ANSI/NFPA 801 An American National Standard December 10, 1985

NFPA 801 Facilities Handling Radioactive Materials 1986

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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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.

Statement on NFPA Procedures

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MGR-FM-85

NFPA 801

Recommended Fire Protection Practice for

Facilities Handling Radioactive Materials

1986 Edition

This edition of NFPA 801, *Recommended Fire Protection Practice for Facilities Handling Radioactive Materials,* was prepared by the Technical Committee on Atomic Energy, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 18-20, 1985 in Baltimore, Maryland. It was issued by the Standards Council on December 10, 1985, with an effective date of December 30, 1985, and supersedes all previous editions.

The 1986 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 801

The Committee on Atomic Energy was organized in 1953 for the purpose of providing the fire protection specialist with certain fundamental information about radioactive materials and their handling, and to provide designers and operators of such laboratories with some guidance on practices necessary for fire safety. The first edition of NFPA 801, whose coverage was limited to laboratories handling radioactive materials, was adopted at the 1955 NFPA Annual Meeting.

In 1970 the format was revised, and it was updated to reflect current thinking and practices. It was also expanded to apply to all locations, exclusive of nuclear reactors, where radioactive materials are stored, handled, or used.

The 1975 edition was a reconfirmation of the 1970 edition with editorial changes.

The 1980 edition included a clarified statement regarding the presence of and levels of radiation; cautionary statements about the assumption of risks by the fire officer and the importance of training in the handling of radioactive materials by fire department personnel; a clarification concerning the variations of the intensity of a radiation field; and a restyling of the document to conform with the NFPA Manual of Style.

The 1985 edition revises and updates previous material for clarification in recognition of technology and terminology changes.

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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.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Contents

NFPA 801

Recommended Fire Protection Practice for

Facilities Handling Radioactive Materials

1986 Edition

Information on referenced publications can be found in Chapter 7.

Chapter 1 Introduction

1-1 Scope. This text deals with practices aimed at reducing the risks of fires and explosions at facilities handling radioactive materials and also with certain methods for minimizing personnel hazards and property damage by radioactive contamination resulting from fire or explosion. The recommendations are applicable to all locations, exclusive of nuclear research or power reactors, where radioactive materials may be stored, handled or used, including hospitals, laboratories, and industrial properties.

1-2 Purpose. The nature of radioactive materials is such that their involvement in fires or explosions can act to impede the efficiency of fire fighting personnel, thus resulting in increased potential for damage by radioactive contamination.

This text is prepared to provide an outline for the fire protection specialist, including fire service personnel, of basic information concerning radiation protection methods, and provides some guidance on fire protection practices to those persons responsible for the design or operation of facilities which involve the storage, handling, or use of radioactive materials.

Additional specific requirements for nuclear reactors are delineated in NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power Plants*; and recommendations for research reactors are described in NFPA 802, *Recommended Fire Protection Practice for Nuclear Research Reactors.*

All other applicable NFPA codes, standards, and recommended practices should be followed.

1-3 Definitions.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

Combustible. Any material which does not comply with the definition of either noncombustible or limited combustible.

Fire Prevention. Measures directed towards avoiding the inception of fire.

Fire Protection. Methods of providing for fire control or fire extinguishment.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Limited Combustible. As applied to a building construction material, a material, not complying with the definition of noncombustible material, that in the form in which it is used has a potential heat value not exceeding 3500 Btu per lb (8.14×10^6 J/kg) (*see NFPA 259, Standard Test Method for Potential Heat of Building Materials*), and complies with one of the following paragraphs (a) or (b):

(a) Materials having a structural base of noncombustible material with a surfacing not exceeding a thickness of ⅛ in. (3.175 mm) that has a flame spread rating not greater than 50.

(b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion, as tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

Materials subject to increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Noncombustible. A material which, in the form in which it is used and under the conditions anticipated, will not aid combustion or add appreciable heat to an ambient fire. Materials when tested in accordance with Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C (1382°F), ASTM E136, and conforming to the criteria contained in Section 7 of the referenced standard shall be considered as noncombustible.

Should. Indicates a recommendation or that which is advised but not required.

Units. Metric units in this document are in accordance with the International System of Units which is officially abbreviated SI in all languages. For a full explanation see the Metric Practice Guide, ASTM E380; ANSI Z210.1.

Chapter 2 Sources of Radiation — The Nature of the Fire Problem

2-1 General.

2-1.1 Radioactive materials are substances which spontaneously decay, emitting energetic rays or particles in the process. Certain elements occur in more than one form. The various forms are chemically identical, but differ in their atomic weights. These different forms of the same elements are called isotopes. Those which are radioactive are called radioactive isotopes. It is possible for an element to have one or more nonradioactive (stable) isotopes and one or more radioactive isotopes (radionuclides). Each of the radioisotopes emits a definitive type or types of radiation. In discussing radioactive material, therefore, it is always necessary to use the terminology which identifies the particular isotope, such as uranium-238 or, alternatively, 238 uranium.

2-1.1.1 Some radioisotopes occur in nature and may be separated by various physical or chemical processes and others are produced in particle accelerators or nuclear reactors.

2-1.1.2 Emissions from radioactive materials cannot be detected directly by any of the human senses. Of themselves, radioactive materials present no unusual fire hazards as their fire characteristics are no different from the fire characteristics of the nonradioactive form of the same element.

2-1.1.3 The presence of radioactive materials may complicate a fire fighting situation by presenting hazards of which the fire fighter may be unaware and may cause real or imagined hazards to fire fighters, which may inhibit normal fire fighting operations. The dispersal of radioactive materials by fumes, smoke, water, or by the movement of personnel may cause a radiation contamination incident which may contribute greatly to the extent of damage, complicate cleanup and salvage operations, and delay the restoration of normal operations.

2-2 Fire Problems.

2-2.1 Facilities handling radioactive materials should be designed and operated with special recognition given to the properties of radioactive materials. The effects of the presence of radioactive substances upon the extent of loss caused by fire or explosion are:

(a) Possible interference with manual fire fighting due to the fear of exposure of fire fighters to radiation.

(b) Possible increased delay in salvage work and in resumption of normal operations following fire, explosion, or other damage due to radioactive contamination and the consequent need for decontamination of buildings, equipment, and materials.

(c) Possible increase in the total damage resulting from contamination of buildings and equipment to the point that they are unusable.

2-2.2 Radioactive materials may be expected to melt, vaporize, become airborne, or oxidize under fire conditions. None of these alterations will slow down or halt the radioactivity. It is conceivable that certain radioactive materials under fire conditions might be converted to radioactive vapor or oxidized to a radioactive dust or smoke. This dust or smoke could be carried by air currents and subsequently deposited on other parts of the burning buildings or even on neighboring buildings or land. These loss and personal injury aggravating characteristics of radioactive materials justify a high degree of protection against fire and explosion at those facilities where this potential exists. The use of fire resistive building components and equipment is highly desirable in those areas where radioactive materials are to be stored or used. Some form of automatic protection, such as automatic sprinklers, would be highly advantageous wherever combustibles are encountered. The installation of automatic extinguishing systems will make it less necessary for personnel to expose themselves to possible danger, will start the fire control process automatically, will sound an alarm and make efficient use of the available water supply. However, caution should be exercised to assure that the hazards of criticality and reactivity be considered.

2-2.3 Some commonly encountered radionuclides are pyrophoric (e.g., plutonium) and, as such, should be given special consideration. Radionuclides generate heat and may have to be cooled in storage; these too require special consideration.

2-2.4 In view of the possibility of the spread of radioactive materials during a fire, certain precautions and procedures should be incorporated into emergency planning for fire fighting operations.

2-2.4.1 The property manager should keep the local fire department advised of the locations and general nature of radioactive materials on hand. Emergency planning is most necessary in order that fire fighters may function at maximum efficiency without exposing themselves to harmful radiation on the one hand and without causing unwarranted fears of radiation hazard to inhibit the fire fighting effort on the other. Specific provision should be made where necessary by the property manager and the fire department for monitoring service, protective clothing, and respiratory protective equipment, the need for which is determined by the nature of the specific hazard. The radiation hazard can usually be anticipated in emergency planning studies. (*See Chapter 6, Protection Against Fire and Explosion.*)

2-3 Radiation Hazards and Protection Methods.

2-3.1 Significant levels of radiation exposure may occur under emergency conditions and could cause acute injury or death. This should be understood by fire fighters in order that they will understand that radiation exposures which are tolerable in the event of a fire or other accident, especially where rescue operations are called for, are unsuitable for day-in, day-out exposure.

2-3.1.1 Based on information provided by a health physicist, the level of radiation risk to be assumed should be decided by the officer in charge of the fire fighting operation, based on knowledge and the importance of the operation to be accomplished. In the absence of information from a health physicist, the risk should be assumed to be significant.

2-3.2 Nature of the Hazard of Radioactivity. In order that fire fighting personnel may understand how to effectively protect themselves against dangerous amounts of radiation, it is necessary that they be familiar with the basic nature of radiation and the safeguards which are generally provided under normal operating conditions at those facilities where this hazard is to be found. While quite brief and simplified, the following paragraphs should assist in identifying for the fire fighter those areas of concern:

(a) For brief definitions of some of the terms used, "radioactivity" may be defined as the spontaneous emission of rays or particles during change of an atom's nucleus. "Radioactive decay" means the spontaneous disintegration of a nucleus. Each radioactive isotope has a "half-life" — a period of time that is a characteristic of the particular isotope in which the intensity of nuclear radiation, ascribable to that isotope, progressively decreases by half. However, products formed by the radioactive decay of the original isotope may in turn be radioactive.

(b) The unit for measuring the quantity of radioactivity in the source material is the curie; also the millicurie (one one-thousandth curie) and the microcurie (one one-millionth curie). The term "curie" was originally designated as the standard to measure the disintegration rate of radioactive substances in the radium family (reported as 3.7×10^{10} atomic disintegrations per sec per gram of radium). It has now been adapted to all radioisotopes and refers to the amount of the isotope that has the same disintegration rate as 1 gram of radium.

The curie has been historically, and is still, the most commonly used unit for source strength. However, the SI unit for source strength is the becquerel. One becquerel is equal to one disintegration per second. Hence, one curie is equal to 3.7×10^{10} becquerels.

(c) Among the radiations likely to be encountered are alpha particles, beta particles, gamma rays, and neutrons. The first three come from many radioactive materials, but neutrons are likely to be present in the vicinity of nuclear reactors or accelerators only while they are in operation, or from certain special neutron source materials. Neutrons, alpha particles, and beta particles are small bits of matter — smaller than an individual atom. Gamma rays (and X-rays) are electromagnetic radiations (like radio waves but with much shorter wave lengths).

(d) All radioactive emissions are capable of injuring living tissue. The fact that these radiations are not detectable by the senses makes them insidious, and serious injury may be done without the recipient of the injury being aware of it at the time. Because of their relatively high penetrating power, gamma rays and neutrons may be a serious external hazard (i.e., may be very dangerous even when arising from a source outside of the body). Beta particles, being less penetrating, can be somewhat of an external hazard if approached within inches but are mainly an internal hazard; while alpha particles, because of their extremely low penetrating power, are entirely an internal hazard (i.e., can only injure the body if emanating from a source within the body after having entered the body in some manner).

(e) These radiations are measured in roentgens, a unit representing the amount of radiation absorbed or which will produce a specified effect. Radiation dosages are measured in rems, a dose unit which will produce a specified effect in man. The ultimate effect upon the human body will depend on how and where the energy is expended. In industry, safeguards are provided for the purpose of keeping radiation exposure to personnel to a practical minimum and under certain amounts.

The roentgen and rem have been historically, and are still, the most commonly used units for radiation dosage. The current SI unit for dosage is the sievert. One sievert is equal to 100 rem. A sievert is equivalent to one joule per kilogram.

(f) In an emergency case, such as a necessary rescue operation, it is considered acceptable for the exposure to be raised within limits for single doses. The National Council on Radiation Protection and Measurement has recommended that, in a life saving action, such as search for and removal of injured persons or entry to prevent conditions that would injure or kill numerous persons, the planned dose to the whole body should not exceed 100 rems. During less stressful circumstances, where it is still desirable to enter a hazardous area to protect facilities, eliminate further escape of effluents, or to control fires, it is recommended that the planned dose to the whole body should not exceed 25 rems. These rules may be applied to the fire fighter for a single emergency; further exposure is not recommended. Internal radiation exposure may be guarded against by adequate respiratory equipment.

2-3.3 Personnel Protection Methods. 'Monitoring" is the process of measuring the intensity of radiation associated with a person, object, or area. It is done by means of instruments which may be photographic or electronic. Instruments used by personnel for radiation detection or measurement include:

(a) Film badge — a piece of photographic film which records gamma and beta radiation.

(b) Pocket dosimeter — measures gamma radiation.

(c) Geiger-Muller counter — measures beta and gamma radiation.

(d) Scintillation counter — measures alpha, beta, and gamma radiation.

(e) Ionization chamber — measures alpha, beta, and gamma radiation.

(f) Proportional counter — measures alpha radiation.

(g) Gamma survey meter — measures intensity of gamma radiation.

(h) TLD - Thermoluminescent Dosimeter. A crystal chip that records ionizing radiation.

2-3.3.1 Common effects of excessive (200 roentgens or more) nuclear radiation on the body include vomiting, fever, loss of hair, loss of weight, a decrease in the white blood cell count, and an increased susceptibility to disease. Radioactive materials absorbed into the body often tend to accumulate at a particular location (e.g., plutonium and strontium tend to collect in the bone) the radioactivity, concentrated in a particular organ, gradually destroys the cell tissue so that the organ is no longer capable of performing its normal function, and the entire body suffers.

2-3.3.2 Radiation injury requires prompt, highly specialized treatment. Instruments should be provided to detect radiation contamination in clothing or on the skin. There should be a routine monitoring of the degree of exposure to the various particles and rays. Personnel working in the facility will generally be required to wear pocket radiation meters or indicators which are examined periodically, and records of the exposure shall be kept for future reference.

2-3.3.3 The practice of placarding dangerous areas is for the protection of both regular operating personnel and those who, like fire fighters, may have to deal with an emergency situation. If fire fighters are to have the best protection, they should inspect, long before they are called to any fire, the premises where there may be radiation hazards to consider during fire operations. Also, by frequent follow-up inspections, they should reach an agreement with the scientists or other personnel directing the facilities as to steps to be taken in case of fire.

2-3.3.4 Fire fighters who may attend fires in properties where there are hazards of radioactivity should be given special training in what to wear for protection and what to do by way of cleanup or decontamination of their persons, clothing, or equipment afterward. In all cases, they should have and be trained in the use of suitable radiation monitoring equipment themselves or have monitoring specialists with them.

2-3.4 **Protection from External Radiation.** In the case of external nuclear radiation, the dosage, and hence the injury therefrom, may be kept to a minimum in several ways.

2-3.4.1 First, only the smallest possible portion of the body should be exposed, (e.g., the hands, rather than the entire body).

2-3.4.2 Second, by efficient organization of the work procedure, the time spent in the hazardous area and thereby, the time of exposure, may be kept to a minimum.

2-3.4.3 Third, the intensity of radiation during exposure may be minimized by maintaining the greatest possible distance (e.g., by using long-handled tools for manipulating radioactive materials); or by the use of suitable materials interposed between the radiation source and the person for shielding. Radiation intensity decreases (inversely) as the square of the distance from the source only when the source is a point source. This relationship is more complex with multiple point sources and does not apply to large sources until the distance is equal to one-half the maximum dimension of the source. Practically speaking, this could be 30 to 50 ft (9.1 to 15.2 m). The cases in which a fire fighter will encounter a single point source are probably in the minority, and therefore, the conservative statement should be used.

2-3.5 **Protection from Internal Radiation.** The possibility of radioactive materials entering the body may be reduced by the wearing of protective face masks and clothing while in a hazardous area. These masks should fit properly and be of a type which will prevent the entry of the particular radioactive materials encountered into the lungs or digestive system. Clothing should be of such a nature as to prevent the entry of radioactive materials into the body through wounds, scratches, or skin abrasions. Eating, drinking, smoking, and chewing must be avoided while in, or while awaiting decontamination after being in, radioactive areas.

2-3.5.1 Personnel working with radioisotopes are commonly subjected to routine biomedical checks for possible ingested radioactivity. Where applicable, routine checks are also made to show that a permissible concentration of radioactive material in the body, the air, or elsewhere is not exceeded.

2-3.5.2 Biomedical checks are promptly conducted whenever human ingestion of dangerous quantities of radioactive materials is suspected for any reason. When fire fighters are exposed to radiation and there is any doubt as to the severity of the exposure, they should be given this kind of biomedical examination.

2-4 "Sealed" and "Unsealed" Radioactive Materials.

2-4.1 For purposes of this publication, a "sealed" radiation source is one which is tightly encapsulated (or the practical equivalent by bonding or other means) and is not intended to be opened at the facility. An "unsealed" source is one that is not so sealed and/or is intended to be opened at the facility.

2-4.1.1 The protection of properties against the spread of radioactive contamination as the result of fire or explosion is considerably simplified by the fact that many radioactive materials are shipped, stored, and in some cases used, without ever exposing the radioactive material itself to air. In many cases the shipping containers, or even the use containers, may have sufficient integrity to withstand a fire or an external explosion. Examples are: metallic cobalt 60 sources tightly encapsulated in steel and sealed sources used in "beta gage" thickness and measuring devices. It may be noted that there have been several instances of stainless steel encapsulated "beta gage" sources surviving appreciable fire exposures without release of the radioactive isotope contained therein.

2-4.1.2 The principal reason radioactive materials are sealed is to prevent spread of contamination. In some cases the manufacturer of the container may not thoroughly consider fire resistance and it is important to remember that a sealed source may burst if its contents are subject to thermal expansion as a result of exposure to fire.

2-4.1.3 Unsealed sources, such as may be found in laboratories during transfer and use, may be readily spread about during a fire or an explosion.

2-5 Applications.

2-5.1 The specific application for ionizing radiation is somewhat governed by the physical makeup of the source, whether it is in the "unsealed" or "sealed" form, and sometimes by its radiation intensity.

2-5.2 Most of the thousands of scientific and industrial uses of radioactive materials take advantage of one or more of the types of radiations emitted, i.e., alpha, beta, gamma rays, and neutrons. Certain radioisotope applications take advantage of the ultrasensitive detection capability of certain instruments for extremely small amounts of radioisotopes. Other uses take advantage of the ability of radiation to penetrate matter, while the extremely energetic sources have the ability to bring about biological, chemical, and physical changes.

2-5.3 The most common nuclear radiation applications can be grouped into the following categories:

(a) Radioisotope "tracer" applications utilize small amounts of short-lived, unsealed sources, involving easily detectable radiation emissions of the particular radioisotope employed. Such applications have found wide use in medical diagnosis, biological and agricultural explorations, water surveys, irrigation control, underground leak and seepage detection, atmospheric pollution, flow and transport rates in processing operations, lubrication and wear measurements, rapid chemical analysis for continuous process control, and activation analysis.

(b) Radioactive gages and process control instruments utilize the more penetrating types of radiation from sources which are sealed to prevent the radioactive material from leaking out. The radioactive material in no way enters into the system or process. This includes a wide range of operations from measuring thickness or density to monitoring height and levels in storage and process equipment.

(c) Certain of the intensive sources of radiation have the ability to ionize gases. One of the important applications is to prevent accumulation of static electricity on moving machinery. Here the ionized air effects an "atmospheric grounding" and prevents buildup of static charges (radium and polonium as low-penetrating alpha emitters have been used, along with the more penetrating beta-emitter krypton-85). These sources are also being used as activating agents with self-luminous (phosphorescent) paints and coatings for various markings, emergency lighting, and instrument panels.

(d) Radioactive materials are being employed in the development of atomic batteries (as "isotopic power fuels"). The small currents generated are utilized in low-current demand micro-circuits; also, the liberation of thermal energy during radioisotope decay is converted into useful electricity through thermoelectric couples or thermionic systems. The sources include some fission products and some of the radioactive materials obtained by neutron-irradiation of special target materials.

(e) Powerful sources are used in industrial radiography and nondestructive testing of critical process equipment. The leading industrially used isotope of high-energy emission is cobalt-60, which is obtained by the activation of cobalt in a reactor.

The industrial radiographer has a choice of X-ray machines or radioisotopes. In many cases the latter offers the most advantages. The increased availability of cobalt-60 has expanded its use greatly in more extensive radiographic inspection as a routine testing procedure. Steel thicknesses of from ½ in. to 6 in. (12.7 to 152 mm) can be radiographically evaluated and many companies are now licensed to provide such examination services.

Other radioisotopes which have less energetic gamma ray emissions than cobalt-60 are coming into wider use for lighter materials such as aluminum, copper, zinc, and thin sections of steel.

(f) Powerful sources of high intensity radiation such as from cobalt-60 are used in food preservation, and in radiological sterilization of pharmaceutical and medical supplies. Research and development indicate considerable promise in polymerization of plastics, vulcanization of rubber, improvement of wood properties, graft polymerization of plastics, and in catalyzing chemical reactions.

2-6 Nuclear Reactors.

2-6.1 Nuclear reactors present special problems that require individual study. They are used for electric power generation, research purposes, production of radioisotopes, and ship propulsions.

2-6.1.1 The fire protection requirements for nuclear power plants are published in NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power Plants.* The general fire protection recommendations for research reactors are published in NFPA 802, *Recommended Fire Protection Practice for Nuclear Research Reactors.*

2-7 Nuclear Reactor Fuel Element Manufacture.

2-7.1 Certain radioactive nuclides are fissile (fissionable). Neutrons absorbed by such nuclides emit additional neutrons plus energy, largely in the form of heat. Because more neutrons are emitted than are absorbed, a self-sustained nuclear chain reaction is possible when certain conditions are met. These conditions include a minimum quantity of fissile material (critical mass) and other factors such as shape, geometry, reflection, and moderation (or slowing down of neutrons). Fissile materials to be used in a nuclear reactor are arranged in specific arrays using fuel elements in order to optimize conditions for fission to take place. When a nuclear chain reaction takes place where it was not intended, a "criticality" accident is said to have occurred.

2-7.1.1 The external radiation hazards present during fabrication of uranium-235 fuel elements is of a low order. Uranium-233 and plutonium-239 present severe inhalation hazards to personnel; therefore, an enclosed protection system must be used. These systems are called "glove boxes." They may be extensive, with appreciable glass or transparent plastic areas, and present unique fire protection problems. Under normal conditions, the radiation hazard, although present, can be largely protected against. On the other hand, if a "criticality" incident should occur, the type and quantity of radiation emitted create grave hazards to personnel. Even a small fire within a "glove box" can produce serious consequences if not properly controlled. Fire control systems and procedures for "glove boxes" should be carefully developed and applied before the boxes are used. Generally such protective systems are custom-designed for each particular application. (*See Section 5-4.*)

2-7.1.2 In handling fissile materials, precautions should be taken not only to protect against the normal radiation hazard, but also against the "criticality" hazard caused by the assembly of a "minimum critical mass." To avoid criticality during fire emergencies, fissile materials that have been arranged to minimize the possibility of a criticality occurring should be moved only if absolutely necessary. If it becomes necessary to move such fissile materials, it should be done under the direction of a responsible person on the staff of the facility and in batches that are below the critical mass, or moved in layers that minimize the possibility of a "criticality" occurring. Since water is a reflector and a moderator of neutrons, concern for a "criticality" hazard sometimes leads to the unjustified and unevaluated exclusion of fire protection water from the area where fissile materials are stored or handled. The possibility of water moderation and reflection bringing about a "criticality" accident can be calculated in advance. If, in fact, such a hazard exists, combustible material that would require the use of water for fire fighting should be eliminated. If combustible materials are unavoidably present in quantity sufficient to constitute a fire risk, water or other suitable extinguishing agent should be provided for fire fighting purposes. The fissile materials should be so arranged that water moderation and reflection will not present a hazard. In many facilities, fissile materials are stored and handled in sprinklered areas.

2-7.1.3 In addition to the hazards of radiation and the potential for accidental "criticality," fuel element manufacture will often involve the use of combustible metals such as uranium and plutonium and combustible cladding material such as zirconium. The prevention of fires involving combustible metals requires special techniques. (*See NFPA 48, Standard for the Storage, Handling and Processing of Magnesium; NFPA 481, Standard for the Production, Processing, Handling and Storage of Titanium; and NFPA 482, Standard for the Production, Processing, Handling and Storage of Zirconium.*)

It is important to remember that nuclear fuel elements are extremely valuable and extraordinary precautions may be necessary to protect them from the effects of an otherwise inconsequential fire.

2-8 Nuclear Fuel Reprocessing.

2-8.1 Reactors are generally capable of utilizing only a very small part of the fuel in its elements and as a result it is economical to recover the remaining fuel by processing the so-called "spent" elements in specially designed facilities. These plants contain large quantities of radioactive materials (fission products) extracted from spent nuclear fuel elements which were produced as by-products during nuclear fission. Processing operations will usually involve large quantities of flammable and/or corrosive liquids. Fire and explosion hazards will be present and the possibility of an accidental "criticality" incident, although guarded against and remote, will also be present.

2-8.2 The large quantities of highly radioactive materials present require massive shielding for personnel safety, and most chemical processing and maintenance operations are conducted entirely by remote controls. Fire hazards are present during the sawing and chopping of fuel elements containing combustible metals, either in the form of fuel or cladding, and in the chemical processing operation. Specially designed fire detection and control systems are used to protect these operations. Ventilating systems should be so arranged as to maintain their integrity under fire conditions. Such facilities handling large quantities of highly radioactive materials require the application of a high degree of fire protection planning in all areas.

2-9 Particle Accelerators.

2-9.1 Particle accelerators include Van de Graaff generators, linear accelerators, cyclotrons, synchrotrons, betatrons, or bevatrons. The machines are used, as the name implies, to accelerate various charged particles of which atoms are composed to tremendous speeds and consequently, to high energy levels. Radiation machines furnish scientists with atomic particles in the form of a beam, which may be utilized for fundamental studies of atomic structure. In addition, they furnish high energy radiation, which may be utilized for radiography, therapy, or chemical processing.

2-9.1.1 These machines emit radiation only while in operation and attempts to extinguish a fire in the immediate vicinity of the machine should be delayed until the machine power supply can be disconnected.

2-9.1.2 Certain "target" materials become radioactive when bombarded by atomic particles and for this reason monitoring equipment should be used during fire fighting operations to estimate the radiation hazard. The usual hazard presented by particle accelerators is largely that of electrical equipment. There are, however, some important exceptions to this. Some installations have used such hazardous materials as liquid hydrogen, or other flammable materials, in considerable quantities. Large amounts of paraffin have been used for neutron shielding purposes. Another factor is the possible presence of combustible oils used for insulating and cooling.

2-9.2 Industrial applications include chemical activation, acceleration of polymerization in plastics production, and the sterilization and preservation of packaged drugs and sutures. The general fire protection and prevention measures for these machines should include the use of noncombustible or limited combustible (Type I or Type II) construction housing, noncombustible or slow-burning (e.g. IEEE-383) wiring and interior finishing, and the elimination of as much other combustible material as possible (*see NFPA 220, Standard on Types of Building Construction*). Automatic sprinkler protection should be provided for areas having hazardous amounts of combustible material or equipment. Special fire protection should be provided for any high voltage electrical equipment.

Chapter 3 Arrangement of Facilities Handling "Unsealed" Radioactive Materials

3-1 Special Considerations.

3-1.1 There are special considerations which should be applied in the arrangement of facilities handling radioactive materials. The radioactive materials themselves may or may not present special fire characteristics, but the combating of a fire may be inhibited by the presence of radioactive materials, and the restoration of the property after the fire has been extinguished may be complicated by the problem of radioactive contamination. It should be recognized that radioactive contamination may be the most costly element in a fire loss; therefore, the control of a fire loss is inextricably related to the control of radioactive contamination. Some of the important features to be considered in this connection are:

(a) Grouping of facilities handling significant quantities of unsealed radioactive materials facilitates air cleaning, fire and process control procedures, and decontamination.

(b) Where the probability of radioactive contamination is a serious matter, the design of many other building components may become critical. Light fixtures, electric conduits, ceilings, heating and cooling systems, and operating equipment should be designed and installed with the view of facilitating decontamination.

3-2 Location with Respect to Other Buildings and within Buildings.

3-2.1 Facilities having quantities of radioactive materials that might become airborne in case of fire or explosion should be located well away from other important buildings or operations where contamination could interfere seriously with plant operations or where radioactive substances could come in contact with materials susceptible to damage.

3-2.1.1 In general, facilities handling radioactive materials should be so located that there is no through or cross traffic.

Particular attention should be given to the location of intakes and outlets of air cleaning systems. A breakdown in an air cleaning system can be more serious if the discharged air can immediately be drawn into another system. General isolation of radiation facilities from all other plant facilities causes an increase in both construction and operating costs, but should be undertaken if a study of the possible results of a contamination incident indicates that this is justified. In order to avoid unnecessary complication of accidents, such facilities should be located away from those handling explosives, or flammable materials.

3-3 Planning for Decontamination. The extent to which decontamination might be necessary depends upon the amount of radioactive material being handled, its half-life, type of radiation emitted, and its chemical and physical form. Taking all of these into account, a realistic assumption should be made as to the extent of a possible contamination incident. When decontamination is necessary, it is accomplished by hand, often by personnel not skilled in the work of clean-up, but highly paid because of their other skills, and often in a hurry. All these factors tend to raise costs and thus justify capital expenditures to reduce them to a minimum through good emergency planning procedures. The basic purpose is to provide construction that will confine a contamination incident as closely as possible and which also will include easily cleaned surfaces.

3-4 Construction.

3-4.1 Buildings in which radioactive materials are to be used should preferably be of single-story height without basements or other below-grade spaces. Construction should be limited combustible or noncombustible (Type I or Type II) construction including interior finish, acoustical or insulating treatments, and partitions.

3-4.1.1 Floors. Selection of floor materials for any facility should meet the demands of comfort, appearance, cost, ease of maintenance, and resistance to wear, corrosion, fire and water. In addition, the particular work may require that the floor be electrically conductive or nonsparking. To all of these requirements the radioisotope facility adds the requirements that the floors have a continuous surface, that they have a low porosity and that they can be easily cleaned or replaced. Because of the weight of materials used for shielding purposes, the floor may be required to withstand heavier than normal loads.

3-4.1.2 Removable sheeting or strippable coatings meeting the requirements for limited combustible should be used for surfaces directly exposed to contamination. These coatings are applied as solutions which may contain flammable solvents and can be applied with spray guns to specially prepared bases and removed without great difficulty. The use of spray guns for applying such materials may be hazardous, especially in small areas or rooms. Care should be taken to provide sufficient forced ventilation in the area and to remove all sources of ignition to avoid a possible fire or explosion.

3-4.1.3 Care should also be used in removing and disposing of these coatings. Not only should their contaminated nature be considered, but some, when burned, liberate corrosive vapors which can cause extensive damage to sensitive equipment.

3-4.1.4 The practice of constructing combustible structures, or the use of house trailers with combustible interior finish for the housing of experimental equipment within or adjacent to a structure, provides the fuel for a hot, fast fire which can do serious structural damage to an unprotected steel building. Even in a sprinklered building the loss may be severe. Such structures should be built of noncombustible or limited combustible materials, or should be provided with automatic sprinklers, even if the building in which they are located is sprinklered.

Chapter 4 Service Facilities

4-1 Special Considerations.

4-1.1 The design and installation of such service facilities as light and power, heating and ventilation, storage, and waste disposal at facilities not handling radioactive materials usually present no major problems. The introduction of radioactive materials into a plant presents additional hazards to both personnel and property, which warrants special considerations of these services. Inadequate attention to the design features of service facilities has unfortunately contributed to the extent of decontamination found to be necessary following fires and explosions. It is considered good practice to analyze the design of each service for the purpose of determining what effect the service would have upon the spread of contamination following an accident. An appraisal of the seriousness of contamination spread may then be used to determine the necessity for modifying the design of the service facility under consideration.

4-2 Heating and Ventilating.

4-2.1 The design of the heating and ventilating system must ensure that airborne radioactivity of the building atmosphere is within permissible limits. The choice of either a central system of ventilation or a system composed of individual units is dependent upon that particular building and the processes it houses. A basic principle which should be followed is that there can be no reverse flow of radioactive gases or dusts from "hot" areas into areas of low or normal activity. If the area of high activity can be maintained at slightly below atmospheric pressure, the flow of air will have the proper direction to minimize the spread of contamination should an accident occur.

4-2.2 Hoods serve as the primary means of air removal from some facilities. Electric motors driving ventilating equipment should be located outside the exhaust stream to reduce the possibility of their being contaminated. No part of the exhaust system within the building should be under positive pressure. All hoods in a single area should be controlled by a master-switch in order that contaminants will not be drawn into the room from an unused hood.

4-2.3 The degree of contamination of the exhaust stream may be such as to require filtration, washing, or electrostatic precipitation before discharge to the outer atmosphere. Recirculation of air within an area wherein dangerous radioactive materials are handled should not be permitted under any circumstances. Careful attention should be given to the disposal of filters – especially if they are loaded with materials having any significant degree of combustibility. The use of combustible filters introduces a serious fire hazard into the ventilating system and requires automatic sprinklers or other special fire protection. In the absence of protection systems within the ducts and for the filter banks, fires in combustible filters become extremely difficult to extinguish.

4-2.3.1 The accidental burning of combustible filters carrying radioactive contaminants may create a serious contamination exposure situation which could involve large areas as the radioactive material is discharged from the exhaust system.

4-2.3.2 Self-cleaning filters which pass through a viscous liquid yield a radioactive sludge to be disposed of, and the filter system may require additional fire protection because of the combustible nature of the liquid. Such systems should generally be avoided in areas wherein radioactive materials are handled.

4-2.3.3 The use of filters of low combustibility, such as those which comply with Underwriters Laboratories Inc. Standard No. 58, is recommended. Their use considerably reduces the likelihood of the spread of contamination by fire. Roughing filters, when necessary, should be constructed of materials which will not contribute to the fire hazard.

4-2.3.4 Fresh air inlets should be located to reduce the possibility of radioactive contaminants being introduced. Such inlets should be located where it would be most unlikely for radioactive contaminants to be present. For example, they should not be located near storage areas of combustible radioactive waste material which upon ignition could discharge radioactive combustion products that may be picked up by the ventilating system.

4-3 Light and Power.

4-3.1 Lights, ventilation, and operation of much remote-controlled equipment are dependent upon a reliable source of electrical power. Location of transformers, switches, and control panels well away from "high activity" areas ensures that maintenance work can be done without direct exposure to radiation from such areas. The need for effective ventilation during and immediately after an emergency such as a fire is of considerable importance. An auxiliary power system should be available to provide temporary lighting, ventilation, and radiation monitoring equipment in those facilities wherein the radioactive materials being handled are potentially dangerous to personnel.

4-3.2 It is important that electrical equipment be selected for its ease of decontamination and early restoration to service in those areas wherein a contamination incident is considered likely. Electrical conduits leading from "hot" areas should be internally sealed to prevent entrance of radioactive materials.

4-4 Storage.

4-4.1 With exception to those amounts needed for immediate or continuous use, chemicals, materials, and supplies should be in separate storerooms and not in areas where work with radioactive materials is conducted.

4-4.2 Automatic sprinkler protection provides the best means for controlling fires involving combustible occupancies and should be provided unless it can be shown that their operation will definitely create a situation more hazardous than that brought about by uncontrolled fire. It is very important that radioactive materials not be stored in the same area as other materials, especially if either are flammable or combustible in nature.

4-4.3 Special consideration should be given to the storage of radioactive compressed gases as their release under fire or explosion conditions can result in a severe loss by contamination. Storage facilities for such gases should be designed with the peculiar characteristics of the gases in mind. Special noncombustible storage facilities located remotely from the main facility may be necessary in some cases.

4-4.4 If stored radioactive materials require a cooling system, the cooling system should be periodically checked and maintained in good working condition.

4-5 Waste Disposal.

4-5.1 The disposal of liquid radioactive waste usually will present no fire hazards unless the liquids are combustible. Such combustible liquids should be handled with recognition of their fire hazard as well as of their radioactivity.

4-5.2 Special attention should be given to the prompt disposal of combustible waste, particularly such waste as absorbent paper and rags which have been used to clean radioactive contaminated surfaces. It becomes especially important if the waste has been used to apply nitric acid or other oxidizing chemicals that are subject to spontaneous heating. Waste that is collected during normal activity should be stored in metal containers having tight self-closing covers, and should be removed from the operating areas of the facility at the end of each work day.

4-5.3 Care should be exercised in selecting the locations for the storage of radioactive waste material. Such material should not be located near the fresh air intakes to the air-conditioning systems nor the air intakes for air compressors. Should the products of combustion of waste materials containing long-lived radioactive materials be dispersed through air-conditioning or compressed air systems, a decontamination problem of serious magnitude could result.

Chapter 5 Equipment for Handling and Processing Radioactive Materials

5-1 General.

5-1.1 All equipment to be used for handling and processing radioactive materials should be designed to minimize fire and explosion potentials. There are many types of equipment and systems for handling radioactive materials but most may be classified as either benches, hoods, glove boxes, or "hot" cells.

5-2 Benches.

5-2.1 Benches are used for handling relatively small amounts of alpha- or beta-emitting materials. Benches should be of noncombustible construction with a nonporous continuous working surface which may easily be decontaminated. One or two layers of blotting paper on the bench top to absorb small spills will usually not materially increase the fire hazard.

5-3 Hoods.

5-3.1 Hoods are similar to benches, with the addition of an enclosure and an exhaust system for removing vapors. In addition to fire protection (*see Section 6-3.3*), the nature of the operations conducted within the hood may require a filter system to prevent the spread of radioactive materials. If filters are used, they should have a low degree of combustibility. (*See Section 4-2.*)

5-4 Glove Boxes.

5-4.1 The term "glove box" is used broadly to describe a system designed to contain materials, generally alpha-radiation emitters, which present little or no external radiation hazard but would present a serious problem if they became airborne. Such boxes may be large and used to conduct a wide variety of operations involving flammable liquids and gases, combustible solids, and toxic materials. The sides are fitted with long rubberlike gloves which permit manual operations to be conducted without personal contact with the hazardous materials. Special ventilation and fire protection systems are usually considered to be necessary.

5-4.2 Construction Materials. Construction materials should be noncombustible or limited combustible. Combustible construction materials or materials which are noncombustible but lack fire integrity introduce special problems. All surfaces should be nonporous and easy to decontaminate. Surface coatings are often used to provide a ready means for the removal of contamination but the fire hazards connected with their application should be considered.

5-4.3 Materials Handled in Glove Boxes. All materials to be introduced into these boxes, as well as the construction materials used, should be chosen to minimize the possibility of an explosion, fire, or uncontrolled exothermic chemical reaction. The confinement provided by the boxes together with often near-static air conditions are conducive to the production of explosive mixtures of flammable vapors and gases with air.

The quantity of combustible materials within glove boxes should be kept to an absolute minimum. Special extinguishing agents or systems, compatible with the materials being handled, should be provided within glove boxes in order to avoid the delay and hazard inherent in introducing the extinguishant from outside.

5-4.3.1 Care should be exercised when handling combustible metals within such enclosures. It is possible that low-melting point alloys such as iron-plutonium that are often more pyrophoric than the parent materials, may be formed.

5-4.4 Equipment Used in Glove Boxes. Electrical equipment, including motors and heat-producing devices such as ovens, hot plates, soldering irons and direct flame devices such as torches and burners, present special hazards which should be safeguarded.

5-4.4.1 The small volume and low air velocity conditions provide for less than normal heat removal. The vulnerability of rubber gloves to melting or burning through as a result of very brief contact with heat sources requires that glove port covers be kept immediately available.

5-4.5 Ventilating Systems. Glove boxes are usually connected to a special ventilating system and are normally under constant air flow. Fire dampers are not often installed because of interference with contamination control. The ventilating systems should be designed to constantly maintain a negative pressure within the boxes even under fire conditions. In this connection, consideration should be given to two principal problems.

(a) Smoke and soot from burning material can quickly clog roughing and high efficiency filters in the exhaust system. This may cause rapid spread of the radioactive materials outside the box as a result of pressure created by the fire.

(b) The flexible connections, if any, between the glove boxes and the exhaust system should be of fire retardant materials.

5-4.6 Containment and Fire Control. The containment system may lose its integrity due to fire or explosion originating in or outside the glove box. For fire originating outside the glove boxes, automatic sprinklers are commonly used and are effective for conventional fire control and extinguishment. Fire occurring within the glove boxes may involve materials of construction or combustibles within the boxes. These situations may be difficult to control unless advance consideration has been given to the specific fire problem which may develop under the specific conditions of glove box use. Where such hazards exist, consideration should be given to an automatic fire detection and control system within glove boxes. This system should detect and control the fire before it destroys the glove box integrity or creates smoke which clogs the filters. Where explosion possibilities exist within a glove box, provision should be made for explosion suppression or venting by a predetermined path to a safe area.

5-4.6.1 It is important that airborne contamination does not spread beyond the confines of the room or building in which it originates. This indicates the need for the most efficient and prompt suppression and isolation of fire. To the extent that water from the sprinkler system cleanses the air of airborne contamination, it can reduce a serious three-dimensional airborne contamination problem to a much more manageable two-dimensional waterborne contamination problem.

5-4.7 Fire Prevention. Fire prevention may be improved by the conventional techniques of reducing to a minimum the amount of combustible materials, by eliminating or safeguarding sources of ignition, or by inerting the glove box with a gas such as argon, helium, or nitrogen. In some cases, moisture-free air may be used to prevent the formation of combustible and sensitive metal hydrides.

5-4-7.1 An effective fire prevention program for glove boxes is one that necessarily involves a study of all parameters and the interactions which enter into their construction and operation. Since the specific fire that might occur in a glove box can usually be anticipated and, in fact, can be studied in advance under controlled conditions, it is possible to provide a control and extinguishment system tailored to the specific hazard.

5-4.7.2 The development of a process and the process hazard control system must proceed simultaneously. The operation should not be permitted to begin until the control system is fully operable.

5-5 "Hot" Cells.

5-5.1 A "hot" cell is a heavily shielded enclosure in which gamma-emitting radioactive materials can be handled by persons using remote manipulators while viewing the operation through shielded windows or monitors.

5-5.1.1 While possessing all of the fire and explosion hazards of glove boxes, the damage potential is increased by the nature of the high gamma-ray producing materials used. The safeguards recommended for glove boxes apply equally to "hot" cells.

Chapter 6 Protection Against Fire and Explosion

6-1 General. The hazard of radioactivity may, without adequate emergency planning, act to seriously impede fire fighting operations and result in unnecessary injury to personnel and increased property damage. By anticipating emergency fire and explosion situations and by providing special training for fire fighting personnel, the total hazards of radioactivity can be considerably mitigated. Special techniques and equipment will often be required.

6-2 Organization for Emergencies.

6-2.1 In a well-organized facility wherein radioactive materials are located, fire control starts well before the fire occurs. The need for prefire planning for such facilities cannot be overemphasized. A firm statement of policy by the management of the facility as to the intent of the plan, its scope, its importance, and its organization will materially assist in its effective application. It should be published, reviewed at periodic intervals, and kept current.

6-2.1.1 The areas of consideration of facility management in designing their emergency program should include, as a minimum, the following:

(a) A self-inspection program.

(b) A private fire fighting organization and an outline for its training.

(c) A private security organization and an outline for its training.

(d) Personnel control as it relates to emergency situations.

(e) Health physicist responsibilities.

(f) Liaison with public emergency organizations.

(g) Procedures for loss minimization and decontamination.

(h) The safeguarding of valuable process data and records.

(i) Community relations.

6-2.1.2 The above items are basic in nature and should be molded into a well-considered organizational approach to meet the specific needs of each facility. No organization to cope with emergencies can be expected to function efficiently without training and practice on the part of all involved. Familiarity with established procedures and how to implement them quickly is a necessary ingredient for effective control of fire and explosion-connected emergencies.

6-3 Fire and Explosion Prevention and Control.

6-3.1 Self-Inspection Program. Personnel best qualified to prevent the occurrence of fire are those who have an intimate knowledge of those factors likely to create a fire situation at a specific facility. Many insurance related and public fire protection organizations provide effective fire inspection services at intervals, but the value of these services can be greatly enhanced by thorough self-inspections of the facility by knowledgeable people on the premises who have a good understanding of the hazards to be safeguarded.

6-3.1.1 To be effective, a self-inspection program should be formal and conducted objectively. The reports of these inspections should be reviewed by management at a level that can initiate corrective action. For best results, the self-inspection report forms should be specifically designed for each facility and include all aspects of basic fire protection as well as those indigenous to the facility.

6-3.2 Automatic Sprinklers. Effective protection against fire damage is provided by automatic sprinklers. Combustible contents or the presence of flammable liquids or gases calls for automatic fire protection even if the building construction is noncombustible or limited combustible. The instinctive concern on the part of the facility management about unnecessary water damage is not borne out by the record. To reduce the danger of accidental discharge of water on delicate apparatus, which may be susceptible to water damage, a specially engineered sprinkler system such as a preaction system with advance alarm may be used. Individual items can, if necessary, be shielded with hoods. Lack of sprinkler protection usually results in fire control efforts by high pressure hose streams and the resultant water damage will far exceed that which would have been caused by sprinklers.

6-3.3 Other Fire Control Systems. Where automatic sprinklers cannot be provided due to the presence of water-reactive materials or the proven possibility of criticality, alternate automatic fire extinguishing systems should be considered (*see NFPA 803, Standard for Fire Protection for Light Water Nuclear Power Plants, Section 10-1*).

6-3.4 Portable Extinguishers. Incipient fires may be controlled by portable fire extinguishers. This phase of fire control is particularly important, even though automatic sprinklers have been provided. A supply of portable hand fire extinguishers suitable for use on the specific hazards should be provided (*see NFPA 10, Portable Fire Extinguishers*). Special fire potentials sometimes encountered involve unusual chemicals or combustible metals. Some special extinguishers are effective on incipient fires in combustible metals such as may be found on benches, in hoods, or in glove boxes. Generally, the extinguishant must be tailored to the particular metal involved. Dry powder extinguishers, approved for combustible metal fires, are effective on most such materials.

6-3.5 Fire Detection. The need for, and the type of, detection services most desirable should be related to the hazard, the extinguishing controls available, public and private fire departments, and all combinations of these.

Various devices, operating on different principles, are available for detecting fire (*see NFPA 72E, Standard on Automatic Fire Detectors*). Additional considerations prior to selection should include:

(a) Response characteristics.

(b) Maintanence requirements.

(c) Testing requirements.
(d) Adaptability to environment.
(e) Accessibility.

Chapter 7 Referenced Publications

7-1 The following documents or portions thereof are referenced within this recommended practice and should be considered part of the recommendations of this document. The edition indicated for each reference is current as of the date of the NFPA issuance of this document. These references are listed separately to facilitate updating to the latest edition by the user.

7-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1984, *Standard for Portable Fire Extinguishers*

NFPA 48-1982, *Standard for the Storage Handling and Processing of Magnesium*

NFPA 72E-1984, *Standard on Automatic Fire Detectors*

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

NFPA 255-1984, *Standard Method of Test of Surface Burning Characteristics of Building Materials*

NFPA 259-1982, *Standard Test Method for Potential Heat of Building Materials*

NFPA 481-1982, *Standard for the Production, Processing, Handling and Storage of Titanium*

NFPA 482-1982, *Standard for the Production, Processing, Handling and Storage of Zirconium*

NFPA 802-1983, *Recommended Fire Protection Practice for Nuclear Research Reactors*

NFPA 803-1983, *Standard for Fire Protection for Light Water Nuclear Power Plants*

7-1.2 Other Publications. The following is a selection of additional referenced material:

The following publication is available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062:

UL 586, *Test Performance of High Efficiency Particulate, Air Filter Units.*

The following publications are available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19105:

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*

ASTM E380 (ANSI Z210.1), *The Metric Practice Guide.*

The following publication is available from the Institute of Electrical and Electronics Engineers, 345 East 47th St., New York, NY 10070:

IEEE 383, *Standard for Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations.*

Appendix A Additional Publications

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

The following is a selection of additional reference material.

The National Council on Radiation Protection and Measurement has issued a number of reports on specific radiation protection subjects. These reports are available from NCRP Publications, P. O. Box 4867, Washington, DC 20008, or from the U. S. Government Printing Office. Some applicable publications include:

NCRP 30, *Safe Handling of Radioactive Materials-NBS Handbook 92*, 1964

NCRP 38, *Protection Against Neutron Radiation*, 1971

NCRP 39, *Basic Radiation Protection Criteria*, 1971

Standards of the U. S. Nuclear Regulatory Commission for protection against radiation are published in the Code of Federal Regulations as Part 20, Chapter 1, Title 10, available at most libraries. Revisions are printed in the Federal Register, available at subscribing libraries or by subscription from the Government Printing Office.

A bimonthly magazine, *Nuclear Safety*, is available from the Government Printing Office. It covers many areas of interest, including general safety, accident analysis, operating experiences, and current events.

Specific requirements for facilities handling radioactive materials have been issued by the American Nuclear Insurers, The Exchange, 270 Farmington Ave., Farmington, CT 06032, and the MAERP Reinsurance Association, 1151 Boston-Providence Turnpike, Norwood, MA 02062.

SUBMITTING PROPOSALS ON
NFPA TECHNICAL COMMITTEE DOCUMENTS

Contact NFPA Standards Administration for final date for receipt of proposals on a specific document.

INSTRUCTIONS

**Please use the forms which follow for submitting proposed amendments.
Use a separate form for each proposal.**

1. For each document on which you are proposing amendment indicate:
   (a) The number and title of the document
   (b) The specific section or paragraph.

2. Check the box indicating whether or not this proposal recommends new text, revised text, or to delete text.

3. In the space identified as "Proposal" include the wording you propose as new or revised text, or indicate if you wish to delete text.

4. In the space titled "Statement of Problem and Substantiation for Proposal" state the problem which will be resolved by your recommendation and give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If a statement is more than 200 words in length, the technical committee is authorized to abstract it for the Technical Committee Report.

5. Check the box indicating whether or not this proposal is original material, and if it is not, indicate source.

6. If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members and alternates of the technical committee.

NOTE: The NFPA Regulations Governing Committee Projects in Paragraph 10-10 state: Each proposal shall be submitted to the Council Secretary and shall include:

(a) identification of the submitter and his affiliation (Committee, organization, company) where appropriate, and

(b) identification of the document, paragraph of the document to which the proposal is directed, and

(c) a statement of the problem and substantiation for the proposal, and

(d) proposed text of proposal, including the wording to be added, revised (and how revised), or deleted.