

NFPA 69

Standard on Explosion Prevention Systems

2002 Edition



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An International Codes and Standards Organization

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NFPA 69
Standard on
Explosion Prevention Systems
2002 Edition

This edition of NFPA 69, *Standard on Explosion Prevention Systems*, was prepared by the Technical Committee on Explosion Protection Systems, and acted on by NFPA at its May Association Technical Meeting held May 19–23, 2002, in Minneapolis, MN. It was issued by the Standards Council on July 19, 2002, with an effective date of August 8, 2002, and supersedes all previous editions.

This edition of NFPA 69 was approved as an American National Standard on July 19, 2002.

Origin and Development of NFPA 69

In 1965, an NFPA Committee was appointed to develop standards for explosion protection systems. These standards would include 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 includes new information on spark detection and extinguishment system design. A reorganization of the protection methods now reflects a hierarchy based upon the degree of explosion prevention. The LOC values for gases and vapors in Annex C have been updated based upon recent research. The standard has been revised to reflect NFPA *Manual of Style* requirements.

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

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

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

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex F lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. 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 appropriate technical committee.

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

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.

1.3 Application.

1.3.1 This standard shall apply to systems and equipment used for the prevention of explosions by the prevention or control of deflagrations.

1.3.2 This standard shall not apply to following:

- (1) Devices or systems designed to protect against detonations
- (2)*Design, construction, and installation of deflagration vents
- (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 the following:
 - (a) NFPA 86, *Standard for Ovens and Furnaces*
 - (b) NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere*

(c) NFPA 86D, *Standard for Industrial Furnaces Using Vacuum as an Atmosphere*

(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, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 70, *National Electrical Code*®, 2001 edition.

NFPA 72®, *National Fire Alarm Code*®, 1999 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 1999 edition.

NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere*, 1999 edition.

NFPA 86D, *Standard for Industrial Furnaces Using Vacuum as an Atmosphere*, 1999 edition.

NFPA 651, *Standard for the Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders*, 1998 edition.

2.3 Other Publications.

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

ASME *Boiler and Pressure Vessel Code*, Section VIII, 1998.

ASME B31.3, *Process Piping*, 1999.

2.3.2 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 2079, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration for Gases and Vapors*, 2000.

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

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.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible 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. [68:3.3]

3.3.3 Combustible. Capable of undergoing combustion.

3.3.4 Combustible Dust. Any finely divided solid material, 420 microns or smaller in diameter (material passing a U.S. No. 40 standard sieve), that presents a fire or deflagration hazard. [654:1.5]

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. [68:3.3]

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. [68:3.3]

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

3.3.13 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.

3.3.14* 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.

3.3.15 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.

3.3.16 Flame Speed. The speed of a flame front relative to a fixed reference point. Flame speed is dependent on turbu-

lence, the equipment geometry, and the fundamental burning velocity. [68:3.3]

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

3.3.17.1 Lower Flammable Limit (LFL). The lower flammable limit is the lowest concentration of a combustible substance in an oxidizing medium that will propagate a flame.

3.3.17.2 Upper Flammable Limit (UFL). The upper flammable limit is the highest concentration of a combustible substance in an oxidizing medium that will propagate a flame.

3.3.18 Flammable Range. The range of concentrations between the lower and upper flammable limits. [68:3.3]

3.3.19 Gas. The state of matter characterized by complete molecular mobility and unlimited expansion; used synonymously with the term *vapor*. [68:3.3]

3.3.19.1 Inert Gas. A gas that is noncombustible and nonreactive.

3.3.19.2 Purge Gas. An inert or a combustible gas that is continuously or intermittently added to a system to render the atmosphere nonignitable.

3.3.20 Hybrid Mixture. A mixture of a flammable gas with either a combustible dust or combustible mist. [68:3.3]

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

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

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

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

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

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

3.3.23* Limiting Oxidant Concentration (LOC). The concentration of oxidant below which a deflagration cannot occur. Materials other than oxygen can act as the oxidants. [86:2.2]

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

3.3.25 Maximum Pressure (P_{max}). The maximum pressure developed in a contained deflagration for an optimum mixture. [68:3.3]

3.3.26 Mist. A dispersion of fine liquid droplets in a gaseous medium. [68:3.3]

3.3.27 Oxidant. Any gaseous material that can react with a fuel (either gas, dust, or mist) to produce combustion. Oxygen in air is the most common oxidant. [68:3.3]

3.3.28 Padding. See 3.3.1.

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

3.3.30 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.

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

3.3.32 Vapor. See 3.3.19.

3.3.33 Ventilation. The changing of an atmosphere of any space by natural or mechanical means.

Chapter 4 General Requirements

4.1* 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.

4.1.1 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

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

- (1) Spark extinguishing systems
- (2) Deflagration suppression
- (3) Isolation methods
- (4) Deflagration pressure containment

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

4.3 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

4.3.1 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

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

4.3.3 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.

4.4 Plans.

4.4.1 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.

4.4.2 Details of the plans shall include the following:

- (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

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

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

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

4.6* Inspection and Maintenance.

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

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

Chapter 5 Deflagration Prevention by Oxidant Concentration Reduction

5.1 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.

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

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

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

5.2 Design and Operating Requirements.

5.2.1* 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) Leakage of purge gas to surrounding areas
- (8) Need for breathing apparatus by personnel

5.2.2 Limiting Oxidant Concentrations (LOC).

5.2.2.1* Table C.1(a), Table C.1(b), and Table C.1(c) shall be permitted to be used as a basis for determining limiting ox-

idant concentrations of flammable gases or suspensions of combustible dusts.

5.2.2.2 For fuel/inert/oxidant combinations not listed in Table C.1(a), Table C.1(b), and Table C.1(c) 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, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration for Gases and Vapors*, shall be permitted to be used.

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

5.2.3 Use of Purge Gas Systems.

5.2.3.1 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.

5.2.3.2 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.

5.2.3.3 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.

5.2.3.4* 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.

5.3 Purge Gas Sources.

5.3.1 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.

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

- (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

5.4 Purge Gas Conditioning.

5.4.1 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.

5.4.2 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.

5.4.3 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.

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

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

5.5.2 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.

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

5.5.3.1 Blowdown connections for moisture traps shall be provided.

5.5.3.2 Moisture traps shall be protected from freezing.

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

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

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

5.5.6.1 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.

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

5.5.7* 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.

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

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

5.6 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.

5.6.1 Multiple inlets and outlets shall be permitted.

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

5.7 Instrumentation.

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

5.7.1.1 Instrumentation shall be calibrated at scheduled intervals.

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

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

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

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

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

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

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

5.7.2.5 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.

5.7.2.6 The requirement of 5.7.2.5 shall not apply to partial oxidation processes.

5.7.2.7 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.

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

5.7.2.7.2 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 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.

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

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

5.7.3.2 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.

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

Chapter 6 Deflagration Prevention by Combustible Concentration Reduction

6.1* 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).

6.2 Basic Design Considerations.

6.2.1 All of the following factors shall be considered in the design of a system intended to reduce the combustible concentration below the lower flammable limit (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

6.2.2* The lower flammable limits of the combustible components shall be determined at all operating conditions, including startup and shutdown.

6.3 Design and Operating Requirements.

6.3.1 Combustible Concentration Limit. The combustible concentration shall be maintained at or below 25 percent of the lower flammable limit (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 lower flammable limit.
- (2) Aluminum powder production systems designed and operated in accordance with NFPA 651, *Standard for the Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders*, shall be permitted to be maintained at or below 50 percent of the lower flammable limit.

6.3.2* 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.

6.3.3 Ventilation or Air Dilution.

6.3.3.1 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.

6.3.3.2 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.

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

6.4 Instrumentation.

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

6.4.2 Instrumentation shall be calibrated at scheduled intervals.

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

Chapter 7 Deflagration Prevention by Hot Particle Detection and Intervention Systems

7.1 Application. Spark extinguishing systems shall be permitted to be considered for reducing the frequency of deflagrations in transport and receiving systems that handle combustible particulate solids.

7.1.1 Spark detection and extinguishing 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.

7.1.2 Spark extinguishing systems shall be used for the detection and extinguishment of sparks or embers as they pass through ducts that transport combustible dusts or solids.

7.1.3 The spark extinguishing system shall operate by means of detectors that sense the radiation from a hot or glowing particle and actuate a special extinguishing system that quenches the particle.

7.1.4 Because the detection is by means of radiation, spark detection systems shall not be used in duct systems that have openings through which incident light could affect the detectors, unless the detectors are designed to be insensitive to visible light.

7.2 Limitations.

7.2.1 Spark extinguishing systems shall not be used for ducts designed to transport flammable gases.

7.2.2 Spark extinguishing systems shall not be used where the extinguishing agent creates a hazard.

7.2.3* Spark detection and spark extinguishing systems shall be limited to the detection and extinguishment of sparks or embers traveling at the system transport velocity.

7.2.4 Spark detection and spark extinguishing systems shall not be used in extinguishing deflagration flame fronts or flow isolation.

7.3 Spark Detection and Spark Extinguishing System Design Considerations.

7.3.1* General. Spark detection and spark extinguishing systems shall be listed or approved.