An Introduction to Automatic Fire Sprinklers, Part 1

A paper from [JordanFire.Net]

Abstract

Museum management is entrusted with the responsibility of protecting and preserving the institution's collections, operations and occupants. Constant attention is required to minimize adverse impact due to climate, pollution, theft, vandalism, insects, mold and fire. Because of the speed and totality of its destructive forces, fire constitutes one of the more serious threats.

Collections must be safeguarded from fire. Vandalized or environmentally damaged objects can be repaired and stolen objects recovered, however, fire destroyed items are gone forever. An uncontrolled fire can obliterate an entire room's contents within a few minutes and completely burnout a building in a couple hours.

Fire protection experts generally agree that automatic sprinklers represent the single, most significant aspect of a fire management program. Properly designed, installed, and maintained systems can overcome deficiencies in risk management, building construction, and emergency response. They may also enhance the flexibility of building design and use by increasing the overall safety.

Nonetheless, sprinklers frequently cause considerable debate among museum facility experts. Typical concerns include the potential for inadvertent operation, increased damage due to water release, and aesthetic impact. As a result many museums and historic houses have avoided fire sprinkler protection.

This article will present an overview of sprinkler systems including system types, components, operations, and common anxieties.

1: Fire Growth and Behavior

Before attempting to understand sprinklers, it is beneficial to possess a basic knowledge of fire development and behavior. The role and interaction of fire sprinklers in the protection process can then be better realized.

A fire is essentially a chemical reaction in which a carbon based material (fuel), mixes with oxygen (usually as a component of air), and is heated to a point where flammable vapors are produced. Cultural properties frequently contain numerous fuels including furnishings, records, interior finishes, display cabinets, office equipment, laboratory chemicals, and many collections items.

Basically, anything which contains wood, plastic, paper, fabric, or combustible liquids should be considered a fuel.

The flammable vapors will spread until they either dissipate or come in contact with a sufficiently hot item (ignition source). If sufficient dispersement happens, the fire risk is eliminated. If the latter occurs, however, a combustion process begins. Common ignition sources in heritage facilities encompass electric lighting and power systems, heating and air conditioning equipment, heat producing conservation and maintenance activities, and electric office appliances. Arson is unfortunately one of the most common cultural property ignition sources, and must always be considered in fire safety planning. Any item, action, or process which produces heat is a potential ignition source.

The typical accidental fire begins as a slow growth, smoldering process which may last from a few minutes to several hours. This smoldering duration is dependent on fuel type, arrangement, and available oxygen. During this incipient period, heat generation will increase producing light to moderate smoke. A smell of smoke is usually the first indication that an incipient fire is underway. It is during this incipient stage that early detection (either human or automatic) followed by a timely emergency response can enhance the probability of successful fire control before significant loss.

As the fire reaches the end of the incipient period, there is usually adequate heat to permit the onset of open, visible flames. Once flames have appeared, the fire has changed from a relatively minor situation to a serious event. Rapid flame and heat growth will follow with temperatures quickly exceeding 1,000° C (1,800° F). Contents will ignite, structural fatigue becomes possible, and occupant lives become seriously threatened. Within 3-5 minutes room temperatures may be sufficiently high to "flash", igniting all combustibles within the space. At this point, most contents will be destroyed and human survivability becomes impossible. Significant smoke generation in excess of several thousand cubic feet per minute will occur, obscuring visibility and impacting contents remote from the fire. Immediate occupant evacuation is necessary to avoid harm.

If the building is structurally sound, heat and flames will consume all remaining combustibles and self extinguish (burn out). However, if wall and/or ceiling fire resistance is inadequate, (i.e. open doors, wall/ceiling breaches, combustible building construction), the fire will spread into adjacent spaces to start the process over. Unchecked, complete destruction or "burn out" of the entire building and contents will ultimately result.

Successful fire suppression is dependent on extinguishing flames before, or immediately upon, flaming combustion. Otherwise, damage will be too severe to recover. Often a trained person with portable fire extinguishers becomes the first line of defense. This may be productive. However, should an immediate response fail, or the fire grow rapidly, extinguisher capabilities will be surpassed. More powerful suppression methods, either fire department hoses or automatic systems, then become essential.

A fire can have a far reaching impact on the institution's buildings, contents and mission. Fire consequences may include:

Collections damage.

> Most institutions house unique and irreplaceable objects. Fire generated heat and smoke can totally destroy, or severely damage items beyond repair.

Operations and mission damage.

> Museums often contain education facilities, conservation laboratories, catalogue services, administrative support staff offices, exhibition production, retail, and food service. Adverse impact on these services is possible.

Structure damage.

> Museum buildings provide the "shell" which safeguards collections, operations and occupants from weather, pollution, vandalism and numerous other environmental elements. A fire can destroy walls, floors, ceiling/roof assemblies and structural support. Systems which illuminate, control temperature and humidity, and supply electrical power may also be affected.

Knowledge loss.

> Books, manuscripts, photographs, films, recordings and other archival collections contain a vast wealth of information which can be destroyed by fire.

Injury or loss of life.

The lives of staff and visitors will be endangered.

Public relations impact.

Staff and visitors expect safe conditions in museum buildings. Those who donate or loan collections presume these items will be safeguarded. A severe fire could shake public confidence with a devastating public relations impact.

Building security.

A fire represents the single greatest security threat! Given the same amount of time, an accidental or intentionally set fire can cause far greater harm to collections than the most accomplished thieves. Immense volumes of smoke and toxic fumes can cause confusion and panic, thereby creating the ideal opportunity for unlawful entry and theft. Unrestricted firefighting operations will be necessary, adding to the security risk. Arson fires set to conceal a crime are common.

To minimize fire risk and its impact, institutions should develop and implement comprehensive and objective fire protection programs. Program elements should include:

Risk reduction (fire prevention).

The institution should attempt to identify and remedy fire hazards in order to prevent ignition. A fire which does not occur is most desired.

Barriers to limit initial fire spread.

Fire walls, ceilings and other construction elements should confine the fire to the smallest possible size. The desired maximum fire area will be dependent on the contents contained within barrier confines. It must be recognized that all items within the barrier are subject to loss.

Occupant life safety (egress) systems.

Adequate, protected escape routes must be available so that all occupants can safely evacuate during an emergency.

Manual and automatic fire detection.

Delayed detection is a common factor in most significant loss fires. Means must be available so that an occupant discovering the fire can sound an alert to notify emergency forces. Automatic detection systems are suggested for spaces which may not be occupied at all times.

Manual fire suppression equipment.

The availability of portable extinguishers, fire hose equipment, and properly trained personnel is important for fire control during early stages of development.

Appropriate automatic fire suppression systems.

Automatic suppression systems represent the most effective means of limiting overall fire loss. Various systems are available which control fires by utilizing water, chemicals or gaseous agents. Statistically, water based automatic sprinkler systems are the most reliable, safe, and capable means of automatic suppression.

Coordinated disaster recovery/management procedures.

Often overlooked in emergency system development is what will occur after the disaster has subsided. The institution must develop appropriate emergency response procedures to minimize content loss and facility downtime.

Each emergency program element is important toward overall accomplishment of the institution's fire safety goal. Depending on the respective institution's fire safety objectives, the degree of emphasis placed on each element may vary. It is important for management to outline desired protection objectives during a fire and establish a program which addresses these goals. The basic question asked is, "What maximum fire size and loss can the institution accept?" With this information, goal oriented protection can be implemented.

2: Sprinkler System Benefits

Fire sprinklers are most effective during the fire's initial flame growth stage. A properly selected sprinkler will detect the fire's heat, initiate alarm and begin suppression within moments after flames appear. In most instances sprinklers will control fire advancement within a few minutes of their activation. This will in turn result in significantly less damage than otherwise would happen without sprinklers.

Sprinkler systems offer several benefits to building owners, operators, and occupants. These benefits include:

Immediate identification and control of a developing fire.

Sprinkler systems respond at all times, including periods of low occupancy. Control is generally instantaneous.

Immediate alert.

In conjunction with the building fire alarm system, automatic sprinkler systems will notify occupants and emergency response personnel of the developing fire.

Reduced heat and smoke damage.

Significantly less heat and smoke will be generated when the fire is extinguished at an early stage.

Enhanced life safety.

Staff, visitors and fire fighters will be subject to less danger when fire growth is checked.

Design flexibility.

Egress route and fire/smoke barrier placement becomes less restrictive since early fire control minimizes demand on these systems. Greater utilization of exhibition and assembly spaces is usually a benefit.

Enhanced Security.

A sprinkler controlled fire decreases demand on security forces, minimizing intrusion opportunities.

Decreased insurance expenditure.

Sprinkler controlled fires are less damaging than fires in non-sprinklered buildings. This results in lower insurance reimbursements. Insurance underwriters will usually offer reduced premiums in sprinkler protected properties which can save a large amount of capital. This is especially important when funds are limited.

These benefits should be considered when deciding on the selection of automatic fire sprinkler protection.

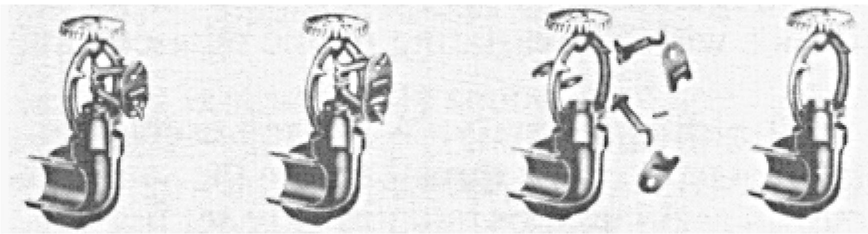
3: Sprinkler System Operation

For most fires, water represents the ideal extinguishing agent. Fire sprinklers utilize water by direct application onto flames and heat. This action cools the combustion process and prevents ignition of adjacent combustibles.

Sprinkler systems are essentially a series of water pipes which are supplied by a reliable water supply. At selected intervals along these pipes are independent, heat activated valves known as sprinkler heads. It is the sprinkler which is responsible for water distribution onto the fire. Most sprinkler systems also include an alarm to alert occupants and emergency forces when sprinkler activation (fire) occurs.

During the incipient fire stage, heat output is relatively low and unable to cause sprinkler operation. As the fire intensity increases, however, the sprinkler's sensing elements become exposed to elevated temperatures (typically in excess of 135-225°F/57-107°C)and they begin to deform. Assuming temperatures remain high, as they would during an increasing fire, the element will fatigue after an approximate 30 second to 4 minute period. This will release the sprinkler's seals allowing water to discharge onto the fire. In most situations less than 2 sprinklers are needed to suppress the fire. In fast growing fire scenarios such as a flammable liquid spill, up to 12 sprinklers may be required for control.

Illustrations 3-1 and 3-2 show a typical sprinkler system in operation.



Illustrations 3-1: Typical Sprinkler Release Sequence

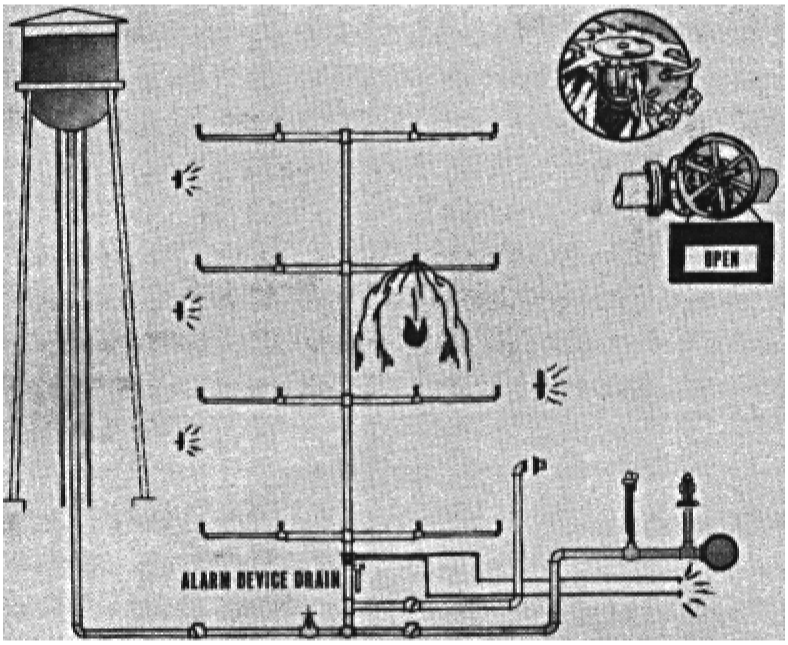


Illustration 3-2: Sprinkler System in Operation

Additional actions may occur when sprinkler activation happens. These include initiation of building and/or fire department alarms, operation of supplemental water supply systems, shutdown of selected electrical and mechanical equipment closing of fire doors and dampers, and suspension of processes.

When fire fighters arrive they will verify that the system has contained the fire and, when satisfied, shut off the water flow and restore services. It is at this point that staff will normally be permitted to enter the damaged space and perform salvage duties.

4: System Components and Types

The basic components of a sprinkler system are the sprinklers, system piping, and a dependable water source. Most systems also require an alarm, system control valves, and means to test the equipment. Illustration 4-1 shows the arrangement of a typical sprinkler system.

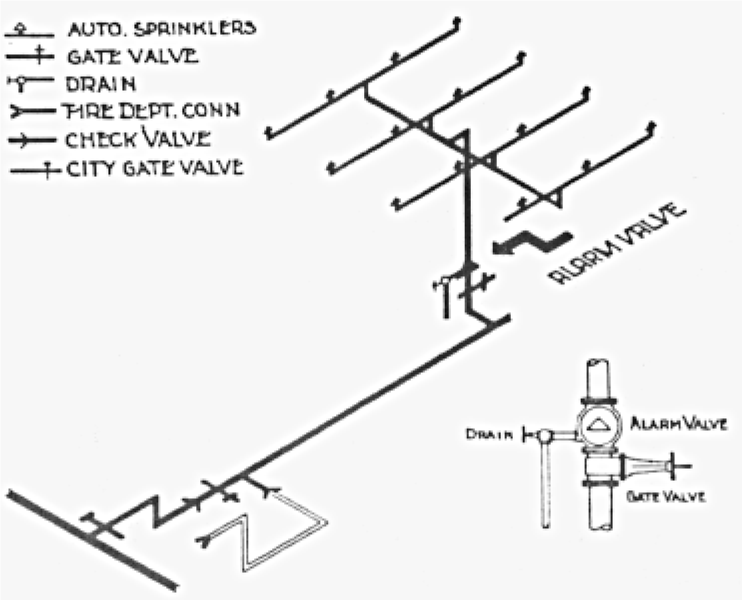


Illustration 4-1: Typical Sprinkler System

The sprinkler is the spray nozzle which distributes water over a defined fire hazard area (typically 150-225 sq. ft.). Each sprinkler operates by actuation of its own temperature linkage. The typical sprinkler consists of a frame, thermal operated linkage, cap, orifice, and deflector. Styles of each component may vary but the basic principles of each remain the same.

Frame.

The frame provides the main structural component which holds the sprinkler together. The water supply pipe connects to the sprinkler at the base of the frame. The frame holds the thermal linkage and cap in place, and supports the deflector during discharge. Frame styles include standard and low profile, flush, and concealed mount. Some frames are designed for extended spray coverage, beyond the range of normal sprinklers. Standard finishes include brass, chrome, black, and white. Custom finishes are available for aesthetically sensitive spaces. Special coatings are available for areas subject to high corrosive effect. Selection of a specific frame style is dependent on the size and type of area to be covered, anticipated hazard, visual impact features, and atmospheric conditions.

Thermal linkage.

The thermal linkage is the component which controls water release. Under normal conditions the linkage holds the cap in place and prevents water flow, however, as the link is exposed to heat it weakens and releases the cap. Common linkage styles include soldered metal levers, frangible glass bulbs, and solder pellets. Each link style is equally dependable.

As mentioned previously, the common operating temperature is usually between 135-225°F/57-107°C. Higher temperature sprinklers, however, may be utilized where excessive ambient temperatures exist, i.e. mechanical plant rooms.

Upon reaching the desired operating temperature, an approximate 30 second to 4 minute time lag will follow. This lag is the time required for linkage fatigue and is largely controlled by the link materials and mass. Standard responding sprinklers operate closer to the 3-4 minute mark while quick response (QR) sprinklers operate in significantly shorter periods. Selection of a sprinkler response characteristic is dependent upon the existing risk, acceptable loss level and desired response action.

In museum applications the advantage of quick response sprinklers becomes apparent. The faster a sprinkler reacts to a fire, the sooner the suppression activity is initiated, and the lower the potential damage level. This is particularly beneficial in high value or life safety applications where the earliest possible extinguishment is a fire protection goal. It is important to understand that response time is independent of response temperature. A quicker responding sprinkler will not activate at a lower temperature than a comparable standard head.

Cap.

The cap provides the water tight seal which is located over the sprinkler orifice. This component is held in place by the thermal linkage. Operation of the linkage causes the cap to fall from position and permit water flow. Caps are constructed solely of metal or a metal with a teflon disk.

Orifice.

The machined opening at the base of the sprinkler frame is the orifice. It is from this opening which extinguishing water flows. Most orifice openings are 1/2 inch diameter with smaller bores available for residential applications and larger openings for higher hazards.

Deflector.

The deflector is mounted on the frame opposite the orifice. The purpose of this component is to break up the water stream discharging from the orifice into a more efficient extinguishing pattern. Deflector styles determine how the sprinkler is mounted, by the angle of their tines. Common sprinkler mounting styles are upright (mounted above the pipe), pendent (mounted below the pipe, i.e. under ceilings), and sidewall sprinklers which discharge water in a lateral position from a wall. The sprinkler must be mounted as designed to ensure proper action. Selection of a particular style is often dependent upon physical building constraints.

Illustration 4.2 shows the components of a typical, standard sprinkler head while illustration 4.3 shows the various simplified sprinkler head styles.

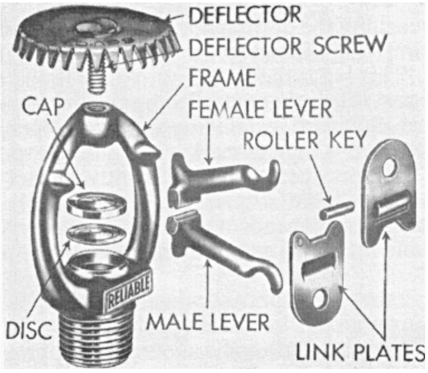


Illustration 4-2: Standard Sprinkler Head Components

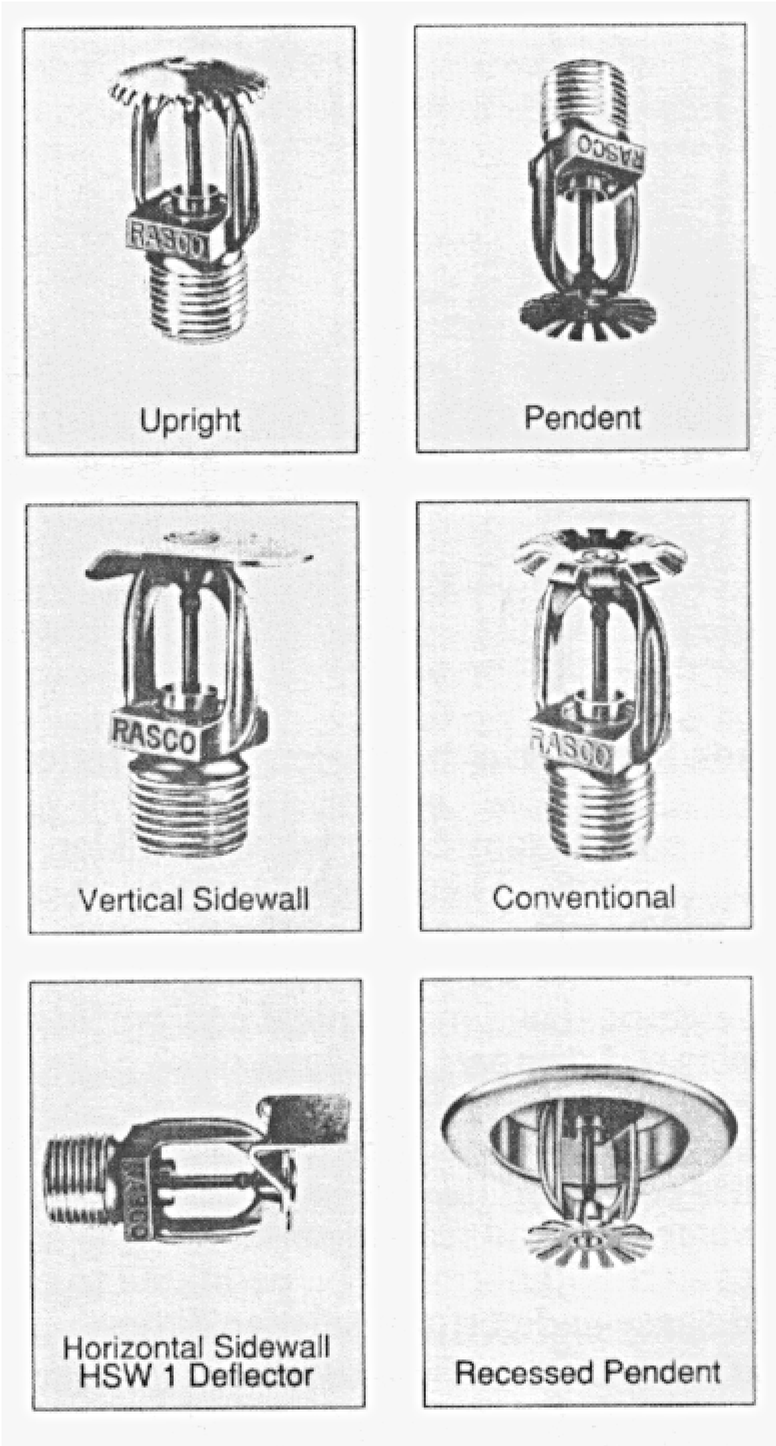


Illustration 4-3: Standard Sprinkler Head Styles

A sprinkler which has received widespread interest for museum applications is the on/off sprinkler. The principle behind these products is that as a fire occurs, water discharge and extinguishing action will happen similar to standard sprinklers. As the room temperature is cooled to a safer level, a bi-metallic snap disk on the sprinkler closes and water flow ceases. Should the fire reignite, operation will once again occur.

The advantage of on/off sprinklers is their ability to shut off which theoretically can reduce the quantity of water distributed, and resultant damage levels. The problem, however, is the long time period which may pass before room temperatures are sufficiently cooled to the sprinkler's shut off point. In most museums the building's construction will retain heat and prevent the desired sprinkler shut down. Frequently, fire emergency response forces will have arrived and will have closed sprinkler zone control valves, before the sprinkler's shut down feature has functioned.

On-off sprinklers typically cost 8-10 times more than the average sprinkler. This added cost is only beneficial when assurance can be made that these products will perform as intended. Therefore, on-off sprinkler use in museum facilities should remain limited.

Selection of specific sprinklers is based on: risk characteristics, ambient room temperature, desired response time, hazard criticality and aesthetic factors. Several sprinkler types may be used in a museum facility.

All sprinkler systems require a reliable water source. In urban areas, a piped public service is the most common supply, while rural areas generally utilize private tanks, reservoirs, lakes, or rivers. Where a high degree of reliability is desired, or a single source is undependable, multiple supplies may be utilized.

Basic water source criteria include:

The source must be available at all times.

> Fires can happen at any time and therefore, the water supply must be in a constant state of readiness. Supplies must be evaluated for resistance to pipe failure, pressure loss, droughts, and other issues which may impact availability.

The system must supply adequate sprinkler supply and pressure.

> A sprinkler system will create a hydraulic demand, in terms of flow and pressure, on the water supply. The supply must be capable of meeting this demand. Otherwise, supplemental components such as a fire pump or standby tank must be added to the system.

The supply must provide water for the anticipated fire duration.

> Depending on the fire hazard, suppression may take several minutes to over an hour. The selected source must be capable of providing sprinklers with water until suppression has been achieved.

The system must provide water for fire department hoses operating in tandem with the sprinkler system.

Most fire department procedures involve the use of fire attack hoses to supplement sprinklers. The water supply must be capable of handling this additional demand without adverse impact on sprinkler performance.

Sprinkler water is transported to fire via a system of fixed pipes and fittings. Piping material options include various steel alloys, copper, and fire resistant plastics. Steel is the traditional material with copper and plastics utilized in many sensitive applications.

Primary considerations for selection of pipe materials include:

Ease of installation.

The easier the material is installed, the less disruption is imposed on the institution's operations and mission. The ability to install a system with the least amount of disturbance is an important consideration, especially in sprinkler retrofit applications where building use will continue during construction.

Cost of material versus cost of protected area.

Piping typically represents the greatest single cost item in a sprinkler system. Often there is a temptation to reduce costs by utilizing less expensive piping materials which may be perfectly acceptable in certain instances, i.e. office or commercial environs. However, in museum applications where the value of contents may be far beyond sprinkler costs, appropriateness of the piping should be the deciding factor.

Contractor familiarity with materials.

A mistake to be avoided is one in which the contractor and pipe materials have been selected, only to find out that the contractor is inexperienced with the pipe. This can lead to installation difficulties, added expense, and increased failure potential. A contractor must demonstrate familiarity with the desired material before selection.

Prefabrication requirements or other installation constraints.

In some instances such as a fine art vaults, requirements may be imposed to limit the amount of work time in the space. This will often require extensive prefabrication work outside of the work area. Some materials are easily adapted to prefabrication.

Material cleanliness.

Some pipe materials are cleaner to install than others. This will reduce the potential for soiling collections, displays, or building finishes during installation. Various materials are also resistant to accumulation in the system water which could discharge onto collections. Cleanliness of installation and discharge should be a consideration.

Labor requirements.

Same pipe materials are heavier or more cumbersome to work with than others. Consequently additional workers are needed to install pipes which can add to installation costs. If the number of construction workers allowed into the building is a factor, lighter materials may be beneficial.

Table 4-1 presents some of the main advantages and disadvantages of common sprinkler piping materials, which should be evaluated prior to selection.

Table 4-1

Material	Advantages	Disadvantages	Notes
Steel	Relative ease of installation	Weight	
	High degree of contractor familiarity	Installation cleanliness	1
	Most readily available	Requires regular flushing to maintain water cleanliness	1
	Material cost		
	Highly durable and impact resistant		
Copper	Light weight	Material cost, especially fittings	2
	Easily prefabricated	Fewer contractors are familiar with copper installation techniques	
	Relatively clean installation	Flame brazed joints are the most durable. Special care must be exercized to minimize fire risks associated with installation	3
	Exceptionally long		

	projected lifespan	
Plastic	Light weight	Material cost
	Very easy to install without specialized tools or process	Their use is not permitted in all occupancy types
	Resistant to water corrosion	They may not be used for dry-pipe or preaction systems
	Highest water flow coefficients, often allowing smaller diameter pipes.	
	Generally flexible to install	

Other major sprinkler system components include:

Control valves.

A sprinkler system must be capable of shut down after the fire has been controlled, and for periodic maintenance and modification. Control valves provide this function. In the simplest system a single shut-off valve may be located at the point where the water supply enters the building. In larger buildings the sprinkler system may consist of multiple zones with a control valve for each. Control valves should be located in readily identified locations to assist responding emergency personnel.

Alarms.

Alarms alert building occupants and emergency forces when a sprinkler water flow occurs. The simplest alarms are water driven gongs supplied by the sprinkler system. Electrical flow and pressure switches, connected to a building fire alarm system, are more common in large buildings. Alarms are also provided to alert building management when a sprinkler valve is closed.

Drain and test connections.

Most sprinkler systems have provisions to drain pipes during system maintenance. Drains should be properly installed to remove all water from the sprinkler system, and prevent water from leakage onto protected spaces, when piping service is necessary. It is advisable to install drains at a remote location from the supply, thereby permitting effective system flushing to remove debris. Test connections are usually provided to simulate the flow of a sprinkler flow, thereby verifying the working condition of alarms. Test connections should be operated every 6 months.

Specialty valves.

Dry-pipe and preaction sprinkler systems require complex, special control valves that are designed to hold water from the system piping until needed. These control valves also include air pressure maintenance equipment and emergency operation/release systems.

Fire hose connections.

Fire fighters will often supplement sprinkler systems with hoses. Firefighting tasks are enhanced by installing hose connections to sprinkler system piping. The additional water demand imposed by these hoses must be factored into the overall sprinkler design in order to prevent adverse system performance.

End of Part 1 Part 2 will appear in the January Issue.

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Notes

Note 1: Specialty steel materials, notably galvanized and stainless, are available which are cleaner to install and maintain. Water discharge is generally clean compared to standard steel materials. Some of these materials are also readily prefabricated, minimizing installation disturbances.

Note 2: Techniques are available to extrude fittings from pipe materials, thereby reducing overall installation costs.

Note 3: Other fitting options are available, notably screw thread fittings. In sprinkler systems, however, these are subject to leaks and are generally not recommended.

An Introduction to Automatic Fire Sprinklers, Part II

by Nick Artim

Abstract

Museum management is entrusted with the responsibility of protecting and preserving the institution's collections, operations and occupants. Constant attention is required to minimize adverse impact due to climate, pollution, theft, vandalism, insects, mold and fire. Because of the speed and totality of its destructive forces, fire constitutes one of the more serious threats.

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Nonetheless, sprinklers frequently cause considerable debate among heritage facility experts. Typical concerns include the potential for inadvertent operation, increased damage due to water release, and aesthetic impact. As a result many heritage properties have avoided fire sprinkler protection.

This article will present an overview of sprinkler systems including system types, components, operations, and common anxieties.

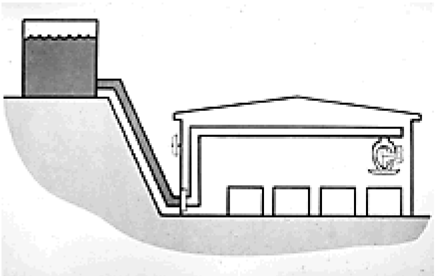
For **Part I** see WAAC Newsletter September 1994, Volume 16, Number 3.

1: Fire Growth and Behavior
2: Sprinkler System Benefits
3: Sprinkler System Operation
4: System Components and Types

Part II

5: System Types

There are three basic types of sprinkler systems: wet pipe, dry pipe, and preaction. Each has unique applicability, depending on a variety of conditions such as potential fire severity, anticipated fire growth rates, content water sensitivity, ambient conditions, and desired response. In large multi-function facilities, such as a major museum or library, two or more system types may be employed.



Wet pipe systems are the most common sprinkler system. As the name implies, a wet pipe system is one in which water is constantly maintained within the sprinkler piping. When a sprinkler activates this water is immediately discharged onto the fire.

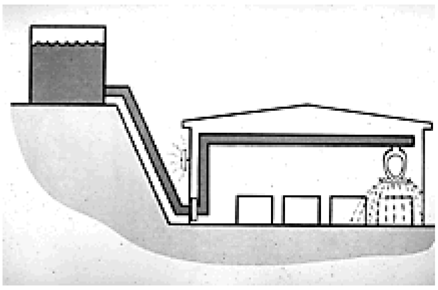
Wet pipe system advantages include:

- **System simplicity and reliability.** Wet pipe sprinkler systems have the least number of components and therefore, the lowest number of items to malfunction. This produces unexcelled reliability which is important since sprinklers may be asked to sit in waiting for many years before they are needed. This simplicity aspect also becomes important in facilities where system maintenance may not be performed with the desired frequency.
- **Relative low installation and maintenance expense.** Due to their overall simplicity, wet pipe sprinklers require the least amount of installation time and capital. Maintenance cost savings are also realized since less service time is generally required, compared to other system types. These savings become important when maintenance budgets are shrinking.
- **Ease of modification.** Heritage institutions are often dynamic with respect to exhibition and operation spaces. Wet pipe systems are advantageous since modifications involve shutting down the water supply, draining pipes and making alterations. Following the work, the system is pressure tested and restored. Additional work for detection and special control equipment is avoided which again saves time and expense.
- **Short term down time following a fire.** Wet pipe sprinkler systems require the least amount of effort to restore. In most

instances, sprinkler protection is reinstated by replacing the fused sprinklers and turning the water supply back on. Preaction and dry-pipe systems may require additional effort to reset control equipment.

The main disadvantage of these systems is that they are not suited for sub-freezing environments. There may also be a concern where piping is subject to severe impact damage and could consequently leak, e.g. warehouses.

The advantages of wet systems make them highly desirable for use in most heritage applications. With limited exceptions they represent the system of choice for museum, library and historic building protection.



A dry pipe sprinkler system is one in which pipes are filled with pressurized air or nitrogen, rather than water. This air holds a remote valve, known as a dry pipe valve, in a closed position. Located in a heated space, the dry-pipe valve prevents water from entering the pipe until a fire causes one or more sprinklers to operate. Once this happens, the air escapes and the dry pipe valve releases. Water then enters the pipe, flowing through open sprinklers onto the fire.

Illustrations 5-1 and 5-2 show the typical dry pipe sprinkler system.

Illustration 5-1. Dry Pipe System, Non-Fire.

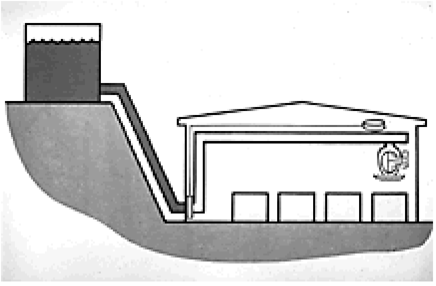
Illustration 5-2. Illustration 5-2: Dry Pipe System, Discharge. The main advantage of dry pipe sprinkler systems is their ability to provide automatic protection in spaces where freezing is possible. Typical dry pipe installations include unheated warehouses and attics, outside exposed loading docks and within commercial freezers.

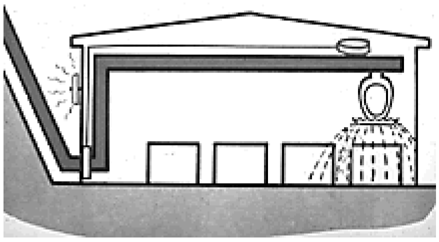
Many heritage managers view dry pipe sprinklers as advantageous for protection of collections and other water sensitive areas. This perceived benefit is due to a fear that a physically damaged wet pipe system will leak while dry pipe systems will not. In these situations, however, dry pipe systems will generally not offer any advantage over wet pipe systems. Should impact damage happen, there will only be a mild discharge delay, i.e. 1 minute, while air in the piping is released before water flow.

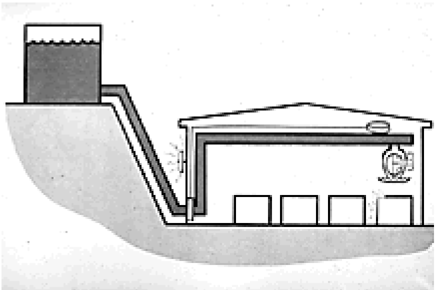
Dry pipe systems have some disadvantages which must be evaluated before selecting this equipment. These include:

- **Increased complexity.** Dry pipe systems require additional control equipment and air pressure supply components which increases system complexity. Without proper maintenance this equipment may be less reliable than a comparable wet pipe system.
- **Higher installation and maintenance costs.** The added complexity impacts the overall dry-pipe installation cost. This complexity also increases maintenance expenditure, primarily due to added service labor costs.
- **Lower design flexibility.** There are strict requirements regarding the maximum permitted size (typically 750 gallons) of individual dry-pipe systems. These limitations may impact the ability of an owner to make system additions.
- **Increased fire response time.** Up to 60 seconds may pass from the time a sprinkler opens until water is discharged onto the fire. This will delay fire extinguishing actions, which may produce increased content damage.
- **Increased corrosion potential.** Following operation, dry-pipe sprinkler systems must be completely drained and dried. Otherwise remaining water may cause pipe corrosion and premature failure. This is not a problem with wet pipe systems where water is constantly maintained in piping.

With the exception of unheated building spaces and freezer rooms, dry pipe systems do not offer any significant advantages over wet pipe systems. Their use in heritage buildings is generally not recommended.







The third sprinkler system type, pre-action, employs the basic concept of a dry pipe system in that water is not normally contained within the pipes. The difference, however, is that water is held from piping by an electrically operated valve, known as a pre-action valve. Valve operation is controlled by independent flame, heat, or smoke detection.

Two separate events must happen to initiate sprinkler discharge. First, the detection system must identify a developing fire and then open the preaction valve. This allows water to flow into system piping, which effectively creates a wet pipe sprinkler system. Second, individual sprinkler heads must release to permit water flow onto the fire. Illustrations 5-3 through 5-5 show the operation of a typical preaction system.

Illustration 5-3. Pre-Action System, Non-Fire.

Illustration 5-4. Pre-Action System, Pre Discharge.

Illustration 5-5. Pre-Action System, Discharge.

In some instances, the preaction system may be set up with a double interlock in which pressurized air or nitrogen is added to system piping. The purpose of this feature is two-fold: first to monitor piping for leaks and second to hold water from system piping in the event of inadvertent detector operation. The most common application for this system type is in freezer warehouses.

The primary advantage of a pre-action system is the dual action required for water release: the pre-action valve must operate and sprinkler heads must fuse. This feature provides an added level of protection against inadvertent discharge. For this reason, preaction systems are frequently employed in water sensitive environments such as archival vaults, fine art storage rooms, rare book libraries and computer centers.

There are some disadvantages to pre-action systems. These include:

- **Higher installation and maintenance costs.** Preaction systems are more complex with several additional components, notably a fire detection system. This adds to the overall system cost.
- **Modification difficulties.** As with dry-pipe systems, preaction sprinkler systems have specific size limitations which may impact future system modifications. In addition, system modifications must incorporate changes to the fire detection and control system to ensure proper operation.
- **Potential decreased reliability.** The higher level of complexity associated with preaction systems creates an increased chance that something may not work when needed. Regular maintenance is essential to ensure reliability. Therefore, if the facility's management decides to install preaction sprinkler protection, they must remain committed to installing the highest quality equipment, and to maintaining these systems as required by manufacturer's recommendations.

Provided the application is appropriate, preaction systems have a place in heritage buildings, especially in water sensitive spaces.

A slight variation of pre-action sprinklers is the deluge system, which is basically a pre-action system using open sprinklers. Operation of the fire detection system releases a deluge valve, which in turn produces immediate water flow through all sprinklers in a given area. Typical deluge systems applications are found in specialized industrial situations, i.e. aircraft hangers and chemical plants, where high velocity suppression is necessary to prevent fire spread. Use of deluge systems in heritage facilities is rare and typically not recommended.

Another pre-action system variation is the on-off system. This system utilizes the basic arrangement of a pre-action system, with the addition of a thermal detector and non-latching alarm panel. The system functions similar to any other pre-action sprinkler system, except that as the fire is extinguished, a thermal device cools to allow the control panel to shut off water flow. If the fire should reignite, the system will turn back on.

In certain applications on/off systems can be effective, however, care must be exercised when selecting this equipment to ensure that they function as desired. In most urban areas, it is likely that the fire department will arrive before the system has shut itself down, thereby defeating any actual benefits.

6: Sprinkler Concerns

Several common misconceptions about sprinkler systems exist. Consequently, heritage building owners and operators are often reluctant to provide this protection, especially for collections storage and other water sensitive spaces. Typical misunderstandings include:

- **When one sprinkler operates, all will activate.** With the exception of deluge systems (discussed later in this article), only those sprinklers in direct contact with the fire's heat will react. Statistically, approximately 61% of all sprinkler controlled fires are stopped by two or less sprinklers.
- **Sprinklers operate when exposed to smoke.** Sprinklers function by thermal impact against their sensing elements. The presence of smoke alone will not cause activation without high heat.
- **Sprinkler systems are prone to leakage or inadvertent operation.** Insurance statistics indicate a failure rate of approximately 1 head failure per 16,000,000 sprinklers installed per year. Sprinkler components and systems are among the most tested systems in an average building. Failure of a proper system is very remote.

Where failures do occur, they are usually the result of improper design, installation or maintenance. To avoid problems, the institution should carefully select those who will be responsible for the installation and be committed to proper system maintenance.

The system designer should understand the institution's protection objectives, operations and fire risks. This individual should be knowledgeable about system requirements and flexible to implement unique, thought out solutions for those areas where special aesthetic or operations concerns exist. The designer should be experienced in the design of systems in architecturally sensitive applications.

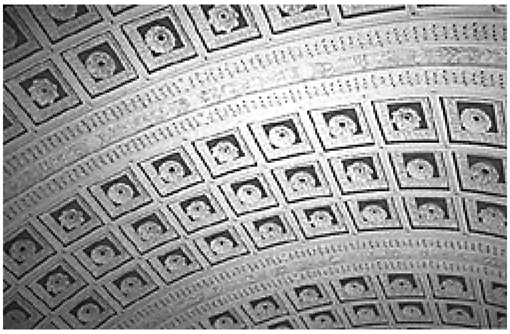
Ideally, the sprinkler contractor should be experienced working in heritage applications. However, an option is to select a contractor experienced in water sensitive applications such as telecommunications, pharmaceutical, clean rooms, or high tech manufacturing. Companies including AT&T, Merck, and IBM have very stringent sprinkler installation requirements. If a sprinkler contractor has demonstrated success with these type organizations, then they will be capable of performing satisfactorily in a heritage site.

The selected sprinkler components should be provided by a reputable manufacturer, experienced in special, water sensitive hazards. The cost differential between the average and the highest quality components is minimal, however the long term benefit is substantial. When considering the value of a facility and its contents, the extra investment is worthwhile.

- **Sprinkler activation will cause excessive water damage to contents and structure.** Water damage will occur when a sprinkler activates. This issue becomes relative, however, when compared to alternative suppression methods. The typical sprinkler will discharge approximately 25 gallons per minute (GPM) while typical fire department hoses delivers 100-250 GPM. Sprinklers are significantly less damaging than hoses. Since sprinklers usually operate before the fire becomes large, the overall water quantity required for control is lower than situations where the fire continues to increase until firefighters arrive. Table 6-1 shows approximate comparative water application rates for various manual and automatic suppression methods.

Table 6-1: Fire Suppression Water Application Rates.

Delivery Method	**Liters/min.**	**Gallons/min.**
Portable Fire Extinguisher/Appliance	10	2.5
Occupant Use Fire Hose	380	100
Sprinkler (1)	95	25
Sprinkler (2)	180	47
Sprinkler (3)	260	72
Fire Dept., Single 1.5" Hose	380	100
Fire Dept., Double 1.5" Hose	760	200
Fire Dept., Single 2.5" Hose	950	250
Fire Dept., Double 2.5" Hose	1900	500



One final point to consider is that the water damage is usually capable of repair and restoration. Burned out contents, however, are often beyond mend.

- **Sprinkler systems look bad and will harm the buildings appearance.** This concern has usually resulted from someone who has observed a less than ideal appearing system, and admittedly there are some poorly designed systems out there. Sprinkler systems can be designed and installed with almost no aesthetic impact.

To ensure proper design, the institution and design team should take an active role in the selection of visible components. Sprinkler piping should be placed, either concealed or in a decorative arrangement, to minimize visual impact. Only sprinklers with high quality finishes should be used. Often sprinkler manufacturers will use customer provided paints to match finish colors,while maintaining the sprinkler's listing. The selected sprinkler contractor must understand the role of aesthetics.

Illustration 6-1 provides an example of a well installed sprinkler in an architecturally sensitive space. (Note, the sprinkler is in one of the plaster ceiling rosettes.)

Illustration 6-1. With proper attention to selection, design, and maintenance sprinkler systems will serve the institution without adverse impact. If the institution or design team does not possess the experience to ensure the system is proper, a fire protection engineer experienced in heritage applications can be a great advantage.

7: Water Mist

One of the most promising extinguishing technologies involves the use of fine water droplets, known as micromist.

This technology represents a potential solution to the protection void left by the environmental concerns, and subsequent demise of Halon 1301 gas.

Micromist systems discharge limited water quantities at very high release pressures (approximately 1,000 psi). This produces droplets of less than 20 microns diameter, resulting in exceptionally high efficiency cooling and fire control with significantly little water. Initial system tests have demonstrated successful fire extinguishment in hotel room scenarios, mockup library bookstacks, computer rooms and underfloor cable spaces. In most situations these fires have been extinguished with 1-5 gallons of water. Many of the test scenarios have been suppressed in less than 1 minute, with all fire scenarios extinguished within 5 minutes. Water saturation, often associated with standard firefighting procedures, is avoided. Other anticipated micromist benefits include: lower installation costs, minimal aesthetic impact, and known environmental safety.

The micromist system consists of:

- **Water supply:** Water may be provided by either the piped building system or a dedicated tank arrangement. System operating pressure is produced by a high pressure pump.
- **Piping and nozzles:** Piping is generally 1/2 inch diameter stainless steel, which is clean and easily installed. This material comes prefabricated from the factory, with final site assembly performed using simple compression fittings. Welding, brazing, or threading operations are avoided. Nozzles are approximately the size of a pencil eraser.
- **Detection and control equipment.** Micromist discharge is controlled by selected, high reliability intelligent detectors or by an advanced technology VESDA smoke detection system. These systems represent the premier, state-of-the-art, fire detection technology. Thus, the probability of inadvertent discharge is drastically reduced.

A leading micromist system is under joint development by Baumac International, Reliable Automatic Sprinkler Corporation, Marriott Hotels, and the University of Maryland Fire and Rescue Institute. Equipment controls are being developed by Fire Control Instruments (FCI), Notifier Corporation and IEI North America. To date, this consortium has compiled an extensive data base, testing micromist is a variety of "live fire" situations.

While success has been impressive, several questions remain regarding mist capabilities and constraints. In particular, what factors impact mist success and, what is the level of collateral content damage upon extinguishment? Several cultural heritage fire problems will be simulated and analyzed during upcoming tests. Representative heritage collections will be placed in a micromist discharge. Following micromist suppression each item will be removed and examined by collections management experts for damage and establishment of required restoration effort.

Several heritage institutions are providing materials and technical expertise for the test program. These include the National Gallery of Art, the National Library of Canada, the Field Museum of Natural History, the National Archives of Canada, the Library of Congress, the Architect of the Capitol, the National Library of Scotland, and the National Park Service. With their input, the ultimate benefit of micromist will be established.

Additional information on this technology will be forthcoming as developments progress.

8: Summary:

In summary:

- Heritage management must identify the desired objectives which the selected fire suppression system is to attain. Once these issues have been established, protection systems can be selected to accomplish target goals.
- Automatic sprinklers often represent the most important fire protection option for most heritage applications.
- The successful application of sprinklers is dependent upon careful design and installation of high quality components by capable engineers and contractors. A properly selected, designed and installed system will offer unexcelled reliability.
- Sprinkler system components should be selected for compliance with the institution's objectives.
- Wet pipe systems offer the greatest degree of reliability and are the most appropriate system type for most heritage fire risks.
- With the exception of spaces subject to freezing conditions, dry pipe systems do not offer advantages over wet pipe systems in heritage buildings.
- Pre-action sprinkler systems are beneficial in areas of highest water sensitivity. Their success is dependent upon selection of proper suppression and detection components and management's commitment to properly maintain systems.

- Water mist (micromist) represents a very promising alternative to gaseous agent systems. This technology is under development with availability anticipated in 12-18 months.
- Most system failures are the result of improper system maintenance. Management must remain committed to providing proper system maintenance to ensure reliability, and avoid the temptation to cut back on system service.

Additional Information.

The following information sources are available to assist with selection of fire sprinkler systems:

- **Fire Safety Network**; Post Office Box 895; Middlebury, Vermont 05753; USA. Telephone 802/388-1064.
- **National Fire Protection Association**; Batterymarch Park; Quincy, Massachusetts 02269; USA. Telephone 617/770-3000.
- **Reliable Automatic Sprinkler, Inc.**; 1800 Sandy Plains Parkway, Building 100, Suite 108; Marietta, Georgia 30066; USA. Telephone: 800/652-1819 or 404/421-1633. Attention: Mr. Thomas L. Multer, Special Hazards Manager.