations. Occupant issues include the number and "type" of persons who may be in or around the facility at any time. How many people will be there at any time? Are workers or visitors limited to specific time shifts, or is there around-the-clock use? Are people capable of escaping an incident on their own? Do they need staff assistance because they are bedridden or incarcerated? Does the facility have its own emergency evacuation and care plan that coincides with the fire department's?

- Water supplies and fire protection systems. NFPA 1620 recommends a thorough assessment of the water supply and fire protection systems. The pre-incident plan should identify on-site water supplies and locate alternate sources in the neighborhood. The estimated fire flow should be computed beforehand using recognized formulas and water supplies capable of delivering that flow clearly identified. Fire protection equipment features--such as fire department connections for sprinklers and standpipes, main control valves, fire pump controls, fire alarm systems, and smoke management systems--should be included in the plan and operating sequences for sophisticated systems explained in easy-to-understand descriptions.

- Special hazards. One of the key elements of any pre-incident plan is the recognition and identification of special hazards. This is especially important in the area of performance-based designs where alternate means of protection may have been employed. Special hazards include obvious items such as explosives or toxic materials and some less-obvious ones such as electrical or mechanical hazards, confined spaces, inert atmospheres, openings between floors, complex product piping systems, and unique architectural features.

Fire departments have recognized the value of pre-incident planning for a long time. It is better to arrive on the scene of an incident prepared to address its unique hazards than to let the incident control the response. With performance-based designs, the potential variations in building layout, means of access and egress, and fire protection features may vary dramatically from those with which fire officers are familiar.

Do you want a better understanding of performance-based design? The United States Fire Administration's National Fire Academy offers a new six-day course called "Evaluating Performance-Based Designs." The course is intended to help local fire and building officials obtain familiarity with performance-based design concepts so they may feel confident reviewing plans submitted for their approval. Performance Technologies International, Inc., of Annandale, Virginia, developed the pilot materials. The International Fire Marshals Association, Society of Fire Protection Engineers (SFPE), and National Institute of Standards and Technology made significant contributions to course content.

Course content includes a comparison of prescriptive and performance design and building codes, an introduction to fire dynamics, an overview of available fire models, the SFPE "Process Method" for fire safe design, and the importance of documentation and ongoing inspection to the success of performance-based design.

Fire service and allied professionals interested in taking the regularly scheduled courses should check their 2003 National Fire Academy Catalog of Activities for a course synopsis, prerequisites, and upcoming dates.

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Author(s): James G. Munger, Robert Neale

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FIRE DEPARTMENT OPERATIONS AT SPRINKLERED PROPERTIES

BY DAVID R. BLOSSOM, ALCM, CFPS, CFI1

Will Rogers once said, "It isn't what we don't know that gives us trouble, it's what we know that ain't so." Although these words typically provoke a smile when quoted, at the same time, they can haunt us when we find ourselves believing something that may not be accurate. What do you believe about the fire sprinkler-protected buildings in your district?

Once, in most fire protection districts you could almost count on your fingers and toes the number of buildings protected by fire sprinkler systems. Prior to the early 1970s, sprinkler-protected buildings were not common. Typically, they were restricted to large manufacturing, textile, warehouse, and industrial occupancies. Protected properties usually had very simple "tree" or pipe schedule systems.

As laws were enacted requiring fire sprinkler protection, the number of protected buildings began to increase. When the advantages of sprinkler systems were recognized, the systems proliferated. Variances allowed in building codes allowed provisions for sprinkler protection to take the place of costlier requirements.

Today, we may be surprised to find a building that does not have this protection. What is worse, we may not even notice when sprinklers are present and take for granted that they are properly maintained and fully operational. If you live in an area of the country in which the majority of its growth has occurred in the past 30 years, most of the commercial buildings built in that period would be protected with fire sprinklers.

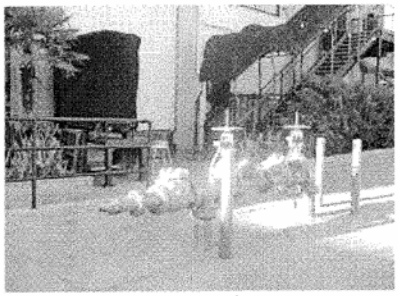
When there were few buildings with sprinkler protection, it was more likely that the local fire department was familiar with the buildings that had fire sprinklers. It was also highly probable that the department had a through knowledge of the buildings' sprinkler systems and the unique hazards of the properties.

Why is this topic important? You would be shocked to know that at any one time, a full 25 percent of the fire sprinkler systems in your jurisdiction may be in some way impaired. This can range from fully

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to partially closed control valves, a change in occupancy from that originally protected by the fire sprinkler system, or a reduction in the water supply resulting from growth in the area. What does this mean for you?



Click here to enlarge image

(1) A fire backflow preventer assembly with OS&Y valves, tamper switches, and an FDC. Can you determine from this vantage point what part of the building/complex sprinkler system this valve assembly controls? (Photos by author.)

Erroneous assumptions about local fire sprinkler systems can result in costly mistakes at the very least, fatalities at the worst. After the fire has started is the wrong time to find out about the condition of these systems.

The majority of commercial properties are required by code to include fire sprinklers, creating two interesting situations. First, there is generally an assumption that most newer properties have fire sprinkler protection. Second, it is nearly impossible for the public fire service to be familiar with the details of the myriad sprinkler-protected properties in its community. There may be a general understanding of sprinkler system basics, including how they work, the location of the control valves (maybe), and some standard procedures for responding to buildings protected with these systems. However, the old adage, "It's what you don't know that can hurt you" should be carefully considered when it comes to sprinkler-protected buildings.

Often fire sprinklers are installed because they are required by code. Usually, there are trade-offs in having these systems. If you are going to "make" me install fire sprinklers, then other requirements can be reduced: fewer fire hydrants, reduced need for fire stopping, larger "compartments" within a fire division, less costly building materials, and so forth. The reduced requirements often allowed for cost savings. The key is that these trade-offs require the presence of a properly designed fire sprinkler system with an adequate water supply. Without this suppression system, you have a structure with no fire protection designed to less stringent building requirements.

This is just one reason fire personnel must be aware of the adequacy of the fire sprinkler system and must know how to use the system to properly manage a fire.

To address this need, the National Fire Pro- tection Association (NFPA) developed a pamphlet in 1933, later published as NFPA 13E, Recommended Practice for Fire Department Operations in Properties

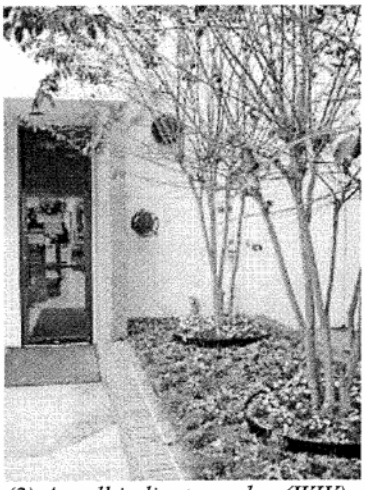
Protected by Sprink-ler and Standpipe Systems. As stated in the Scope section, this document is intended to assist fire departments.

"This recommended practice provides basic procedures and information for use in fire department operations concerning properties equipped with certain fixed fire protection systems. The fixed systems covered in this recommended practice are interior automatic sprinkler systems, exterior sprinkler systems, and standpipe systems."

Although this may sound like a relatively simple task, one only has to look just below the surface and discover that in most jurisdictions, it would take a well-trained staff to apply the management techniques contained in this document. This guide, intended to provide assistance with preplanning and operations during fire conditions, can be challenging to implement.

EARLY SPRINKLER SYSTEM OPERATIONS

When NFPA 13E was originally published, and for most of its existence, fire sprinkler systems were typically found in large industrial warehouse and manufacturing facilities or small special hazard facilities. For the most part, these buildings were protected by one or two systems that were relatively simple to identify and work with. The "tree" or pipe schedule wet-pipe system was the most commonly used (pipe sizes were selected from a chart based on the number of sprinkler heads supplied by a specific size of pipe). Because of its relatively simple design, the pipe schedule method allowed for the selection of the proper pipe size to deliver water in quantities based on hazards identified as light, ordinary, and extra hazard. The basic procedure in many departments was for the first or second responding engine company to lay a supply line from the hydrant and connect to the fire department connection (siamese/FDC) and prepare to pump into the system at 150 psi if a working fire was discovered. Because the layout was relatively simple, with one connection and control valve for the system, there was little concern about operations related to these systems.



(2) A wall indicator valve (WIV) and water motor gong (WMG) located at a shopping mall. Can you determine from this vantage point what part of the mall this

sprinkler system valve serves?

TODAY'S CHALLENGES

As buildings have become larger with the proliferation of shopping centers, covered malls, large hotel properties, hospitals, sports arenas, distribution warehouses, and similar complex occupancies, there have been correlating changes with sprinkler protection. It is not uncommon to find multiple systems in these buildings, because of area protection limits set within NFPA 13, Fire Sprinkler Code. In inspecting the exterior of these buildings, you discover multiple fire department connections, control valves, test valves, and the like.

In warm climates, the riser for the system may be outside, making access and observation of system controls relatively easy. This is especially helpful during fire conditions when accessing the building interior may be difficult. In addition, there are often sectional control valves within the building that may be in a storeroom, a false or drop ceiling area, and so forth. When the building is visited under normal conditions, there is little problem locating these system controls.

However, during a fire emergency, it is very difficult to identify main and sectional control valves and verify system components. American Water Works Association (AWWA) requirements for backflow prevention devices to protect the potable water system caused an increase in the number of control valves. It is likely that a single riser system may have five shutoff valves. Although sometimes they are monitored with tamper switches, most are installed with the indicating valves located for physical observation to make certain they are open.

Now add multiple systems within a large building, and there could be dozens of valves to monitor. On large systems on private or yard mains, there could be any number of sectional valves. These private yard mains are not easily identifiable by casual observation. Often valves are located in pits outside to provide protection from freezing temperatures. Usually, post indicator valves (PIV) are used for below-ground valves, allowing the valve to be placed below the frost line and to provide visual and mechanical valve monitoring.

One potential danger is that the indicating portion of the valve, the post indicator, may be removed. With this gone, the position of the valve cannot be easily determined. I found one situation at a beverage distributor in which the indicating portion of a PIV had been removed and the opening capped and covered with asphalt during a repaving.

PREPLANNING FOR PROTECTED PROPERTIES

NFPA 13E encourages the development of standard operating procedures for responding to fire incidents in sprinkler-protected properties. To accomplish this, the fire department and the property owner need to cooperate.

FIRE DEPARTMENT PROCEDURES

By following a simple six-point plan, you can develop a response plan that is easily duplicated throughout your department. It should include the following:

1. Procedures for personnel to check on arrival all valves in the sprinkler system to ensure that they are fully open.

2. One of the first responding engine companies should be responsible for connecting supply lines into the FDC/siamese.

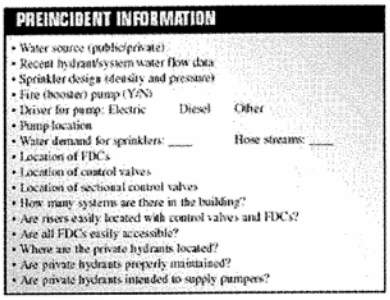
3. Post a member at the main control valves for the systems that are flowing water.

4. Don't shut off the sprinklers too soon.

5. Don't rob the sprinkler systems of their water supply by connecting hoses to yard hydrants unless you have water flow data that confirm that there is adequate water for the sprinkler and for fire department use.

6. Let the sprinklers do their work.

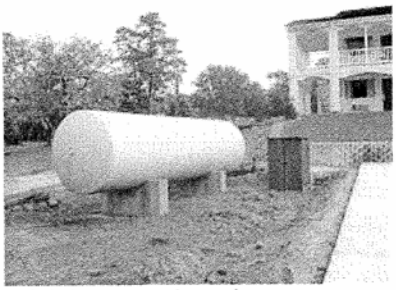
There have been many instances in which sprinkler systems have been rendered ineffective because of shut or partially closed valves. By assigning personnel to check the valves on arrival, you can confirm that the system is unimpaired. Laying supply lines into the sprinkler system will provide two immediate advantages. First, if the main control valve is shut, you can supply the system with adequate water when the FDC is upstream from the shut control valves. Second, two 21/2-inch supply lines will provide sufficient water supply for 20 to 25 operating sprinkler heads. Providing this supplemental water supply to the system will ensure that the system is receiving adequate water. Typically, these lines should be charged to 150 psi. There are serious consequences if the sprinkler system is shut down too soon. The reason for doing so is often to allow smoke and steam to disperse from the area to increase visibility or to reduce water damage. Do not rush to do this; if the fire is not under control, it will fuse more sprinkler heads in the fire area, thus requiring much more water when the system water supply is restored. Remember, one sprinkler head operating directly over the seat of a fire and producing 20 gpm of flow will be more effective than a hose stream from across the building. Let the system do its job and manage the fire by monitoring the system's effectiveness and supporting its operation. In most situations, a system designed for the occupancy's hazard will control and even extinguish the fire. Robbing the system of its water supply typically occurs when yard hydrants on the same supply as that feeding the sprinkler system are used to supply handlines or, worse, pumpers.



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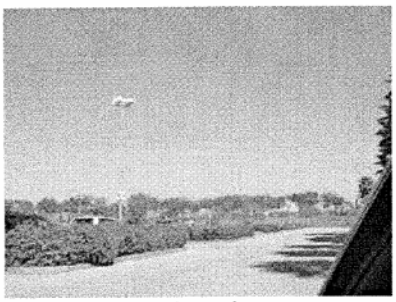
In most situations, the original design of the sprinkler system will allow for between 250 and 500 gallons of water for the fire department to use. Using more water than this will reduce the available water supply to the sprinklers to the point where the ability of the sprinkler to operate properly is hindered. If there is a fire (booster) pump to augment the pressure to the fire sprinkler system, post a

firefighter at the pump control panel to ensure proper operation. Remember, this pump is to supply additional pressure only; it cannot provide more water than the water system can deliver. It would be wise for emergency personnel responsible for this duty to receive specific training from pump manufacturers so that they are familiar with the pump, valves, controllers, and proper operation.



Click here to enlarge image

(3) A pressure tank supplying the sprinkler system for a hotel. Once this water supply is exhausted, you will need to augment the water supply to the system. Some simple calculations will tell you how long the water supply should last based on projected water flow through standard sprinkler heads.



Click here to enlarge image

(4) Can you spot the hydrants? There are three in this picture. Hint: One of them is yellow and visible at the far distant bushes in the photo. Could you easily find them during an emergency situation? Look for them now, not when you need them.

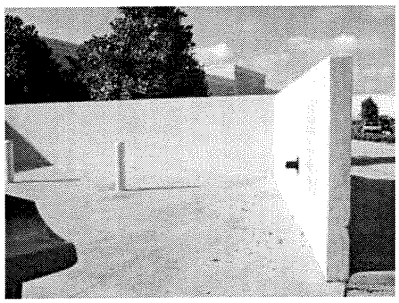
WATER SUPPLY

The most critical concern is ensuring that the sprinkler systems receive an adequate water supply. In developed areas, most are supplied from the public water distribution system. In remote areas, wells or tanks with pressure boosted by pumps may be the primary water source. Elevated tanks have the advantage of providing the necessary pressure from gravity to feed the system, independent of pumps. However, all tanks are limited by the amount of water they can hold. Once that water is gone, you might as well shut off the supply valve.

Some large industrial complexes will provide one or two FDCs that may feed all sprinkler systems. Often, yard hydrants are connected to these systems, which creates additional concerns. This is less common today. To save on installation costs, eliminating the single FDC for a group of buildings reduces the amount of pipe needed. Thus, today you will find a single large building may have eight or 10 or more fire department connections around the property. You can generally assume that one FDC connects to one system. You must know if you are connecting to the system that is operating when you arrive. There are only two ways to ensure this: Know the systems, and properly mark each FDC to indicate which riser is supplied from the connection. The next time you are observing conditions at a large facility, see how quickly you can identify which system protects a particular building area.

EVALUATING SPRINKLER SYSTEM INFORMATION

It is important to have easily accessible information about the sprinkler-protected properties in your area. The property owner should provide adequate signage for all control valves and fire department connections. Where there are multiple FDCs and risers, you must be able to readily identify which FDC and control valves are for the area of the building burning. Simple signs at the FDC that give the location of the riser supplied and the area of the building protected will immediately tell you if you are connecting to the correct system. When the FDC is located on the outside wall, you can generally assume that the riser is located on the inside of the wall. When the FDC is at the street or away from the building, it may be difficult to know exactly which system is supplied by the FDC. Encourage the property owner to provide "as built" plans for the above and underground piping in an easily accessible location. It is not unusual for these documents to be lost over time. All hydraulically calculated systems are provided with full drawings and calculations that are given to the owner. They will usually end up lost somewhere on the property. It is strongly recommended that the building owner properly file this information to allow quick access.



Click here to enlarge image

(5) This FDC, one of several at a shopping mall, is hidden on the inside of a wall constructed to hide the loading dock area from traffic in

the public areas of the property. Assuming you would know to look behind this wall, you will notice that there is no sign indicating which section of the building sprinkler system is supplied from this FDC. Find out where each FDC is located and which system each FDC supplies before you encounter a fire situation.

SIMPLE EXERCISE

The next time you are out on company surveys, select a large property protected by a fire sprinkler system. Approach the first sprinkler riser area on the outside of the building. From this vantage point, answer the following:

- What section of the building does this riser (control valve and FDC) serve?
- If I connect to the FDC at this location, will it also supply the other systems on the property?
- Are there any sectional control valves anticipated in the system? Where? How many?
- Is there a single or multiple main water supply to this and other risers?
- Is there a fire "loop" that connects all of the risers for the building to one supply?
- Does this fire protection loop have sectional control valves? How many? What systems would be isolated by the closing of one or two valves?
- Is the underground supply an actual loop, or are there dead-end sections?
- Are the hydrants on the property connected to the same underground as the sprinkler systems?
- How will pumping from these hydrants affect the supply to the sprinkler systems?
- Do I really know as much about the fire sprinkler and hydrant water supply as I think I do? After all, we typically expect things to work the way we assume they do or have done in the past. However, if there is a poor water supply in an area, you can diminish adequate water supply to the sprinkler system by connecting to a hydrant too close to the system riser. Partially shut control valves will greatly reduce the ability to properly supply the fire sprinkler system with adequate water. If the FDC connects to the riser above the control valve, then you will bypass this obstruction and improve water supply to the system.

SOLUTIONS: WHAT TO DO

The first step in finding real solutions is often the most difficult to identify. If you know that information about the sprinkler system is missing, then this can be collected from available resources. However, it is much more difficult to know what information is needed. Start by determining what information you need to know about a particular building. Develop a basic list of information common to all properties. A good source is the NFPA's Fire Protection Handbook, specifically the "Pre-Incident Planning for Industrial and Commercial Facilities" section. This will help you to understand what type of data you need to evaluate conditions on the property and to develop good incident plans.

Next, create a list of indicators that should prompt a deeper look at the details to discover unusual arrangements or conditions. When do you know when you have all the information you need and can stop the evaluation? This depends on how much information you want to collect before the incident.

You may not be concerned with the name of the contractor who installed the system, for example. However, if you encountered a problem during a fire, you might want to contact someone familiar with the system; typically, the building owner knows nothing about it.

See the highlighted information on the type of information you may want to collect while completing your evaluations.

In most situations, large properties do not have signs identifying the control valves, the FDCs, and other components. This is a particular concern where valve pits are used for control valves that can become hidden by leaves, bushes, and other obstructions.

A WELL-PROTECTED PROPERTY

Signs of a well-protected property should increase your confidence during the initial evaluation. When approaching the building, are there visible signs indicating the FDC location? Are these visible when approaching the building, or do you have to know where to look beforehand? Does the FDC indicate which system is supplied and the area of the building protected? If the FDC is not located near the riser control valve, is there information about where the valve is located? If there are multiple systems, there should be a logical numbering system that indicates the total number of systems, say, "System 3 of 6." Other information that should be provided is the area of the building protected: "System 3 of 6, mall section K, stores 102 through 146," or "System 3 of 6, northwest building quadrant."

The total number of systems, which FDC supplies which system, and the building area protected will also help to determine which system should be supplied in which order if multiple systems must be supplied. For example, if the fire is located in the section of the building protected by System 3, but the fire area is located adjacent to the area protected by System 2, should the fire spread into the area protected by System 2, that system would need to be supplied from the FDC. By knowing the systems and the FDC location, you can have the system directly involved supplied first and will know which system should be supplied second. If this sounds complicated, just imagine it is 2 a.m. and you are without knowledge or easily accessible information about the building fire sprinklers. Delays in connecting to the right system and managing the incident could result in unnecessary property damage and may also result in liability for the wrong decision making. Gather the information now, and develop response plans with the building management and your department personnel.

PRIVATE HYDRANTS

The condition of private hydrants should be highly suspect. The public water department does not maintain them. The only maintenance is contracted or arranged for by the property owner, if at all. Recent incidents have highlighted the necessity for verifying the reliability of these hydrants. A fire at a resort with a convention center resulted in a total loss of the meeting facilities. The first responding engine company connected to the private hydrant closest to the building. Opening the hydrant valve did not provide any water, and it took several minutes to locate and connect to the next closest public hydrant. As a result, the fire advanced rapidly, resulting in a total loss of the building.

A local fire department was checking the hydrants and water supply in an industrial park area and contacted the local water department to conduct hydrant flow tests. The water department told the fire department that the water department's maps indicated that the hydrants in the industrial park were private. The water department was reluctant to operate these hydrants to obtain water flow data because

of potential liability. Hydrant flows at the hydrants just outside the industrial complex were accomplished, but the condition of the private hydrants could not be determined.

The lingering questions remain: Who is responsible for those private hydrants? Are they being maintained? Will their condition be determined only if and when they are needed during a fire? When responding to a fire, it is wise not to assume that the hydrant you are selecting is being maintained.

Your initial evaluation of fire sprinkler systems may cause you to realize just how much you don't know. Initially, you may feel that you made certain assumptions and depended on others to properly monitor these systems. Although codes require that the owner and sprinkler contractor maintain these systems, your life and reputation are on the line. The good news is that once you have identified what you need to know and have developed your response plans, this will not change significantly from one building to the next. Although the problem may look overwhelming at the onset, your increased confidence in these systems and your capability to use them will be well worth the effort.

You will be very surprised at how much you will learn about the protected properties in your area. You will also probably be amazed at how much you didn't know before you began this journey. n

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HOW RELIABLE ARE PRIVATE FIRE HYDRANTS?

BY DAVID R. BLOSSOM, ALCM, CFPS, CFI1

THE OLD ADAGE THAT A CHAIN IS ONLY AS STRONG as its weakest link is a perfect description of fire protection systems. In addition, the theory that anything that can go wrong will go wrong also applies. I recall hearing many years ago, as a teenager, about the reliability of the Apollo/Saturn V moon rocket, that if only one percent of the systems did not work properly, hundreds, if not thousands, of things would go wrong. It all had to work and work perfectly. I think we all can agree that this also applies to firefighting. Yet, at the same time, I would speculate that we often are not concerned about some of the simplest and most reliable elements of firefighting operations, such as the good old reliable fire hydrant. However, can you think of a more potentially weaker and extremely important link than a hydrant that doesn't work?

BRIEF HYDRANT HISTORY

Fire hydrants have been so reliable that they are often taken for granted. After all, you are depending only on a simple valve to open and allow water to flow from the underground main, through a hose, into the pump, and discharge through the nozzle, extinguishing the fire. What could be simpler? The basic design and operation method of a fire hydrant have not changed much over the past 150 years-except for the days when they were called fire "plugs" because the hydrant was a wooden plug hammered into a wooden water main.

Today, the hydrant is either the dry barrel or wet barrel type. The dry barrel is commonly used in areas where freezing occurs and the wet barrel where there is no freeze potential. But, we must keep in mind that a chain is only as strong as its weakest link and apply it to the tried and true fire hydrant, plug, or whatever you want to call it. This "link" is critical to "putting the wet stuff on the red stuff." It is so critical in fact that little else will happen if the hydrant is not working properly, and many large losses have occurred because of hydrants that would not work. This has a profound effect on the ability to not only control the fire but also to initiate rescue operations; protect firefighting personnel; and, of course, complete extinguishment.

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WHAT COULD GO WRONG?

Several years ago while I was evaluating fire protection for a plastic bottle manufacturing plant, questions arose about the water supply for the fire sprinklers and public fire service needs. It was considered so important that it was decided that the necessary time and money would be spent to obtain additional information about the water supply. The local water department conducted hydrant flow tests. Area maps were reviewed to identify underground main sizes, hydrant locations, and relevant historical information.

The water department representatives found that the underground mains and hydrants in the entire industrial complex were not in that water department's system and that it had no records or information for the complex. The hydrants were part of a system of private mains and hydrants that had been installed by the developer. Several blocks of large warehouse and manufacturing facilities had no reliable water supply system from the perspective that it was not inspected, tested, or maintained. Would you like to rely on that system to fight a major fire in a 100,000-square-foot warehouse, let alone buildings now reaching 750,000 square feet or more? Worse yet, would you even know that such a system was not being maintained and not in a reliable condition? After all, the hydrants look the same as those in the public system.

The result of this attempt to obtain accurate information about the water supply for this multimillion-dollar facility was that insurance coverage could not be obtained. Based on the odds, it is likely that the private hydrants on this private system would work and deliver the water needed to fight a fire. However, how confident would you feel inside a 100,000-square-foot warehouse advancing a hose stream from a pumper connected to a hydrant and underground system that had been in use for 25 years or more and there was no verification that the system had been tested during that time?

Incidents Involving Inoperative Private

Date	*Location*	*Details*
June 2001	Wesley Chapel, FL	Three inoperative private hydrants hinder firefighting at Saddlebrook Resort; $1 million loss.
June 2001	Tampa, FL	Fire at apartment complex with two private hydrants; caps rusted shut
June 2002	Clearwater, FL	Condominium complex with broken hydrants; two fatalities
June 2003	Pinellas County, FL	Fire at apartment complex with only two private hydrants; only two required when originally constructed in 1966

Private Hydrant Maintenance Requirements

Interval	*Service*
Monthly	Visually inspect: general condition including caps
Annually	Flow testing recommended: opened fully for one minute, check drainage of dry-barrel and wall hydrants after flow, lubricate
After each use	All of the above

Note: Ensure that the hydrant is free of obstruction, snow, ice, and so on. Maintain records of inspections.
Source: National Fire Protection Association 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 2002 Edition.*

Click here to enlarge image

A recent experience. A fire occurred in a convention and meeting building at Saddlebrook Resort in Wesley Chapel, on the west coast of Florida. The fire started in a kitchen area and rapidly spread to the remainder of the building. The first-arriving engine connected to the hydrant nearest the building and began advancing a hoseline. When the hydrant was opened, the unexpected happened: There was no water to charge the line. It was discovered that three private hydrants on the property were not in working condition. Crews advancing hoselines had to abandon the fight until alternate hy-drants on the municipal water supply could be accessed and long hoselines were laid to supply the fireground. Precious minutes were lost, resulting in the total loss of the building, estimated at more than $1 million.

See "Incidents Involving Inoperative Private Hydrants" above.

HISTORY OF THE PRIVATE HYDRANT CONCEPT

Initially, most fire hydrants were "private," in that they were installed privately and supplied by cisterns, tanks, or other limited sources. Over the years, the concept of fire hydrants migrated to the public water company or municipal/governmental water utility. As time progressed and municipalities began to look at the cost of providing fire hydrants (installation and continual maintenance), property owners were again asked to provide the hydrants for their developments. Large shopping malls, hospital complexes, warehouse and distribution facilities, apartment complexes, and so on, all required numerous hydrants to allow readily accessible water supplies. The result was that large developments were required to bear the cost of installing and maintaining hydrants on their properties. In discussing this with the fire official for one central Florida county, he indicated that his district relied heavily on private hydrants. The reality is that private hydrants are prevalent; however, few are maintained according to recognized standards and their working condition is questionable. How confident are you that the next private hydrant you connect to will work? If you are not aware of which hydrants in your area are private or public, you may assume that all are being maintained. You would be assuming incorrectly and could be making a fatal mistake.

PRIVATE HYDRANT REQUIREMENTS

The *Uniform Fire Prevention Code* and 12 other National Fire Protection Association (NFPA) codes and standards, including NFPA 5000, Building Construction and Safety Code; NFPA 24, *Standard for Installation of Private Fire Service Mains and Their Appurtenances*; and NFPA 25, Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, address requirements for private fire hydrants. The American Water Works Association (AWWA) publication M17, In-spection, Operations and Maintenance of Fire Hydrants 1980, provides guidelines for the care and maintenance of fire hydrants. Public water companies and municipalities often refer to this publication, but those responsible for the private hydrants in your district or response area may not even know the document exists.

Nearly all documents state that the property management/owner is responsible for maintaining and testing private hydrants and related underground piping. Although this is practical in terms of responsibility, there are some concerns with accountability. The building owner/management may be responsible for the care and maintenance of the private hydrant and water system and may not know what is required for properly maintaining these appliances. Worse yet, after many years, the property management may not even be aware that the hydrants are on a private system and are its responsibility. The water department may assume that the private owner is complying with the requirements, and the area's fire service may assume that the hydrants are public and that the water department is maintaining them. There can be serious repercussions when the weakest link in the chain breaks and the hydrant you are counting on is not operable when you need it the most.

APPLYING RESULT-ORIENTED SOLUTIONS

A three-step approach is needed to determine the locations of the private hydrants in your area and who, if anyone, is maintaining them:

Coordinate with the water department. Check maps of the water system to determine locations in which

there are connections from the public mains to the private water system or hydrants. This does not have to be a completely separate system to an industrial area or complex. The private hydrant could be located on a private loop around a shopping mall or in a private gated community; it could even be a single hydrant installed in an out-of-the-way area of a property near a fire department connection to a fire sprinkler or standpipe system. The point is that these private hydrants could be anywhere and may be very difficult to identify.



Click here to enlarge image

(1) Private hydrant at rear of retail shopping center. (Photos by author.)

Conduct an area survey. Using the information from your community's water system maps and the street/road maps, visit all suspected private hydrant and private water system locations and determine the location, number, and types of private hydrants in the area surveyed (are they "yard hydrants" in old industrial plants?). Use this information to develop action plans for contacting all responsible persons to determine the level of hydrant maintenance-and, thus, reliability. Determine the responsible owner/management for each hydrant/system. In some instances, this may be as simple as identifying the building or the property near the hydrant's location.



(2) Private hydrant at hospital obstructed by a fence.

Contact the owners. This will allow you to review records on the inspection, testing, and maintenance of

the private mains and hydrants and should provide you with reliable fire-flow information. You may discover that the responsible party is unaware of its responsibility or the requirements for maintaining these systems. This will give you an opportunity to inform the owner about what is required and to follow up to make certain that these hydrants and systems are being maintained. You may also choose to institute a color-coding system involving painting all private hydrants a specific color, for easy identification. This will help to ensure follow-up maintenance and firefighters' being able to identify private hydrants when they use them.



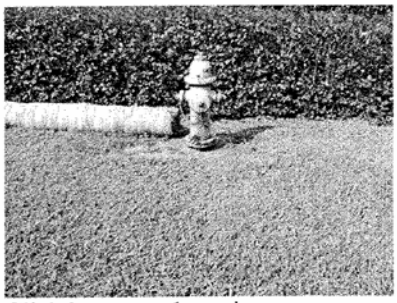
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(3) Private hydrants well off the main street at a warehouse complex.

The coloring system could also incorporate color coding for available water flow. A combination, say orange for the hydrant barrel and another color for the bonnet, which signifies the expected water flow, will give two good pieces of information about the hydrant encountered at an incident: the hydrant is privately owned and maintained and the volume of water flow you can expect. To determine the water available, you would have to perform a hydrant flow test or obtain the results of such a flow test from the owner or contractor maintaining the hydrant(s). (See "Classification and Marking of Hydrants Based on Flow Capacity" on page 104.)

POTENTIAL OBSTACLES

It may be more difficult to determine who is responsible for hydrants on streets within a large property development or an industrial complex. For these areas, try to gather any information you can to facilitate a check of the county property records. However, remember that the owner of the property on which the building is located may not be the same owner as that for the property on which the hydrant is. A developer who constructed and planned the complex may have sold or leased the property for the individual building sites but may have retained the streets, water supply, and so on, as part of the infrastructure of the development.



Click here to enlarge image

4) Does this private hydrant look reliable?

In some instances, the property may have been occupied many years ago by a government installation that was turned over to private use. Some time ago while completing an evaluation of a large complex of warehouses being used to store peanuts, it was discovered that the warehouse complex had been part of an active air base during World War II. When the military no longer needed the base, it was deeded to the local community for use as an industrial complex. In this situation, the availability of reliable information on the water system depended on the transfer of information from the military at the time the property was turned over. The local fire and water department reportedly handled the maintenance of the hydrant system. The hydrant system and fire sprinkler supply depended on the elevated storage tank and a diesel-driven fire pump, the reliability of which could not be easily determined.



Click here to enlarge image

5) This private hydrant is near the fire department connection (FDC) at a manufacturing facility. Note the poor access because of parking. The hydrant and the FDC are not visible from the street.

In some instances, a development, residential or otherwise, within the limits of a fire protection district may have its own private water system. You might assume that the hydrants within the residential area are a part of the municipal water system and generally have the same flow and pressure as other areas in the district. However, such a system may provide only a minimum fire flow of 500 gallons per minute (gpm). It is common policy for these private systems to be turned over to the area's governmental jurisdiction. When the area served by the private water system experiences growth, a mutual need must

be considered. The municipality may have extended its water system to the area, but it may be barely adequate because of the distance from the water plant or pumping station. The private system may have reached its maximum capability and may need additional capacity. Giving the private system to the public water company usually meets both needs. Connecting the two systems and improving pumping and storage capacities often result in a greater supply to the newly joined systems. Following the changes in these systems over time is important to ensure that there is enough water available for fire protection.

ENFORCEMENT

In discussing this issue, we cannot overlook the importance and challenges of enforcement. Although most property owners do not neglect private hydrant maintenance through commission or willfully fail to provide maintenance, the fact remains that there will be many situations where private hydrant owners will fail to comply with codes and locally adopted ordinances. It is imperative that those charged with enforcement remain vigilant in this area. At the same time, there is recognition that many enforcement agencies often do not have adequate staffing. A potential solution may be to conduct company inspections at which time potential hydrant problems can be identified and brought to the attention of the property owner and problem situations can be referred to the appropriate agency for follow-up and action.

Classification and Marking of Hydrants Based on Flow Capacity

Class	*Color*	*Rated Capacity*
Class AA	light blue	1,500 gpm or greater
Class A	green	1,000 to 1,499 gpm
Class B	orange	500 to 999 gpm
Class C	red	below 500 gpm

Source: NFPA Fire Protection Handbook, "Uniform Hydrant Marking"

Click here to enlarge image

Although it takes some time, detective work, and cooperation among several parties, the benefits of such a policy outweigh the efforts. Your confidence in the hydrants and water systems in your response area should greatly increase. You reduce the potential for water supply impairments and at the same time increase safety and firefighting reliability. Through this exercise, you may determine that managing this information warrants the position of a water supply officer within your department. This individual can work closely with the water department, the owners/management of private hydrants/systems, and your fire inspection and suppression divisions to help ensure that there will be plenty of water for firefighting. The need for staffing this position will depend on the complexity of the water supply to your area and the presence of dry hydrant locations. It is likely that you will make some amazing discoveries as you investigate the water system(s) in your area; it is better to be surprised before the hydrant on which you are depending is needed. Once the initial districtwide evaluation is completed, the majority of the work is done. From that point, it is simply maintaining updated information and checking to see that the private systems are being properly maintained. Implementing the suggestions presented here will greatly improve the reliability of the private hydrant water supplies on which you may have to rely one day. ■

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Hydrant Flow Capacity and Classification

All hydrant flow capacities are determined with a residual flow pressure of 20 psi. (The methodology for conducting flow tests is outside the scope of this article.) The results will show three things:

The static pressure within the water system. Although a true static pressure is the pressure within the system with no water flowing, in reality, the static pressure used will be the pressure at a given hydrant from which no water is flowing. The static pressure will be representative of the "normal" pressure in the system under normal usage conditions.

The residual pressure of the water supply while flowing water from a specific hydrant. This will be plotted on hydraulic graph paper and will show the residual pressure and water flow at the residual pressure. From this point, the line on the graph will intersect with the flow at the 20-psi pressure of the system.

The actual flow in gallons per minute available at the 20-psi minimal pressure used to determine the available water flow for the system at that point.

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Author(s) : David Blossom

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MEDIA FOR

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

Group Final Project

The presentations required at the conclusion of the course are scored as follows:

1. The format and content of the presentation includes all of the elements listed in the objectives for the assignment in accordance with the learning outcomes.

2. The presentation time is a minimum of 20 minutes but no more than 30 minutes. Each member of the group must participate in development and presentation of the project.

3. Instructors will document the evaluation of students' presentations on the Group Presentation Rubric. Any corrective and/or diagnostic comments about the students' plans should also be written on the form.

4. Instructors will record the appropriate grade for each student on Master Grade Sheet.

5. Instructors will share grade sheets, including any comments/recommendations with the student after completion of the presentation and grading.

6. The Group Project will constitute 30 percent of final grade for each student.

Final Exam

Each student will be given an exam consisting of 50 multiple-choice questions. The exam will constitute 50 percent of the final grade.

Final Course Grade

- attendance = 10 percent;
- student activities = 10 percent;
- final group project = 30 percent; and
- final exam = 50 percent.

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ATTACHMENT 3

GROUP PRESENTATION RUBRIC

CATEGORY	4	3	2	1	Score
Preparedness	Student is completely prepared and has obviously rehearsed.	Student seems pretty prepared but might have needed a couple more rehearsals.	The student is somewhat prepared, but it is clear that rehearsal was lacking.	Student does not seem at all prepared to present.	
Comprehension	Student is able to accurately answer almost all questions posed by classmates about the topic.	Student is able to accurately answer most questions posed by classmates about the topic.	Student is able to accurately answer a few questions posed by classmates about the topic.	Student is unable to accurately answer questions posed by classmate about the topic.	
Content	Shows a full understanding of the topic.	Shows a good understanding of the topic.	Shows a good understanding of parts of the topic.	Does not seem to understand the topic very well.	
Posture and Eye Contact	Stands up straight, looks relaxed and confident. Establishes eye contact with everyone in the room during the presentation.	Stands up straight and established eye contact with everyone in the room during the presentation.	Sometimes stands up straight and established eye contact.	Slouches and/or does not look at people during the presentation.	
Collaboration with Peers	Almost always listens to, shares with, and supports the efforts of others in the group. Tries to keep people working well together.	Usually listens to, shares with, and supports the efforts of others in the group. Does not cause "waves" in the group.	Often listens to, shares with, and supports the efforts of others in the group but sometimes is not a good team member.	Rarely listens to, shares with, and supports the efforts of others in the group. Often is not a good team member.	
Volume	Volume is loud enough to be heard by all audience members throughout the presentation.	Volume is loud enough to be heard by all audience members at least 90% of the time.	Volume is loud enough to be heard by all audience members at least 80% of the time.	Volume often too soft to be heard by all audience members.	
Stays on Topic	Stays on topic all (100%) of the time.	Stays on topic most (99-90%) of the time.	Stays on topic some (89%-75%) of the time.	It was hard to tell what the topic was.	

Total: _____

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