

# NFPA 851

## Fire Protection for Hydroelectric Generating Plants

### 1987 Edition



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

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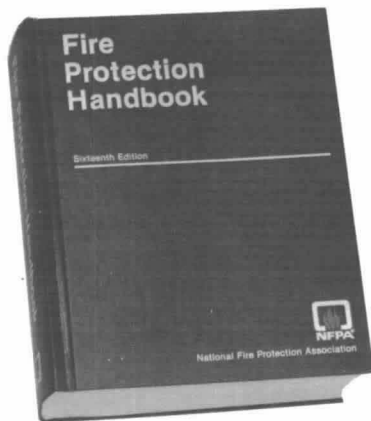
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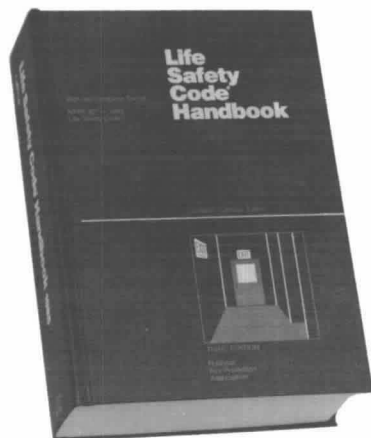
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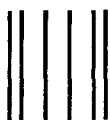
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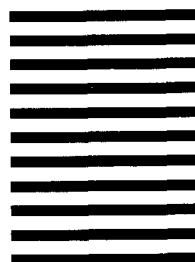
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## **NFPA 851**

### **Recommended Practice for Fire Protection for Hydroelectric Generating Plants**

#### **1987 Edition**

This first edition of NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*, was prepared by the Technical Committee on Non-Nuclear Power Generating Plants, and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1987 in Cincinnati, Ohio. It was issued by the Standards Council on June 10, 1987, with an effective date of June 30, 1987.

The 1987 edition of this standard has been approved by the American National Standards Institute.

#### **Origin and Development of NFPA 851**

The Committee on Non-Nuclear Power Generating Plants was organized in 1979 to have primary responsibility for documents on fire protection for non-nuclear electric generating plants. The Hydroelectric Subcommittee was formed in 1982 to write this document. This is the Committee's second document and the Hydroelectric Subcommittee's first document.

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**NFPA 851**  
**Recommended Practice for**  
**Fire Protection for**  
**Hydroelectric Generating Plants**  
**1987 Edition**

Information on referenced publications can be found in Chapter 7.

## Chapter 1 Introduction

**1-1 Scope.** This document provides recommendations (not requirements) for fire prevention and fire protection for hydroelectric generating plants. The term "hydroelectric generating plant" may also be referred to as "station," "project," "unit(s)," "facility," or "site."

### 1-2 Purpose.

**1-2.1** This document provides guidance for those charged with the design, construction, and operation of hydroelectric generating plants.

**1-2.2** This document provides fire prevention and fire protection recommendations primarily to safeguard physical property and continuity of power production, but its application will also enhance safety of site personnel. This document is not intended to restrict new technologies or alternate arrangements.

### 1-3 Application.

**1-3.1** This document is intended for use by persons knowledgeable in the application of fire protection to hydroelectric generating plants.

**1-3.2** The recommendations contained in this document are intended for new installations only, as the application to existing installations may not be practicable.

**1-3.3** It must be recognized that rigid uniformity of generating station design and operating procedures does not exist, and that each facility will have its own special conditions which impact on the nature of the installation. Many of the specific recommendations herein may require modification after due consideration of all local factors involved. Individual generating units, particularly those of less than 25 MW, should be given a cost-benefit analysis to determine the extent to which fire protection is justified.

### 1-4 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 that does not comply with the definition of either noncombustible or limited combustible.

**Combustible Liquid.** A liquid having a flash point at or above 100°F (37.8°C). (*See NFPA 30, Flammable and Combustible Liquids Code.*)

**Fire Barrier.** A fire barrier is a continuous membrane, either vertical or horizontal, such as a wall or floor assembly, that is designed and constructed with a specified fire resistance rating to limit the spread of fire, and which will also restrict the movement of smoke. Such barriers may have protected openings.

**Fire Loading.** The amount of combustibles present in a given area, expressed in Btu per sq ft (kJ/m<sup>2</sup>).

**Fire Point.** The lowest temperature at which a liquid in an open container will give off sufficient vapors to burn when once ignited. It is generally slightly above the flash point.

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

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

**Fire Protection Rating.** The time, in minutes or hours, that materials and assemblies used as opening protection have withstood a fire exposure as established in accordance with test procedures of NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, and NFPA 257, *Standard for Fire Tests of Window Assemblies*, as applicable.

**Fire Rated Penetration Seal.** An opening in a fire barrier for the passage of pipe, cable, duct, etc., that has been sealed so as to maintain a barrier rating.

**Fire Resistance Rating.** The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

**Flammable Liquid.** Any liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psia (276 kPa) absolute pressure at 100°F (37.8°C). (See NFPA 30, *Flammable and Combustible Liquids Code*.)

**High Fire Point Liquid.** A combustible dielectric liquid listed as having a fire point of not less than 572°F (300°C).

**Interior Finish.** The exposed interior surfaces of buildings including, but not limited to, fixed or movable walls and partitions, columns, and ceilings. Interior finish materials are grouped in the following classes:

**Class A Interior Finish.** Materials having flame spread 0–25, smoke developed 0–450 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Includes any material classified at 25 or less on the flame spread test scale and 450 or less on the smoke test scale where any element thereof when so tested does not continue to propagate fire.

**Class B Interior Finish.** Materials having flame spread 26–75, smoke developed 0–450 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Includes any material classified at more than 25, but not more than 75 on the flame spread test scale and 450 or less on the smoke test scale.

**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 ( $8.14 \times 10^6$  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  $\frac{1}{8}$  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 ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C (1382°F)*, and conforming to the criteria contained in Section 7 of the referenced standard shall be considered noncombustible.

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

**1-5 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 ASTM E380/ANSI Z210.1, *Metric Practice Guide*.

## Chapter 2 Administrative Controls

### 2-1 General.

**2-1.1** This chapter provides recommended criteria for the development of administrative procedures and controls necessary for the execution of the fire prevention and fire protection activities and practices for hydroelectric generating plants.

**2-1.2** The administrative controls recommended in this chapter should be reviewed and updated periodically.

**2-1.3** The intent of this chapter can be met by incorporating the features of this chapter in the plant's operating procedures or otherwise as determined by plant management.

### 2-2 Management Policy and Direction.

**2-2.1** Corporate management should establish a policy; and institute a program to promote the conservation of

property and continuity of operations as well as protection of safety to life by adequate fire prevention and fire protection measures at each facility.

**2-2.2** Proper preventative maintenance of operating equipment as well as adequate operator training are important aspects of a viable fire prevention program.

### 2-3 Fire Risk Evaluation.

**2-3.1** A fire risk evaluation should be initiated early in the design process to assure that the fire prevention and fire protection recommendations as described in this document have been evaluated in view of the plant's specific considerations regarding design, layout and anticipated operating requirements. The evaluation should result in a list of recommendations based upon acceptable means for separation or control of common and special hazards, the control or elimination of ignition sources, and the suppression of fires.

### 2-4 Fire Prevention Program.

**2-4.1** A written plant fire prevention program should be established, and as a minimum, should include the following:

(a) Firesafety information for all employees and contractors. This information should include, as a minimum, familiarization with fire prevention procedures, plant emergency alarms and procedures, and how to report a fire.

(b) Documented plant inspections including provisions for remedial actions to correct conditions which increase fire hazards.

(c) A description of the general housekeeping practices and the control of transient combustibles.

(d) Control of flammable and combustible liquids and gases in accordance with appropriate NFPA standards.

(e) Control of ignition sources to include smoking, grinding, welding and cutting. (*See NFPA 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.*)

(f) Fire report, including an investigation and a statement on the corrective action to be taken (*see Appendix A*).

### 2-5 Testing, Inspection, and Maintenance.

**2-5.1** Upon installation, all fire protection systems should be preoperationally inspected and tested in accordance with applicable NFPA standards. Where appropriate standards do not exist, inspection and test procedures outlined in the purchase and design specifications should be followed.

**2-5.2** All fire protection systems and equipment should be periodically inspected, tested, and maintained in accordance with applicable *National Fire Codes*® (*see Table 2-5.2 for guidance*).

**2-5.3** Testing, inspection, and maintenance should be documented with written procedures, results and follow-up actions recorded.

**Table 2-5.2 Reference Guide for Fire Equipment Inspection, Testing, and Maintenance**

Item	NFPA No.
Supervisory and Fire Alarm Circuits	71/72A-D/26/72H
Fire Detectors	72E/72H
Manual Fire Alarms	71/72H
Sprinkler Water Flow Alarms	13A/71/72H
Sprinkler and Water Spray Systems	15/13A
Foam Systems	11A/11C/16
Halogenated Agent, Chemical & CO <sub>2</sub> Systems	12/12A/17/12B
Fire Pumps & Booster Pumps	20
Water Tanks & Alarms	13A/71
P.I.V.'s and O.S. & Y. Valves	13A/26/72H
Fire Hydrants and Associated Valves	13A/24/26
Fire Hose and Standpipes	14/1962
Portable Fire Extinguishers & Hose Nozzles	10/1962
Fire Brigade Equipment	1972
Fire Doors	80
Smoke Vents	204M
Emergency Lighting	70
Radio Communication Equipment	1221

NOTE: Inspection intervals for unattended plants may be extended to normal plant inspections.

### 2-6 Impairments.

**2-6.1** A written procedure should be established to address impairments to fire protection systems and as a minimum this procedure should include the following:

(a) Identification and tracking of impaired equipment.

(b) Identification of personnel to be notified (e.g., plant fire brigade chief, public fire department, etc.).

(c) Determination of needed fire protection and fire prevention measures.

**2-6.2** Impairments to fire protection systems should be as short in duration as practical. If the impairment is planned, all necessary parts and personnel should be assembled prior to removing the protection system(s) from service. When an impairment is not planned, or when a system has discharged, the repair work or system restoration should be expedited.

**2-6.3** Once repairs are completed, tests should be made which will ensure proper operation and restoration of full fire protection equipment capabilities. Following restoration to service, the parties previously notified of the impairment should be advised.

### 2-7 Fire Emergency Plan.

**2-7.1.** A written fire emergency plan should be developed and, as a minimum, this plan should include the following:

(a) Response to fire alarms and fire systems supervisory alarms.

(b) Notification of personnel identified in the plan.

(c) Evacuation of personnel, not directly involved in fire fighting activities, from the fire area.

(d) Coordination with security forces or other designated personnel to admit public fire department and control traffic and personnel.

(e) Fire extinguishment activities.

(f) Periodic drills to verify viability of the plan.

(g) Control room operator(s) activities during fire emergencies. Approved breathing apparatus should be readily available in the control room area.

## 2-8 Fire Brigade.

**2-8.1** The size of the plant and its staff, the complexity of fire fighting problems and the availability and response time of a public fire department should determine the requirements for a fire brigade.

**2-8.2** If a fire brigade is provided, its organization and training, including special fire fighting conditions unique to hydroelectric plants, should be identified in written procedures.

NOTE: Recommendations contained in NFPA 600, *Recommendations for Organization, Training and Equipment of Private Fire Brigades*, and OSHA 1910.156 should be consulted for additional information.

## Chapter 3 General Plant Design

### 3-1 Plant Arrangement.

#### 3-1.1 Fire Area Determination.

**3-1.1.1** The hydroelectric generating plant should be subdivided into separate fire areas as determined by the fire risk evaluation for the purposes of limiting the spread of fire, protecting personnel, and limiting the resultant consequential damage to the plant. Fire areas should be separated from each other by approved fire barriers, spatial separation, or other approved means.

**3-1.1.2** Determination of fire area boundaries should be based on consideration of the following: types, quantity, density, and locations of combustible material; location and configuration of plant equipment; consequences of losing plant equipment; location of fire detection and suppression systems; and personnel safety/exit requirements. It is recommended that most fire barriers separating fire areas be of two hours fire resistance rating. If a fire area is defined as a detached structure, it should be separated from other structures by an appropriate distance (see NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*). Unless consideration of the above factors indicates otherwise, it is recommended that fire area boundaries be provided as follows:

(a) To separate cable spreading room(s) and cable tunnel(s) from adjacent areas.

(b) To separate the control room, computer room, or combined control/computer room from adjacent areas. Where the control room and computer room are

separated by a common wall, the wall need not have a fire resistance rating.

(c) To separate rooms with major concentrations of electrical equipment, such as switchgear room and relay room, from adjacent areas.

(d) To separate battery rooms from adjacent areas.

(e) To separate maintenance shop(s) from adjacent areas.

(f) To separate main fire pump(s) from reserve fire pump(s), when these pumps provide the only source of water for fire protection.

(g) To separate fire pumps from adjacent areas.

(h) To separate warehouses and combustible storage areas from adjacent areas.

(i) To separate emergency generators from each other and from adjacent areas.

(j) To separate oil storage and purification rooms from adjacent areas.

(k) To separate fan rooms and plenum chambers from adjacent areas (fire dampers may not be advisable in emergency ventilation ducts — see Section 3-4).

(l) To separate office areas from adjacent areas.

(m) To separate oil-filled governor equipment from cable concentrations or other combustible materials.

(n) To separate telecommunication rooms from adjacent areas.

#### 3-1.2 Outdoor Oil-Insulated Transformers.

**3-1.2.1** Outdoor oil-insulated transformers should be separated from adjacent structures and from each other by firewalls, spatial separation, or other approved means, for the purpose of limiting the damage and potential spread of fire from a transformer failure.

**3-1.2.2** Determination of the type of physical separation should be based on consideration of the following: type and quantity of oil in the transformer, size of a postulated oil spill (surface area and depth), type of construction of adjacent structures, power rating of the transformer, fire suppression systems provided, and type of electrical protective relaying provided.

**3-1.2.3** Unless consideration of the factors in 3-1.2.2 indicates otherwise, it is recommended that any oil-insulated transformer containing 500 gal (1893 L) of oil or more be separated from adjacent noncombustible or limited combustible structures by a 2-hr rated firewall, or by spatial separation in accordance with Table 3-1.2.3. Where a firewall is provided between structures and a transformer, it should extend vertically and horizontally as indicated in Figure 3-1.2.3.

NOTE: As a minimum, the firewall should extend at least 1 ft (0.31 m) above the top of the transformer casing and oil conservator tank and at least 2 ft (0.61 m) beyond the width of the transformer and cooling radiators.

**3-1.2.4** Unless consideration of the factors in 3-1.2.2 indicates otherwise, it is recommended that adjacent oil-insulated transformers containing 500 gal (1893 L) or more of oil, be separated from each other by a 2-hr rated

**Table 3-1.2.3 Outdoor Oil-Insulated Transformer Separation Criteria**

Transformer Oil Capacity	Minimum (Line-of-Sight) Separation Without Firewall
Less than 500 gal (1893 L)	See 3-1.2.2
500 to 5,000 gal (1893-18925 L)	25 ft (7.6 m)
over 5,000 gal (18925 L)	50 ft (15 m)

firewall, or by spatial separation in accordance with Table 3-1.2.3. Where a firewall is provided between transformers, it should extend at least 1 ft (0.31 m) above the top of the transformer casing and oil conservator tank and at least 2 ft (0.61 m) beyond the width of the transformer and cooling radiators.

**3-1.2.5** Where a firewall is provided, it should be designed to withstand the effects of exploding transformer bushings or lightning arrestors.

NOTE: A higher noncombustible shield may be provided to protect against the effects of an exploding transformer bushing.

**3-1.2.6** Where a firewall is not provided, the edge of the postulated oil spill (i.e. containment basin, if provided) should be separated by a minimum of 5 ft (1.5 m) from the exposed structure to prevent direct flame impingement on the structure.

**3-1.2.7** Outdoor transformers insulated with a high fire point liquid should be separated from each other and from adjacent structures which are critical to power generation by firewalls or spatial separation based on consideration of the factors in 3-1.2.2, 3-1.2.5, and 3-1.2.6.

### 3-1.3 Indoor Transformers.

**3-1.3.1** Oil-insulated transformers of greater than 100 gal (379 L) oil capacity installed indoors should be separated from adjacent areas by fire barriers of 3-hr fire resistance rating.

NOTE: Where multiple transformers of less than 100 gal (379 L) capacity each are located within close proximity, additional fire protection may be required based on the fire risk evaluation.

**3-1.3.2** Transformers insulated with high fire point liquids, having a rating above 35 KV and installed indoors, should be separated from adjacent areas by fire barriers of 3-hr fire resistance rating.

**3-1.3.3** Where transformers are protected by an automatic fire suppression system, the fire barrier fire resistance rating may be reduced to one hour.

### 3-1.4 Circuit Breakers.

**3-1.4.1** The preferred location for oil circuit breakers is outdoors. Consideration should be given to dry or gas-cooled circuit breakers for indoor applications.

**3-1.4.2** Oil-cooled circuit breakers should be separated from adjacent areas by fire barriers having a 3-hr fire resistance rating.

### 3-1.5 Openings in Fire Barriers.

**3-1.5.1** All openings in fire barriers should be provided with fire door assemblies, fire dampers, penetration seals (fire stops), or other approved means having a fire protection rating consistent with the designated fire resistance rating of the barrier. Windows in fire barriers (e.g., control rooms or computer rooms) should be provided with a fire shutter or automatic water curtain. Penetration seals provided for electrical and piping openings should be listed or should meet the requirements for an "F" rating when tested in accordance with ASTM E814, *Fire Tests of Through-Penetration Fire Stops*. Other test methods for qualifications of penetration seals, such as IEEE 634, *Testing of Fire Rated Penetration Seals*, may be considered for this application.

NOTE: Listed penetration seals for large diameter piping may not be commercially available. In such instances the design should be similar to listed configurations.

**3-1.5.2** Fire door assemblies, fire dampers, and fire shutters used in 2-hr rated fire barriers should be rated not less than 1½ hrs (see NFPA 80, *Standard for Fire Doors and Windows*).

**3-1.5.3** Fire dampers may be omitted in fire barriers of one hour or less fire resistance rating (see NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*).

### 3-2 Life Safety.

**3-2.1** Hydroelectric generating stations should be designed and constructed in accordance with the applicable sections of NFPA 101®, *Life Safety Code*®, to facilitate the incorporation of beneficial code features within the design criteria as they address the life safety of the building occupants.

**3-2.2** Section 4, Classification of Occupancy and Hazard of Contents, of NFPA 101, *Life Safety Code*, should be the determinant of the classification of occupancy for any given structure.

**3-2.3** Structures should be classified as follows, as defined in NFPA 101:

(a) General areas should be considered as special purpose industrial occupancies.

NOTE: Hydroelectric powerhouse structures protected in accordance with this document meet the intent of NFPA 101, *Life Safety Code*, for additional travel distances.

(b) Temporary occupancies and means of egress inside the structures and piers of large "bulb" units should be evaluated based on Occupancies in Unusual Structures.

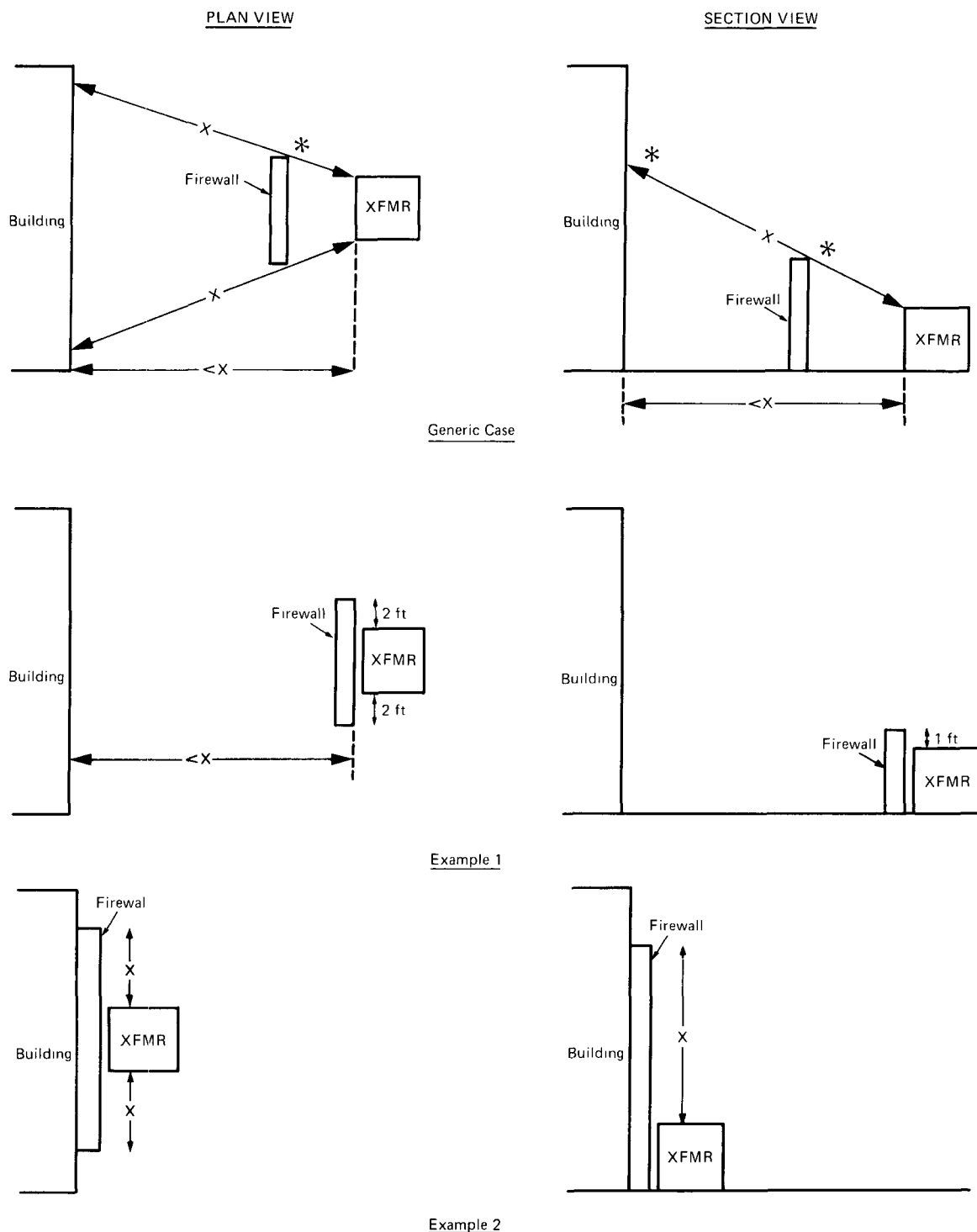
(c) Open structures and underground structures (e.g., tunnels) should be considered as occupancies in unusual structures.

(d) General office structures should be considered business occupancies.

(e) Warehouses should be considered storage occupancies.

### 3-3 Building Construction Materials.

**3-3.1** Construction materials being considered for

Notes:

X = Minimum separation distance from Table 3-1.2.3.

\* Also see Note in 3-1.2.3.

For SI Units: 1 ft = 0.305 m.

Figure 3-1.2.3 Illustration of Oil-Insulated Transformer Separation Recommendations.

hydroelectric generating plants should be selected based upon the fire risk evaluation using the following standards:

- (a) NFPA 220, *Standard on Types of Building Construction*
- (b) NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*
- (c) NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*
- (d) NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*
- (e) NFPA 259, *Standard Test Method for Potential Heat of Building Materials*.

**3-3.2** Building components for all powerhouse and subsurface structures should be of noncombustible or limited combustible materials except as noted in 3-3.3.

**3-3.3** Roof coverings should be Class A in accordance with NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*. Metal roof deck construction, when used, should be Class I listed or approved.

### **3-3.4 Interior Finish.**

**3-3.4.1** Cellular or foam plastic materials should not be used in interior finish in buildings critical to the generation processes or in subsurface structures.

**3-3.4.2** Interior finish in buildings critical to power generation should be Class A.

**3-3.4.3** Interior finish in building not critical to the generation processes should be Class A or Class B.

## **3-4 Smoke and Heat Venting, Heating, Ventilating, and Air Conditioning.**

### **3-4.1 Smoke and Heat Venting.**

**3-4.1.1** Smoke and heat vents are not substitutes for normal ventilation systems unless designed for dual usage. They should not be used to assist such systems for comfort ventilation. They should not be left open where they can sustain damage from high wind conditions. They should be included in surveillance programs to assure availability in emergency situations.

**3-4.1.2** Heat vents should be provided for areas identified by the fire risk evaluation. Where heat vents are provided, heat generated under fire conditions should be vented from its place of origin directly to the outdoors.

**3-4.1.3** Smoke venting should be provided for areas identified by the fire risk evaluation. Where smoke venting is provided, smoke should be vented from its place of origin in a manner that does not interfere with the operation of the plant.

**3-4.1.3.1** Separate smoke ventilation systems are preferred; however, smoke venting can be integrated into normal ventilation systems using automatic or manually positioned dampers and motor speed control. (See *NFPA 90A, Standard for the Installation of Air Conditioning*

*and Ventilating Systems and NFPA 204M, Guide for Smoke and Heat Venting*.) Smoke venting may also be accomplished through the use of portable smoke ejectors.

**3-4.1.3.2** Consideration should be given to smoke venting for the following areas: control room, cable spreading room(s), and switchgear room.

**3-4.1.3.3** In the areas with gaseous fire extinguishing systems, the smoke ventilation system should be properly interlocked to assure the effective operation of the gaseous fire extinguishing systems.

**3-4.1.3.4** Smoke removal system dampers, where installed, are normally operable only from an area immediately outside of, or immediately within, the fire area served since it is desired to have entry into, and inspection of, the fire area by fire fighting personnel prior to restoring mechanical ventilation to the fire area. Smoke removal system dampers may be operable from the control room if provisions are made to prevent premature operation. This can be accomplished using thermal interlocks or administrative controls.

**3-4.1.4** The fan power supply wiring and controls for smoke exhaust should be located external to the fire area served by the fan or be installed in accordance with the fire risk evaluation.

**3-4.1.5** Ventilation exhaust systems, particularly those for subsurface portions of underground facilities, should have fans able to continuously exhaust smoke and chemical fumes which may result from fires or from extinguishing fires. The design and selection of the fans and other elements of the system should take into account additional ventilation needs for removing smoke and high temperature gases. Therefore, the fan and its associated components, along with any ductwork, should be capable of handling high temperatures without deforming. The specific weight and volume of the heated air during a fire and the climatic conditions should also be considered. Total fan capacity should be provided so that ventilation requirements can be met with the largest fan out of service.

**NOTE:** When fire heats air and introduces products of combustion into the air in tunnels and in underground hydroelectric plants, the ventilation conditions which existed while the air was cold are altered. Frictional resistance to flow of heated air containing products of combustion is much greater than frictional resistance to flow of cold air which does not contain products of combustion. In the event of mild heating, increased resistance to flow would decrease the rate of ventilation. Then, after the fire is contained and the air is cooled, the air and smoke could be evacuated. Therefore, considerations for the health and safety of people underground should cause the designers to increase the rate of evacuating hot air containing smoke.

As the fire underground increases the temperature of the air, ventilation flow may be reversed. The cooler ventilating air may flow in one direction occupying much of the lower spaces of tunnels while plumes of heated air flow rapidly outward from the area of the fire beneath the tunnel ceiling in the opposite direction from, and above, the mass of cooler air. The designer must then consider the stratification of air flow, the numerous nodes or junctures between tunnels and shafts, the likely frictional resistances with and without fire, and the placement and capacities of the fans and fire stops.

Some useful information is available in the proceedings of Session XI, *Fires*, of the 2nd International Mine Ventilation Con-

gress. The designer is advised to be thoroughly familiar with *Chapter 41, Fire and Smoke Control*, in the *ASHRAE Handbook*.

### 3-4.2 Normal Heating, Ventilating, and Air Conditioning Systems.

**3-4.2.1** For normal heating, ventilating, and air conditioning systems, see NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, or NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, as appropriate.

**3-4.2.2** Air conditioning for the control room should provide a pressurized environment to preclude the entry of smoke in the event of a fire outside the control room.

**3-4.2.3** Plastic ducts, including listed fire retardant types, should not be used for ventilating systems. Listed plastic fire retardant ducts with appropriate fire protection may be used in areas with corrosive atmospheres.

**3-4.2.4** Fire dampers (doors) compatible with the rating of the barrier should be provided at the duct penetrations to the fire area (*see Section 3-1*) unless the duct is protected throughout its length by a fire barrier equal to the rating required of fire barrier(s) penetrated.

**3-4.2.5** Smoke dampers, where installed, should be installed in accordance with NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

**3-4.2.6** The fresh air supply intakes to all areas should be located remotely from the exhaust air outlets and smoke vents of other fire areas to minimize the possibility of drawing products of combustion into the plant.

**3-4.2.7** Fire hazards should not be located in the principal access or air supply (e.g., conduits, shafts, tunnels) in order to avoid loss of fresh air in the event of a fire.

### 3-5 Drainage.

**3-5.1** Provisions should be made in all fire areas of the plant for removal of all liquids directly to safe areas or for containment in the fire area without flooding of equipment and without endangering other areas (*see Appendix A of NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection*). Drainage and prevention of equipment flooding should be accomplished by one or more of the following:

- (a) Floor drains.
- (b) Floor trenches.
- (c) Open doorways or other wall openings.
- (d) Curbs for containing or directing drainage.
- (e) Equipment pedestals.
- (f) Pits, sumps, and sump pumps.

NOTE: Draining the space above the turbine head cover by gravity may not be possible. Both AC and DC drainage pumps discharging into piping leading to the station sump are often provided with suction in the well where the shaft first extends

above the gland seal. In addition, gravity drainage may be impossible from some of the enclosed volumes of "bulb" units. In such cases, accumulated liquids from oil spills and from fire suppression must be pumped to sumps or to other containment volumes.

**3-5.2** The provisions for drainage and any associated drainage facilities (pits, sumps, and sump pumps) should be sized to accommodate all of the following:

- (a) The spill of the largest single container of any flammable and/or combustible liquid in the area.
- (b) The maximum design volume of discharge from the expected number of fire hose lines operating for a minimum of 20 minutes.
- (c) The maximum design volume of discharge from the fixed fire suppression system(s) operating for a minimum of 20 minutes.

NOTE: The provisions for drainage and any associated drainable facilities (pits, sumps, drains to downstream surge chamber and/or tail tunnels or tailrace, and sump pumps) for underground power plants should be sized to accommodate the discharge from the maximum expected discharge of fixed fire suppression system(s) operating for a minimum of two hours.

**3-5.3** Floor drainage from areas containing flammable or combustible liquids should be trapped to prevent the spread of burning liquids beyond the fire area.

**3-5.4** Where gaseous fire suppression systems are installed, floor drains should be provided with adequate seals or the fire suppression system should be sized to compensate for the loss of fire suppression agent through the drains.

**3-5.5** Drainage facilities should be provided for outdoor oil-insulated transformers or the ground should be sloped such that oil spills will flow away from buildings, structures, and adjacent transformers. Unless drainage from oil spills is accommodated by sloping the ground around transformers away from structures or adjacent equipment, consideration should be given to providing curbed areas or pits around transformers. The pit and/or drain system should be sized in accordance with 3-5.2. The curbed area or pit may be filled with uniformly graded, crushed stone, as a means of minimizing ground fires.

**3-5.6** For facilities consisting of more than one generating unit, a curb or trench drain should be provided on solid floors where the potential exists for an oil spill, such that oil released from an incident on one unit will not expose an adjacent unit.

**3-5.7** For environmental reasons, liquid discharges resulting from oil spills or operation of a fire suppression system may have to be treated (e.g., oil separation).

**3-5.8** An emergency power supply should be provided for principal drainage pumps in situations where flooding would be dangerous.

### 3-6 Emergency Lighting.

**3-6.1** Emergency lighting should be provided for means of egress in accordance with the NFPA 101, *Life Safety Code*.

**3-6.2** Emergency lighting should be provided for critical plant operations areas.



### 3-7 Lightning Protection.

3-7.1 Lightning protection, where required, should be provided in accordance with NFPA 78, *Lightning Protection Code*.

## Chapter 4 General Fire Protection Systems and Equipment

### 4-1 General Considerations.

4-1.1 All fire protection systems, equipment and installations should be dedicated to fire protection purposes.

### 4-2 Water Supply.

4-2.1 The water supply for the permanent fire protection installation should be based on the largest fixed fire suppression system demand plus the maximum hose stream demand of not less than 500 gpm (31.5 L/sec) for a two-hour duration.

4-2.2 If a single water supply is utilized, two independent connections should be provided. If a situation can arise in which the primary water supply may become unavailable (e.g., dewatering of penstocks), an auxiliary supply should be provided. Each supply should be capable of meeting the requirements in 4-2.1.

4-2.2.1 Where multiple fire pumps are required, the pumps should not be subject to a common failure, electrical or mechanical, and should be of sufficient capacity to meet the fire flow requirements determined by 4-2.1 with the largest pump out of service.

4-2.2.2 Fire pumps should be automatic starting with manual shutdown. The manual shutdown should be at the pump controllers only. (See NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*.)

NOTE: For unattended stations see Section 4-9.

4-2.2.3 If tanks are of dual-purpose use, a standpipe or similar arrangement should be provided to dedicate the amount determined by 4-2.1 for fire protection use only. (See NFPA 22, *Standard for Water Tanks for Private Fire Protection*.)

4-2.2.3.1 Where tanks are used, they should be filled from a source capable of replenishing the two-hour supply for the fire protection requirement in an eight-hour period. The eight-hour (time) requirement for refilling may be extended if the initial supply exceeds the minimum storage requirement on a volume per time ratio basis. It is normally preferred for the refilling operation to be accomplished on an automatic basis.

4-2.3 Each water supply should be connected to the yard main by separate connections, arranged and valve controlled to minimize the possibility of multiple supplies being impaired simultaneously.

4-2.4 In some rivers and tributaries, the existence of microorganisms limits the use of raw water for fire pro-

tection without treatment. Consideration of water quality may prevent long-term problems relating to fire protection water supply.

4-2.5 Upstream water is frequently the fire protection water supply. Water for fire suppression should not be taken downstream from any closure device in a penstock, flume, or forebay.

### 4-3 Valve Supervision.

4-3.1 All fire protection water system control valves should be under a periodic inspection program (see Chapter 2) and should be supervised by one of the following methods:

(a) Electrical supervision with audible and visual signals in the main control room or other constantly attended location.

(b) Locking valves open. Keys should be made available only to authorized personnel.

(c) Sealing of valves. This option should be followed only when valves are within fenced enclosures under the control of the property owner.

### 4-4 Supply Mains and Hydrants.

4-4.1 Supply mains and fire hydrants should be installed on the plant site. (See NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.)

4-4.1.1 Remotely located plant-related facilities should be reviewed on an individual basis to determine the need for fire protection. If excessively long extensions of underground fire mains are necessary for fire protection at these locations, it may be acceptable to supply this need from an available service main in the immediate area.

4-4.1.2 The supply mains should be looped and of sufficient size to supply the flow requirements determined by 4-2.1 to any point in the loop considering the most direct path to be out of service. Pipe sizes should be designed to encompass any anticipated expansion and future water demands.

4-4.1.3 Indicator control valves should be installed to provide adequate sectional control of the fire main loop to minimize plant protection impairments.

4-4.2 Each hydrant should be equipped with a separate shutoff valve located on the branch connection to the supply main.

### 4-5 Standpipe and Hose Systems.

4-5.1 Standpipe and hose systems should be installed (see NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*). The standpipe and hose system is an extension of the fire main and hydrant system. The hose stations should be capable of delivering the hose stream demand for the various hazards in buildings.

4-5.2 Fire main connections for standpipes should be arranged so that a fire main break may be isolated without interrupting service simultaneously to both fixed protection and hose connections protecting the same

hazard or area. For the important hazards the arrangement should permit operation of at least two hose lines on a fire. For areas of high water demand, the installation should meet the requirements for a Class III system (see *NFPA 14, Standard for the Installation of Standpipe and Hose Systems*). For other areas, a Class II system may suffice.

**4-5.3** The standpipe piping should be capable of providing minimum volume and pressure for the highest hose stations.

**4-5.4** Due to the open arrangement of these plants, locations of hose stations should take into account safe egress for personnel operating hose lines.

**4-5.5** Spray nozzles having shutoff capability and listed for use on electrical equipment should be provided on hoses located in areas near energized electrical equipment.

#### **4-6 Portable Fire Extinguishers.**

**4-6.1** For first aid fire protection, suitable fire extinguishers should be installed in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

#### **4-7 Fire Suppression Systems and Equipment — General Requirements.**

**4-7.1** Fire suppression systems and equipment should be provided in all areas of the plant as identified in Chapter 5 or as determined by the fire risk evaluation. The applicable NFPA standards should be used for design of the fire suppression systems except as modified in this chapter.

**4-7.2** Selection of extinguishing agent should be based upon:

- (a) Type of hazard.
- (b) Effect of agent discharge on equipment.
- (c) Health hazards.

NOTE: Personnel hazards created by the discharge of CO<sub>2</sub> should be considered in the design of the system. The design should take into account the immediate release of CO<sub>2</sub> into the protected area and the possibility of CO<sub>2</sub> leakage, migration, and settling into adjacent areas and lower elevations of the plant. See NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, for hazards to personnel. As a minimum, if CO<sub>2</sub> systems are provided, they should be provided with an odorizer for alerting personnel, and breathing apparatus should be provided for operators in areas that cannot be abandoned.

#### **4-8 Fire Signaling Systems.**

**4-8.1** Fire detection and automatic fixed fire suppression systems should be equipped with local audible and/or visual signals with annunciation in the main control room or another constantly attended location (see *NFPA 72D, Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*). Audible fire alarms should be distinctive from other plant system alarms.

**4-8.2** Automatic fire detectors should be installed in accordance with NFPA 72E, *Standard on Automatic Fire Detectors*.

**4-8.3** The fire signaling system or plant communication system should provide the following:

(a) Manual fire alarm devices (e.g., pull boxes or page party stations) should be installed in all occupied buildings. Manual fire alarm devices should be installed for remote yard hazards as identified by the fire risk evaluation.

(b) Plant-wide audible fire alarm and/or voice communication systems for purposes of personnel evacuation and alerting of plant emergency organization. The plant public address system, if provided, should be available on a priority basis.

(c) Two-way communications for the plant emergency organization during emergency operations.

(d) Means to notify the public fire department.

#### **4-9 Unattended Plants.**

**4-9.1** Hydroelectric plants that are operated unattended, or with minimal staffing, present special fire protection concerns.

**4-9.2** Consideration should be given both to the delayed response time of the fire brigade or public fire fighting personnel (which may be several hours) and to the lack of personnel available to alert others on site to a fire condition.

**4-9.3** The fire risk evaluation should address delayed response and lack of communication. This may establish the need to provide additional fire protection measures to prevent a major fire spread prior to the arrival of fire fighting personnel. The delayed response by personnel to the site may necessitate automatic shutoff of fire pumps.

**4-9.4** If automatic water based fire suppression systems are utilized, a cycling deluge valve should be considered. The arrangement will depend on the type of system and the hazard protected. Thermal detection is recommended. (System design should be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, or NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.)

**4-9.5** Remote annunciation of the fire signaling panel to one or more constantly attended locations is critical for emergency response. The fire signaling panel should be located at the entry to the plant.

**4-9.6** An emergency lighting system for critical operating areas which depends on batteries or fuel supplies should be manually operated from a switch at the entry to the plant. The emergency lighting may consist either of fixed units or of portable lights. See 3-6.2.

**4-9.7** It is important that the responding fire brigade or public fire fighting forces be familiar with access, plant fire protection systems, emergency lighting, specific hazards, and methods of fire control. This should be reflected in the plant fire emergency plan (see *Section 2-7*).

## Chapter 5 Identification and Protection of Hazards

**5-1 General.** The identification and selection of fire protection systems should be based on the fire risk evaluation. This chapter identifies fire and explosion hazards in hydroelectric generating stations and specifies the recommended protection criteria unless the fire risk evaluation indicates otherwise.

### 5-2 Turbine-Generator Hydraulic Control and Lubricating Oil Systems.

**5-2.1** Hydraulic control systems should use a listed fire resistant fluid. If a listed fire resistant fluid is not used, hydraulic control equipment should be protected as described below.

Determination of the need for fire resistant fluid should be based on the quantity of fluid involved in the system; whether or not equipment which utilizes this fluid will operate hot or be exposed to external sources of ignition; and whether exposure problems are created for adjacent equipment by the use of non-fire resistant fluid.

**5-2.2** Whenever possible, oil piping should be welded and flanged to minimize the possibility of an oil leak due to severe vibration. Fire extinguishing systems, where installed for hydraulic control equipment, should include protection for reservoirs, other equipment, valves and associated piping.

**5-2.3** Oil piping should be routed away, or be shielded from, electrical equipment or other sources of ignition.

**5-2.4** Fixed fire protection for this equipment, where provided, should be as follows:

**5-2.4.1** Automatic wet pipe sprinkler systems utilizing a design density of 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) for the entire hazard area (see 3-5.3).

**5-2.4.2** Automatic foam-water sprinkler systems providing a density of 0.16 gpm/ft<sup>2</sup> (0.11 L/sec-m<sup>2</sup>).

**5-2.4.3** Halon 1301 or CO<sub>2</sub> gaseous systems of either the local application or total flooding types. Safety considerations associated with these extinguishing agents should be evaluated prior to the selection of gas-type protection systems.

NOTE: When areas/rooms are located beneath areas protected by CO<sub>2</sub> (or other extinguishing gases), consideration should be given in the design for the possible settling of the gas to lower levels and its effect on personnel who may be in these areas.

**5-2.5** Consideration for protection of horizontal/vertical turbine bearings should be made based on the fire risk evaluation.

**5-2.6** Curbs [minimum 6 in. (0.15 m) high] and/or drains (see Chapter 3) should be provided around oil storage tanks within the oil storage or oil purification areas.

**5-2.7** Fire extinguishing systems, where installed for lube oil systems employing combustible-type oil, should

include protection for the reservoirs, pumps and all oil lines, especially where unions exist on piping and beneath any shielded area where flowing oil can collect. Facilities not provided with curbs or drains should extend coverage for a distance of 20 ft (6 m) from the oil lines, when measured from the outermost oil line.

**5-2.8** Clean/dirty oil storage areas should be protected based on the fire risk evaluation. As this area generally represents the largest concentrated oil storage in the plant, the designer should consider, as a minimum, the installation of fixed automatic fire protection systems, and the ventilation and drainage requirements in Chapter 3.

### 5-3 Generator Windings.

**5-3.1** Protection of generator windings should be provided by gaseous systems (Halon 1301 or CO<sub>2</sub> total flooding type) and/or waterspray rings.

**5-3.2** Gaseous suppression systems should be actuated by protective relays and/or fire detection systems.

**5-3.3** Waterspray rings should be manually actuated or automatically actuated by an interlocked system which requires the unit to be tripped.

### 5-4 Control, Computer, and Communication Rooms.

**5-4.1** Control/computer/telecommunication rooms should meet applicable requirements of NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*.

**5-4.2** A smoke detection system should be installed throughout these rooms including walk-in-type consoles, above suspended ceilings where combustibles are installed, and below raised floors. Where the only combustibles above the false ceiling are cables in conduit and the space is not used as a return air plenum, smoke detectors may be omitted from this area.

**5-4.3** A pre-action sprinkler system, designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, for these rooms should be considered during the fire risk evaluation. In addition, Halon 1301 fire extinguishing systems, designed in accordance with NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, should be considered for areas beneath raised floors which contain cables, or for areas or enclosures containing equipment that is of high value or is critical to power generation. Individual equipment/cabinet protection could be considered in lieu of total flooding systems.

### 5-5 Cable Concentrations.

**5-5.1** Consideration should be given to the use of fire retardant cable insulation such as the types which pass the flame propagation test of the Institute of Electrical and Electronics Engineers (IEEE-383).

**5-5.2** Areas with significant concentrations of combustible cable jacketing or oil-filled cable should be protected with automatic sprinkler or waterspray systems. However, if water-type systems cannot be used, foam,

total flooding CO<sub>2</sub>, or Halon 1301 should be provided. System designs and installation should be in accordance with: NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*; NFPA 11A, *Standard for Medium and High Expansion Foam Systems*; NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*; NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*; NFPA 13, *Standard for the Installation of Sprinkler Systems*; and NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.

**5-5.3** Sprinkler or water spray systems should be designed for a density of 0.30 gpm/ft<sup>2</sup> (0.20 L/sec-m<sup>2</sup>) over 2500 ft<sup>2</sup> (232 m<sup>2</sup>). This coverage is for area protection. Individual cable tray tier coverage may be required based on the fire risk evaluation.

**5-5.4** A suitable alternative for combustible jacket cable automatic protection would be cable with fire retardant coatings. The method of protection should be based on the fire risk evaluation.

Care should be exercised in selection of fire retardant coatings to ensure that derating of the cable is considered. Consideration should also be given to the ability to add or remove cables and to make repairs to cables protected with fire retardant coatings.

**5-5.5** Grouped electrical cables should be routed away from exposure hazards or protected as required by the fire risk evaluation. In particular, care should be taken to avoid routing cable trays near sources of ignition or flammable/combustible liquids. When such routing is unavoidable, cable trays should be designed and arranged to prevent the spread of fire.

## **5-6 Cable Tunnels.**

**5-6.1** When protection is required by the fire risk evaluation, cable tunnels should be protected by automatic water spray, automatic wet-pipe sprinkler or foam systems designed in accordance with NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*; NFPA 11A, *Standard for Medium and High Expansion Foam Systems*; NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*; or NFPA 16, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*.

**5-6.2** Portable high expansion foam generators may be used to supplement fixed fire protection system(s). (See NFPA 11C, *Standard for Mobile Foam Apparatus*).

**5-6.3** Ventilation and drainage should be provided for these areas in accordance with Chapter 3.

## **5-7 Outdoor Transformers.**

**5-7.1** Oil-filled main, station service, and startup transformers should be protected with automatic water spray systems per NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection* (see Chapter 3).

## **5-8 Indoor Oil-Filled Electrical Equipment.**

**5-8.1** Automatic sprinkler, foam-water, and water spray systems should be considered for oil-filled electrical

equipment in accordance with NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*; NFPA 11A, *Standard for Medium and High Expansion Foam Systems*; NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*; and NFPA 16, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*. Where the hazard is not great enough to warrant a fixed fire suppression system, automatic fire detection should be considered (see 4-8.2).

## **5-9 Battery Rooms.**

**5-9.1** Battery rooms should be provided with ventilation to limit the concentration of hydrogen to one percent by volume.

## **5-10 Switchgear and Relay Rooms.**

**5-10.1** Switchgear rooms and relay rooms should be provided with smoke detection systems.

## **5-11 Emergency Generators.**

**5-11.1** The installation and operation of emergency generators should be in accordance with NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

**5-11.2** Emergency generators located within main plant structures should be protected by automatic sprinkler, water spray, foam-water sprinkler, or gaseous-type extinguishing systems. Sprinkler and water spray protection systems should be designed for a 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) density over the fire area.

When gaseous suppression systems are used on combustion engines, which may be required to operate during the system discharges, consideration should be given to the supply of engine combustion air and outside air for equipment cooling.

## **5-12 Air Compressors.**

**5-12.1** Automatic sprinkler protection, with a density of 0.25 gpm/sq ft (0.17 L/sec-m<sup>2</sup>) over the fire area, should be considered for air compressors containing a large quantity of oil. Design and installation should be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. Where the hazard is not great enough to warrant a fixed fire suppression system, automatic fire detection should be considered (see 4-8.2).

## **5-13 Hydraulic Systems for Gate and Valve Operators.**

**5-13.1** Hydraulic control systems should use a listed fire resistant fluid. Automatic sprinkler protection, designed for a density of 0.25 gpm/sq ft (0.17 L/sec-m<sup>2</sup>) over the fire area should be considered for hydraulic systems containing a large quantity of oil. Design and installation should be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. Where the hazard is not great enough to warrant a fixed fire suppression system, automatic fire detection should be considered (see 4-8.2).

## **5-14 Fire Pumps.**

**5-14.1** Rooms housing diesel-driven fire pumps should be protected by automatic sprinkler, water spray, or foam-water sprinkler systems. If sprinkler and water

spray protection systems are provided they should be designed for a density of 0.25 gpm/sq ft (0.17 L/sec-m<sup>2</sup>) over the fire area.

#### 5-15 Storage Rooms and Shops.

5-15.1 Automatic sprinklers should be provided for storage rooms and shops containing combustible materials that present an exposure to surrounding areas that are critical to plant operations. See NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 231, *Standard for General Storage*; and NFPA 231C, *Standard for Rack Storage of Materials*. (For oil storage rooms, see 5-2.8.)

#### 5-16 Warehouses.

5-16.1 Automatic sprinklers should be provided for warehouses which contain high-value equipment and combustible materials that are critical to power generation or that constitute a fire exposure to other important buildings. See NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 231, *Standard for General Storage*; and NFPA 231C, *Standard for Rack Storage of Materials*.

#### 5-17 Auxiliary Heating.

5-17.1 The storage and piping systems of fuels in the gaseous or liquefied state should comply with NFPA 31, *Standard for the Installation of Oil Burning Equipment*; NFPA 54, *National Fuel Gas Code*; NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gas*; NFPA 85A, *Standard for Prevention of Furnace Explosions in Fuel-Oil and Natural Gas-Fired Single Burner Furnaces*; NFPA 85B, *Standard for Prevention of Furnace Explosions in Natural Gas-Fired Multiple Burner Boiler-Furnaces*; and NFPA 85D, *Standard for Prevention of Furnace Explosions in Fuel Oil-Fired Multiple Burner Boiler-Furnaces*, as applicable.

## Chapter 6 Fire Protection for the Construction Site

### 6-1 Introduction.

6-1.1 Although many of the activities in hydroelectric generating plant construction are similar to the construction of other large industrial plants, sites for hydroelectric generating plants are frequently located in remote areas with restricted access and limited construction space. Congested or distant construction facilities may be required and specialized activities such as deep excavation and tunneling may be encountered. An above average level of construction fire protection is justified due to the life safety consideration of the large number of on-site personnel, high value of materials, and length of construction period.

6-1.2 Requirements for plants and areas under construction should be determined from NFPA 241, *Standard for Safeguarding Building Construction and Demolition Operations*, except as modified by this chapter.

### 6-2 Administration.

6-2.1 The responsibility for fire prevention and fire protection for the entire site during the construction period should be clearly defined. The administrative responsibilities should be to develop, implement, and periodically update as necessary the measures outlined in this practice.

6-2.2 The responsibility for fire prevention and fire protection programs among various parties on site should be clearly delineated. The fire protection program which is to be observed, and the owner's right to administration and enforcement should be established.

6-2.3 The fire prevention and fire protection program should include a fire risk evaluation of the construction site and construction activities at any construction camp (see Chapter 2).

6-2.4 Written administrative procedures should be established for the construction site and such procedures should, as a minimum, be in accordance with Sections 2-4, *Fire Prevention Program*; 2-5, *Testing, Inspection and Maintenance*; and 2-7, *Fire Emergency Plan*.

6-2.5 Security guard service, including recorded rounds, should be provided through all areas of construction during times when construction activity is not in progress (see NFPA 601, *Standard for Guard Service in Fire Loss Prevention*).

(a) The first round should be conducted one-half hour after the suspension of work for the day. Thereafter, rounds should be made every hour.

(b) Where partial construction activities occur on second and third shifts, the security service rounds may be modified to include only unattended or sparsely attended areas.

(c) In areas where automatic fire detection or extinguishing systems are in service, with alarm annunciation at a constantly attended location, rounds may be decreased to every three hours following the suspension of work, after the first round.

6-2.6 Construction should be coordinated so that planned permanent fire protection systems are installed and placed in service as soon as possible, at least prior to the introduction of any major fire hazards identified in Chapter 5. In-service fire detection and fire extinguishing systems provide important protection for construction materials, storage, etc., even before the permanent hazard is present. Temporary fire protection systems may be warranted during certain construction phases. The need and type of protection should be determined by the individual responsible for fire prevention and fire protection. Construction and installation of fire barriers and fire doors should be given priority in the construction schedule.

### 6-3 Site Clearing, Excavation, and Tunneling.

#### 6-3.1 Site Clearing.

6-3.1.1 Prior to clearing forest and brush covered areas, the owner should ensure that a written fire control plan is prepared and that fire fighting tools and equipment are

made available as recommended by NFPA 295, *Standard for Wildfire Control*. Contact should be made with local fire and/or forest agencies for current data on restrictions and fire potential, and to arrange for necessary permits.

**6-3.1.2** All construction vehicles and engine-driven portable equipment should be equipped with effective spark arrestors. Vehicles equipped with catalytic converters should be prohibited from wooded and heavily vegetated areas.

**6-3.1.3** Fire tools and equipment should be used for fire emergencies only and should be distinctly marked.

**6-3.1.4** Each site utility vehicle should be equipped with at least one fire fighting tool, portable fire extinguisher, or backpack pump filled with 4 to 5 gallons (15 to 19 L) of water.

**6-3.1.5** Cut trees, brush, and other combustible spoil should be disposed of promptly.

**6-3.1.6** Where it is necessary to dispose of combustible waste by onsite burning, designated burning areas should be established with approval by the owner, and should be in compliance with federal, state, and local regulations and guidelines. The contractor should coordinate burning with the agencies responsible for monitoring fire danger in the area, and obtain all appropriate permits prior to the start of work (see Section 6-2).

**6-3.1.7** Local conditions may require the establishment of fire breaks by clearing or use of selective herbicides in areas adjacent to property lines and access roads.

### **6-3.2 Excavation and Tunneling.**

**6-3.2.1** Construction activities related to tunnels, shafts, and other underground excavations are strictly regulated by federal and state agencies. Fire prevention consists of adequate ventilation, good housekeeping, and limiting the types of fuel, explosives, and combustibles underground as well as adjacent to entrances and ventilation intakes. Inspection of site conditions and the testing of air quality should be assigned to qualified personnel specifically trained in the use of those instruments specified by the regulating agency.

**6-3.2.2** Pre-excavation geologic surveys should include tests for carbonaceous or oil-bearing strata, peat, and other organic deposits which may be the source of combustible dusts or explosive gases.

**6-3.2.3** The use of vehicles and equipment requiring gasoline, LP gas, and other fuels in excavations with limited air circulation should be restricted.

**6-3.2.4** A general plan of action for use in times of emergency should be prepared for every underground excavation (see Section 6-2).

### **6-3.3 Construction Equipment.**

**6-3.3.1** Construction equipment should meet the requirements of NFPA 121, *Standard on Fire Protection for Self-Propelled Mobile Surface Mining Equipment*, and NFPA 512, *Standard for Truck Fire Protection*.

### **6-4 Construction Warehouses, Shops, Offices, and Construction Camps.**

**6-4.1** All structures that are to be retained as part of the completed plant should be constructed of materials as required in Chapter 3, and should comply with other requirements of this document for the completed plant.

**6-4.2** Construction warehouses, offices, trailers, sheds, and other facilities for the storage of tools and materials should be located with consideration of their exposure to major plant buildings or other important structures. These buildings should be located according to the requirements of NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, and NFPA 224, *Standard for Homes and Camps in Forest Areas*, as applicable.

**6-4.3** Mobile homes should be installed and located according to the requirements of NFPA 501A, *Standard for Firesafety Criteria for Manufactured Home Installations, Sites and Communities*. Insulating materials utilized in mobile homes should be noncombustible.

**6-4.4** Large central office or storage facilities, when provided, should be located so as not to expose major plant buildings or other important structures. They may be of substantial value, contain high value computer equipment, irreplaceable construction records, or other valuable contents, the loss of which may result in significant construction delays. The fire risk evaluation may indicate a need for automatic sprinklers or other protection, the desirability of subdividing the complex to limit values exposed by one fire, or a combination of the above.

**6-4.5** Construction camps comprised of mobile buildings arranged with the buildings adjoining each other to form one large fire area should be avoided. If buildings cannot be adequately separated, consideration should be given to installing fire walls between units or installing automatic sprinklers throughout the buildings.

**6-4.6** Construction camp buildings should be designed and installed in accordance with NFPA 101, *Life Safety Code*.

**6-4.7** Area fire alarms should be connected to a constantly attended central location such as fire station or site manager's office with monitoring and central alarm control. Dormitory buildings and bunkhouses should be provided throughout with smoke detection. The alarm panels for the individual buildings served should be located at the entrance to the building. Detector installation should conform to NFPA 72D, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*, and NFPA 72E, *Standard on Automatic Fire Detectors*.

**6-4.7.1** The location for central alarm control should be provided with the following:

- (a) Remote fire pump start button.
- (b) Manual siren start/stop button.
- (c) Provision for alerting the fire crew by VHF radio, fire alert paging, etc.

(d) Monitors for communication between security guard and fire crew at place of fire.

(e) Radio link between security guards' office and the respective fire department.

**6-4.8** Warehouses and shops may contain materials whose loss or damage would cause a delay in startup and/or severe financial loss. Although some of these structures are considered to be "temporary" and will be removed upon completion of the plant, the fire and loss potential should be thoroughly evaluated and protection provided where warranted. Where the fire risk evaluation indicates a need for protection for warehouses and shops the following guidelines should apply.

**6-4.8.1** Building construction materials should be non-combustible or limited combustible. See Chapter 3.

**6-4.8.2** Automatic sprinkler systems should be designed and installed in accordance with the applicable NFPA standards (*NFPA 13, Standard for the Installation of Sprinkler Systems*, *NFPA 231, Standard for General Storage*, or *NFPA 231C, Standard for Rack Storage of Materials*). Waterflow alarms should be provided and located so as to be monitored at a constantly attended location as determined by the individual responsible for fire prevention and fire protection.

**6-4.8.3** Air-supported structures are sometimes used to provide temporary warehousing space. Although the fabric envelope may be a fire retardant material, the combustibility of contents and their value must be considered, as with any other type of warehouse. Because it is impractical to provide automatic sprinkler protection, air-supported structures should only be used for noncombustible storage. An additional consideration is that relatively minor fire damage to the fabric envelope may leave the contents exposed to the elements.

**6-4.9** Temporary enclosures, including trailers, inside permanent plant buildings, should be prohibited except where permitted by the individual responsible for fire prevention and fire protection. Where the floor area of a combustible enclosure exceeds 100 sq ft (9.3 sq m) or where the occupancy presents a fire exposure, the enclosure should be protected with an approved automatic fire extinguishing system.

**6-4.10** Construction kitchens should have automatic protection installed over the fryers. Guidance is provided in Chapter 7 of NFPA 96, *Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment*.

**6-4.11** Vehicle repair facilities should meet the requirements of NFPA 88B, *Standard for Repair Garages*.

**6-4.12** The handling, storage, and dispensing of flammable liquids and gases should meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, and NFPA 395, *Standard for the Storage of Flammable and Combustible Liquids on Farms and Isolated Construction Projects*.

## **6-5 Construction Site Laydown Areas.**

**6-5.1** Fire hydrant systems with an adequate water supply should be provided in laydown areas where the need is determined by the individual responsible for fire prevention and fire protection (*see Chapter 4*).

**6-5.2** Combustible materials should be separated by a clear space to allow access for manual fire fighting equipment (*see 6-8*). Access should be provided and maintained to all fire fighting equipment including fire hoses, extinguishers, and hydrants.

## **6-6 Temporary Construction Materials.**

**6-6.1** The use of listed pressure-impregnated fire retardant lumber or listed fire retardant coatings would be generally acceptable. Pressure-impregnated fire retardant lumber must be used in accordance with its listing and manufacturer's instructions. When exposed to the weather or moisture (e.g., draft tubes, semi-spiral cases), the fire retardant used must be suitable for this exposure. Fire retardant coatings are not acceptable on walking surfaces or surfaces subject to mechanical damage.

**6-6.2** For tarpaulins and plastic films of listed weather resistant, fire retardant materials, see the Large Scale Test specified in NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*.

**6-6.3** Consideration should be given to providing sprinkler protection for combustible form work where a fire could cause substantial damage or construction delays.

## **6-7 Underground Mains, Hydrants, and Water Supplies.**

**6-7.1** Where practical, the permanent underground yard system, fire hydrants, and water supply (at least one totally reliable source of required capacity), as recommended in Chapter 4, should be installed during the early stages of construction. Where provision of all or part of the permanent underground system and water supply is not practical, temporary systems should be provided. Temporary water supplies should be hydrostatically tested, flushed, and arranged to maintain a high degree of reliability, including protection from freezing and loss of power. When using construction water in permanent systems, adequate strainers should be provided to prevent clogging of the system by foreign objects and dirt.

**6-7.2** The necessary reliability of construction water supplies, including redundant pumps, arrangement of primary and backup power supplies, and use of combination service water and construction fire protection water should be reviewed by the individual responsible for fire prevention and fire protection.

**6-7.3** Hydrants should be installed, as recommended by Chapter 4, in the vicinity of main plant buildings, important warehouses, office or storage trailer complexes, important outside structures and laydown areas with combustible construction, construction camp complexes, or combustible concrete form work (e.g., draft tube and turbine-generator blockouts). Where practical, the underground main should be arranged utilizing post indicator valves to minimize the possibility that any one

break will remove from service any fixed water extinguishing system or leave any area without accessible hydrant protection.

**6-7.4** A fire protection water supply should be provided on the construction site and should be capable of furnishing the largest of the following for a minimum of 2-hr duration:

- (a) 750 gpm (47 L/sec), or
- (b) The in-service fixed water extinguishing system with the highest water demand plus 500 gpm (32 L/sec) for hose streams.

NOTE 1: The highest water demand should be determined by the hazards present at the stage of construction, which may not correspond with the highest water demand of the completed plant.

NOTE 2: The water supply should be sufficient to provide adequate flow and pressure for hose connections at the highest elevation.

**6-7.5** Vehicles, equipment, materials, and supplies should not be placed so that access to fire hydrants and other fire fighting equipment is obstructed.

**6-7.6** Fixed systems should be provided as soon as construction permits. These systems should be provided in continuous operating condition.

**6-7.7** As fixed water extinguishing systems are completed, they should be placed in service, even when the available construction phase fire protection water supply is not adequate to meet the system design demand. The extinguishing system can at least provide some degree of protection, especially where the full hazard is not yet present. However, when the permanent hazard is introduced, the water supply should be capable of providing the designed system demand.

**6-7.8** On sites where large differences in elevations exist between construction facilities, satisfying pressure requirements at the highest elevation may result in hazardous pressure conditions at the lower elevations unless some approved method of pressure regulation is included in the system. Attempting to compensate for high-pressure conditions by partially opening dry barrel hydrants may result in erosion at the hydrant thrust block and should be avoided.

## **6-8 Fire Suppression Systems and Equipment.**

**6-8.1** In general, fire suppression equipment should be:

- (a) Provided where risk of fire exists.
- (b) Suitable as to type and size for combating any likely fire.
- (c) Protected from mechanical damage.
- (d) Located for easy access at well identified stations.
- (e) Maintained in good operating condition.
- (f) Protected from freezing.

**6-8.1.1** Portable fire extinguishers of suitable capacity should be provided where:

- (a) Flammable liquids are stored or handled.
- (b) Temporary oil- or gas-fired equipment is used.

(c) A tar or asphalt kettle is used.

(d) Where welding or open flames are in use.

See NFPA 10, *Standard for Portable Fire Extinguishers*.

**6-8.2** First aid fire fighting equipment should be provided. See NFPA 600, *Recommendations for Organization, Training and Equipment of Private Fire Brigades*, and NFPA 241, *Standard for Safeguarding Building Construction and Demolition Operations*.

**6-8.3** Hoses and nozzles should be available at strategic locations inside hose cabinets, hose houses, or on dedicated fire response vehicles.

**6-8.4** No fire protection equipment or device should be made inoperable or used for other purposes.

**6-8.5** If fire hose connections are not compatible with local fire fighting equipment, adapters should be made available.

## **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 the 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 11-1983, *Standard for Low Expansion Foam and Combined Agent Systems*

NFPA 11A-1983, *Standard for Medium and High Expansion Foam Systems*

NFPA 11C-1986, *Standard for Mobile Foam Apparatus*

NFPA 12-1985, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A-1987, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 12B-1985, *Standard on Halon 1211 Fire Extinguishing Systems*

NFPA 13-1987, *Standard for the Installation of Sprinkler Systems*

NFPA 13A-1987, *Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems*

NFPA 14-1986, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 15-1985, *Standard for Water Spray Fixed Systems for Fire Protection*



NFPA 16-1986, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*

NFPA 17-1985, *Standard for Dry Chemical Extinguishing Systems*

NFPA 20-1987, *Standard for the Installation of Centrifugal Fire Pumps*

NFPA 22-1987, *Standard for Water Tanks for Private Fire Protection*

NFPA 24-1987, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 26-1983, *Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection*

NFPA 30-1987, *Flammable and Combustible Liquids Code*

NFPA 31-1987, *Standard on the Installation of Oil Burning Equipment*

NFPA 37-1984, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*

NFPA 54-1984, *National Fuel Gas Code*

NFPA 58-1986, *Standard for the Storage and Handling of Liquefied Petroleum Gases*

NFPA 70-1987, *National Electrical Code*

NFPA 71-1987, *Standard for the Installation, Maintenance and Use of Signaling Systems for Central Station Service*

NFPA 72A-1987, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service*

NFPA 72B-1986, *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1986, *Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1986, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*

NFPA 72E-1987, *Standard on Automatic Fire Detectors*

NFPA 72H-1984, *Guide for Testing Procedures for Local, Auxiliary, Remote Station and Proprietary Protective Signaling Systems*

NFPA 75-1987, *Standard for the Protection of Electronic Computer/Data Processing Equipment*

NFPA 78-1986, *Lightning Protection Code*

NFPA 80-1986, *Standard for Fire Doors and Windows*

NFPA 80A-1987, *Recommended Practice for Protection of Buildings From Exterior Fire Exposures*

NFPA 85A-1987, *Standard for Prevention of Furnace Explosions in Fuel-Oil and Natural Gas-Fired Single Burner Boiler-Furnaces*

NFPA 85B-1984, *Standard for Prevention of Furnace Explosions in Natural Gas-Fired Multiple Burner Boiler-Furnaces*

NFPA 85D-1984, *Standard for Prevention of Furnace Explosions in Fuel Oil-Fired Multiple Burner Boiler-Furnaces*

NFPA 88B-1985, *Standard for Repair Garages*

NFPA 90A-1985, *Standard for the Installation of Air Conditioning and Ventilating Systems*

NFPA 90B-1984, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*

NFPA 96-1987, *Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment*

NFPA 101-1985, *Life Safety Code*

NFPA 121-1986, *Standard on Fire Protection for Self-Propelled and Mobile Surface Mining Equipment*

NFPA 204M-1985, *Guide for Smoke and Heat Venting*

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

NFPA 224-1985, *Standard for Homes and Camps in Forest Areas*

NFPA 231-1987, *Standard for General Storage*

NFPA 231C-1986, *Standard for Rack Storage of Materials*

NFPA 241-1986, *Standard for Safeguarding Building Construction and Demolition Operations*

NFPA 251-1985, *Standard Methods of Fire Tests of Building Construction and Materials*

NFPA 252-1984, *Standard Methods of Fire Tests of Door Assemblies*

NFPA 253-1984, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*

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

NFPA 256-1987, *Standard Methods of Fire Tests of Roof Coverings*

NFPA 257-1985, *Standard for Fire Tests of Window Assemblies*

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

NFPA 295-1985, *Standard for Wildfire Control*

NFPA 501A-1987, *Standard for Firesafety Criteria for Manufactured Home Installations, Sites and Communities*

NFPA 512-1984, *Standard for Truck Fire Protection*

NFPA 600-1986, *Recommendations for Organization, Training and Equipment of Private Fire Brigades*

NFPA 601-1986, *Standard for Guard Operations in Fire Loss Prevention*

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NFPA 1221-1984, *Standard for the Installation Maintenance and Use of Public Fire Service Communications Systems*

NFPA 1962-1979, *Standard for Care, Use and Maintenance of Fire Hose Including Connections and Nozzles*

NFPA 1972-1987, *Standard on Helmets for Structural Fire Fighting*

## 7-1.2 Other Publications.

### 7-1.2.1 ANSI Publications. American National Stan-

dards Institute Inc., 1450 Broadway, New York, NY 10018.

**ANSI Z210.1** *Metric Practice Guide*

**7-1.2.2 ASTM Publications.** 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 (See ANSI Z210.1)

ASTM E814, *Fire Tests of Through-Penetration Fire Stops*

**7-1.2.3 IEEE Publications.** Institute of Electrical and Electronics Engineers, 345 East 47 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*

IEEE 634, *Testing Fire Rated Penetration Seals*

**7-1.2.4 OSHA Publications.** Occupational Safety and Health Administration, Department of Labor, Washington, DC.

OSHA 1910.156, *Fire Brigades*, 1981

29 CFR 1926, *Safety and Health Regulations for Construction, Subpart S - Tunnels and Shafts, Caissons, Cofferdams and Compressed Air*

**7-1.2.5** Mine Safety and Health Administration, Washington, DC.

30 CFR 1 through 199, *Mineral Resources*

**7-1.2.6 ASHRAE Publication.** American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329.

*ASHRAE Handbook - Chapter 41, Fire and Smoke Control*

**7-1.2.7** Proceedings of XI International Mine Ventilation Congress.

## Appendix A

## Sample Fire Report

*This Appendix is part of the recommendations of this NFPA document.*

Name of Company \_\_\_\_\_

Date of fire: \_\_\_\_\_ Time of Fire: \_\_\_\_\_ Operating Facility \_\_\_\_\_

Under Construction \_\_\_\_\_

Plant or location where fire occurred: \_\_\_\_\_

Description of facility, fire area or equipment (include nameplate rating) involved: \_\_\_\_\_

Cause of fire, such as probable ignition source, initial contributing fuel, equipment failure causing ignition, etc: \_\_\_\_\_

Story of fire, events and conditions, preceding, during and after the fire: \_\_\_\_\_

Types and approx. quantities of portable extinguishing equipment used: \_\_\_\_\_

Was fire extinguished with portable equipment only? \_\_\_\_\_ Public fire department called \_\_\_\_\_

Employee Fire Brigade at this location? \_\_\_\_\_ Qualified for incipient fires? \_\_\_\_\_

For interior structural fires? \_\_\_\_\_

Was fixed fire extinguishing equipment installed? \_\_\_\_\_

Type of fixed extinguishing system: \_\_\_\_\_

Automatic operation \_\_\_\_\_, manually actuated \_\_\_\_\_ or both \_\_\_\_\_

Specific type of detection devices: \_\_\_\_\_

Did fixed extinguishing system control \_\_\_\_\_ and/or extinguish fire? \_\_\_\_\_

Did detection devices and extinguishing system function properly? \_\_\_\_\_

"no," why not? \_\_\_\_\_

Estimated direct damage due to fire, \$ \_\_\_\_\_, or, between \$ \_\_\_\_\_ and \$ \_\_\_\_\_

Estimated additional (consequential) loss, \$ \_\_\_\_\_. Nature of additional loss: \_\_\_\_\_

Estimated time to complete repairs/replacement of damaged equipment/structure: \_\_\_\_\_

Number of persons injured: \_\_\_\_\_ Number of fatalities: \_\_\_\_\_

What corrective or preventive suggestions would you offer to other utilities who may have similar equipment, structures or extinguishing systems? \_\_\_\_\_

Submitted by \_\_\_\_\_ Title \_\_\_\_\_

## Index

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