NFPA® 69

Standard on Explosion Prevention Systems

2008 Edition

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2008 Edition

This edition of NFPA 69, *Standard on Explosion Prevention Systems*, was prepared by the Technical Committee on Explosion Protection Systems. It was issued by the Standards Council on June 4, 2007, with an effective date of June 24, 2007, and supersedes all previous editions.

This edition of NFPA 69 was approved as an American National Standard on June 24, 2007.

Origin and Development of NFPA 69

In 1965, an NFPA Committee was appointed to develop standards for explosion protection systems. These standards included information on inerting to prevent explosions and on venting to minimize damage from an explosion.

A tentative draft on explosion prevention systems was presented at the NFPA Annual Meeting in New York City in May 1969. This tentative document was officially adopted in May 1970. NFPA 69 was revised in 1973 and reconfirmed in 1978.

In 1982, the Committee on Explosion Protection Systems began a thorough review of NFPA 69, including the development of a chapter on the technique of deflagration pressure containment. The results of that effort became the 1986 edition.

The 1992 edition of NFPA 69 incorporated a new chapter on deflagration isolation systems. Partial amendments were made to refine definitions, improve descriptions of oxidant concentration reduction techniques, improve material on deflagration suppression, and fine-tune deflagration pressure containment material.

The 1997 edition of this standard included some reorganization and updating of the technical material to improve its usability. New material was added on enrichment to operate above the upper flammable limit as a means of explosion protection with minimum oxidant concentrations for preventing explosions. Material was added for provisions on reliability of explosion protection control systems and deflagration suppression systems for consistency with other NFPA standards.

The 2002 edition of NFPA 69 included new information on spark detection and extinguishment system design. A reorganization of the protection methods reflected a hierarchy based on the degree of explosion prevention. The limiting oxidant concentration values for gases and vapors in Annex C were updated based on recent research. The standard was revised to reflect the requirements of the *Manual of Style for NFPA Technical Committee Documents*.

The 2008 edition incorporates a comprehensive revision to the standard that includes a performance-based option in addition to the existing specification methods for explosion prevention. This revision includes new requirements for detection and ignition control, suppression, and active and passive isolation. The Committee also has added a chapter on passive suppression using expanded metal mesh or polymer foams. A new chapter on installation, inspection, and maintenance addresses the concept of safety integrity and reliability. New definitions supporting the expanded requirements have been added and existing definitions updated to conform to the NFPA Glossary of Terms.

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Committee Scope: This Committee shall have primary responsibility for documents on explosion protection systems for all types of equipment and for buildings, except pressure venting devices designed to protect against overpressure of vessels such as those containing flammable liquids, liquefied gases, and compressed gases under fire exposure conditions, as now covered in existing NFPA standards.

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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.

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 extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex G. 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 G.

Chapter 1 Administration

1.1 Scope. (Reserved)

1.2 Purpose.

1.2.1 This standard shall cover the minimum requirements for installing systems for the prevention of explosions in enclosures that contain flammable concentrations of flammable gases, vapors, mists, dusts, or hybrid mixtures.

1.2.2 This standard shall provide basic information for design engineers, operating personnel, and authorities having jurisdiction.

1.2.3* To meet a minimum level of reliability, explosion prevention and control systems designed and installed in accordance with the requirements of this standard shall include, but not be limited to, the following:

(1) Design system verification through testing
(2) Third-party inspection and approval of protection systems by an internationally recognized testing laboratory for the function intended, as specified in Chapters 7 through 14.
(3) Management of change
(4) Regular testing and maintenance
(5) Commissioning tests
(6) Design documentation

1.3 Application. This standard shall apply to methods for preventing and controlling explosions.

1.3.1 When desired by the owner or operator, or required by the authority having jurisdiction, or when required by other standards, explosion prevention shall be achieved by one or more of the following methods as required to mitigate the damage, prevent the transport of the ignition source, and propagate the deflagration:

(1) Using the methods in Chapter 7 or 8 to control the environment within the protected enclosure, such that a deflagration cannot occur
(2) Using the methods in Chapter 9, 11, or 12 to prevent the propagation of a deflagration to connected vessels or prevent the transport of an ignition source
(3) Using the methods in Chapter 10, 13, or 14, or of NFPA 68 to mitigate the effects of the deflagration, such that the protected enclosure will not be uncontrollably breached

1.3.1.1 It shall be permitted to use the methods in Chapters 4 and 5 in lieu of the methods in Chapters 7 through 14.

1.3.1.2 This standard shall apply to methods for predeflagration detection or control of an ignition. When desired by the owner or operator, or required by the authority having jurisdiction, or when required by other standards, predeflagration detection or control of an ignition shall be achieved by methods described in Chapter 9.

1.3.1.2.1 These methods shall be permitted to be used independently to reduce the frequency of deflagrations.

1.3.1.2.2 These methods shall be permitted to be used as an additional detector for a method of Chapter 10, 11, 12, or 13.

1.3.1.2.3 These methods shall not interfere with the operation of the validated system.

1.3.1.2.4 These methods shall not be permitted to be used as the sole detector for a method of Chapter 10, 11, 12, or 13.

1.3.1.3* When another standard requires explosion prevention or control in accordance with NFPA 69 for an enclosure and that enclosure is interconnected to other enclosures by a line containing combustible dust, gas, mist, or hybrid mixtures that could transmit flame or pressure from the original enclosure, explosion prevention or control shall be provided for interconnected enclosures by one of the following methods:

(1) Deflagration isolation as discussed in Chapters 11 and 12
(2) Explosion venting of the interconnected enclosures within the limitations specified in NFPA 68, Section 8.10
(3) Containment as discussed in Chapter 13
(4) Expanded metal mesh or polymer foam as discussed in Chapter 14

1.3.1.4 It shall be permitted to eliminate deflagration isolation protection for interconnected enclosures based on a documented risk analysis acceptable to the authority having jurisdiction, unless isolation protection is specifically required for such enclosure by other standards.

1.3.2 This standard shall not apply to the following conditions:

(1) Devices or systems designed to protect against detonations
(2)*Design, construction, and installation of deflagration vents

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(3) Protection against overpressure due to phenomena other than internal deflagrations
(4) Chemical reactions other than combustion processes
(5) Unconfined deflagrations, such as open-air or vapor cloud explosions
(6) Rock dusting of coal mines, as covered by 30 CFR 75
(7) General use of inert gas for fire extinguishment
(8)*Preparation of tanks, piping, or other enclosures for hot work, such as cutting and welding
(9) Ovens or furnaces handling flammable or combustible atmospheres, as covered by NFPA 86
(10) Marine vapor control systems regulated by 33 CFR 154
(11) Marine vessel tanks regulated by 46 CFR 30, 32, 35, and 39

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.

1.5 Equivalency. Nothing in the 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 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities,* 2008 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2007 edition.

NFPA 70, *National Electrical Code®,* 2008 edition.

NFPA 72®, National Fire Alarm Code®, 2007 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 2007 edition.

NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter,* 2004 edition.

NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair,* 2005 edition.

NFPA 484, *Standard for Combustible Metals,* 2006 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2006 edition.

2.3 Other Publications.

2.3.1 API Publications. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

API 510, *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration,* 1997.

2.3.2 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME *Boiler and Pressure Vessel Code,* Section VIII, 2007.

ASME B31.3, *Process Piping,* 2004.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 257, *Standard Test Methods for DC Resistance or Conductance of Insulating Materials,* 2005.

ASTM D 3574, *Standard Test Methods for Flexible Cellular Materials — Slab, Bonded and Molded Urethane Foams,* 2003.

ASTM E 2079, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration for Gases and Vapors,* 2007.

2.3.4 CEN Publications. European Committee for Standardization, 36 rue de Stassart, B-1050 Brussels, Belgium.

EN 12874, *Flame Arresters — Performance Requirements, Test Methods and Limits for Use,* 2001.

2.3.5 Military Specifications. Department of Defense Single Stock Point, Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-DTL-83054C, *Baffle and Inerting Material, Aircraft Fuel Tank,* 2003.

MIL-PRF-87260A, *Foam Material, Explosion Suppression, Inherently Electrically Conductive, for Aircraft Fuel Tank and Dry Bay Areas,* 1992.

2.3.6 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Part 1910.146, "Permit-Required Confined Spaces Standard."

Title 29, Code of Federal Regulations, Part 1910.147, "The Control of Hazardous Energy (Lock-Out/Tag-Out)."

Title 30, Code of Federal Regulations, Part 75.

Title 33, Code of Federal Regulations, Part 154, "Waterfront Facilities."

Title 46, Code of Federal Regulations, Part 30.

Title 46, Code of Federal Regulations, Part 32, "Shipping."

Title 46, Code of Federal Regulations, Part 35.

Title 46, Code of Federal Regulations, Part 39.

Title 49, Code of Federal Regulations, Part 173.24, U.S. Department of Transportation, "General Requirements for Packaging and Packages."

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2.3.7 Other Publications.

Bartknecht, W., *Explosions: Course, Prevention, Protection,* Springer-Verlag, Heidelberg, Germany, 1989.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2007 edition.

NFPA 72®, National Fire Alarm Code®, 2007 edition.

NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft,* 2004 edition.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas,* 2004 edition.

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 defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary,* 11th edition, shall be the source for the ordinarily accepted meaning.

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 Blanketing (or Padding). The technique of maintaining an atmosphere that is either inert or fuel-enriched in the vapor space of a container or vessel.

3.3.2 Burning Velocity.

3.3.2.1 ***Flame Burning Velocity.*** The burning velocity of a laminar flame under specified conditions of composition, temperature, and pressure for unburned gas.

3.3.2.2 ***Fundamental Burning Velocity.*** The burning velocity of a laminar flame under stated conditions of composition, temperature, and pressure of the unburned gas. [**68,** 2007]

3.3.3 Combustible. Capable of undergoing combustion.

3.3.4* Combustible Dust. A combustible particulate solid that presents a deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape.

3.3.5* Combustible Particulate Solid. A combustible solid material comprised of distinct particles or pieces, regardless of size, shape, or chemical composition, that is capable of being pneumatically conveyed.

3.3.6 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.

3.3.7 Concentration Reduction.

3.3.7.1 ***Combustible Concentration Reduction.*** The technique of maintaining the concentration of combustible material in a closed space below the lower flammable limit.

3.3.7.2 ***Oxidant Concentration Reduction.*** The technique of maintaining the concentration of an oxidant in a closed space below the concentration required for ignition to occur.

3.3.8 Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [**68,** 2007]

3.3.9 Deflagration Pressure Containment. The technique of specifying the design pressure of a vessel and its appurtenances so they are capable of withstanding the maximum pressures resulting from an internal deflagration.

3.3.10 Deflagration Suppression. The technique of detecting and arresting combustion in a confined space while the combustion is still in its incipient stage, thus preventing the development of pressures that could result in an explosion.

3.3.11 Detonation. Propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium. [**68,** 2007]

3.3.12 Enclosure. A confined or partially confined volume. [**68,** 2007]

3.3.13 Enclosure Strength (P_{es}). Up to two-thirds the ultimate strength for low-strength enclosures; for high-strength enclosures the enclosure design pressure sufficient to resist P_{red}. [**68,** 2007]

3.3.14 Explosion. The bursting or rupture of an enclosure or a container due to the development of internal pressure from a deflagration.

3.3.15 Fast-Acting Valve. A valve that closes a path of deflagration propagation in a pipe or duct in response to upstream detection of a deflagration.

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3.3.16* Flame Arrester. A device that prevents the transmission of a flame through a flammable gas/air mixture by quenching the flame on the surfaces of an array of small passages through which the flame must pass.

3.3.17 Flame Front Diverter. A device that opens in response to the pressure wave preceding the flame front of the deflagration, thereby venting the pressure wave and flame front.

3.3.18 Flame Speed. The speed of a flame front relative to a fixed reference point. [**68,** 2007]

3.3.19* Flammable Limits. The minimum and maximum concentrations of a combustible material in a homogeneous mixture with a gaseous oxidizer that will propagate a flame.

3.3.19.1 ***Lower Flammable Limit (LFL).*** The lowest concentration of a combustible substance in an oxidizing medium that will propagate a flame.

3.3.19.2 ***Upper Flammable Limit (UFL).*** The highest concentration of a combustible substance in a gaseous oxidizer that will propagate a flame. [**68,** 2007]

3.3.20 Flammable Range. The range of concentrations between the lower and upper flammable limits. [**68,** 2007]

3.3.21 Gas. The state of matter characterized by complete molecular mobility and unlimited expansion; used synonymously with the term *vapor.* [**68,** 2007]

3.3.21.1 ***Inert Gas.*** A gas that is noncombustible and nonreactive.

3.3.21.2 ***Purge Gas.*** An inert or a combustible gas that is continuously or intermittently added to a system to render the atmosphere nonignitible.

3.3.22* Hybrid Mixture. A mixture of a flammable gas at greater than 10 percent of its lower flammable limit with either a combustible dust or a combustible mist. [**68,** 2007]

3.3.23 Inerting. A technique by which a combustible mixture is rendered nonignitible by adding an inert gas or a noncombustible dust. *(See also 3.3.1, Blanketing.)*

3.3.24* Isolation. A means of preventing certain stream properties from being conveyed past a predefined point.

3.3.24.1 ***Chemical Isolation.*** A means of preventing flame front and ignition from being conveyed past a predetermined point by injection of a chemical suppressant.

3.3.24.2 ***Deflagration Isolation.*** A method employing equipment and procedures that interrupts the propagation of a deflagration flame front past a predetermined point.

3.3.24.3 ***Flow Isolation.*** A method employing equipment and procedures that interrupts flow and prevents pressure rise beyond a predetermined point.

3.3.24.4 ***Ignition Source Isolation.*** A method employing equipment and procedures that interrupts the propagation of an igniting medium past a predetermined point.

3.3.25* Limiting Oxidant Concentration (LOC). The concentration of oxidant in a fuel-oxidant-diluent mixture below which a deflagration cannot occur under specified conditions.

3.3.26 Liquid Seal. A device that prevents the passage of flame by passing the gas mixture through a noncombustible liquid.

3.3.27 Maximum Experimental Safe Gap (MESG). The maximum clearance between two parallel metal surfaces that has been found, under specified test conditions, to prevent an explosion in a test chamber from being propagated to a secondary chamber containing the same gas or vapor at the same concentration. [**497,** 2004]

3.3.28 Maximum Pressure (P_{max}). The maximum pressure developed in a contained deflagration for an optimum mixture. [**68,** 2007]

3.3.29 Mist. A dispersion of fine liquid droplets in a gaseous medium. [**68,** 2007]

3.3.30 Oxidant. Any gaseous material that can react with a fuel (either gas, dust, or mist) to produce combustion. [**68,** 2007]

3.3.31 Padding. See 3.3.1.

3.3.32 Pressure Piling. A condition during deflagration in which pressure increases in the unreacted medium ahead of the propagating combustion zone.

3.3.33* Reduced Pressure (P_{red}). The maximum pressure developed in a vented enclosure during a vented deflagration. [**68,** 2007]

3.3.34* Self-Decomposing Mixtures. Materials or mixtures capable of propagating a flame in the absence of oxidant.

3.3.35 Spark Extinguishing System. An extinguishing system in which the radiant energy of a spark or an ember is detected and the spark or ember is quenched.

3.3.36 Suppressant. The chemical agent used in a deflagration suppression system to extinguish the deflagration.

3.3.37 Trouble Signal. A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or component. [**72,** 2007]

3.3.38 Vapor. See 3.3.21.

3.3.39 Ventilation. The changing of air within a compartment by natural or mechanical means. [**302,** 2004]

Chapter 4 General Requirements

4.1 Goal. The goal of this standard shall be to provide effective deflagration prevention and control for enclosures where there is the potential for a deflagration.

4.2 Objectives.

4.2.1 Life Safety.

4.2.1.1 Deflagration prevention and control for occupied enclosures shall prevent the structural failure of the enclosure and minimize injury to personnel in adjacent areas outside of the enclosure.

4.2.1.2 Deflagration prevention and control for unoccupied enclosures shall prevent the rupture of the enclosure.

4.2.1.3 Deflagration prevention and control shall be arranged to avoid injury to personnel.

4.2.2 Property Protection.

4.2.2.1 Deflagration prevention and control systems shall be designed to limit damage of the protected enclosure.

4.2.2.2 Deflagration prevention and control systems shall be arranged to avoid ignition of adjacent property.

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4.2.2.3 Deflagration prevention and control systems shall be designed to avoid damage to adjacent property.

4.2.2.4 Deflagration prevention and control shall be designed to avoid projectile damage to adjacent property.

4.2.3 Hazard Analysis.

4.2.3.1 The design basis deflagration hazard scenario shall be identified and documented.

4.2.3.2 A documented risk evaluation acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the level of protection to be provided.

4.3 Compliance Options.

4.3.1 Options. Deflagration protection and control meeting the goals and objectives of Sections 4.1 and 4.2 shall be provided in accordance with either of the following:

(1) The performance-based provisions of 4.3.2
(2) The prescriptive-based provisions of 4.3.3

4.3.2 Performance-Based Design. A performance-based design shall be in accordance with Chapter 5 of this standard.

4.3.3 Prescriptive-Based Design. A prescriptive-based design shall be in accordance with Chapters 6 through 15 of this standard.

Chapter 5 Performance-Based Design Option

5.1 General Requirements.

5.1.1 Qualifications. The performance-based design shall be prepared by a person with qualifications acceptable to the authority having jurisdiction.

5.1.2 Design Documentation. The design methodology and data sources shall be documented and maintained for the life of the protected enclosure.

5.1.3 Maintenance of Design Features.

5.1.3.1 To continue meeting the performance goals and objectives of this standard, the design features required for each prevention and control system shall be maintained for the life of the protected enclosure.

5.1.3.2 Any changes to the design shall require approval of the authority having jurisdiction prior to the actual change.

5.2 Performance Criteria.

5.2.1 Prevention and control system design shall be based on the documented hazard scenario.

5.2.2 Prevention and control systems shall limit the reduced pressure (P_{red}) within an enclosure to meet the objectives in 4.2.1.1 and 4.2.1.2.

5.2.3 Deflagration Prevention and Control.

5.2.3.1 Combustible material outside the enclosure shall not attain their ignition temperature from flame or hot gases.

5.2.3.2 Prevention and control systems shall limit the risk of damage to exposed structures.

5.2.3.3 Prevention and control systems shall not expose personnel to flame, hot gases, hot particles, toxic materials, or projectiles.

5.2.3.4 Prevention and control systems shall limit the risk of flame spread from vessel to vessel via interconnected ducts.

5.2.4 Inspection and Maintenance.

5.2.4.1 Prevention and control systems shall be regularly inspected and maintained to confirm the ability to perform as designed.

5.2.4.1.1 If no guidance is given from the performance-based design documents, the requirements of Chapter 15 of this standard shall apply.

5.2.4.2 Inspection and maintenance shall be documented and retained for at least 1 year or the last three inspections.

Chapter 6 General Prescriptive Requirements

6.1* Methods. The methods recognized in this standard shall be grouped based on the prevention of combustion or on the prevention or limitation of damage after combustion occurs.

6.1.1 Methods Based on the Prevention of Combustion. The following shall be considered methods based on preventing combustion:

(1) Oxidant concentration reduction
(2) Combustible concentration reduction

6.1.2 Methods Based on the Prevention or Limitation of Damage. The following shall be considered methods based on preventing or limiting damage:

(1) Predeflagration detection and ignition control systems
(2) Deflagration suppression
(3) Isolation methods
(4) Deflagration pressure containment

6.2 Limitations. The limitations specific to each method shall be considered and are specified in the corresponding chapter for each method.

6.3 Factors to Be Considered. The following factors shall be considered in the selection of one of the methods and the design of the system:

(1) Effectiveness of each method
(2) Reliability of the system
(3) Personnel hazards inherent in each method

6.3.1 The reliability of the system chosen shall be assessed using the following factors:

(1) System design basis
(2) Possibility of electrical and mechanical malfunction
(3) Dependence on sophisticated activating systems
(4) Need for special installation, training, operating, testing, and maintenance procedures
(5) Further limitations as presented in each chapter

6.3.2 In general, explosion prevention systems shall be used to protect processing, storage, and materials-handling equipment.

6.3.3 When explosion prevention techniques are applied to rooms, buildings, or other enclosures where personnel are present, consideration shall be given to the safety of the personnel.

6.3.4 When using the techniques of Chapters 10, 11, 12, or 13, or of NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, the enclosure strength, P_{es}, of the protected

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equipment shall be determined and all pertinent calculations or test information, acceptable to the AHJ, shall be documented and certified by a licensed professional engineer.

6.3.4.1 P_{red} shall not exceed two-thirds of the ultimate strength for the enclosure, provided deformation of the equipment can be tolerated.

6.3.4.2 Where deformation cannot be tolerated, P_{red} shall not exceed two-thirds of the yield strength for the enclosure.

6.3.4.3 Determination of required enclosure strength shall be in accordance with NFPA 68, Section 4.3.

6.4 Plans.

6.4.1 Plans, system specifications, and manufacturer's recommendations for testing and maintenance shall contain information that enables the authority having jurisdiction to evaluate the explosion hazard and the effectiveness of the system.

6.4.2 Details of the plans shall include the following information:

(1) Pertinent chemical and physical characteristics of the materials involved
(2) Location of hazards
(3) Enclosures or limits and isolation of the hazards
(4) Exposures to the hazards

6.5 Acceptance Test. All new system installations and modifications shall be tested or otherwise evaluated to confirm the operational integrity of the system.

6.5.1 Tests shall be in accordance with the manufacturer's recommendations.

6.5.2 A written report of the tests shall be provided to the users.

6.6* Inspection and Maintenance.

6.6.1* All systems shall be inspected for operability in accordance with the manufacturer's recommendations.

6.6.2 An inspection and preventive maintenance schedule shall be established in accordance with the manufacturer's recommendations.

6.7 Housekeeping. In facilities handling combustible particulate solids where such material(s) cannot be completely and reliably contained within the process equipment during normal operation, there can be a significant risk for secondary explosions from dust deposits in the process area. In such situations, housekeeping shall be performed in accordance with NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*; NFPA 484, *Standard for Combustible Metals*; and NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities.*

Chapter 7 Deflagration Prevention by Oxidant Concentration Reduction

7.1 Application. The technique for oxidant concentration reduction for deflagration prevention shall be permitted to be considered where a mixture of oxidant and flammable material is confined to an enclosure within which the oxidant concentration can be controlled.

7.1.1* The system shall be maintained at an oxidant concentration that is low enough to prevent a deflagration.

7.1.2 Oxidant concentration reduction shall be permitted to be applied to rooms or buildings, but because oxygen-deficient atmospheres cannot sustain life, one of the following shall apply:

(1) Operations in such areas shall be remotely controlled.
(2) Operating personnel shall be provided with breathing apparatus as well as other safeguards.

7.1.3 Warning Signs.

7.1.3.1 Where oxidant concentration reduction that poses an asphyxiation hazard is employed, warning signs shall be posted.

7.1.3.2 These warning signs shall be applied to either the inerting system components, the enclosure, or both.

7.2 Design and Operating Requirements.

7.2.1* Design Considerations. The following factors shall be considered in the design of a system intended to reduce the oxidant concentration:

(1) Required reduction in oxidant concentration
(2) Variations in the process, process temperature and pressure, and materials being processed
(3) Source purge gas supply and equipment installation
(4) Compatibility of the purge gas with the process
(5) Operating controls
(6) Maintenance, inspection, and testing
(7) Personnel exposure due to leakage of purge gas to surrounding areas
(8) Need for breathing apparatus by personnel
(9)*Reduced effectiveness of purge gas due to equipment leakage and loss through vents

7.2.2 Protection System Design and Operation.

7.2.2.1* The owner or operator shall be responsible for a thorough analysis of the process to determine the type and degree of deflagration hazards inherent in the process.

7.2.2.2 Information required for the oxidant concentration monitoring and control shall be compiled and documented. This shall include, but not be limited to, the following information:

(1) Monitoring and control objectives
(2) Monitored and controlled areas of the process
(3) Dimensioned drawings of the process with the following information:
  (a) Equipment make and model if available, including volumes and diameters and design strengths
  (b) Plan and elevation views with flows indicated
(4) Startup, normal, shutdown, temporary operations, and emergency shutdown process conditions and ranges for the following factors:
  (a) Flow
  (b) Temperature
  (c) Pressure
  (d) Oxidant concentration
(5) Process flow diagram and description
(6) Ambient temperature in process area
(7) Process interlocks

7.2.2.3 The owner or operator shall disclose any and all process information required for the protection system design.

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7.2.2.4 The owner or operator shall be responsible for the maintenance of the system after installation and acceptance based on procedures provided by the vendor. Maintenance records shall be retained for inspection by the authority having jurisdiction.

7.2.2.5 The owner or operator shall be responsible for periodic inspection of the system by personnel trained by the system manufacturer. The inspection frequency shall be in accordance with Section 15.7.

7.2.2.6 Management of Change. The effect of any process change shall be addressed as specified in Section 15.11.

7.2.2.7 All documentation relevant to the protection system shall be retained in accordance with Chapter 15.

7.2.3 Limiting Oxidant Concentrations (LOCs).

7.2.3.1* Table C.1(a) and Table C.1(b) shall be permitted to be used as a basis for determining LOCs of flammable gases or suspensions of combustible dusts.

7.2.3.1.1 For gases and vapors, if the LOC values according to ASTM E 2079, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration for Gases and Vapors,* are available, then these shall be used.

7.2.3.1.2 For gases and vapors, if the LOC values according to ASTM E 2079 are not available, then the LOC values obtained in flammability tubes shall be used after adjustment by subtracting 2 percent by volume oxidant as indicated in the adjusted columns in Table C.1(a).

7.2.3.2 For fuel, inert, and oxidant combinations not listed in Table C.1(a) or Table C.1(b) or for situations when the process conditions differ from the conditions under which the existing data were obtained, the test methods described in ASTM E 2079 shall be permitted to be used.

7.2.3.3 The extent of oxidant reduction shall be determined by testing where conditions vary significantly from the test conditions under which the data were obtained.

7.2.4 Use of Purge Gas Systems.

7.2.4.1 An additional backflash prevention or protection system shall be installed if a purge gas system is used for lines collecting flammable mixtures and the collection system terminates at a flare or incinerator.

7.2.4.2 Hard-piped vapor control systems shall not require flame arresters at each source connection to the system, provided that the system is designed to operate outside the flammable range.

7.2.4.3 Systems requiring hookups prior to vapor transfer, such as vapor collection from mobile vehicles, shall be purged to a level below the LOC prior to transfer, or backflash protection shall be provided near the point of connection.

7.2.4.4* Where oxygen-deficient atmospheres are maintained in equipment operating under conditions that might form pyrophoric iron sulfides or other pyrophoric materials, a procedure shall be developed to prevent uncontrolled oxidation of the sulfides or other pyrophoric materials.

7.3 Purge Gas Sources.

7.3.1 The purge gas shall be obtained from a source that is capable of continuously supplying the required amount of purge gas to maintain the necessary degree of oxidant deficiency.

7.3.2 Possible sources of purge gas shall include, but shall not be limited to, the following sources:

(1) Commercially available inert gas, such as nitrogen, carbon dioxide, argon, or helium, supplied from high-pressure tanks or cylinders or from air separation plants
(2) Inert gas supplied from a gas generator that burns or catalytically oxidizes a hydrocarbon to produce an oxygen-deficient purge gas
(3) Products of combustion from process furnaces or boiler furnaces for which purification or cooling could be necessary to avoid contamination
(4)*Steam, if it can be supplied at a rate that raises and maintains the protected vessel or system at a temperature high enough to prevent condensation of the steam
(5) High-purity nitrogen supplied by air oxidation of ammonia
(6) Inert gas supplied by removal of oxygen from air by absorption, adsorption, chemical reaction, or membrane permeation
(7) Fuel gases such as methane or natural gas

7.4 Purge Gas Conditioning.

7.4.1 Purge gas shall be conditioned to minimize contaminants that might be harmful to the gas distribution system or that might interfere with the operation of the system.

7.4.2 Before introduction, the purge gas shall be at a temperature compatible with the process being protected to minimize the chance of thermal ignition or condensation.

7.4.3 Purge gas that is distributed in a system subject to freezing temperatures shall have a dew point such that water condensation cannot occur at the minimum ambient temperature to which the system will be exposed.

7.5 Piping Systems. Purge gas distribution systems shall be designed and installed in accordance with recognized engineering practices.

7.5.1 Where purge gas exceeds a gauge pressure of 103 kPa (15 psi), the piping system shall be designed in accordance with ASME B31.3, *Process Piping*.

7.5.2 Where required, piping systems shall be provided with filters, screens, or other means of preventing foreign material from entering critical parts of the system, such as pressure regulators, valves, and instrumentation.

7.5.3 Where required, moisture traps shall be provided and lines shall drain toward the traps.

7.5.3.1 Blowdown connections for moisture traps shall be provided.

7.5.3.2 Moisture traps shall be protected from freezing.

7.5.4 When flue gas or combustion gas is used, means shall be provided to prevent propagation of flame into the system being protected.

7.5.5* Manual shutoff valves shall be provided at each major division point in the distribution system.

7.5.6 The inert gas distribution system shall be designed to prevent contamination by hazardous process materials.

7.5.6.1 Where required, check valves or other design features shall be incorporated to prevent the potential for contamination due to loss of purge gas supply or to excessive pressure in the process unit being protected.

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7.5.6.2 A single check valve shall not be considered a positive backflow connection.

7.5.7* Cross-connections between the purge gas distribution system and any other system shall be prohibited unless one of the following criteria is met:

(1) Positive measures shall be taken to prevent backflow from the other system into the purge gas system.
(2) Cross-connections to backup purge gas systems shall be permitted without backflow prevention unless backflow could create a hazard.

7.5.8 The entire distribution system shall be cleaned and functionally tested prior to being placed in service.

7.5.9 The gases from an enclosure or vessel being purged shall be vented to a safe location.

7.6 Application of Purge Gas at Points of Use. Purge gas shall be introduced and exhausted so that distribution is ensured and the desired reduction in oxidant concentration is maintained throughout the system being protected.

7.6.1 Multiple inlets and outlets shall be permitted.

7.6.2 Connections between the purge gas distribution piping and the protected enclosure or system shall be designed for maximum purge gas pressure.

7.7 Instrumentation.

7.7.1* General. Instrumentation shall be provided to monitor the purge gas being supplied to the distribution system.

7.7.1.1 Instrumentation shall be calibrated according to the requirements in Chapter 15.

7.7.1.2 When the conditions being measured are critical to the safety of personnel, alarms shall be provided to indicate abnormal operation of the system.

7.7.2 Systems Operated Below the Limiting Oxidant Concentration (LOC).

7.7.2.1* Instrumentation shall be installed in as many points as necessary to ensure the desired oxidant concentration reduction within the protected system.

7.7.2.2 The determination of the LOC for the system shall be based on the worst credible case gas mixture yielding the smallest LOC.

7.7.2.3 A safety margin shall be maintained between the LOC and the normal working concentration in the system.

7.7.2.4* The safety margin shall take into account all of the following factors:

(1) Fluctuations occurring in the system
(2) Sensitivity and reliability of monitoring and control equipment
(3) Probability and consequences of an explosion

7.7.2.5 One of the following requirements shall be met where the oxygen concentration is continually monitored:

(1) A safety margin of at least 2 volume percent below the worst credible case LOC shall be maintained.
(2) The LOC shall be less than 5 percent, in which case the equipment shall be operated at no more than 60 percent of the LOC.

7.7.2.6 The requirement of 7.7.2.5 shall not apply to partial oxidation processes.

7.7.2.7 Where the oxygen concentration is not continuously monitored, all of the following requirements shall be met:

(1) The oxygen concentration shall be designed to operate at no more than 60 percent of the LOC or 40 percent of the LOC if the LOC is below 5 percent.
(2) The oxygen concentration shall be checked on a regularly scheduled basis.

7.7.2.7.1* The vapor space in low-pressure field storage tanks that have padding shall not require checking of the oxygen concentration.

7.7.2.7.2 The procedure of pulling a partial vacuum and then breaking the vacuum with inert gas shall be permitted without measuring the oxygen concentration if all of the following conditions apply:

(1) The vacuum condition is held for a time to check for leakage.
(2) The vacuum level is monitored.
(3) The vacuum-creating medium is compatible with the process chemistry.
(4) The residual oxygen partial pressure is calculated or demonstrated by test to be at least 40 percent below the LOC.

7.7.3 Systems Operated Above the Upper Flammable Limit (UFL).

7.7.3.1* Systems operating above the UFL shall be permitted to be used, and the UFL shall be determined at the conditions applicable to the system.

7.7.3.2 Vent headers operated near atmospheric pressure shall be permitted to be rendered nonflammable by the addition of at least 25 volume percent of natural gas or methane where both of the following criteria are met:

(1) The vent headers shall not contain any vapor with a UFL greater than that of hydrogen in air (75 percent).
(2) The vent headers shall not contain oxygen in concentrations greater than can be derived from ambient air.

7.7.3.3 Instrumentation to control methane flow shall be acceptable to the authority having jurisdiction.

Chapter 8 Deflagration Prevention by Combustible Concentration Reduction

8.1* Application. The technique for combustible concentration reduction shall be permitted to be considered where a mixture of a combustible material and an oxidant is confined to an enclosure and where the concentration of the combustible can be maintained below the lower flammable limit (LFL).

8.2 Basic Design Considerations.

8.2.1 All of the following factors shall be considered in the design of a system intended to reduce the combustible concentration below the LFL:

(1) Required reduction in combustible concentration
(2) Variations in the process, process temperature and pressure, and materials being processed
(3) Operating controls
(4) Maintenance, inspection, and testing

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8.2.2* The LFLs of the combustible components shall be determined at all operating conditions, including startup and shutdown.

8.2.3 Protection System Design and Operation.

8.2.3.1* The owner or operator shall be responsible for a thorough analysis of the process to determine the type and degree of deflagration hazards inherent in the process.

8.2.3.2 Information required for the monitoring and control of the concentration of combustible components shall be compiled and documented. This information shall include, but not be limited to, the following:

(1) Monitoring and control objectives
(2) Monitored and controlled areas of the process
(3) Dimensioned drawings of the process with the following:
  (a) Equipment make and model if available, including volumes and diameters and design strengths
  (b) Plan and elevation views with flows indicated
(4) Startup, normal, shutdown, temporary operations, and emergency shutdown process conditions and ranges for the following:
  (a) Flow
  (b) Temperature
  (c) Pressure
  (d) Oxidant concentration
  (e) Fuel concentration
(5) Process flow diagram and description
(6) Ambient temperature in process area
(7) Process interlocks

8.2.3.3 The owner or operator shall disclose any and all process information required for the protection system design.

8.2.3.4 The owner or operator shall be responsible for the maintenance of the system after installation and acceptance based on procedures provided by the vendor. Maintenance records shall be retained for inspection by the authority having jurisdiction.

8.2.3.5 The owner or operator shall be responsible for periodic inspection of the system by personnel trained by the system manufacturer. The inspection frequency shall be in accordance with Section 15.7.

8.2.3.6 Management of Change. The effect of any process change shall be addressed as specified in Section 15.11.

8.2.3.7 All documentation relevant to the protection system shall be retained in accordance with Chapter 15.

8.3 Design and Operating Requirements.

8.3.1 Combustible Concentration Limit. The combustible concentration shall be maintained at or below 25 percent of the LFL, unless the following conditions apply:

(1) Where automatic instrumentation with safety interlocks is provided, the combustible concentration shall be permitted to be maintained at or below 60 percent of the LFL.
(2) Aluminum powder production systems designed and operated in accordance with NFPA 484 shall be permitted to be maintained at or below 50 percent of the LFL.

8.3.2* Catalytic Oxidation. Where catalytic oxidation is used for combustible concentration reduction, flame arresters shall be provided and the following requirements shall apply:

(1) Flame arresters shall be provided in all inlets to the catalytic oxidation unit.
(2) Flame arresters shall be periodically inspected and maintained.

8.3.3 Ventilation or Air Dilution.

8.3.3.1 If ventilation is used, the outlets from the protected enclosures shall be located so that hazardous concentrations of the exhausted air cannot enter or be drawn into the fresh air intakes of environmental air–handling systems.

8.3.3.2 Air intakes shall meet one of the following requirements:

(1) They shall be located so that combustible material cannot enter the air-handling system, even in the event of spills or leaks.
(2) They shall be provided with gas detectors that automatically interlock to stop air intake.

8.3.3.3 Filters, dryers, or precipitators in the air intakes shall be located such that they are accessible for cleaning and maintenance.

8.4 Instrumentation.

8.4.1 Instrumentation shall be provided to monitor the control of the concentration of combustible components.

8.4.2 Instrumentation shall be calibrated according to the requirements of Chapter 15.

8.4.3 Where the enclosure being protected presents a personnel hazard, alarms shall be provided to indicate abnormal operation of the system.

Chapter 9 Predeflagration Detection and Control of Ignition Sources

9.1 Application. Systems used for the predeflagration detection and control of ignition sources shall be permitted to be used to reduce the probability of the occurrence of deflagrations in systems that handle combustible particulate solids.

9.1.1 Systems used for the predeflagration detection and control of ignition sources shall be used in conjunction with other explosion prevention or explosion protection measures, such as deflagration suppression or deflagration venting, for those systems posing a dust explosion hazard.

9.1.2 Design of systems used for predeflagration detection and control of ignition sources shall be based on various techniques that include, but are not limited to, the use of the following systems:

(1) Optical sensing systems
(2) Gas sensing systems

9.1.3 Optical sensing and gas sensing systems shall be permitted to be used for the detection, control, and extinguishment of ignition sources as they pass through ducts, chutes, hoppers, belts, or similar conveyors or develop in an enclosure.

9.1.4 The optical sensing systems shall operate by means of detectors that sense the radiation from a hot or glowing particle and actuate a means to control or extinguish, such as water spray, carbon dioxide flooding, steam snuffing, diverter valve, stop valve, or initiation of stop material in-feed to the process, if appropriate.

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9.1.5 The gas sensing systems shall operate by means of sensing the formation of gaseous thermal decomposition products and actuate a means of control or extinguishment such as alarms, automated shutdown, or the release of the extinguishing system.

9.2 Limitations.

9.2.1 Optical sensing systems and gas sensing systems shall not be used for systems handling flammable gases or hybrid mixtures.

9.2.2 Optical sensing systems and gas sensing systems shall not be used in extinguishing or isolating deflagration flame fronts.

9.3 Optical Sensing System and Gas Sensing System Design Considerations.

9.3.1 General. Optical sensing systems and gas sensing systems shall be listed or approved as a complete system that includes a means to actuate automatic shutdown or other actions described in 9.1.4 and 9.1.5.

9.3.2 Optical Sensing Equipment.

9.3.2.1 Spacing between a detector and control mechanism shall be based on parameters including, but not limited to, the following criteria:

(1) Linear velocity of the material in the duct
(2) Response time of the sensor
(3) Actuator circuitry
(4) Response time of the control mechanism

9.3.2.2 The system manufacturer's application design and guidance shall ensure that a sufficient number of detectors are installed to detect radiant energy at any location in the cross-sectional area of the duct, chute, hopper, belt conveyor, or similar transport system.

9.3.2.3 Provisions shall be made to prevent obscuration of optical sensors.

9.3.2.4 Sensors shall be protected from the accumulation of foreign material that would prevent functioning.

9.3.3 Gas Sensing Equipment.

9.3.3.1 The system shall take air samples at inlets and outlets and evaluate the differential concentration of the selected thermal decomposition products.

9.3.3.2 The design of the gas sensing system shall be based on parameters including, but not limited to, the following criteria:

(1) Process flow
(2) Process flow velocity
(3) Potential measurement interferences (contamination)
(4) Volume
(5) Air exchange rate
(6) Sensor response time

9.3.4 Power and Control Units.

9.3.4.1 A power and control unit shall supply energy to accomplish all of the following processes:

(1) Power all sampling devices, sample preparation unit, control processor, etc.
(2) Energize all electrically actuated extinguishing and control systems
(3) Energize visual and audible alarms
(4) Transfer all auxiliary control and alarm contacts
(5) Control system-disabling interlock and process shutdown circuits

9.3.4.2 The power and control unit shall, as a minimum, fully and continuously supervise all of the following components:

(1) Wiring circuits for opens and other faults
(2) AC power supply (primary)
(3) System safety interlock circuitry
(4) System-disabling interlock circuitry
(5) Releasing outputs
(6) Electrical extinguishing actuators
(7) Air sampler flow (gas sensing only)
(8) Visible and audible alarms
(9) Circuit ground fault

9.3.4.3 In addition to noncritical trouble alarms, the power and control unit shall have separate contacts capable of initiating an orderly shutdown of the protected process upon receipt of any trouble signal that indicates a potentially disabled protection system.

9.3.4.4 The supervisory signal circuits shall be provided with visual and audible trouble signals.

9.4 Testing.

9.4.1 A functional test of all system functions shall be conducted in accordance with the manufacturer's specifications.

9.4.2* The design system shall be based on testing relevant to the early detection and control system.

9.5 Protection System Design and Operation.

9.5.1 Process Analysis.

9.5.1.1* The owner or operator shall be responsible for a thorough analysis of the process to determine the type and degree of deflagration hazards inherent in the process.

9.5.1.2 Factors such as the type of combustible material, the enclosure internal geometry, the total volume to be protected, and the operating conditions shall be reviewed in detail.

9.5.1.3 The potential process malfunctions that could affect the extent of the deflagration hazard shall be determined.

9.5.2 The information required for the detection and control system design shall include, but not be limited to, the following:

(1) Protection objective
(2) Protected area of the process
(3) Dimensioned plan and elevation drawings of the process with equipment make and model, if available
(4) Dimensions of inlet and outlet connections
(5) Internal obstructions of protected enclosure
(6) Startup, normal, shutdown, temporary operations, and emergency shutdown process conditions and ranges for the following:
    (a) Flow rate and direction
    (b) Temperature
    (c) Pressure
    (d) Oxidant concentration
    (e) Fuel concentration
(7) Process flow diagram and description
(8) Currently installed protection equipment
(9) Ambient temperature in process area
(10) Explosibility properties of the combustible material
(11) Process interlocks

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9.5.3 The owner or operator shall disclose any and all process information required for the protection system design.

9.5.4 Maintenance and Inspection.

9.5.4.1 The owner or operator shall be responsible for the maintenance of the system after installation and acceptance.

9.5.4.2 Maintenance records shall be retained for inspection by the authority having jurisdiction in accordance with Section 15.9.

9.5.4.3 The owner or operator shall be responsible for periodic inspection of the system by personnel trained by the system manufacturer.

9.5.4.4 The inspection frequency shall be in accordance with Section 15.7.

9.5.5 Management of Change. The effect of any process change shall be addressed as specified in Section 15.11.

9.5.6 All design documentation relevant to the detection and control system shall be retained in accordance with Chapter 15.

9.6 System Manufacturer's Additional Responsibilities.

9.6.1* The system manufacturer shall provide the owner or operator with information and documentation supporting the design; this information shall be suitable for review by the AHJ.

9.6.2 Upon request, the system manufacturer shall provide to the owner or operator documentation supporting that the design is in compliance with the manufacturer's independent third-party approval, including application limitations, and is suitable for the hazard to be protected.

9.6.3 The system manufacturer shall provide to the owner or operator design specifications based on the data provided by the owner or operator as specified in 9.5.2.

9.6.3.1 Documentation shall be made of the data used in the design.

9.6.3.2 Method of determination shall be consistent with third-party approval and available for review by the authority having jurisdiction.

9.6.4 The system manufacturer shall provide to the owner or operator mechanical and electrical drawings of the system.

9.6.5 The system manufacturer shall provide to the owner or operator installation instructions, operating manuals, and maintenance instructions.

9.6.6 At commissioning, the system manufacturer and the owner or operator shall document that the installation is in accordance with the design and that the system is armed and functional.

9.6.6.1 Variances and any corrective actions shall be identified with the responsible party for any action identified.

9.6.6.2 Changes made at or during installation shall be approved by the system manufacturer and the owner or operator and suitably documented.

9.6.6.3 Concurrence of the AHJ shall be obtained as appropriate.

9.7 Actuation of Other Devices and Systems.

9.7.1 The detection and control system shall be permitted to actuate other devices and systems such as high-speed isolation valves, chemical or mechanical isolation devices, or deluge valves as applicable.

9.8 Process Shutdown.

9.8.1 Upon activation, the detection and control system shall be permitted to initiate an immediate, automatic shutdown of the protected process.

9.8.2 Upon receipt of a trouble signal from the detection and control system, the protected process shall be permitted to initiate an immediate, automatic, and orderly shutdown.

Chapter 10 Deflagration Control by Suppression

10.1* Application.

10.1.1 The technique for deflagration suppression shall be permitted for flammable gases, combustible mists, combustible dusts, or hybrid mixtures that are subject to deflagration in a gas-phase oxidant.

10.1.2 Enclosures that can be protected by a deflagration suppression system shall include, but shall not be limited to, the following equipment:

(1) Processing equipment, such as reactor vessels, mixers, blenders, pulverizers, mills, dryers, ovens, filters, screens, and dust collectors
(2) Storage equipment, such as atmospheric or low-pressure tanks, pressure tanks, and mobile facilities
(3) Material-handling equipment, such as pneumatic and screw conveyors and bucket elevators
(4) Laboratory and pilot plant equipment, including hoods, glove boxes, test cells, and other equipment
(5) Aerosol filling rooms

10.1.3* The suppression system shall be of a design that has been tested under deflagration conditions to verify performance.

10.1.4 The detection conditions; the positioning of the detection points; and the location, quantity, and volume of suppressant containers shall be based upon factors such as, but not limited to:

(1) Time required for detection
(2) Suppressant discharge pattern
(3) Suppressant concentration as a function of time
(4) Suppressant efficiency
(5) Explosibility characteristics of the combustible material
(6) Physical characteristics of the protected enclosure

10.2 Limitations.

10.2.1 Deflagration suppression is successful only where the suppressant can be distributed during the early stages of flame and pressure development.

10.2.2 Deflagration suppression is limited by the physical and chemical properties of the reactants in the system, as well as the design and pressure resistance of the enclosure.

10.2.3* The pressure resistance of the protected enclosure shall not be less than the maximum suppressed deflagration pressure (including effects of suppressant discharge) for the duration of the pressure increase.

10.3 Personnel Safety.

10.3.1* Disarming and Lockout and Tagout Procedures.

10.3.1.1 Disarming and OSHA lockout and tagout procedures (found in 29 CFR 1910.147) and confined space entry

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procedures (found in 29 CFR 1910.146), NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, or local country equivalent, shall be followed prior to entering an enclosure protected by deflagration suppression systems.

10.3.1.2 The deflagration suppression system shall be disarmed and locked out and tagged out prior to performing maintenance operations on the protected enclosure or suppression system if discharging the suppressant could result in injury.

10.3.1.3 Suppressors protecting unoccupied enclosures shall meet applicable OSHA requirements.

10.3.1.3.1 All suppressors shall be provided with a means to prevent release of stored energy into the protected enclosure.

10.3.1.3.2 The suppression system shall be configured to prevent arming while such means are in place.

10.3.1.3.3 Locks and tagging shall be used to identify suppressors that have such prevention means in place.

10.3.1.4 Operation of the protected process shall be interlocked through the suppression system control panel so that operation cannot be resumed until the suppression system is armed.

10.3.2 Warning Signs.

10.3.2.1 Suppression systems shall be equipped with warning signs indicating that the enclosure is protected with a suppression system.

10.3.2.2 These warning signs shall be applied to suppression system components, the enclosure, or both.

10.4 Basic Design Considerations.

10.4.1 General. The design of a deflagration suppression system shall consider, but shall not be limited to, the following components:

(1) Deflagration characteristics of the combustible material
(2) Identification and design specifications of equipment to be protected
(3) Detection technique(s)
(4) Suppressant type, quantity, and suppressing characteristics
(5) Access to components and ease of maintenance
(6) Deflagration propagation between process vessels
(7) Startup, normal operation, and upset conditions

10.4.2 System Design Verification.

10.4.2.1* System design methodology and application range shall have been supported by appropriate testing and verified by an independent party acceptable to the AHJ.

10.4.2.2 The system design shall be based on testing relevant to the application.

10.4.3 Suppression System Design and Operation.

10.4.3.1 Process Analysis.

10.4.3.1.1* The owner or operator shall be responsible for a thorough analysis of the process to determine the type and degree of deflagration hazards inherent in the process.

10.4.3.1.2 Factors such as the type of combustible material, the enclosure internal geometry, the total volume to be protected, and the operating conditions shall be reviewed in detail.

10.4.3.1.3 The potential process malfunctions that could affect the extent of the deflagration hazard shall be determined.

10.4.3.2 The suppression system design shall include, but not be limited to, the following information:

(1) Protection objective
(2) Protected area of the process
(3) Dimensioned plan and elevation drawings of the process with equipment make and model, if available
(4) Pressure resistance of protected enclosures
(5) Internal obstructions of protected enclosure
(6) Startup, normal, shutdown, temporary operations, and emergency shutdown process conditions and ranges for:
    (a) Flow
    (b) Temperature
    (c) Pressure
    (d) Oxidant concentration
    (e) Fuel concentration
(7) Process flow diagram and description
(8) Currently installed protection equipment
(9) Ambient temperature in process area
(10) Explosibility properties of the combustible material
(11) Process interlocks

10.4.3.3 The owner or operator shall disclose any and all process information required for the protection system design.

10.4.3.4 Maintenance and Inspection.

10.4.3.4.1 The owner or operator shall be responsible for the maintenance of the system after installation and acceptance.

10.4.3.4.2 Maintenance records shall be retained for inspection by the authority having jurisdiction in accordance with Section 15.9.

10.4.3.4.3 The owner or operator shall be responsible for periodic inspection of the system by personnel trained by the system manufacturer.

10.4.3.4.4 The inspection frequency shall be in accordance with Section 15.7.

10.4.3.5 Management of Change. The effect of any process change shall be addressed as specified in Section 15.11.

10.4.3.6 All design documentation relevant to the protection system shall be retained in accordance with Chapter 15.

10.4.4 System Manufacturer's Additional Responsibilities.

10.4.4.1* The system manufacturer shall provide the owner or operator with information and documentation that supports the design and is suitable for review by the AHJ.

10.4.4.2 Upon request, the system manufacturer shall provide to the owner or operator documentation supporting that the design is in compliance with the manufacturer's independent third-party approval, including application limitations, and is suitable for the hazard to be protected.

10.4.4.3 The system manufacturer shall provide to the owner or operator design specifications based on the data provided by the owner or operator as specified in 10.4.1.

10.4.4.3.1 Documentation shall be made of the data used in the design.

10.4.4.3.2 The final reduced deflagration pressures shall be provided.

10.4.4.3.3 Method of determination shall be third party approved and available for review by the authority having jurisdiction.

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10.4.4.4 The system manufacturer shall provide to the owner or operator mechanical and electrical drawings of the protection system.

10.4.4.5 The system manufacturer shall provide to the owner or operator installation instructions, operating manuals, and maintenance instructions.

10.4.4.6 At commissioning, the system manufacturer and the owner or operator shall document that the installation is in accordance with the design and that the system is armed and functional.

10.4.4.6.1 Variances and any corrective actions shall be identified with the responsible party for any action identified.

10.4.4.6.2 Changes made at or during installation shall be approved by the system manufacturer and the owner or operator and suitably documented.

10.4.4.6.3 Concurrence of the AHJ shall be obtained as appropriate.

10.4.5 Actuation of Other Devices and Systems. The deflagration suppression system shall be permitted to actuate other devices and systems such as high-speed isolation valves, chemical or mechanical isolation devices, or deluge valves as applicable.

10.4.6 Process Shutdown. Upon activation, the suppression system shall initiate an immediate, automatic shutdown of the protected process.

10.4.6.1 Upon receipt of a trouble signal from the suppression system, which indicates the protection system could be compromised, the protected process shall initiate an immediate, automatic, and orderly shutdown.

10.4.6.2 Upon receipt of a supervisory signal from the suppression system, which indicates that a problem exists but that the protection system is not compromised, qualified personnel shall investigate and repair the problem at the next shutdown period.

10.4.6.3 It shall be permitted to manually shut down the protected process in lieu of automatic shutdown when supported by a hazard analysis approved by the AHJ.

10.5 Control Panels.

10.5.1 A control panel with a standby battery backup of no less than 24 hours shall be provided with each suppression system that supplies energy to accomplish the following actions:

(1) Power all detection devices
(2) Energize all electrically operated actuating devices
(3) Energize local visual and audible alarms
(4) Transfer all auxiliary control and alarm contacts
(5) Control system–disabling interlock and process shutdown circuits

10.5.2 The control panel shall, as a minimum, fully and continuously supervise the following components:

(1) Wiring circuits for opens and other faults
(2) ac power supply (primary)
(3) Battery voltage, presence, and polarity
(4) System safety interlock circuitry
(5) System-disabling interlock circuitry, including lockout and tagout status
(6) Releasing outputs
(7) Electrically operated actuating devices
(8) Detection devices
(9) Local visual and audible alarms
(10) Circuit ground fault
(11) Suppressor pressure indicators

10.5.2.1 The minimum number of detection devices shall be either one device that is a transducer with a continuously monitored process parameter output, or two devices that are switches or transducers that are not continuously monitored, where the two switches are connected such that an alarm condition on either switch will activate the system.

10.5.2.2* Additional detection devices shall be permitted for the purpose of reducing spurious failures.

10.5.3* The supervisory circuits in 10.5.2 shall be provided with a visual and an audible signal.

10.5.4 Control panel contacts shall be provided that enable the owner or operator to initiate an orderly, automatic shutdown of the process and protection system should unauthorized entry of a protected enclosure be attempted.

10.6 Detection Devices.

10.6.1* The deflagration shall be detected by the sensing of one or more of a specified pressure, a specified rate of pressure rise, a vent burst, or the radiant energy from the combustion process.

10.6.2 Provisions shall be made to minimize obscuration of radiant energy detectors.

10.6.3 Detection devices shall be located to minimize accumulation of foreign material that would affect functioning.

10.6.4 Detection devices shall be mounted so that their maximum temperature rating, as specified by the manufacturer, is not exceeded.

10.7 Electrically Operated Actuating Devices.

10.7.1* Electrically operated actuating devices shall be mounted so that their maximum temperature rating, as specified by the manufacturer, is not exceeded.

10.7.2 The operating characteristics of the as-installed actuating device circuits shall be within the manufacturer's specifications.

10.8* Suppressant and Suppressant Storage Containers.

10.8.1* The suppressant shall be compatible with the combustible material in the protected enclosure.

10.8.2 The suppressant shall be effective at the expected extremes of temperature encountered in the protected enclosure.

10.8.3 If agent storage container pressure falls below the manufacturer's required level, a trouble signal shall be sent to the control unit indicating a disabled protection system.

10.8.4 Suppressant storage containers, if used as pressurized shipping containers, shall be designed to meet the requirements of the U.S. Department of Transportation, 49 CFR Part 173.24.

10.8.5 Suppressant storage containers, if not used as pressurized shipping containers, shall be designed, fabricated, inspected, certified, and stamped in accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code.*

10.8.6 The design pressure shall be suitable for the maximum pressure developed at 55°C (130°F) or at the maximum controlled temperature limit.

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Chapter 11 Deflagration Control by Active Isolation

11.1 Application.

11.1.1* The technique of deflagration isolation shall be permitted for interruption or mitigation of flame, deflagration pressures, pressure piling, and flame-jet ignition between enclosures that are interconnected by pipes or ducts.

11.1.2* Isolation techniques may be active, which requires detection, control, and a pneumatic or electrical response that creates an isolating barrier; or passive, which responds to the deflagration pressure to create the isolating barrier.

11.1.3 Active isolation system design shall be permitted to be based on various techniques that include, but are not limited to, the use of the following equipment:

(1) Flame front extinguishing system (chemical isolation)
(2) Fast-acting mechanical valve (explosion isolation valves)
(3) Actuated float valve
(4) Actuated pinch valve

11.1.4 The isolation system type shall be of a design that has been tested under deflagration conditions to verify performance.

11.1.5* The detection conditions, and the positioning of the detection points and the minimum and maximum barrier locations shall be based on a quantitative analysis that includes factors such as, but not limited to, the following parameters:

(1) The entire range of flammable concentrations
(2) Time required for detection for the least-sensitive and the most-sensitive mixtures
(3) Possible ignition locations in the primary enclosure
(4) Time required for barrier formation
(5) Flame speeds and pressures expected in the pipe
(6) Time of flame front propagation to the barrier position
(7) Flow velocity

11.1.6 Piping, ducts, and enclosures protected by an isolation system shall be designed to withstand estimated pressures as provided by the isolation system manufacturer.

11.2* Isolation Techniques. Isolation methods shall be permitted to be used to interrupt or mitigate flame propagation, deflagration pressure, pressure piling, and flame-jet ignition between items of equipment. Active isolation systems shall be permitted to be based on various techniques that include, but are not limited to, the use of the following components:

(1) Chemical barrier
(2) Fast-acting mechanical valve
(3) Externally actuated float valve
(4) Actuated pinch valve

11.2.1 Chemical Barrier.

11.2.1.1* The function of a chemical isolation system is to inject a barrier of extinguishing agent into the interconnection prior to the arrival of the flame front.

11.2.1.2 The chemical isolation system shall consist of one or more detectors, a control panel, and agent injection equipment.

11.2.1.2.1 Actuation shall be based on detection of pressure or radiant energy with a control panel to provide the initiating signal to the agent containers.

11.2.1.2.2 The agent containers shall be fitted with a fast-acting release that permits injection of agent within milliseconds of receiving the initiating signal.

11.2.1.2.3 Agent containers shall be designed to discharge the agent rapidly.

11.2.1.2.4 The size and number of containers shall be selected to provide the required barrier.

11.2.1.3 The isolation design shall include all information required to install and operate the system, including the following information:

(1) Detection specification of activation pressure or pressure rate of rise
(2) Detector location requirements and limits for pressure or optical detection
(3) Minimum placement location for agent container(s) relative to the protected volume or detector location
(4) Maximum placement location for agent container(s) relative to the protected volume or detector location
(5) Required distance downstream of agent container(s)
(6) Agent identity and minimum container pressure at ambient conditions
(7) Size, number, and orientation of agent container(s)
(8) Maximum process and ambient temperature

11.2.1.4 Extinguishing Agents and Containers.

11.2.1.4.1 The extinguishing agent shall be chemically compatible with the material normally conveyed through the pipe system being protected.

11.2.1.4.2 The extinguishing agent shall be of a type that is effective at all temperatures that are to be encountered in the application.

11.2.1.4.3* Extinguishing agent containers, if used as shipping containers, shall be designed to meet the requirements of the U.S. Department of Transportation, 49 CFR Part 173.24.

11.2.1.4.4 If not used as shipping containers, extinguishing agent containers shall be designed, fabricated, inspected, certified, and stamped in accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code*.

11.2.1.4.5 The design pressure shall be suitable for the maximum pressure developed at 55°C (130°F) or at the maximum controlled temperature limit.

11.2.1.5 Limitations. The specific application limitations created by equipment performance specifications and process conditions shall not be exceeded. These limitations include the following:

(1) Minimum and maximum distance of a barrier from the duct entrance
(2) Process flow rates
(3) Direction of flow
(4) Flow resistance
(5) $P_{detection}$ less than P_{stat} when the enclosure is vented
(6) Process temperature and pressure

11.2.1.6 Chemical isolation system components exposed to the process environment shall be capable of withstanding the maximum expected deflagration pressure.

11.2.2* Fast-Acting Mechanical Valves.

11.2.2.1 Fast-acting mechanical valves shall prevent propagation of flame and combustion-generated pressure beyond the fast-acting valves by providing a positive mechanical seal. The mechanical valve shall be capable of withstanding the maximum expected deflagration pressures, including pressure piling.

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11.2.2.2* The mechanical isolation system shall consist of one or more detectors, a control panel, and a fast-acting valve assembly.

11.2.2.2.1 Actuation shall be based on detection of pressure or radiant energy with a control panel, to provide the initiating signal to the mechanical valve.

11.2.2.2.2 The mechanical valve assembly shall include a means of rapidly moving the valve trim.

11.2.2.3 The isolation design shall include all information required to install and operate the system, including the following information:

(1) Detection specification of activation pressure or rate for pressure detection
(2) Detector location requirements and limits for pressure or optical detection
(3) Minimum placement location for mechanical valve relative to the protected volume or detector location
(4) Maximum placement location for mechanical valve relative to the protected volume or detector location
(5) Maximum process and ambient temperature
(6) Minimum actuation pressure

11.2.2.4 Limitations. The specific application limitations created by equipment performance specifications and process conditions shall not be exceeded. These limitations include the following:

(1) Minimum and maximum distance of a valve from the duct entrance
(2) Process flow rates
(3) Direction of flow
(4) Orientation of the valve
(5) Flow resistance
(6) $P_{detection}$ less than P_{stat} when the enclosure is vented
(7) Process temperature

11.2.2.5* Mechanical isolation system components exposed to the process environment shall be capable of withstanding the maximum expected deflagration pressure, including pressure piling.

11.2.3 Externally Actuated Float Valve.

11.2.3.1* The externally actuated float valve shall isolate the explosion by means of a moveable valve plug pressing upon a valve seat.

11.2.3.2* The float valve shall be actuated and caused to move by pneumatic discharge from a pressurized container, by the discharge of a gas generator into a pneumatic cylinder connected to the float, or by other high-speed actuation means.

11.2.3.3 The externally actuated float valve system shall consist of one or more detectors, a control panel, a float valve, and a pressure container or gas generator actuation device.

11.2.3.3.1 Actuation shall be based on detection of pressure or radiant energy with a control panel to provide the initiating signal to the actuator.

11.2.3.3.2 When used, the container shall be pressurized with gas to close the float valve rapidly and completely.

11.2.3.4* The isolation design shall include all information required to install and operate the system, including the following:

(1) Detection specification of activation pressure or rate of pressure rise
(2) Detector location requirements and limits for pressure or optical detection
(3) Minimum placement location for float valve relative to the protected volume or detector location
(4) Maximum placement location for float valve relative to the protected volume or detector location
(5) Maximum process and ambient temperature
(6) Maximum and minimum process flow rate
(7) Maximum permissible dust loading
(8) Minimum actuation pressure

11.2.3.5 Limitations. The specific application limitations created by equipment performance specifications and process conditions shall not be exceeded. These limitations include the following:

(1) Minimum and maximum distance of a valve from the duct entrance
(2) Process flow rates
(3) Direction of flow
(4) Orientation of the valve
(5) Flow resistance
(6) $P_{detection}$ less than P_{stat} when the enclosure is vented
(7)*Process temperature and pressure

11.2.4 Actuated Pinch Valve.

11.2.4.1* The pinch valve shall isolate the explosion by means of a collapsible elastomer pinch.

11.2.4.2* The pinch valve shall be actuated and caused to close by gas discharge from a pressurized cylinder connected to the pinch.

11.2.4.3 The actuated pinch valve system shall consist of one or more detectors, a control panel, a pinch valve, and a pressure cylinder.

11.2.4.3.1 Actuation shall be based on detection of pressure or radiant energy with a control panel, to provide the initiating signal to the actuator.

11.2.4.3.2 The container shall be pressurized with gas sufficient to close the pinch valve rapidly and completely.

11.2.4.4 The isolation design shall include all information required to install and operate the system, including the following:

(1) Detection specification of activation pressure or rate of pressure rise
(2) Detector location requirements and limits for pressure or optical detection
(3) Minimum placement location for pinch valve relative to the protected volume or detector location
(4) Maximum placement location for pinch valve relative to the protected volume or detector location
(5) Maximum process and ambient temperature
(6) Maximum and minimum process flow rates
(7)*Maximum permissible dust loading
(8) Minimum actuation pressure

11.2.4.5 Limitations. The specific application limitations created by equipment performance specifications and process conditions shall not be exceeded. These limitations include the following:

(1) Minimum and maximum distance of a valve from the duct entrance
(2) Process and ambient temperatures

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(3) $P_{detection}$ less than P_{stat} when the enclosure is vented
(4) Process flow rates
(5) Maximum deflagration pressure

11.2.4.6 Where the normal operation of the equipment is under vacuum, the pinch valve shall be configured with an equalization line to avoid pinch infringement into the process flow stream.

11.3 Personnel Safety.

11.3.1 The safety of personnel working with and around explosion prevention equipment shall be addressed as specified in Section 15.10.

11.3.2* Disarming and Lockout/Tagout Procedures.

11.3.2.1 Disarming and OSHA lockout/tagout procedures (29 CFR 1910.147) and confined space entry procedures (29 CFR 1910.146), or local country equivalent, shall be followed prior to entering an enclosure or ductwork protected by an isolation system.

11.3.2.2 The isolation system shall be disarmed and locked out/tagged out prior to performing maintenance operations on the protected enclosure, ducting, or isolation system if actuation could result in injury.

11.3.2.3 Isolation systems shall meet applicable OSHA requirements.

11.3.2.3.1 Isolation systems shall be provided with a means to prevent release of stored energy.

11.3.2.3.2 The system shall be configured to prevent arming while such means are in place.

11.3.2.3.3 Locks and tagging shall be used to identify systems that have such prevention means in place.

11.3.2.4 Operation of the protected process shall be interlocked through the isolation system control panel so that operation cannot be resumed until the isolation system is armed.

11.4 Basic Design and Operation.

11.4.1 System Design Verification.

11.4.1.1* System design methodology and application range shall have been supported by appropriate testing and verified by an independent third party acceptable to the AHJ.

11.4.1.2 The system design methodology shall be based on testing relevant to the isolation system.

11.4.1.3 Chemical (Barrier) Isolation. The system testing shall consider, but not be limited to, the following design factors or performance measures:

(1) Flame propagation behavior for relevant system conditions
(2) Detection parameters for specific placement locations, with consideration given to the potential range of fuels, ignition locations, and detector type
(3) Barrier formation dynamics, including duration
(4) Agent (barrier) concentration or quantity requirement
(5) Minimum and maximum barrier locations
(6) Post-barrier extinguishing distance
(7) Pressure at barrier placement

11.4.1.4 Mechanical Isolation. The system testing shall consider, but not be limited to, the following design factors or performance measures:

(1) Flame propagation behavior for relevant system conditions
(2) Detection parameters for specific placement locations, with consideration given to the potential range of fuels, ignition locations, and detector type
(3) Activation dynamics of the closure
(4) Minimum and maximum placements
(5) Pressure at valve placement
(6) Pressure limitation of hardware

11.4.1.5 Actuated Float Valve. The system testing shall consider, but not be limited to, the following design factors or performance measures:

(1) Flame propagation behavior for relevant system conditions
(2) Detection parameters for specific placement locations, with consideration given to the potential range of fuels, ignition locations, and detector type
(3) Activation dynamics of the closure
(4) Minimum and maximum placements
(5) Pressure at valve placement
(6) Pressure limitation of hardware

11.4.1.6 Actuated Pinch Valve. The system testing shall consider, but not be limited to, the following design factors or performance measures:

(1) Flame propagation behavior for relevant system conditions
(2) Detection parameters for specific placement locations, with consideration given to the potential range of fuels, ignition locations, and detector type
(3) Activation dynamics of the closure
(4) Minimum and maximum placements
(5) Pressure at valve placement
(6) Pressure limitation of hardware

11.4.2 Protection System Design and Operation.

11.4.2.1* The owner or operator shall be responsible for a thorough analysis of the process that shall be conducted to determine the type and degree of deflagration hazards inherent in the process.

11.4.2.2 The information required for the isolation design shall include, but not be limited to, the following:

(1) Protection objective
(2) Protected area of the process
(3) Dimensioned drawings of the process with equipment make and model if available, including volumes and diameters and design strengths
(4) Plan and elevation views with flows indicated
(5) Startup, normal, shutdown, temporary operations, and emergency shutdown process conditions and ranges for:
  (a) Flow
  (b) Temperature
  (c) Pressure
  (d) Oxidant concentration
  (e) Fuel concentration
(6) Process flow diagram and description
(7) Previously installed protection equipment
(8) Ambient temperature in process area
(9) Explosibility properties of the combustible materials
(10) Process interlocks

11.4.2.3 The owner or operator shall disclose any and all process information required for the protection system design.

11.4.2.4 Maintenance.

11.4.2.4.1 The owner or operator shall be responsible for the maintenance of the system after installation and acceptance based on procedures provided by the vendor.

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11.4.2.4.2 Maintenance records shall be retained for inspection by the authority having jurisdiction in accordance with Section 15.9.

11.4.2.5 Inspection.

11.4.2.5.1 The owner or operator shall be responsible for periodic inspection of the system by personnel trained by the system manufacturer.

11.4.2.5.2 The inspection frequency shall be in accordance with Section 15.7.

11.4.2.6 Management of Change. The effect of any process change shall be addressed as specified in Section 15.11.

11.4.2.7 All design documentation relevant to the protection system shall be retained in accordance with Chapter 15.

11.4.3* System Manufacturer's Additional Responsibilities. The system manufacturer shall provide the owner or operator with information and documentation that supports the design and that is suitable for review by the AHJ.

11.4.3.1 Upon request, the system manufacturer shall provide to the owner or operator documentation supporting that the design is in compliance with the manufacturer's independent third-party approval, including application limitations, and is suitable for the hazard to be protected.

11.4.3.2 The system manufacturer shall provide to the owner or operator design specifications based on the data provided by the owner or operator as specified in 11.4.2.2.

11.4.3.2.1 Documentation shall be made of the data used in the design.

11.4.3.2.2 The final reduced deflagration pressures shall be provided.

11.4.3.2.3 Method of determination shall be third party approved and available for review by the authority having jurisdiction.

11.4.3.3 The system manufacturer shall provide to the owner or operator mechanical and electrical drawings of the protection system.

11.4.3.4 The system manufacturer shall provide to the owner or operator installation instructions, operating manuals, and maintenance instructions.

11.4.3.5 At commissioning, the system manufacturer and the owner or operator shall document that the installation is in accordance with the design and the system was armed and functional.

11.4.3.5.1 Variances and any corrective actions shall be identified with the responsible party for any action identified.

11.4.3.5.2 Changes made at or during installation shall be approved by the system manufacturer and owner or operator and suitably documented.

11.4.3.5.3 Concurrence of the AHJ shall be obtained as appropriate.

11.4.4 Process Shutdown. Upon activation, the isolation system shall initiate an immediate, automatic shutdown of the protected process.

11.4.4.1 Upon receipt of a trouble signal from the isolation system, the protected process shall initiate an immediate, automatic, and orderly shutdown.

11.4.4.2 The owner or operator shall be permitted to manually shut down the protected process in lieu of automatic shutdown when supported by a hazard analysis approved by the AHJ.

11.4.5 Installation, Inspection, and Maintenance. The installation, inspection, and maintenance of explosion prevention systems shall be addressed as specified in Chapter 15.

11.5 Detection Devices.

11.5.1* The deflagration shall be detected by sensing one or more of a specified pressure, a specified rate of pressure rise, a vent burst, or the radiant energy from the combustion process.

11.5.2 Provisions shall be made to minimize obscuration of radiant energy detectors.

11.5.3 Detection devices shall be located to minimize accumulation of foreign material that would affect functioning.

11.5.4 Detection devices shall be mounted so that their maximum temperature rating, as specified by the manufacturer, is not exceeded.

11.6 Electrically Operated Actuating Devices.

11.6.1* Electrically operated actuating devices shall be mounted so that their maximum temperature rating, as specified by the manufacturer, is not exceeded.

11.7 Control Panels.

11.7.1 A control panel with a standby battery backup of no less than 24 hours shall be provided with each isolation system that supplies energy to accomplish the following actions:

(1) Power all detection devices
(2) Energize all electrically operated actuating devices
(3) Energize local visual and audible alarms
(4) Transfer all auxiliary control and alarm contacts
(5) Control system-disabling interlock and process shutdown circuits

11.7.2 The control panel shall, as a minimum, fully and continuously supervise the following conditions:

(1) Wiring circuits for opens and other faults
(2) AC power supply (primary)
(3) Battery voltage, presence, and polarity
(4) System safety interlock circuitry
(5) System-disabling interlock circuitry including lockout and tagout status
(6) Releasing outputs
(7) Electrically operated actuating devices
(8) Detection devices
(9) Local visual and audible alarms
(10) Circuit ground fault
(11) Isolation container pressure indicators

11.7.3* The supervisory circuits in 11.7.2 shall be provided with visual and audible signals.

11.7.4 Control panel contacts shall be provided that enable the owner or operator to initiate an orderly, automatic shutdown of the process and protection system should unauthorized entry of a protected enclosure be attempted.

11.7.5 If a pressurized container pressure falls below manufacturer's required level, a trouble signal shall be sent to the control unit indicating a disabled protection system.

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