



January 1974

U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 3.16

GENERAL FIRE PROTECTION GUIDE FOR PLUTONIUM PROCESSING AND FUEL FABRICATION PLANTS

A. INTRODUCTION

Each applicant for a license to possess and use special nuclear material in a plutonium processing and fuel fabrication plant as defined in §70.4(r) of 10 CFR Part 70, "Special Nuclear Material," must satisfy the provisions of §70.23, "Requirements for the Approval of Applications." Paragraphs (a)(3) and (4) of §70.23 require that the applicant's proposed equipment and facilities and proposed procedures be adequate to protect health and minimize danger to life or property.

At plutonium processing and fuel fabrication plants, a principal risk to health and safety is the release and dispersal of radioactive materials from a fire or explosion. Fire protection programs for these plants should prevent, detect, extinguish, limit, or control fires and explosions and their concomitant hazards and damaging effects. This guide presents methods acceptable to the Regulatory staff for complying with §§70.23(a)(3) and (a)(4) with respect to fire protection for plutonium processing and fuel fabrication plants.

B. DISCUSSION

The principal purposes of a fire protection program for a plutonium processing and fuel fabrication plant are the protection of the general public from radioactive and toxic material, protection of plant personnel, and protection against loss of confinement.

Structures, systems, and components important to safety should be designed and located so they can continue to perform their safety functions effectively under credible fire and explosion exposure conditions. Heat-resistant and noncombustible materials should be used wherever practical throughout the facility,

particularly in locations vital to the functioning of confinement barriers and systems, to methods of controlling radioactive materials within the facility, and to the maintenance of safety control functions. The adverse effects of fires and explosions on structures, systems, and components important to safety can be minimized by providing systems with sufficient capacity and capability for detecting and suppressing explosions and fires and transmitting alarms to one or more central control areas. It is important in the design of the plant and fire-suppression systems to include provisions to protect against adverse effects in the event of fire-suppression system operation or failure.

Implementation of the above entails an evaluation of such factors as the expected maximum amount of combustible material in each area of the plant; severity, intensity, and duration of credible fires; assurance of confinement of radioactive and other potentially dangerous contaminants; arrangements and structural design features of buildings for control of smoke, heat, flame, and combustible and explosive gases; and systems for fire detection, confinement, control, and suppression.

Water should be the principal fire suppressor, and special consideration should be given to selection of water sources, water distribution systems, fire pumps, and automatic and manual fire extinguishing systems to control and extinguish a credible fire in any area. Automatic sprinkler or equivalent coverage should be provided throughout the facility with provisions for special hazard fire control measures where particular hazards exist.

USAEC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the AEC Regulatory staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Published guides will be revised periodically, as appropriate, to accommodate comments and to reflect new information or experience.

Copies of published guides may be obtained by request indicating the divisions desired to the U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Director of Regulatory Standards. Comments and suggestions for improvements in these guides are encouraged and should be sent to the Secretary of the Commission, U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Chief, Public Proceedings Staff.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siteing
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust Review
10. General

Incipient fires may be controlled by portable fire extinguishers. This phase of fire control is particularly important, even though automatic sprinklers have been provided. Consideration should be given to the selection of portable fire extinguishers suitable for use on specific hazards that may be encountered.

The need for fire detection devices and the type most desirable should be related to combinations of hazards involved, extinguishing controls available, and public and private fire departments. Various detection devices operating on different principles for detecting fire are available. These include the principles of fixed temperature, rate of temperature rise, presence of combustion and pyrolysis products, or various combinations of these principles.

Fire protection systems may be subject to effects of natural phenomena such as seismic motion and floods, missiles, fire and explosion, and other accidents. These systems should continue to perform their safety functions effectively under credible accident conditions. Where possible, continuity of fire protection systems should be assured by such means as standby equipment and fail-safe control systems.

The ability of the systems to perform their safety functions effectively can be assured by periodic testing of safety-related components during normal operation of the systems to demonstrate their ability to perform at design efficiency and to verify their availability for emergencies.

An important aspect of a fire protection program is training of a fire-fighting organization and maintenance of its competence with periodic drills.

The fire protection program should provide for the use of appliances, equipment, and materials listed by such testing organizations as the Underwriters' Laboratories, Inc. (UL) and the Factory Mutual Research Corp. (FM) as meeting their standards.

Fire protection programs should conform to the provisions of the following codes and standards as applicable:

1. National Fire Codes of the National Fire Protection Association (NFPA).
2. Fire Prevention Code of the American Insurance Association (AIA).
3. Fire Protection Standards and Bulletins of the Factory Insurance Association (FIA).
4. Standards of the American Petroleum Institute (API).
5. One of the four model building codes:
 - a. National Building Code of the AIA
 - b. Uniform Building Code of the International Conference of Building Officials (ICBO)

- c. Southern Standard Building Code of the Southern Building Code Congress
- d. Basic Building Code of the Building Officials Conference of America

C. REGULATORY POSITION

Plutonium processing and fuel fabrication plants should be designed to assure the confinement of hazardous materials during normal or abnormal conditions including fires and explosions. The release of radioactive material to the environment or to an area in which levels of radioactivity are normally sufficiently low to permit personnel access should be reduced to a level as low as practicable in accordance with the provisions of 10 CFR Part 20.

1. General Features

a. Fire protection systems for plutonium processing and fuel fabrication plants should be designed to assure that any credible fire or explosion will not prevent the operation or use of structures, systems, equipment, and components whose continued integrity and/or operability are essential to assure confinement of radioactive materials, hereafter designated as "essential items."

b. Where possible, each fire protection system should be designed so that the failure of any one component (equipment or control device) will not disable the entire fire protection system. Fire protection systems and components should have fail-safe features with provision for operation and trouble alarm indication.

c. Onsite emergency power supply systems should be provided to operate applicable fire protection systems and components as well as other systems and components important to safety. Fire protection systems should be capable of operating during normal power outage. The onsite emergency power sources and the electrical distribution circuits should have independence and testability to assure performance of their safety functions assuming any single failure.

d. The design of fire-suppression systems should include provisions to protect against adverse effects in the event of system operation or failure. For example, collection systems should be provided for runoff water in the event of normal or abnormal flow from an automatic sprinkler system.

e. The fire protection systems should be designed to withstand tornado conditions without loss of operating capability due to mechanical damage to the systems or components to the extent that they will prevent the uncontrolled release of radioactive materials.

f. Components of fire protection systems should be designed to withstand the effects of earthquakes and remain functional to the extent that they will prevent the uncontrolled release of radioactive materials.

g. Criteria for fire protection equipment, systems, components, and programs should comply with the

intent of applicable provisions of the National Fire Codes of the NFPA. Fire protection appliances, equipment, and materials that have been examined by and meet the standards of such nationally recognized testing organizations as UL and FM should be used.

2. Building Construction and Facilities

a. The plutonium processing and fuel fabrication plant should be designed and constructed using building components of heat-resistant and noncombustible material wherever practicable, particularly in locations vital to the functioning of confinement barriers and systems.

b. Where practicable, materials and equipment designed for minimum fire potential should be selected. Structural members including walls, partitions, columns, beams, floors, and roofs should be of noncombustible, fire-resistive construction with fire-resistance ratings sufficient for protection against credible fire exposures.

c. Assuming failure of any fire suppression system which is not designed as an essential item, the structural shell (and its supporting members) surrounding any area handling plutonium, where the plutonium could be accidentally dispersed and cause exposure to either operating personnel or the public, should be designed with sufficient fire resistance that it will remain standing and continue to act as a confinement structure during any credible accident conditions resulting from fires. The fire resistance rating of the shell should not be less than 2 hours.¹ Penetrations in this shell should incorporate, as a minimum, equivalent protection against credible fire exposures.

d. Suspended ceilings and their supports should be of noncombustible construction as listed by UL² or FM.³ Insulation for pipes and ducts, sound attenuating materials, and their adhesives should also be noncombustible. Concealed spaces should be devoid of combustibles. Materials used should have a rating of 25 or less with respect to flame spread, fuel contribution, and smoke development.⁴

e. Exits from plutonium processing areas and rooms should be strategically located so that radiation exposure of personnel will be minimal during evacuation of the area or room through a confinement barrier in the event of a breach of processing equipment confinement resulting from fires and explosions. Such a barrier would be a partition separating two different air zones.⁵ The air flow through the barrier should be in the direction opposite to the exit travel.

f. Electrical wiring systems and their supporting members (i.e., conduits, trays, troughs, raceways, and distribution frames) servicing essential items should be protected against fire. Cable enclosures, fire stops at fire barrier walls, floors, and ceilings, and non-flame-propagating electrical insulation should be used in the design of electrical wiring systems to minimize the spread of fire.

g. Structures, systems, equipment, and components in processing areas requiring hydraulic,

lubricating, cooling, and insulating fluids should be protected from fire and its spread by use of minimum volumes of fluids, by use of fire-resistant fluids, by fire barrier isolation, by provision for automatic fire suppression, and by installation of curbs, catch basins, or other confinement designs that minimize the spread of fluid leakage.

h. Provision should be made for protection of the plant against lightning damage.

i. Protective barriers should be provided around high-pressure or other potentially dangerous systems.

3. Ventilation Systems

The ventilation systems should be designed to withstand any credible fire and explosion and continue to act as confinement barriers. Fire protection for ventilation systems is discussed in Regulatory Guide 3.12.⁶

4. Glove Boxes, Hoods, and Other Process Enclosures

a. Glove boxes and process enclosures should be provided with fire stops in connecting tunnels to prevent the spread of fire. The fire stops between enclosures should normally be closed. Where operations require that the fire stops be in the open position, they should be designed to be closed automatically upon operation of the fire-detection system. Provision should also be made for manual operation of fire stops.

b. Chemical fume or particulate exhaust hoods should be equipped with full-closing sashes and provided with fire detectors. Provisions should be made for manual fire suppression where fire or explosion hazards exist.

c. Additional fire protection features of glove boxes and other process enclosures are discussed in Regulatory Guide 3.12.⁶

5. Sprinkler Systems

a. Automatic water sprinkler coverage using components listed by UL⁶ or FM⁷ should be provided throughout the facility except in areas where nuclear criticality or other hazards specifically preclude its use. Nonaqueous systems, using components listed by UL⁶ or FM⁷ should be used in areas not protected by automatic water sprinklers (see regulatory position C.6) or for other special applications.

b. Automatic water-type extinguishing systems include wet-pipe, preaction sprinkler, open head deluge, water spray, and systems utilizing automatic "on-off" flow control. Selection of a specific type of system should take into account parameters such as speed of operation, ambient temperature, and required volume and optimum use of water.

c. Wet-pipe conventional automatic sprinklers should be used in nonprocess areas of the facility.

d. For process areas, the sprinkler system selected should minimize the quantity of water used, the

unintentional operation of sprinkler heads, the spread of contamination by water, the extent of cleanup operations, and the possibility of criticality.

6. Special Automatic Extinguishing Systems

a. Areas not protected by automatic water sprinklers should be protected by some other fire suppression agents such as inert gas, carbon dioxide, high-expansion foam, or halogenated organic compounds.

b. Selection of a carbon dioxide extinguishing system should take into account such considerations as type of fire hazard, protection of personnel, and process enclosure pressurization.

c. Selection of a halogenated extinguishing system should take into account such considerations as process enclosure pressurization, protection of personnel, type of fire hazard, adverse reaction with pyrophoric metals, and corrosive thermal decomposition products.

d. For other special applications, such as solvent extraction areas, consideration should be given to inert gas, dry chemical, high-expansion foam, and "wet water" fire extinguishing systems. Dry chemical systems should not be used in the vicinity of filter installations in order to minimize fouling of filters.

7. Fire Protection Water Systems

a. Potable and process water systems should be arranged so they can be shut down without affecting the water supply to the fire systems. Fire protection water supply and distribution systems required for essential item protection should be designed and constructed so that continuity of protection in the event of any credible accident conditions is assured.

b. The water supply for the permanent fire protection installation should have a minimum of two reliable, independent sources and sufficient capacity (based on the maximum water demand) for fire fighting until other sources of water become available. Water supplies containing salt or other materials deleterious to the fire protection systems should be avoided wherever possible.

c. Water for fire fighting and fire suppression systems should be furnished to the site by a loop distribution system encircling the site buildings. Hydrants served by this system should be strategically located around the loop. Valves or valve assemblies listed by UL⁶ or FM³ should be provided for proper sectional control of the loop.

d. Fire water pumps should be equipped with automatic-starting features and be listed by UL⁶ or FM³ for fire service. Where water supply pressure is provided by pumps only, there should be a minimum of two pumps, at least one of which should be driven by nonelectrical means, preferably diesel engine. Emergency power should be supplied to an electric-driven fire pump in the event of failure of the normal power supply (see regulatory position C.I.c). Multiple fire water pumps

should be selected so that the maximum water demand for fire fighting will be supplied with the largest pump out of service.

Alarms for pump startup and operation and for power failure should be provided for the pump system and arranged to sound in a constantly attended location. A small pressurizing pump should be provided to automatically maintain the desired static pressure on the fire protection water supply system and minimize unnecessary operation of the fire water pumps.

e. Water should be supplied to each water spray extinguishing system from the water main loop around the facility. A water spray system may be used for heat removal for the high-efficiency filtration system serving as a final means of effluent cleaning for the ventilation systems. This water spray system should have a dedicated water supply, in addition to the normal water supply, sized to operate the system during a credible fire or explosion even if all other water supplies fail.

f. Collection systems should be provided for runoff water from fire-fighting activities and all other water breaks or leaks in process areas. Nuclear criticality, confinement, sampling, volume determination, and retrievability of liquids and solids should be considered in the design of collection systems. The size of the collection system for fire-fighting water should be based on the maximum amount of water which could be used in fighting a credible fire.

8. Manual Fire-Fighting Equipment

a. Provision should be made for portable fire extinguishers listed by UL⁶ or FM³ and suitable for use on specific hazards that may be encountered. The number of fire extinguishers required should be determined considering the area and arrangement of the plant or occupancy, the severity of the hazards, the anticipated classes of fires, and the distances to be traveled to reach extinguishers.

b. Standpipe and hose systems using components listed by UL⁶ or FM³ should be provided and installed in both process and nonprocess areas. Standpipes should be so located that they are protected against mechanical and fire damage. Hose outlets should be easily accessible.

9. Fire Detection, Signal, and Alarm Systems

a. Provision should be made for fire detection and alarm systems using components listed by UL⁶ or FM³. These systems should consist of fire detectors, signaling devices, and audible and visual indicators in a constantly attended location, as well as in appropriate locations about the plant. A means should be provided to monitor the status and functioning of the fire-detection, signal, and alarm systems as well as other fire protection system components located throughout the plant. Provision should be made for periodic testing and checkout of these systems.

b. A plant-wide public address and two-way communication system should be provided.

c. Manual fire alarm stations should be installed throughout the facility at readily accessible locations. These stations should be connected to the plant-wide alarm system.

d. Fires should be indicated audibly by alarms that are set off by fire suppression and detection systems. Each sprinkler system should be equipped with a flow alarm on the plant-wide alarm system.

e. Glove boxes and enclosures should be equipped with fire and/or smoke detectors to provide both a local alarm and a zone and location signal on the plant-wide alarm system.

f. The inlet duct to a multistage high-efficiency filter plenum serving as a final means of effluent cleaning for the ventilation systems should be provided with heat and smoke detectors that actuate a local alarm and an automatic fire alarm station on the plant-wide alarm system.

10. Gas-Handling Equipment

a. Hydrogen should be premixed to a nonflammable percentage with inert gas prior to introduction into the plant to control the potential hazard. The storage of unmixed gases should be external to the plant proper. Mixing should be performed before or at the plant entry point.

b. A nonflammable inert-gas-H₂ mixture within the flammability limits of gases and vapors listed in Bureau of Mines Bulletins 503⁷ and 627⁸ should be used in reducing gas atmosphere furnaces to preclude a hydrogen explosion. This atmosphere should be monitored by a suitable continuous monitoring system as specified in Regulatory Guide 3.7.⁹ In the event that pure hydrogen is required for process reasons, an enclosed offgas burner or other suitable means of offgas disposal should be used.

c. Entry of air into a furnace operating with reducing gas should be precluded by the use of inert-gas-purged locks or other suitable means at the furnace entry and exit. Furnace gas should be exhausted through an enclosed, filtered offgas system.

d. Process furnaces should be provided with a system for automatically shutting off the furnace gas and purging with inert gas in the event of power failure, loss of coolant water, loss of exhaust fan, overtemperature, or detection of hydrogen in the vicinity of the furnace.

e. Flammable gas should not be introduced into plutonium processing buildings except when specifically required for process reasons.

11. Flammable Materials

a. Special control should be exercised over the

handling of flammable, toxic, and explosive gases, chemicals, and materials admitted to the plutonium handling areas. Solvents and other flammable liquids, other than small quantities in use, should be stored in a separate building or unexposed storage area. Safety cans listed by UL¹⁰ or FM³ should be used for flammable liquids. Where practicable, covered noncombustible containers listed by UL¹⁰ or FM³ should be provided for combustible wastes.

b. Provisions should be made for isolation between incompatible chemicals, materials, and processes such as solvent extraction.

c. Flammable and combustible materials should not be stored in finished product storage areas or shipping areas.

12. Quality Assurance Program

A quality assurance program should be established for the design, construction, testing, operation, and maintenance of all structures, systems, equipment, and components of fire protection systems in accordance with the criteria in Appendix B of 10 CFR Part 50.

13. Procedures, Organization, and Training

a. Fire emergency procedures should be established for plant personnel. A plant fire protection organization should be trained and equipped to deal effectively with fire or explosion emergencies. Selected personnel should be specifically trained in fire-fighting techniques, industrial hygiene, health physics, and nuclear safety. Operating personnel and new employees should be periodically instructed in the proper use of plant fire-fighting equipment and emergency fire procedure. Decontamination procedures should be covered in training programs. Drills should be held periodically.

b. Arrangements should be made with offsite fire departments for assistance to the plant fire protection organization in the event of an onsite fire. Offsite fire departments should be familiarized with plant fire emergency procedures, fire protection organization, layout, and unusual hazards. Drills should be held periodically.

c. An approved recorded watchman service, central station supervisory service, or constant occupancy of all important areas should be provided to maintain a satisfactory degree of surveillance of the property at all times.

d. In establishing the programs in this section, consideration should be given to criteria implementing the Commission's regulations for the protection of special nuclear material in fuel manufacturing facilities.

REFERENCES

1. ANSI A2.1-1972, "Methods of Fire Tests of Building Construction and Materials," American National Standards Institute, (also designated ASTM E119-71). Copies may be obtained from American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.
2. Underwriters' Laboratories Building Materials List (latest edition). Copies may be obtained from Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Ill. 60611.
3. Factory Mutual Approval Guide (latest edition). Copies may be obtained from Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, Mass. 02062.
4. ASTM E84-70, "Method of Test for Surface Burning Characteristics of Building Materials," American Society for Testing and Materials. Copies may be obtained from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.
5. Regulatory Guide 3.12, "General Design Guide for Ventilation Systems of Plutonium Processing and Fuel Fabrication Plants," Directorate of Regulatory Standards, USAEC.
6. Underwriters' Laboratories Fire Protection Equipment List (latest edition). Copies may be obtained from Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Ill. 60611.
7. H. F. Coward and G. W. Jones, "Limits of Flammability of Gases and Vapors," Bureau of Mines Bulletin 503, 1952. Copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
8. M. G. Zabetakis, "Flammability Characteristics of Combustible Gases and Vapors," Bureau of Mines Bulletin 627, 1965. Copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
9. Regulatory Guide 3.7, "Monitoring of Combustible Gases and Vapors in Plutonium Processing and Fuel Fabrication Plants," Directorate of Regulatory Standards, USAEC.
10. Underwriters' Laboratories Gas and Oil Equipment List (latest edition). Copies may be obtained from Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Ill. 60611.