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NFPA 232AM Archives and Records Centers 1991 Edition

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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MGR FM-90

NFPA 232AM

Manual for Fire Protection for

Archives and Records Centers

1991 Edition

This edition of NFPA 232AM, *Manual for Fire Protection for Archives and Records Centers*, was prepared by the Technical Committee on Record Protection, released by the Correlating Committee on Storage, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 12-14, 1990 in Miami, FL. It was issued by the Standards Council on January 11, 1991, with an effective date of February 8, 1991, and supersedes all previous editions.

The 1991 edition of this standard has been approved by the American National Standards Institute.

Origin and Development of NFPA 232AM

The Committee on Record Protection prepared this manual on Fire Protection for Archives and Record Centers as a source of guidance in planning fire protection for collections of records stored in large volumes. It supplements NFPA 232, *Standard for the Protection of Records*, which does not contain provisions for protecting large archives and record centers. This document is neither a standard nor a recommended practice, but a manual that hopefully will give records managers and others charged with safeguarding large collections the information they need to plan intelligently for fire protection. The manual was first presented to the 1970 NFPA Annual Meeting, which tentatively adopted it.

The revised 1980 edition was officially adopted on May 21, 1980 at the NFPA Annual Meeting in Boston, Massachusetts. It was released by the Standards Council on June 11, 1980. The 1986 edition was merely a reconfirmation of the 1980 edition.

The 1991 edition has been completely revised in order to make it more understandable to the user. Most changes are editorial in nature. Substantive changes are present in two new chapters that deal with construction features as well as building equipment and associated facilities. New appendix materials are added concerning salvage procedures for damaged library materials.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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Chapter 1 Introduction

Information on referenced publications can be found in Chapter 8 and Appendix C.

1-1 Scope. This manual applies to collections of records in file rooms exceeding 50,000 cu ft (1416 m^3) and to all archives and records centers.

Since its adoption in 1947, NFPA 232, *Standard for the Protection of Records*, has been the recognized standard for protection of records against fire. However, it is concerned primarily with relatively small quantities of records kept immediately accessible to the originator or user. NFPA 232AM covers facilities larger than contemplated in NFPA 232.

1-2 Purpose. The purpose of this manual is to provide guidance for firesafe storage in archives and records centers where the size or character of the records holdings is not contemplated in NFPA 232 and to give archivists, records managers, and others charged with safeguarding large collections the information they need to plan intelligently for fire protection.

1-3 Definitions. For the purpose of this manual, the following terms have the meanings indicated.

Archives. Noncurrent records preserved because of their historic value. Also applied to the building, structure, or enclosure where they are deposited or retained.

File Room. An area for the storage and reference of current records.

Records Center. A building or enclosure for the retention and reference of semicurrent records pending their ultimate disposition.

Chapter 2 General

2-1 Types of Record Media. This manual concerns traditional paper records and records on magnetic, photographic, micrographic, and other special media. It is not possible to assure total fire protection of records in archives and records center facilities. It is possible, however, to provide a very high level of fire protection that would normally limit the potential loss of records in such facilities to a small amount. In view of this, it is important that the archivist or records manager knows the degree of protection available or, conversely, the degree of potential damage from the protection systems available for the archives or records center and determine which, if any, of the records need a higher level of protection available from the use of special vaults, safes, or insulated containers (*see NFPA 232, Standard for the Protection of Records*). It is essential that storage of cellulose nitrate film is not permitted in archives or records centers. (*See NFPA 40, Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film, and NFPA 232.*)

2-2 Arrangement. Storage devices include, but are not limited to, traditional file cabinets, records storage boxes (corrugated or solid fiberboard cartons), transfer cases, and miscellaneous containers of varying construction. The usual arrangement is either cartons on freestanding shelving or filing cabinets. Locations may vary from a separate area within a general office complex to especially constructed records facilities. It is not uncommon to find records stored in basements or attics, in office spaces, in factories or warehouses, or in underground or other readily available facilities, all of various constructions and levels of firesafety. Keeping all records storage at least 3 in. (76 mm) above the floor will minimize the effect of flooding.

2-3 Fire Risk Evaluation Factors. In considering the protection of records stored in mass, several basic items to be evaluated are:

(a) Exposure from the building housing the records, from nearby buildings, or from neighboring operations; i.e., the possibility of involving the records in a fire originating outside of the records facility;

(b) Potential of fire initiation within the records facility, including the susceptibility of the records or containers to ignition;

(c) Potential of fire development presented by the stored records themselves, particularly as it relates to the available or proposed fire control capabilities or mechanisms;

(d) Potential impact of fire development in the stored records on the housing structure and adjacent operations;

(e) Fire control systems with the resultant extent and type of damage from fire, fire effects (heat, smoke, etc.), and fire extinguishing efforts (principally water and physical disruption of records necessary to effect manual fire fighting); and

(f) Potential life threat to occupants and fire service personnel.

2-4 Exposure. A maximum amount of care or the most sophisticated of protection systems within the records storage area would be of little avail for records stored within a structure that burns as a result of some action or operation outside of the records area. A consideration of any archivist or records manager is the potential of the records being the victim of fire initiating external to the operations. The degree of additional risk imposed by neighbors varies according to the type and height of the building, the nature or hazard of the neighbors, and the type of protection the neighboring operations have. Any reasonable degree of protection for records stored in mass in any multistory building needs fire-resistive construction adequately designed to withstand the maximum fire impact of the exposing occupancy within. The same applies to single story buildings unless a proper fire wall separates the records area from the remainder of the building. When

records must be housed in a building that may burn around them, properly rated vaults, safes, or insulated containers capable of resisting a total burnout (*see NFPA 232, Standard for the Protection of Records*) are the only known means of protection that can give reasonable assurance of records recovery. When a separate building or a segregated floor or section of a fire-resistive building is used for records storage, however, the methods described in the following chapters would provide a degree of protection commensurate with the type of system selected.

2-5 Facility Design. The inherent risks in the storage of large quantities of records and the requirement to incorporate appropriate passive and active systems to deter, detect, contain, and control records storage fires mandate that an experienced and competent fire protection engineer be consulted regarding the design of new facilities or major alterations to existing facilities.

2-6 Fire Prevention Program. The most important factor in preventing fire loss in records facilities is the maintenance of a good fire prevention program based on good housekeeping, orderliness, maintenance of equipment, and absolute prohibition of smoking or use of open flame devices. All of these items are fundamental precepts of good records management. Experience has shown, however, that regardless of how careful or complete the fire prevention program, the risk of fire initiation through either human error or situations beyond the control of the archivist or records manager (such as lightning striking the facility) is a distinct possibility, and any program based entirely on fire prevention activities will be perpetually at risk of a major disaster.

2-7 Operations in Records Storage Areas. Work within records storage areas is normally limited to placing records in, retrieving records from, or removing records from storage. Any additional operations may introduce ignition hazards and may be inappropriate in records storage areas. In archival facilities, records storage areas should be separated from processing areas, offices, and research rooms by a proper fire wall. Records center facilities involve considerably more staff activity in the records storage areas. Whenever records centers and archives are within the same facility, the archival storage area should be separated from the records center storage area by a fire wall.

Other fire risks in the records storage areas can be reduced by:

(a) The use of manual instead of power-operated equipment;

(b) The use of electric instead of gas-fueled fork lifts;

(c) Prohibiting the use of portable space heaters, lights on extension cords, hot plates, coffee makers, duplicating devices, battery chargers, welding or cutting torches, and other such ignition sources within storage areas;

(d) Prohibiting the storage of oils, paints, or other flammables in or contiguous to the records areas.

2-8 Fire Retardant Treatments. Some attempts have been made to develop economical methods of increasing the fire resistance of typical records storage cartons. The most frequently attempted method is coating the cartons with an intumescent type of fire retardant paint. Tests of cartons protected by such paint properly applied show that the coating prevents actual ignition of the cardboard. However, intumescent paint does not intumesce effectively under about 400°F (204°C). The temperature of even a small exposure fire (such as might occur on a library cart) would weaken the paper in the box to the point where the box would break open under the weight of the paper it contains, exposing the ordinary combustible paper contents of the box. Similar results have occurred in tests of boxes that have been covered with aluminum foil with the additional effect of transmission of the heat through the aluminum, causing ignition of the cardboard carton beneath it. In a small-scale test conducted as a joint effort of the NFPA Committee on Record Protection and the U.S. General Services Administration, the effect of fire retardant paint coating on boxes demonstrated a very brief delay only in the ignition and development of fire up and across the face of the records storage. In essence, the fact that paper is in the form of a records container does not change its inherent characteristic of easy ignition and rapid fire development.

Chapter 3 Fire Characteristics

3-1 Metal Containers.

3-1.1 Fire Initiation. In some facilities all of the records are kept in metal file equipment or equivalent metal containers (closed on six sides), and the arrangement, housekeeping, and operational methods prohibit the maintenance of any combustible materials whatsoever outside of the steel containers. Where the surrounding building and all materials involved in it are noncombustible, the risk of fire or the possibility of fire development may be considered to be the burnout of one drawer and damage to the materials in the surrounding drawers above, below, behind, and beside the drawer of origin where:

(a) All of the records are kept exclusively in metal file cabinets or equivalent metal cabinets (closed on all six sides);

(b) The arrangement, housing, and operational methods prohibit combustible materials outside of the metal containers; and

(c) The surrounding buildings and all materials involved in them are noncombustible.

3-1.2 Fire Development. Where all of the records housed are contained within closed metal file equipment, transfer cases, or similar containers (whether or not of the insulated type) such that no fuel is exposed to flames outside the containers, and there are no other combustibles in the area, there would not be any significant fire development from most initiating sources. Fire spread from a significant ignition source would be very slow.

3-2 Open Shelving.

3-2.1 Fire Initiation. Records facilities use various shelf filing equipment, normally with the records either contained simply in file folders or in various styles of open or closed cartons. Typically, rows of records face each other across long service aisles about 30 in. (762 mm) in width. The exposed faces present a wall of paper. Paper has an ignition temperature of approximately 450°F (232°C). Where exposed files are involved, the loose ends of the papers or the edge of the file folders can be ignited almost instantly by any source ranging from a match to a faulty fluorescent ballast or by direct contact with an exposed incandescent light bulb. Because of their mass, closed cartons resist ignition slightly longer, but there is a good probability that a simple match could ignite them. Ignition of a few pieces of paper, such as might occur on a service cart, could readily ignite the faces of the boxes.

3-2.2 Initial Fire Development. Where records are stored on open-type shelving, it can be expected that fire development would occur and would approximate a typical pattern of development demonstrated in tests conducted on high-piled storage by Underwriters Laboratories Inc., Factory Mutual Research Corporation, and in tests conducted on 6-ft (1.8-m) high archives shelving arrangements by the U.S. General Services Administration. In each instance the initiating fire was small [2 lb of paper laid on the floor in the Underwriters Laboratories test, 1/2 pt (0.24 L) of heptane on cellucotton in an open carton of records in the Factory Mutual tests, and two open cartons of records on a library cart in the U.S. General Services Administration test]. The initial fire development progressed for a brief period at a low level, producing the type of fire that could be approached and easily extinguished if promptly discovered. The period of low-level development lasted between a minimum of about 3 min to a maximum of about 12 to 15 min, with the average approximately 5 min. During this period the fire was directly approachable, since heat levels were not high; however, significant quantities of smoke were produced. The temperature levels at the ceiling were sufficiently low so that it is unlikely that any heat-reacting fire detection devices would have signaled the presence of fire. In view of the relatively large smoke production, smoke detectors could have detected such a fire early in its development. In tests with 14-ft (4.3-m) open shelving, smoke detectors operated within 30 sec to 1 min, but fire was judged to be beyond portable extinguisher control in less than 3 min, providing little justification for the cost of installing smoke detection systems in this case.

3-2.3 Full Fire Development. By the end of the relatively short early development stage in each of the tests described above, a sufficient number of the exposed boxes had been preheated so that the fire development characteristics changed suddenly, the temperatures increased rapidly, and the flames enveloped large areas, extending almost immediately beyond human approach and capability of attack by simple portable extinguishers. Fire development moved rapidly from this point. In each of these cases a fire control mechanism was being tested, and the fires were not allowed to progress to their ultimate potential.

In some Factory Mutual tests, however, loose records in boxes were released by the fire and exfoliated into the aisle, providing very rapid acceleration of the fire and something approaching full fire development in a limited area, perhaps 60-70 sq ft (5.6-6.5 m^2). On the other hand, in the same test series a fire test was conducted in which all of the papers were oriented perpendicular to the aisle and stored loose on edge in shelving 14 ft (4.3 m) high. The box fronts were removed to expose the loose paper edges. Contrary to expectations, the fire developed slowly and was never beyond control of modest local forces employing small hose. Prevention of exfoliation of burning paper apparently served to avoid the dramatic increase in fire intensity.

3-2.4 Fire Severity Potential. Unless fire development is stopped by either manual or automatic fire extinguishment, the entire records storage in one room or floor could quickly become involved in fire. The extension of the fire and the extent of damage would be directly related to the total quantity of combustibles involved. The severity of a fire is approximately 1 hr for each 10 lb per sq ft (49 kg/m^2) of gross weight of combustibles involved. The weight of paper in a typical records storage area is equivalent to approximately 10 lb per sq ft (49 kg/m^2) for each shelf height of storage. A typical center with records stored 7 shelves high contains approximately 70 lb of fuel per sq ft (342 kg/m^2) of floor area, and in one where records are stored 15 shelves high, the weight of paper would approximate 150 lb per sq ft (732 kg/m^2). In either case, there are no traditional types of fire-resistive construction capable of withstanding the total impact of burnout. This is particularly important in any case where records are stored in a multistory building.

3-2.5 Inherent Fire Capacity. Any archives or records centers using open-type shelving have the inherent capability of not only self-destruction of the records holdings but also destruction of the facility itself and the neighboring operations unless all fires are stopped in their early stages.

3-3 Mobile Shelving.

3-3.1 Fire Initiation. Records facilities in which shelving is mounted on rollers, usually on tracks, are used to conserve space. One aisle is provided for a series of shelving units, and, to gain access to a particular shelf, units are moved manually or by a motor until the aisle appears at the desired shelf unit. Ignition sources are similar to those in open-type shelving but with the added potential of an ignition source from the electric drive units. Slow-developing, burrowing fires may be expected except in the exposed aisle, where a fire would be similar to that in open-type shelving.

3-3.2 Initial Fire Development. Tests conducted by Factory Mutual Research Corporation for the U.S. General Services Administration and U.S. Library of Congress indicated that fires originating in the open aisle could be expected to follow the pattern of open shelving fires in initial development and quickly involve both faces. The

length and height of mobile units is determined by available space, loaded weight, access time, and other factors. For practical reasons, 25 ft (7.6 m) is a practical limit for length. Fire spread down an open aisle with facing combustible storage is likely to be rapid. Fire spread tunneling through the shelving array is likely to be very slow, giving some opportunity for control and extinguishment by a public fire department if the fire is discovered and reported promptly.

3-3.3 Fire Severity Potential. The potential for a total burnout of a records facility is exactly the same as for a similar amount of records on open shelving, except that for a fire to spread beyond control of a municipal fire department will take considerably longer with mobile shelving.

3-3.4 Inherent Fire Capacity. Like records stored on open shelving, records stored on mobile shelving have the inherent capability to self-destruct and destroy the facility itself. Slow spread of a fire within the shelves improves the chance of outside aid being effective.

Chapter 4 Fire Control

4-1 General. The basic elements of fire control are twofold—detection of the fact that a fire exists plus its extinguishment. The individual efficiency and capability of both the detection and extinguishment actions determine the ultimate degree of safety or, conversely, the extent of damage in case of fire.

4-2 Water. Most archivists or records managers have a very significant concern about water damage. In view of the constant problems involved in leakage of domestic water systems, steam mains, rain intrusion from leaky roofs or windows, and the resultant damages from mildew or decomposition of paper, this concern is readily understood. It is important, however, for the archivist or records manager to realize that wet records can be recovered, but burned records cannot. Also, unless there is a specialized fire extinguishing system to control the development and growth of a fire, responding fire fighting forces would have no choice but to attack the fire with fire department hose streams. In many records facilities the quantity of paper fuel involved is such that the fire department would have to attack a fire from a distance and under very adverse conditions. This would normally force the department to use heavy hose streams having the characteristics of a hydraulic ram. Wide and forceful disruption of the records storage arrangement would be a normal effect of efforts to prevent total destruction.

4-3 Salvage. Recovering wet records is a problem whether the records are wet or damp as a result of a fire or from another source, such as flood, hurricane, heavy rainstorm, roof leakage, spillage from operations located above, or a breakdown of any of the numerous water or steam systems in the building. Virtually any wet paper records can be recovered, provided prompt and proper action is taken. Effective salvage requires prompt action, special techniques, facilities, and expert advice. Preplanning is essential.

NOTE: Archivists and records managers interested in pursuing this point further should obtain a copy of NFPA 910, *Recommended Practice for the Protection of Libraries and Library Collections*, which contains Appendix E on "Salvage of Wet Books," and the Federal Fire Council Recommendation Practice No. 2, "Salvaging and Restoring Records Damaged by Fire and Water," is available from the Clearinghouse, U.S. Department of Commerce, Springfield, Virginia 22151. Salvage of wet records from the 1973 fire at the Military Personnel Records Center, St. Louis, Missouri, is treated in considerable detail in the July 1974 NFPA *Fire Journal* and the October 1974 *American Archivist*. Also useful as background material is the publication *Conservation of Library Materials*, a manual and bibliography on the care, repair, and restoration of library materials by George M. and Dorothy G. Cunha (Metuchen, NJ: The Scarecrow Press, Inc., 1971; two volumes; LC #77-163871). Volume I is the manual, and Volume II is the bibliography.

4-4 Fire Extinguishers. Regardless of other types of fire extinguishment systems provided, it is essential that every records storage facility be provided with an adequate supply of well-distributed Class A portable fire extinguishers suitable for extinguishing fires in paper and plastic records. It is desirable that the type of extinguishers provided be the trigger action type in which the flow can be started and stopped by the operator. More thorough coverage of extinguishers is provided in NFPA 10, *Standard for Portable Fire Extinguishers*. Gaseous extinguishers are not effective for extinguishing deep-seated fires in paper materials. The presence of proper extinguishers would enable the working or guard force, on discovering a fire or responding to an alarm from an early warning detection system, to attack and extinguish the fire while it is small, with minimum damage to the records. It is important that such local forces are properly instructed in the use of small extinguishing appliances.

4-5 Fire Departments. The fire department is an essential part of any fire protection. The role that the fire department plays depends on the type and capabilities of an automatic extinguishment system. Where no extinguishing system is provided and total dependence is placed on the fire department for control of any fire that exceeds the capabilities of persons using hand extinguishers, it could be expected that the fire department would be forced to make a massive attack because of the size and position of the fire at the time of arrival. The actions of fire fighters are limited by their tolerance to heat and smoke. To reach the actual seat of the fire, the fire department may undertake actions disruptive or damaging to records that are not actually burning. Rows of records may block access to the seat of the fire. High density smoke may conceal the seat of the fire. To save the structure and to prevent propagation of the fire to other areas, it may be necessary for the fire fighters to disrupt the storage arrangement in unignited areas to obtain access to the ignited area or to place high-pressure hose streams in a general sweeping action, attempting to provide a general cooling/quenching effect. In any sizable records facility the

total fuel would certainly require the use of heavy hose streams (in some communities fire departments have the capability and would likely use monitor- or snorkle-type hose streams). Properly constructed fire walls (confining the fire to a single fire area) would assist a fire department in limiting the size of a fire. All of the records within the fire area would probably be seriously affected by either fire or water from the high pressure streams or both.

4-6 Role of Fire Department and Extinguishing Systems. When an automatic extinguishing system of proper design is provided, the role of the fire department changes to one of assisting and supplementing the automatic extinguishing system, rather than direct fire attack.

4-6.1 If the system is an automatic sprinkler system, the primary actions of the fire department would be to supplement the water supply, determine the proper time to discontinue the flow of water, extinguish fire in any small, shielded areas that the sprinkler system could not reach, and overhaul the actual burned areas to prevent rekindling or reignition. For additional information see NFPA 13E, *Recommendations for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems.*

4-6.2 Where a total flooding carbon dioxide or Halon 1301 system is provided and has been successful in its operation, the prime purpose of the fire department would be to vent the gas and to prevent the possibility of rekindling by wetting and removing the materials that were actually ignited. The phasing out of the carbon dioxide gas is a critical period, and, unless the smothering action has been totally effective, rekindling of a serious fire can occur. This is a very critical point and should be executed only with the full capabilities of the fire department standing in readiness.

4-6.3 If high expansion foam is used, the operation of the fire department would be to assist in removal of the foam and to extinguish any small glows (deep-seated fires) or flames that may be found as the foam is removed. Depending on the situation, it may be desirable to continue the presence of the high expansion foam for a soaking period. The period of time that the foam is kept in place, however, affects the degree of wetting. It is, therefore, desirable that overhaul procedures be carried out rapidly but cautiously, with extinguishing equipment standing by in readiness.

4-7 Fire Department Preplanning. Essential in all systems of fire control is fire department preplanning for attack in specific locations. It is important that the archivist or records manager contact the appropriate chief officer of the responding fire department and work out prefire planning arrangements. The best extinguishing system can be defeated if a fire officer, for lack of proper knowledge, makes improper use of it or prematurely removes an automatic system from operation. Conversely, lack of knowledge and a sense of caution may cause a fire officer to keep an extinguishing system in operation for an excessive period of time, increasing damage to the records from the extinguishing agent.

Chapter 5 Fire Control Systems

5-1 Detection.

5-1.1 General. In any fire control system the first step should be the detection of the presence of fire with immediate notification of emergency response forces, including the fire department. (See Section 5-5.) A number of different methods of detection are available, ranging from highly sophisticated devices for almost immediate detection of products of combustion to dependence on passers by. Detection of fire, while vitally important, does not in itself prevent fire damage. Detection must be followed by extinguishment, which includes the use of fire extinguishers or other first aid fire appliances by personnel or guards of the facility, attack by the fire department using the various manually directed appliances at its disposal, or control by automatic suppression systems, such as sprinklers, carbon dioxide, or halon. The capabilities and efficiency of each of these systems vary significantly and can also affect the extent of fire damage.

5-1.2 Human Detection Capabilities. An evaluation of the various methods of fire detection will recognize that any detection system that relies only on casual observation by persons external to the records storage is undependable, and a facility that depends upon detection by passersby is at risk of total burnout. Some record centers assign responsibility for fire detection by providing watchmen or guards around the clock or a combination of employee responsibility during the workday and watchmen or guards during the remainder of the period. While this approach is superior to dependence on casual observation, it must be considered very limited. (The major fire at the Military Records Center in St. Louis was first reported by a passerby, although the building had guard patrols.) As previously described, the period during which such observation could detect and react to a small fire situation is quite limited if, for instance, a fire were to initiate within the service aisles of the stack area. Since this is usually the most critical and damaging type of fire, it is considered to be the most necessary for early detection. Normally, guard rounds are regulated at intervals of 1 hr or more. A major fire catastrophe could develop between periods of observation of the most alert and conscientious guard. The presence of guards can be effective in peripheral situations, such as a small office fire. They also can function in fire prevention programs. They are, however, of limited value in controlling a fire in record shelving, except to call the fire department.

5-1.3 Heat Detection. Heat detection equipment, either fixed temperature or rate-of-rise, is used, at times, in records facilities. As described in Chapter 3, Fire Characteristics, these devices are not likely to respond to a fire until it has developed into its major stage. At this point, unless there is an installed automatic extinguishing system, the fire is likely to be beyond the capabilities of local forces. It may severely challenge the municipal fire department by the time they are summoned and set up operations, thereby complicating the fire fighting problems and increasing the resultant records damage. On the other

hand, if the heat-actuated detection equipment is used to operate an automatic fire control system, it could provide a very effective service.

5-1.4 Automatic Sprinkler Detection. In considering detection systems that cause the operation of an extinguishing system, it is necessary to consider briefly the detection aspects of automatic water sprinkler systems. Each automatic sprinkler is a fixed temperature device that opens (fuses) when heated to a preset temperature. When the automatic sprinkler system is equipped with a waterflow detection device, the sprinkler system becomes inherently a fixed temperature fire detection system as well as an automatic water extinguishing system. For this reason the detection of waterflow in the sprinkler system is important, and it is considered axiomatic that every sprinkler system installed in a records storage facility should be equipped with waterflow detection that activates the building fire alarm system and thus transmits the alarm.

5-1.5 Early Warning Detection. These devices, known generically as smoke detectors, respond to either the visible (smoke) or invisible (molecular size) products of combustion, or both, produced from the moment of ignition. In a properly engineered installation, these devices can detect a smoldering fire in its low energy stage. Where ignition from a smoldering fire is likely, they can give warning very early in the fire development.

5-1.5.1 Listed or approved smoke detectors include ionization type, photoelectric beam or spot type, infrared type, etc. It is possible, if the need warrants, that these early warning systems may activate associated fire extinguishing systems. These may be considered as part of the overall system in any important record collection where a smoldering fire is possible.

5-1.5.2 Total dependence on the combination of smoke detection and hand fire extinguisher attack still leaves the facility subject to a major disaster. Dependence solely on an early warning detection system exposes the facility to full fire development before effective efforts can be undertaken.

5-1.6 Locating Smoke Detectors. It is important that the system be individually engineered by competent personnel. Where the devices are used, they are installed because of the desire to obtain the earliest possible knowledge of the existence of a fire. The various types of air movements, including stratification caused by heating or other air-handling systems, as well as that provided by the records storage arrangement, are important considerations. It is best practice that the system be capable of detecting and locating the presence of fire in any portion of the records storage area within a brief period of time. While the time element specified will directly affect the cost of the system, it will also affect the extent of the damage. Generally, the shorter the time for detection, the higher the cost of the system. For further information refer to NFPA 72E, *Standard on Automatic Fire Detectors*.

5-1.7 Protective Signaling Systems. Heat and smoke detectors as described in 5-1.2, 5-1.3, 5-1.4, and 5-1.5 require a signal transmission system to report the fire to the fire department, sound the local alarm, and/or activate fire suppression systems, ventilation controls, etc., as appropriate. Installation requirements and recommendations for signaling systems are detailed in NFPA 71 and 72. Each of these systems is briefly described as follows:

(a) *Central Station Signaling Systems* (NFPA 71). This type of an alarm system directs the transmission of an emergency signal to an accredited central station. In turn, the central station will alert the public fire department. Regular testing and maintenance are normally the contractual responsibility of the central station operator.

(b) *Local Protective Signaling Systems* (NFPA 72). This type of an alarm system, though essentially designed as an evacuation building alarm for life safety purposes, is capable of providing an audible emergency signal to anyone in attendance and who may be in a position to take emergency action.

(c) *Auxiliary Protective Signaling Systems* (NFPA 72). This type of an alarm system deals with direct connection to a municipal fire alarm system (manual street fire alarm boxes) by means of an "auxiliarized" circuit to the nearest manual fire alarm station. A split responsibility exists for testing and maintenance needs between that portion of the system owned by the municipality and that which is privately owned.

(d) *Remote Station Protective Signaling Systems* (NFPA 72). This type of transmission system incorporates a direct connection, by the use of leased wire facilities, to a fire department alarm headquarters. Testing and maintenance requirements are normally the contractual responsibility of the accredited organization that provides the service.

(e) *Proprietary Protective Signaling Systems* (NFPA 72). This type of system typically exists within a single large privately owned or governmental complex of buildings. The transmission of the emergency signal is directed to a central headquarters, also similarly owned and operated and which is fully manned 24 hr per day as well as equipped to provide a permanent record of all emergency signals.

5-2 Automatic Sprinkler Systems.

5-2.1 General. The most effective fire protection element and the most economical automatic fire control system for protection of archives and records centers is the automatic wet-pipe sprinkler system. Such systems are also the most frequently opposed by records managers because of their concern with water damage. Three factors serve to dispel this reaction:

(a) Sprinklers actually constitute a method of fire control involving a minimum rather than a maximum of water.

(b) Each sprinkler operates individually and the operation of any one does not cause the operation of any other sprinkler; therefore, only those sprinklers in the heat of the fire operate and discharge water.

(c) Wet records are recoverable; burned records are not recoverable.

5-2.1.1 The probability of sprinkler operation at a time when no fire exists is insignificant.

5-2.1.2 Because of the rapid heat development in records storage areas, high temperature ratings of the sprinklers [250°F to 300°F (121°C to 149°C)] are commonly used in lieu of the ordinary rating [135°F to 170°F (57°C to 77°C)] to limit the number of sprinklers that would operate in a fire to those that must directly act in extinguishment. (*See NFPA 13, Standard for the Installation of Sprinkler Systems.*) In archival storage areas, consideration should be given to using ordinary ratings [135°F to 170°F (57°C to 77°C)] when the risks of fire development exceed the risks of water damage.

5-2.2 Waterflow Alarms. Where a records center is protected by an automatic sprinkler system, provision of a waterflow alarm that transmits a signal to the fire department on the fusing (opening) of one or more sprinklers eliminates the possibility of a sprinkler operating undetected and discharging water for a long period of time, excessively wetting the records underneath, even though it had already successfully extinguished the fire. The waterflow alarm feature, in addition to signaling the existence of a fire, will also detect the flow of water in the rare instance of accidental or malicious damage to the system.

5-2.3 Sprinkler Operation Characteristics. The sprinkler system operates only when the fire has reached the point of rapid heat rise and has passed the phase of development where hand fire extinguishment could be expected to be undertaken successfully. Both tests and fire experience have shown that sprinklers can be expected to confine the fire to a relatively small portion of the row of shelving where the fire started. The sprinkler discharge would not necessarily extinguish fire concealed under the shelves or inside mobile shelving. It would definitely slow down or prevent further fire propagation, remove the heat, and prevent further damage or collapse of the stack equipment. Thus, fire fighters entering the building could approach the seat of the fire and use small hose streams to quench the glowing or flaming areas.

5-2.4 Sprinklers—Expected Results. Under normal conditions in a sprinkler protected facility, it is probable that fire would be confined to an area of between 100 and 500 sq ft (9.3 and 46.4 m^2). Water damage would consist primarily of superficial wetting of cartons in those areas where cartons were involved or edge and bottom wetting of open file records. The areas of water damage to the degree described above would probably extend about 10 to 20 ft (3.0 to 6.1 m) to each side of the area of fire damage. The records on top of the top shelves would be the wettest; those on lower shelves would be shielded from direct impact of water and considerably drier. It is expected that total extinguishment and shutdown should take place normally before failure of the corrugated or pressboard cartons. In this respect, cartons with wire-stapled lap-joints (rather than glued) are less likely to fail. Containers that are die cut for assembly without use of glue or staples are also well-suited as protection against water damage and for avoiding possible injury and corrosion problems involved with wire staples. Boxes with handholes are more susceptible to water damage. Water discharge from the sprinklers is in the form of a fine spray and, therefore, would not disturb the position of the records storage. Fire department operations in a sprinklered facility will probably cause only minimum physical disruption. It is probable that smoke and soot damage would be minimal. Solid fiberboard (archival) boxes resist water damage to a much greater extent than corrugated cartons.

5-2.5 Sprinklers—Special Systems. There are four special types of sprinklers that lend themselves to records protection. (*For installation details refer to NFPA 13, Standard for the Installation of Sprinkler Systems.*) They are:

(a) The pre-action system is a system in which the sprinkler piping normally is dry, and the control valve opens only when the heat detection devices detect the development of a fire. As in the wet-pipe system, individual sprinklers are fused so that only those directly over the fire will operate. Although more costly than the ordinary system, it has the advantage of eliminating the discharge of water if a sprinkler or a line is accidentally or deliberately broken. It is more expensive than a wet-pipe system in that a complete detection system is required in addition to the sprinkler system. It is less reliable than a wet-pipe system in that it will not operate if the detection system is inoperative.

(b) The recycling system is an adaption of the pre-action sprinkler system with a recycling feature. When the sprinkler or sprinklers have extinguished the fire and the heat drops below a preset temperature [such as 140°F (60°C)], the detectors cause a timing cycle to start that automatically discontinues the waterflow by closing a special valve in about 5 min. The system remains in readiness, and, should the fire redevelop, it would cycle and start again. The system has the advantages of automatically determining when the temperature has decreased and of shutting the system off, making it almost impossible for maintenance personnel or others to shut the valve accidentally.

Like the pre-action system, the recycling system requires a separate detection system. Since the system is designed to recycle, the detection system must be fire resistant and thus somewhat more expensive. An advantage of the recycling system over other sprinkler systems is that if the system shuts off prematurely (fire continues or rekindles), it is reactivated automatically when the ceiling temperature increases.

(c) *On-Off Sprinkler Heads.* Sprinkler heads are available that have a recycling feature. Installed on wet-pipe sprinkler systems, each head operates individually at a predetermined temperature, but when the temperature drops below the predetermined temperature, the head shuts off. Each head works independently, on and off, depending upon the fire situation in its immediate area. No separate detection system is required. The technology of the on-off heads is relatively new, and long-term reliability data are not available.

(d) *Dry-Pipe Sprinkler Systems.* Also of interest for protection of records storage is the dry-pipe system. The sprinkler piping is filled with compressed air. The release of air pressure, as through a fused sprinkler head, allows the water valve to open and supply water to the sprinkler

piping. Each head operates independently, as do all other types in this section. Releasing air pressure through a fused sprinkler head takes appreciable time, during which the fire may grow and open additional sprinkler heads. Dry-pipe sprinkler systems are used primarily for protection of unheated areas where freezing may occur.

5-3 High Expansion Foam.

5-3.1 General. High expansion foam is a total flooding medium, meaning that it inundates the protected space with the extinguishing agent. The foam surrounds all the materials within the protected area with an aggregate of bubbles, each of which carries a small amount of water. The characteristics of high expansion foam are more extensively covered in NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*.

In tests conducted by the U.S. Atomic Energy Commission involving records media, high expansion foam extinguished test fires quickly and easily by filling the entire volume of the storage space. The degree of wetting was low; generally it did not penetrate normal corrugated fiberboard cartons. (Cartons with stapled or interlocking edges tend to hold up quite well, while cartons with glued edges tend to come apart and expose the records contents to foam. Identification labels tend to slip off.)

However, after exposure to the foam it was found necessary to take corrective drying action on all the materials within the area contacted by the foam.

NOTE: Data on these tests are published in an Atomic Energy Commission report, "High Expansion Foam Fire Control for Records Storage Center," IDO-12050, March 1966. Available from the Clearinghouse, U.S. Department of Commerce, Springfield, VA 22157. See also Beers, R.J., "High Expansion Foam Fire Control for Record Storage," *Fire Technology*, Vol. 2, No. 2, May 1966, pp. 108-117.

5-3.2 Design of High Expansion Foam System. NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, states the minimum requirements and design of systems that would provide adequate protection. There are three types of high expansion foam systems available: total flooding systems, local application systems, and portable foam application devices. For the purposes of this manual, total flooding systems are most applicable. Total flooding involves filling the storage space with foam to a level above the combustible material.

Total flooding systems require maintenance of sufficient foam to submerge the hazard, length of time of coverage of the hazard, and minimum rate of discharge to compensate for breakdown of foam by sprinkler discharge, shrinkage, fire, and other factors. High expansion foam systems require venting, closure of openings through which foam would escape, and maintenance of foam to cover the hazard to ensure control and extinguishment of fires. The rate of application of high expansion foam is high, and a large vent area is needed for the displaced air. Automatic activation of the system is by a heat detection system similar to that discussed for other systems.

5-4 Gaseous Extinguishment.

5-4.1 General. Extinguishment by total flooding with gas is favored by many archivists and records managers on the basis that, if no water is applied to a fire, no water damage occurs, and salvage problems are simplified. Two principal gases for this application are Halon 1301 and carbon dioxide. Total flooding involves filling the entire protected volume with a specific concentration of gas.

5-4.2 Halon 1301 Gas Systems. While water-based agents depend on cooling and quenching, and carbon dioxide depends primarily on oxygen-exclusion, Halon 1301 inhibits burning by chemically interacting with the flame radical. Halon 1301 (bromotrifluoromethane) is a liquefied gas under pressure, which is an effective flame-inhibitor while at the same time exhibiting low toxic and corrosive properties. Design is covered by NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*. Use of this agent for total flooding applications in records storage facilities has been limited, and installation should be attempted only with expert guidance.

Halon 1301, being a flame inhibitor, is not effective at normal concentrations against smoldering fire. In a records storage facility, it is important that application be undertaken as early as possible in the fire, before it becomes deep-seated. To be effective, it is also important that the system be automatic, total flooding, and employ a properly responsive detection system. It is essential that means be provided to contain the gas without significant leakage for an extended period of time. Halon 1301 systems are relatively expensive, and most installations have been limited to protection of high value collections in modest-sized spaces [less than 50,000 cu ft (1416 m^3)]. Total extinguishment by Halon 1301 of a fire in Class A (paper) storage is not likely because of establishment of smoldering. Prevention of flaming fire pending arrival of the municipal fire department may be adequate. Rapid fire growth would be inhibited in the interim. The fire department would be expected to use water to complete the extinguishment, possibly in conditions of low visibility. Many installations sound an evacuation alarm prior to gas discharge to avoid having occupants breathe halon or halon decomposition products. Use of Halon 1301 is not recommended for ordinary record centers or archive facilities but may be appropriate for protection of isolated smaller collections and high intrinsic value records.

5-4.3 Carbon Dioxide Systems.

5-4.3.1 General. Fire extinguishment can be accomplished by a total flooding carbon dioxide system with a soaking period. The design and proper installation of such a system is critical. (*The basic reference in this area is NFPA 12, Standard on Carbon Dioxide Extinguishing Systems.*)

5-4.3.2 Systems for record storage protection are designed to provide a concentration of 65 percent in the protected space, to control stratification, and to maintain soaking for 30 min. Openings not required for pressure venting must be closed at the time of discharge to avoid loss of carbon dioxide during the soaking period. Under-

designed carbon dioxide systems are subject to failure at the time of fire. Proper performance can only be assured by actual testing to make sure that the design concentration will be achieved and maintained for the full soaking period.

5-4.3.3 Since atmospheres containing fire extinguishing concentrations of carbon dioxide will not sustain life, it could be fatal to be trapped in the flooded space. Ample warning and time delay must be given prior to discharge to allow occupants to escape from the area to be flooded. A person could not safely leave the area after the discharge starts. Provision is made for exhausting the atmosphere after the soaking period without creating a hazardous atmosphere in another location.

5-4.3.4 For effective fire control, the activation of the carbon dioxide system should be automatic in response to fire, triggered by a properly designed and installed heat detection system.

5-4.3.5 Discharge of carbon dioxide may cause condensation of humidity (fogging), which can obstruct vision.

5-5 Comparisons of Extinguishing Systems.

5-5.1 There are a number of factors involved in comparing extinguishing systems. Original cost, reliability, cost of agent, susceptibility to false operation, area of application, damage to records by fire and by extinguishing agent, and consequences of failure are all important factors for consideration. All automatic systems are damage-initiated; a fire must be established that causes damage before an automatic system detects and reacts. Generally, the smaller the fire a system will detect, the more sensitive it is and the more subject it is to false operation. It is important that the alarms for all systems be connected to the municipal fire department so that it is notified of a fire when the system activates.

5-5.2 Automatic sprinklers are the most reliable and economic means of controlling fire in a records center. Wet-pipe sprinklers with hydraulically designed piping, adequate water supply, and supervised valves are reliable and trouble-free. Cyclic systems, pre-action systems, and dry-pipe systems, provided for assurance against water damage, introduce failure potentials in the system and can slow system functioning in a fire and result in a larger fire to extinguish. In a fire, only sprinklers in the immediate vicinity of the fire are activated. In the Factory Mutual full-scale test series, with sprinklers located as unfavorably as possible, the three tests opened 6, 16, and 3 sprinklers, respectively. This covered 600, 1600, and 300 sq ft (56, 149, and 28 m^2) out of an installed array of 77 heads that represented a facility having approximately 400 heads. In these tests, as in most records fires, whatever the extinguishment means, final extinguishment was by hoseline. All of the records wetted but not burned were recoverable.

5-5.3 Detectors are available that will react to a spark, but the most sensitive used in a records center is a smoke detector. Where used for discharging agent, it is usually desensitized by requiring two detectors on alternate circuits to react prior to agent discharge. Although smoke detectors react promptly when exposed to smoke, a smoldering fire does not have the "lift" to carry smoke to a high ceiling, and detectors generally react to a smoldering fire after a long period by process of diffusion. A strong heat column from a brisk flaming fire will cause a smoke detector to operate promptly, but heat detectors, including sprinklers, also react quickly to this type of fire. Full-scale fire tests showed little advance warning in flaming fires in a records center by smoke detectors.

Detectors are of value only to initiate extinguishment and life safety warnings. To initiate manual extinguishment by local forces is advantageous in that an incipient fire may be discovered and extinguished with minimal damage by employees using extinguishers or hand hose. If fire is more than incipient, employees are at hazard because of lack of experience, breathing equipment, and protective gear. A municipal fire department is much better equipped for manual fire fighting with protective gear, heavy hose streams, and broad experience. The times required for discovery, reporting, travel, and setup may result in an established fire beyond manual control by municipal forces, as occurred in the unsprinklered Military Personnel Records Center fire and many other fires in records centers.

5-5.4 Gaseous extinguishment has the potential for least damage if all elements perform as designed. Automatic operation of the system and automatic closure of leakage openings is essential to the success of these systems. Neither halon nor carbon dioxide can be expected to extinguish a deep-seated fire condition that would occur if an archives or records center fire were allowed to become well-developed before application of the extinguishing gas. Gas leakage through a blocked-open door, a temporary opening, or a fire-caused breach could also result in a failure. Gas extinguishing systems, using more sensitive detectors, are used mainly on incipient fires to minimize damage and because the larger the fire, the less assured is extinguishment. Using more sensitive detection results in more false operations, which are undesirable because of the high cost of agent and because of hazards to personnel. All materials in the enclosure are equally treated by the gas, whether near the fire or away from the fire. Final extinguishment is usually performed by the fire department using hose streams. If the area is obscured by smoke, which is likely, directing hose streams may be haphazard and result in widespread water damage.

5-5.5 Automatic high expansion foam has the capacity to overcome a well-established fire and in this factor is much superior to gaseous extinguishment and better than sprinklers. Like gaseous extinguishment, high expansion foam will escape through unclosed openings, although a very lightweight partition such as fine mesh screen will contain it. Also, like gas, all materials in the enclosure are equally exposed to the extinguishing agent. As the foam will dampen kraft boxes (and perhaps loosen identification labels), all materials in the enclosure are damaged slightly and must be dried. Final extinguishment by fire department hose streams will probably be required.

5-6 Installation and Maintenance of Systems and Equipment. To provide reasonable assurance that a fire detection control system, appliance, or device will perform satisfactorily, it is necessary that the installation be in compliance with the recognized standards, the manufacturer's instructions, and that complete operational tests be conducted.

After installation, it is important that a complete routine scheduled maintenance program that follows recognized standards and manufacturer's instructions be developed and adhered to. This may be performed either by competent maintenance employees or by service contractors.

Chapter 6 Construction

6-1 General Principles for New Construction.

6-1.1 The more important general principles for firesafe records center and archives construction are set forth below. Detailed recommendations for good practice are also contained in various NFPA publications. In most localities building codes and ordinances will govern to a large extent the type of construction to be used.

Codes frequently provide for the safety of persons in the building but not for the preservation of the building or the collections. Therefore, it is of critical importance at the conception of the project for the records custodian to specify the level of firesafety to be achieved in the construction. For single story, aboveground facilities, consideration should be given to including a clause in the professional service contract(s) for the design of the project that requires retaining and providing the consultant services of a qualified fire protection engineer, acceptable to the records custodian, to participate in the development of the firesafety system, including the determination of the requirements in the final project documentation. For multistory or below-grade facilities, the services of a qualified fire protection engineer are essential.

6-1.2 Design of the automatic sprinkler protection and other fire protection and detection systems and building construction are interrelated. In addition to protecting combustible contents and providing improved safety to life, automatic fire suppression systems may in some cases enable use of less expensive construction than would be possible without them. Properly designed automatic sprinkler systems in all areas of an archives or records center are mandatory.

6-1.3 For records center and archives construction, it is desirable to select materials and types of construction that are either noncombustible or that have resistance to fire. Fire-resistive construction is desirable and for multistory structures is essential. Fire-resistive construction is defined in NFPA 220, *Standard for Types of Building Construction*, and requires structural members, including walls, partitions, columns, floor, and roof construction to be of noncombustible materials and have fire-resistance ratings from 2 to 4 hr, depending on the structural members.

6-1.3.1 Columns within shelving are potentially exposed to high temperatures exceeding the fire resistivity of steel. Therefore, building columns within the records storage area should be 2-hr construction from the floor to the point where they meet the roof-forming system.

6-1.3.2 Standard sprinklers may not protect light-weight roof structures (such as bar joists) in the early fire development. Quick-acting sprinklers may avoid this problem.

6-1.4 The contents of an archive, or even a records center, are valuable, sometimes of very high value or even irreplaceable, but always combustible. Therefore, every effort should be made to construct the building so that it will resist the spread of fire. This means that during a fire the walls, roof, floor, columns, and partitions should prevent the passage of flame, smoke, or excessive heat and continue to support their loads. "Fire resistant" is not the same as "noncombustible." A noncombustible structure may not keep a fire from spreading because some materials that will not burn lose their strength when exposed to intense heat. This might cause walls or floors to collapse. Many types of construction using various building materials have been tested and rated according to the length of time they will resist fire. The duration of the resistance needed by the archive or records center depends on the amount of combustible material in the contents of each room as well as the structure itself. Different structural assemblies have fire resistances ranging from less than 1 to more than 6 hr.

NOTE: NFPA 220, *Standard on Types of Building Construction*, classifies and defines various kinds of building construction. The Building Materials List published by Underwriters Laboratories Inc., under the heading "Fire Resistance Classification," gives information on structural assemblies that have been tested in accordance with NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

6-1.5 It is unwise to construct records centers and archives of materials that will contribute fuel to a fire and that, by the nature of the construction, create combustible concealed spaces. Voids between a ceiling and the floor above are good examples of concealed spaces through which fire can spread rapidly and where access for fire fighting is difficult.

6-1.6 The term "compartmentation" in fire prevention is used to mean the subdivision of a building into relatively small areas so that fire or smoke may be confined to the room or section in which it originates. This principle can be applied to records centers and archives without restricting the flexibility of arrangement of stack areas or the flow of visitors. Compartmentation requires fire-resistive wall and floor construction, with openings provided with self-closing or automatic fire doors having specific fire-resistive ratings. A major records keeper limits records center storage in a single fire subdivision to about 40,000 sq ft (3720 m^2) and archives storage in a single fire subdivision to 25,000 sq ft (2325 m^2). Offices, research rooms, and other support facilities should always be separated from the records storage areas by a properly rated fire-resistive wall.

In a similar way, properly enclosed stairways equipped with fire doors will prevent the spread of fire, smoke, and heat from one level to another. Elevator shafts, dumbwaiters, and all other vertical openings through the structure should also be safeguarded. Air-handling systems

(ventilation, heating, and cooling) should be constructed and equipped to prevent the passage of smoke, heat, and fire from one fire area to another or from one level to another as provided in NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

6-1.7 Some architects have designed facilities that are underground, or largely so, or are windowless, or which are completely ventilated by mechanical means. While these types of construction have advantages in controlling temperatures, humidity, and air pollution, they do create problems for fire extinguishment and life safety in event of fire. These problems are greatly magnified if loss of power impairs ventilating systems. Alternative means for permitting the escape of heat and smoke should be provided; adequate roof ventilation is particularly essential as heated gases and smoke tend to rise. Provisions should be made for the safe emergency evacuation of people as well as for access by the fire department to the fire area. "Knockout" panels located to permit direct access to well maintained aisleways within the structure are invaluable for this purpose. Fire department officials should be consulted and should have knowledge of these to avoid unnecessary breaching of walls in the case of fire. Automatic sprinklers are essential in these types of buildings and are recommended. Smoke detection systems can provide critically important early detection to activate a smoke control system and give early warning to occupants.

NOTE: See NFPA *101, Life Safety Code,*® Chapter 30, for guidance in providing life safety measures for underground structures and windowless buildings.

6-1.8 Consideration should be given to the proper selection of interior finishes and furnishings. Highly flammable wall and ceiling finishes should be avoided. NFPA *101, Life Safety Code*, and most building codes specify minimum requirements for interior finish materials. Draperies, where used, should be noncombustible.

6-2 Records Storage Areas.

6-2.1 Fuel loads in records storage areas may range from 30 lb per sq ft (146 kg/m^2) to hundreds of lb per sq ft (approximately 1000 kg/m^2) with corresponding fire durations of more than commonly used building construction can withstand. Furthermore, the higher fuel loading in records storage areas may result in fire durations that more nearly resemble those in warehouse occupancies than those found in business occupancies. Observations on the Military Personnel Records Center fire in St. Louis in 1973 indicate that a fire in a lower floor of a multistory building with sprinklers not installed, shut off, or inadequately designed will result in total loss of the building, no matter how it is subdivided, unless the fire load is less than the structural fire resistance. There is no recognized construction that will support a building above an uncontrolled archives or records center fire.

6-2.2 In some archives and records centers the part of the building used to house records is only a shell. The metal stacks are self-supporting and extend through several floor levels of the building. The stack floors are merely platforms that provide a walkway through the stacks. This results in slot-like openings between the stacks and the walkways, permitting a rapid, uninterrupted upward flow of air, heat, smoke, and flames. In new records centers and archives, or in major renovations of existing structures, these types of stacks should be avoided. Floors should be of conventional building construction with appropriate fire-resistive ratings and the shelves installed thereon as ordinary furniture.

6-2.3 In records storage areas where high-rise, self-supporting stacks are used, special attention should be given to fire protection as follows:

(a) The most efficient automatic fire detection available, together with suitable reporting means, should be provided;

(b) Complete automatic sprinkler protection should be provided, including waterflow alarms; and

(c) A plan of action should be worked out in advance with the fire department, to determine the best means of gaining access to the stacks, of venting smoke, and of reaching and fighting a stack fire at its source.

6-2.4 The practice of mounting records storage shelves on tracks is now appearing in new records center and archives construction and renovations as an application of modern warehousing technology (compact storage). This practice results in high fire load density that can lead to a fire that will threaten even the strongest code-prescribed fire barriers and construction e.g., cause structural collapse. Without sprinkler protection for compact storage, fire endurance may exceed the resistance of fire compartment walls and the ability of the fire service to control it. Automatic sprinklers should be mandatory.

Associated fire protection problems that require consideration include the following:

(a) Existing automatic fire detection and fire suppressant systems may have to be modified.

(b) Compact storage modules may conceal the origin of smoke, compounding the difficulty of locating and extinguishing the fire.

(c) Compact storage modules prevent penetration of water from hose streams for fire extinguishment.

Proper engineering can effectively solve these problems

NOTE: See page 11-73 of the NFPA *Fire Protection Handbook* (16th Edition) for a discussion of fire protection in compact storage. Underwriters Laboratories Inc. conducted additional tests on August 29 and 31, 1989. Published results of these tests are available from the National Archives and Records Administration (NAFS), Washington, DC 20408.

6-2.5 Service Aisles. Otherwise dead-end service aisles should be terminated at least 18 in. (458 mm) from the wall to prevent entrapment by fire.

6-3 Protection Against Outside Exposure Fires.

6-3.1 Outside fires present an exposure hazard. Clear space provides optimum protection. If sufficient clear space cannot be provided, the exterior walls of the records

center or archives facing adjacent buildings should be of masonry or other adequately fire-resistive construction without doors, windows, or other openings. Where openings in an exposed wall are necessary, provision should be made to prevent heat or flames from a nearby fire being transmitted through them. Such protection includes fire windows with wired glass, fire doors, outside sprinklers, fire shutters, or a combination of these. Combustible roof coverings, window frames, and eaves may add to the hazard from an exposure fire and should be given special consideration in planning fire protection.

6-3.2 The requirements for protection from exposure fires are determined by the distance from neighboring buildings and the comparative hazards of their occupancies, e.g., residence, factory, office building, etc. With so many variables, the records center or archives need to consider the risk of fire spreading from neighboring occupancies -- whether in other buildings or in the same building as the records center or archives (e.g., universities, museums, and other institutions). Determining the severity of such exposures is a matter of judgment based on the factors contributing to the hazard of radiant and convected heat.

NOTE: See NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, for further guidance.

Chapter 7 Building Equipment and Facilities

7-1 Heating Systems.

7-1.1 A major potential source of fires is malfunction of heating equipment. For this reason, boilers and furnaces of central heating systems should be cut off from the remainder of the structure by rated fire walls or separations.

7-1.2 Oil- and gas-fired heating equipment, piping, and fuel oil storage facilities should be installed and maintained in accordance with the requirements of recognized safe practices. Heating equipment should be inspected and serviced at least annually by qualified personnel or a service contractor. All heating units should have safety devices appropriate for the particular type of installation. Combustibles, such as paper, wood, and textiles, should be kept away from the steam or other heat piping and ducts.

7-1.3 Open-flame (gas and oil) space heaters are not compatible with storage of archives and valuable records and should be avoided whenever possible. Piping of fuel should be avoided in the vicinity of records storage areas.

7-1.4 The requirements for safety and fire protection where gas is used as fuel for heating are found in NFPA 54, *National Fuel Gas Code*. Requirements for use of liquefied petroleum gas as fuel may be found in NFPA 58, *Storage and Handling of Liquefied Petroleum Gases*. NFPA 31, *Oil Burning Equipment*, contains requirements to follow in the installation of oil burners and equipment used with them. The previously mentioned NFPA 90A, *Air Conditioning and Ventilating Systems*, contains requirements applying to air duct systems used for heating and ventilating. All these standards prescribe reasonable provisions for safety of life and property from fire.

7-2 Electrical Systems.

7-2.1 Installation and modifications to provide for the changing needs of the records center or archives including lighting, TV, sound systems, shop machinery, and appliances should be made by licensed or qualified electricians in conformity with NFPA 70, *National Electrical Code*.® The equipment should be listed.

7-2.2 Light Fixtures. Narrow aisle spaces [approximately 30 in. (800 mm)] mandate a limitation on the width of suspended continuous lighting fixtures because they can limit sprinkler penetration into the aisle. It has been shown that a 9-in. (230-mm) fixture in a 30-in. (800-mm) aisle will not materially interfere with water spray from a conventional sprinkler. "Large drop" sprinklers have not been tested against this obstacle. Lights tight against the ceiling can be arranged not to interfere with sprinkler distribution.

7-3 Means of Egress.

7-3.1 It is imperative that security measures not impede the safe emergency evacuation of visitors and employees. Attendance can vary greatly with the time of year, exhibits, and other special events. Therefore, in planning the capacity of exits, serious consideration should be given to the maximum number of people who might be expected to be in the building at any given time. NFPA *101, Life Safety Code*, contains information on construction, protection, and occupancy features designed to minimize danger to life from fire, smoke, fumes, and panic before buildings are vacated. The *Life Safety Code* is the basis for legal requirements governing exit facilities in many government jurisdictions and should be consulted in planning life safety measures for a records center or archives.

7-3.2 Locking Devices. It is common for records centers and archives security measures to funnel all occupants through a few exits that can be closely monitored. Unfortunately, this often means that other doors required for egress are locked in violation of the *Life Safety Code*.

The 1991 edition of the *Life Safety Code* includes equivalency concepts that allow the authority having jurisdiction to permit locking systems on these doors provided that they afford an equivalent level of life safety to that prescribed in the Code. There are electromechanical and electromagnetic locking devices available that can satisfy this requirement when installed in a properly designed system. Some of these systems provide an appropriate time delay before opening. Hydraulic and pneumatic devices are available that may meet this requirement. A properly designed system should address the following considerations:

(a) Any failure of the device or the system should cause the system to fail open (unlocked).

(b) Sprinkler system operation should cause the system to unlock in the fire zone of origin.

(c) Fire alarms in the building should cause the system to unlock.

1. A manual fire alarm box should be provided at each exit egress door controlled by the system that leads directly outside the building.

2. A sign should be placed on each required exit door stating that the door will unlock in a 15- to 30-sec period upon pushing the panic bar or when the fire alarm sounds. Letters used in the sign should be 1½ in. (38 mm) high with ¼ in. (6 mm) stroke.

(d) Smoke detection should cause the system to unlock.

(e) Conduct a daily functional test protocol with specific assignment of responsibility for conducting it.

NOTE: Use of these security devices or systems in combination with panic hardware maintains protection against unauthorized ingress while the system is unlocked for egress.

7-4 Air Conditioning and Ventilation Systems. Central air conditioning equipment should be located and installed in a manner that will not increase fire hazards to records center or archives visitors or collections. Air conditioning ducts should be equipped with automatic fire dampers and fan shutoffs as set forth in NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

7-5 Lightning Protection. Lightning is always a possible fire hazard, more so in some areas or locations than in others. Lightning protection can be more effectively and economically incorporated in the course of new construction than as an afterthought. NFPA 78, *Lightning Protection Code*, prescribes methods of protecting buildings from damage by lightning.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this manual and should be considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1990 edition

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1988 edition

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1989 edition

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 1989 edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1989 edition

NFPA 13E, *Recommendations for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, 1989 edition

NFPA 31, *Standard for the Installation of Oil Burning Equipment*, 1987 edition

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*, 1988 edition

NFPA 54, *National Fuel Gas Code*, 1988 edition

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1989 edition

NFPA 70, *National Electrical Code*, 1990 edition

NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*, 1989 edition

NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*, 1990 edition

NFPA 72E, *Standard on Automatic Fire Detectors*, 1990 edition

NFPA 78, *Lightning Protection Code*, 1989 edition

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 1987 edition

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1989 edition

NFPA *101*, *Life Safety Code*, 1991 edition

NFPA 220, *Standard on Types of Building Construction*, 1985 edition

NFPA 232, *Standard for the Protection of Records*, 1991 edition

NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*, 1990 edition

NFPA 910, *Recommended Practice for the Protection of Libraries and Library Collections*, 1985 edition

NFPA *Fire Protection Handbook*, 1986 (16th Edition)

Appendix A

This Appendix is not a part of the recommendations of this NFPA document, but is included for information purposes only.

Many members of the Society of Fire Protection Engineers are involved in the consulting phase of the fire protection engineering profession. They are employed by consulting organizations or in many cases head their own firms. The services offered vary depending upon the particular expertise of the firm. To obtain the names of consulting firms in a particular geographic area, contact the Executive Director, Society of Fire Protection Engineers, 60 Batterymarch Street, Boston, MA 02110. Telephone (617) 482-0686.

Appendix B Salvage of Water-Damaged Library Materials

This Appendix is not a part of the recommendations of this NFPA document, but is included for information purposes only.

The following material is extracted from *Procedures for Salvage of Water-Damaged Library Materials* by Peter Waters, Restoration Officer, Library of Congress, 1975 (an LC Publication on Conservation of Library Materials). Although it is directed to the recovery of water-damaged books, many of the procedures, warnings, and structures also apply to other types of records and archival material.

The reader will find additional references in Appendix C: Referenced Publications and Informational Publications.

Assessment of Damage and Planning for Salvage

Weather is the critical factor in determining which course to take after any flood or fire in which museum, archival, or library materials are damaged. When it is hot and humid, salvage must be initiated with a minimum of delay to prevent or control the growth of mold. When the weather is cold, more time can be taken to plan salvage operations and experiment with various drying procedures.

The first step is to establish the character and degree of damage. Once an accurate assessment of the damage has been made, firm priorities and plans for salvaging the damaged materials can be drawn up. These plans must include a determination of the special facilities and equipment required. Overcautious, unrealistic, or inadequate appraisals of damage can result in the loss of valuable materials. Speed is of the utmost importance, but careful planning is equally essential in the salvage effort.

Where water damage has resulted from fire fighting measures, cooperation with the fire marshal is vital for a realistic appraisal of the feasibility of salvage efforts. Fire marshals and safety personnel will decide when a damaged building is safe to enter. In some cases, areas involved in the fire may require a week or longer before they are cool enough to be entered. Occasionally, parts of a collection may be identified early in the salvage planning effort as being especially vulnerable to destruction unless they receive attention within a few hours after the fire has abated. If the fire marshal appreciates such needs, it may be possible to provide means of access to the area even when other parts of the building remain hazardous.

Once all entrances and aisles are cleared, the most important collections, including rare materials and those of permanent research value, should be salvaged first, unless other materials would be more severely damaged by prolonged immersion in water. Examples of the latter are books printed on paper of types widely produced between 1880 and 1946, now brittle or semibrittle. However, materials in this category that can be replaced should be left until last.

Salvage operations must be planned so that the environment of flooded areas can be stabilized and controlled both before and during the removal of the damaged materials. In warm, humid weather, mold growth may be expected to appear in a water-damaged area within 48 hr. In any weather, mold will appear within 48 hr in unventilated areas made warm and humid by recent fire in adjacent parts of the building. For this reason, every effort should be made to reduce high temperatures and vent the areas as soon as the water has receded or been pumped out. Water-soaked materials must be kept as cool as possible by good air circulation until they can be stabilized. To leave such materials more than 48 hr in temperatures above 70°F (21°C) and humidity above 70 percent will almost certainly result in heavy mold growth and lead to high restoration costs.

Damaged most by these conditions are volumes printed on coated stock and such highly proteinaceous materials as leather and vellum bindings. Starch-impregnated cloths, glues, adhesives, and starch pastes are affected to a lesser degree. As long as books are tightly shelved, mold will develop only on the outer edges of the bindings. Thus no attempt should be made in these conditions to separate books and fan them open. Archival files packed closely together on the shelves in cardboard boxes or in metal file cabinets are the least affected.

As a general rule, damp books located in warm and humid areas without ventilation will be subject to rapid mold growth. Archival files that have not been disturbed will not be attacked as quickly by mold. Very wet materials, or those still under water, will not develop mold. As they begin to dry after removal from the water, however, both the bindings and the edges of books will be quickly attacked by mold, especially when in warm, unventilated areas. A different problem exists for books printed on coated stock, since if they are allowed to dry in this condition, the leaves will be permanently fused together.

Summary of Emergency Procedures

1. It is imperative to seek the advice and help of trained conservators with experience in salvaging water-damaged materials as soon as possible. The Library of Congress is an excellent information source for technical advice where needed. Contact: Preservation Office, Library of Congress, Washington, DC, Telephone (202) 287-5212.

2. Turn off heat and create free circulation of air.

3. Keep fans and air conditioning on at night, except when a fungicidal fogging operation is in process because a constant flow of air is necessary to reduce the threat of mold.

4. Brief each worker carefully before salvage operations begin, giving full information on the dangers of proceeding except as directed. Emphasize the seriousness of timing and the priorities and aims of the whole operation. Instruct workers on means of recognizing manuscripts, materials with water-soluble components, leather and vellum bindings, materials printed on coated paper stock, and photographic materials.

5. Do not allow workers to attempt restoration of any items on site. (This was a common error in the first ten days after the Florence flood, when rare and valuable leather- and vellum-bound volumes were subjected to scrubbing and processing to remove mud. This resulted in driving mud into the interstices of leather, vellum, cloth, and paper; caused extensive damage to the volumes; and made the later work of restoration more difficult, time consuming, and extremely costly.)

6. Carry out all cleaning operations, whether outside the building or in controlled environment rooms, by washing gently with fresh, cold running water and soft cellulose sponges to aid in the release of mud and filth. Use sponges with a dabbing motion; do not rub. These instructions do not apply to materials with water soluble components. Such materials should be frozen as quickly as possible.

7. Do not attempt to open a wet book. (Wet paper is very weak and will tear at a touch.) Hold a book firmly closed when cleaning, especially when washing or sponging. A closed book is highly resistant to impregnation and damage.

8. Do not attempt to separate single-sheet materials unless they are supported on polyester film or fabric.

9. Do not attempt to remove all mud by sponging. Mud is best removed from clothes when dry; this is also true of library materials.

10. Do not remove covers from books, as they will help to support the books during drying. When partially dry, books may be hung over nylon lines to finish drying. Do not hang books from lines while they are very wet because the weight will cause damage to the inside folds of the sections.

11. Do not press books and documents mechanically when they are water soaked. This can force mud into the paper and subject the materials to stresses that will damage their structures.

12. Use soft pencils for making notes on slips of paper, but do not attempt to write on wet paper or other artifacts.

13. Clean, white blotter paper, white paper towels, strong toilet paper, and unprinted newsprint paper may be used for interleaving in the drying process. When nothing better is available, all but the color sections of printed newspapers may be used. Great care must be taken to avoid rubbing the inked surface of the newspaper over the material being dried; otherwise some offsetting of the ink may occur.

14. Under no circumstances should newly dried materials be packed in boxes and left without attention for more than a few days.

15. Do not use bleaches, detergents, water-soluble fungicides, wire staples, paper or bulldog clips, adhesive tape, or adhesives of any kind. Never use felt-tipped fiber or ballpoint pens or any marking device on wet paper. Never use colored blotting paper or colored paper of any kind to dry books and other documents.

Appendix C Referenced Publications and Informational Publications

C-1 The following documents or portions thereof are referenced within this manual for informational purposes only and thus are not considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

Bryan, John L. *Automatic Sprinkler and Standpipe Systems.* Quincy: National Fire Protection Association, 1990, illus., bibliography.

This book is a detailed study of the functioning, engineering, and application of a variety of fire suppression systems utilizing water as the extinguishing agent.

Custer, Richard L. P. and R. G. Bright. *Fire Detection: The State-of-the-Art.* NBS Technical Not 839. Washington, DC: National Bureau of Standards, U.S. Dept. of Commerce, June 1974, 110 pp., illus., bibliography.

Federal Fire Council Recommended Practice No. 2 (see page 8). (See also page 16.)

Morris, John. *Managing the Library Fire Risk.* Berkeley: University of California Office of Insurance and Risk Management, 1975, 99 pp.

Investigates various aspects of fire prevention and control, with emphasis on the value of automatic fire protection systems. Contains descriptions of several library fires and a chapter on the salvage of wet books. Includes photos, chapter bibliographies, and articles reprinted from fire journals.

Advisory Committee on the Protection of Archives and Records Centers. *Protecting Federal Records Centers and Archives From Fire.* Washington, DC: General Services Administration, April 1977, 202 pp., illus., bibliography.

Following the disastrous fire in the Military Personnel Records Center in Overland, Missouri in July 1973, GSA appointed a committee to review the present state-of-the-art in records protection and to make recommendations on improved fire protection practices for federal archives and records centers. This book is the report of that committee.

Waters, Peter. *Procedures for Salvage of Water-Damaged Library Materials.* Washington, DC: The Library of Congress, 1975, 30 pp.

The most comprehensive and up-to-date manual on the salvage of water-damaged materials. Also contains a list of individuals to contact for professional advice and sources for supplies, equipment, and services. Emphasis is placed on having a plan of action before the emergency occurs. Free from Library of Congress.

Willman, Spawn, "After the Water Comes," PLA Bulletin, Pennsylvania Library Association, Vol. 28, No. 6 (November 1973), pp 243-251.

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