# Section 4

# Fire Protection

## 4.1 - Rationale

The speed and totality of a fire's destructive forces represent one of the most significant threats to archives. In a relatively short time, the impact of a fire can cause serious structural damage to a facility and may damage collections beyond recovery. Archival facilities, because of their unique holdings, require a higher level of fire safety than is normally required for commercial buildings. Consequently, these guidelines supplement the mandated building and fire codes for commercial buildings.

Since fire protection technologies are constantly evolving, the guidelines in this chapter are not meant to be comprehensive and newer alternatives many not be fully reviewed here. Where alternatives are proposed it must be the responsibility of the design professional or equipment supplier to submit technically appropriate documentation to demonstrate equivalency.

Fire safety objectives must be set for the facility. They must establish acceptable loss levels and subsequent protection levels for collections, the building, and continuity of operations.

- Life safety must not be less than prescribed by mandated local, state, provincial, or federal codes and standards.
- The fire detection and alarm system must include Americans with Disabilities Act (ADA) features and functionality, or equivalent.
- Archives must be provided with a reasonable level of protection against damage or loss from fire, combustion products and fire suppression actions. This protection level may vary depending on the unique aspects of specific collections, items, and categories.
- The facility must be provided with protection against catastrophic loss of integrity from fire, combustion products, and fire suppression actions.
- The archives program must be reasonably protected against operational downtime and impact from fire, combustion products, and fire suppression actions. The acceptable period of downtime must be defined by the archives administrator.
- The archives facility must be designated a smoke-free building.

**4.1.1** Principles of fire (fire basics)

- Fire triangle
- Fire classifications

**4.1.2** Causes of fires in archives: unsafe use & unsafe practice (e.g., smoking, open flame, cooking, melting); arson; building system failure (e.g., damaged or inadequate wiring, malfunctioning heating system); small apparatus failure (e.g., small heater, heat gun); natural (lightning strike, forest fire); spread from adjacent building

**4.1.3** Damage to collections: complete destruction; charring; melting; embrittlement; soot accumulation (discolouration, smell); physical damage (crushing, tearing); water-related damage (tide lines, bleeding inks, deformation, mould); dissociation (lost labels); theft.

## 4.2 - FIRE RISK ASSESSMENT

A fire risk assessment must be conducted when planning a new facility or major renovation to an existing facility. This assessment must identify potential fire threats and their potential impact on the facility, collections, organizational mission, and persons within the structure. It must also evaluate fire protection elements, identifying appropriate solutions that achieve the desired fire safety goals and objectives. It is recommended that a risk assessment be conducted for existing facilities every five years to maintain a continued level of fire safety. This risk assessment should be undertaken by someone experienced in archives fire safety such as a fire protection engineer, insurance representative, fire or building official, or other technically qualified person.

## 4.3 - BUILDING CONSTRUCTION

The building provides the enclosure that safeguards the collections and related operations from weather, adverse environmental conditions, and security threats. Protecting the repository from fire damage is paramount. Construction requirements for the repository must comply with National Fire Protection As- sociation (NFPA) #232, *Standard for the Protection of Records and Storage*, NFPA #909, *Code for the Protection of Cultural Resources* and the local mandated building code. Where conflicts between the codes arise the most restrictive requirements must apply for archival facilities.

Critical fire safe aspects of the facility must include:

- water supply to the site and building;
- fire detection, fire suppression, and fire alarms systems;
- properly rated construction and roof materials;
- fire rated doors;
- preventing fire ignition from mechanical and electrical systems;
- preventing fire spread by selecting furniture and finishes that lower flame spread and smoke generation and are constructed with a low flame spread rating;
- isolating fire and smoke to prescribed areas of a floor of the building. Compartmentalizing building spaces will prevent migration of fire and will vary depending on how the spaces are used;
- isolating fire and smoke to the floor where the fire occurs;
- evacuating smoke and toxic gases after a fire occurs;
- preventing fire spread from an adjacent building or outside sources into the facility.

## 4.4 - COLLECTIONS STORAGE CONSTRUCTION

Collection storage areas must have the highest level of fire safe integrity. Stacks, vaults, storage rooms, and other areas housing library or archival materials must be constructed to resist the entry of fire, smoke, water, and toxic gases. Refer to Sections 2.3 and 2.4 for construction guidelines.

### 4.4.1 Structure

- Ideally, all walls, ceilings, and floors of a collection storage area should be constructed of a masonry material (concrete, concreate block, stone, or brick). Combustible materials such as wood are not recommended for use in any portion of the construction or finish of a collection storage area or of the building's structural members that support a collection storage area. In addition, collection storage areas and all supporting structures should be designed and constructed to ensure that the structure will withstand all the conditions that a fire may impose upon it for the entire fire duration.
- The duration of the stack fire resistance must not be less than 1.5 times the anticipated fire duration of all combustibles within the stack. In the absence of accurate knowledge regarding the fire duration, the stack enclosure must not be less than four hours. Stack fire resistance must not be reduced if fire suppression is provided even when permitted by the building code.
- All building structural members that support stacks must have a fire resistance rating at least equal to that of the stack enclosure. In a nonfire-resistive building, stacks shall be ground supported. In addition, the stack's support structure must be of adequate strength to carry the full load of the building structure plus the wet weight of the stack structure and contents.
- Safes, file cabinets, or record containers housing archival records that are housed outside of stacks must have a minimum fire resistance of two hours.

### 4.4.2 Walls

- Stack walls must be free from penetrations except for openings that are required for essential systems. Conduit penetrations in stacks must be through walls. Floors and roofs shall not be pierced for conduit.
- Exterior walls of stacks must have the same fire rating as interior walls and must be free from penetrations. Exception: Exterior openings that are required for proper ventilation and are fitted with automatic fire and smoke dampers that provide a fire resistance rating equivalent to the wall may be used in archival facilities.
- Smoke barrier walls with self-closing doors must be provided for all multiple floor shelving systems in stacks to prevent vertical smoke migration.

- All stacks greater than 500 square feet [46.5 square meters] in area must be provided with means to extract smoke directly to the exterior. Extract can be mechanical or passive.

### 4.4.3 Doors

- All stack door openings must be protected with fire rated doors with a fire rating in hours equal to the classification of the stack walls. Doors must be listed and labeled in accordance with American National Standards Institute (ANSI)/Underwriters Laboratories (UL) 155, *Tests for Fire Resistance of Vault and File Room Doors.* Stack doors must be equipped with automatic closing devices to maintain the door in a normally closed and latched position.
- All other fire doors in the repository should be equipped with automatic closing devices and maintained in a normally closed position. Exception: Where closed doors interfere with normal business operations and smoke detection is provided, they may be held open with magnetic devices that release and close the doors upon activation of the smoke detection system operation.

### 4.4.4 Elevators/Stairways

- Elevators, stairways, conveyors, and other shafts must not open directly into stacks. Exception: Stairways, elevators, conveyors, and shafts that are located within the stack and are exclusive for use of the respective space.

## 4.5 MECHANICAL SYSTEMS

Climate control for the stacks must be accomplished by fixed systems. Portable heating, air conditioning, or humidity control equipment must not be used in stacks. Exception: Equipment used for temporary stabilization and recovery may be used in emergency situations.

### 4.5.1 Location

- Boilers, furnaces, humidification, dehumidification, air conditioning, and other climate conditioning equipment that serve the stack must not be located within the stack enclosure. In addition, all controls for utilities that serve stacks must be located outside of the stack so that access to the controls does not re- quire entry to the stack.
- Ducts and pipes that do not serve the stack must not enter or pass through the stack. Any pipe that serves a stack must have its point of penetration through the wall completely filled with cement or other approved grouting.

### 4.5.2 Mechanical Ducts

- All mechanical ducts serving the stack must be provided with an automatic, combined fire and smoke damper that is equipped to completely close the duct opening and shut down fans that serve the duct in the event of fire. The individual damper or combination thereof must provide equivalent fire resistance rating to the stack wall.
- Duct smoke detectors should be provided in the supply and re- turn ducts of the air handling systems and be designed to shut down the individual air handler unit if smoke is detected in the system.
- There should be a main shut-off of the air handling systems. It should be possible to shut down the air handling system manually and override the automatic controls during a fire emergency. This shut-off switch should be located in the fire control panel.

## 4.6 - ELECTRICAL SYSTEMS

- All stack wiring must be in conduit and installed in accordance with National Electrical Code (NEC), NFPA #70. All circuits that serve stacks must be fitted with arc-fault circuit interrupters (AFCI). Wiring within stacks must be limited to those necessary for illumination. Electrical and communications cabling that does not serve the respective stack must not pass through the stack. Exception: Power limited circuits as defined by NEC, NFPA #70 for security, fire detection and alarm, and temperature/humidity monitoring. Where a conduit or cable serves the stack, the point of penetration through the wall shall be completely filled with cement or other approved grouting.
- The electrical distribution equipment, including communications panels, must not be located within stacks. Stack electrical and lighting circuits must be arranged so that they are de-energized when the stack's main lock is engaged. Automatic timers may be used to shut lights off after thirty minutes.
- Exception: Power limited circuits as defined by NEC, NFPA #70 for security, fire detection and alarm, and temperature/humidity monitoring may be used in stacks.
- Lighting and electrical power within stacks must only be accomplished by fixed systems. Portable lighting and extension cords must not be used in stacks. Exception: Portable equipment used for temporary stabilization and recovery may be used in emergencies.

## 4.7 - FIRE DETECTION AND ALARM

Once a fire starts it must be detected and an alarm sounded. For stacks and other spaces that house archives this detection must be during the fire's incipient (smoldering) phase, prior to the appearance of the visible flames. All archival facilities must have automatic fire detection and alarm systems. The smoke detection/fire alarm system shall be connected to an approved central station monitoring service.

The fire detection and alarm system must be installed and maintained in compliance with the current pamphlet of NFPA #72, *National Fire Alarm Code* and the fire alarm equipment manufacturer's technical requirements.

### 4.7.1 Smoke Detection

- The entire repository must be provided with automatic smoke detection. Those portions of the building where smoke detection is not technically feasible, (i.e., areas subject to freezing) should be provided with rate-of-rise thermal detection or other suitable thermal detection.
- Smoke detection for stacks must be highly sensitive, capable of detecting smoke obscuration rates of 0.04% or less. Detector spacing in stacks must not exceed 450 square feet [42 square meters] per detector or detection point. A fire protection analysis must be conducted to determine the other areas in the facility where high sensitivity smoke detection is necessary, and the ap- propriate equipment then provided.
- Smoke and other automatic detection devices must be placed to avoid physical impact due to collections access and normal operations.

### 4.7.2 Fire Alarms

- All smoke and fire detection devices in stacks must provide annunciation at the fire alarm control panel and all supplemental enunciator panels to indicate the specific stack where smoke or a fire has been detected.
- Manual fire alarm call boxes shall be provided throughout the facility, including at all stack egress doors.

**Table X: smoke detectors**

| Detectors | Features | Applications |
|---|---|---|
| **Ionization smoke detector** | Air molecules are ionized by a radioactive material creating an electric circuit. When smoke enter in the detector, it reduces the flow of current which activates an alarm. | Most common and low cost. Detect invisible products of combustion at the incipient stage. Not appropriate for cooking areas and washrooms. |
| **Photoelectric smoke detector** | The detector contains a LED source and a photo sensor. The alarm is activated either by the light obscuration or light scattering detector type. By obscuration, the light source and sensor are aligned, and the smoke will reduce the amount of light at the sensor. By scattering, the source and sensor are not aligned, and the smoke will disperse the light and will be detected. | Detect smoke from fires that begin with a long period of smoldering which produce a large quantity of visible smoke. |
| **Laser smoke detector** | The detector contains a laser source and a photo sensor. The alarm is activated by the light scattering or and obscuration detector types. Sensitivity is improved with optical design, dust filters and algorithms. | Detect smoke in early stage of incipient. Alarm can be set up to different amount of smoke. The use of algorithms and dust filters minimized the false alarm due to sudden generation of dust. |
| **Air sampling smoke detector** | Suction tubes are used to draw air towards a laser smoke detector. also call smoke aspiration system. | Detect smoke in very early stage of incipient. One detector with a single pipe can monitor many rooms. |
| **Duct detector** | Simply a smoke detector in the return air duct. | When smoke is detected, the alarm is activated, and the HVAC system is shut down. This detector should not be powered by the HVAC system because when shutting |
| | | down the HVAC system which may cause a fire alarm. |
| **Optical Beam smoke detector** | Type of photoelectric smoke detector. A single beam detector can be used for the entire length of a large space. | Designed for large open spaces such as place of worships and high ceiling storages. its small size and its numbers required for a large room is an advantage for heritage and aesthetic installations. |

**Table X: heat detectors**

| Detectors | Features | Applications |
|---|---|---|
| **Fixed temperature heat detector** | Detector is activated by the melting of a metal alloy at 58 °C. | The common heat detector. Can provide property protection but not life-safety protection because they do not react quickly enough to incipient fires. Good for dusty working places or in cold or hot areas such as attics and not heated storage building. Less prove to false alarms. |
| **Rate-of-rise heat detector** | Based on thermocouples or thermistors (from the compression of thermal and resistor) and detect a rate of temperature increase of 7 or 8 °C per minute. | As for fixed temperature detector. It can create more false alarm if temperature gradient is caused by opening door or window, oven door. |
| **Bimetallic strip heat detector** | Based on two metals that react differently to temperature. When exposed to heat, the strip is bending until it forms an electric circuit which activated an alarm. The opposite approach also exists when the strip bends and no longer maintains an electric currant. This loss of contact then causes an alarm. The lowest activation temperature available is 68 °C. | Another type of fixed temperature detector. Less used in new fire safety system. |
| **Line heat detector** | Cable along the ceiling. The cable contains two steel conductive wires are isolated by a thermal sensitive polymer. When the temperature at the cable reaches 68 °C, the polymer melts, the wires become in contact creating the electric current and an alarm is activated. | Designed for large open spaces such as places of worship and high ceiling storages. |

link to some CAN museums with their type of fire detect???

**Table X: fire department notification systems**[1]

| Type of system | Description |
|---|---|
| **Protected premises** | The fire alarm system sounds an alarm only in the building where it is activated. No signal is sent out. Someone must call the 911. A high risk of fire propagation if nobody is present on site. |
| **Remote supervising station** | The fire alarm system sounds an alarm through the building and transmits a signal to a remote location. The signal may go directly to the fire department if they are equipped to handle direct alarms. |
| **Central station** | The fire alarm system sounds an alarm in the building and transmits a signal to a third-party off-premises monitoring facility. They are responsible for notifying the fire department to respond, and they must send a person to investigate the site. |
| **Proprietary supervising system** | The fire alarm system transmits a signal to a monitoring location owned and operated by the institution. The alarm may or may not be activated. Facility or security personnel investigate and respond to the incident before informing the fire department. A signal can also be sent immediately to the fire department. The building must be monitored 24 hours a day. This avoids unlocking the emergency doors in the event of a false alarm and putting the institution at risk of theft and vandalism. |

Note 1. adapted from International Association of fire Chiefs and NFPA (2016 p. 161).

## 4.8 - FIRE SUPPRESSION

Once the fire has been detected it must be extinguished to limit damage to archival collections and the facility. If the fire is detected while it is small and a trained person is present, it may be controlled with a portable fire extinguisher or other similar manual firefighting tool. However once the fire exceeds approximately 3 feet [1 meter] in height, professional fire fighters are required to extinguish the fire. Automatic fire suppression systems can identify a developing fire and respond within minutes to isolate the fire's size until the fire department arrives.

### 4.8.1 Manual Fire Fighting Systems

- All floor areas must be provided with portable fire extinguishers that are appropriate for the anticipated fire scenario. Fire extinguishers shall be installed in accordance with the current pamphlet of NFPA #10, *Standard for Portable Fire Extinguishers*.
- A minimum of one portable fire extinguisher for Class A (ordinary combustibles) fires shall be located within each stack and within 25 feet [8.2 meters] of the stack door. For multiple tiered stacks a minimum of one fire extinguisher must be located on each tier.
- Fire department standpipe systems and fire hoses should be placed outside of the stack to permit the fire department to connect their equipment prior to entering the stack enclosure. This also protects the collections from accidental operation of standpipes and hoses during non-fire conditions.

### 4.8.2 Automatic Fire Fighting Systems

- Where required, all fire suppression systems must be designed and installed in accordance with applicable NFPA standards.

    - Sprinkler systems: the standard is NFPA #13, *Standard for the Installation of Sprinkler Systems.*
    - Water mist systems: the standard is NFPA #750, *Standard for Water Mist Fire Protection Systems*.
    - Gas agent systems: the standard is NFPA #2001, *Standard on Clean Agent Fire Extinguishing Systems.*

- All fire suppression systems must also comply with NFPA #909, *Standard for Fire Protection of Cultural Properties.* Where performance alternatives to standard fire suppression component placement is necessary to comply with specific facility and/or archives requirements, they must be reviewed and approved by a licensed fire protection engineer.
- Automatic fire suppression systems must be technically appropriate for the anticipated fire scenarios. The system must confine substantial thermal damage to an area that does

not exceed ap- proximately one-half of the floors where it starts and to a maxi- mum of 1,500 square feet [140 square meters]. Administrators may require smaller damage areas for specific collections.

- Sprinkler and water mist fire suppression systems in archival facilities must be wet-pipe or pre-action type systems.
- Dry-pipe systems must only be used for spaces that are subject to freezing.
- All fire suppression systems must be kept in proper working order in accordance with the applicable standards.

#### 4.8.2.1 *Stacks*

- An automatic fire suppression system must be provided for stacks greater than 500 square feet [46.5 square meters] in area. Exception: A space that contains only noncombustible collections including packing or crating materials, noncombustible shelves and cabinets, or where collections are stored in noncombustible cabinets may use a different fire suppression system.
- Sprinkler and water mist fire suppression systems in repositories including stacks must be wet-pipe or pre-action type systems. Dry-pipe systems must only be used for spaces that are subject to freezing.
- Sprinkler and water mist systems must be individually zoned for each stack and must have dedicated shut-off valves for each stack. All valves must have clear signage indicating the portion of the facility that they control. All security and facilities staff members must be familiar with the location of valves. Each sprinkler zone must be specifically monitored by the fire alarm system, which indicates the zone with an activated sprinkler.

#### 4.8.2.2 *Compact Mobile Shelving Systems*

- An automatic fire suppression system must be provided for all stacks where compact mobile shelving is used for the storage of collections. Exception: Compact storage that contains only non- combustible collections or collections stored in noncombustible cabinets on the compact system may use a different fire suppression system.
- Compact mobile shelving systems that are installed within existing buildings must have the sprinkler system evaluated by a fire protection engineer or other technically qualified person to ensure that the sprinklers are able to provide the proper level of protection. Sprinkler system modifications or appropriate supplemental suppression must be implemented as necessary before installation of the compact shelving.
- Compact mobile shelving systems that are installed in new or renovated stacks should consider electrically operated shelving that can automatically go into “fire mode.” Upon activation of a smoke detector, water flow alarm, or manual alarm, fire

mode allows the shelving rows to automatically separate to create minimum 5-inch aisles. Electric mobile systems can also be programmed to go into fire mode when the archival facility is closed for business.

- Fire protection for archival materials stored on compact mobile shelving measuring 8 shelves high (111 inches [2.8 meters] tall) must use a wet-pipe automatic sprinkler system with 165°F [74°C] quick response sprinklers (Response to Intervention [RTI]=50) spaced on a maximum of 100 square feet [9.2 square
- meters] per sprinkler and with design for a minimum flow density of 0.30 gallons per minute/square foot over the most remote 1500 square feet [140 square meters] of floor area. De- signers should consider using lower temperature (135°F [57°C] or 155°F [68°C]) sprinkler heads.
- Recent fire tests have shown that high bay electric mobile shelving systems can safely go 30 feet [9 meters] high providing
  30 shelves per bay of shelving without the addition of in-rack sprinkler installations as long as Early Suppression Fast Response (ESFR) sprinklers are used and the archival material is stored in boxes. Additional provisions for fire protection on the high bay mobile shelving include 6 inch [15 centimeters] longitudinal flue spaces between the back to back shelving rows and 3 inches [8 centimeters] transverse flue spaces between adjacent shelving units.

#### 4.8.2.3 *Exhibition/Laboratories/Processing/Hold Areas*

- An automatic fire suppression system must be provided for all areas where archival materials are exhibited, treated, or temporarily stored.

#### 4.8.2.4 *Cold Storage*

- Clean agent systems (gas agent extinguishing system) that comply with NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, or pre-action sprinkler systems must be used in cold stacks and other areas subject to temperatures below 40°F [4.4°C]. When using a clean agent system, the gas manufacturer or authorized distributor must provide proof that the agent has been tested and demonstrate successful fire extinguishment in scenarios that are similar to those in the proposed protected area.

## 4.9 - LOW OXYGEN SYSTEM

- A Low Oxygen System is a promising technology that currently is used in a few European facilities and is undergoing evaluation by several cultural heritage organizations in North America.
- The Low Oxygen System recognizes that fires cannot achieve full flaming combustion when room oxygen levels are below 16% which is less than the nominal 21% oxygen found in air. A smoldering fire may occur that can be detected by a smoke detection system and extinguished with simple methods. However, without a source for a flaming fire some of the traditional fire suppression methods, such as sprinklers, may not be needed.
- The 16% oxygen level is accomplished by special nitrogen generators that are connected to the building's air handling system. To be successful the room must be relatively air tight. A healthy person can work in this atmosphere for a designated time period without harm.
- As the technology advances, this section will provide more specific guidelines.

**Table X: comparison of selected automatic fire suppression systems for museum objects**

| System Type | Description | Advantages | Disadvantages |
|---|---|---|---|
| **Wet pipe sprinkler system** | - Sprinkler pipes are constantly filled with water | − Extremely reliable<br>− Faster response than dry pipe systems<br>− Relatively easy and economical to install and maintain | − Not for use in environments susceptible to freezing (< 4 °C)<br>− Accidental discharge can result in water and mold damage |
| **Dry pipe sprinkler system** | - Pipes are filled with pressurized gas (air or nitrogen)<br>- When sprinkler head is activated, compressed gas is released so water can flow out of the pipes | − Can be used in environments susceptible to freezing<br>− Minimal water leakage and accidental discharge of water | − Delay in initial response (code allows up to 60 seconds)<br>− Requires more maintenance than a wet pipe system<br>− Pipes susceptible to inline corrosion if not maintain with an over pressure of nitrogen<br>− Requires reliable power to maintain inline pressure<br>− After operation, pipes can corrode if not thoroughly drained and dried |
| **Pre-action sprinkler system** | - Type of dry pipe system that have closed heads with no water in the piping; the fire detection system opens a valve that charges pipes with water. Then acts like a wet-pipe system | - Less risk of inadvertent or accidental water damage as no water kept in the pipes | - Problems with the detection system can affect the operation of the sprinkler system |
| **Clean agent suppression system** | - Discharges a fire extinguishing gas (halogenated agents or $CO_2$) instead of water | − Can be used everywhere including in cold storage rooms and areas subject to temperatures below 4°C.<br>− Eliminates the possibility of water damage to collections from fire suppression | − If not properly maintained and pressurized the system will not discharge<br>− Gas requires tightly sealed compartments for effective operation<br>− Suppression agent levels must be maintained for several minutes after |

| | | | |
|---|---|---|---|
| | | | discharge to prevent re-ignition<br>− Lite weight objects can be displaced due to gas released |
| **Water mist suppression system** | - A higher pressure, low water system that discharges extremely small water particles | − Reduces potential for water damage to collections and historic fabric<br>− Uses a maximum of 10% of the water released with a typical wet or dry pipe system<br>− Can be used to protect structures lacking water by using a water storage tank | − Cost estimated at 50 to 100% more expensive than a wet pipe system |
| **Hybrid water mist and inert gas system** | - Typically, nitrogen is used as inert gas, but it can also be blend with other inert gases.<br>- The ratio water/nitrogen is in the range of 7 to 15% | - As for water mist but use a maximum of 1% of the water released with a typical wet or dry pipe system | - As for water mist<br>- more expensive because of two pipe network system (gas and water). |
| **Deluge suppression system** | - Type of dry pipe system but does not have closed sprinkler heads<br>- When activated water will be released by all heads | - Could be used for very special applications where large fire can develop rapidly such as collection of cellulose nitrate films or there is a high risk of explosion in presence of combustible liquids, ammunitions, or explosives | - System not suitable for most institution operations due to the large volume of water that would be discharged during use |