National Fire Protection Association

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2008 SEP -8 P 12: 04

September 4, 2008

Ms. Patricia W. Silvey, Director
Office of Standards, Regulations, and Variances
Mine Safety and Health Administration
1100 Wilson Blvd. Room 2350
Arlington, VA 22209-3939

RE: RIN 1219-AB60 Conveyor Belt Combustion Toxicity and Smoke Density

Dear Ms. Silvey:

The National Fire Protection Association (NFPA) commends the Mine Safety and Health Administration (MSHA) for providing the opportunity to comment on their efforts to improve the safety of underground coal mining operations, in particular by revising its approval test in existing regulations on flame-resistant conveyor belts for use in underground coal mines.

As you may be aware, our NFPA 120 Standard for Fire Prevention and Control (2004) covers minimum requirements for reducing loss of life and property from fire and explosion in the following: (1) Underground bituminous coal mines (2) Coal preparation plants designed to prepare coal for shipment (3) Surface building and facilities associated with coal mining and preparation (4) Surface coal and lignite mines.

In addition the NFPA Technical Committee on Fire Tests administers 27 standards that address in significant detail fire testing of materials for a wide range fire test situations and applications. Some of these documents, such as NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter* (2004), may be directly applicable.

All NFPA codes and standards are developed through the voluntary consensus process and are accredited by the American National Standards Institute (ANSI). Further, they are all publically available in read-only format through the NFPA website at www.nfpa.org. Congress, in several cases has mandated the adoption of NFPA codes and standards, including, for example, NFPA 101 Life Safety Code, for health care facilities participating in Medicaid and Medicare programs.

Research reports from the Fire Protection Research Foundation relating to this subject may be useful, and these are available for download to the public at the Foundation's

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website at www.nfpa.org/foundation. Although it does not specifically address smoke density or the toxic potency of smoke and other products produced from combustion of conveyor belting or similar materials, the Foundation's research report, *Characterizing Smoke from Residential Materials* (2007) and the accompanying data may be helpful to you.

Please contact this office to request additional copies of these documents. If you have any questions or require additional information concerning this matter, please do not hesitate to contact me at (202) 898-1229 or Casey Grant, Program Director, Fire Protection Research Foundation at (617) 984- 7284 .

Sincerely,

Nancy McNabb, AIA
Director, Government Affairs

cc: c grant

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

NFPA 120

Standard for

Fire Prevention and Control in Coal Mines

2004 Edition

This edition of NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, was prepared by the Technical Committee on Mining Facilities and acted on by NFPA at its May Association Technical Meeting held May 23–26, 2004, in Salt Lake City, UT. It was issued by the Standards Council on July 16, 2004, with an effective date of August 5, 2004, and supersedes all previous editions.

This edition of NFPA 120 was approved as an American National Standard on August 5, 2004.

Origin and Development of NFPA 120

In 1977, with the formation of the Mining Committee, this standard, NFPA 120, formerly NFPA 653, was reassigned to the Committee on Mining Facilities. The change in numerical identity of the standard was in keeping with the numbering sequence assigned to the Mining Committee for other documents now under development. NFPA 120 represents a complete revision of former NFPA 653 and also includes changes in style in accordance with the NFPA *Manual of Style*.

The 1971 edition of NFPA 653, *Coal Preparation Plants*, was the same as the 1959 edition and was adopted at the NFPA 1971 Annual Meeting. The 1959 edition of NFPA 653 was prepared by the NFPA Committee on Dust Explosion Hazards and was adopted at the 1958 Annual Meeting with an amendment adopted in 1959.

The 1994 edition of NFPA 120 included a variety of technical and editorial updates. Previous editions not already mentioned include versions issued in 1984 and 1988.

The 1999 edition addressed the need for emergency lighting, expanded the types of portable fire extinguishers used, and expanded and clarified the types of fire suppression equipment used. The water supply requirements also were clarified.

The 2004 edition applies the NFPA *Manual of Style* to the document. It also incorporates all the appropriate sections of NFPA 121 and NFPA 123, which was done in an effort to consolidate common requirements.

The Coal Mining Task Group for the 2004 edition consists of the following members: Matt Bujewski, Chair, Marsh Inc.; Tim Gierer, Alltype Fire Protection; Dennis Brohmer, Ansul Inc.; Jay Senn, Peabody Energy Group; Charlie Russell, Arch Coal Inc.; Brent Sullivan, Coteau Properties; Carol Boring, Mine Safety and Health Administration; Alex Smith, NIOSH; Mario Orozco, Zurich Services Corp.; Mike Wegleitner, Falkirk Mining Co. (alternate for Brent Sullivan); and Bill Wilson, U.S. Department of Labor (alternate for Carol Boring).

Technical Committee on Mining Facilities

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Rep. FM Global/FM Research

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Bruce Watzman, National Mining Association, DC [U]
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James J. (J. J.) Kenny, Marsh Canada Ltd., Canada [I]
(Alt. to M. J. Bujewski)
David A. Pelton, Tyco Suppression Systems, WI [M]
(Alt. to D. D. Brohmer)

Richard P. Bielen, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

Committee Scope: This Committee shall have primary responsibility for documents on safeguarding life and property against fire, explosion, and related hazards associated with underground and surface coal and metal and nonmetal mining facilities and equipment.

Contents

NFPA 120

Standard for

Fire Prevention and Control in Coal Mines

2004 Edition

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for mandatory extracts are given in Chapter 2 and those for nonmandatory extracts are given in Annex B. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex B.

Chapter 1 Administration

1.1 Scope.

1.1.1* This standard shall cover minimum requirements for reducing loss of life and property from fire and explosion in the following:

(1) Underground bituminous coal mines
(2) Coal preparation plants designed to prepare coal for shipment
(3) Surface building and facilities associated with coal mining and preparation
(4) Surface coal and lignite mines

1.1.2 This standard shall not apply to the following:

(1) Flammable and combustible liquids produced in underground coal mines
(2) Other equipment and processes, such as coal pulverizers, used to condition coal for firing in boilers at power-generating plants or gasification plants or for utilization in certain special processes

1.2 Purpose. This standard shall be intended for the use and guidance of those charged with designing, constructing, purchasing, testing, installing, examining, approving, operating, or maintaining fire prevention, fire protection, or fire-fighting equipment in underground bituminous coal mines, coal preparation plants, and surface mining equipment and processes.

1.3* Application.

1.3.1 This standard shall be based on the current state of the art, and application to existing installations shall not be mandatory. Nevertheless, operating mines are urged to adopt those features of this standard that are considered applicable and reasonable for existing installations.

1.3.2 At times it will be necessary for those responsible for the storage of flammable and combustible liquids and the use of diesel-powered equipment within underground bituminous coal mines to consult an experienced fire protection specialist, and it shall be permitted.

1.3.3 Only those skilled in fire protection shall be considered competent to design and supervise the installation of mine fire protection systems.

1.3.4 Coal preparation plants shall be designed by experienced persons familiar with fire and explosion hazards in coal-processing plants.

1.3.5 At times it will be necessary for those charged with purchasing, testing, approving, and maintaining fire protection equipment for self-propelled and surface mining equipment to consult an experienced fire protection specialist.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.4.4 Operators are urged to avail themselves of any information that will prevent dust dispersions, eliminate sources of ignition, or otherwise reduce fire and explosion hazards by improving conditions in their plants.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2002 edition.
NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2002 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2002 edition.
NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2003 edition.
NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2002 edition.
NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.
NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.
NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks,* 2003 edition.
NFPA 58, *Liquefied Petroleum Gas Code,* 2004 edition.
NFPA 68, *Guide for Venting of Deflagrations,* 2002 edition.
NFPA 69, *Standard on Explosion Prevention Systems,* 2002 edition.
NFPA 70, *National Electrical Code®,* 2002 edition.
NFPA 72®, National Fire Alarm Code®, 2002 edition.
NFPA 85, *Boiler and Combustion Systems Hazards Code,* 2004 edition.
NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.
NFPA *101®, Life Safety Code®,* 2003 edition.
NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response,* 2001 edition.
NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 2004 edition.
NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting,* 2001 edition.
NFPA 1961, *Standard on Fire Hose,* 2002 edition.
NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose,* 2003 edition.
NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2004 edition.

2.3 Other Publications.

2.3.1 API Publications. American Petroleum Institute, 1220 L Street NW, Washington, DC 20005.

API 2000, *Standard for Venting Atmospheric and Low-Pressure Storage Tanks,* 1992 edition.

2.3.2 U.S. Bureau of Mines Publications. National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161.

Schedule 2G.

2.3.3 USDA Forest Service Publication. U.S. Department of Agriculture Forest Service, 1400 Independence Ave., SW, Washington, DC 20250-0003.

Specification 182.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is 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.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

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

3.2.7 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Adequate Ventilation. Air volume and velocity shall be sufficient to dilute, render harmless, and carry away flammable or explosive concentrations of dusts and vapors.

3.3.2 Atmospheric Tank. A storage tank that has been designed to operate at pressures from atmospheric through 1.0 psig (760 mm Hg through 812 mm Hg) measured at the top of the tank.

3.3.3* Boiling Point. The temperature at which the vapor pressure of a liquid equals the surrounding atmospheric pressure. For purposes of defining the boiling point, atmospheric pressure shall be considered to be 14.7 psia (760 mm Hg). For mixtures that do not have a constant boiling point, the 20 percent evaporated point of a distillation performed in accordance with ASTM D 86, *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure,* shall be considered to be the boiling point.

3.3.4 Closed Container. A container as herein defined, so sealed by means of a lid or other device that neither liquid nor vapor will escape from it at ordinary temperatures. [**30A:**3.3]

3.3.5 Coal Preparation. The separation, crushing, screening, washing, drying, storage, and loadout of coal to make ready for market.

3.3.6 Combustible. Capable of undergoing combustion.

3.3.7* Combustible Liquid. Any liquid that has a closed-cup flash point at or above 37.8°C (100°F).

3.3.8 Combustible Liquid Storage Area — Fixed. An area used for storage of Class II and Class III combustible liquids that is infrequently moved, and where the aggregate quantity present shall not exceed 5000 gal (18,925 L). Handling of liquids incidental to transfer can take place within a storage area.

3.3.9 Combustible Liquid Storage Area — Mobile. Self-propelled or mobile equipment fitted with suitable containers or tanks and other related fixtures used for the storage, transport, and dispensing of Class II and Class III combustible liquids. The aggregate quantity of combustible liquid carried on such equipment does not exceed 1000 gal (3785 L).

3.3.10 Combustible Liquid Storage Area — Portable. An area used for storage of Class II and Class III combustible liquids that is periodically moved, and where the aggregate quantity present does not exceed 1000 gal (3785 L). Handling of liquids incidental to transfer can take place within a storage area.

3.3.11 Combustion. A chemical process of oxidation that occurs at a rate fast enough to produce heat and usually light in the form of either a glow or flame. [**211**:3.3]

3.3.12 Container. Any vessel of 450 L (119 gal) or less capacity used for transporting or storing liquids. [**30**:3.3]

3.3.13 Diesel-Powered Equipment. Any device powered by a diesel engine. [**122**:3.3]

3.3.14 Dry Pipe Sprinkler System. A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers. [**13**:3.4]

3.3.15 Emergency Egress. An egress from a compartment or work station in emergencies when the normal egress is unusable.

3.3.16 Equipment Operator. The authorized person who starts, controls, or stops mining equipment.

3.3.17 Fire Detector. An automatic device designed to detect the presence of fire and initiate action. [**122**:3.3]

3.3.18 Fire-Resistant Construction. Masonry walls or equivalent having at least a 1-hour fire rating, including compressible materials having an equivalent fire resistance capability.

3.3.19 Fire-Resistant Enclosure. An enclosure that is constructed of fire-resistant construction.

3.3.20 Fire Risk Assessment. The evaluation of the relative danger of the start and spread of fire; the generation of smoke, gases, or toxic fumes; and the possibility of explosion or other occurrence endangering the lives and safety of personnel or causing significant damage to property. [**122**:3.3]

3.3.21 Fixed Fire Suppression System. A total flooding or local application system consisting of a fixed supply of extinguishing agent permanently connected for fixed agent distribution to fixed nozzles that are arranged to discharge an extinguishing agent into an enclosure (total flooding), directly onto a hazard (local application), or a combination of both; or an automatic sprinkler system. [**122**:3.3]

3.3.22* Flammable Liquid. A liquid that has a closed-cup flash point that is below 37.8°C (100°F) and a maximum vapor pressure of 2068 mm Hg (40 psia) at 37.8°C (100°F).

3.3.23 Flammable Liquid Storage Area. Area used for storage of Class I liquids.

3.3.24* Flash Point. The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with the air, near the surface of the liquid or within the vessel used, as determined by the appropriate test procedure and apparatus specified in 1.7.4 [of NFPA 30]. [**30**:1.7]

3.3.25 Hand Hose Line System. A hose and nozzle assembly connected by fixed piping or connected directly to a supply of extinguishing agent. [**122**:3.3]

3.3.26 Hydrant. A valved hose connection.

3.3.27 Important Structures. A structure that is considered not expendable in an exposure fire.

3.3.28 Inby. A mining term that means in the direction of the face of the mine or further into the mine.

3.3.29 Intrinsically Safe. As applied to equipment and wiring, equipment and wiring that are incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. [**99**:3.3]

3.3.30 Liquid. Any material that has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials.*

3.3.31 Low Pressure Tank. A storage tank designed to withstand an internal pressure above 0.5 psig (3.5 kPa) but not more than 15 psig (102.4 kPa).

3.3.32 Mine Operator. Any owner, lessee, or other person who operates, controls, or supervises a mine. [**122**:3.3]

3.3.33 Mobile Equipment. Wheeled, skid-mounted, track-mounted, or rail-mounted equipment capable of moving or being moved.

3.3.34 Noncombustible. Not capable of supporting combustion.

3.3.35 Normal Operation. The regular performance of those functions for which a machine or accessory is designed.

3.3.36 Operating Area. An area where mining of coal is taking place or area where construction is underway.

3.3.37 Outby. A mining term that means in the direction away from the face of the mine or toward the outside of the mine; opposite of inby.

3.3.38 Permissible Equipment. A completely assembled machine or accessory for which formal approval has been issued, allowing operation in a potentially explosive methane and air-mixture environment.

3.3.39 Pipeline System. An arrangement of piping, valves, connections, and allied equipment installed in a mine for the purpose of transporting, transferring, or dispensing flammable or combustible liquids. [**122**:3.3]

3.3.40 Portable Extinguisher. An extinguisher of the hand-held or wheeled type that is capable of being carried or moved about, or a transportable system consisting of a hose reel or rack, hose, and discharge nozzle assembly connected to a supply of suppressant.

3.3.41 Portable Tank. Any closed vessel having a liquid capacity over 227 L (60 U.S. gal) and not intended for fixed installation, including intermediate bulk containers (IBCs), as defined and regulated by the U.S. Department of Transportation.

3.3.42 Pressure Vessel. A container or other component designed in accordance with the ASME *Boiler and Pressure Vessel Code.* [**52**:3.3]

3.3.43 Safety Can. A listed container, of not more than 18.9 L (5 gal) capacity, having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

3.3.44 Self-Closing Door. Doors that, when opened and released, returns to the closed position. [**80**:1.4]

3.3.45 Self-Propelled Equipment. Any unit that contains a motive power train as an integral part of the unit and is not rail mounted. [**122**:3.3]

3.3.46 Suitable. That which is appropriate and has the qualities or qualifications to meet a given purpose, occasion, condition, function, or circumstance. [**122**:3.3]

3.3.47 Tank. A closed vessel having a liquid capacity in excess of 227 L (60 gal).

3.3.48 Task Trained. Instructed in the safety and health aspects and safe work procedures of the task prior to performing such tasks.

3.3.49 Unattended. Any machine or device that is not regularly operated by a miner or not in direct line of sight of a miner that is assigned within 500 ft of the equipment during each production shift.

Chapter 4 Underground Mining Operations

4.1 General. This chapter shall cover minimum requirements for reducing loss of life and property from fire in underground coal mines.

4.2* Fire Prevention. Precautions shall be taken to prevent the ignition of flammable vapors and combustible materials.

4.2.1 Smoking materials, matches, and lighters shall not be allowed underground.

4.2.2 Methane monitors shall be provided on equipment used to cut coal from the face.

4.2.2.1 The methane monitors shall alarm at 1 percent concentration and be interlocked to shut down the machine at a 2 percent concentration of methane.

4.2.3 Cutting and Welding. Cutting and welding and compressed gas usage shall be in accordance with Section 7.1.

4.2.4 Housekeeping.

4.2.4.1 Maintenance and operating practices shall prevent the accidental release of flammable or combustible liquids.

4.2.4.2 A cleanup plan shall be established, implemented, and monitored to prevent the accumulation of loose coal and other combustible materials.

4.2.4.3 Where flammable or combustible liquids are used or handled, means shall be provided to dispose of leakage or spills.

4.2.4.4 Waste receptacles shall be provided for combustible refuse.

4.2.4.5 Routes designated for access to fire protection equipment shall be kept clear of obstructions.

4.2.5 Underground Maintenance Shops.

4.2.5.1* Underground maintenance shops that are intended for use longer than 6 months shall be enclosed structures of fire-resistant construction, including floor, roof, roof supports, doors, and door frames, or shall be protected with an automatic fire suppression system. *(See 5.3.7.3 for information on fire suppression systems.)*

4.2.5.2 The shop area shall be ventilated directly to a return airway.

4.2.6* Belt Conveyors. Belt conveyors installed in underground coal mines shall, as a minimum, meet all the requirements of Section 9.4 of this standard.

4.2.7 Hydraulic Fluids.

4.2.7.1 Fire-resistant hydraulic fluid shall be approved by the authority having jurisdiction.

4.2.7.2 Unattended hydraulic equipment shall employ fire-resistant hydraulic fluid and be protected by an automatic fire suppression system.

4.2.7.3 Where fire-resistant fluids are required, samples of in-use fire-resistant fluids of the invert emulsion type shall be collected quarterly.

4.2.7.3.1 Samples of the in-use fire-resistant fluids shall be tested individually to determine if the water content will make the fluid fire resistant.

4.2.7.3.2 When a sample of the in-use fire-resistant fluids indicates that the water content is insufficient for the fluid to be fire resistant, the fluid shall be replaced or water shall be added to restore the fire resistance of the fluid.

4.2.7.3.3 When water is added to the hydraulic system of any machine, a sample shall be taken and analyzed within 24 hours.

4.2.8 Flammable Liquids Storage and Use. The storage and use of flammable liquids underground shall conform to Section 7.5.

4.2.9 Combustible Liquids Storage and Use. The storage and use of combustible liquids underground shall conform to Section 7.6.

4.3* Fire Protection.

4.3.1 Water Supply for Mine Fire Protection.

4.3.1.1 General Requirements.

4.3.1.1.1* Water distribution lines shall extend from the surface to each operating area.

4.3.1.1.2 Water distribution lines from a suitable underground supply of water shall be permitted to replace the surface distribution lines if sufficient quantity is available and power for the pump(s) will not be affected or interrupted during a fire.

4.3.1.1.3 The operator shall choose the entry in which the water line is located, and it shall be protected by the choice of location.

4.3.1.1.4 Water flow and ventilation airflow shall be in the same direction unless provision is made to ensure the availability of fire-fighting water on the upwind side of a fire in the entry containing the water line.

4.3.1.1.5 Where applicable, water lines shall be protected against freezing.

4.3.1.1.6 Water lines that are 50 mm (2 in.) or larger in diameter shall be joined with flanges, mechanical grooved fittings, threaded fittings, or other fittings.

4.3.1.1.7 At least every third joint shall be capable of allowing limited motion and emergency rearrangement.

4.3.1.1.8 Pipe and fittings shall be of metal construction and designed to withstand the anticipated water pressure.

4.3.1.1.9* Water lines shall be equipped with shutoff valves at intervals not exceeding 1525 m (5000 ft).

4.3.1.1.10 A shutoff valve shall be provided in each branch line at the point where it is coupled to the main water line.

4.3.1.2 Water Demand.

4.3.1.2.1* All coal mine water systems shall be capable of simultaneously supplying three hose streams, each with a flow rate of at least 3.2 L/sec (50 gpm), and a nozzle pressure of at least a gauge pressure of 345 kPa (50 psi) for a total of 9.6 L/sec (150 gpm), applied through the maximum expected lay of hose.

4.3.1.2.2* The mine water system shall be capable of supplying the required hose stream water demand continuously for 24 hours or the sprinkler water demand continuously for 2 hours, whichever is the greater supply.

4.3.1.3 Hydrants.

4.3.1.3.1* The mine operator shall choose the entry in which hydrants are to be located, except for belt conveyor entries where hydrants shall be located in the same entry as the belt, locate personnel doors, and provide fire hose that reaches parallel entries where risk of fires exists.

4.3.1.3.2* Hydrants that supply water to a fire hose shall be provided on the water line at intervals not exceeding 91.4 m (300 ft) for belt conveyors and 152.4 m (500 ft) for haulage tracks.

4.3.1.3.3 Hydrants shall be located in the belt entry and accessible.

4.3.1.3.3.1 If staggered crosscuts are used, hydrant locations and crosscuts with personnel doors shall be located to provide a route for laying a fire hose to parallel entries.

4.3.1.3.3.2 At least one hydrant shall be located upwind of the area protected by an automatic sprinkler system.

4.3.1.4 Maintenance. The water supply system shall be maintained operable.

4.3.2* Protective Signaling Fire Detection Systems.

4.3.2.1 General Requirements.

4.3.2.1.1* The design and installation of all fire detection systems shall be approved for the intended use.

4.3.2.1.2 Fire detectors and related signaling system components used to initiate an audible or visual alarm, automatic activation of a fire suppression system, or equipment shutdown shall be listed or approved for the intended use.

4.3.2.1.3* Signaling system input, alarm, and releasing circuits shall be supervised.

4.3.2.1.3.1 The presence of a fault, alarm, or release shall initiate a signal in the protected area and remotely in a constantly attended location.

4.3.2.1.3.2 The signal specified in 4.3.2.1.3.1 shall indicate which condition has occurred.

4.3.2.1.3.3 A trouble signal shall not be required when the main power supply is intentionally shut off during periods of mine inactivity.

4.3.2.1.4* All components of protective signaling systems used inby the last open crosscut or in return air shall be classified as permissible or intrinsically safe.

4.3.2.2 Selection and Application.

4.3.2.2.1* Carbon monoxide (CO) detectors or the equivalent shall be installed along all belt conveyors and at all unattended automatic belt heads (where mine cars are loaded automatically).

4.3.2.2.2 Heat Detectors.

4.3.2.2.2.1 Heat detectors shall not be acceptable for fire detection signaling for underground coal belt conveyors.

4.3.2.2.2.2 Heat detectors shall be acceptable to activate a fire protection suppression system.

4.3.2.2.3* Compartment sizes and contours, airflow patterns, obstructions, and other characteristics of the protected area shall determine the placement, type, sensitivity, and, where applicable, number of detectors.

4.3.2.2.4 The fire alarm shall identify a fire within each belt flight (segment).

4.3.2.2.5 Fire detection systems shall be installed so as to minimize the possibility of damage from roof falls and from the moving belt and its load.

4.3.2.2.6 The voltage of automatic fire alarm systems shall not exceed 120 volts.

4.3.2.2.7 The system shall be designed to provide an alarm up to 4 hours after the source of power to the belt is shut off.

4.3.2.2.8 An audible and visual alarm shall be provided either at the location of the belt or at a constantly attended location that has a telephone or equivalent communication with those miners who might be endangered.

4.3.2.2.9 The alarm system shall be equipped with a "trouble" signal to indicate open circuits, shorts, ground faults, or any other defects.

4.3.2.2.10 The alarm system shall include a manual reset feature.

4.3.2.2.11 Inspections and Tests.

4.3.2.2.11.1 The alarm system shall be inspected weekly, and a functional test of the complete system shall be made every 6 months.

4.3.2.2.11.2 Records of the inspections and test shall be kept.

4.3.2.3 Inspection, Maintenance, and Testing.

4.3.2.3.1 Fire detection systems and associated equipment shall be tested after installation according to the manufacturer's or designer's instruction manual.

4.3.2.3.2 The detection system shall be inspected visually weekly.

4.3.2.3.3 At least every 6 months, all fire detection systems, including alarms, shutdowns, and other associated equipment, shall be maintained and tested in accordance with the manufacturer's or designer's instruction manual.

4.3.3 Fire Protection Systems.

4.3.3.1 General Requirements.

4.3.3.1.1 Mining equipment requiring a fixed fire protection system shall be protected by a system with the capacity to suppress the largest anticipated fires in the protected areas and shall meet the following criteria:

(1) They shall be listed or approved for the purpose.
(2) They shall be located or guarded so as to be protected against physical damage.
(3)*They shall be actuated either automatically or manually.
(4)*They shall be provided with an agent distribution hose or pipe secured and protected against damage, including abrasion and corrosion, and shall be flame resistant.
(5) They shall be provided with discharge nozzle blowoff caps or other devices or materials to prevent the entrance of moisture, dirt, or other material into the piping. The discharge nozzle protective device shall blow off, blow out, or open upon agent discharge.
(6) The fire protection system shall be installed so that system actuation causes shutdown of the protected equipment.

4.3.3.1.2 Automatically actuated systems other than water-based sprinkler systems shall have a manual actuator capable of being activated from the operator's compartment or other accessible location.

4.3.3.1.3 Fire protection systems other than automatic sprinkler systems shall be installed and operate in accordance with the applicable NFPA standards.

4.3.3.1.4* Where the nature of a coal mine does not allow the NFPA standards to be followed, systems that provide equivalent protection shall be approved by the authority having jurisdiction.

4.3.3.2 Applications.

4.3.3.2.1* The following equipment and facilities shall be protected by approved automatic fire protection systems satisfying the requirements of 4.3.3.3 through 4.3.3.5.4.5:

(1)*Drive areas of belt conveyors [including drive motor(s), reducer, head pulley, and belt storage unit (takeup), including its power unit], controls, and the top and bottom of the first 15.24 m (50 ft) of belt from the drive shall be protected in accordance with 9.4.6.
(2) Flammable and combustible liquid storage areas shall be protected by either one of the following:
   (a) Automatic water-based fixed fire protection systems installed for the protection of Class I or Class II liquid storage areas shall be of the Class B foam–water type.
   (b) Permanent diesel fuel storage areas shall be protected with a dry-chemical system or a system that provides equivalent protection according to the authority having jurisdiction.
(3) Maintenance shops shall be protected by an approved automatic fire protection system.
(4) Unattended hydraulic equipment shall use fire-resistant hydraulic fluid.
(5) Unattended electrical equipment such as enclosed electric motors, controls, transformers, rectifiers, and other equipment that does not have a hydraulic system shall be protected by an approved automatic fire protection system.
(6) Unattended electrical equipment located on noncombustible material and spaced at least 0.61 m (2 ft) from coal or other combustible material shall not be required to be protected with an automatic fire suppression system.
(7) Unattended electrical equipment located on noncombustible material and separated from coal or other combustible material by a fire-resistive layer or wall shall not be required to be protected with an automatic fire suppression system.

4.3.3.2.2* Air Compressors. Air compressors with motors that exceed 5 horsepower shall be protected by an approved automatic fire protection system interlocked to shut down the power to the compressor and by one of the following:

(1) A person in constant attendance, within the line of sight of the compressor, and equipped with a portable fire extinguisher
(2) Containment within an enclosure that is constructed of noncombustible materials, ventilated to prevent overheating of the compressor, and designed to provide containment of any possible fire involving the compressor

4.3.3.2.3 High-Expansion Foam.

4.3.3.2.3.1 Where high-expansion foam is used, provision shall be made to supply uncontaminated air for foam making.

4.3.3.2.3.2 The foam system shall be tested with the water supply to determine the quality of the foam-making capabilities.

4.3.3.3 Sprinkler System Requirements.

4.3.3.3.1* Automatic water-based fixed fire protection systems installed for the protection of Class I or Class II liquid storage areas shall be of the foam–water type.

4.3.3.3.2* Where the requirements of Section 8.2 are satisfied by installing automatic sprinkler systems, such systems shall comply with the requirements of 4.3.3.3.2.1 and 4.3.3.3.2.2.

4.3.3.3.2.1 An indicating, full-flow, slow-opening water control valve shall be located at the tap of the water line supplying the sprinkler system.

4.3.3.3.2.2 When the sprinkler system is put into operation, the slow-opening valve specified in 4.3.3.3.2.1 shall be sealed in the open position.

4.3.3.3.2.3 A waterflow switch or alarm valve, with associated inspector's test connection, capable of detecting the flow through one opened sprinkler shall be installed in the piping feeding the sprinklers.

4.3.3.3.2.4 The alarm device shall be connected to an alarm system that will alarm at a constantly attended location.

4.3.3.3.2.5 The alarm system shall identify the sprinkler system involved.

4.3.3.3.2.6 In dry-pipe automatic sprinkler systems, the alarm system shall be actuated by flow through a dry-pipe valve.

4.3.3.3.2.7 A paddle-type water flow switch shall not be used.

4.3.3.3.2.8* Sprinklers shall be standard orifice pendent, upright, or sidewall-type automatic sprinklers.

4.3.3.3.2.9 Sprinklers shall be installed in the upright position on a dry-pipe system.

4.3.3.3.2.10* For sprinkler systems installed to protect the equipment and facilities indicated in 4.3.3.2.1(2) through 4.3.3.2.1(7), sprinklers shall be spaced no more than 3.66 m (12 ft) apart, and the protection of any one sprinkler shall not exceed 9.3 m^2 (100 ft^2).

4.3.3.3.2.11* Sprinklers shall be located so that the discharge will not be obstructed.

4.3.3.3.2.12 For belt conveyors, the entire top belt surface shall be wetted.

4.3.3.3.2.13 Sprinkler deflectors shall be located at a distance below the roof of not less than 25.4 mm (1 in.) nor greater than 508 mm (20 in.).

4.3.3.3.2.14 Roof cavities containing combustible material such as wood or coal in the area to be protected shall be protected by installation of upright sprinklers within the cavity at the top of riser pipes so that the deflectors are within 508 mm (20 in.) of the roof.

4.3.3.3.2.15* Piping in sprinkler systems shall comply with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

4.3.3.3.2.16 Nonmetallic pipe shall not be used downstream of the sprinkler control valve unless investigated and approved for this purpose.

4.3.3.3.2.17 Hangers supporting sprinkler piping shall be metallic.

4.3.3.3.2.18 At least one hanger shall be attached to each length of pipe.

4.3.3.3.2.19 Provision shall be made to drain all parts of the system.

4.3.3.3.2.20 Drain connections shall be sized as shown in Table 4.3.3.3.2.20.

Table 4.3.3.3.2.20 Sizes of Drain Connections

Riser or Main Size	Size of Drain Connection
Up to 2 in.	¾ in. or larger
2½ in. to 3½ in.	1¼ in. or larger
4 in. and larger	2 in. only

For SI units, 1 in. = 25.4 mm.

4.3.3.3.2.21 Trapped piping sections shall be equipped with auxiliary drains or otherwise arranged to facilitate draining.

4.3.3.3.3 Wet-pipe sprinkler systems shall not be used where chance of freezing exists.

4.3.3.3.4 Where danger of freezing exists, sprinkler systems filled with antifreeze solution shall be permitted and shall meet the requirements of 4.3.3.3.4.1 through 4.3.3.3.4.21.

4.3.3.3.4.1* If automatic sprinkler systems are connected to public water supplies or to piping supplying water for drinking, antifreeze solutions other than water solutions of pure glycerine [chemically pure (CP) or U.S. Pharmacopeia (USP) 96.5 percent grade] or propylene glycol shall not be used.

4.3.3.3.4.2 The glycerine–water and propylene glycol–water mixtures provided in Table 4.3.3.3.4.2 shall be permitted to be used.

4.3.3.3.4.3 If automatic sprinkler systems are not connected to public water systems or to piping that supplies water for drinking, the commercially available materials shown in Table 4.3.3.3.4.3 shall be permitted to be used in antifreeze solutions.

4.3.3.3.4.4* A soft-seat check valve shall be connected to the tee in the water line feeding the automatic sprinkler system.

4.3.3.3.4.5 The water control valve shall be connected close to the discharge side of the check valve.

4.3.3.3.4.6 A 6.35 mm (¼ in.) soft-seat relief valve made of corrosion-resistant bronze or stainless steel shall be connected to the sprinkler piping near the shutoff valve.

4.3.3.3.4.7 The relief valve shall be set to open at a pressure of 1.379 kPa (200 psi) above the maximum water-line pressure (i.e., the maximum system pressure).

4.3.3.3.4.8* A suitable air chamber shall be connected to the piping.

4.3.3.3.4.9 The connection port to the chamber shall be fitted with a small, high-pressure, corrosion-resistant ball valve.

4.3.3.3.4.10 The connection from the ball valve to the sprinkler piping shall be permitted to use a small-diameter hydraulic hose having a working pressure of at least the maximum system pressure.

4.3.3.3.4.11 The air chamber shall be filled with compressed air at a pressure equal to the maximum water-line pressure.

Table 4.3.3.3.4.2 Properties of Water-Based Solutions

Material	Solution (by volume)	Specific Gravity at 15.6°C (60°F)	Freezing Point	
			°C	°F
Glycerine (CP or USP grade)	50% water	1.133	−26.1	−15
	40% water	1.151	−30.0	−22
	30% water	1.165	−40.0	−40
Propylene glycol	70% water	1.027	−12.8	+9
	60% water	1.034	−21.1	−6
	50% water	1.041	−32.2	−26
	40% water	1.045	−51.1	−60

CP: chemically pure; USP: U.S. Pharmacopeia 96.5%.
Note: Based on a hydrometer scale 1.000 to 1.200 (subdivisions 0.002).

Table 4.3.3.3.4.3 Antifreeze Solutions to Be Used If Public Water Is Not Connected to Sprinklers

Material	Solution (by volume)	Specific Gravity at 15.6°C (60°F)	Freezing Point °C	Freezing Point °F
Glycerine*				
Diethylene glycol	50% water	1.078	−25.0	−13
	45% water	1.081	−32.8	−27
	40% water	1.086	−41.1	−42
Ethylene glycol	61% water	1.056	−23.3	−10
	56% water	1.063	−28.9	−20
	51% water	1.069	−34.4	−30
	47% water	1.073	−40.0	−40
Propylene glycol*				
Calcium chloride 80% "flake," fire protection grade†	2.83 lb $CaCl_2$/gal water	1.183	−17.8	0
Add corrosion inhibitor	3.38 lb $CaCl_2$/gal water	1.212	−23.3	−10
of sodium bichromate,	3.89 lb $CaCl_2$/gal water	1.237	−28.9	−20
¼ oz/gal water	4.37 lb $CaCl_2$/gal water	1.258	−34.4	−30
	4.73 lb $CaCl_2$/gal water	1.274	−40.0	−40
	4.93 lb $CaCl_2$/gal water	1.283	−45.6	−40

For SI units, 1 lb/gal = 0.119 kg/L.
Note: Based on a hydrometer scale 1.000 to 1.200 (subdivisions 0.002).
*See Table 4.3.3.3.4.2.
†Free from magnesium chloride and other impurities.

4.3.3.3.4.12 Where connected to the system piping, the air chamber shall be oriented so that the connection port is located at the bottom of the chamber.

4.3.3.3.4.13 With the shutoff valve still closed, the sprinkler piping shall be filled with the antifreeze solution, and the following procedures shall be performed:

(1) High points of the piping shall be vented to obtain reasonably complete filling.
(2) The valve on the air chamber shall be opened and sealed.
(3) If possible, the pressure of the antifreeze solution shall be raised to the line pressure before the shutoff valve is opened and sealed.
(4) Finally, the system shall be checked carefully for leaks.

4.3.3.3.4.14* With all other fill, drain, and vent valves closed, a high-pressure air compressor shall be connected to a valve opening, and pressure in the piping shall be raised at least to the water-line pressure.

4.3.3.3.4.15 The valve at the opening shall be closed, and the valve shall be plugged.

4.3.3.3.4.16 The system shall be checked for leaks, especially in the area of the piping where the air is believed to exist.

4.3.3.3.4.17 If the pressure gauge shows that the system is still tight after 24 hours, the shutoff valve shall be opened, making the system operational.

4.3.3.3.4.18 The shutoff valve shall be sealed in the open position.

4.3.3.3.4.19 Sprinkler systems filled with antifreeze solution shall employ antifreeze solution mixtures that are rated for the lowest temperature to which the sprinkler system could be exposed.

4.3.3.3.4.20* The antifreeze solution shall be mixed and tested before being pumped into the sprinkler system piping.

4.3.3.3.4.21 A pressure gauge shall be provided in a protected location on the downstream side of the shutoff valve.

4.3.3.3.5* Where danger of freezing exists, a dry-pipe sprinkler system shall be permitted and shall meet the requirements of 4.3.3.3.5.1 through 4.3.3.3.5.7.

4.3.3.3.5.1 The dry-pipe valve and its accessories shall be installed in a separate area and shall be protected against freezing and mechanical injury.

4.3.3.3.5.2 If the separate area described in 4.3.3.3.5.1 is ventilated with return air, all electrical components shall be permissible or intrinsically safe.

4.3.3.3.5.3 Water pressure shall be regulated not to exceed the maximum pressure specified by the manufacturer of the dry-pipe valve.

4.3.3.3.5.4 The dry-pipe valve shall be installed in accordance with the manufacturer's instructions.

4.3.3.3.5.5 Mechanical grooved couplings, including gaskets used on dry-pipe systems, shall be listed for dry-pipe service.

4.3.3.3.5.6 Operation of the dry-pipe system and supervision of the system, including pressure of the air supply, shall be signaled to an attended location. Signaling to an attended location shall be permitted to utilize alarm systems serving fire detection equipment.

4.3.3.3.5.7 The system air supply shall be provided from a reliable source such as a dedicated compressor and shall be equipped with an air maintenance device.

4.3.3.4 Inspection, Maintenance, and Testing.

4.3.3.4.1 All fire suppression systems shall be tested after installation in accordance with the appropriate NFPA standard.

4.3.3.4.2 If an applicable NFPA standard does not exist, then a fire suppression system shall be tested in accordance with the manufacturer's or designer's instruction manual.

4.3.3.4.3 Testing shall not require the discharge of suppressant unless there is no other satisfactory manner in which the reliability and integrity of the system can be verified.

4.3.3.4.4 Fire suppression systems, alarms, and interlocks shall be inspected at least weekly and maintained in accordance with the appropriate NFPA standard. If an applicable NFPA standard does not exist, then the fire suppression system, alarm, and interlock shall be examined and checked thoroughly for proper operation in accordance with the manufacturer's or designer's manual.

4.3.3.4.5 All persons who inspect, test, operate, or maintain fire suppression systems shall be trained. Annual refresher training shall be provided.

4.3.3.5 Automatic Sprinkler System Acceptance Testing.

4.3.3.5.1 Flushing of Water-Line Connections.

4.3.3.5.1.1 Water-line connections and lead-in connections shall be flushed at the maximum flow rate available before connection is made to the sprinkler piping in order to remove foreign material.

4.3.3.5.1.2 Flushing shall be continued until the water is clear.

4.3.3.5.2 Flow Testing of Sprinkler Systems.

4.3.3.5.2.1 Wet-pipe closed automatic sprinkler systems shall be flow-tested by operating flow through the maximum number of sprinklers expected to open, but not through fewer than eight open sprinklers.

4.3.3.5.2.2 If the system contains fewer than eight sprinklers, all sprinklers shall be flow-tested as specified in 4.3.3.5.2.1.

4.3.3.5.2.3 If the residual pressure measured downstream of the opened sprinklers is 68.9 Pa (10 psi) or greater, the system shall be considered acceptable.

4.3.3.5.2.4 Closed sprinkler systems installed to protect areas where the water discharge could damage the area or its contents shall not be required to be tested by operating flow through opened sprinklers.

4.3.3.5.2.5 Where the condition(s) in 4.3.3.5.2.4 exist, the alternative test of operating flow through a 5.08 cm (2 in.) valve test connection shall be permitted to be used.

4.3.3.5.2.6 Portable sprinkler systems that are dismantled and reinstalled in new areas shall be flow-tested following the initial installation.

4.3.3.5.3 Tests of Dry-Pipe Sprinkler Systems.

4.3.3.5.3.1 Where there is no risk of freezing, new dry-pipe systems shall be flow-tested and hydrostatically tested in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

4.3.3.5.3.2 A dry-pipe valve shall be tested according to the manufacturer's recommendations.

4.3.3.5.3.3* Where there is risk of freezing in dry-pipe systems, an air pressure of 276 kPa (40 psi) shall be pumped up and allowed to stand 24 hours, and all leaks that allow a loss of pressure over 10.3 kPa (1½ psi) during the 24 hours shall be stopped.

4.3.3.5.4 Sprinkler System Maintenance.

4.3.3.5.4.1 All sprinkler systems shall be maintained in accordance with the manufacturer's requirements or in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

4.3.3.5.4.2 As a minimum, all closed sprinkler systems, except antifreeze systems, shall be retested annually by operating flow through the end fitting in all lines to remove any silt buildup.

4.3.3.5.4.3 If pendent sprinklers are used on wet-type sprinkler systems, the end sprinkler on each line shall be removed and examined annually to check for silt buildup.

4.3.3.5.4.4 If silt buildup is found, all sprinklers on the line shall be removed, the line flushed, and new sprinklers installed.

4.3.3.5.4.5 Antifreeze Systems.

(A) Each year at the onset of freezing weather, a small amount of antifreeze shall be drawn from the drain valve and the test valve(s) and tested with a hydrometer to ensure that the solution is suitable for the lowest temperature expected.

(B) If the test described in 4.3.3.5.4.5(A) shows that the solution is not suitable, the solution shall be replaced.

4.3.3.6 Fire Suppression for Self-Propelled Equipment.

4.3.3.6.1* Fire suppression systems consisting of an agent container and a network of agent distribution hose or pipe with discharge nozzles attached shall be used to protect self-propelled equipment and shall comply with the following:

(1) The system shall suppress any potential fire on the equipment it is intended to protect.
(2) The fire suppression system shall be approved for the purpose, and the components shall be located or guarded to protect against damage.
(3) Fire suppression systems shall be either automatically or manually actuated.
(4) Automatically actuated systems designed to incorporate manual actuation shall be equipped with one or more such devices accessible for actuation and shall be maintained in operable condition.
(5) Discharge nozzles shall be provided with blow-off caps or other devices to prevent the entrance of moisture or other environmental materials into the piping.
(6) The protective device shall blow off, blow out, or open upon agent discharge.
(7) The electrical components of systems installed on equipment that might be operated inby the last open crosscut or in return air shall be permissible.
(8) A standby source of power shall be provided if electrical power is the only means of actuation.

(9) All fire suppression equipment and systems shall be tested after installation in accordance with the manufacturer's or designer's recommendations.
(10) Testing shall not require the discharge of agent unless there is no other feasible way to evaluate the system.
(11)*An installation and maintenance manual shall be provided for all fire suppression systems.

4.3.3.6.2* Fire suppression systems shall be provided for protection of attended, electrically powered, self-propelled equipment such as cutting machines, continuous miners, shearers, roof and coal drills, loaders, shuttle cars, scoops, and locomotives that use hydraulic fluid, unless fire-resistant hydraulic fluid is used.

4.3.3.6.3 Cutting machines, continuous miners, shearers, and other machines that supply water through a hose for dust control during mining shall be permitted to use this water source for fire protection, provided a diversion valve is at or outby the operator's station to permit quick and convenient diversion of water to the fire suppression nozzles.

4.3.4 Manual Fire Fighting.

4.3.4.1 Portable Fire Extinguishers.

4.3.4.1.1 General Requirements.

4.3.4.1.1.1* Portable fire extinguishers used in underground coal mines shall be listed, multipurpose (ABC) dry-chemical types having a minimum nominal capacity of 4.6 kg (10 lb) of extinguishing agent, and shall meet the requirements of NFPA 10, *Standard for Portable Fire Extinguishers.*

4.3.4.1.1.2 Portable extinguishers shall be kept in their designated places.

4.3.4.1.1.3 Extinguishers shall be located where they will be accessible in the event of fire.

4.3.4.1.1.4 In areas where visual obstruction cannot be completely avoided, visible markings shall be provided to indicate the location.

4.3.4.1.1.5 Extinguishers subject to dislodgment shall be installed in brackets specifically designed for this problem.

4.3.4.1.1.6 Extinguishers shall be protected from physical damage.

4.3.4.1.1.7 Damaged extinguishers shall be repaired, replaced, or removed from service.

4.3.4.1.1.8 At least one hand-portable fire extinguisher having a nominal capacity of 9.1 kg (20 lb) with a minimum rating of 10-A:60-B:C shall be located outside of, but not more than 3.0 m (10 ft) from, the opening into each flammable and combustible storage area and maintenance shop.

4.3.4.1.1.9 The installation of manual or automatic fire suppression systems shall not waive the requirement of 4.3.4.1.1.8.

4.3.4.1.1.10 Where portable fire extinguishers are provided within flammable and combustible storage areas, travel distance to a portable extinguisher shall not exceed 12.2 m (40 ft).

4.3.4.1.2 Selection and Application.

4.3.4.1.2.1 Multipurpose (ABC) dry-chemical extinguishers shall be provided for protection of the following:

(1) Ventilation doors on trolley wire-supplied track haulageways
(2) Pumps and pump rooms
(3) Conveyor belt drives
(4) Belt head loading equipment
(5) Air compressors
(6) Electrical equipment such as transformers, load centers, rectifiers, circuit breakers, generators, and starters
(7) Rotary dump areas
(8) Battery-charging areas
(9) Intervals of 15.2 m (75 ft) along a longwall face unless washdown hose is present
(10) Flammable and combustible liquid storage areas
(11) Mobile equipment used for the storage, transport, and dispensing of combustible liquids
(12) Electric- or diesel-powered mobile equipment
(13) Self-propelled equipment

4.3.4.1.2.2 The installation of an automatic or manually operated fire suppression system shall not eliminate the requirement for a portable fire extinguisher.

4.3.4.1.2.3* At least one multipurpose (ABC) dry-chemical extinguisher having a nominal capacity of 13.6 kg (30 lb) or greater of agent or two multipurpose (ABC) dry-chemical extinguishers having a nominal capacity of 13.6 kg (20 lb) or greater of agent each shall be provided in each working section of a mine, including the headgate of a longwall face.

4.3.4.1.3 Inspection and Maintenance.

4.3.4.1.3.1 Portable fire extinguishers shall be inspected, maintained, and recharged as specified in NFPA 10, *Standard for Portable Fire Extinguishers*, Chapters 6 and 7, and shall include the requirements of 4.3.4.1.3.2 through 4.3.4.1.3.9.

4.3.4.1.3.2* Visual Inspection.

(A) Portable fire extinguishers shall be inspected visually at least monthly.

(B) The visual inspection shall confirm the following:

(1) The extinguisher is in its designated place.
(2) The tamper seals are intact.
(3) The extinguisher gauge is in the operable range (if extinguisher is stored pressure type).
(4) There is no obvious physical damage or condition to prevent operation.

4.3.4.1.3.3 Extinguishers shall be subjected to a thorough maintenance examination at least once every 12 months.

4.3.4.1.3.4 Maintenance procedures shall include a thorough examination of the extinguisher, including mechanical parts, extinguishing agent, and the means of expulsion.

4.3.4.1.3.5 Any detected troubles or impairments shall be corrected or replaced immediately by competent personnel.

4.3.4.1.3.6 Each extinguisher shall have a durable tag or label securely attached on which the date of the maintenance services shall be recorded.

4.3.4.1.3.7 All extinguishers shall be recharged after any discharge.

4.3.4.1.3.8 All extinguishers shall be recharged as deemed necessary through inspection and maintenance.

4.3.4.1.3.9 Portable extinguishers shall be hydrostatically tested at intervals not exceeding those specified in NFPA 10, *Standard for Portable Fire Extinguishers*, Chapter 5.

4.3.4.2 Hand Hose Line Systems.

4.3.4.2.1 Selection and Application.

4.3.4.2.1.1* Fire hose for use in underground coal mines shall be a minimum of 38 mm (1½ in.) in diameter, single or multiple jacket, and of a type suitable for coal mine use.

4.3.4.2.1.2 The hose shall meet the minimum applicable standards of NFPA 1961, *Standard on Fire Hose.*

4.3.4.2.1.3 Hose lines employing natural fibers shall not be used in underground coal mines.

4.3.4.2.1.4* Fire hose, including couplings, shall be rated for the maximum line pressure that can exist on the mine water system, or there shall be provision for limiting the line pressure to the working pressure of the hose.

4.3.4.2.1.5 Nozzle flow pressure shall be adjusted to provide hose control.

4.3.4.2.1.6* Couplings for fire hose used in underground coal mines shall have straight, iron pipe threads or National Standard Thread.

4.3.4.2.1.7 Where hose or hose-connected equipment is brought in from outside the mine, compatible adapters shall be available.

4.3.4.2.1.8* Hose nozzles shall be capable of delivering a straight stream and a spray discharge.

4.3.4.2.1.9* Fire hose shall be stored in caches, and caches shall contain hose to reach all areas covered by the hydrants that the cache will serve.

4.3.4.2.1.10 Each cache shall contain at least one hose nozzle and one hose wrench.

4.3.4.2.1.11* Caches of fire hose shall be provided at strategic underground locations as follows:

(1) At each intersection with an active submain
(2) At the mouth of each panel
(3) At and on the intake side of each conveyor belt drive
(4) At the entrance to each shop and storage area as defined in 4.2.5, 4.2.8, and 4.2.9
(5) In each operating area
(6) At intervals not to exceed 1525 m (5000 ft) along the main haul route or travelway

4.3.4.2.1.12 Hand hose line systems, if used, shall be installed in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, and shall be a minimum of either 38.1 mm (1½ in.) lined or 25.4 mm (1 in.) hard rubber.

4.3.4.2.1.13 Hand hose lines that are designated for fire fighting and that have the capability to be used in Class I or Class II liquid storage areas shall be equipped to discharge a foam–water solution and shall be in accordance with the applicable sections of NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam.*

4.3.4.2.2* Maintenance. Caches of fire hose shall be checked at least every 6 months to ensure that the inventory of hose, nozzles, wrenches, and adapters is complete, and the following requirements shall apply:

(1) At least one length of hose from each cache shall be pressure-tested annually in accordance with NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose.*
(2) The tested hose shall be tagged and dated so that a different length of hose is tested each year.
(3) If any length of hose fails the pressure test, all lengths of hose in the cache shall be tested.
(4) Hose lines that fail the test shall be replaced.

4.3.4.3 Portable Foam-Generating Devices.

4.3.4.3.1 General Requirements.

4.3.4.3.1.1 Portable foam generators, fire hose, foam concentrate, and emergency fire-fighting materials in accordance with 4.3.4.5 shall be accessible within 60 minutes of fire notification.

4.3.4.3.1.2 Portable foam-generating devices and associated equipment shall be listed or approved for that purpose.

4.3.4.3.2 Maintenance.

4.3.4.3.2.1 At least annually, a thorough maintenance examination of the foam-generating devices and associated equipment, including foam concentrate, shall be made by the mine operator.

4.3.4.3.2.2 Operation of foam-generating equipment during training sessions conducted at least annually shall satisfy the maintenance examination requirement.

4.3.4.4 Rock Dust.

4.3.4.4.1 At least 109 kg (240 lb) of bagged, dry rock dust shall be stored upwind and kept available for fire fighting at or near the following areas:

(1) Maintenance and shop areas
(2) Combustible liquid storage area
(3) Working section
(4) Belt drive area
(5) Belt-head loading area
(6) Ventilation doors on trolley wire–supplied track haulageways

4.3.4.4.2 Where it is impractical to store for fire extinguishment purposes, rock dust shall be permitted to be replaced with an additional portable extinguisher having a nominal capacity of 4.5 kg (10 lb) of multipurpose (ABC) dry-chemical extinguishing agent.

4.3.4.5 Emergency Materials.

4.3.4.5.1 Emergency materials for fighting mine fires shall be near the shaft bottom or other entrance to the mine.

4.3.4.5.2 If the shaft bottom or other entrance to the mine is more than 3.2 km (2 mi) from a working section, additional caches of emergency materials shall be located within 3.2 km (2 mi) of the working section.

4.3.4.5.3 Emergency materials shall include fire hose and necessary adapters, multiple hydrants, wrenches and nozzles, brattice boards and cloth, wood posts, cap pieces, wood wedges, spad guns and spads, or other specialized equipment for installing line brattice, nails, bags of sealant or cement, saws, hammers, axes, shovels, and picks.

4.3.4.5.4 Caches of emergency materials shall be checked at least every 6 months to ensure that the inventory of materials is complete.

4.3.4.6* Training.

4.3.4.6.1 All miners shall be instructed annually in fire prevention and fire-fighting techniques.

4.3.4.6.2 All employees shall be instructed in emergency evacuation procedures.

4.3.4.6.3 All persons who inspect, test, operate, or maintain fire suppression systems shall be trained in the functions they are to perform.

Chapter 5 Surface Mining Operations

5.1 General. This chapter shall cover surface bituminous and subbituminous coal and lignite mining operations.

5.2* Fire Prevention. Risk reduction practices shall follow the principles of minimizing ignition sources and reducing exposure of combustible materials to ignition sources.

5.2.1 Housekeeping.

5.2.1.1 Spills, leaks, excess lubricants, and combustible materials such as oil-soaked wastes, rubbish, and accumulations of environmental debris shall not be allowed to accumulate in quantities that could create a fire hazard.

5.2.1.2 Approved metal receptacles shall be provided where oil-soaked wastes or rubbish are not immediately removed to a safe place for disposal.

5.2.1.3 The storage and handling of flammable or combustible liquids on or within equipment shall be in accordance with Chapter 7 of NFPA 30, *Flammable and Combustible Liquids Code.*

5.2.1.4 Access to fire protection equipment on mining equipment shall be kept clear of obstructions.

5.2.2 Inspection and Maintenance of Equipment. Hydraulic, coolant, lubrication and fuel lines, electrical wiring, and fire prevention devices shall be inspected and maintained in accordance with the manufacturers' recommendations.

5.2.3 Training. Personnel shall be instructed in the emergency procedures to be followed during a fire.

5.2.4 Flammable and Combustible Liquid Storage on Equipment and in Buildings. Flammable and combustible liquid storage and usage shall be in accordance with Sections 7.3 and 7.4.

5.2.5 Compressed Gas Storage and Usage. Compressed gas storage and usage shall be in accordance with Section 7.1.

5.3 Fire Protection.

5.3.1 Fire protection for the purposes of this standard shall be defined in the broad sense to include fire detection and fire suppression.

5.3.2 Fire suppression systems shall include dry-chemical, gaseous, water mist, foam, or sprinklers.

5.3.3 Fire suppression systems and fire alarm systems shall be installed in accordance with applicable NFPA standards.

5.3.4 Fire Extinguishers for Equipment.

5.3.4.1* A 9.1 kg (20 lb) ABC-type fire extinguisher shall be provided at intervals not to exceed 15.24 m (50 ft) travel distance, including the lower frame areas of draglines.

5.3.4.2 The fire-extinguishing agent applied by hand-portable extinguishers to hazards involving energized electrical equipment shall be nonconductive.

5.3.4.3 Portable extinguishers shall be maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, and kept in their designated places at all times.

5.3.4.4 Extinguishers shall be located on each vehicle and shall be accessible.

5.3.4.5 In areas where obstruction to visual observation cannot be completely avoided, visible markings shall be provided to indicate the location of the fire extinguishers.

5.3.4.6 Extinguishers installed under conditions where they can be subject to physical damage shall be guarded to protect against damage.

5.3.4.7 The installation of an automatic or manually operated fire suppression system shall not eliminate the portable fire extinguisher requirement.

5.3.4.8 Portable fire extinguishers shall be inspected, maintained, and recharged as specified in NFPA 10, *Standard for Portable Fire Extinguishers*, Chapter 6, and the following:

(1) Portable fire extinguishers shall be inspected visually at least monthly.
(2) The visual inspection shall ensure the following:
   (a) The extinguisher is in its designated place.
   (b) The tamper seals are intact.
   (c) The extinguisher gauge is in the operable range (if the extinguisher is the stored-pressure type).
   (d) There is no obvious physical damage or condition that will prevent proper operation.
(3) Extinguishers found to be defective or deficient by visual inspection shall be replaced.
(4) Extinguishers shall be subjected to a maintenance examination at least once every year.
(5) Maintenance procedures shall include a thorough examination of the extinguishers, including mechanical parts, extinguishing agent, and expellant.
(6) Any troubles or impairments shall be corrected.
(7) All extinguishers shall be recharged after use in accordance with the manufacturer's recommendations.
(8)*Each extinguisher shall have a permanent tag attached on which the inspection date shall be recorded.

5.3.4.9 Portable extinguishers shall be tested hydrostatically at intervals not exceeding those specified in NFPA 10, *Standard for Portable Fire Extinguishers*, Chapter 7.

5.3.5 Draglines and Electric Shovels.

5.3.5.1 Center Pin/Collector Ring Area.

5.3.5.1.1 An automatic fire suppression system shall be installed in the center pin/collector ring area of the dragline.

5.3.5.1.2 An automatic fire suppression system shall be installed in the ring gear area of shovels.

5.3.5.1.3 Suppression system alarms shall be transmitted to the operator's cab. An audible and visual alarm shall be provided.

5.3.5.1.4 A manual actuator shall be provided just outside the center pin/collector ring area.

5.3.5.2 Propelling and Leveling Hydraulics.

5.3.5.2.1* An automatic fire suppression system shall be installed in the hydraulic pump area.

5.3.5.2.2* The system shall send audible and visual alarms to the operator's cab.

5.3.5.2.3 A manual actuator shall be located just outside the hydraulic compartment area.

5.3.5.3 Lube Oil Pumping and Storage.

5.3.5.3.1* Automatic lube oil systems that are located in a segregated room shall be provided with an automatic fire suppression system.

5.3.5.3.2 The system shall send an audible and visual alarm to the operator's cab.

5.3.5.3.3 A manual actuator shall be located just outside the lube oil room.

5.3.5.3.4 Lube oil rooms shall have automatic door closers or shall have the door interlocked to shut upon actuation of the fire suppression system.

5.3.5.4 Transformers.

5.3.5.4.1 Oil-filled transformers located in the tail section, enclosed rooms, or other inaccessible locations shall be provided with an automatic fire suppression system.

5.3.5.4.1.1 The system shall transmit an audible and visual alarm to the operator's cab.

5.3.5.4.1.2 A manual actuator shall be located just outside the transformer area.

5.3.5.4.2* Transformers located in areas other than those listed in 5.3.5.4.1 shall be protected with a Class BC, minimum 45.4 kg (100 lb), fire extinguisher.

5.3.5.4.3 Gas-in-oil analysis shall be performed on the transformer based on the manufacturer's recommendations.

5.3.5.4.4 Thermographic scanning shall be performed on transformers on an annual basis.

5.3.5.5 Electrical Room or Cabinet.

5.3.5.5.1 Enclosed electrical rooms shall be protected with a total flooding gaseous extinguishing agent or equivalent fire suppression system.

5.3.5.5.1.1 The system shall be installed in accordance with NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems.*

5.3.5.5.1.2 The system shall be actuated by a smoke, ultraviolet/infrared (UV/IR), or heat detector system and send an audible and visual alarm to the operator's cab.

5.3.5.5.1.3 The ventilation system shall be interlocked to the gaseous extinguishing system to shut down upon first detection.

5.3.5.5.1.4 The room shall be sealed to maintain the design gaseous extinguishing concentration.

5.3.5.5.2 Electrical rooms shall be maintained at a positive pressure to reduce the chances of dust entering the room.

5.3.5.5.3 Electrical cabinets shall be protected with a gaseous fire suppression system.

5.3.5.5.3.1 The system shall be installed in accordance with NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems.*

5.3.5.5.3.2 The system shall be actuated by a smoke, UV/IR, or heat detector system and send an audible and visual alarm to the operator's cab.

5.3.5.6 Manual Extinguishing Equipment.

5.3.5.6.1 Minimum 100 lb ABC-type extinguishers shall be accessible to persons on the main deck of the dragline.

5.3.5.6.2 The location and number of extinguishers shall be determined by what is practical for the machine.

5.3.6 Hydraulic/Diesel Excavators.

5.3.6.1 An automatic fire suppression system shall be provided over the hydraulic pumps and engine compartment.

5.3.6.1.1* For hydraulic systems above 567.8 L (150 gal) in the lines, a dual agent system shall be provided.

5.3.6.1.2 A manual actuator shall be located in the operator's cab and at the means of egress from the machine.

5.3.6.2 The machine shall be interlocked to shut down upon discharge of the extinguishing system.

5.3.6.3 A means shall be provided to automatically relieve the hydraulic pressure upon discharge of the extinguishing system.

5.3.6.4 Adequate fire resistance shielding shall be provided between the hydraulic hoses and the turbocharger and engine manifold to prevent hydraulic fluid from being sprayed on hot mechanical parts.

5.3.6.5 The fire detection electrical wiring within fire hazard areas, such as battery compartments, engine compartments, and so forth, shall be outfitted with a fire-resistant sleeve.

5.3.6.6 The fire suppression actuation lines within fire hazard areas shall be outfitted with a fire-resistant sleeve.

5.3.7 Mobile Equipment.

5.3.7.1 Portable Fire Extinguishers.

5.3.7.1.1* All self-propelled surface mining equipment, including but not limited to bulldozers, front-end loaders, haulage trucks, cranes, graders, scrapers, draglines, drills, shovels, and mobile diesel and electrical equipment, shall be equipped with at least one listed portable multipurpose (ABC) dry-chemical extinguisher having a nominal capacity of 4.5 kg (10 lb) of agent or greater.

5.3.7.1.2 Portable extinguishers installed on small units of self-propelled and mobile mining equipment, including but not limited to miniature loaders, individual personnel transports, and small mobile generators, shall have a minimum rating of 2-A:10-B:C and a nominal capacity of 2.27 kg (5 lb) of extinguishing agent.

5.3.7.2 Fire Detection.

5.3.7.2.1 Fire detectors shall be permitted to be used to initiate audible or visual warning, automatic actuation of a fire suppression system, or equipment shutdown.

5.3.7.2.2 Fire detectors shall be tested and listed for the application.

5.3.7.2.3 Compartment sizes and contours, airflow patterns, obstructions, and other characteristics of the protected area shall determine the placement, type, sensitivity, durability, and, where applicable, number of detectors.

5.3.7.2.4 All fire detection systems and applicable equipment shall be tested after installation in accordance with *NFPA 72, National Fire Alarm Code,* and fire suppression systems standards.

5.3.7.2.4.1 It shall not be necessary for testing to require the discharge of any associated fire suppression system.

5.3.7.2.5* At least every 6 months, all fire detection systems, including alarms, shutdowns, and other associated equipment, shall be thoroughly examined and checked for proper operation in accordance with the manufacturer's recommendations.

5.3.7.2.5.1 Any equipment found deficient shall be repaired or replaced, and the system retested for operation in accordance with the manufacturer's instructions.

5.3.7.2.6 Between the maintenance examinations or tests, the detection system shall be inspected visually, in accordance with an approved schedule necessitated by conditions as determined by the mine operator.

5.3.7.3 **Fixed Suppression Systems.** Haul trucks with a capacity of over 85 tons shall have a fixed fire suppression system protecting the engine compartment and hydraulic pump and other hazard areas.

5.3.7.3.1* Other large mining equipment such as but not limited to dozers, endloaders, drills, graders, and scrapers shall have a fixed fire suppression system protecting the engine compartment and hydraulic pump and other hazard areas.

5.3.7.3.2 Mining equipment requiring a fire suppression system shall be protected by a system to suppress potential fires in the protected areas and shall comply with the following:

(1) The fire suppression system shall be listed or approved for the purpose.
(2) Where installed, the equipment shall be located or guarded so as to be protected against physical damage.
(3) Fire suppression systems shall be automatically actuated.
(4)*Automatically actuated systems shall also have a manual actuator capable of being activated from the operator's compartment or other location.
(5) Agent distribution hose or pipe shall be secured and protected against damage, including abrasion and corrosion.
(6) Except for automatic sprinkler systems, discharge nozzles shall be protected against entrance of environmental debris, including moisture, dust, dirt, or insects, by blow-off caps or other similar devices or materials.
(7) Except for automatic sprinkler systems, the nozzle cover shall open or blow off upon discharge of the system.
(8) The automatic fire suppression system shall be installed so that system actuation causes shutdown of the protected equipment.
(9) Up to a 30-second delay shall be included in the design of the interlock system for the operator to maintain control of the equipment.

5.3.7.3.3 A standby source of power shall be provided where electrical power is the only means of fire suppression system actuation.

5.3.7.3.4 All fire suppression equipment and systems shall be tested after installation in accordance with the manufacturer's or designer's recommendations.

5.3.7.3.4.1 Testing shall not require the discharge of suppressant unless there is no other manner in which the reliability and integrity of the system can be verified.

5.3.7.3.5 An installation-and-maintenance or owner's manual that describes system operation and maintenance requirements shall be provided for all fire suppression equipment.

5.3.7.3.6* In accordance with the manufacturers' or designers' recommended inspection and maintenance procedures and schedules, but not to exceed every 6 months, all fire suppression systems, including alarms, shutdowns, and other associated equipment, shall be thoroughly examined and checked for proper operation by competent personnel.

5.3.7.3.6.1 Any equipment found deficient shall be repaired or replaced, and the system retested for proper operation.

5.3.7.3.6.2 Between regular maintenance examinations or tests, the system shall be inspected visually, in accordance with the manufacturer's or designer's recommended schedule.

5.3.7.3.6.3 Testing shall be in accordance with the applicable NFPA standards.

5.3.7.3.7 Fire suppression systems shall be maintained in operating condition at all times.

5.3.7.3.8 Use, impairment, and restoration of the system shall be reported to the mine operator.

5.3.7.3.9 All persons who can be expected to inspect, test, maintain, or operate a fire suppression system shall be trained to perform their intended tasks.

5.3.7.3.10 Where inadvertent discharge of the fire suppression system during servicing could result in injury to personnel, provisions shall be made to safeguard against accidental actuation of the system.

5.3.7.3.11 All operators, supervisors, and maintenance personnel of self-propelled and mobile equipment shall be trained in the use of fire suppression equipment.

Chapter 6 Coal Processing

6.1 General.

6.1.1 Materials and Construction.

6.1.1.1 Coal mine surface buildings and structures, housing, and supporting coal-processing and coal-handling equipment shall be of noncombustible construction.

6.1.1.2 Dry coal screening, crushing, dry cleaning, and other operations producing coal dust shall be conducted in open structures to prevent the accumulation of dust concentration levels that can create explosion hazards.

6.1.1.2.1 Where open structures are impractical, enclosed buildings shall be provided with explosion venting in accordance with 6.2.3 and shall be located so as to minimize fire and explosion exposure to major buildings and equipment.

6.1.1.2.2 Location of the processes described in 6.1.1.2 in the main plant building shall be permitted, provided the dust-producing area is equipped with explosion venting in accordance with 6.2.3 and is separated from the remainder of the building by construction designed to withstand the pressure buildup from an explosion prior to pressure relief by means of explosion vents.

6.1.2 Coal Dust Control.

6.1.2.1 Dedusters.

6.1.2.1.1 All dedusting equipment shall be connected directly to a suction system capable of moving enough air to prevent the leakage of dust from the system.

6.1.2.1.2 The suction system shall discharge the dust-laden air by the shortest possible route to collectors outside the building.

6.1.2.2* Pneumatic Cleaners.

6.1.2.2.1 Dust-collecting systems with suction hoods at the cleaners, suction ducting that maintains at least a 20 m/sec (4000 ft/min) air velocity, and dust collectors having pressure release venting shall be installed.

6.1.2.2.2 Belt conveyor–type transfers and loading points associated with the cleaners shall be hooded similarly and connected to dust collectors.

6.1.3 Coal Storage. Coal storage facilities shall be in accordance with 9.5.2.

6.2 Fire and Explosion Prevention.

6.2.1 Electrical Classification of Hazard.

6.2.1.1 Plant areas of open construction where coal dust or any combustible gases liberated from the coal are dispersed to the open atmosphere shall be classified nonhazardous.

6.2.1.2 Plant areas isolated from the coal process, such as control rooms, electrical equipment rooms, or substations, that are provided with ventilation to prevent the accumulation of combustible gases or coal dust shall be classified nonhazardous.

6.2.1.3 Enclosed areas of processing plants where coal is wet to prevent particles from becoming airborne or where dry coal dust does not accumulate shall be classified nonhazardous.

6.2.1.4* Enclosed areas where the failure or malfunction of the ventilation would result in the accumulation of explosive concentrations of methane gas shall be designated as Class I, Division 2 locations in accordance with Article 500 of NFPA 70, *National Electrical Code.*

6.2.1.4.1* Electrical equipment approved as "permissible" by the Mine Safety and Health Administration (MSHA) shall be acceptable in locations classified Class I, Division 1.

6.2.1.5 Areas of a processing plant normally designated as Class I shall be permitted to be considered nonhazardous, provided the following conditions are met:

(1) Ventilation to prevent an accumulation of an explosive or ignitable mixture of gases
(2) Failsafe continuous methane monitoring designed to sound an alarm when the methane–air mixture reaches 20 percent (1 percent methane by volume) of the lower explosive level (LEL)
(3) An interlock to stop the process equipment automatically when the methane–air mixture reaches 40 percent (2 percent methane by volume) of the LEL
(4) An electrical system arranged so that when methane concentrations reach 40 percent of the LEL, all electrical circuits including control circuit conductors are de-energized
(5) Any equipment that is needed to restore the plant to a methane–air mixture of less than 20 percent (1 percent methane by volume) of the LEL, such as lighting, ventilation, or sump pumps, installed in accordance with Class I, Division 1 requirements

6.2.1.6* Enclosed areas in which coal dust is not in suspension in explosive or ignitable quantities or in which coal dust might be present in explosive or ignitable quantities or might be in suspension in the air due to a malfunction shall be designated as Class II, Division 2 in accordance with Article 500 of NFPA 70, *National Electrical Code.*

6.2.1.7* The structure of a preparation plant shall be connected to a common electrical ground.

6.2.1.7.1 Any electrical equipment that is mounted on a concrete pad shall be grounded to the metal structure with a shunt.

6.2.1.7.2 Where the structure is nonmetallic, a separate grounding grid for equipment shall be provided.

6.2.1.8 Positive pressure shall be maintained in process control rooms to prevent the entry of fugitive dust.

6.2.1.9 Electrical Equipment Rooms. Positive pressure shall be maintained in electrical equipment rooms, such as switchgear rooms, motor control centers, and cable-spreading rooms, to prevent the entry of fugitive dust.

6.2.1.9.1 Thermographic scanning shall be performed on switchgear and motor starters on an annual basis.

6.2.1.10 Tools that are actuated by electrical power shall not be used in areas with explosive gases or dusts.

6.2.2 Dust Collectors and Dust Removal Equipment.

6.2.2.1 Those areas in which combustible dust is or might be in suspension in the air continuously, intermittently, or periodically under normal operating conditions shall be provided with a dust-collecting system or systems to collect such dust and prevent its discharge to the atmosphere.

6.2.2.1.1 All coal-handling equipment or machinery that produces dust shall be connected to a dust collector with ducts and hoods that are designed to provide suction volume and velocity to collect and transport all the dust produced.

6.2.2.1.2 Hoods, enclosures, and ducts shall be of noncombustible construction, designed and maintained in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

6.2.2.1.3 All dust collectors, other than those that are an integral part of dust-producing equipment, shall be located outside the working areas, preferably outside the building or in separate rooms that are vented to the outside.

6.2.2.2 When a plant or handling facility is planned, special consideration shall be given to the location of the dust-producing equipment with respect to the location of the dust collection devices to ensure that the connecting ducts will be as straight and as short as possible.

6.2.2.2.1* All dry dust collectors shall be of noncombustible construction, equipped with explosion doors or vents.

6.2.2.2.2 The entire dust-collecting system shall conform to NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

6.2.2.3 In no case shall the design of the dust removal system be such that the dust is drawn through the fan before entering the collector. Fans shall be of noncombustible construction.

6.2.2.4* Ducts shall be designed to maintain a velocity of not less than 22.9 m/sec (4500 ft/min) to ensure the transport of both coarse and fine particles and to ensure re-entrainment if for any reason the particles should fall out before delivery to the dust collector (e.g., in the event of a power failure).

6.2.2.4.1 In bag-type dust collectors, the bags shall be constructed of antistatic, fire-resistant material and shall be provided with an electrical ground.

6.2.2.4.2 Dust collector hoppers shall be sloped at approximately 60 degrees to ensure material flow.

6.2.2.4.2.1 Zero-speed switches and high-level alarms shall be used to identify conditions that can lead to spontaneous combustion.

6.2.2.4.2.2 Hopper discharge valves or screw conveyors shall be provided to discharge the dust continually.

6.2.2.4.2.3 Hoppers shall not be used as storage bins.

6.2.2.4.3 Hood takeoffs shall have a minimum area of four times the area of the duct.

6.2.2.4.3.1 Duct work also shall be supplied with blast gates and dampers for individual pickup volume adjustment.

6.2.3 Explosion Venting.

6.2.3.1* Explosion venting shall be provided in areas where coal dust might be present in explosive or ignitable quantities, such as in coal preparation plant buildings, and in sections of buildings housing screens, pneumatic coal-cleaning equipment, dryers, and other dust-producing machinery.

6.2.3.2 Ventilating hoods and exhaust ducts shall not be acceptable as explosion-venting devices unless they are designed for a dual purpose and function to provide direct release of excess pressure to the outside.

6.2.3.3 Equipment vents or ducts used to direct the energy of an explosion in equipment to the outside of the building or a safe location shall be as short as possible and shall be designed to withstand the explosion pressure.

6.2.3.3.1 Vent closures, which might be necessary to permit proper functioning of equipment and to prevent the escape of dust during normal operation, shall be designed to open at the lowest possible increase in pressure or shall be of flexible or frangible materials that blow out or rupture to permit the release of explosion pressure.

6.2.4* Flammable and Combustible Liquids and Liquefied Petroleum Gas. Flammable and combustible liquids and compressed gases shall be stored and used in accordance with Chapter 7.

6.2.5 Maintenance. The user shall have responsibility for establishing a maintenance program that ensures that equipment is in working order.

6.2.5.1 All coal-handling equipment and machinery shall be maintained in accordance with the manufacturers' recommendations.

6.2.6 Housekeeping. Provision shall be made for cleaning to prevent the accumulation of coal dust.

6.2.6.1 Combustible waste materials shall not be permitted to accumulate in locations where a fire or an explosion hazard can be created.

6.3* Preparation Plants and Crusher Buildings. This section shall apply to preparation plants, tipples, crushers inside buildings, and crushers in belowgrade areas. Open air crushers do not pose a significant hazard and shall be excluded from the requirements of this section.

6.3.1 Building Construction.

6.3.1.1 Buildings and equipment shall be shaped, installed, or protected so as to minimize the surface area on which coal dust can accumulate.

6.3.1.2 Access for cleaning or washing down shall be provided.

6.3.1.3 Access platforms or walkways installed between floors shall be permitted to be open-grid construction to facilitate cleaning.

6.3.1.4 Walls or partitions isolating sections of the plant that contain dust-producing operations shall be constructed and installed to minimize the transmission of dust to adjacent areas.

6.3.1.5 To prevent the accumulation of dust on exposed wall or partition framing, metal siding or other equivalent material shall be installed on the side facing the dust-producing section.

6.3.1.6 Doors in the walls or partitions required by 6.3.1.4 shall be self-closing.

6.3.1.7 Drain systems shall be provided in areas where cleaning is accomplished by washing down.

6.3.1.8 Two remote means of egress shall be provided on each floor of the plant.

6.3.1.9 Emergency lighting shall be provided at the means of egress stairways in accordance with NFPA *101*, *Life Safety Code*, Section 7.9.

6.3.1.10 Emergency exit signs shall be provided at the means of egress stairways in accordance with NFPA *101*, *Life Safety Code*, Section 7.10.

6.3.1.11 If lightning protection is required, it shall be in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems.*

6.3.2 Fire Protection.

6.3.2.1 Portable Extinguishers.

6.3.2.1.1 Every building or room of a plant where combustible material is present or dry coal is processed or handled shall be provided with approved portable multipurpose fire extinguishers.

6.3.2.1.2 The number of approved portable extinguishers, their type, and their distribution shall be in accordance with NFPA 10, *Standard for Portable Fire Extinguishers,* except that the smallest extinguisher shall have a nominal capacity of 9.07 kg (20 lb) of agent and a minimum rating of 10-A:60-B:C.

6.3.2.1.3 Extinguishers employing agents having a B:C rating shall be permitted to be used if the hazard is confined solely to electrical equipment.

6.3.2.2 Fixed Fire Protection Systems.

6.3.2.2.1* Where required by the authority having jurisdiction, fixed fire protection systems shall be provided and shall be designed in accordance with the appropriate NFPA standards, depending on the agent utilized.

6.3.2.2.2 Working plans for the fixed fire protection system shall be submitted for approval to the authority having jurisdiction.

6.3.2.2.3 Combustible hydraulic and lube oil systems that exceed 94.6 L (25 gal) and are located in below-grade areas shall be protected by an automatic fire suppression system.

6.3.2.3 Standpipe and Hose Systems.

6.3.2.3.1* Class III standpipe systems shall be provided in all coal preparation plants and crusher buildings in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems.*

6.3.2.3.2 When automatic sprinkler systems are to be supplied through the standpipe system, hydraulic calculations shall be used to ensure that the piping and the water supply meet the hose and automatic sprinkler demands simultaneously.

6.3.2.3.3 Hose stations on or in conveyor galleries shall be provided with hoses that are of length equal to the distance between water supply connections.

6.3.2.4 Water Supply.

6.3.2.4.1* Availability. An available supply of water shall be provided for fire protection systems and manual fire-fighting purposes.

6.3.2.4.2 Fire Mains. Where fire mains and hydrants are provided, the water supply system shall be installed and maintained in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

6.3.2.4.3 Other Water Supplies. Where public or private fire mains are not provided, alternative water supplies complying with NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting,* shall be provided.

6.3.2.4.4* Capacity.

6.3.2.4.4.1 The water supply capacity shall be capable of providing the estimated water needed for fire-fighting purposes for a minimum duration of 2 hours.

6.3.2.4.4.2 Water pumps installed as part of a process water system and designed for the calculated flows and pressures required for fire fighting shall be permitted to be used to supply fire mains.

6.3.2.5 Inspection and Maintenance of Fire Protection Equipment.

6.3.2.5.1 Portable extinguishers shall be maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

6.3.2.5.1.1 Fire extinguishers shall be inspected on a 6-month basis.

6.3.2.5.2 Water-based fire protection systems shall be maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

6.3.2.5.3 Any fire protection system, including sprinklers, installed in accordance with the requirements of this standard shall be maintained to provide assurance that the system will operate.

6.3.2.5.4 All persons who inspect, test, or maintain fixed fire protection systems shall be trained in accordance with the appropriate NFPA standards and the manufacturers' specifications.

6.3.2.5.4.1 Those persons described in 6.3.2.5.4 shall receive refresher instructions at least every 5 years.

6.3.2.6 Surveillance.

6.3.2.6.1 Periodic surveillance for fire hazards shall be conducted when the plant, or any part thereof, is not in operation or not constantly attended.

6.3.2.6.2 Frequency of surveillance shall be dependent on the type of coal product involved and its susceptibility to self-heating and other site conditions.

6.4 Dryers.

6.4.1* General.

6.4.1.1 Thermal coal-drying systems shall be located at least 30.5 m (100 ft) from any underground coal mine opening.

6.4.1.2 Dryers that have been idle for more than 30 days or shut down because of a fire or any other emergency condition during normal operation shall be checked to ensure that there is no burning material within the system before being placed back in service.

6.4.2 Loss Prevention Design Features. Dryer heating units that are fired by pulverized coal shall be installed, operated, and maintained in accordance with NFPA 85, *Boiler and Combustion Systems Hazards Code.*

6.4.2.1 Dryers of the direct-fired type shall be designed and operated so that combustion is complete as possible within the furnace/air heater before the gases of combustion come in direct contact with the coal drying in the drying chamber.

6.4.2.2 Dryers shall be designed and constructed to be dust-tight, with smooth surfaces to prevent the accumulation of coal.

6.4.2.3 Where coal can be exposed to excessive heat on normal or emergency shutdown, a bypass stack with an automatically controlled damper shall be installed to direct the products of combustion away from the coal.

6.4.2.4 Thermal dryer systems that have a hot gas inlet or plenum chambers where fly ash or coal siftings might accumulate shall be equipped with drop-out doors or ports to facilitate removal of these solids.

6.4.2.4.1 Where continuous means of removing drop-out solids are not provided, checking and manual clean-out shall be provided as conditions warrant.

6.4.2.5* All internal areas of thermal coal dryers where coal solids could possibly hang up or accumulate under any abnormal operating condition, such as in the drying chamber or dry cyclone collector, shall be equipped with explosion relief vents that open directly to the outside atmosphere.

6.4.2.5.1 These explosion relief vents shall be of the quantity, size, and location to operate in excess of the design normal pressure.

6.4.2.5.2 Explosion vents shall be checked or tested at least once each month, and records kept to verify these checks.

6.4.2.5.3 Explosion vents shall be directed away from personnel work areas and walkways.

6.4.2.6 During system operation, visual checks shall be made of all the mechanical components and equipment associated with the drying system as conditions warrant.

6.4.2.7* Indirect heat exchange–type dryers, such as thermal disk processors, shall be given special consideration in the design of fire protection for the dryer and dryer building.

6.4.3 Instrumentation and Control.

6.4.3.1 Instrumentation and control panels on thermal dryers shall be located in an area relatively free of moisture, vibration, dust, and noise.

6.4.3.2 The panel shall be located within the range and view of the supervising operator.

6.4.3.3 The operator control room shall be provided with windows or other means, such as video cameras, that give visual contact with the thermal drying system.

6.4.3.4 The panel shall include recording-type control instruments, monitoring indicators, alarms, and temperature limits set to maintain normal operation.

6.4.3.5 Audible and visual alarms shall be interlocked electrically to provide shutdown of the drier when temperatures are exceeded or other emergency malfunctions occur.

6.3.2.3.3 Hose stations on or in conveyor galleries shall be provided with hoses that are of length equal to the distance between water supply connections.

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6.4.2.4.1 Where continuous means of removing drop-out solids are not provided, checking and manual clean-out shall be provided as conditions warrant.

6.4.2.5* All internal areas of thermal coal dryers where coal solids could possibly hang up or accumulate under any abnormal operating condition, such as in the drying chamber or dry cyclone collector, shall be equipped with explosion relief vents that open directly to the outside atmosphere.

6.4.2.5.1 These explosion relief vents shall be of the quantity, size, and location to operate in excess of the design normal pressure.

6.4.2.5.2 Explosion vents shall be checked or tested at least once each month, and records kept to verify these checks.

6.4.2.5.3 Explosion vents shall be directed away from personnel work areas and walkways.

6.4.2.6 During system operation, visual checks shall be made of all the mechanical components and equipment associated with the drying system as conditions warrant.

6.4.2.7* Indirect heat exchange–type dryers, such as thermal disk processors, shall be given special consideration in the design of fire protection for the dryer and dryer building.

6.4.3 Instrumentation and Control.

6.4.3.1 Instrumentation and control panels on thermal dryers shall be located in an area relatively free of moisture, vibration, dust, and noise.

6.4.3.2 The panel shall be located within the range and view of the supervising operator.

6.4.3.3 The operator control room shall be provided with windows or other means, such as video cameras, that give visual contact with the thermal drying system.

6.4.3.4 The panel shall include recording-type control instruments, monitoring indicators, alarms, and temperature limits set to maintain normal operation.

6.4.3.5 Audible and visual alarms shall be interlocked electrically to provide shutdown of the drier when temperatures are exceeded or other emergency malfunctions occur.

6.4.3.6 Control instruments shall be checked and serviced by a technician at least every 3 months.

6.4.3.7 Where pneumatic controls are used, instrument quality air shall be provided.

6.4.3.8 A schematic diagram showing the locations of thermocouples, pressure taps, and other controls shall be posted at the control panel.

6.4.3.9 Written procedures, including start-up, normal shutdown, and emergency shutdown procedures, shall be provided and posted at the control panel.

6.4.3.10 All main fans shall be inspected and shall have bearing temperature and vibration detectors.

6.4.3.11 Coal feed bins shall have low-level alarms.

6.4.4 Fire Protection for Drying Chambers. Drying chambers shall be protected by an automatic water spray system.

6.4.4.1 The automatic spray system shall include a manual control.

6.4.4.2 The source for the fire protection water shall be such that the required volume flow rate and pressure of clean (solid-free) water are available at all times and that the exposed piping is protected against freezing.

6.4.5* Explosion Venting.

6.4.5.1 Buildings shall be provided with explosion venting in accordance with NFPA 69, *Standard on Explosion Prevention Systems*, and shall be located to minimize fire and explosion exposure to other buildings and equipment.

6.4.5.2 Cyclone collectors used with dryers shall be equipped with explosion vents equal in size to the cross-sectional area of the exhaust sleeve to supplement the venting area provided at the exhaust opening.

6.4.5.3 Dryers shall be designed and installed, if possible, with their explosion vents opening directly to the outside.

6.4.5.3.1 This venting shall be permitted to be accomplished by installation of the dryer along an outside wall of the building, directly under the roof, or by a portion of the dryer being extended through the roof.

6.4.5.3.2 If such locations are not practicable, ducts to the outside of the building shall be as short as possible and designed to withstand explosion pressure.

6.4.5.3.3 Access floors, platforms, walkways, and stairs on the thermal dryer structure shall be located so that personnel are not in the line of an explosion vent.

6.5 Conveyors. Conveyors shall be in accordance with Section 9.1.

6.6 Mobile Equipment. Mobile equipment used in coal processing areas shall conform to 5.3.7.

Chapter 7 Storage and Use of Compressed Gases and Flammable and Combustible Liquids

7.1* Compressed Gas Storage and Usage — Cutting and Welding.

7.1.1 Procedures and Maintenance of Equipment.

7.1.1.1 Cutting and welding shall be performed only by persons who have been task trained.

7.1.1.2 Personal protective equipment shall be worn by personnel during welding or flame cutting operations.

7.1.1.3 Before any cutting or welding is performed, prior approval shall be granted by management or its designated agent.

7.1.1.4 Compressed gas shall be used only for its intended purpose.

7.1.1.5 Compressed oxygen shall not be used to blow coal dust from clothing or machinery.

7.1.1.6 Manifolding of cylinders containing gases used for cutting and welding shall be permitted only in shops ventilated with sufficient quantity and velocity to dilute, render harmless, and clear away flammable or explosive concentrations of vapors.

7.1.1.7 When not in use, the compressed gas cylinder valve shall be closed.

7.1.1.8 Cutting and welding equipment shall be maintained in operating condition with all safeguards in place and functioning.

7.1.1.9 Flashback and backflow preventers shall be installed at the outlets of all pressure regulators and on the hose connections used in cutting, welding, brazing, and soldering torches.

7.1.2 Fire Prevention and Control.

7.1.2.1* Cutting or welding shall not be performed on or within containers or tanks that have stored combustible or flammable materials until such containers or tanks have been purged and cleaned or have been inerted.

7.1.2.2 Cutting or welding shall not be performed within 15.2 m (50 ft), measured horizontally, of explosives, blasting agents, or flammable or combustible liquid storage areas unless separated by a noncombustible barrier.

7.1.2.3 Electrical cutting and welding equipment shall be electrically grounded.

7.1.2.4 All machinery and operations producing combustible dust within range of welding sparks shall be shut down prior to the start of the welding or cutting operation and shall remain inoperative until a final inspection is completed.

7.1.2.5* Before cutting and welding operations are undertaken, the following precautions shall be observed:

(1) The immediate area shall be cleaned and cleared of combustible material and, if underground, wetted down with water or coated with rock dust.
(2) Open gear cases and combustible machine components located within 7.6 m (25 ft) of cutting or welding operations shall be covered with noncombustible material.
(3) Fire-extinguishing equipment, including fully charged and operable multipurpose (ABC) dry-chemical extinguishers, rock dust, or water hose, shall be within 7.6 m (25 ft) of the cutting or welding operation.
(4) In the case of a portable fire extinguisher, a single unit having a nominal capacity of 9.1 kg (20 lb) with a minimum rating of 4-A:40-B:C shall be within 7.6 m (25 ft) of the cutting or welding operation.

(5) Tests for methane gas (CH_4) shall be made before cutting or welding in any area where methane gas is likely to be present, and the following shall apply:
  (a) Cutting or welding shall not be permitted to begin or continue unless the concentration of methane gas is less than 1 percent by volume.
  (b) Methane concentration shall be continuously monitored during the cutting and welding operation.
(6) Where cutting or welding is necessary inby the last open crosscut, a continuous fire watch shall be maintained.
(7) Where inby equipment to be modified or repaired can be moved, it shall be moved outby the last open crosscut before cutting or welding.
(8) Ventilation shall be established prior to and maintained during cutting or welding.
(9) Flammable and combustible liquids shall not be dispensed within 15.2 m (50 ft) of cutting or welding operations.
(10) Freshly painted surfaces shall be permitted to dry so that ignitable vapor is not present before cutting or welding.

7.1.2.6 Combustibles posing a fire hazard shall be relocated or protected with a fire-retardant cover or fire-retardant barrier.

7.1.2.7 Where welding or cutting with an arc or a flame is performed where combustible materials are present and cannot be removed or protected from ignition sources, a fire watch shall be provided.

7.1.2.7.1 Where a fire watch is required, it shall be maintained for a minimum of 30 minutes after completion of cutting or welding operations to detect and extinguish smoldering combustibles.

7.1.2.7.2 The fire watch shall have fire-extinguishing equipment available and be trained in its use.

7.1.2.7.3 Fire watchers shall be familiar with the facilities and the procedures for sounding an alarm in the event of a fire.

7.1.2.8 Openings or cracks in walls, partitions, floor decks, or ducts shall be covered tightly with a noncombustible material to prevent the passage of sparks to adjacent areas.

7.1.2.9 Where welding is being performed on a metal wall, partition, ceiling, or roof, precautions shall be taken to prevent ignition of combustibles on the other side due to conduction or radiation.

7.1.2.10 In confined spaces, positive ventilation shall be established prior to start-up of cutting or welding operations.

7.1.2.11 Noncombustible barriers shall be installed below welding or cutting operations that are being performed in or over shafts, silos, and similar openings.

7.1.2.12 Inspection.

7.1.2.12.1 Inspection for sparks, smoldering material, and fire shall be made during cutting or welding.

7.1.2.12.2 After completion of the work, a search of the area, including the floors above and below, shall be made for fires and for development of smoldering fires.

7.1.3 Underground Transport. Compressed gas cylinders for cutting or welding shall be transported as follows:

(1) The cylinders shall be disconnected from regulators.
(2) The cylinders shall be protected with a metal cap or headband (fence-type metal protector around the valve stem).
(3) The cylinders shall be secured by devices that will hold them in place during transit.
(4) The cylinders shall be placed in electrically insulated, substantial containers designed to hold the cylinders during transit on a trolley wire haulage system.
(5) The cylinders shall be labeled "empty" or "MT" if the gas has been expended.

7.1.4 Underground Storage. Compressed gas cylinders stored underground shall meet all the requirements of Section 7.1.

7.1.4.1* Compressed gas cylinders shall be clearly marked using the designations of the U.S. Department of Transportation (DOT).

7.1.4.2 Compressed gas cylinders shall be placed in storage areas that shall be designated for the purpose, constructed of noncombustible material or rock-dusted, and free of trash and combustible or flammable liquids.

7.1.4.3 Compressed gas cylinders shall be stored and secured in an upright position or angled with the valve end elevated.

7.1.4.4 Compressed gas cylinders shall be protected against damage from the following:

(1) Falling material
(2) Contact with power lines and energized electrical machinery
(3) Heat from cutting or welding operations

7.1.4.5 The valves of the compressed gas cylinder shall be closed and protected from physical damage when not in use.

7.1.4.6 Compressed gas cylinders shall not be stored or left unattended inby the last open crosscut.

7.1.4.7 Where located in other than underground shops, compressed gas cylinders not in use shall have the regulators removed, and the valves shall be protected by being covered with protective metal caps, by tank design, or by other approved equivalent protection.

7.1.4.8 Flammable compressed gas shall be segregated from oxygen by a fire-resistive barrier (e.g., steel plating or concrete blocks) or by a distance of 6.1 m (20 ft).

7.1.5 Surface Storage.

7.1.5.1 Storage of compressed gases on an excavating machine shall be limited to that used on a daily basis.

7.1.5.2 Acetylene, oxygen, and other compressed gas cylinders shall be kept in the upright position and secured against falling over.

7.1.5.3 A metal or caged barrier shall be provided above cylinders in storage if there is the potential for falling objects.

7.1.5.4 Flammable compressed gas shall be segregated from oxygen by a fire-resistive barrier (e.g., steel plating or concrete blocks) or by a distance of 6.1 m (20 ft).

7.1.5.5 Storage of flammable gases and oxygen shall be located outside buildings or in a room designed in accordance with NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks.*

7.1.5.6 All electrical equipment within an enclosed storage room containing flammable gases shall be Class I, Division 2, Group A, B, C, or D.

7.1.5.7 Outside storage areas shall be kept clear of dry vegetation and combustible materials for a minimum distance of 7.6 m (25 ft).

7.1.5.8 Storage areas shall be provided with physical protection from vehicle damage.

7.1.5.9* Compressed gas cylinders shall be clearly marked using the designations of the DOT.

7.1.5.10 Empty cylinders shall be clearly marked "Empty" or "MT" or stored in a separate area.

7.2 Liquid Propane Storage and Use. The storage, use, and handling of liquefied petroleum gases (LP-Gases), such as propane or butane, shall be in accordance with NFPA 58, *Liquefied Petroleum Gas Code.*

7.3 Flammable and Combustible Liquid Storage Tanks on the Surface.

7.3.1* Design and Location of Storage Tanks.

7.3.1.1 Storage tanks shall be built, installed, and used in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

7.3.1.2* The tank shall be listed for its use.

7.3.1.3 Aboveground flammable liquids storage tanks shall be located a minimum of 15.2 m (50 ft) from important structures.

7.3.1.4 Aboveground combustible liquid storage tanks shall not be stored closer than 1.5 m (5 ft) from important structures.

7.3.1.5 Aboveground tanks shall not be located within 30.5 m (100 ft) of mine openings, fan installations, hoist houses, or any buildings connected to these operations.

7.3.1.6 The contents of the storage tank shall be identified by the designations given in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response.*

7.3.2* Control of Spillage from Aboveground Tanks. Facilities shall be provided so that any accidental discharge will be prevented from endangering important facilities or adjoining property or from reaching waterways.

7.3.3 Normal and Emergency Venting.

7.3.3.1 Atmospheric storage tanks shall be vented in accordance with API 2000, *Standard for Venting Atmospheric and Low-Pressure Storage Tanks.*

7.3.3.2 As an alternative to 7.3.3.1, the normal vent shall be at least as large as the largest filling or withdrawal connection, but in no case shall it be less than 31.75 mm (1¼ in.) nominal diameter.

7.3.3.3 Aboveground tanks storing flammable liquids shall have the vent normally closed and be equipped with a flame arrester.

7.3.3.4* Emergency Relief.

7.3.3.4.1 Emergency relief shall be provided for all aboveground tanks storing material with a flash point less than 93.33°C (200°F).

7.3.3.4.2 The relief shall be in the form of a relief valve or a weak roof-to-shell seam.

7.3.3.5 Tanks containing material with a flash point greater than 93.33°C (200°F) that are located in the same diked area as liquids with lower flash points shall also conform to 7.3.3.4.

7.3.3.6* Vent piping shall be located so that the discharge is above the fill pipe opening and at least 3.7 m (12 ft) above the adjacent ground level.

7.3.4 Fuel Lines.

7.3.4.1 Fuel lines shall be equipped with valves to cut off fuel at the source.

7.3.4.2 Fuel lines with flexible piping shall be equipped with a fusible link activated automatic shutoff valve located at the point where the fuel line exits the storage tank.

7.3.5 Leakage and Overfill of Buried Tanks.

7.3.5.1 Buried tanks with flammable liquids shall have a leak detection program in effect.

7.3.5.2 Accurate inventory records of buried tanks with flammable liquids shall be maintained.

7.3.5.3 Buried tanks shall be equipped with an overfill alarm interlocked to shut off the feed when the tank is 95 percent full and to alarm at 90 percent.

7.3.6 Vehicle Barriers. Vehicle barriers shall be provided around aboveground stationary storage tanks or fuel pumps that are located in an area subject to vehicular traffic.

7.3.7 Control of Ignition Sources.

7.3.7.1 Signs warning against smoking or open flames shall be posted so they can be readily seen.

7.3.7.2 Storage tanks containing flammable liquids shall be grounded.

7.3.7.3 Tank trucks with flammable liquids shall be grounded by being electrically bonded to the fill pipe when storage tank filling operations are taking place.

7.3.7.4 Areas surrounding storage tanks shall be kept free of grass, weeds, underbrush, or other combustible material such as trash or leaves for at least 7.6 m (25 ft) in all directions.

7.3.8 Fire Extinguishers. Two fully charged and operable 9.1 kg (20 lb) extinguishers with minimum ratings of 4-A:40-B:C shall be provided within 9.1 m (30 ft) of the tank or pump.

7.4 Flammable and Combustible Liquid Storage on Surface Equipment and in Buildings.

7.4.1 The storage, use, and handling of flammable and combustible liquids in surface buildings shall conform with NFPA 30, *Flammable and Combustible Liquids Code,* except Sections 4.6.7, 6.7, and 7.5 and Chapters 1, 2, and 3.

7.4.2 Flammable and combustible liquids on equipment, except in fuel tanks on vehicles, shall be stored and handled in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

7.4.3 Flammable liquids of a quantity greater than 94.6 L (25 gal) shall be stored in a flammable liquids cabinet.

7.4.4 All flammable aerosols shall be stored in a flammable liquids cabinet.

7.4.5* On equipment, combustible liquid storage in drums or totes shall not exceed a 1-day supply.

7.4.6 Upon request, the mine operator shall provide the authority having jurisdiction with information regarding the composition and flash point of the flammable and combustible materials.

7.4.7 Smoking and Open Flames.

7.4.7.1 Smoking and open flames shall be prohibited in areas or locations where fire or explosion hazards exist.

7.4.7.2 Signs warning against smoking and open flames shall be posted.

7.4.8 Vehicle Refueling.

7.4.8.1 Vehicles using liquid fuels shall be refueled only at locations designated for that purpose and from approved dispensing pumps and nozzles.

7.4.8.2 Engines, except diesel engines, shall be shut off during refueling.

7.5 Flammable Liquids Stored and Used Underground.

7.5.1 General.

7.5.1.1* Electrical equipment in flammable liquid storage areas shall be classified as one of the following:

(1) Class I, Division 1 as specified in NFPA 70, *National Electrical Code*
(2) "Permissible" electrical equipment

7.5.1.2 Flammable liquids in storage shall be kept in closed containers.

7.5.1.3 Flammable liquids shall be permitted to be used only where there are no open flames or other sources of ignition within the possible path of vapor travel in flammable concentrations.

7.5.1.4 Flammable liquid containers shall be returned to a flammable liquid storage area after use.

7.5.1.5 All aerosol cans shall be treated as containing flammable liquids unless otherwise specifically identified.

7.5.1.6 Individual aerosol cans that are used regularly in normal operations shall be permitted on mobile equipment or in tool cabinets and shall be protected from mechanical damage.

7.5.2 Flammable Liquid Containers.

7.5.2.1 Flammable paints shall be stored only in original containers or cans of not over 18.9 L (5 gal) capacity.

7.5.2.2 All other flammable liquids shall be transferred to a listed safety can prior to being transported underground.

7.5.2.3 Safety cans containing Class IA flammable liquids shall not exceed 7.6 L (2 gal) capacity.

7.5.2.4 All flammable liquid containers shall be labeled with the word "Flammable."

7.5.2.5 Flammable liquid containers shall be stored in a stable manner.

7.5.3 Flammable Liquid Storage Areas.

7.5.3.1 Flammable liquids shall be stored in one of the following:

(1) Listed or approved noncombustible storage cabinets
(2) Cabinets meeting the requirements specified in Section 6.3 of NFPA 30, *Flammable and Combustible Liquids Code*
(3) An enclosure of fire-resistive construction

7.5.3.2 In operating areas, containers of flammable liquids and aerosol cans shall be stored at least 7.6 m (25 ft) away from potential ignition sources such as energized trolley wire, energized electrical equipment, and other operating equipment.

7.5.3.3 The aggregate quantity of flammable liquids, including aerosol cans, in a flammable liquid storage area shall not exceed 227 L (60 gal).

7.5.4 Dispensing Flammable Liquids.

7.5.4.1 Flammable liquids shall be drawn from or transferred into containers using only the following methods:

(1) From safety cans
(2) From a container by means of a device that draws through an opening in the top of the container
(3) By gravity through a listed or approved self-closing valve or self-closing faucet

7.5.4.2 Transferring flammable liquids by means of an electric pump or pressurizing a container with air shall be prohibited.

7.5.4.3 Transferring flammable liquids by pressure of inert gas shall be permitted only if controls, including pressure relief devices, are provided to limit the pressure so it cannot exceed the design pressure of the container.

7.5.4.4 At least one portable fire extinguisher having a nominal capacity of 9.1 kg (20 lb) with a minimum rating of 4-A:60-B:C shall be located not more than 9.1 m (30 ft) from any area where flammable liquid is dispensed.

7.6 Combustible Liquids Stored and Used Underground.

7.6.1 General.

7.6.1.1 This chapter shall not apply to combustible liquids in use, such as the following:

(1) Diesel fuel in the fuel tanks of diesel-powered vehicles
(2) Hydraulic fluid in the reservoirs of hydraulic equipment
(3) Lubricating oil in the lubrication reservoirs of operating equipment

7.6.1.2 Combustible liquids in approved tanks or containers meeting the following requirements shall be exempt from the requirements for storage areas:

(1) Class II combustible liquids stored in containers meeting the requirements of this chapter and not exceeding 227 L (60 gal)
(2) Class III combustible liquids stored in containers or approved tanks as specified in this chapter and not exceeding 2498 L (660 gal)

7.6.1.3 Combustible liquid containers shall be stored and shall be kept closed while stored in the following manner:

(1) Drums holding 208 L (55 gal) and 114 L (30 gal) shall be set vertically, unless seam height will not allow, and not over one drum high.
(2) Drums holding 60.6 L (16 gal) shall be set vertically and not over two drums high.
(3) Pails holding 18.9 L (5 gal) shall be set vertically and not over four pails high.
(4) Cartons holding grease cartridges shall not be stacked over three cartons high.

7.6.1.4 Ventilation shall be provided wherever combustible liquids are stored to prevent the accumulation of ignitable vapors.

7.6.2 Combustible Liquid Containers and Tanks.

7.6.2.1 Tanks for handling combustible liquids shall be substantially constructed and fitted with filler caps, vents, and discharge valves that are protected in the event of derailment or ribbing of the vehicle carrying the tanks.

7.6.2.2* Containers shall be acceptable to the authority having jurisdiction.

7.6.2.3 Containers larger than 18.9 L (5 gal) shall be provided with vacuum and pressure relief.

7.6.2.4 The capacity limitations for combustible liquids in containers and portable tanks shall be in accordance with the definitions for *container* and *portable tank* in Chapter 3.

7.6.2.5 Combustible liquid storage tanks intended for fixed installation and portable installations in accordance with NFPA 30, *Flammable and Combustible Liquids Code*, shall be of materials compatible with the liquid stored.

7.6.2.6 Atmospheric tanks shall be built in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

7.6.2.7 The operating pressure of storage tanks shall not exceed their design working pressure.

7.6.2.8 Low-pressure tanks shall be built in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

7.6.2.9 The operating pressure of the vessel shall not exceed the design working pressure.

7.6.2.10* Pressure vessels shall be built in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

7.6.2.11 Storage tanks shall be vented to prevent the development of vacuum or pressure from distorting the shell or roof of the tank as a result of filling or emptying and atmospheric temperature changes.

7.6.2.12 Protection shall also be provided to prevent overpressure from any filling source exceeding the design pressure of the tank.

7.6.2.13* Storage tank vents shall be at least as large as the filling or withdrawing lines but no less than 31.75 mm (1¼ in.) nominal inside diameter.

7.6.2.14 If more than one fill or withdraw line can be used simultaneously, the vent capacity shall be based on the maximum anticipated simultaneous flow.

7.6.2.15 Vent pipes shall be constructed to drain toward the tank without sags or traps to collect liquid.

7.6.2.16 Connections for all tank openings shall be liquidtight.

7.6.2.17 Each connection to a tank through which liquid normally can flow shall be provided with an external valve located at the shell of the tank.

7.6.2.18 Tanks containing combustible liquids shall be provided with a means for quick cutoff of flow in the event of fire in the vicinity of the tank.

7.6.2.19 Openings for manual gauging, if independent of the fill pipe, shall be kept closed when not gauging.

7.6.2.19.1 Each opening for any liquid shall be protected against liquid overflow and possible vapor release by means of a spring-loaded cap or other device.

7.6.2.19.2 Substitutes for manual gauging shall be permitted.

7.6.3* Transfer and Transport of Combustible Liquids.

7.6.3.1 Combustible liquid shall be permitted to be transferred into the mine by pipeline, portable tank, closed container, or safety can.

7.6.3.2 When combustible liquid is transferred into the mine, it shall be transported or transferred directly to the storage area or location where it will be used.

7.6.3.3 Combustible liquid shall not be transported in the same conveyance with personnel unless the items are secured or are small enough to be carried by hand without increasing the risk of an accident.

7.6.3.4 Combustible liquid containers or tanks loaded on rail or trackless vehicles shall be secured against shifting and damage during transit.

7.6.3.5 Rail or trackless vehicles that carry supplies for production areas in addition to combustible liquids shall have provisions for securing or separating those supplies from the lubricants and combustible liquids so that, in the event of derailment or ribbing, the supplies will not puncture containers or tanks.

7.6.3.6 Vehicles carrying combustible liquids shall be kept clean of accumulations of oil, grease, and other combustible material.

7.6.3.7 Spilled combustible liquids shall be cleaned up immediately.

7.6.3.8 Any remaining residue shall be covered with an oil absorbent or rock dust.

7.6.3.9 Combustible liquid containers or tanks shall be at least 305 mm (12 in.) below energized trolley wires or protected from contacting the wire by insulation while being transported by trolley wire–powered systems.

7.6.3.10* The quantity of combustible liquid in containers or tanks off-loaded from transport vehicles and stored in an operating area shall not exceed a 3-day supply for operations in that area.

7.6.3.11 A single tank or container with a capacity exceeding a 3-day supply shall be permitted.

7.6.3.12* Pipeline systems used for combustible liquid transfer shall be permitted to be either wet or dry pipe installations.

7.6.3.12.1 Piping, valves, and fittings used for combustible liquid transfer shall be designed for the expected working pressures and structural stresses as follows:

(1) Piping, valve, and fitting burst strengths shall be at least four times the static pressure.
(2) The pipeline shall be designed to withstand the mechanical and thermal stresses caused by exposure to fire.

7.6.3.12.2 A manual shutoff valve shall be installed in the pipeline at the surface storage tank and at the point of underground discharge.

7.6.3.12.3 An additional shutoff valve shall also be installed in each branch line where the branch line joins the main line.

7.6.3.12.4 The pipeline system shall be guarded and protected against physical damage.

7.6.3.12.5 Guarding by choice of location shall be considered an acceptable practice.

7.6.4 Temporary Areas for the Storage of Combustible Liquids in Portable Containers.

7.6.4.1 Portable combustible liquid storage areas shall meet one of the following criteria:

(1) They shall be located a minimum of 30.5 m (100 ft) from explosives magazines, electrical substations, shops, working faces, or other combustible liquid storage areas
(2) They shall be separated from explosives magazines, electrical substations, shops, working faces, or other combustible liquid storage areas by unexcavated coal or rock or by a masonry bulkhead.

7.6.4.2 Unless equipped with an approved fire protection system, the storage area shall be a minimum of 30.5 m (100 ft) from any shaft station and 7.6 m (25 ft) from energized trolley wire.

7.6.4.3 A portable combustible liquid storage area shall be recessed or otherwise located and protected from accidental damage by mobile equipment or blasting.

7.6.4.4 The aggregate quantity of diesel fuel in a combustible liquid storage area for portable containers or tanks shall not exceed 1892.7 L (500 gal).

7.6.4.5 The aggregate quantity of Class II and Class III combustible liquids in a combustible liquid storage area for portable containers or tanks shall not exceed 3785 L (1000 gal)

7.6.5* Fixed Areas for Class II Liquid Storage.

7.6.5.1 Fixed combustible liquid storage areas shall be located as follows:

(1) A minimum of 30.5 m (100 ft) from explosives magazines, electrical substations, shaft stations, slope bottoms, and shops
(2) A minimum of 30.5 m (100 ft) from other flammable or combustible liquid storage areas or separated by one of the following:
  (a) Unexcavated coal
  (b) Rock
  (c) Masonry bulkhead with a minimum thickness of 102 mm (4 in.) of blocks or 51 mm (2 in.) of reinforced gunite
(3) A minimum of 30.5 m (100 ft) from any working face and out of the line of sight of blasting or a minimum of 152 m (500 ft) within line of sight from any working face to avoid damage from fly rock
(4) A minimum of 7.6 m (25 ft) from normally energized trolley wire

7.6.5.2 All fixed combustible liquid storage areas shall be enclosed and protected by an approved, fixed automatic fire suppression system.

7.6.5.2.1 All fixed combustible liquid storage area enclosures shall be of noncombustible construction, including floor, roof, roof supports, doors, and door frames.

7.6.5.2.2 Exposed coal within all fixed combustible liquid storage areas shall be covered with noncombustible materials such as gunite, shotcrete, or preformed masonry.

7.6.5.2.3 Bulkheads, if used, shall be sealed and be built of or covered with noncombustible materials.

7.6.5.2.4 All fixed combustible liquid storage area enclosures shall be constructed to provide suitable spill containment or shall be provided with a suitable floor drain to direct spilled liquid to a containment sump or vessel.

7.6.5.2.5 All openings to the storage area enclosures shall be sealed with fire-resistive stoppings.

7.6.5.2.6 The access opening through which containers are moved shall be located on the intake side.

7.6.5.2.7* All doors shall be of the self-closing type and shall be listed or approved and constructed of noncombustible materials.

7.6.5.2.8 A personnel door shall be provided on the side where air enters the enclosure.

7.6.5.2.9 The storage area enclosure shall be vented directly to the return or the surface.

7.6.5.2.10* Tanks shall rest 0.305 m (12 in.) above the ground or on foundations made of concrete, masonry, piling, or steel.

7.6.5.2.11 Tank foundations shall be designed to prevent accumulation of combustible liquid under the tank, to minimize the possibility of uneven settling of the tank, and to minimize corrosion in any part of the tank resting on the foundation.

7.6.5.2.12 All piping, valves, and fittings shall be suitable for the expected working pressures and structural stresses.

7.6.5.2.13 Ventilation shall be provided to prevent the accumulation of ignitable vapors.

7.6.5.2.14 Empty or idle combustible pallet storage within the combustible liquid storage area shall not be permitted.

7.6.5.2.15 The aggregate quantity of Class II and Class III combustible liquids in a fixed combustible liquid storage area shall not exceed 18,925 L (5000 gal), of which Class II shall not exceed 3785 L (1000 gal).

7.6.6 Fixed Storage Areas for Class III Combustible Liquids. Class III combustible liquids shall be stored in fire-resistive containers within an enclosure of fire-resistant construction.

7.6.7 Storage, Transport, and Dispensing of Combustible Liquids Using Mobile Equipment.

7.6.7.1 Where combustible liquids are stored on mobile equipment such as mobile service trucks, the equipment shall be parked at a fixed location or a location that meets the requirements of 7.6.4 when not in use.

7.6.7.2 The aggregate quantity of combustible liquids carried on mobile equipment shall not exceed 3785 L (1000 gal).

7.6.7.3 Diesel fuel tank trucks shall not exceed 1892.7 L (500 gal) storage capacity.

7.6.8* Dispensing Combustible Liquids.

7.6.8.1 Class III combustible liquids shall be permitted to be dispensed through the application of positive pressure to containers or tanks only where the containers or tanks are certified as pressure vessels.

7.6.8.2 Class II combustible liquids shall not be dispensed using compressed gas.

7.6.8.3 Where electrically powered pumps are used to dispense combustible liquids, a switch or circuit breaker shall be provided at a location away from dispensing devices, including remote pumping systems, to shut off the power to all dispensing devices in an emergency.

7.6.8.4 Dispensing nozzles for Class II combustibles shall be of the self-closing type without a latch-open device.

7.6.8.5 At least one portable fully charged and operable fire extinguisher having a nominal capacity of 9.1 kg (20 lb) with a minimum rating of 4-A:60-B:C shall be located not more than 9.1 m (30 ft) from any area where combustible liquid is dispensed.

7.6.8.6 Dispensing Class II combustible liquid from containers or tanks shall be accomplished by an approved transfer pump or by gravity flow.

7.6.8.6.1 Where needed, containers or tanks shall be equipped with an approved vent.

7.6.8.6.2 If a manual valve is used, it shall be of the self-closing type without a latch-open device.

7.6.8.7 Spillage shall be cleaned up.

7.6.8.8 Remaining residue shall be covered with an oil absorbent or rock dust.

Chapter 8 Mine Surface Buildings

8.1 Construction.

8.1.1 This chapter shall include mine offices, bathhouses, warehouses, vehicle storage, and shops.

8.1.2 Offices over 1393.55 m^2 (15,000 ft^2), warehouses over 929 m^2 (10,000 ft^2), and shops over 464.5 m^2 (5000 ft^2) shall be constructed of noncombustible materials or provided with an automatic sprinkler system installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

8.2 Fire Prevention.

8.2.1 No smoking shall be allowed in warehouses.

8.2.2 Combustible storage shall be maintained at least 0.914 m (3 ft) from electrical panels and electric resistance heaters.

8.2.3 Oily waste or rags that can create a fire hazard shall be placed in covered metal containers.

8.2.4 Battery rooms shall be in accordance with NFPA 70, *National Electrical Code,* Article 480.

8.2.4.1 Battery-charging installations shall be located in a designated area that is protected against damage from mobile equipment.

8.2.4.2 Each battery-charging installation shall be equipped with the following:

(1) Approved portable multipurpose fire extinguisher(s)
(2) Ventilation for the removal of generated gases from charging batteries
(3) A means for flushing spilled electrolyte

8.3 Life Safety.

8.3.1 Two means of egress shall be provided from multistory buildings.

8.3.2 For office, bathhouse, and warehouse areas, emergency lighting shall be provided in each stairwell or hallway that is the means of egress in accordance with NFPA *101, Life Safety Code.*

8.3.3 For office, bathhouse, and warehouse areas, emergency exit signs shall be provided along the means of egress.

8.4 Flammable and Combustible Liquids.

8.4.1 All storage and handling of flammable and combustible liquids shall conform to the guidelines established in NFPA 30, *Flammable and Combustible Liquids Code.*

8.4.2 The quantity of flammable liquids and aerosols stored outside a flammable liquids storage cabinet shall not exceed 94.6 L (25 gal).

8.4.3 Other than in shops, the quantity of combustible liquids outside a flammable liquids storage cabinet or room constructed in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* shall not exceed 454.25 L (120 gal).

8.4.4 Dispensing of flammable or combustible liquids in warehouses shall be prohibited.

8.4.5 Storage of acetylene, oxygen, or other welding gases inside warehouses shall be prohibited.

8.4.6 Drip pans shall be provided to catch leakage or spillage wherever flammable or combustible liquids are dispensed.

8.4.7 Fusible link–actuated automatic closers shall be provided on all parts cleaning tanks.

8.5* Compressed Gas Storage and Usage. Storage and use of compressed gases in and around mine buildings shall be in accordance with Section 7.1.

8.6 Fire Detection and Protection.

8.6.1 For multistory office buildings, a central station or proprietary alarm system shall be installed in accordance with *NFPA 72, National Fire Alarm Code.*

8.6.1.1 Alarms shall include smoke detectors, duct detectors, and manual pull stations.

8.6.1.2 In addition, if sprinklers are installed, water flow, valve tamper, and low building temperature alarms shall be provided.

8.6.1.3 All equipment shall be listed or approved for its intended use.

8.6.2* If sprinkler systems are installed, they shall be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

8.6.3* If fire hydrants are installed, they shall be in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

8.6.4 If a building is more than two stories high, a standpipe system shall be installed in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems.*

8.6.5 If a gaseous fire suppression system is installed in a computer or telephone equipment room, it shall be in accordance with NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems.*

8.6.6* Fire extinguishers shall be provided and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

8.6.6.1 Fire extinguishers shall be inspected at least every 6 months.

Chapter 9 Coal Conveyance and Storage

9.1* Conveyors — General.

9.1.1* Belt conveyors shall meet the following minimum requirements:

(1) Belt alignment limit switches shall be provided on conveyors to shut down belts that are tracking improperly.
(2) Slip switches shall be provided to detect a slipping or jammed belt and shall be interlocked to shut off driving power when the belt stops or slows down by more than 20 percent of its normal speed.
(3) Slip switches shall be tested on a weekly basis.
(4) Shutoff power shall be provided on contributing conveyors to prevent any operating conveyor from discharging material to a stopped downstream conveyor.

(5) Means shall be provided to remove tramp metal and other foreign objects as early in the handling process as possible.
(6) Hydraulic systems for belt alignment, if provided, shall use only listed fire-retardant hydraulic fluids or shall be protected by an automatic fire protection system.
(7) Alarms shall annunciate in the operator's control room.
(8) Electrical equipment shall be classified as Class I, Division 2, Group F in all areas where required by NFPA 70, *National Electrical Code*.
(9) Guarding for machinery in the drive area and at other points along the belt shall be made of noncombustible material.

9.1.2* Structures supporting belt conveyors shall be designed to prevent coal accumulations.

9.1.2.1 The design shall include any surface near the belting that can catch and retain fine coal liable to ignite spontaneously.

9.1.3 Consideration shall be given to the possibility of static electrical discharge at the conveyor head and tail pulleys located in dry climates where bituminous and lower ranking-type coals are handled.

9.1.3.1 Factors that shall be considered are belting materials, belt speed, and housekeeping of spilled coal dust.

9.1.3.2 Where such conditions as described in 9.1.3 exist, the use of static dissipators or eliminators shall be considered.

9.1.4 Attention shall be given to the prevention of and cleaning of accumulations of fine coal dust beneath and close to belt conveyors.

9.2 Overland Conveyors.

9.2.1 Chute plug alarms shall be provided for long runs of belt or critical conveyor systems.

9.2.2 The conveyor path shall be kept free of all grass, weeds, trash, or any other material that could create an exposure to the belt should it catch on fire.

9.2.3 Motor control center (MCC) buildings for conveyor systems shall be kept free of accumulations of coal dust.

9.3 Below-Grade Reclaim Conveyors.

9.3.1 Methane detection shall be provided in below-grade reclaim conveyor areas.

9.3.2 Equipment shall be interlocked to de-energize upon detection of a 2 percent concentration of methane.

9.3.3 Portable methane detectors are an acceptable alternative to fixed detectors, provided a reading is taken once per shift.

9.4 Underground Conveyors.

9.4.1 Underground conveyor belts shall be of a flame-resistant material and approved by the authority having jurisdiction.

9.4.2 Entries in which belt conveyors are installed shall be kept free of accumulations of coal and coal dust around the belt idlers, pulleys, and belt edges and shall be rock-dusted.

9.4.3* Fixed combustible material such as posts, cribbing, and roof supports shall be guarded from contact by the belt by the use of noncombustible material or by distance and shall be located at a distance of at least 152.4 mm (6 in.) from any idler or pulley.

9.4.4 Belt conveyor installations shall use a support structure without a deck between the upper and lower belt flights.

9.4.5 Belts that carry the load of the belt on a low-friction metal deck without rollers shall be permitted to be used.

9.4.6 Automatic Fire Suppression Systems at the Belt Drive.

9.4.6.1 Deluge water spray systems, foam systems, closed-head sprinkler systems, or dry-chemical systems automatically actuated by rise in temperature shall be installed at main and secondary belt conveyor drives.

9.4.6.2 Fire suppression systems shall extend to the belt drive, hydraulic takeup unit electrical controls, discharge roller, drive motors, gear reducing unit, and conveyor belt to a distance of 15.2 m (50 ft) on the downwind side.

9.4.6.3 Piping for the deluge, foam, or closed-head sprinkler system shall be metal and listed for sprinkler applications.

9.4.6.4 The application rate shall not be less than 10.2 $L/min/m^2$ (0.25 gpm/ft^2) of the top surface of the top belt.

9.4.6.5 The discharge shall be directed at both the upper and the bottom surface of the top belt and the upper surface of the bottom belt.

9.4.6.6 The water supply shall be free of excessive sediment and corrosives and provide the required flow for not less than 10 minutes. A strainer with a flush-out connection and manual shutoff valve shall be provided.

9.4.6.7 Maximum distance between nozzles on a branch line shall not exceed 2.4 m (8 ft).

9.4.6.8 The system shall be interlocked to shut down the conveyor and provide an audible and a visual alarm.

9.4.6.9 The components of the system shall be located so as to minimize the possibility of damage by roof fall or by the moving belt and its load.

9.4.6.10 Fire suppression systems shall also comply with 4.3.3.3.

9.4.6.11 Deluge water spray systems shall meet the requirements of 9.4.6.11.1 through 9.4.6.11.3.

9.4.6.11.1 The system shall be activated by heat detectors.

9.4.6.11.1.1 Heat detectors shall be located at the belt drive, hydraulic takeup unit (unless fire-resistive fluid is used), discharge roller, and the roof above the conveyor.

9.4.6.11.1.2 Heat detectors at the roof line should be spaced 2.4 m to 3.048 m (8 ft to 10 ft) apart along the entire length of the protected area of the belt.

9.4.6.11.2 The nozzles shall be full cone, corrosion resistant, and provided with blow-off dust covers.

9.4.6.11.3 A closed sprinkler head shall be used over the electrical controls.

9.4.6.12 Foam systems shall meet the requirements of 9.4.6.12.1 through 9.4.6.12.4.

9.4.6.12.1 The system shall be activated by heat detectors.

9.4.6.12.1.1 Heat detectors shall be located at the belt drive, hydraulic takeup unit (unless fire-resistive fluid is used), discharge roller, and the roof above the conveyor.

9.4.6.12.1.2 Heat detectors at the roof line should be spaced 2.4 m to 3.048 m (8 ft to 10 ft) apart along the entire length of the protected area of the belt.

9.4.6.12.2 The nozzles shall be full cone, corrosion resistant, and provided with blow-off dust covers.

9.4.6.12.3 The system shall have a capacity to last 25 minutes.

9.4.6.12.4 A closed sprinkler head should be used over the electrical controls.

9.4.6.13 Sprinkler systems shall meet the following requirements:

(1) The sprinklers shall be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, as far as practical, and shall have components that have been listed.
(2) The water supply shall be capable of supplying a constant flow of water with all heads functioning for a period of 10 minutes.
(3) The sprinkler head activation temperature shall not be less than 65.6°C (150°F) or greater than 148.9°C (300°F).

9.4.7 Manual Extinguishing.

9.4.7.1 Water lines shall be installed parallel to the entire length of belt conveyors and shall be equipped with fire taps with valves at 91.4 m (300 ft) intervals.

9.4.7.2 The threads on the hose taps shall be protected against dirt and rock grit that can prevent a quick connection.

9.4.7.3 The hose tap at the belt drive area shall be at least 15.24 m (50 ft) upwind of the belt drive.

9.4.7.4* At least 152.4 m (500 ft) of fire hose with fittings shall be stored at strategic locations along the conveyor belt, that is, at transfer points, drive areas, and tailpieces.

9.4.7.5 For each conveyor belt exceeding 609.6 m (2000 ft) in length, an additional cache of materials as specified in 9.4.7.4 shall be provided.

9.4.7.6 For mines using a track haulage system, the same criteria as those in Section 9.2 through 9.2.3 shall be met.

9.4.7.7 The following materials shall be stored within 91.4 m (300 ft) or 5 minutes of a belt drive:

(1) 152.4 m (500 ft) of fire hose or a high-expansion foam device and 61 m (200 ft) of hose
(2) Tools to open a stopping between the belt entry and the adjacent intake entry
(3) 108.8 kg (240 lb) of rock dust

9.4.7.8 Foam.

9.4.7.8.1 The foam generator shall produce foam sufficient to fill 30.5 m (100 ft) of belt haulageway in not more than 5 minutes.

9.4.7.8.2 A 1-hour supply of foam shall be kept on hand.

9.4.7.9 The entry containing the main water line and crosscuts containing water outlets shall be accessible.

9.4.7.10 Suitable communication lines to the surface shall be provided in the belt haulageway or adjacent entry.

9.4.7.11 A crew consisting of at least five members for each shift shall be trained in fire-fighting operations. Fire drills shall be held at intervals not exceeding 6 months.

9.4.7.12 Two 9.1 kg (20 lb) dry-chemical extinguishers shall be located at the drive areas.

9.4.8* A dust suppression water spray system actuated by a "conflow" switch or similar device shall be provided at the belt feeder.

9.4.9 Electrical equipment shall be permissible where required by the authority having jurisdiction.

9.5* Coal Storage — General. Coal bins, bunkers, and silos shall meet the following requirements:

(1) Storage durations shall be limited to prevent spontaneous combustion.
(2) Equipment shall be of noncombustible construction designed to minimize coal hang-up.
(3) Means shall be provided to remove burning, wet, or smoldering coal so it can be disposed of without producing an explosion or a fire.

9.5.1 Storage Bins.

9.5.1.1 All interior bins handling dusty material shall be vented in accordance with 6.2.2.

9.5.1.2 Storage bins for coal shall be located so that sources of heat not intended specifically to control the temperature of coal do not raise the temperature of the coal in the bin, causing spontaneous combustion materially.

9.5.2 Coal Silos.

9.5.2.1 Coal shall not be stored in silos and bunkers for long periods. If coal must be stored for a long period, air entrainment shall be prevented using the following methods:

(1) Covering the top of the stored coal with a binder material
(2) Inerting the stored coal with recommended inert gas

9.5.2.2 Areas in the storage (hideouts) that can allow pockets of coal to form, dry, and combust spontaneously shall be removed.

9.5.2.3 Storage silos shall be constructed of noncombustible material.

9.5.2.4 Electrical equipment shall be installed to meet the requirements of NFPA 70, *National Electrical Code*, in effect at the time of installation.

9.5.2.5 If a dust collector is provided, it shall be equipped with explosion relief panels in accordance with NFPA 68, *Guide for Venting of Deflagrations*. The dust collector shall be grounded and have antistatic, fire-resistant bags.

9.5.2.6 Wash-down hoses shall be provided at the bottom of the silo.

9.5.2.7 Dual high-level cutoff switches shall be provided for the silo. The feed conveyor shall be interlocked to shut down on the low–high indication.

9.5.2.8 The silo shall be maintained on a regular cleaning schedule to minimize the buildup of coal beneath the hopper and other areas inside the silo.

9.5.2.9 Deluge water spray systems, foam systems, closed-head sprinkler systems, or dry-chemical systems automatically actuated by rise in temperature shall be installed over the belt drive areas on top of a silo.

9.5.3 Stacker Tubes and Coal Storage Piles.

9.5.3.1 Coal piles shall be designed to minimize the entrainment of air.

9.5.3.1.1 Minimization shall be permitted by development of a compacted edge around the pile.

9.5.3.1.2 The edge described in 9.5.3.1.1 shall be sealed with binder to aid in sealing.

9.5.3.2 All layers in the coal pile shall be compacted.

9.5.3.3 Hot spots or areas of spontaneous combustion shall be removed by digging.

9.5.3.4 The use of water for extinguishment shall be used at a minimum.

9.5.3.5 Active storage piles shall be worked to prevent dead pockets of coal, a potential source of spontaneous heating.

9.5.3.6 Coal piles shall not be located above heat sources, such as steam lines, or sources of air, such as manholes.

9.5.3.7 Coal placed in long-term storage shall be piled in layers, appropriately spread, and compacted prior to the addition of subsequent layers to reduce air movement and to minimize water infiltration into the pile.

9.5.3.8 Where possible, storage piles shall be arranged to allow access to the pile with earth-moving equipment in the event of developing hot spots or fire.

Chapter 10 Truck, Rail, and Barge Loadouts

10.1 Construction.

10.1.1 The loadout shall be constructed of noncombustible material.

10.1.2 Conveyor systems shall be in accordance with Section 9.1.

10.2 Fire Prevention.

10.2.1 No smoking shall be allowed in the loadout control room.

10.2.2* Loadout control rooms shall be designed, constructed, and maintained to reduce the chances of coal dust entering the room.

10.2.3 Combustible storage shall be maintained at least 0.914 m (3 ft) from all electrical panels, gas-fired heaters, and electric resistance heaters.

10.2.4 Trash and other unnecessary combustibles shall not be allowed to accumulate in the loadout control room.

10.2.5 Motor control centers shall be thermographically scanned on an annual basis to identify hot spots and loose electrical connections.

10.2.6 Hydraulic equipment shall have the following alarms interlocked to shut down the equipment:

(1) Low oil pressure
(2) High oil temperature
(3) Low oil level

10.3 Life Safety.

10.3.1 Two means of egress shall be provided from the loadout control room if the room is more than two levels high.

10.3.2 For multistory buildings, emergency lighting shall be provided in accordance with NFPA *101, Life Safety Code.*

10.3.3 For multistory buildings, emergency exit signs shall be provided along the means of egress.

10.4 Fire Detection and Protection.

10.4.1 A smoke detector system shall be installed in the loadout control room in accordance with *NFPA 72, National Fire Alarm Code.*

10.4.1.1 The smoke detector system shall actuate an audible and visual alarm system.

10.4.1.2 For infrequently occupied or remote locations, the system shall send an alarm to a constantly attended location.

10.4.2* A gaseous fire suppression system shall be installed in loadout control rooms that are not regularly occupied and located in remote areas.

10.4.3 An automatic fire suppression system shall be installed to protect hydraulic pumps that have a capacity over 189.3 L (50 gal).

10.4.3.1 The system shall be actuated by a heat detector system.

10.4.3.2 The system shall be interlocked to shut off the power to the unit.

10.4.3.3 A listed fire-resistive fluid shall be an acceptable alternative to an automatic fire suppression system.

10.5 Manual Fire Fighting.

10.5.1* Fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

10.5.2 For multistory buildings, an emergency response plan shall be developed with the input of the local fire department.

10.5.3 For areas subject to flood, an emergency response plan shall be developed to include fire-fighting procedures during a flood.

Chapter 11 Emergency Response and Manual Fire Fighting

11.1* Emergency Procedures.

11.1.1 Emergency procedures shall be provided to instruct all miners in the location and use of fire-fighting equipment, location of escapeways and exits, and evacuation procedures.

11.1.2 The emergency procedures shall include a specific fire-fighting and evacuation plan with procedures for evacuation of all miners not required for fire-fighting activities, rapid assembly and transportation of personnel and equipment to the fire scene, and operation of the fire suppression equipment available at the mine.

11.1.3 All employees shall receive annual instruction on emergency evacuation procedures.

11.1.4 All employees shall receive annual instruction on the procedures for discharging portable fire extinguishers and the proper method of fire attack.

11.1.5 For underground mines, the following additional criteria shall be met:

(1) Fire drills shall be held on a 90-day basis. A record of the drill shall be kept and include the date, the number of persons participating, the area of the mine involved, the procedures followed, and the equipment used.
(2) At least two miners in each working section on each production shift shall be proficient in the use of all fire suppression equipment in that section and know the location of the equipment.

11.1.6 An annual tour of the surface area of the mine shall be arranged with the local fire department. The tour shall include all surface buildings, major equipment, the location of flammable and combustible liquid storage, a discussion of the water supply availability, and the location of electrical shutoffs.

11.2 Underground Operations.

11.2.1 General.

11.2.1.1 An emergency response team shall be available and trained in basic fire-fighting techniques that would include, but not be limited to, fire hose, foam generators, fire extinguishers, and smoke control.

11.2.1.2 Each operator of attended equipment and each miner assigned to job duties normally in sight of the equipment shall be proficient in the use of the fire suppression devices on that equipment.

11.2.1.3 On a maintenance shift, the foreman and at least one miner for every five shall be proficient in the use of fire suppression equipment available in the mine and know the location of the equipment.

11.2.2 Fire-Fighting Team. Mines shall have a fire-fighting team trained in basic fire-fighting techniques, for example, hose streams and foam generation.

11.2.2.1 The fire-fighting team shall have at least 16 hours of refresher training per year.

11.2.2.2 The team shall consist of at least five members on each shift.

11.2.2.3 Self-contained breathing apparatus (SCBA) and fire-retardant coats, boots, and gloves shall be provided for the fire-fighting team.

11.2.3 Emergency Vehicle.

11.2.3.1 All mines shall be provided with an emergency vehicle outfitted with fire hose, appropriate fittings, a "Y" or a "siamese" connection, two adjustable fire department–quality fog nozzles, various tools, and pressure regulators (where necessary).

11.2.3.2 If an underground water car is provided, it shall be at least 3785 L (1000 gal) capacity and shall have at least 91.4 m (300 ft) of fire hose with nozzles.

11.2.3.2.1 A water car shall be capable of providing flow through a hose of 50 gpm at a nozzle pressure of 50 psi.

11.2.3.2.2 A portable dry-chemical car shall be permitted to be provided as long as it carries the extinguishing capacity equivalent to a water car.

11.2.3.2.3 The dry-chemical car described in 11.2.3.2.2 shall be no farther than 3.2 km (2 mi) from each working section.

11.2.4 Foam Generator. A high-expansion foam generator shall be available within 60 minutes of fire notification and have enough foam to supply the fire-fighting operation for 35 minutes.

11.2.5 Fire Hose and Hydrants.

11.2.5.1* Water lines installed parallel to haulage tracks using mechanized equipment in the track or adjacent entry shall be equipped with outlet valves at intervals of not more than 152.4 m (500 ft), and with 152.4 m (500 ft) of fire hose with fittings suitable for connection shall be provided at strategic locations.

11.2.5.2 Hydrants shall be provided along belt conveyors at intervals not to exceed 91.4 m (300 ft).

11.2.5.3 At least 152.4 m (500 ft) of fire hose shall be provided for each belt flight and strategically positioned within that belt flight.

11.2.5.4 The threads on the hose and hydrants shall be protected against dirt and rock grit.

11.2.5.5* Multiple hydrant assemblies, with the tools needed for their installation, shall be provided as part of each cache of emergency materials.

11.2.5.6 Fire hose shall be lined with a material having flame-resistant qualities meeting requirements for hose in the U.S. Bureau of Mines' Schedule 2G.

11.2.5.6.1 The covers of the fire hose shall be polyester or other material with flame-spread qualities and mildew resistance equal or superior to polyester.

11.2.5.6.2 The bursting pressure shall be at least four times the water pressure at the valve to the hose inlet with the valve closed.

11.2.5.6.3 The maximum water pressure in the hose nozzle shall not exceed a gauge pressure of 689.5 kPa (100 psi).

11.2.6 Barricading Materials. In addition to specific area equipment, the following equipment shall be readily available at locations not exceeding 3.2 km (2 mi) from each working section:

(1) 304.8 m (1000 ft) of brattice boards
(2) Two rolls of brattice cloth
(3) Two hand saws
(4) 11.3 kg (25 lb) of 8d nails
(5) 11.3 kg (25 lb) of 10d nails
(6) 11.3 kg (25 lb) of 16d nails
(7) Three claw hammers
(8) 25 bags of wood fiber plaster or 10 bags of cement (or equivalent material)
(9) 4536 kg (5 tons) of rock dust

11.3 Surface Operations.

11.3.1 Fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

11.3.2 If fire hydrants are provided, they shall be installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

11.3.3 If fire hydrants are not provided, water trucks shall be the fire-fighting water source.

11.3.3.1 Water trucks shall be equipped with a pump, fire hose, nozzles, and appropriate fittings.

11.3.3.2 The water truck shall be equipped with a water cannon (turret).

11.3.3.3 The water truck shall be equipped with a connection to enable the fire department to take suction from the tank.

11.3.4 Fire hose and couplings shall be listed or approved. Cotton- or cotton-polyester-jacketed hose shall be treated in accordance with the U.S. Department of Agriculture Forest Service Specification 182 for mildew resistance.

11.3.5 Water lines shall be capable of delivering at least 378.5 L/min (100 gpm) at a hose nozzle pressure of 689.5 kPa (100 psi).

11.3.6 The water pressure at the hose nozzle shall not be excessively high so as to present a hazard to the hose operator.

11.3.7 The hose connections shall have threads compatible with the local fire department's hoses, or a supply of adapters shall be available to adapt the hose connections to the fire department hoses. The local fire department shall be consulted to ensure thread compatibility for hose connections.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1 In the development of this document, the data in NIOSH Information Circular 9470, "Analysis of Mine Fires for All Underground and Surface Coal Mining Categories: 1990–1999," were examined. Table A.1.1.1 shows the number of fires for underground coal mines, surface fires at underground coal mines, at surface coal mines, and at coal preparation plants, as well as the number of fire injuries and coal production for the time period from 1990 to 1999.

Analysis of the data shows a general decrease in the number of fires over the 10-year period, particularly from 1996 to 1999, while coal production increased slightly. The largest number of fires over the 10-year period, as well as for each 2-year time period, occurred at surface coal mines. There were 164 injuries due to fire during the 10-year period, with the number decreasing significantly over the last 4 years. There were two fatalities in 1991.

A.1.3 Because of the uniqueness of coal mining, provisions in this standard can differ from commonly accepted fire protection standards and guides for other types of occupancies.

A.3.2.1 Approved. 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, 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 that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, 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, or 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 or her 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.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations 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.

A.3.3.3 Boiling Point. Where an accurate boiling point is unavailable for the material in question, or for mixtures that do not have a constant boiling point, for the purposes of this standard, the 10 percent point of a distillation performed in accordance with ASTM D 86, *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*, can be permitted to be used as the boiling point of the liquid.

A.3.3.7 Combustible Liquid. NFPA 30, *Flammable and Combustible Liquids Code*, classifies combustible liquids as follows:

(1) Class II liquids include those having flash points at or above 37.8°C (100°F) and below 60°C (140°F).
(2) Class IIIA liquids include those having flash points at or above 60°C (140°F) and below 93.4°C (200°F).
(3) Class IIIB liquids include those having flash points at or above 93.4°C (200°F).

Table A.1.1.1 Number of Coal Mine and Preparation Plant Fires, Injuries Due to Fire, and Coal Production from 1990 to 1999

	Number of Fires*					
Years	Underground Coal Mines	Surface at Underground Coal Mines	Surface Coal Mines	Coal Preparation Plants	Number of Fire Injuries*	Coal Production† (10^6 short tons)
1990–1991	25	17	67	23	59	2,004
1992–1993	18	14	37	22	29	1,928
1994–1995	23	16	47	18	39	2,059
1996–1997	6	7	40	8	19	2,155
1998–1999	15	11	24	20	18	2,218
1990–1999 Total	87	65	215	91	164	10,364

*Derived from MSHA "Fire Accident Abstract" and "Fire Accident Report" publications.

†Derived from MSHA "Injury Experience in Coal Mining" publications.

A.3.3.22 Flammable Liquid. NFPA 30, *Flammable and Combustible Liquids Code*, subdivides Class I liquids as follows:

(1) Flammable liquid Class IA include those having flash points below 22.8°C (73°F) and having a boiling point below 37.8°C (100°F).
(2) Flammable liquid Class IB include those having flash points below 22.8°C (73°F) and having a boiling point at or above 37.8°C (100°F).
(3) Flammable liquid Class IC include those having flash points at or above 22.8°C (73°F) and below 37.8°C (100°F).

A.3.3.24 Flash Point. As an alternative, ASTM D 3243, *Method of Test for Flash-Point of Aviation Turbine Fuels by Setaflash Closed Tester*, can be permitted to be used for testing aviation turbine fuels within the scope of this procedure.

As an alternative, ASTM D 3278, *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*, can be permitted to be used for paints, enamels, lacquers, varnishes, and related products and their components having flash points of 0°C to 110°C (32°F to 230°F) and having a viscosity lower than 150 stokes at 25°C (77°F).

A.4.2 Potential sources of ignition include, but are not limited to, the following:

(1) Smoking
(2) Open flames
(3) Cutting and welding
(4) Hot surfaces
(5) Frictional heat
(6) Static, electrical, and mechanical sparks
(7) Spontaneous ignition, including heat-producing chemical reactions
(8) Radiant heat

A.4.2.5.1 Automatic-closing doors provide a higher level of fire protection and are therefore recommended.

A.4.2.6 Belt fires originating away from the drive area usually have been caused by idlers with defective or stuck bearings. Tests have shown that such idlers can become moderately hot [93°C to 149°C (200°F to 300°F)]. The coal task group has been unable to find reliable evidence that idlers can become hot enough to ignite fire-retardant belting directly.

It appears that a warm or hot idler can cause fine coal dust accumulated around the idler to ignite. Then, when the belt has been stopped, coal burning beneath the belt ignites the belting.

The key to avoiding belt fires is to prevent the accumulation of fine coal dust around idlers. If a metal deck is provided between the carrying strand and the return strand of the belt, coal dust accumulates around the troughing idlers. Where possible, return idlers should be supported at a substantial height above the bottom so that coal dust is not likely to build up around return idlers. With proper clearance beneath these idlers, accumulations of coal dust can be cleaned up more easily.

Slat-type, self-cleaning tail pulleys are recommended. Coal dust discharged by such pulleys should be cleaned up frequently. Both good maintenance and good fire prevention necessitate that noisy bearings, which might indicate probable failure, be changed promptly before they become hot.

Conveyor belt fires have been caused by belts that lose proper alignment, with the edge of the moving belt then contacting combustible material. Loss of alignment can result from a number of factors, including displacement of idlers or pulleys and movement of supporting structure, spillage of conveyed material, and failure of a bearing (typically on a pulley). Where alignment is affected significantly, the edge of the belt can rub abrasively on the structure and objects near the edge of the belt. If the object on which the belt rubs is metal, the metal can become worn and heated. The edge of the belt can be damaged extensively, but the belt probably will not ignite because a point on the edge of the moving belt is in contact with the metal for only a very short period and will cool before it returns to the point of contact. The metal can become quite warm, but because it is a good conductor of heat, it will not become hot enough to ignite the belt if the belt stops. Nevertheless, if the material contacted is wood or another combustible, the combustible material could be heated by the friction of the edge of the moving belt until it ignites. Keeping combustible material away from the edge of the belt and use of alignment switches should prevent such fires.

A.4.3 For further information see NIOSH Information Circular 9452, *An Underground Coal Mine Fire Preparedness and Response Checklist: The Instrument.*

A.4.3.1.1.1 Routing of water lines has caused severe problems in fighting fires at some large mines. These mines had multiple intake shafts spaced apart at considerable distances. Such a ventilation can create a neutral point between the shafts, with fresh air moving from each shaft toward the neutral point. At the original opening of one mine, a water source was established and the water line was extended as the mining developed farther away from the original opening. With the water line extended to each new intake shaft and passing through each neutral point, a condition of opposite direction of flow of air and water existed beyond each neutral point.

If a fire occurs in an area of opposite flow, the fire has to be approached in the same direction as the airflow, but the water flow is moving through the fire area. Usually water lines in a fire area are damaged or broken by falling sections of burning roof. When a water line breaks in such a situation, the fire fighters are without water, and direct fire fighting is no longer possible. The fire then can be controlled only by sealing. At least one large coal mining company now provides an additional water source at each new intake shaft to ensure the ability to fight such fires.

The likelihood of this problem appears to be increasing as more mines are ventilating belt entries with air moving outby, while the water flow is inby. In some cases, mine management has recognized the problem and has developed procedures to change the direction of airflow in the event of a fire. Reversing the airflow should be done at a point close to and outby the fire to avoid pushing smoke-laden air back onto the fire. After the belt entry outby the fire has been cleared of smoke, the airflow can be reversed for the full length of the entry if desired.

Mines that obtain their water supply from an underground source also can have this problem of opposite directions of air flow and water flow. Usually there is no sure solution except to provide an alternative source of water or a large storage of water on the surface. If the power for the pumps is fed from the high-voltage system that feeds the mine and the fire damages the high-voltage cable anywhere on the system, the power can trip the entire system and shut down the pumps. Coordination of the electrical protective equipment or even a separate power supply might be needed to ensure that the pumps continue to supply water for fire fighting.

Even in situations where air and water are flowing in the same direction, management must recognize that water lines or hydrants in a burning entry are likely to be broken by the falling sections of burning roof. In such situations, a planned shutdown of the water line should be undertaken as soon as possible so a multiple hydrant can be installed in the water line at a convenient location close to the fire. With the multiple hydrant in place, at least three fire hose can be served effectively from the water line.

Because of the many factors that should guide the choice of location of water lines and hydrants, management should be properly qualified to select these locations, but management also should be able to justify its choice. Reliability of the water supply and ability of fire hose streams to reach a fire at any location or entry served by the water line should be the criteria by which the location is chosen.

A.4.3.1.1.9 Shutoff valve intervals of 305 m (1000 ft) are recommended. Indicator-type shutoff valves with labels specifying the normal operating position are recommended.

A.4.3.1.2.1 Water distribution lines generally cannot meet the capacity requirements of 4.3.1.2.1 unless 127 mm (5 in.) or 152.4 mm (6 in.) pipe is used for main water lines and 101.6 mm (4 in.) pipe is used for branch lines to producing areas. Higher nozzle pressures are recommended.

A.4.3.1.2.2 The required hose stream water demand equals a minimum supply of 817,560 L (216,000 gal).

A.4.3.1.3.1 Hydrants in a coal mine normally are only a valve screwed onto a tee that is installed on the water line. For the female coupling of a fire hose to be connected to a male thread, a pipe nipple usually is screwed into the discharge side of the valve. Because the threads of steel pipe nipples generally corrode if left exposed, brass nipples often are used instead of steel nipples. Many mines have begun to use Schedule 80 plastic nipples instead of steel. Regardless of the nipple material, the threads of the nipple should be protected against physical damage.

A properly designed system of hydrants and fire hose should make a good connection of fire hose lines to the hydrants without the need for tools.

The choice of locations for hydrants should be made to ensure that fire hose lines can be laid quickly from hydrants located on the water line through crosscuts to a fire located in any parallel entry or crosscut, rather than to provide convenience for use in the entry where the water line is located.

A.4.3.1.3.2 Hydrants should preferably be located in crosscuts, and stoppings in such crosscuts should be fitted with a man door.

A.4.3.2 Automatic detection systems and automatic sprinkler systems in mining facilities need to be specifically addressed for the following reasons:

(1) The contents of a mine occupancy are continually changing. Most items are not fixed and are designed to be moved with the mining operation. A mine operates as a heavy-duty excavation construction site and, thus, has the same transitory nature as a construction site.
(2) Unlike aboveground industrial occupancies, great distances are not unusual within an underground mine. Mines covering 64.75 km^2(25 mi^2) or more are common.
(3) Mines have extremely harsh and unusual environments compared to aboveground industrial occupancies. Heavy concentrations of combustible dusts, the presence of explosive gases, temperature extremes, saturated humidity conditions, standing water, unstable strata, roof-to-floor heights that vary from 710 mm to 6.1 m (28 in. to 20 ft), and complex ventilation systems are all commonplace. The possibility of abuse from heavy machinery is a common hazard.
(4) Mining occupancies exhibit unique physical characteristics not found in any other type of occupancy. One example is the extreme pressures that can occur in a water line.
(5) Mines employ specialized facilities, equipment, and production processes not utilized in other industries. Fire protection efforts that fail to consider the unusual operating characteristics and fire protection requirements of underground coal mining systems could result in nonoptimal protection or the inadvertent introduction of hazards.

30 CFR 75.1103-4 provides requirements for installing fire detection systems in underground coal mines in the United States.

A.4.3.2.1.1 An automatic fire detector is a device designed to detect the presence of fire and initiate action. For the purpose of this standard, automatic fire detectors are classified as follows:

(1) *Heat detector*: a device that detects an abnormally high temperature or rate of temperature rise
(2) *Smoke detector*: a device that detects the visible or invisible particles of combustion
(3) *Flame detector*: a device that detects the infrared, ultraviolet, or visible radiation produced by a fire
(4) *Fire-gas detector*: a device that detects gases produced by a fire
(5) *Other fire detectors*: devices that detect a phenomenon other than heat, smoke, flame, or gases produced by a fire

Fire detectors should be installed as follows:

(1) *Vertical Placement*. Because the hot gases from a fire will rise owing to buoyancy forces, combustion products initially will be stratified near the roof of an entry. As the stratified gas layer moves away from the fire, the resultant cooling and dilution eventually will produce a well-mixed flow of combustion products. Data from full-scale fires indicate that some degree of stratification can exist at distances of hundreds of feet from the source of the fire.

    Because of this effect, fire detectors should be located at a vertical distance from the entry roof that does not exceed 25 percent of the average entry height. For example, in an entry with a height of 1.8 m (6 ft), the maximum distance from the roof at which a sensor should be located is 0.5 m (1½ ft). The maximum distance refers to the location of the actual sampling intake of the detector used.
(2) *Lateral Placement*. In general, the point of origin of a fire is unpredictable. It can occur along the floor, ribs, or roof of the entry. To provide optimum protection, it is recommended that the fire detectors be located within 0.6 m (2 ft) of the approximate midpoint of the entry.

    For entries in which the point of origin of the fire can be better estimated (such as a belt entry), the detectors should be located in such a manner that they provide for the estimated best coverage of that entry.

A.4.3.2.1.3 Batteries charged by the mine power system should indicate the condition of the batteries upon either manual or automatic activation of a battery check circuit.

For further information see *NFPA 72, National Fire Alarm Code*.

A.4.3.2.1.4 Electrical equipment classified as "permissible" or "intrinsically safe" is certified as meeting the requirements of 30 CFR, Part 18, Chapter 1.

A.4.3.2.2.1 Based on U.S. Bureau of Mines Report of Investigation 9570, "Hazards of Conveyor Belt Fires," CO and smoke detectors provide a significant improvement over point type heat detectors in warning of a potential fire on conveyor belts.

A.4.3.2.2.3 U.S. Bureau of Mines Report of Investigation 9380, "Fire Detection for Conveyor Belt Entries," provides information on smoke and CO sensor alarm levels and sensor spacing as a function of belt entry cross-sectional area and belt entry air velocity.

A.4.3.3.1.1(3) Depending on the size of the equipment, additional manual actuators could be needed to provide quick access for activation of the system.

A.4.3.3.1.1(4) For further information on flame resistance, see 30 CFR 18.65.

A.4.3.3.1.4 For criteria of equivalent protection, see 30 CFR 75.1107-13.

A.4.3.3.2.1 Wet-pipe automatic sprinkler systems have been found to be the preferred fire suppression systems for underground coal mines for the following reasons:

(1) They are the simplest systems available.
(2) They are the most reliable systems available.
(3) They provide selective operation, because only sprinklers close to the fire operate.
(4) They have the best performance record, especially on fires of Class A materials and of Class IIIB combustible liquids.
(5) They need minimal maintenance.
(6) They are nonelectrical.
(7) They use a limited quantity of water.
(8) The initial investment is low.

The major problem associated with automatic sprinkler systems in underground coal mines is the possibility of exposure to freezing conditions during cold weather. Another problem that can exist in very deep mines is that some of the listed components for automatic sprinkler systems might be unable to withstand the very high water pressure encountered (see U.S. Bureau of Mines Report of Investigation 9451, "Effect of Pressure on Leakage of Automatic Sprinklers"). It is not uncommon to encounter pressures above a gauge pressure of 3448 kPa (500 psi). The committee recommends testing sprinkler system components under anticipated maximum pressures. If sprinkler components are found to be unable to withstand the maximum pressure of the water line, the use of pressure regulators might be necessary. Experience has shown that pressure regulators can require considerable maintenance. Also, if the pressure regulating valve should leak, it might be necessary to provide a small relief valve on the discharge side of the regulating valve to prevent overpressure.

A.4.3.3.2.1(1) Under Report No. H0122086, "Suppression of Fires on Underground Coal Mine Conveyor Belts," the Department of the Interior, U.S. Bureau of Mines (USBM), conducted a series of full-scale fire tests.

The tests demonstrated that standard, 12.7 mm (½ in.) orifice, nominal 100°C (212°F) automatic sprinklers, located over the belt on 3 m (10 ft) centers, effectively controlled every test fire while opening only two sprinklers, with residual pressure held to a constant a gauge pressure of 69 kPa (10 psi).

From the time that the USBM tests were conducted, underground belts have tended to become wider to carry increased tonnage; therefore, belt fire suppression systems should be designed to supply more sprinklers than indicated by these tests. Because many conveyor belts stretch a long distance in a straight line, a fire scenario would involve only a portion of the belt, regardless of the overall length of the belt. Because the actual incidence of belt fires is low in underground coal mines, and most of those are in the area of the belt drive and the belt takeup, protection of only the area from the discharge pulley to the end of the takeup is needed. If the belt structure contains a deck between upper and lower strands of the belt, automatic sprinklers should be located beneath the deck, virtually doubling the size of the sprinkler system.

If the sprinkler system is extended to cover a distance greater than 30.5 m (100 ft) in one direction from the point where the pipe holding the automatic sprinklers along the roof is fed, then a hydraulic calculation of the system is recommended. Long runs of pipe should be flow tested as required by 4.3.3.5.4.1, with the eight open sprinklers installed at the distant end of the pipe run. Branch piping intended to protect limited areas should be piped with adequately sized pipe to carry the required water flow. Table A.4.3.3.2.1(1) should be used to determine the minimum size of pipe.

Table A.4.3.3.2.1(1) Minimum Pipe Sizes per Number of Sprinklers

Pipe Size	Maximum Number of Sprinklers on Pipe
1 in.	2
1¼ in.	3
1½ in.	5

Note: For SI units, 1 in. = 25.4 mm.

Larger systems should be separately flow tested as required by 4.3.3.5.4.1.

A.4.3.3.2.2 Because many air compressors are moved frequently, the fire suppression system needs to be equally portable. Some compressors that have a deck or lid over the compressor have been fitted with piping and sprinklers attached to the underside of the deck. Other compressors without a deck have suitable piping with at least two sprinklers 3.0 m (10 ft) apart. The piping is made to be attached to roof bolts or otherwise suitably supported over the centerline of the compressor. The piping needs to be equipped with a pressure switch that prevents the operation of the compressor unless the piping is under pressure and with a flow switch that shuts the compressor down if water flows. If a fire hose is used to connect the piping to a water line, the connection point of the hose to the sprinkler piping should be located so that a fire on the compressor will not damage the fire hose.

A.4.3.3.3.1 Underground shaft mines that use diesel-powered equipment generally employ underground diesel fuel storage areas to facilitate equipment refueling. Adit-type mines in the western United States might initially locate diesel fuel storage and refueling facilities on the surface; however, as the active mine workings progress farther from the adit portal(s), these facilities will likely be moved underground.

A common means of fire protection currently found in many underground diesel fuel storage areas is the use of fixed water sprinkler systems. However, it is felt that this situation represents a significant safety hazard. According to the NFPA *Fire Protection Handbook*, water sprinklers can be permitted to be used on diesel fuel for control but not for extinguishment.

In "The Health and Safety Implications of the Use of Diesel-Powered Equipment in Underground Mines," a report by an interagency task group prepared for MSHA in 1985, the simple conclusion was that "water spray or fog usually will not extinguish diesel fuel fires."

In an underground coal mine, fire control is not sufficient; fire extinguishment is essential for the following reasons:

(1) Unlike an underground metal or nonmetal mine, the mineral in a coal mine is combustible, and, indeed, all fire prevention and protection provisions in an underground coal mine are aimed at preventing the ignition of the coal. In a metal or nonmetal mine, if fire control efforts are unsuccessful in extinguishing a fire on a piece of diesel equipment or a diesel fuel fire, personnel can be evacuated and the fire can be allowed to consume all available fuel materials, thereby self-extinguishing. In an underground coal mine, this practice would almost certainly result in the ignition of the coal and the consequent loss of part or all of the mine.
(2) Even if a fire does not grow in intensity or spread to the coal, toxic smoke and fire gases are produced as long as it burns, which can endanger persons within the mine.
(3) According to the NFPA *Fire Protection Handbook*, overpressure failure of containers exposed to fire is considered the principal hazard of closed-container flammable and combustible liquid storage.
(4) Even a "controlled" fire can cause such container failure, producing a fire so intense that the sprinkler system is unable to control it, much less extinguish it.
(5) Water sprays are not effective in extinguishing pressure fires, running fuel fires, and obstructed spill fires, all of which could occur in a diesel refueling area.
(6) Water supplies are limited in many underground mines. Fire "control" should be considered temporary, because when the water supply is depleted, the fire will grow immediately to the maximum intensity.
(7) The vapor pressure of diesel fuel increases with elevation, due to reduced barometric pressure. As a result, even fuels without flash point–reducing additives can become flammable, depending on the altitude at which they are used. This reduction in flash point can result in reclassification of the diesel fuel to a Class IC flammable liquid. There is no clear consensus in the literature and industry practice as to the effectiveness of fixed water sprays in controlling and extinguishing fires involving Class IC flammable liquids. Although industry practice strongly favors fixed water sprays for such applications, the literature and available research results clearly indicate the ineffectiveness of fixed sprays on Class IC liquids, especially in the case of pressure fires, running fuel fires, and obstructed spill fires.

Therefore, water sprinkler systems installed for the protection of diesel fuel storage areas are considered inadequate; foam–water systems should be utilized. See the applicable sections of NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.*

A.4.3.3.3.2 The alarm system that serves sprinklers protecting the drive area of a belt conveyor also should be permitted to serve as the fire detection system installed over that portion of the belt conveyor.

A.4.3.3.3.2.8 Some automatic sprinklers might not withstand the water pressure that can be encountered in deep mines. Information on the effect of high water pressure on automatic sprinklers can be found in U.S. Bureau of Mines Report of Investigation 9451, "Effect of Pressure on Leakage of Automatic Sprinklers."

Under U.S. Bureau of Mines Report of Investigation 9538, "Performance of Automatic Sprinkler Systems for Extinguishing Incipient and Propagating Conveyor Belt Fires Under Ventilated Conditions," NIOSH conducted a series of full-scale fire tests under ventilated conditions of 1.1 and 4.0 m/s (225 and 800 ft/min) for fires up to 10.8 MW. The tests demonstrated that pendent and horizontal sidewall types were both able to extinguish incipient belt fires. Directional sprinklers showed a slightly improved performance in terms of maximum heat release rate at the lower airflow. Both pendent and horizontal sidewall sprinkler types were able to extinguish propagating fires. Horizontal sidewall sprinklers showed an increased effectiveness compared to the pendent sprinklers because of the increased upstream coverage area of the water discharge in terms of maximum heat release rate.

A.4.3.3.3.2.10 The restrictions on sprinkler spacing apply to sprinklers on the same line and those located between sprinklers on adjacent lines.

A.4.3.3.3.2.11 Where sprinkler positioning is such that full coverage can be impaired, such as where a single line of sprinklers protects a belt conveyor with little clearance, a flow test should be conducted to determine if adequate wetting of surface areas is achieved. Additional sprinklers should be provided in the event that adequate coverage is not achieved, or alternative arrangements such as rotated lines or sidewall sprinklers should be considered. Consideration also should be given to the need for noncombustible baffles to protect sprinklers from the discharge of adjacent sprinklers located within 1.8 m (6 ft).

A.4.3.3.3.2.15 Pipe and fittings that permit limited motion of the pipe are recommended, as they allow the pipe to be held closer to the roof. If threaded fittings are used, steel pipe with extra-strength threaded fittings is recommended. Copper or aluminum might be permitted if it is adequate for the pressure.

A number of mines are using aluminum pipe or tubing with groove-type couplings and fittings. Where water pressure does not exceed 3448 kPa (500 psi), grooved couplings having a 12.7 mm (½ in.) female national pipe thread (FNPT) outlet are being used to provide connections for sprinklers. Piping put together in this manner can be located closer to an undulating roof, especially if the pipe lengths are short enough to put the couplings (and the automatic sprinklers) on 3.0 m (10 ft) centers. Mines using groove-type couplings claim that most of the pipe can be precut and grooved in the shop, which simplifies installation underground. Rolled grooves are recommended because they do not reduce the strength of the pipe as much as cut grooves. If cut grooves are used, Schedule 40 or heavier pipe should be used.

A.4.3.3.3.4.1 Local plumbing or health codes should be consulted for specific requirements and permissibility.

A.4.3.3.3.4.4 A tee or tees should be located at any high point where a sizable volume of air can be trapped. The tee should be fitted with a valve or plug to allow venting of air while the system is filled with antifreeze solution.

A.4.3.3.3.4.8 The purpose of the air chamber is to absorb the expansion of the liquid that takes place when the system is warmed by summer temperatures. The relief valve protects against excessive pressure that can occur if the chamber does not contain sufficient air.

The chamber can easily be filled with compressed air if a high-pressure compressor is available; however, care should be used during pressurizing to avoid overpressure beyond the strength of the chamber. An alternative method is to use the water pressure to compress air into the chamber. The piping has to be empty of liquid. The drain and vent valves are closed. The chamber is connected to a high point of the piping, and the valve on the chamber is opened. The shutoff valve is partly opened so the piping will fill with water, but not too rapidly. The water compresses the air into the chamber to the proper pressure. The valve on the chamber is closed, and the piping is drained. The piping is then filled with mixed antifreeze solution, and the system can be put into operation.

The formula for percent of air chamber volume to volume of system piping, as follows, should be used to calculate the minimum volume of the air chamber or the volume of the solution withdrawn:

$$\frac{V_c}{V_s} = (\beta)(\Delta T)\left[\frac{P_m}{(P_m - P_1)}\right]$$

where:

V_c = Volume of air chamber.
V_s = Total volume of system piping.
β = Effective coefficient of expansion. (Table A.4.3.3.3.4.8 shows the variation of different solution concentrations for steel and aluminum pipe.)
ΔT = Total maximum expected temperature range to which the system will be exposed, from the highest in summer to the lowest in winter, in degrees Celsius.
P_1 = Maximum waterline pressure.
P_m = Maximum pressure designed for the sprinkler system. This pressure is the pressure setting of the relief valve.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, describes another satisfactory method to limit pressure. It uses a check valve with a small hole drilled in the clapper of the check valve and a U-loop pipe having a minimum drop of 1.5 m (5 ft). The check valve and the U-loop have to be installed in a nonfreezing area, and often the height might not allow a 1.5 m (5 ft) U-loop.

A.4.3.3.3.4.14 An alternative arrangement to an air chamber is to fully fill the sprinkler piping with antifreeze solution and then withdraw a suitable volume to create an air chamber. A recommended formula for calculating the volume to be withdrawn can be found in A.4.3.3.3.4.8.

A number of coal mines have used antifreeze systems successfully but without an air chamber. The method used to fill the antifreeze systems is to calculate the amount of antifreeze (usually ethylene glycol) needed to protect the full volume of the piping. This amount is put into the empty system. Then with the drain and test valves closed, the shutoff valve is opened, allowing water to flow into the piping. This process traps air in the system, which absorbs expansion of the liquid. While this method does not provide accurate control of the concentration of the antifreeze solution, and initially the mixing is not uniform, it does work if done before cold weather arrives. It appears that the mix became uniform in about a month.

This method of filling the sprinkler piping allows the piping system to be simpler than the method that uses a special air chamber; however, it does pose certain problems. First, it should be recognized that compressed air can find leaks in piping that holds a liquid successfully. Also, air leaks are difficult to find, while liquid leaks are obvious. Finally, because of the greater contact between the air and the liquid in this method, there is a greater chance that the liquid will absorb more of the air than occurs in the alternative system. Therefore, it is recommended that the volume of liquid removed be substantially greater than the calculation.

It is important to recognize that any loss of air by leakage or solubility will be replaced by water from the waterline. This also occurs as cold weather comes on, and the liquid contracts as it cools. This results in dilution of the antifreeze solution. The formulation of the antifreeze solution tends to provide more antifreeze than is indicated by Table 4.3.3.3.4.2 and Table 4.3.3.3.4.3, so the system can live with some dilution. Also, a second test of the antifreeze solution should be performed annually, so that mines using these antifreeze solutions gain experience in the safe operation of these systems.

A.4.3.3.3.4.20 The major reason for changing the method of filling and mixing is that, with the old method, there was a chance of discharging nearly pure antifreeze on a fire if it occurred before the mix became uniform. The glycols and glycerin are combustible liquids unless they are mixed with water to create solutions, as shown in Table 4.3.3.3.4.2 and Table 4.3.3.3.4.3.

Table A.4.3.3.3.4.8 Solution Concentrations Used to Compress Air in Steel and Aluminum Pipes

			Solution Concentrations	
Solutions	Percent Water	Specific Gravity*	For Steel Pipe	For Aluminum Pipe
Ethylene glycol solutions	61	—	0.00050	0.00046
	56	—	0.00051	0.00048
	51	—	0.00052	0.00049
	47	—	0.00053	0.00050
Calcium chloride solutions	—	1.186	0.00020	0.00016
	—	1.218	0.00020	0.00017
	—	1.239	0.00026	0.00022
	—	1.260	0.00028	0.00025
	—	1.272	0.00030	0.00026
	—	1.283	0.00030	0.00026

*Measured at 15.6°C (60°F).

Solutions of calcium chloride are inherently fire safe. Glycol or glycerin solutions are quite safe when applied at the minimum rate. In addition, continued flow of the sprinkler system will quickly discharge all the antifreeze solution, after which the discharge is water only.

Care should be used in making calcium chloride–water solutions, because mixing flake calcium chloride and water will give off some heat. Also, the corrosion inhibitor is classified as a toxic chemical. Strict adherence to product safety data sheets, available from suppliers, should be followed.

A.4.3.3.3.5 Dry-pipe automatic sprinkler systems are more complex and more difficult to design and install than wet-pipe systems. The committee recommends that all systems be designed and installed at a mine by skilled and experienced personnel.

A pressure relief valve, set to relieve at a pressure below the maximum pressure rating of the dry-pipe valve, should be installed between the pressure regulating valve and the dry-pipe valve. The reclosing pressure of the relief valve should be higher than the set pressure of the regulating valve.

A.4.3.3.5.3.3 The clapper of a differential-type dry-pipe valve should be held off its seat during any test in excess of 345 kPa (50 psi), to prevent damaging the valve.

A.4.3.3.6.1 The actuation of a fire suppression system on self-propelled equipment should cause shutdown of the protected equipment.

A.4.3.3.6.1(11) Because exposure to some agents or their decomposition products could be hazardous to personnel, it is recommended that the appropriate NFPA standard for the agent under consideration be consulted to determine the agent's use and limitations, recognizing that the mine environment can make prompt evacuation difficult.

A.4.3.3.6.2 Pipe or hose supplying open spray nozzles should be sized to avoid excessive pressure loss. Open nozzles provide a good spray pattern with 68.9 Pa to 137.9 Pa (10 psi to 20 psi) of water pressure at the nozzles. If nozzle pressure exceeds 174.6 Pa (25 psi), additional or larger orifice nozzles can be permitted to be used to increase the water flow. If nozzle pressure is less than 137.9 Pa (20 psi), smaller orifice nozzles should be used to increase the pressure. The objective is to obtain the maximum flow of water at a pressure high enough to provide a reasonable spray pattern.

The water spray should be directed upward to wet the roof over the machine. This prevents the fire from spreading to the coal, which should be the primary objective of the fire protection system. Also, water will fall back down onto the machine, cooling and possibly extinguishing the flames. Alternatively, the nozzles can be directed at the fire hazard areas of the machine. The risk of this method is that the fire could be in an area not covered by the sprays and could spread to the coal.

A.4.3.4.1.1.1 Larger capacity extinguishers that provide more agent and longer discharge time are recommended.

A.4.3.4.1.2.3 It is not the intent of 4.3.4.1.2.3 to allow two lower rated fire extinguishers to be used to achieve a higher overall rating.

A.4.3.4.1.3.2 Visual inspections require documentation only at 6-month intervals.

A.4.3.4.2.1.1 Hydrants should be located to ensure that fire hose can be laid quickly from hydrants, which are located on the water line in any of the entries, through crosscuts to a fire located in parallel entries or crosscuts, rather than being located for convenient use in the entry where the water line is located.

A.4.3.4.2.1.4 Fire hose should be purchased as an entire unit that consists of the hose and couplings. The pressure rating should include both the hose and the couplings.

A.4.3.4.2.1.6 These threads are also referred to as National Pipe Straight Hose (NPSH). National Hose (NH) is also known as National Standard Thread (NST) and National Standard (NS).

Threads of 38 mm (1½ in.) or 50 mm (2 in.) hose couplings should be straight, iron pipe thread, now labeled NPSH. While it is always preferable to use fire hose adapters, NPSH couplings can be attached to standard male pipe threads. This is especially important because of the large number of hydrants needed on water lines.

Where the gasket of a fire hose coupling is in good condition, the coupling should be tightened with bare-hand pressure only. It usually will not leak. Hose wrenches are needed to uncouple hose only. Overtightening couplings with hose wrenches harms the gaskets.

Rocker lug couplings are preferred to pin-type couplings.

Most mines use NPSH threads because the couplings will attach to male pipe threads of the same size.

A.4.3.4.2.1.8 It should be noted that most mines are now shifting to 38 mm (1½ in.) plastic adjustable nozzles, which are not available in 50 mm (2 in.) size.

A.4.3.4.2.1.9 In many fires, fire hose has to be carried to the fire. If manual transport is necessary, the hose should be coiled into "bundles" or "doughnuts," with the male coupling at the center. In this manner, the hose is in proper orientation for use, and the exposed threads of the male coupling are protected. Hose lengths should be limited to 30.5 m (100 ft) or less, because greater lengths make the hose bundle too large and heavy.

It is sometimes preferable to coil bundles or doughnuts of fire hose starting with the approximate center point of the hose at the center of the bundle. A coil made in this manner positions the hose couplings on the outside so the hose can be laid starting at the hydrant moving toward the nozzle or from the nozzle back to the hydrant with equal efficiency.

Where high pressures are a concern, pressure relief devices can be used. The devices can be stored with the hose cache.

A.4.3.4.2.1.11 Consideration should be given to providing caches at intervals of less than 1525 m (5000 ft) where conditions warrant. A single hose cache might satisfy more than one of the required locations.

A.4.3.4.2.2 Fire hose requires special consideration at coal mines. Cotton- or linen-jacketed hose should not be used, as it is subject to mildew attack. Even mildew-treated hose does not endure. Rubber-lined and rubber-jacketed hose resists mildew attack, but this type of hose is heavy, stiff, and expensive. Neoprene-lined, polyester hose with rocker lug couplings is probably the best hose for mine use. The use of pin-type couplings should be avoided because the pins are easily broken or knocked off.

In low coal and where the water supply can deliver about 3.2 L/sec (50 gpm) at proper pressure, 38 mm (1½ in.) hose should be used. Where the water supply is able to provide 378.5 L/min to 757 L/min (100 gpm to 120 gpm) at proper pressure, 50 mm (2 in.) hose is preferable. Hose of 64 mm (2½ in.) has no advantage over 50 mm (2 in.) hose, and the extra weight and cost of 64 mm (2½ in.) hose is considerable.

Many mines have standardized on 38 mm (1½ in.) fire hose, even though their water lines can supply substantially more water than is required to get proper discharge from a 38 mm (1½ in.) hose nozzle. Some of these mines provide at least two valved connections (hydrants) in operating areas so that more than a single 38 mm (1½ in.) hose line can be used if needed. In some cases, short lengths of pipe with two or more hydrants are available for use at other points along the water lines. These multiple hydrants can be put in the line at joints where the water line is joined with grooved couplings.

While the total water flow of two 38 mm (1½ in.) hose lines is about the same as one 50 mm (2 in.) hose line, in the opinion of many experienced mine fire fighters, two 38 mm (1½ in.) hose lines provide greater flexibility during a fire-fighting operation.

A.4.3.4.6 While regulatory agencies have legal powers and responsibilities in a mine fire situation, the mine operator should have a preplanned organization capable of managing an effective fire-fighting effort. This organization has to be prepared, resolute, and capable. As part of periodic training, the organization should conduct fire drills that involve all levels of mine management. The regulatory agencies also should be invited to participate in fire drills. Training develops management capability and promotes cooperation between concerned agencies and mine management.

A.5.2 Fires adversely affect all types of self-propelled and mobile surface mining equipment, including, but not limited to, trucks, front-end loaders, crawlers, drills, shovels, and draglines. Most fires occur on or near engine exhaust systems, high-speed drive lines, malfunctioning high-pressure–high-temperature hydraulic systems, or faulty electrical components.

Total elimination of fire hazards is impossible, because sources of ignition and fuel for fires are inherent in the basic equipment design. The problem is further complicated by the collection of environmental debris. Therefore, efforts to reduce fire losses must be aimed at fire prevention and fire suppression.

To improve fire protection and prevention on surface mining equipment, some manufacturers of mining equipment emphasize the reduction of the fire potential of specific items in the original design of their equipment. Such items include turbochargers, exhaust manifolds and exhaust pipe shielding and insulation, location of combustible and flammable liquid reservoirs, and hydraulic and fuel-line routing.

Most surface mining equipment is required to have at least one hand-portable extinguisher mounted in a readily accessible location. Extinguishers are most effective when used by trained operators. However, considering the size and configuration of machines found at a mine, fires can be difficult or impossible to fight with a hand-held extinguisher. For this reason, fire suppression systems have been developed to aid in suppressing those fires that are hard to access and thereby to reduce "off-road" equipment fire losses.

The key to operator protection is early detection of fires to provide a warning to the operator, fuel shutoff to minimize fuel for the fire, and fire suppression during its earliest stages. Specialized systems to perform these functions can be required to protect the operator and the machines. To be totally effective, however, system operation must be fully understood by owners and operators, and provisions must be made for periodic inspection and maintenance.

Fire suppression systems, including hand-portable extinguishers, offer the mining industry a cost-effective tool by which personnel and investments in mining equipment can be protected.

A.5.3.4.1 This paragraph is not intended to include the boom of a dragline or shovel.

A.5.3.4.8(8) The same record tag or label can also indicate if recharging was performed.

A.5.3.5.2.1 A dry-chemical system is the preferred system for these areas.

A.5.3.5.2.2 Smoke detectors are not recommended because of the harsh environment.

A.5.3.5.3.1 Automatic systems are not necessary if the area is easily accessible for manual fire fighting.

A.5.3.5.4.2 Carbon dioxide would not be the best choice for fighting this type of fire due to the potential for the gas to be dispersed before the oxygen concentration is reduced enough to affect the fire.

For transformers over 5000 kVA, a fixed fire suppression system is recommended.

A.5.3.6.1.1 Equipment in this category is generally a vehicle weight of 200,000 lb or more and the size of a Hitachi 1800, Caterpillar 5230, Komatsu PC1000-6, Liebherr R984, DeMag H95, and Hitachi 1100.

A.5.3.7.1.1 Depending on the size of the vehicle and size of the fire, a 9.1 kg (20 lb) fire extinguisher could be more effective.

A.5.3.7.2.5 NFPA and manufacturers require 6-month inspections.

A.5.3.7.3.1 The following are examples of large equipment:

(1) Track dozer of 300 horsepower or more or 70,000 lb weight or more (e.g., Caterpillar D8R)
(2) Front-end loader of 400 horsepower or more and vehicle weight of 100,000 lb (e.g., Caterpillar 988)
(3) Wheel dozer of 300 horsepower or more and vehicle weight of 60,000 lb or more (e.g., Caterpillar 824G)
(4) Grader of 275 horsepower or more and vehicle weight of 55,000 lb or more (e.g., Caterpillar 16H)
(5) Pull-type scraper of 450 horsepower or more and vehicle weight of 98,000 lb or more (Caterpillar 631E)
(6) Scraper with push/pull twin engine of 450 horsepower and 490 horsepower or more and vehicle weight of 113,000 lb or more (e.g., Caterpillar 637E)
(7) Blast hole drill of 360 horsepower or more and weight of 68,000 lb or more (e.g., Ingersol-Rand DM-30)

A.5.3.7.3.2(4) Depending on the size of the equipment, additional ground-level manual actuators could be needed to provide quick access for manual activation of the system.

A.5.3.7.3.6 Six months is required by NFPA standards and manufacturers.

A.6.1.2.2 Pneumatic coal-cleaning systems employ low-pressure air, usually pulsed, to effect a separation between relatively dry coal and mechanically associated impurities. The coal is usually 19 mm (¾ in.) and smaller, with up to 4 percent surface moisture. The pickup of fines from the feed coal in the process air stream creates a potentially explosive mixture. However, approximately 2 m/sec (400 ft/min) air velocity dissipates methane from the coal and, in practice, reduces explosion and fire hazards to very low proportions inside the equipment. Nonetheless, in the area surrounding the equipment, a potential fire hazard exists from unintentionally vented fine coal, and the potential for all hazards increases where the cleaners are preceded by thermal dryers.

A.6.2.1.4 Electrical components of ventilation equipment installed in the open and separated from the ventilation air being pulled from the hazardous area can be permitted to be considered nonhazardous.

A.6.2.1.4.1 Electrical equipment classified as "permissible" is certified as meeting the requirements of 30 CFR Part 18, Chapter 1.

A.6.2.1.6 Approved, intrinsically safe electrical equipment can be permitted to be used in any areas classified as "hazardous."

A.6.2.1.7 The intent of this requirement is the avoidance of arcing ignition sources resulting from differing electrical potentials between metal structural elements or between any such element and ground. The metal building elements might include the building frame (beams, columns, etc.), roof panels, building or control room panels, building utilities such as piping, ducts, or conduit, or other items. The objective of connecting metal parts to a ground is recognized as the best means of avoiding arcing between building elements or between those elements and ground or other grounded items. Any arrangement that provides both a good ground and a system of metal continuity from the ground to all metal elements achieves the intent. Where construction provides solid, secure metal-to-metal contact, the necessary continuity normally is provided. In cases where grounding is in question, resistance measurements should be made between the most remote elements or the most suspected elements or both and ground. If tests show less than 0.1 ohm resistance to ground, the arrangement can be permitted to be considered satisfactory. Testing should be done during dry weather when ground moisture is at a minimum. If lightning protection is provided, additional bonding of major building members to lightning system conductors might be required. Such bonding, however, can be permitted to serve the grounding needs covered by this requirement.

A.6.2.2.2.1 For further information, see NFPA 68, *Guide for Venting of Deflagrations.*

A.6.2.2.4 Round ducts should be used wherever possible. All ducts should limit the number of bends and irregularities that could interfere with free airflow. Rectangular ducts should be used only where clearance prevents the use of round ducts. Rectangular ducts should be made as nearly square as possible to minimize the deposit of combustible materials.

A.6.2.3.1 Provision of 0.1 m^2 (1 ft^2) of building vent for each 2.3 m^3 (80 ft^3) of volume or space in which an explosion might occur generally is considered adequate for coal preparation plants, although the amount of venting needed to minimize structural damage that might be caused by a dust explosion varies according to the strength of the building, extent of the hazard, location and distribution of vents, properties of the coal dust, and other factors. Reference should be made to NFPA 68, *Guide for Venting of Deflagrations*, in the sizing of explosion vents.

A.6.2.4 Bulk storage of Class II combustible liquids should be located outside the preparation plant and should be appropriate for the nature of the liquids and the quantities being stored. Tanks within the preparation plant should be of limited size, holding no more than the quantities needed for one and one-half shifts of operation. Each tank should be fitted with an overflow pipe of ample size to return the full volume of the transfer pump to the bulk storage tank. Tanks within the preparation plant should be isolated from the rest of the plant. The isolated area containing the tanks should be protected with an automatic sprinkler system that can provide a density of 6.1 L/min · m^2 (0.15 gpm/ft^2) over the entire area with all heads flowing. The floors beneath these tanks should have curbs, adequate slope, and floor drains able to handle the liquid from the tanks as well as the discharge from all automatic sprinklers.

A.6.3 A typical coal preparation plant process begins with raw coal entering a breaker where coal and undesirables, such as rocks, are separated. From the breaker, the coal is crushed and screened to size and then transferred, usually by belt conveyor, to the washing process. During the washing process, the dirty coal is separated from clay and rock by water washing or by chemical flotation. From the washing process, the clean, wet coal is conveyed to a drying process whereby surface moisture is reduced. A variety of dryers can be used, such as centrifugal, fluidized bed, or thermal disk processors. From the drying process, the clean, dry coal is conveyed to storage facilities, such as bins, silos, and coal barns, and then loaded out for transport or shipment by rail, surface, or conveyor for downstream use. *(See Figure A.6.3.)*

A.6.3.2.2.1 Examples of where fixed protection might be needed in coal preparation include conveyor belts, galleries, tunnels, beneath bins, transfer houses, silo head houses, dust collectors, rotary compressors, and other areas such as switch gear rooms, control rooms, change houses, and combustible and flammable liquids storage or process areas. These areas should be considered ordinary hazards. Areas with noncombustible construction or noncombustible contents are areas where fixed protection might not be needed.

A.6.3.2.3.1 Standpipes should be located in exterior stairways. Where exterior stairways are not provided, standpipes should be located as close to stairways as practicable. This arrangement will provide fire fighters with ready access to fire-fighting water. Ideally, plants should have exterior stairways with standpipes on opposite ends of the plant. These stairways will provide fire fighters with two angles of attack.

When applying water, fire fighters should exercise care to avoid the use of solid hose streams in locations where the streams could create explosions by disturbing dust deposits.

Fire hose should not be used for washdown purposes.

In plants where the vibration anticipated is sufficient to cause movement of the fire protection system resulting in the wear of water piping at the hangers, it might be necessary to install vibration absorbers.

A.6.3.2.4.1 A readily available supply can include a dedicated fire protection water supply, a pond or other large body of water, an industrial process water system, or large water trucks (tankers). If water trucks (tankers) are used, they should be of a capacity and quantity to deliver a continuous source of water for the duration of the fire-fighting effort. Personnel should be trained in emergency vehicle operation and mobile water supply shuttle procedures. If an impounded body of water is provided, it should be close and accessible enough to the protected property to allow fire fighters a quick response.

A.6.3.2.4.4 Chapter 8 and Appendix G of NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting,* outline suggested methods for determining the estimated water supply (fire flow) that can be necessary for fire-fighting purposes.

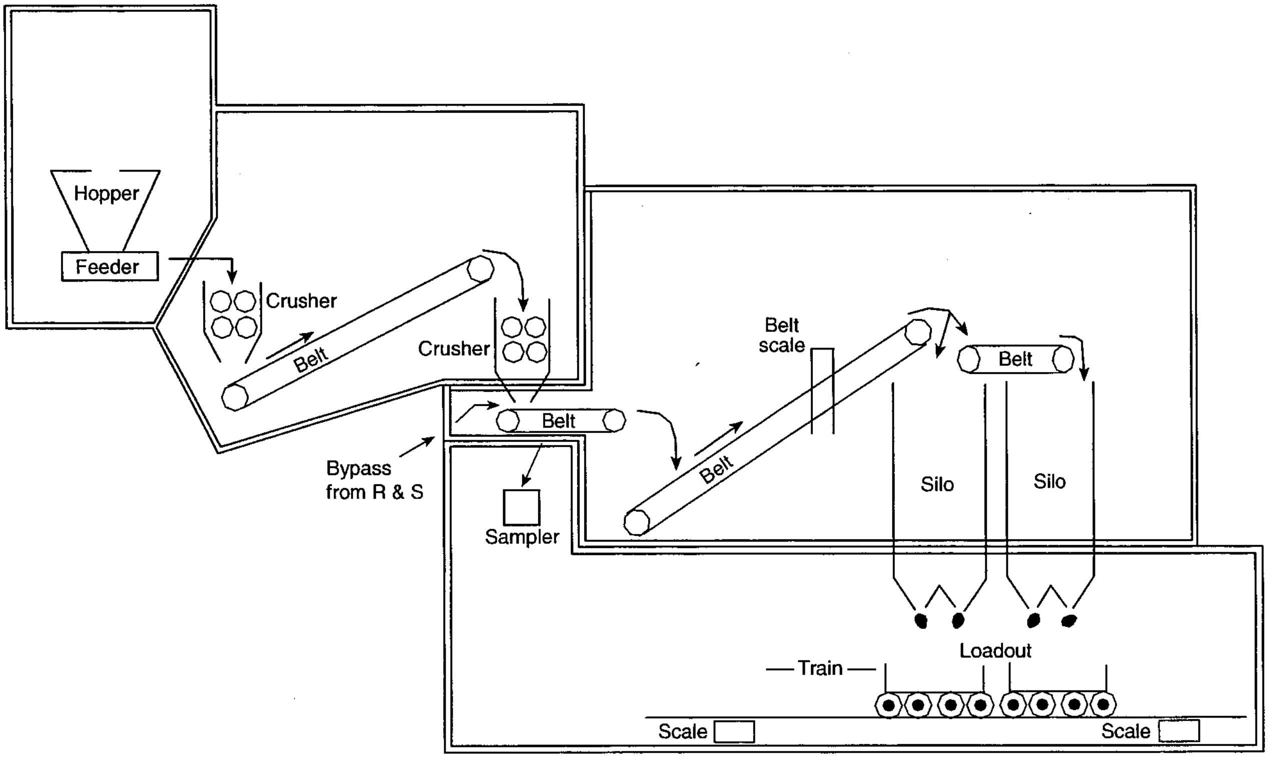

FIGURE A.6.3 Typical Coal Preparation Plant.

A.6.4.1 Thermal coal dryers can be of any type that conforms to the requirements of Section 6.4, including rotary dryers, continuous carrier dryers, vertical tray and cascade dryers, multilouver dryers, suspension or flash dryers, and fluidized bed dryers. These direct-fired convection-type dryers constitute the majority of currently operational units. Almost all these units utilize special direct-fired air heater–type furnaces, usually coal fired by stokers or by pulverized fuel systems.

A.6.4.2.5 For further information, see NFPA 68, *Guide for Venting of Deflagrations.*

A.6.4.2.7 Thermal oil systems are used in coal preparation plants to indirectly dry coal in thermal disk processors. Severe losses have occurred due to lack of inadequate sprinkler protection, poor siting and confinement of expansion and storage tanks and heaters, improper piping arrangement, and inadequate interlocks and controls. Even though the woodworking industry has unique equipment that needs hot oil applications, the hot oil heating and distribution systems are similar, and the concepts provided in NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities,* can be utilized for the coal preparation industry.

Chapter 9 of NFPA 664 is the primary reference in NFPA standards for thermal oil systems used in industrial processes. While NFPA 664 addresses loss prevention in a specified occupancy (wood products), other standards might be applicable to any industrial process featuring thermal oil systems.

A.6.4.5 Guidance for design of vent ducts is provided in NFPA 68, *Guide for Venting of Deflagrations.*

A.7.1 Gas and electric welding or cutting procedures shall be in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

A.7.1.2.1 For additional information, see NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair,* and AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting Containers and Piping That Have Held Hazardous Substances.*

A.7.1.2.5 If the coal is susceptible to spontaneous combustion, water should not be used to wet down the area. Rock dust should be used.

A.7.1.4.1 For information on labeling of compressed and liquefied gas cylinders, see CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers.*

A.7.1.5.9 For information on labeling of compressed and liquefied gas cylinders, see CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers.*

A.7.3.1 Buried tanks do not create a fire hazard but preferably should be at least 1.5 m (5 ft) from all buildings.

A.7.3.1.2 Information on the design and construction of atmospheric tanks can be found in API 650, *Standard for Welded Steel Tanks for Oil Storage;* UL 142, *Standard for Steel Above-Ground Tanks for Flammable and Combustible Liquids;* or UL 80, *Standard for Steel Inside Tanks for Oil Burner Fuel.*

Low pressure tanks and pressure vessels can be permitted to be used as atmospheric tanks.

A.7.3.2 This can be accomplished by diking or drainage with remote impounding. See 4.3.2.3.2 of NFPA 30, *Flammable and Combustible Liquids Code*, for additional details.

A.7.3.3.4 For additional information see Annex B of NFPA 30, *Flammable and Combustible Liquids Code*.

A.7.3.3.6 For additional information see Section 5.7 of NFPA 30, *Flammable and Combustible Liquids Code*.

A.7.4.5 Combustible liquid storage in drums or totes preferably should be stored outside.

A.7.5.1.1 Electrical equipment classified as "permissible" is certified as meeting the requirements of 30 CFR Part 18, Chapter 1.

A.7.6.2.2 Containers and portable tanks for combustible liquids authorized by the U.S. Department of Transportation should be acceptable as storage containers.

A.7.6.2.10 Information on the design and construction of pressure vessels can be found in the ASME *Boiler and Pressure Vessel Code*, "Code for Unfired Pressure Vessels," Section VIII, Division I.

A.7.6.2.13 Information on venting can be found in API 2000, *Standard for Venting Atmospheric and Low-Pressure Storage Tanks*.

A.7.6.3 The terms *transfer* and *transport* are used synonymously to mean movement of combustible liquid in closed containers, tanks, safety cans, or pipelines between underground locations.

A.7.6.3.10 The greatest risk of fire involving substantial quantities of combustible liquids exists when rail supply cars are being moved, especially on a trolley wire–powered rail system. In contrast, cars parked where trolley and feed wire are absent or de-energized represent a distinctly lower risk. Limiting the storage of lubricants in operating areas to a 3-day rather than a 1-day supply reduces the frequency of transport and, as a result, the overall risk of fire.

A.7.6.3.12 Where pressurized pipeline systems are used for combustible liquid transfer, consideration should be given to providing a pressure-sensing interlock downstream of the transfer pump discharge. This interlock should be suitable for Class I, Division 2 locations and should be arranged to shut down the pump immediately upon loss of line pressure.

A.7.6.5 The principal Class II combustible liquid used in a coal mine is diesel fuel.

A.7.6.5.2.7 There are no listed doors for storage areas in underground mines.

A.7.6.5.2.10 Information on tank foundations can be found in Appendix E of API 650, *Standard for Welded Steel Tanks for Oil Storage*, and Appendix B of API 620, *Recommended Rules for the Design and Construction of Large, Welded, Low-Pressure Storage Tanks*.

A.7.6.8 No requirements for bonding or grounding to dissipate static electricity are included in NFPA 30, *Flammable and Combustible Liquids Code*, which does not require bonding or grounding for combustible liquids handled at temperatures below their flash points.

It is recognized, however, that certain conditions can exist that could necessitate bonding or grounding, such as those of temperature and altitude, which can reduce the flash point of diesel fuel.

For additional information on static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A.8.5 A manifold system should be considered for all new installations in shop buildings.

A.8.6.2 Automatic sprinkler protection provides the most affordable fire protection. Where water supplies are adequate, sprinkler protection should be strongly considered for office and warehouse occupancies.

A.8.6.3 If an adequate water supply is available, a fire hydrant should be installed within 15.24 m (50 ft) of the warehouse, shop, and office building.

A.8.6.6 For office buildings, a minimum of one 4.5 kg (10 lb) extinguisher should be provided for every 279 m^2 (3000 ft^2) of building area. Travel distance from any point to the nearest extinguisher should not exceed 22.86 m (75 ft). For shop and warehouse areas, a minimum 9.1 kg (20 lb) extinguisher should be provided for every 22.86 m (75 ft) travel distance within the building.

Large-wheeled, dry-chemical or foam extinguishers should be considered for shop and warehouse areas. The type of fires that can occur in these areas can be too large to be handled by a hand-held extinguisher.

A.9.1 Unless the conveyor is very long, burning coal on a moving belt is not likely to ignite the belt. Also, if the belt should ignite, the burning of the belt is likely to be extinguished after the burning coal has been discharged and the belt continues to run. No reports of running conveyor belts in and around preparation plants that have caught fire and burned have been located. Every reported case of belts catching fire and burning has occurred after the belts have been stopped.

Some preparation plants use the froth flotation process t separate impurities from fine coal. The agents typically used ir froth flotation are Class II combustible liquids. The coal recov ered from the froth cells is coated minimally with these agents. I has been found that frothed coal carried on conveyor belts wil coat the belting with the agents, causing the coated belting t ignite easily and the flame spread to become significantly mor rapid than usual. It is recommended that belts that carry frothe coal be protected with automatic sprinklers. While the froth fl tation process operates as a water slurry and presents no risk c fire, the reagents normally used are No. 2 fuel oil and meth isobutyl carbinol (MIBC), which are Class II combustible liquid

Fortunately, evidence of heating is easy to detect. Durin the early stage of heating, the odor is unmistakable. Whe heating is more advanced, smoke and steam also might t apparent. If the hot coal is in an exposed storage pile, the h material can be dug out and wetted. If the hot material has material can be loaded onto a conveyor belt, the loading areas should t be loaded onto a conveyor belt, the loading areas should l hosed down, and water should be applied to the hot materi before or as it is loaded onto the belt.

Tunnels under silos or storage piles should be ventilat adequately and should be protected with a system of au matic sprinklers. Separate hose for fire fighting should be p vided. The main tunnel should have exit routes at opposi ends of the tunnel.

A.9.1.1 The U.S. Mine Safety and Health Administrati standards found in 30 CFR for fire-retardant conveyor b materials should be used as a guide. Fire-retardant belt ma rials will burn and, therefore, might require additional f protection.

Stockpile conveyors, reclaim conveyors, and conveyors ing to loadout silos or bins should be fire-resistant belt.

Rip detection also can be considered for long runs or critical belt systems. Critical factors to be considered should be the impact on production if the belt is lost, the cost of the belt itself, availability of spare belting, length of time to repair the belt, and alternatives to bypass the belt if it is lost.

A.9.1.2 A steel deck, which often is placed between the top and bottom strands of a belt conveyor, should not be used. It is recommended that existing decks be removed.

Belt galleries that use supporting trusses with substantial length of span should be set entirely beneath the belt so that, in the event of a fire, the loaded structural members of the truss are not seriously exposed to the heat of the burning belt. The supports for the troughing and return idlers should not be structural parts of the truss. The covering for the belt should be partially open on the walkway side, allowing access to the belt and to the belt idlers for maintenance and fire fighting.

Belts that are located entirely within relatively long-span supporting trusses should be protected by a fixed fire protection system.

Provision for removing burning coal to a safe area utilizing conveyors should be considered. These conveyors might require manual water spray to cool smoldering coal. Flanged openings can be used for removing burning coal if adequate planning and equipment have been provided.

A.9.4.3 To minimize potential frictional ignition, alignment switches can be permitted to be provided at intervals sufficient to prevent the belt from contacting such materials.

A.9.4.7.4 Adjustable fog nozzles should be provided for all hoses.

A.9.4.8 Transfer points can also require dust suppression.

A.9.5 The key concept in coal storage is to prevent spontaneous combustion. Preventing spontaneous combustion requires all of the following:

(1) Eliminating air entrainment in the coal
(2) Eliminating heat sources near the storage
(3) Preventing moisture in the coal

A.10.2.2 This process can be accomplished by pressurization, sealing the room, or air filtration. Housekeeping and coal-wetting agents also can be used to reduce the coal dust in the room. Coal dust should not be allowed to accumulate inside electrical cabinets.

A.10.4.2 CO_2 systems are not recommended for occupied areas. If a CO_2 system is used, it should have a maintenance lockout.

A.10.5.1 If the building has a standpipe system, a fire hose can be used as a substitute for a fire extinguisher as detailed in NFPA 10, *Standard for Portable Fire Extinguishers.*

A.11.1 For mines where the response time of the public fire department is in excess of 30 minutes, an emergency organization that is trained in basic fire-fighting techniques should be developed. Training should consist of the use of large extinguishers and small hose streams 38 mm (1½ in.) to provide immediate fire-fighting efforts until the local fire department arrives. This training would also include procedures for using fire hose off a water truck or any other nearby sources of water. A crew consisting of at least five members for each shift should be trained in fire-fighting operations. Detailed fire-fighting procedures should be developed for each type of potential fire, for example, dragline, shovel, mobile equipment, warehouse, and office. Training should be conducted based on those scenarios.

A.11.2.5.1 Two portable water cars, readily available, can be used in place of the water lines prescribed in 11.2.5.1.

A.11.2.5.5 A multiple hydrant is a short length of 76.2 mm (3 in.) or 101.6 mm (4 in.) pipe, usually with three valved outlets (hydrants) to which fire hose lines can be connected. If the mine is equipped with a foam generator for fighting fires, there should be an additional outlet to feed the generator. An alternative is to assemble the hydrants from grooved pipe fittings that also have threaded tee connections to which the valved outlets are connected. The multiple hydrants should have adapters that allow them to be connected to any of the pipe sizes in use at the mine.

Annex B Informational References

B.1 Referenced Publications. The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

B.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2002 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2002 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2003 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2003 edition.

NFPA 68, *Guide for Venting of Deflagrations,* 2002 edition.

NFPA 72®, National Fire Alarm Code®, 2002 edition.

NFPA 77, *Recommended Practice on Static Electricity,* 2000 edition.

NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair,* 1999 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities,* 2002 edition.

NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting,* 2001 edition.

NFPA *Fire Protection Handbook,* 17th edition.

B.1.2 Other Publications.

B.1.2.1 API Publications. American Petroleum Institute, 1220 L Street NW, Washington, DC 20005-4070.

API 620, *Recommended Rules for the Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* 1990 edition.

API 650, *Standard for Welded Steel Tanks for Oil Storage,* 1993 edition.

API 2000, *Standard for Venting Atmospheric and Low-Pressure Storage Tanks,* 1992 edition.

B.1.2.2 ASME Publication. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME *Boiler and Pressure Vessel Code,* 1992 edition.

B.1.2.3 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials,* 1997 edition.

ASTM D 86, *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure,* 2004 edition.

ASTM D 3278, *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus,* 1996 edition.

B.1.2.4 AWS Publication. American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting Containers and Piping That Have Held Hazardous Substances,* 1988 edition.

B.1.2.5 CGA Publication. Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, VA 20151-2923.

CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers,* 2004.

B.1.2.6 MSHA Publication. Mine Safety and Health Administration, National Mine Health and Safety Academy, 1301 Airport Road, Beaver, WV 25813-9426. (email: Library@MSHA.gov).

"Fire Accident Abstract."

"Fire Accident Report."

"The Health and Safety Implications of the Use of Diesel-Powered Equipment in Underground Mines," report prepared by an interagency task group for MSHA, 1985.

"Injury Experience in Coal Mining."

B.1.2.7 NIOSH Publications. National Institute for Occupational Safety and Health, 1600 Clifton Road, Atlanta, GA 30333.

NIOSH IC 9452, *An Underground Coal Mine Fire Preparedness and Response Checklist: The Instrument,* 2000.

NIOSH IC 9470, "Analysis of Mine Fires for All Underground and Surface Coal Mining Categories: 1990–1999," 2000.

B.1.2.8 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 80, *Standard for Steel Inside Tanks for Oil Burner Fuel,* 2003 edition.

UL 142, *Standard for Steel Above-Ground Tanks for Flammable and Combustible Liquids,* 2002 edition.

B.1.2.9 USBM Publications. U.S. Bureau of Mines, Publications, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161.

Report No. H0122086, "Suppression of Fires on Underground Coal Mine Conveyor Belts."

RI 9380, "Fire Detection for Conveyor Belt Entries," 1991.

RI 9451, "Effect of Pressure on Leakage of Automatic Sprinklers," 1993.

RI 9538, "Performance of Automatic Sprinkler Systems for Extinguishing Incipient and Propagating Conveyor Belt Fires Under Ventilated Conditions."

RI 9570, "Hazards of Conveyor Belt Fires," 1995.

B.1.2.10 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Title 30, Code of Federal Regulations, Part 18, Chapter 1.

Title 30, Code of Federal Regulations, Part 18.65.

Title 30, Code of Federal Regulations, Part 75. 1103-4.

Title 30, Code of Federal Regulations, Part 75. 1107-13.

B.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

B.2.1 NFPA Publications. National Fire Protection Assocition, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 11A, *Standard for Medium- and High-Expansion Foa Systems,* 1999 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing System* 2000 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing System* 2004 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Prote tion,* 2001 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing System* 2002 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps f Fire Protection,* 2003 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protectio* 2003 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2002 editio

NFPA 230, *Standard for the Fire Protection of Storage,* 2003 editio

NFPA 385, *Standard for Tank Vehicles for Flammable and Co bustible Liquids,* 2000 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 2003 editio

Fire Protection Guide to Hazardous Materials, 11th editio NFPA, 1997.

B.2.2 Other Publications.

B.2.2.1 ACGIH Publication. American Conference of Go ernmental Industrial Hygienists, 1330 Kemper Meadow Driv Cincinnati, OH 45240.

Industrial Ventilation: A Manual of Recommended Practice, 1998.

B.2.2.2 ANSI Publications. American National Standards Ins tute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI A92.2, *Vehicle-Mounted Elevating and Rotating Aerial I vices,* 1979.

ANSI A92.3, *Elevating Work Platforms, Manually Propell* 1980.

ANSI B30.5, *Mobil and Locomotive Cranes,* 1994.

ANSI 505, *Powered Industrial Trucks (NFPA 505-1981),* 199

ANSI 583, *Standard for Electric-Battery-Powered Trucks (UL 5 1996),* 1998.

B.2.2.3 ASTM Publication. American Society of Testing a Materials, 100 Barr Harbor Drive, West Conshohocken, 19428-2959.

ASTM D 56, *Standard Method of Test for Flash Point by the T Closed Cup Tester,* 1993 edition.

ASTM D 93, *Standard Method of Test for Flash Point by Pensky-Martens Closed Tester,* 1990 edition.

ASTM D 323, *Standard Method of Test for Vapor Pressure Petroleum Products (Reid Method),* 1999.

ASTM E 136, *Test Method for Behavior of Materials in a Verti Tube Furnace at 750°C,* 1994.

B.2.2.4 IEEE Publication. Institute of Electrical and Electro ics Engineers, Inc., Three Park Avenue, 17th Floor, New Yo NY 10016-5997.

IEEE Standard 446, *Recommended Practice for Emergency a Standby Power Systems for Industrial and Commercial Applicatio* 1987.

B.2.2.5 SAE Publications. Society of Automotive Enginee 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J53, *Minimum Performance Criteria for Emergency Steer of Wheeled Earthmoving Construction Machines, Recommended Pr tice,* 1984.

SAE J185, *Access Systems for Off-Road Machines, Recommended Practice*, 1988.

SAE J925, *Minimum Access Dimensions for Construction and Industrial Equipment*, 1993.

deLime, T. L., "Improved Fire Protection for Off-Highway Equipment," Society of Automotive Engineers Off-Highway Vehicle Meeting, Milwaukee, Sept. 1979, SAE 790882.

Jewett, J., "Fire Suppression Systems," Society of Automotive Engineers Off-Highway Vehicle Meeting, Milwaukee, Sept. 1979, SAE 790779.

Johnson, G. A., "Improved Fire Protection Systems for Surface Coal Equipment," Society of Automotive Engineers Off-Highway Vehicle Meeting, Sept. 1977, SAE 770744.

Pomroy, W. H., "Improved Automatic Fire Protection Systems for Off-Highway Mine Vehicles," Society of Automotive Engineers Off-Highway Vehicle Meeting, Milwaukee, Sept. 1979, SAE 790880.

B.2.2.6 Former U.S. Department of Interior Bureau of Mines Publications. The following former Bureau of Mines reports and articles are available for Open File (OFR) inspection at the following locations: National Institute for Occupational Safety & Health (NIOSH) Facilities, P.O. Box 18070, Pittsburgh, PA 15326; U.S. Geological Survey, Reston, VA; and the National Mine Health and Safety Academy, Beaver, WV (email: Library@MSHA.gov). They also may be obtained directly from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161.

Note: Publications marked with an asterisk provide information on fire risk assessment.

Report No. H0122086, "Suppression of Fires on Underground Coal Mine Conveyor Belts."

Report No. J0275008, "Annotated Bibliography of Coal Mine Fire Reports."

Baker, R. M., "An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports," 1980. U.S. BuMines OFR 68 (1)-(3)-81. NTIS PB 81-223711.

*Kasten, A. E., "Develop and Test an Automatic Fire Control System for Surface Mining Machinery, Volume I, Systems Development," 1977. U.S. BuMines OFR 119-78. NTIS PB 293 983.

Lease, W., "Development and Testing of a Fire Protection System for Coal Augers," 1975. U.S. BuMines OFR 25-76. NTIS PB 249-865.

Lease, W., "Development, Installation, and Testing Services for an Automatic, Point-Type Thermal Sensor Fire Protection System on a Mining Dozer," 1976. U.S. BuMines OFR 71-77. NTIS PB 266075/AS.

*Lease, W. D., "Development of an Automatic Fire Protection System for Surface Vehicles," 1981. U.S. BuMines OFR 73-82. NTIS PB 82-215765.

*McDonald, L. A., "Development and Test of an Automatic Fire Control System for Surface Mining Machinery, Volume II, Reliability Testing," 1981.

*McDonald, L. A., "Improved Fire Protection System for AN-FO Haulers and Loaders," 1982. U.S. BuMines OFR 46-83.

*Stevens, R. B., "Improved Sensors and Fire Control System for Mining Equipment," 1972. U.S. BuMines OFR 25 (1)-(2)-74. NTIS PB 232405 and NTIS PB 232406.

Stevens, R. B., "Automatic Fire Sensing and Suppression System for Mobile Mining Equipment," 1978. U.S. BuMines OFR 34-79. NTIS PB 294 731.

The following Bureau of Mines reports are available from the Section of Publications, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, PA 15213.

Johnson, G. A., "Automatic Fire Protection Systems for Large Haulage Vehicles; Prototype Development and In-Mine Testing," 1978. U.S. BuMines IC 8683.

*Pomroy, W. H., "Automatic Fire Protection Systems for Surface Mining Equipment," 1980. U.S. BuMines IC 8832.

Pomroy, W. H., "A Statistical Analysis of Coal Mine Fire Incidents in the United States from 1950 to 1977," 1980. U.S. BuMines IC 8830.

*Pomroy, W. H., "Economic Analysis of Surface Mining Mobile Equipment Fire Protection Systems," 1982. U.S. BuMines RI 8698.

U.S. BuMines Mining Research Staff, "Metal Mine Fire Protection Research," 1977. BuMines IC 8752.

U.S. Mines Technology News, No. 27, "Automatic Fire Protection for Surface Coal Augers," 1976.

U.S. BuMines Technology News, No. 50, "Bulldozer Fire Protection," 1978.

U.S. BuMines Technology News, No. 70, "Fire Protection for Blasthole Drill," 1979.

U.S. BuMines Technology News, No. 74, "Fire Protection for Front-End Loaders," 1979.

U.S. BuMines Technology News, No. 77, "Loading Shovel Fire Protection," 1980.

U.S. BuMines Technology News, No. 78, "Fire Protection for Hydraulic Excavators," 1980.

U.S. BuMines Technology News, No. 79, "Automatic Fire Protection for Mining Trucks," 1980.

U.S. BuMines Technology News, No. 106, "Dragline Fire Protection," 1981.

U.S. BuMines Technology News, No. 107, "An-Fo Hauler Fire Protection," 1981.

B.2.2.7 Other Publications.

Accident Prevention Manual for Industrial Operations, National Safety Council, 425 North Michigan Avenue, Chicago, IL 60611.

Jenson, R., ed., "Fire Protection for the Design Professional," 1975. Cahners Books, 89 Franklin Street, Boston, MA 02110.

B.3 References for Extracts. The following documents are listed here to provide reference information, including title and edition, for extracts given throughout the nonmandatory sections of this standard as indicated by a reference in brackets [ ] following a section or paragraph. These documents are not a part of the requirements of this document unless also listed in Chapter 2 for other reasons.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2003 edition.

NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*, 2002 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 edition.

NFPA 99, *Standard for Health Care Facilities*, 2002 edition.

NFPA 122, *Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities*, 2004 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2003 edition.

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Sequence of Events Leading to Publication of an NFPA Committee Document

Call goes out for proposals to amend existing document or for recommendations on new document.

▼

Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

▼

Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

▼

Report — *Report on Proposals* (ROP) — is published for public review and comment.

▼

Committee meets to act on each public comment received.

▼

Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward. Lacking two-thirds approval, supplementary report returns to committee.

▼

Supplementary report — *Report on Comments* (ROC) — is published for public review.

▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP or ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

Appeals to Standards Council on Association action must be filed within 20 days of the NFPA Annual or Fall Meeting.

▼

Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including upholding any appeals.

Committee Membership Classifications

The following classifications apply to Technical Committee members and represent their principal interest in the activity of a committee.

M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.

U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.

I/M *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.

L *Labor:* A labor representative or employee concerned with safety in the workplace.

R/T *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.

E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.

I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.

C *Consumer:* A person who is, or represents, the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in the *User* classification.

SE *Special Expert:* A person not representing any of the previous classifications, but who has special expertise in the scope of the standard or portion thereof.

NOTE 1: "Standard" connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of members or unique interests need representation in order to foster the best possible committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

Sequence of Events Leading to Publication of an NFPA Committee Document

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Committee meets to act on each public comment received.

▼

Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward.
Lacking two-thirds approval, supplementary report returns to committee.

▼

Supplementary report — *Report on Comments* (ROC) — is published for public review.

▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP or ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

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Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including upholding any appeals.

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Mail to: Secretary, Standards Council
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Note: All proposals must be received by 5:00 p.m. EST/EDST on the published proposal-closing date.

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4. Statement of Problem and Substantiation for Proposal: (Note: State the problem that will be resolved by your recommendation; give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

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(Continued from inside front cover)

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NFPA 271

Standard Method of Test for

Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

2004 Edition

This edition of NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter,* was prepared by the Technical Committee on Fire Tests and acted on by NFPA at its May Association Technical Meeting held May 23–16, 2004, in Salt Lake City, UT. It was issued by the Standards Council on July 16, 2004, with an effective date of August 5, 2004, and supersedes all previous editions.

This edition of NFPA 271 was approved as an American National Standard on August 5, 2004.

Origin and Development of NFPA 271

NFPA 271 was originally numbered NFPA 264 and was first published in 1992. NFPA 264 was closely related to and derived from NFPA 264A, *Standard Method of Test for Heat Release Rates for Upholstered Furniture Components or Composites and Mattresses Using an Oxygen Consumption Calorimeter.* NFPA 264 was based on the methods of measuring rates of heat release using an oxygen consumption calorimeter developed at the National Institute of Standards and Technology by Dr. Vytenis Babrauskas, et al. The document provided a general methodology for measuring the heat release rates of a variety of materials in a variety of end uses. It was intended that this approach be adopted and customized for the testing of specific products and materials. Such a bench-scale approach provides a mechanism for deriving information that can be used for product and material evaluation, mathematical modeling, and design purposes, as well as for research and development purposes.

The 1995 edition of NFPA 264 reflected changes that were both editorial and technical in nature. The technical revisions included standardization of the horizontal position as the orientation for testing of specimens. The horizontal orientation provides greater repeatable and reproducible results. The vertical orientation details, located in Annex D, were intended to be used more for research purposes. The definition of sustained flaming was revised from existence of flame for 10 seconds to existence of flame for 4 seconds, in order, to coordinate with other documents.

The 1998 edition of NFPA 264 was renumbered as NFPA 271. The designation was changed for coordination purposes and placed the document in rotation with other documents that use the oxygen consumption calorimeter. The changes to the 1998 edition were only minor in nature. They included updating the document to the latest terminology used in the industry and the current laboratory processes and some editorial clarification. A new section pertaining to the radiation shield was added.

The 2001 edition was a complete revision that incorporated the layout and provisions of the NFPA *Manual of Style,* 2000 edition. Minor revisions included updating ignition circuit applications in Chapter 2 and Annex D, identifying the type of radiation shield not permitted, and correcting the heat release calibration in Chapter 5.

The 2004 edition includes editorial changes to be in further compliance with NFPA's *Manual of Style.* Technical changes include revision to the term *sustained flaming* and new requirements concerning the test environment and the conditioning of text specimens. Advisory information has been added to the annex regarding testing of nonplanar surfaces and the testing of assemblies and materials not specified in the body of the standard. References to test methods similar to that of NFPA 271 are also provided.

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

Committee Scope: This Committee shall have primary responsibility for documents on fire testing procedures, for reviewing existing fire test standards and recommending appropriate action to NFPA, for recommending the application of and advising on the interpretation of acceptable test standards for fire problems of concern to NFPA technical committees and members, and for acting in a liaison capacity between NFPA and the committees of other organizations writing fire test standards. This Committee does not cover fire tests that are used to evaluate extinguishing agents, devices, or systems.

Contents

NFPA 271

Standard Method of Test for

Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

2004 Edition

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

Information on referenced publications can be found in Chapter 2 and Annex G.

Chapter 1 Administration

1.1 Scope.

1.1.1* This test method measures the response of materials exposed to controlled levels of radiant heating, with or without an external igniter.

1.1.2 This test method determines the ignitibility, heat release rate, mass loss rates, effective heat of combustion, and visible smoke development of materials and products.

1.1.3* This test method tests the specimen in the horizontal orientation.

1.2 Purpose.

1.2.1* This test method provides measurements of the behavior of material and product specimens under a specified radiant heat exposure in terms of the rate of heat release, effective heat of combustion, mass loss rate, time to ignition, and smoke production.

1.2.2 The data obtained for a specific test describe the rate of heat and smoke release of the specimen when exposed to the specific conditions and procedures used in performance of that test.

1.2.3 Release rate measurements provide a quantitative measure of specific changes in performance caused by product modification.

1.3 Application.

1.3.1 Significance.

1.3.1.1 This test method is useful for the following:

(1) Evaluations of materials or products
(2) Mathematical modeling
(3) Design of new materials or products
(4) Research and development

1.3.1.2 Types of materials suitable for testing with this method include specimens from an end-use product and the various components used in the end-use product.

1.3.1.3 Release rates for a given material depend on how the material is used, its thickness, and the method of mounting.

1.3.1.4 Other factors, some of which cannot be controlled, that can affect the heat release rate for a given material include the orientation of the material (vertical, horizontal, or otherwise), the types of joints or other methods used for installation, the way the material reacts to fire (melts and drips, recedes, chars, pyrolyzes, intumesces, or flames), and the use of fire retardants.

1.3.1.5 This standard does not purport to address all safety problems associated with its use. The user of this standard shall be responsible for establishing appropriate safety and health practices and for determining the applicability of regulatory limitations prior to use.

1.3.2* Test Limitations.

1.3.2.1* This test method shall not apply to end-use products that do not have planar external surfaces.

1.3.2.2 The test data shall be invalid if any of the following occurs:

(1) The specimen undergoes explosive spalling.
(2) The specimen swells to the point where it touches the spark plug prior to ignition.
(3) The specimen swells to the point where it touches the heater base plate during combustion.

1.3.2.3 If delamination of the specimen occurs, the test results shall be considered suspect, and this shall be described in the test report.

1.3.2.4* This test method shall be performed in a controlled environment under controlled laboratory conditions in order to obtain material properties data for use in evaluating the fire hazard of materials.

1.3.2.4.1 These data alone do not describe the fire hazard of a material's specific end use or predict its response to real fires.

1.3.2.4.2 The data obtained by this test method have not yet been correlated with the real-world fire performance for most materials.

1.3.2.4.3 Thus, caution shall be used in the utilization of such data to evaluate the full-scale fire performance of the end use of materials tested in accordance with this method.

1.3.3 Summary of Test Method.

1.3.3.1 This test method is based on the observation that the net heat of combustion is directly related to the amount of oxygen necessary for combustion: Approximately 13.1×10^3 kJ of heat are released per 1 kg of oxygen consumed.

1.3.3.2 Specimens in the test shall be combusted in ambient air conditions while being subjected to a predetermined external radiant heat flux, which ranges from 0 kW/m^2 to 100 kW/m^2. Combustion shall be initiated with or without a spark ignition.

1.3.3.3 The primary measurements, as a function of time, shall be oxygen concentration and exhaust gas flow rate (for assessing heat release rate).

1.3.3.3.1 Additional measurements shall include specimen mass, for assessing mass loss rate and smoke obscuration, both of them as a function of time, and time to sustained flaming, which is a measure of ignitibility.

1.3.3.3.2 The test method is also suitable for other measurements.

1.3.3.4* This test method shall be intended to determine the heat released by a product or material when exposed to an external radiant heat source.

1.3.3.4.1 It also determines the effective heat of combustion, mass loss rate, time to sustained flaming, and smoke production.

1.3.3.4.2 These properties shall be determined on small-size specimens that are representative of the intended end-use materials.

1.3.3.5 The rate of heat release shall be determined by measurement of the oxygen consumption, which is determined by the oxygen concentration and the flow rate in the exhaust product stream.

1.3.3.5.1 The effective heat of combustion shall be determined from a concomitant measurement of specimen mass loss rate in combination with the heat release rate.

1.3.3.5.2 Smoke development shall be determined from the obscuration of light by the combustion product stream.

1.3.3.6 This test method shall be applicable to various categories of products and shall not be limited to a single fire scenario.

1.3.3.7* Specimens shall be exposed to heating fluxes in the range of 0 kW/m^2 to 100 kW/m^2 in a horizontal orientation.

1.3.3.7.1 External ignition, where used, shall be by electric spark.

1.3.3.7.2 The value of the heating flux and the use of external ignition shall be specified by the relevant material or performance standard or by the test sponsor for research and development purposes.

1.3.3.8 Ignitibility shall be determined as a measurement of time from initial exposure to time of sustained flaming.

1.4 Units.

1.4.1 The values stated in SI units shall be regarded as the standard.

1.4.2 Unless otherwise stated, all dimensions included in the test and figures shall be mandatory and shall be followed within nominal tolerances of 1 mm. Dimensions in figures that are not followed by an asterisk (*) shall be considered nonmandatory.

1.5 Symbols. The following symbols are used in this standard:

A_s	=	nominal specimen exposed surface area (0.01 m^2)
C	=	calibration constant for oxygen consumption analysis (m$^{1/2}$ kg$^{1/2}$K$^{1/2}$)
$-dm/dt$	=	required mass loss rate
$\Delta H_c/r_0$	=	net heat of combustion (kJ/kg)
$\Delta H_{c,eff}$	=	effective heat of combustion (kJ/kg)
I	=	actual beam intensity
I_0	=	beam intensity with no smoke
k	=	smoke extinction coefficient (m^{-1})
L	=	extinction beam path length (m)
m	=	specimen mass (kg)
m_f	=	final specimen mass (kg)
m_i	=	initial specimen mass (kg)
$\dot{m}$	=	specimen mass loss rate (kg/sec)
ΔP	=	orifice meter pressure differential (Pa)
q''	=	total heat release (kJ/m^2)
$\dot{q}$	=	heat release rate (kW)
$\dot{q}''$	=	heat release rate per unit area (kW/m^2)
r_0	=	stoichiometric oxygen/fuel mass ratio
t	=	time (sec)
t_d	=	oxygen analyzer delay time (sec)
Δt	=	sampling time interval (sec)
T_e	=	absolute temperature of gas at the orifice meter (K)
$\dot{v}$	=	volume exhaust flow rate measured at the location of the laser photometer (m^3/sec)
X_{O_2}	=	oxygen analyzer reading, mole fraction of O_2
$X^0_{O_2}$	=	initial value of oxygen analyzer reading
$X^1_{O_2}$	=	oxygen analyzer reading before delay time correction
s_f	=	specific extinction area for smoke (m^2/kg)

Chapter 2 Referenced Publications (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1 Shall. Indicates a mandatory requirement.

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

3.2.3 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Heat of Combustion.

3.3.1.1 ***Effective Heat of Combustion.*** The measured heat release divided by the mass loss for a specified time period.

3.3.1.2* ***Net Heat of Combustion.*** The oxygen bomb calorimeter value for the heat of combustion, corrected for the gaseous state of product water.

3.3.2 Heat Release Rate. The heat evolved from the specimen, per unit of time.

3.3.3 Heating Flux. The incident radiant heat flux imposed externally from the heater on the specimen at the initiation of the test.

3.3.4 Ignitibility. The propensity for ignition, as measured by the time to sustained flaming, in seconds, at a specified heating flux.

3.3.5 Orientation. The plane in which the exposed face of the specimen is located during testing (i.e., horizontally facing the heater).

3.3.6 Oxygen Consumption Principle. The expression of the relationship between the mass of oxygen consumed during combustion and the heat released.

3.3.7 Smoke Obscuration. The reduction of light transmission by smoke, as measured by light attenuation.

3.3.8 Sustained Flaming. The existence of flame for a period of at least 4 seconds.

3.3.9 Visible Smoke. The obscuration of transmitted light caused by combustion products released during the test.

Chapter 4 Test Apparatus

4.1 General. The test apparatus shall consist of the following components:

(1) A conical-shaped radiant electric heater
(2) Specimen holders
(3) An exhaust gas system with oxygen-monitoring and flow-measuring instrumentation
(4) An electric ignition spark plug
(5) A data collection and analysis system
(6) A load cell for measuring specimen mass loss

4.1.1 A general view of the apparatus shall be as shown in Figure 4.1.1.

4.1.2 A cross-sectional view of the heater shall be as shown in Figure 4.1.2.

4.1.3 An exploded view of the horizontal orientation shall be as shown in Figure 4.1.3.

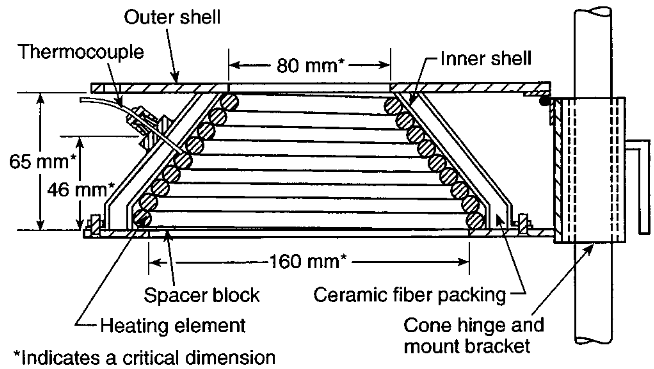


FIGURE 4.1.2 Cross-Sectional View of Heater.

4.2 Conical Heater.

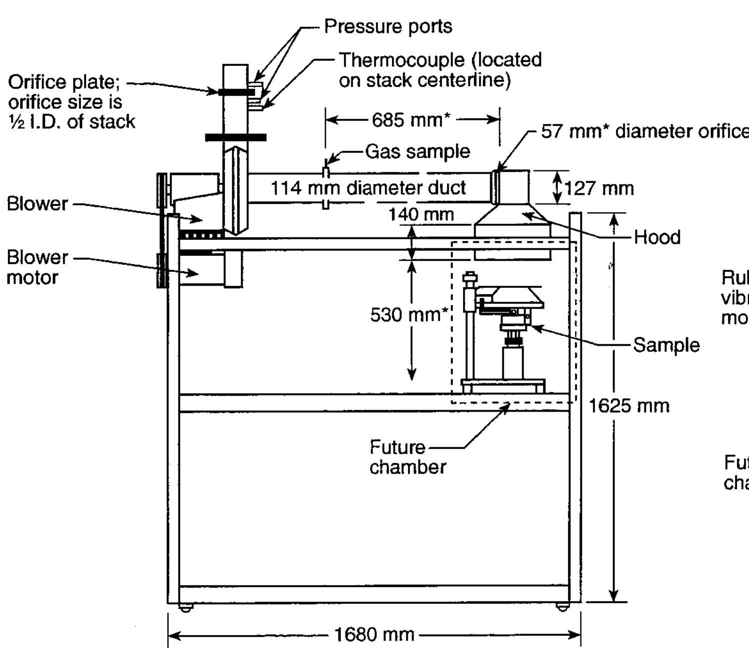
4.2.1 The active element of the heater shall consist of an electrical heater rod, rated at 5000 W at 240 V and tightly wound into the shape of a truncated cone, as shown in Figure 4.1.2.

4.2.2 The heater shall be encased on the outside with a double-wall stainless steel cone packed with a refractory fiber material of approximately 100 kg/m^3 density.

4.2.3* The heater shall be mounted in a horizontal orientation.

4.2.4 The heater shall be capable of producing irradiances on the surface of the specimen of up to 100 kW/m^2.

4.2.5 The irradiance shall be uniform within the central 50 mm × 50 mm area of the specimen to within 10 percent.



*Indicates a critical dimension

FIGURE 4.1.1 Overall View of Apparatus.

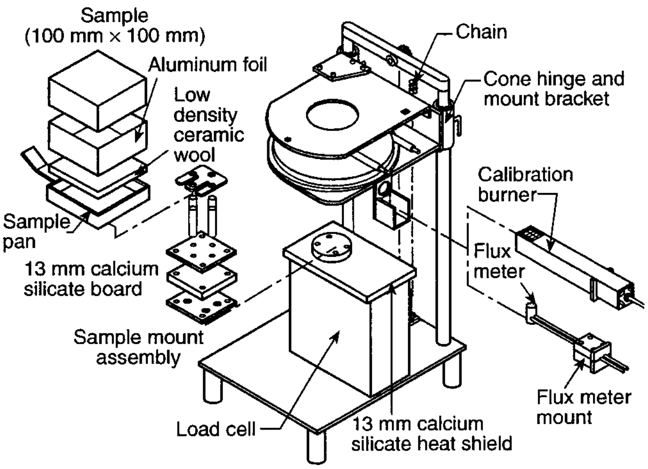


FIGURE 4.1.3 Exploded View, Horizontal Orientation, of Apparatus.

4.2.6 The irradiance from the heater shall be capable of being held at a preset level by means of a temperature controller and three Type K stainless steel–sheathed thermocouples, symmetrically dispersed and in contact with, but not welded to, the heater element, as shown in Figure 4.1.2.

4.2.7 The thermocouples shall be of equal length and wired in parallel to the temperature controller.

4.2.8 The standard thermocouples shall be sheathed, 1.5 mm to 1.6 mm O.D., with an unexposed hot junction. Alternatively, either 3 mm O.D. sheathed thermocouples with an exposed hot junction or 1 mm O.D. sheathed thermocouples with unexposed hot junction shall be suitable for use.

4.2.9 Radiation Shield.

4.2.9.1 The cone heater shall be provided with a removable radiation shield to protect the specimen from the heat flux prior to the start of the test.

4.2.9.2 The shield shall be made of noncombustible material, with a total thickness not to exceed 12 mm.

4.2.9.3 The shield shall be one of the following:

(1) Water-cooled and coated with a durable matte black finish of surface emissivity, $e = 0.95 \pm 0.05$
(2) Not water-cooled, with a metallic reflective top surface
(3) Not water-cooled, with a ceramic, nonmetallic surface that minimizes radiation transfer to the specimen surface

4.2.9.4 The shield shall be equipped with a handle or other suitable means for insertion and removal in accordance with 7.2.2 and 7.2.3.

4.2.9.5 The cone heater base plate shall be equipped with the means for holding the shield in position and allowing its insertion and removal in accordance with 7.2.2 and 7.2.3.

4.3 Temperature Controller.

4.3.1 The temperature controller for the heater shall be capable of holding the element temperature steady to within 2°C.

4.3.2 An acceptable system shall be a three-term controller (proportional, integral, and derivative) and a thyristor unit capable of switching currents up to 25 A at 250 V.

4.3.3 The controller shall have a temperature input range of 0°C to 1000°C, a set scale capable of being read to 2°C or better, and automatic cold junction compensation.

4.3.4 The controller shall be equipped with a safety feature that, in the event of an open circuit in the thermocouple line, causes the temperature to fall to near the bottom of its range.

4.3.5 The thyristor unit shall be of the zero crossing type and not of the phase angle type.

4.3.6 The heater temperature shall be monitored by a meter capable of being read to 2°C or better.

4.4 Exhaust System.

4.4.1 The exhaust gas system shall consist of a high-temperature centrifugal exhaust fan, a hood, intake and exhaust ducts for the fan, and an orifice plate flowmeter as shown in Figure 4.4.1.

4.4.2 The exhaust system shall be capable of developing flows from 0.012 m^3/sec to 0.035 m^3/sec.

4.4.3 A restrictive orifice (57 mm I.D.) shall be located between the hood and the duct to promote mixing.

4.4.4 A ring sampler for gas sampling shall be located in the fan intake duct 685 mm from the hood, as shown in Figure 4.4.1.

4.4.5 The ring sampler shall contain 12 holes to average the stream composition, with the holes facing away from the flow to avoid soot clogging.

4.4.6 The temperature of the gas stream shall be measured using a 1.0 mm to 1.6 mm O.D. sheathed-junction thermocouple or a 3 mm O.D. exposed-junction thermocouple positioned in the exhaust stack on the centerline and 100 mm upstream from the measuring orifice plate.

4.4.7 The flow rate shall be determined by measuring the differential pressure across a sharp-edged orifice (57 mm I.D.) in the exhaust stack at a location at least 350 mm downstream from the fan.

4.4.8 For other features, the geometry of the exhaust system shall not be considered critical. The undisturbed inflow distances to the gas-sampling probe and the measuring orifice shall be sufficient for the flow to be uniformly mixed.

4.5 Load Cell.

4.5.1 The arrangement of the specimen holders on the load cell shall be as indicated in Figure 4.1.3.

4.5.2 The load cell shall have an accuracy of 0.1 g and a measuring range of 500 g.

4.6 Specimen Mounting.

4.6.1 The horizontal specimen holder shall be as shown in Figure 4.6.1.

4.6.2* The bottom of the horizontal specimen holder shall be lined with a layer of low-density (nominal density 65 kg/m^3) refractory fiber blanket with a thickness of at least 13 mm.

4.6.3 The distance between the bottom surface of the cone heater and the top of the specimen shall be adjusted to 25 mm.

4.6.4 A retainer frame and a wire grid, as shown in Figure 4.6.4(a) and Figure 4.6.4(b), respectively, shall be used in the testing of intumescing specimens to reduce unrepresentative edge-burning of composite specimens and for retaining specimens prone to delamination. Other techniques shall be permitted to be utilized if documented in the test report.

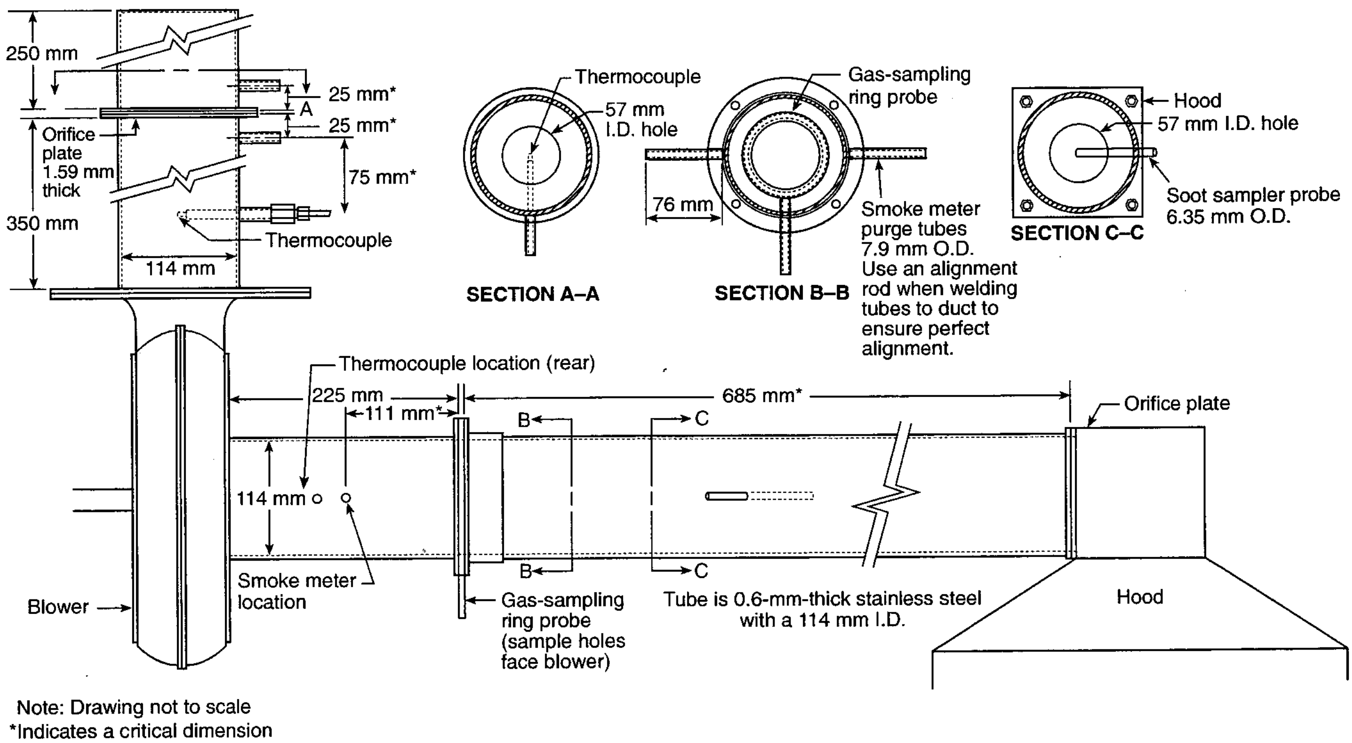


FIGURE 4.4.1 Exhaust System.

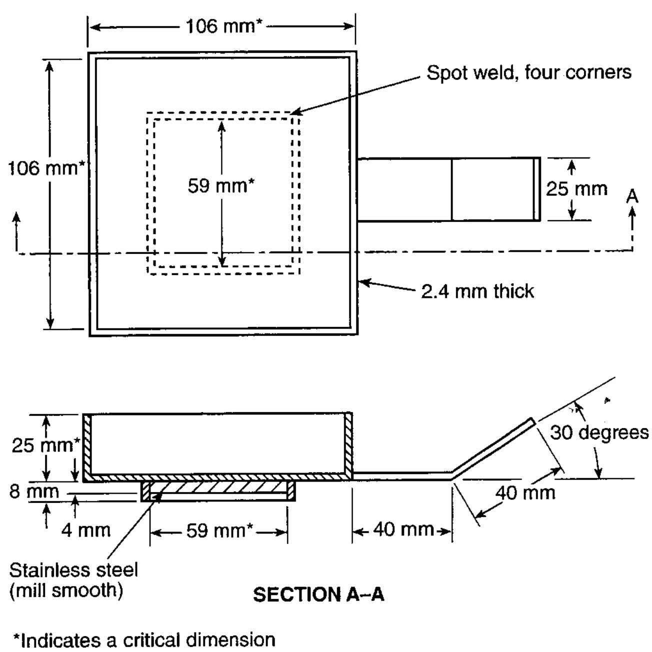


FIGURE 4.6.1 Horizontal Specimen Holder.

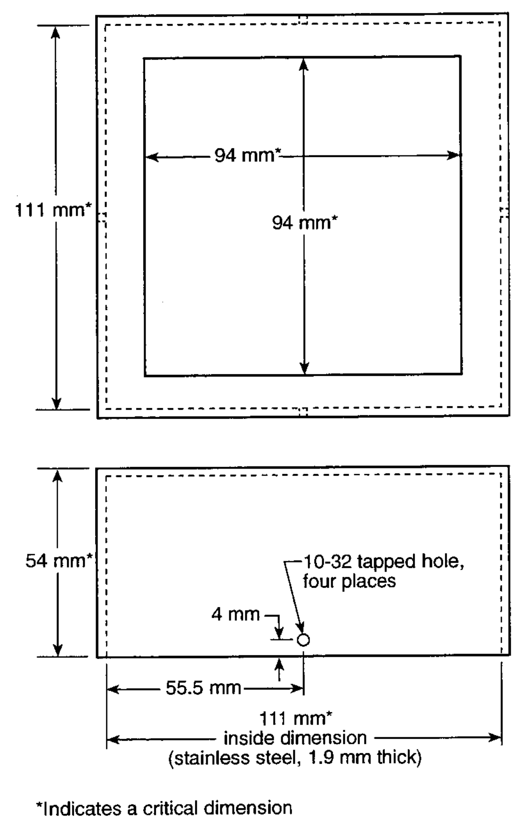


FIGURE 4.6.4(a) Optional Retainer Frame.

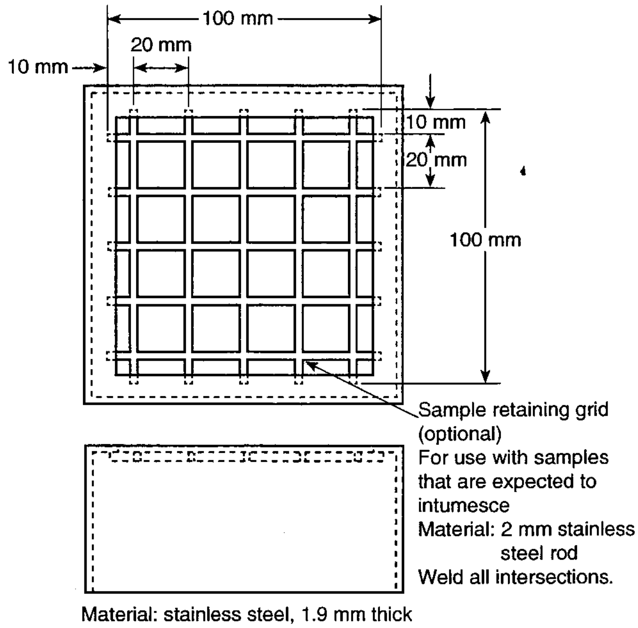


FIGURE 4.6.4(b) Optional Wire Grid.

4.7 Ignition Circuit.

4.7.1 External ignition shall be accomplished by a spark plug powered from a 10 kV transformer or by a 10 kV spark generator.

4.7.2 The length and location of the spark plug or spark generator electrode shall be such that the spark shall have a gap of 3 mm.

4.7.3 The spark gap shall be located 13 mm above the center of the specimen in the horizontal orientation.

4.7.4 If a spark plug and transformer are used, the transformer shall be of a type specifically designed for spark ignition use. The transformer shall have an isolated (ungrounded) secondary to minimize interference with the data transmission lines.

4.7.5 The igniter shall be removed when sustained flaming is achieved for a period of 4 seconds.

4.8 Ignition Timer. The timing device for measuring time to sustained flaming shall be capable of recording elapsed time to the nearest second and shall be accurate to within 1 second in 1 hour.

4.9* Gas Sampling. Gas-sampling arrangements such that as shown in Figure 4.9 shall incorporate a pump, a filter to prevent entry of soot, a cold trap to remove most of the moisture, a bypass system set to divert all flow except that required for the oxygen analyzer, a further moisture trap, and a trap for CO_2 removal where CO_2 is not measured. If CO_2 is removed, an additional moisture trap is required downstream from the CO_2 trap.

4.10 Oxygen Analyzer.

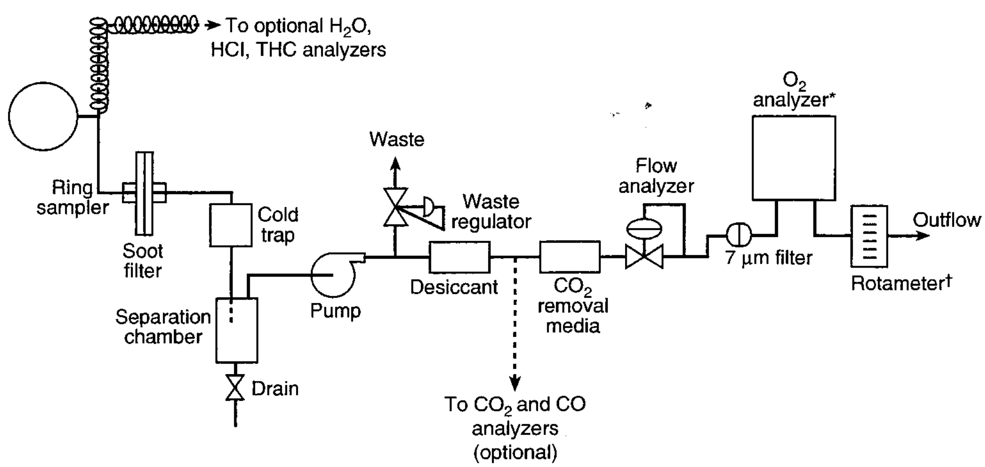
4.10.1 The analyzer shall be of the paramagnetic type with a range of 0 percent to 25 percent O_2.

4.10.2 The analyzer shall exhibit a linear response and drift of not more than 50 ppm O_2 (root-mean-square value) over a period of ½ hour.

4.10.3 The stream pressure shall be regulated upstream of the analyzer to allow for flow fluctuations, and the readings from the analyzer shall be compensated with an absolute pressure regulator to allow for atmospheric pressure variations.

4.10.4 The analyzer and the absolute pressure regulator shall be located in a constant-temperature environment.

4.10.5 The oxygen analyzer shall have a 10 percent to 90 percent response time of less than 12 seconds.



*To include absolute pressure transducer
†On outlet of O_2 analyzer.

FIGURE 4.9 Gas Analyzer Instrumentation.

4.11 Smoke Obscuration–Measuring System.

4.11.1 The smoke-measuring system, as shown in Figure 4.11.1, shall consist of a helium–neon laser, silicon photodiodes as main beam and reference detectors, and appropriate electronics to derive the extinction coefficient and to set the zero reading.

4.11.2 The system shall be designed to be resiliently attached to the exhaust duct by means of refractory gasketing at the location shown in Figure 4.4.1. This can be achieved either by using an optical bench or by split toke mounting in two pieces that are rigidly fastened together.

4.11.3 The meter shall be located in place by means of two small-diameter tubes welded onto each side of the exhaust duct. These tubes shall serve as part of the light baffling for the air purging and shall also allow for any smoke that enters despite the purge flow to be deposited on tube walls before reaching the optical elements.

4.12 Heat Flux Meter.

4.12.1 The total heat flux meter shall be of the Gardon (foil) or Schmidt–Boetler (thermopile) type, with a design range of 100 kW/m^2.

4.12.1.1 The target receiving radiation shall be flat, circular, approximately 12.5 mm in diameter, and coated with a durable, matte black finish.

4.12.1.2 The target shall be water-cooled.

4.12.1.3 Radiation shall not pass through any window before reaching the target.

4.12.1.4 The instrument shall be robust, simple to set up and use, and stable in calibration.

4.12.1.5 The instrument shall have an accuracy within 3 percent and a repeatability within 0.5 percent.

4.12.2 The calibration of the heat flux meter shall be checked whenever the apparatus is recalibrated by comparison with an instrument (of the same type as the working heat flux meter and of similar range) used only as a reference standard. The reference standard shall be fully calibrated at a standardizing laboratory at yearly intervals.

4.12.3 The heat flux meter shall be used to calibrate the heater temperature controller as shown in Figure 4.1.3. The meter shall be positioned at a location equivalent to the center of the specimen face during the calibration.

4.13 Calibration Burner.

4.13.1 A calibration burner shall be used to calibrate the rate of heat release apparatus as shown in Figure 4.1.3. The burner shall be constructed from a square-sectional brass tube with a square orifice covered with wire gauze through which the gas diffuses, as shown in Figure 4.13.1.

4.13.2 The tube shall be packed with ceramic fiber to improve uniformity of flow.

4.13.3 The calibration burner shall be connected to a metered supply of methane with a purity of at least 99.5 percent.

4.14 Optical Calibration Filters. Glass neutral density filters of at least two different values and accurately calibrated at the laser wavelength of 0.6328 microns shall be provided.

4.15 Digital Data Collection.

4.15.1 The data collection system used shall have facilities for the recording of the output from the O_2 analyzer, the orifice meter, the thermocouples, the load cell, and the smoke-measuring system.

4.15.2 The data collection system shall have an accuracy corresponding to at least 50 ppm O_2 for the oxygen channel, 0.5°C for the temperature-measuring channels, and 0.01 percent of full-scale instrument output for all other instrument channels.

4.15.3 The system shall be capable of recording data for at least 1 hour at intervals not exceeding 2 seconds.

4.16 Test Environment. The apparatus shall be located in an atmosphere of relative humidity of between 40 percent and 60 percent and a temperature of between 16°C and 26°C.

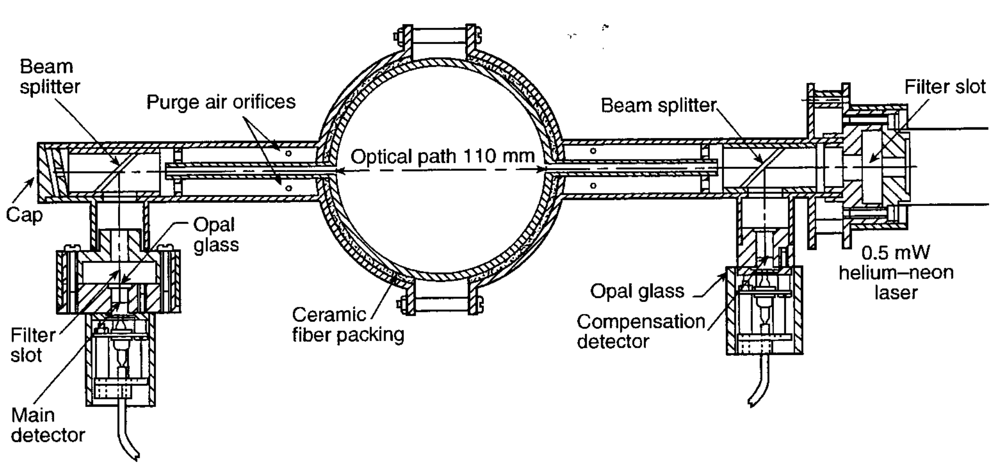


FIGURE 4.11.1 Smoke Obscuration–Measuring System.

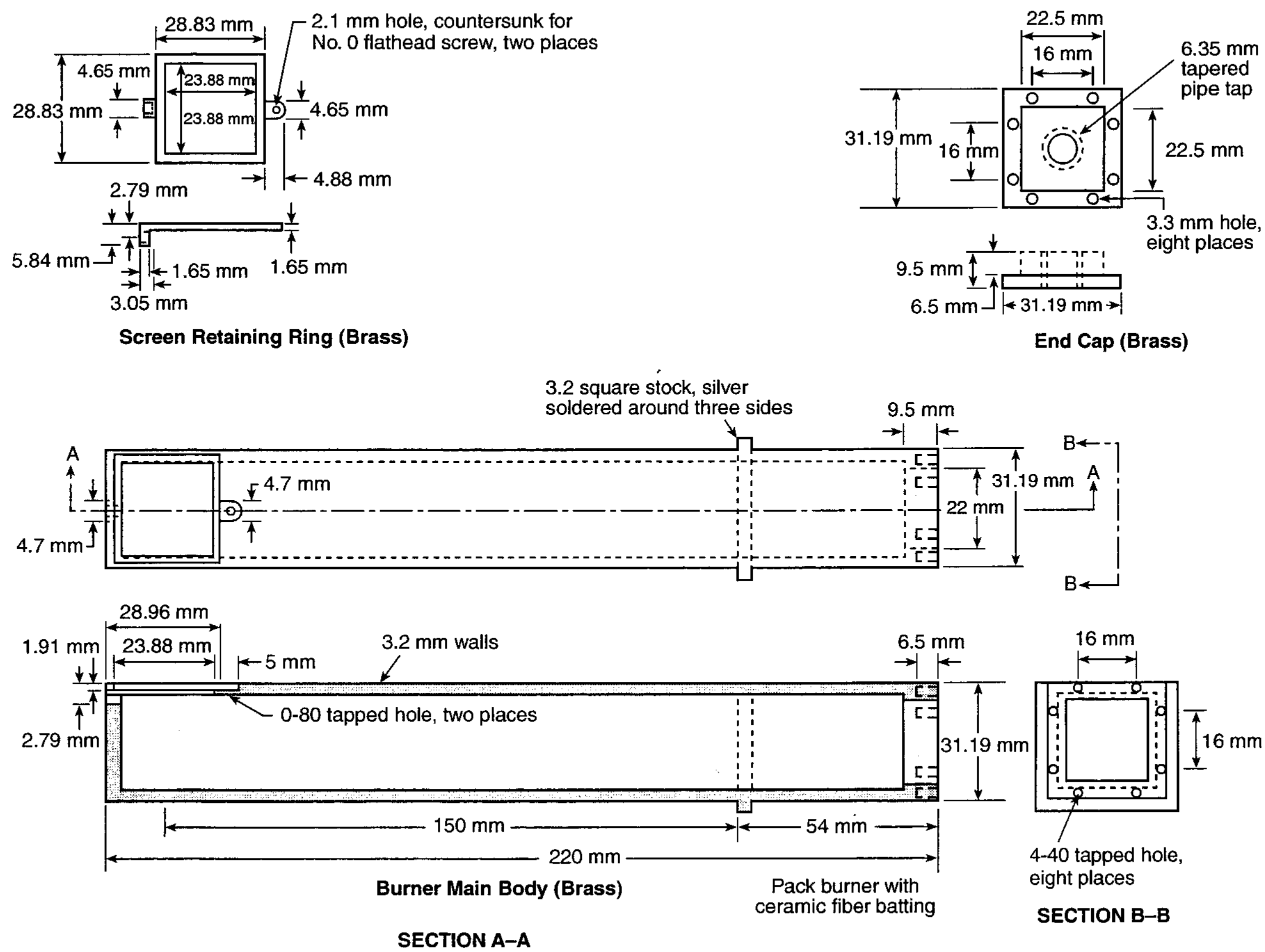


FIGURE 4.13.1 Calibration Burner.

Chapter 5 Calibration of Equipment

5.1 Heater Flux Calibration.

5.1.1 The temperature controller shall be set at the required flux by using the heat flux meter at the start of the test day or after changing to a new flux level.

5.1.2 A specimen or specimen holder shall not be used when the heat flux meter is inserted into the calibration position.

5.1.3 The cone heater shall be operated for at least 10 minutes, and it shall be ensured that the controller is within its proportional band before the calibration is begun.

5.2 Oxygen Analyzer Calibration.

5.2.1 Preliminary Calibration.

5.2.1.1 The oxygen analyzer delay time shall be determined by setting a methane flow rate to the calibration burner that is equivalent to 5.0 kW. The heater shall not be turned on for this calibration.

5.2.1.2 The output of the analyzer shall be recorded on a data acquisition device or on a strip chart recorder as the methane supply, turned on and ignited, reaches a steady value and then returns to baseline after the supply is cut off. The temperature for the exhaust orifice meter shall be recorded at the same time.

5.2.1.3 The turn-on delay shall be determined from the difference between the time at which the temperature reading reaches 50 percent of its ultimate deflection and the time at which the oxygen reading reaches 50 percent of its ultimate deflection. The turn-off delay shall be determined similarly at turn-off.

5.2.1.4 The delay time shall be the average of the turn-on delay and turn-off delay.

5.2.1.5 The delay time value, t_d, subsequently shall be used to time-shift all the oxygen readings.

5.2.1.6 If the oxygen analyzer is equipped with an electric response time adjustment, it shall be set so that at turn-off there is just a trace of overshoot when switching rapidly between two different calibration gases.

5.2.1.7 Scan Timing.

5.2.1.7.1 The timing of the scans by the data collection system shall be calibrated with a timer accurate to within 1 second in 1 hour.

5.2.1.7.2 The data output shall show event times correct to within 3 seconds.

5.2.2 Operating Calibrations.

5.2.2.1 At the start of testing each day, the oxygen analyzer shall be zeroed and calibrated. For zeroing, the analyzer shall be fed with nitrogen gas using the same flow rate and pressure as for the sample gases.

5.2.2.2 Calibration shall be achieved similarly using ambient air and adjusting for a response of 20.95 percent.

5.2.2.3 Analyzer flow rates shall be monitored and set to be equal to the flow rate used when testing specimens.

5.2.2.4 After each specimen has been tested, a response level of 20.95 percent obtained using ambient air shall be verified.

5.3* Heat Release Calibration.

5.3.1 The heat release calibration shall be performed each day at the start of testing.

5.3.2 Methane with a purity of at least 99.5 percent shall be introduced into the calibration burner at a flow rate corresponding to 5 kW based on the net heat of combustion of methane (50.0×10^3 kJ/kg) using a precalibrated flowmeter. The flowmeter used shall be a dry test meter, a wet test meter, or an electronic mass flow controller.

5.3.3 If an electronic mass flow controller is used, it shall be calibrated periodically against a dry test meter or a wet test meter.

5.3.4 The test meter shall be equipped with devices to measure the temperature and pressure of the flowing gas so that appropriate corrections to the reading are made. If a wet test meter is used, the readings also shall be corrected for the moisture content.

5.3.5 The exhaust fan shall be set to the speed to be used for subsequent testing. The required calculations are provided in Chapter 8.

5.4* Load Cell Calibration. The load cell shall be calibrated with standard weights in the range of test specimen weight on each day of testing or when the load cell mechanical zero requires adjustment.

5.5* Smoke Meter Calibration. The smoke meter initially shall be calibrated to read correctly for two different value-neutral density filters and also at 100 percent transmission.

Chapter 6 Test Specimens

6.1* Specimen Size. Test specimens shall be 100 mm × 100 mm, shall be up to 50 mm thick, and shall be cut to be representative of the construction of the end-use product.

6.2 Specimen Testing. For testing, the sides and bottom of each of the specimens shall be wrapped in a single layer of aluminum foil (0.025 to 0.040 mm thick), with the shiny side facing the specimen.

6.2.1* Composite specimens shall be exposed in a manner typical of the end-use condition. They shall be prepared so that the sides are covered with the outer layer(s).

6.2.2* Composite and intumescing materials shall be mounted using techniques that hold them in place within the specimen holder during combustion. The exact mounting and retaining method used shall be specified in the test report.

6.3 Conditioning.

6.3.1 Specimens shall be conditioned to moisture equilibrium (constant weight) at an ambient temperature of 23°C ± 3°C and a relative humidity of 50 percent ± 5 percent.

6.3.2 Test specimens shall be tested within 10 minutes of removal from such conditions if the test conditions differ from those specified in 6.3.1.

Chapter 7 Test Procedure

7.1 Preparation.

7.1.1 Traps.

7.1.1.1 The CO_2 trap and the final moisture trap shall be checked.

7.1.1.2 The absorbents shall be replaced when they are no longer effective.

7.1.1.3 Any accumulated water in the cold trap separation chamber shall be drained.

7.1.1.4 The normal operating temperature of the cold trap shall be 0°C or lower.

7.1.2 Power. The power to the cone heater and the exhaust blower shall be turned on each test day. Power to the oxygen analyzer, load cell, and pressure transducer shall not be turned off on a daily basis.

7.1.3* Exhaust Flow. An exhaust flow rate at a value of 0.024 m^3/sec ± 0.002 m^3/sec shall be set.

7.1.4 Calibration. The required calibration procedures specified in Chapter 5 shall be performed.

7.1.5 Holder. An empty specimen holder with refractory blanket in place shall be placed in the horizontal orientation during warm-up and between tests to avoid excessive heat transmission to the load cell.

7.1.6 Ignition. Where external ignition is used, the spark plug holder shall be positioned in the location appropriate to the orientation being used.

7.2 Procedure.

7.2.1 When the test is ready to be performed, the empty specimen holder shall be removed.

7.2.2 The radiation shield shall be inserted, and the specimen, within the horizontal holder, shall be positioned in place. The holder shall initially be at room temperature.

7.2.3* The radiation shield shall remain in place until load cell equilibrium, but for no longer than 10 seconds total if the shield is not water-cooled.

7.2.4 Data Collection.

7.2.4.1 Data collection shall be initiated on removal of the radiation shield, which is the start of the test.

7.2.4.2 The data collection intervals shall be 2 seconds or less.

7.2.5 The ignition shall be conducted in the following sequence:

(1) Start the ignition timer.
(2) Move the spark igniter into place.
(3) Turn on the power to the spark igniter.

7.2.5.1 The sequence in 7.2.5 shall be accomplished within 2 seconds of the removal of the radiation shield.

7.2.6* Flaming.

7.2.6.1 When flashing or transitory flaming occurs, the times shall be recorded.

7.2.6.2 When flaming is sustained for a period of 4 seconds, the exceeding time at which the sustained flaming started shall be recorded, the spark igniter shall be turned off, and the spark ignition shall then be removed.

7.2.6.3 If the flame self-extinguishes in less than 60 seconds after the spark is turned off, the spark igniter shall be reinserted and shall be turned on.

7.2.6.3.1 If flaming reoccurs, the test shall be stopped, the test data shall be discarded, and the test shall then be repeated without removing the spark igniter until the entire test is completed.

7.2.6.3.2 The events described in 7.2.6.3.1 shall be included in the test report.

7.2.7 Data shall be collected until 2 minutes after any flaming or other signs of combustion cease, until the average mass loss over a 1-minute period has dropped below 150 g/m^2 or until 60 minutes have elapsed, whichever occurs first.

7.2.8 Holder.

7.2.8.1 The specimen holder shall be removed.

7.2.8.2 The empty specimen holder shall be replaced.

7.2.9* After the start of the test, if the specimen does not exhibit sustained flaming within 15 minutes, the test shall be ended. If sustained flaming was not observed, the report shall indicate that there was no ignition. *(See also Section 9.1.)*

7.2.10 Unless otherwise specified in the material or performance standard, three determinations shall be made and reported as specified in Chapter 9. The 180-second mean heat release rate readings shall be compared for the three specimens. If any of these mean readings differs by more than 10 percent from the average of the three readings, then an additional set of three specimens shall be tested. In such cases, the averages for the set of six readings shall be reported.

7.3 Safety Precautions.

7.3.1 The operator shall use protective gloves for insertion and removal of test specimens because the test procedures involve high-temperature and combustion processes and, therefore, hazards exist for burns, ignition of extraneous objects or clothing, and inhalation of combustion products. Neither the cone heater nor the associated fixtures shall be touched while hot except with the use of protective gloves.

7.3.2 The exhaust shall be checked for proper operation before testing and shall discharge into a building exhaust system with adequate capacity.

7.3.3 Provision shall be made for collecting and venting any combustion products that fail to be collected by the normal exhaust system of the apparatus.

Chapter 8 Calculations

8.1* General. The equations in this section shall assume that only O_2 is measured, as indicated on the gas analysis system in Figure 4.9.

8.2* Calibration Constant Using Methane.

8.2.1 The methane calibration shall be performed prior to the day's testing, to check for the proper operation of the instrument and to compensate for minor changes in mass flow determination.

8.2.2* The calibration constant, C, shall be determined from the following equation:

$$C = \frac{5.0}{1.10\left(12.54\times10^{3}\right)}\left(\frac{\sqrt{\Delta P}}{T_e}\right)\left[\frac{X^0_{O_2} - X_{O_2}(t)}{1.105 - 1.5X_{O_2}(t)}\right]$$

where:

5.0 = 5.0 kW of methane supplied
12.54×10^3 = the ratio $\Delta H_c/r_0$ for methane
1.10 = the ratio of oxygen to air molecular weight

8.3 Calculations for Test Specimen. The calculations in this section shall be used for various applications. The applicable material or performance standard shall be consulted for additional calculations.

8.3.1 Heat Release.

8.3.1.1 Prior to performing other calculations, the oxygen analyzer time shift shall be determined by the following equation:

$$X_{O_2}(t) = X^1_{O_2}(t + t_d)$$

8.3.1.2 The heat release rate then shall be determined by the following equation:

$$\dot{q}(t) = \frac{\Delta H_c}{r_0}(1.10)C\sqrt{\frac{\Delta P}{T_e}}\left[\frac{X^0_{O_2} - X_{O_2}(t)}{1.105 - 1.5X_{O_2}(t)}\right]$$

8.3.1.3 The value of $\Delta H_c/r_0$ for the test specimen shall be set to equal 13.1×10^3 kJ/kg, unless a more accurate value is known for the test material. The heat release rate per unit area shall be determined as follows:

$$q''(t) = \frac{q(t)}{A_s}$$

where:
A_s = 0.01 m^2

When the optimal retainer frame and wire grid as shown in Figure 4.6.4(a) and Figure 4.6.4(b) are used, $A_s = 0.0088$ m^2.

8.3.1.4 The total heat released during combustion, $\dot{q}''$, shall be determined by summation:

$$\dot{q}'' = \sum_i \dot{q}''i(t)\Delta t$$

8.3.1.4.1 The summation in 8.3.1.4 shall begin with the first reading after the last negative rate of heat release reading that occurs at the beginning of the test and shall continue until the final reading recorded for the test.

8.3.2 Mass Loss Rate and Effective Heat of Combustion.

8.3.2.1 The required mass loss rate, $-dm/dt$, shall be computed at each time interval using five-point numerical differentiation. The following equations shall be used:

(1) For the first scan ($i = 0$):

$$-\left(\frac{dm}{dt}\right)_{i=0} = \frac{25m_0 - 48m_1 + 36m_2 - 16m_3 + 3m_4}{12\Delta t}$$

(2) For the second scan ($i = 1$):

$$-\left(\frac{dm}{dt}\right)_{i=1} = \frac{3m_0 + 10m_1 - 18m_2 + 6m_3 - m_4}{12\Delta t}$$

(3) For any scan for which $1 < i < n - 1$ (n = total number of scans):

$$-\left(\frac{dm}{dt}\right)_{i} = \frac{-m_{i-2} + 8m_{i-1} - 8m_{i+1} + m_{i+2}}{12\Delta t}$$

(4) For the next to the last scan ($i = n - 1$):

$$-\left(\frac{dm}{dt}\right)_{i=n-1} = \frac{-10m_n - 3m_{n-1} + 18m_{n-2} - 6m_{n-3} + m_{n-4}}{12\Delta t}$$

(5) For the last scan ($i = n$):

$$-\left(\frac{dm}{dt}\right)_{i=n} = \frac{-25m_n + 48m_{n-1} - 36m_{n-2} + 16m_{n-3} - 3m_{n-4}}{12\Delta t}$$

8.3.2.2 The average effective heat of combustion shall be determined as follows, with the summation taken over the entire test length:

$$\Delta H_{c,eff} = \frac{\Sigma_i \dot{q}_i(t)\Delta t}{m_i - m_f}$$

8.3.2.2.1 A time-varying value also shall be determined as follows:

$$\Delta H_{c,eff}(t) = \frac{\dot{q}_i(t)}{-(dm/dt)}$$

8.3.3 Smoke Obscuration.

8.3.3.1 The extinction coefficient, k, shall be determined by the smoke meter electronics as follows:

$$k = \left(\frac{1}{L}\right)\ln\left(\frac{I_0}{I}\right)$$

8.3.3.2 The average specific extinction area obtained during the test shall be as follows:

$$\sigma_{f(avg)} = \frac{\Sigma_i \dot{v}_i k_i \Delta t_i}{m_i - m_f}$$

Chapter 9 Report

9.1 Required Information. The test report shall include the following information unless otherwise specified in the relevant material or performance standard:

(1) Specimen identification code or number.
(2) Manufacturer or submitter.
(3) Date of test.
(4) Operator.
(5) Composition or generic identification.
(6) Specimen thickness.
(7) Specimen mass.
(8) Specimen color(s) and description.
(9) Details of specimen preparation by the testing laboratory.
(10) Test orientation, specimen mounting, and whether the retainer frame, the wire grid, or other special mounting procedure was used.
(11) Heating flux and exhaust system flow rate.
(12) Number of replicate specimens tested under the same conditions. A minimum of three specimens shall be tested, unless exploratory testing only is intended.
(13) Time to sustained flaming(s). If sustained flaming was not observed during the test *(see 7.2.9)*, the report shall state "No ignition."
(14) Heat release rate (per unit area) curve (kW/m^2).
(15)*Peak $\dot{q}''$ and average $\dot{q}''$ values for the first 60 seconds, 180 seconds, and 300 seconds after ignition or for other appropriate periods. For specimens that do not show sustained flaming, the above quantities, tabulated for periods beginning with the first reading after the last negative rate of heat release reading that occurs at the beginning of the test, shall be reported.
(16) Total heat released by the specimen (MJ/m^2). The total heat shall be computed beginning with the first reading after the last negative rate of heat release reading that occurs at the beginning of the test and continuing until the final reading recorded for the test.
(17) Average $\Delta H_{c,eff}$ for the entire test (MJ/kg).
(18) Curve of $\Delta H_{c,eff}$ (MJ/kg). This information is optional.
(19) Mass remaining after test (g).
(20) Sample mass loss (kg/m^2), which is the average specimen mass loss rate (g/m^2·sec) computed over the period that begins when 10 percent of the ultimate specimen mass loss occurs and that ends when 90 percent of the ultimate specimen mass loss occurs.
(21) Smoke obscuration, which shall be reported as the average specific extinction area (m^2/kg).
(22) Values determined for Sections 9.1(12), 9.1(15), 9.1(16), and 9.1(20), averaged for all specimens.
(23) Additional observations, including times of transitory flaming or flashing, if any.
(24) Difficulties encountered in testing, if any.
(25) Duration of test and the criteria used to end the test.
(26) Data recording interval(s).
(27) Calculation method used for heat release.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1 Conducting tests without piloted ignition is best kept for research and development.

This method is similar to the test method contained in ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter (Cone Calorimeter)*, and in ISO 5660, *Reaction-to-Fire Tests — Heat Release, Smoke Production and Mass Loss Rate — Part 1: Heat Release Rate (Cone Calorimeter Method)*.

A.1.1.3 Testing of materials in the horizontal orientation is preferred, especially for regulatory purposes, because such testing is much more reproducible and repeatable than testing performed in the vertical orientation and generally appears to provide a more severe exposure condition. When vertical orientation is used, it is more difficult to control the pyrolysates that evolve from the material's surface for the purpose of external ignition using the point source spark ignition. Convective heat flow along the exposed surface of the sample is also a complicating factor.

A.1.2.1 The relationship of the behavior of materials and products to radiant heat flux exposure is determined by testing specimens in a series of exposures over as broad a range of incident radiant heat fluxes as possible.

A.1.3.2 Testing of materials in the horizontal orientation is preferred, especially for regulatory purposes, because such testing is much more reproducible and repeatable than testing performed in the vertical orientation and generally appears to provide a more severe exposure condition. When vertical orientation is used, it is more difficult to control the pyrolysates that evolve from the material's surface for the purpose of external ignition using the point source spark ignition. Convective heat flow along the exposed surface of the sample is also a complicating factor.

A.1.3.2.1 Specimens having nonplanar surfaces can be tested by this method, but it is not known if the results will be comparable to planar surfaces. In 4.2.5, this method specifies that the irradiance over the center 50 mm × 50 mm of the test specimen be uniform to within 10 percent of the target irradiance. Surface irregularities, such as pitted, pocked, tufted, textured, or uneven surfaces, on otherwise planar specimens or curved, undulating, or corrugated surfaces may be suitable. The conditions of such surfaces should be clearly described in the test report.

A.1.3.2.4 It cannot be assumed that the behavior of materials tested in accordance with this method will be replicated in an actual fire. The response of a material to a real fire is affected by many factors, including the specific end use of the material, the environment in which it is used, and the fire condition to which it might be exposed.

A.1.3.3.4 Additional information on testing is provided in Annex E.

A.1.3.3.7 Additional information on heating flux and the use of external ignition can be found in E.2.3.

A.3.3.1.2 Net Heat of Combustion. For additional information, see ASTM D 3286, *Standard Test Method for Gross Calorific Value of Coal and Coke by the Isoperibol Bomb Calorimeter.*

A.4.2.3 Because the geometry of the heater is critical, the dimensions shown in Figure 4.1.2 should be adhered to closely.

A.4.6.2 A suitable method for adjusting the distance between the bottom surface of the cone heater and the top surface of the specimen is to use a sliding cone height adjustment, if provided, as shown in Figure 4.1.2.

A.4.9 The removal of CO_2 produces water, which should be removed. If an optional CO_2 analyzer is used instead of removing CO_2 from the oxygen analyzer stream, the equations used to calculate the rate of heat release are different from those for the standard case indicated in Chapter 8. The appropriate equations are provided in Annex C.

A.5.3 Calibration can be permitted to be performed with or without the cone heater operating but should not be performed during heater warm-up.

A.5.4 The load cell mechanical zero might have to be adjusted when an edge or retainer frame is used or if the apparatus was not last used in the horizontal orientation.

A.5.5 Once this calibration is set, only the zero value of the extinction coefficient (100 percent transmission) normally needs to be verified prior to each test.

A.6.1 For products of thickness greater than 50 mm, the requisite specimens should be obtained by cutting away the unexposed face to reduce the thickness to 50 mm.

A.6.2.1 It should also be acceptable for composite specimens to be otherwise protected from direct exposure.

A.6.2.2 Such mounting techniques include the use of an edge or retainer frame as shown in Figure 4.6.4(a), wire grid, or other special mounting procedure suitable to the specimen being tested. Figure 4.6.4(b) shows a wire grid suitable for several types of intumescing specimens.

Assemblies should be tested as specified in 6.2.1, or, alternatively, they should be tested using the concepts described herein, as appropriate.

Where the product is a material or composite that is normally attached to a well-defined substrate, it should be tested in conjunction with that substrate, using the recommended fixing technique, for example, bonded with the appropriate adhesive or mechanically fixed.

When assemblies fabricated with composites or with thin materials are tested, the presence of an air gap and the nature of any underlying construction are factors with significant potential to affect the ignition and burning characteristics of the exposed surface. Care should be taken to ensure that the test result obtained on any assembly is relevant to its use in practice.

Thin specimens should be tested with a substrate representative of end-use conditions, such that the total specimen thickness is 3 mm or greater.

Thin specimens that are used with an air space adjacent to the unexposed face should be mounted so that there is an air space of at least 12 mm between its unexposed face and the refractory fiber blanket. This is achieved by the use of a metal spacer frame.

A.7.1.3 Under room temperature conditions, this volume flow rate corresponds to a mass flow rate of approximately 30 g/sec.

A.7.2.3 The radiation shield should remain in place for a sufficient time to ensure stability of operation.

A.7.2.6 The time of sustained flaming to be reported is the time at which the flaming initially is observed, not when the 4-second period that defines sustained flaming has elapsed.

A.7.2.9 Testing should be stopped if explosive spalling or excessive swelling occurs. The procedures described in Chapter 7 might be useful in mitigating these effects.

A.8.1 Appropriate equations for cases where additional gas analysis equipment (CO_2, CO, H_2O) is used are provided in Annex C.

A.8.2 A calibration differing more than 5 percent from the previous calibration is not normal and suggests instrument malfunction.

A.8.2.2 The other variables are as provided in Section 1.5.

A.9.1(15) Certain specimens do not show visible, sustained flaming but do indicate positive rate-of-heat-release values.

Annex B Precision and Bias

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Precision.

B.1.1 Interlaboratory trials were conducted by ASTM Committee E.5 to determine the repeatability and reproducibility of this test method. The results were analyzed in conjunction with the results of a parallel set of interlaboratory trials sponsored by the International Organization for Standardization (ISO). The complete results have been placed on file at ASTM headquarters as the research report RR:E05-1008, *Report to ASTM on Cone Calorimeter Inter-Laboratory Trials*. The results obtained for repeatability and reproducibility are provided in B.1.2 and B.1.3; further details of the interlaboratory trials are provided in Section B.2.

B.1.2 The following definitions of repeatability (r) and reproducibility (R) should be used:

$$r = f\sqrt{2\sigma_r}$$
$$R = f\sqrt{2\sigma_R}$$

where:
σ_r = repeatability standard deviation
σ_R = reproducibility standard deviation

The coefficient $\sqrt{2}$ derived from the fact that r and R refer to the difference between two single test results, and f, which equals approximately 2, corresponds to the probability level of 95 percent being taken. These products then are rounded off as follows:

$$r = 2.8S_r$$
$$R = 2.8S_R$$

For calculations, the sample-based standard deviation estimates, S, are substituted for the population standard deviations, σ, since the latter are not known.

B.1.3 For the materials tested, values for repeatability, r, and reproducibility, R, have been calculated for six variables. These variables, chosen as representative of the test results, are as follows:

$$t_{ig}, \dot{q}''_{max}, \dot{q}''_{180}, \dot{q}''_{tot}, \Delta H_{c,eff}, \sigma_f$$

A linear regression model was used to describe r and R as a function of the mean overall replicates and overall laboratories for each of the six variables. The regression equations are provided. The range of mean values over which the fit was obtained is also indicated. The results for time to sustained flaming, t_{ig}, in the range of 5 seconds to 150 seconds were as follows:

$$r = 4.1 + 0.125t_{ig}$$
$$R = 7.4 + 0.220t_{ig}$$

The results for peak heat release rate, $\dot{q}''_{max}$, in the range of 70 kW/m^2 to 1120 kW/m^2 were as follows:

$$r = 13.3 + 0.131\dot{q}''_{max}$$
$$R = 60.4 + 0.141\dot{q}''_{max}$$

The results for 180-second average heat release rate, $\dot{q}''_{180}$, in the range of 70 kW/m^2 to 870 kW/m^2 were as follows:

$$r = 23.3 + 0.137\dot{q}''_{180}$$
$$R = 25.5 + 0.151\dot{q}''_{180}$$

The results for total heat released, $\dot{q}''_{tot}$, for the range of 5 MJ/m^2 to 720 MJ/m^2 were as follows:

$$r = 7.4 + 0.068\dot{q}''_{tot}$$
$$R = 11.8 + 0.088\dot{q}''_{tot}$$

The results for peak effective heat of combustion, $\Delta H_{c,eff}$, in the range of 7 kJ/g to 40 kJ/g were as follows:

$$r = 1.23 + 0.050\Delta H_{c,eff}$$
$$R = 2.42 + 0.055\Delta H_{c,eff}$$

The results for average specific extinction area, σ_f, in the range of 30 m^2/kg to 2200 m^2/kg were as follows:

$$r = 59 + 0.076\sigma_f$$
$$R = 63 + 0.215\sigma_f$$

B.2 Bias. For solid specimens of unknown chemical composition, as used in building materials, furnishings, and common occupant fuel load, it has been documented that the use of the oxygen consumption standard value of $\Delta H_c/r_0 = 13.1 \times 10^3$ kJ/kg oxygen results in an expected error band of 5 percent compared to true value. For homogeneous materials with only a single pyrolysis mechanism, this uncertainty can be reduced by determining ΔH_c from oxygen bomb measurements and r_0 from ultimate elemental analysis. For most testing, this is not practical, because specimens might be composite and nonhomogeneous and might exhibit several degradation reactions. Therefore, for unknown samples, a 5 percent accuracy limit is recommended. For reference materials, however, careful determination of $\Delta H_c/r_0$ can reduce this source of uncertainty substantially.

Annex C Calculation of Heat Release with Additional Gas Analysis

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Introduction. The equations used to calculate heat release rate assume CO_2 is removed from the gas sample in a chemical scrubber before O_2 is measured. Some laboratories are equipped to measure CO_2; in such a case, it is not necessary to remove the CO_2 from the O_2 line. The advantage in this case is that the chemical scrubbing agent, which is costly and necessitates careful handling, can be avoided.

In this annex, equations are provided that should be used when CO_2 is measured but not scrubbed out of the sampling lines. Two cases are considered. In the first case, part of the dried and filtered sample stream is diverted into infrared CO_2 and CO analyzers. To avoid condensation, the measurement of H_2O concentration in the flow of combustion products necessitates a separate sampling system with heated filters, heated sampling lines, and a heated analyzer.

C.2 Symbols. The following symbols are used in this annex:

C	=	calibration constant for oxygen consumption analysis ($m^{1/2}kg^{1/2}K^{1/2}$)
$\Delta H_c/r_0$	=	net heat of combustion (kJ/kg)
M_a	=	molecular weight of air (kg/kmol)
M_e	=	molecular weight of the combustion products (kg/kmol)
$\dot{m}_e$	=	exhaust duct mass flow rate (kg/sec)
ΔP	=	orifice meter pressure differential (Pa)
$\dot{q}''$	=	heat release rate per unit area (kW/m^2)
t_d	=	oxygen analyzer delay time (sec)
t_d^1	=	delay time of the CO_2 analyzer (sec)
t_d^2	=	delay time of the CO analyzer (sec)
t_d^3	=	delay time of the H_2 analyzer (sec)
T_e	=	absolute temperature of gas at the orifice meter (K)
$X_{CO_2}^0$	=	initial CO_2 reading (mole fraction)
X_{CO}^0	=	initial CO reading (mole fraction)
$X_{H_2O}^0$	=	initial H_2O reading (mole fraction)
$X_{O_2}^a$	=	ambient O_2 reading (mole fraction)
$X_{CO_2}^1$	=	CO_2 reading before delay time correction (mole fraction)
X_{CO}^1	=	CO reading before delay time correction (mole fraction)
$X_{H_2O}^1$	=	H_2O reading before delay time correction (mole fraction)
X_{CO_2}	=	CO_2 reading after delay time correction (mole fraction)
X_{CO}	=	CO reading after delay time correction (mole fraction)
X_{H_2O}	=	H_2O reading after delay time correction (mole fraction)
ϕ	=	oxygen depletion factor

C.3 Where CO_2 and CO Are Measured. As in the case of the oxygen analyzer, measurements of CO_2 and CO should be time-shifted to take into account the transport time in the sampling lines, as follows:

$$X_{O_2}(t) = X_{O_2}^1(t+t_d)$$

$$X_{CO_2}(t) = X_{CO_2}^1(t+t_d^1)$$

$$X_{CO}(t) = X_{CO}^1(t+t_d^2)$$

C.3.1 In this case, the delay times, t_d^1 and t_d^2, for the CO_2 and CO analyzers, respectively, are usually different (smaller) than the delay time, t_d, for the O_2 analyzer.

The exhaust duct flow is calculated as follows:

$$\dot{m}_e = C\sqrt{\frac{\Delta P}{T_e}}$$

C.3.2 The rate of heat release now can be determined as follows:

$$\dot{q} = 1.10\left(\frac{\Delta H_c}{r_0}\right)X_{O_2}^a\left[\frac{\phi - 0.1721 - \phi\left(X_{CO}/X_{CO_2}\right)}{(1-\phi)+1.105\phi}\right]\dot{m}_e$$

C.3.3 The oxygen depletion factor, ϕ, is calculated as follows:

$$\phi = \frac{X_{O_2}^0\left(1-X_{CO_2}-X_{CO}\right)-X_{O_2}\left(1-X_{CO_2}^0\right)}{X_{O_2}^0\left(1-X_{CO_2}-X_{CO}-X_{O_2}\right)}$$

C.3.4 The ambient mole fraction of oxygen is calculated as follows:

$$X_{O_2}^a = \left(1-X_{H_2O}^0\right)X_{O_2}^0$$

The second value in the denominator of the value in brackets in the equation in C.3.2 is a correction factor for incomplete combustion of some carbon to CO instead of CO_2. In fact, the value of X_{CO} is usually very small, so it can be disregarded in the equations in C.3.2 and C.3.3. The practical implication of this correction factor is that a CO analyzer generally does not result in a noticeable increase in accuracy of heat release rate measurements. Consequently, the equations can be used, even if no CO analyzer is present, by setting $X_{CO} = 0$.

C.4 Where H_2O Also Is Measured. In an open combustion system, such as is used in this method, the flow rate of air entering the system cannot be measured directly but is inferred from the flow rate measured in the exhaust duct. An assumption regarding the expansion due to combustion of the fraction of the air that is fully depleted of its oxygen needs to be made. This expansion depends on the composition of the fuel and the actual stoichiometry of the combustion. A suitable average value for the volumetric expansion factor is 1.105, which is accurate for methane.

This value is already incorporated in the equation in C.3.2 for $\dot{q}$. For cone calorimeter tests, it can be assumed that the exhaust gases consist primarily of N_2, O_2, CO_2, H_2O, and CO; thus, measurements of these gases can be used to determine the actual expansion. (It is assumed that the measurements of O_2, CO_2, and CO correspond to a dry gas stream, while the H_2O measurement corresponds to total stream flow.) The mass flow rate in the exhaust duct is then more accurately provided by the following equation:

$$\dot{m}_e = \sqrt{\frac{M_e}{M_a}}C\sqrt{\frac{\Delta P}{T_e}}$$

C.4.1 The molecular weight, M_e, of the exhaust gases is calculated as follows:

$$M_e = \left[4.5+\left(1-X_{H_2O}\right)\left(2.5+X_{O_2}+4X_{CO_2}\right)\right]4$$

C.4.2 Using 28.97 as the value for M_a, the heat release rate is calculated as follows:

$$\dot{q}(t) = 1.10\left(\frac{\Delta H_c}{r_0}\right)\left(1-X_{H_2O}\right)\left[\frac{X_{O_2}^0\left(1-X_{O_2}-X_{CO_2}\right)}{1-X_{O_2}^0-X_{CO_2}^0}-X_{O_2}\right]\dot{m}_e$$

C.4.3 The H_2O readings used in the equation in C.4.2 are time-shifted in a way similar to that for the equations in Section C.3 for the other analyzers:

$$X^0_{H_2O}(t) = X^1_{H_2O}\left(t + t^3_d\right)$$

Additional background on these computations is given in Twilley and Babrauskas, "User's Guide for the Cone Calorimeter."

Annex D Testing of Specimens in the Vertical Orientation

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Introduction. This annex is provided so that the user of this standard has access to a standardized methodology for testing specimens in a vertical orientation using the same apparatus specified in this standard. Although the recommended method of testing specimens is in the horizontal orientation, especially for the purpose of regulating the use of materials, it is believed that testing specimens in the vertical orientation might be useful for research and development purposes. With time and experience, this method of testing might be found suitable for more widespread use.

D.2 Purpose. This test method allows testing of the specimen in the vertical position.

D.3 Basis of Test Method. This alternative test method using the vertical orientation of the test specimen is based on the text in Chapters 1 through 9. To accommodate the vertical orientation of the specimen, the wording has been revised as necessary, and section and paragraph numbers in parentheses have been provided for quick reference.

D.4 Test Limitations.

D.4.1 *(See 1.3.2.)* The test data should be considered to be invalid if any of the following occurs:

(1) The specimen experiences an explosive spalling.
(2) The specimen swells to the point where it touches the spark plug prior to ignition.
(3) The specimen swells to the point where it touches the heater base plate during combustion.
(4) In the vertical orientation, the specimen melts sufficiently to overflow the melt trough.

D.4.2 If delamination of the specimen occurs, the test results should be considered suspect, and this should be described in the test report.

D.5 Exposure. *(See 1.3.3.5.)* Specimens should be exposed to heating fluxes ranging from 0 kW/m^2 to 100 kW/m^2 in a vertical orientation. External ignition, where used, should be by electric spark. The value of the heating flux and the use of external ignition should be specified by the relevant material or performance standard *(see E.2.3)* or by the test sponsor for research and development purposes.

D.6 Definition.

D.6.1 Orientation. *(See 3.3.5.)* The plane in which the exposed face of the specimen is located during testing (i.e., vertically facing the heater).

D.7 Test Apparatus. *(See Section 4.1.)* The test apparatus should consist of the following components:

(1) A conical-shaped radiant electric heater
(2) Specimen holders
(3) An exhaust gas system with oxygen-monitoring and flow-measuring instrumentation
(4) An electric ignition spark plug
(5) A data collection and analysis system
(6) A load cell for measuring specimen mass loss

A general view of the apparatus is shown in Figure 4.1.1, and an exploded view of the vertical orientation is shown in Figure D.7.

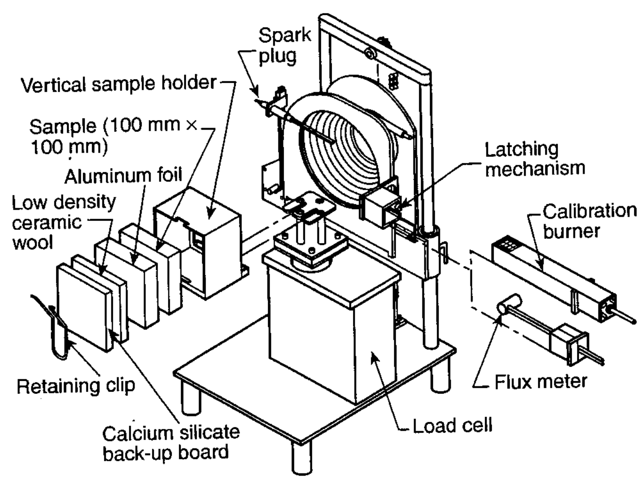
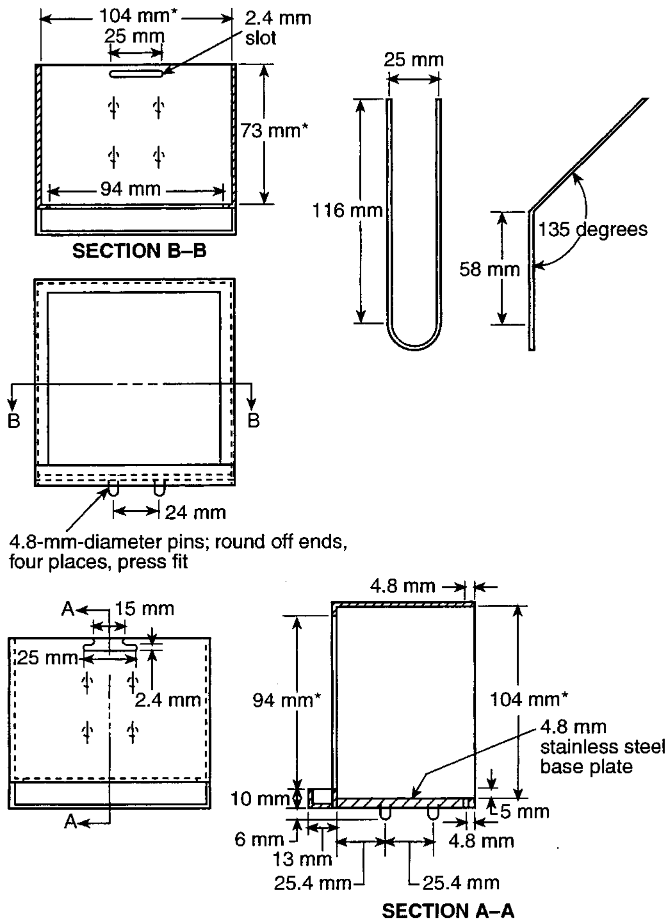


FIGURE D.7 Exploded View, Vertical Orientation, of Apparatus.

D.8 Heater. *(See 4.2.3.)* The heater should be mounted in a vertical orientation. The heater should be capable of producing irradiances on the surface of the specimen of up to 100 kW/m^2. The irradiance should be uniform within the central 50 mm × 50 mm area of the specimen to within 10 percent.

D.9 Specimen Holder. *(See 4.6.1.)* The vertical specimen holder is shown in Figure D.9 and includes a small drip trap to contain a limited amount of molten material. A specimen should be installed in the vertical specimen holder by backing it with a layer of refractory fiber blanket (nominal density 65 kg/m^3). The thickness of the refractory fiber blanket depends on the specimen's thickness but should be at least 13 mm. A layer of rigid, ceramic fiber millboard should be placed behind the fiber blanket layer. The millboard thickness should be such that the entire assembly is rigidly bound together once the retaining spring clip is inserted behind the millboard. In the vertical orientation, the cone heater height should be set so the center of the heater lines up with the specimen center.

D.10 Ignition Circuit. *(See Section 4.7.)* External ignition should be accomplished by a spark plug powered from a 10 kV transformer or by a 10 kV spark generator. The length and location of the spark plug or spark generator electrode should be such that the spark has a gap of 3 mm and that the spark gap is located 5 mm above the top of the holder and in the plane of the specimen face in the vertical orientation. If a spark plug and transformer are used, the transformer should



Material: 1.59 mm stainless steel (except base plate)
* Indicates a critical dimension

FIGURE D.9 Vertical Specimen Holder.

be of a type specifically designed for spark ignition use. The transformer should have an isolated (ungrounded) secondary to minimize interference with the data transmission lines. The igniter should be removed when sustained flaming is achieved for a period of 4 seconds.

Annex E Commentary

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 Introduction. This commentary is provided for the following reasons:

(1) To furnish some insight into the development of the method
(2) To describe the rationale for the design of various features of the apparatus
(3) To describe the use of the data

Additional guidance to the user of this test is provided in reference note 1 *(see Section E.11)*.

E.2 Rate of Heat Release Measurements.

E.2.1 The rate of heat release of a product is one of the most important variables in determining the potential hazard of the product in a fire. With many products that are composed of many surfaces contributing to a fire, their evaluation is complex.[2] For each separate surface, it first should be determined when, if at all, that surface can ignite. The size of the fire should be determined from any items already burning, because this constitutes the external irradiance to nearby items. The flame spread over the surface in question then should be evaluated. The rate of heat release from the whole surface then can be evaluated using the rate of heat release per unit area, for a given irradiance, as a function of time. The rate of heat release per unit area is the only value that can be measured in a bench scale test. The total heat release rate output from the burning object equals the sum of the rates for all surfaces. The fact that some elements might burn out and no longer contribute to the fire also should be considered. The procedure is conceptually straightforward but can be cumbersome to compute.

E.2.2 Many common combustibles do not have the geometrically simple surfaces that are necessary to do computations of this kind. Other complications, such as melting, dripping, or collapsing, also can preclude a detailed mathematical analysis. In such cases, a simpler, more empirical model is appropriate. An example of the use of bench-style heat release rate measurements in deriving a fire hazard assessment is available.[3]

E.2.3 The test method does not prescribe the irradiance levels or whether external ignition should be used. This should be determined separately for each product class. For a given class of applications and products, a comparison with some full-scale fires generally is necessary to determine the time period over which the heat release rate should be calculated. A material or performance standard then can be developed for that product category that can provide further guidance and limitations for testing. For exploratory testing, in the absence of more specific determinations for a given class of applications, a value of 35 kW/m^2 can be permitted to be utilized first. The results obtained might then suggest whether additional testing at different irradiance levels should be performed.

Studies to address the degrees of combustibility of building materials have been performed by Forintek Canada Corporation and Underwriters' Laboratories of Canada (ULC). These studies suggest that an irradiance level of 50 kW/m^2 for an exposure period of 15 minutes might be appropriate for regulatory purposes, whereas the National Institute of Standards and Technology (NIST) research suggests a level of 75 kW/m^2 for 10 minutes.[4,5]

E.3 Choice of Operating Principles.

E.3.1 A number of apparatus have been developed over the years for measuring the rate of heat release; most of these have been reviewed in detail.[6] Traditionally, the simplest measurement scheme is a direct measurement of flow enthalpy from a chamber thermally insulated to create an adiabatic environment. A truly adiabatic apparatus, with the use of guard heaters, is possible but, because of the expense, has not been implemented. A simply insulated combustion chamber leads to a significant undermeasurement of the heat release, so that only an empirical calibration is possible. An example of such an insulated chamber method is described in ASTM E 906, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products.* Furthermore, that calibration could be sensitive to the radiant fraction (or sootiness) of the combustion products.[7,8] A more advanced scheme is an isothermal rather than an adiabatic instrument, with the heat release rate defined as that which is supplied by a substitution burner to maintain isothermal conditions.[9] This scheme provides better results, because only second-order heat loss error terms remain; however, its practical implementation is complex and costly.

E.3.2 It can be concluded that it is difficult to measure heat directly without some heat loss. However, it is simple to capture all combustion products without losing any heat and to measure the oxygen concentration in that stream. Heat release can be computed from such measurements with the availability of the oxygen consumption principle.[10] This principle states that, for most common combustibles, an amount of heat equal to 13.1×10^3 kJ is released for each kilogram of oxygen consumed from the airstream. This constant varies only about 5 percent for most common combustibles; some exceptions are known.[10] The method remains useful even if a significant fraction of the products become CO or soot, rather than CO_2; in these cases, correction terms can be applied.[10,11] A typical case, involving cellulose-producing CO from 10 percent incomplete combustion, has been analyzed with less than 2 percent error.[10] It should be noted that excessively high CO produced as a result of restricted oxygen supply cannot occur in the calorimeter used in this test method, because oxygen intake is not restricted. By adopting the oxygen consumption principle as the method of measurement, it is possible to design an apparatus of significantly improved precision but without excessive complexity. Because heat measurements are not necessary, the apparatus does not need thermal insulation.

E.4 Heater Design.

E.4.1 Experience with various rate of heat release techniques suggests that, for minimal errors in irradiance, the specimen should be exposed to only the following:

(1) A thermostatically controlled heater
(2) A water-cooled plate
(3) Open air

If nearby solid surfaces are not temperature controlled, the surface temperatures can rise due to specimen flame heating and then act as additional sources of radiation to the specimen. Furthermore, where oxygen consumption is used as the measurement principle, a gas-fired heater should not be used because it can cause fluctuations in the oxygen readings (even though fluctuations can be removed by steady-state measurements).

E.4.2 A heater in the shape of a truncated cone first was explored for use in an ignitibility apparatus by the International Organization for Standardization (ISO).[12] The heater adopted in the current method is similar, but not identical, to the ISO cone. The main differences include higher heat fluxes, temperature control, and more rugged design details. In the horizontal orientation, the conical shape approximately follows the fire plume contours, while the central hole allows the stream to emerge without affecting the heater. A thick layer of cool air is pulled along, and the flames do not attach to the side of the cone. The central hole has an additional function: Without the hole, the middle of the specimen would receive a higher irradiance than the edges. With the hole, the irradiance is uniform to within 2 percent. In the vertical orientation, the hole still serves the purpose of providing radiation uniformity although, because of the presence of a natural convection boundary layer, the deviations are higher (from 5 percent to 10 percent).[13]

E.5 Pilot Ignition. Ignition of test specimens in many apparatus is achieved by a gas pilot. This method tends to pose difficulties such as sooting, deterioration of orifices, and contribution to the heat release rate. It is difficult to design a pilot that is centrally located over the specimen, is resistant to blowout, and yet does not apply an additional heat flux to the specimen. (A point of elevated heating on the specimen makes it mathematically difficult to analyze the response of the specimen.) An electric spark is free of most of these difficulties, needing only occasional cleaning and adjustment of the electrodes. For these reasons, an electric spark ignition is recommended.

E.6 Back Face Conditions. The heat loss through the specimen back face can have an influence on the burning rate near the end of the burning time of the back face. For reproducible measurements, the losses through the back face should be standardized. The simplest theoretical boundary conditions — an adiabatic or an isothermal boundary at ambient temperature — are not achievable. However, a reasonable approximation of the former can be made by using a layer of insulating material. This is easier to achieve for the horizontal orientation, in which case a very low density refractory blanket is used. In the vertical orientation, some structural rigidity of the backing is desired; consequently, a layer of high density backing might be necessary.

E.7 Oxygen Analyzer. The analyzer should be of the paramagnetic type, with baseline noise and short-term drift of approximately 50 ppm O_2 or less. Other types of analyzers (e.g., electrochemical and catalytic) generally cannot meet this recommendation. Paramagnetic analyzers also exhibit a linear response. The linearity is normally better than can be determined with 0.1 percent O_2/N_2 gas mixtures. Because an oxygen analyzer is sensitive to stream pressures, either the readings should be compensated with an absolute pressure transducer connected to the analyzer or the pressure should be mechanically regulated for flow fluctuations and atmospheric pressure variations. The analyzer and the pressure-regulating or -measuring devices should be located in a constant-temperature environment to avoid flow errors.

E.8 Limits to Resolution.

E.8.1 Methane calibration studies showed typical fluctuations of 1.5 percent, with a linearity to within 5 percent over the range of 5 kW to 12 kW.[13] Calibrations with other gases show similar results. Calibration gases can be delivered to the burner in a highly steady manner. The uniformity of solid fuels' combustion, however, is governed by the pyrolysis at the surface and, under some circumstances, shows substantial fluctuations. For instance, the fluctuations for poly (methyl methacrylate) are greater than for red oak.[13] Burning thermoplastic specimens occasionally eject individual molten streamers. With solid materials, the limits to resolution can be expected to be set by the specimen pyrolysis process, rather than by instrument limits.

E.8.2 The limits to the speed of any heat release rate technique are set by the slowest-responding element. In the case of the current method, that element is the oxygen analyzer, which typically shows a 10 percent to 90 percent response time of 6.9 seconds. The response times of the pressure transducer and the thermocouple can be much quicker. They should be set only slightly faster, however, to avoid introducing instrument noise without increasing resolution.

E.9 Effective Heat of Combustion. The effective heat of combustion is a constant during the combustion of homogeneous specimens having only a single mode of degradation and is less than the value of the theoretical net heat of combustion. Most organic liquids have a single mode of degradation and, therefore, a constant effective heat of combustion. By contrast, cellulosic products typically show more than one mode of degradation and varying effective heat of combustion. For materials having more than one mode of degradation or for composites or nonhomogeneous materials, the effective heat of combustion is not necessarily constant.

E.10 Smoke Obscuration Measurements.

E.10.1 The smoke measurement system is different from that used in NFPA 258, *Recommended Practice for Determining Smoke Generation of Solid Materials*, for the following reasons:

(1) Simultaneous mass measurements are available.
(2) Irradiances up to 100 kW/m^2 are available.
(3) The combustion takes place in a flow stream, not in a closed box.
(4) A monochromatic light source is used.

E.10.2 Accurate measurement of smoke obscuration requires, among other considerations, the following:

(1) A highly collimated light source, insensitive to stray light
(2) Measurement in a well-mixed, unstratified stream
(3) A high degree of stability against drift due to voltage fluctuations, such as source aging and thermal effects
(4) The ability to make extended measurements without error due to progressive coating of optics by soot

E.10.3 In addition, a monochromatic source should be selected, preferably in the red portion of the spectrum, for ease of interpreting the data according to the theoretical modes.[14] For convenience, direct electric output in logarithmic units to avoid the need for manual range switching or resulting inaccuracies at the high end of the scale should be provided. An instrument has been designed that is intended to meet all those specifications *(see Figure 4.11.1)*.[15] Additional construction details are given in construction drawings available from the Building and Fire Research Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899. The theory for data analysis is from note 1.

E.11 Reference Notes.

1. W. H. Twilley and V. Babrauskas, "User's Guide for the Cone Calorimeter," National Bureau of Standards (U.S.), Special Publication SP 745, 1988.

2. V. Babrauskas, J. R. Lawson, W. D. Walton, and W. H. Twilley, "Upholstered Furniture Heat Release Rates Measured with a Furniture Calorimeter," National Bureau of Standards (U.S.), NBSIR 82-2604, 1982.

3. V. Babrauskas and J. F. Krasny, "Fire Behavior of Upholstery Furniture," National Bureau of Standards (U.S.), NBS monograph 173, 1985.

4. L. R. Richardson, "Determining Degrees of Combustibility of Building Materials," National Building Code of Canada, 1st International Conference and Exhibition on Fire and Materials, September 24–25, 1992.

5. V. Babrauskas, "North American Experiences in the Use of Cone Calorimeter Data for Classification of Products, 1991," Proceedings of the International EUREFIC Seminar, pp. 89–103.

6. M. Janssens, "Calorimetry," *The SFPE Handbook of Fire Protection Engineering*, 3rd edition, Quincy, MA: NFPA, 2002, Section 3, Chapter 2.

7. R. F. Krause and R. G. Gann, "Rate of Heat Release Measurements Using Oxygen Consumption," *Journal of Fire and Flammability*, Vol. 11, April 1980, pp. 117–130.

8. V. Babrauskas, "Performance of the Ohio State University Rate of Heat Release Apparatus Using Poly(methyl methacrylate) and Gaseous Fuels," *Fire Safety Journal*, Vol. 5, 1982, pp. 9–20.

9. J. Tordella and W. H. Twilley, "Development of a Calorimeter for Simultaneously Measuring Heat Release and Mass Loss Rates," National Bureau of Standards (U.S.), NBSIR 83-2708, 1983.

10. C. Huggett, "Estimation of Rate of Heat Release by Means of Oxygen Consumption Measurements," *Fire and Materials*, Vol. 4, 1980, pp. 61–65.

11. W. J. Parker, "Calculations of the Heat Release Rate by Oxygen Consumption for Various Applications," National Bureau of Standards (U.S.), NBSIR 81-2427, 1982.

12. ISO 5657, *Fire Test Reaction to Fire Ignitability of Building Products*, International Organization for Standardization, Geneva, 1997.

13. V. Babrauskas, "Development of Cone Calorimeter — A Bench-Scale Heat Release Rate Apparatus Based on Oxygen Consumption," National Bureau of Standards (U.S.), NBSIR 82-2611, 1982.

14. G. Mulholland, "How Well Are We Measuring Smoke?" *Fire and Materials*, Vol. 6, 1982, pp. 65–67.

15. V. Babrauskas and G. Mulholland, "Smoke and Soot Data Determinations in the Cone Calorimeter," ASTM STP 983, *Mathematical Modeling of Fires*, Philadelphia: American Society for Testing and Materials, 1987, pp. 83–104.

Annex F Method of Determining Suitability of Oxygen Analyzers for Making Heat Release Measurements

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 General. The type of oxygen analyzer best suited for fire gas analysis is of the paramagnetic type. Electrochemical analyzers or analyzers using zirconia sensors generally have been found not to have adequate sensitivity or suitability for this type of work. The normal range of the instrument to be used is 0 volume to 25 volume percent oxygen. The linearity of paramagnetic analyzers normally is better than can be checked by a user laboratory; therefore, verifying their linearity is not necessary. It is important, however, to confirm the noise and short-term drift of the instrument used. A recommended procedure is described in Section F.2.

F.2 Procedure.

F.2.1 Connect two different gas bottles approximately two percentage points apart (for example, 15 volume percent and 17 volume percent) to a selector valve at the inlet of the analyzer.

F.2.2 Connect the electrical power and let the analyzer warm up for 24 hours, with one of the test gases indicated in F.2.1 flowing through it.

F.2.3 Connect a data acquisition system to the output of the analyzer. Quickly switch from the first gas bottle to the second bottle and immediately start collecting data, taking one data point per second. Collect data for 20 minutes.

F.2.4 Determine the drift by using a least-squares analysis fitting procedure to pass a straight line through the last 19 minutes of data. Extrapolate the line back through the first minute of data. The difference between the readings at 0 minutes and at 20 minutes on the fitted straight line represents the short-term drift. Record the drift in units of parts per million of oxygen.

F.2.5 The noise is represented by the root-mean-square deviation around the fitted straight line. Calculate that root-mean-square value and record it in units of parts per million of oxygen.

F.2.6 The analyzer is suitable for use in heat release measurements if the sum of the drift term plus the noise term is ±50 ppm oxygen (note that both terms need to be expressed as positive numbers).

F.3 Additional Precautions. A paramagnetic oxygen analyzer is directly sensitive to barometric pressure changes at its outlet port and to flow rate fluctuations in the sample supply stream. It is essential that the flow rate be regulated. Use either a flow rate regulator of the mechanical diaphragm type or an electronic mass flow rate controller. To protect against errors due to changes in barometric pressure, one of the following procedures should be used:

(1) Control the back pressure to the analyzer with a back pressure regulator of the absolute-pressure type.
(2) Electrically measure the actual pressure at the detector element and provide a signal correction for the analyzer output.

Annex G Informational References

G.1 Referenced Publications. The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

G.1.1 NFPA Publication. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 258, *Recommended Practice for Determining Smoke Generation of Solid Materials*, 2001 edition.

Janssens, M., "Calorimetry," *The SFPE Handbook of Fire Protection Engineering*, 3rd edition, Quincy, MA: NFPA, 2002, Section 3, Chapter 2.

G.1.2 Other Publications.

G.1.2.1 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 3286, *Standard Test Method for Gross Calorific Value of Coal and Coke by the Isoperibol Bomb Calorimeter*, 1996.

ASTM RR: E05-1008, *Report to ASTM on Cone Calorimeter Inter-Laboratory Trials*, 1990.

ASTM E 906, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products*, 1997.

ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter (Cone Calorimeter)*, 2003.

G.1.2.2 ISO Publications. International Organization for Standardization, 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland.

ISO 5657, *Reaction to Fire Tests — Ignitability of Building Products Using a Radiant Heat Source*, 1997.

ISO 5660, *Reaction-to-Fire Tests — Heat Release, Smoke Production and Mass Loss Rate — Part 1: Heat Release Rate (Cone Calorimeter Method)*, 2002.

G.1.2.3 NBS Publications. National Bureau of Standards, now National Institute of Standards and Technology (NIST), 100 Bureau Drive, Gaithersburg, MD 20899.

Babrauskas, V., "Development of Cone Calorimeter — A Bench-Scale Heat Release Rate Apparatus Based on Oxygen Consumption," NBSIR 82-2611, 1982.

Babrauskas, V., and J. F. Krasny, "Fire Behavior of Upholstery Furniture," NBS monograph 173, 1985.

Babrauskas, V., J. R. Lawson, W. D. Walton, and W. M. Twilley, "Upholstered Furniture Heat Release Rates Measured with a Furniture Calorimeter," NBSIR 82-2604, 1982.

Parker, W. J., "Calculations of the Heat Release Rate by Oxygen Consumption for Various Applications," NBSIR 81-2427, 1982.

Tordella, J., and W. H. Twilley, "Development of a Calorimeter for Simultaneously Measuring Heat Release and Mass Loss Rates," NBSIR 83-2708, 1983.

Twilley, W. H., and V. Babrauskas, "User's Guide for the Cone Calorimeter," Special Publication SP 745, 1988.

G.1.2.4 Other Publications.

Babrauskas, V., "North American Experiences in the Use of Cone Calorimeter Data for Classification of Products, 1991," Proceedings of the International EUREFIC Seminar, pp. 89–103.

Babrauskas, V., "Performance of the Ohio State University Rate of Heat Release Apparatus Using Poly(methyl methacrylate) and Gaseous Fuels," *Fire Safety Journal*, Vol. 5, 1982, pp. 9–20.

Babrauskas, V., and G. Mulholland, "Smoke and Soot Data Determinations in the Cone Calorimeter," ASTM STP 983, *Mathematical Modeling of Fires*, Philadelphia: American Society for Testing and Materials, 1987, pp. 83–104.

Huggett, C., "Estimation of Rate of Heat Release by Means of Oxygen Consumption Measurements," *Fire and Materials*, Vol. 4, 1980, pp. 61–65.

Krause, R. F., and R. G. Gann, "Rate of Heat Release Measurements Using Oxygen Consumption," *Journal of Fire and Flammability*, Vol. 11, April 1980, pp. 117–130.

Mulholland, G., "How Well Are We Measuring Smoke?" *Fire and Materials*, Vol. 6, 1982, pp. 65–67.

Richardson, L. R., "Determining Degrees of Combustibility of Building Materials," National Building Code of Canada, 1st International Conference and Exhibition on Fire and Materials, September 24–25, 1992.

G.2 Informational References. (Reserved)

G.3 References for Extracts. (Reserved)

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Call goes out for proposals to amend existing document or for recommendations on new document.

▼

Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

▼

Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

▼

Report — *Report on Proposals* (ROP) — is published for public review and comment.

▼

Committee meets to act on each public comment received.

▼

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▼

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▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP or ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

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▼

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