

NFPA® 318

Standard for the Protection of Semiconductor Fabrication Facilities

2018



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NFPA® 318

Standard for the

Protection of Semiconductor Fabrication Facilities

2018 Edition

This edition of NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*, was prepared by the Technical Committee on Semiconductor and Related Facilities. It was issued by the Standards Council on August 1, 2017, with an effective date of August 21, 2017, and supersedes all previous editions.

This edition of NFPA 318 was approved as an American National Standard on August 21, 2017.

Origin and Development of NFPA 318

The Committee on Cleanrooms was formed in 1988 and held its first meeting during May of that year. The committee was organized into chapter subcommittees that separately prepared individual chapters and related appendix material for review by the full committee at meetings held October 1988, March 1989, September 1989, March 1990, September 1990, and June 1991.

The standard was submitted and adopted at the Fall Meeting in Montreal in 1991. The 1992 edition was the first edition of this standard.

The standard was revised in 1995.

The 1998 and 2000 editions were partial revisions of the standard.

The 2002 edition of this standard incorporated Article 51 of NFPA 1, *Uniform Fire Code*, and was reformatted to comply with the *Manual of Style for NFPA Technical Committee Documents*.

The 2006 edition contained a new chapter addressing quantity limits for hazardous materials following coordination of this information with *NFPA 5000, Building Construction and Safety Code*.

The 2009 edition clarified the requirements for both Type 1 and Type 2 subatmospheric gas systems. Revisions also included the removal of seismic considerations, in order to focus the scope of the document.

The 2012 edition provided additional modifications to the requirements for subatmospheric gas systems (SAGS) based on the technical committee's review of necessary safeguards for these systems. Several reference standards were updated as part of this revision.

The 2015 edition was completely reorganized in an effort to make the standard more user friendly. The term *subatmospheric gas system* was revised to *subatmospheric gas source* throughout the standard to clarify its meaning. Various categories of hazardous materials were identified, and the concept of "HPM risk assessment" was introduced. New requirements were added throughout the standard that encompassed the following subject matter: hazardous materials, liquid chemical storage and handling, gas storage and handling, production and support equipment, waste treatment, and fire protection.

For the 2018 edition, the most noteworthy changes are major revisions to the requirements for both gas-detection systems as well as smoke detection systems. Both topics were technically modified and also revised for clarity. Gas detection criteria has been revised to clarify when detection is needed and where it is required to be physically provided. The smoke detection requirements were revised to include not just minimum capabilities of detectors but also coverage areas, alert and alarm sensitivities, and maximum transport times taken from NFPA 76, which were based on research conducted by the Fire Protection Research Foundation.

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Committee Scope: This Committee shall have primary responsibility for documents on the fire protection for fabrication facilities and comparable fabrication processes for semiconductor, display panel, photovoltaic, and related facilities. When bulk gas systems are involved the responsibility begins at a point downstream of the source valve.

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

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. 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 D.

Chapter 1 Administration

1.1* Scope. This standard applies to semiconductor fabrication facilities and comparable fabrication processes, including research and development areas in which hazardous chemicals are used, stored, and handled and containing what is herein defined as a cleanroom or clean zone, or both.

1.2* Purpose. This standard is intended to provide reasonable safeguards for the protection of facilities containing cleanrooms from fire and related hazards. These safeguards are intended to provide protection against injury, loss of life, and property damage.

1.3 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.

1.3.1 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.

1.3.2 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.

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

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

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

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

1.4.3* Alternative systems, methods, or devices approved as equivalent by the authority having jurisdiction shall be recognized as being in compliance with this standard.

1.5* Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter unit, which is not part of but is recognized by SI, is commonly used in international fire protection. Conversion factors for SI units are found in Table 1.5.

Table 1.5 SI Units of Measure

Name of Unit	Unit Symbol	Conversion Factor
millimeter	mm	1 in. = 25.4 mm
meter	m	1 ft = 0.3048 m
square meter	m ²	1 ft ² = 0.093 m ²
kilopascal	kPa	1 psi = 6.895 kPa
liter	L	1 gal = 3.785 L
liter/minute	L/min	1 gpm = 3.785 L/min 1 ft ³ /min = 28.3 L/min
liter/minute/ square meter	L/min·m ²	1 gpm/ft ² = 40.746 L/min·m ² (mm/min)
liter/second/ square meter	L/s·m ²	1 ft ³ /min·ft ² = 0.044 L/s·m ²
cubic meter/ minute/ square meter	m ³ /min·m ²	1 ft ³ /min·ft ² = 0.31 m ³ / min·m ²

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 1, *Fire Code*, 2018 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2015 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2016 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2018 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2016 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2016 edition.

NFPA 79, *Electrical Standard for Industrial Machinery*, 2015 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2018 edition.

NFPA 92, *Standard for Smoke Control Systems*, 2015 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 385, *Standard for Tank Vehicles for Flammable and Combustible Liquids*, 2017 edition.

NFPA 400, *Hazardous Materials Code*, 2016 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*, 2017 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2017 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2015 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2015 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 edition.

2.3 Other Publications.

2.3.1 ASME Publications. ASME International, Two Park Avenue, New York, NY 10016-5990.

ASME A.13.1, *Scheme for the Identifications of Piping Systems*, 2015.

ASME B31.3, *Process Piping*, 2014.

ASME Boiler and Pressure Vessel Code, 2017.

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

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2015b.

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2014.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2016.

2.3.3 CGA Publications. Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151-2923.

ANSI/CGA G-13, *Storage and Handling of Silane and Silane Mixtures*, 2016.

2.3.4 FM Publications. FM Global, 270 Central Avenue, P.O. Box 7500, Johnston, RI 02919.

ANSI/FM 4910, *Standard for Cleanroom Materials Flammability Test Protocol*, 2013.

2.3.5 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*, 2nd edition, 2015.

2.3.6 SEMI Publications. Semiconductor Equipment and Materials International, 3081 Zanker Road, San Jose, CA 95134.

SEMI F1, *Specification for Leak Integrity of High-Purity Gas Piping Systems and Components*, 1996.

SEMI S3, *Safety Guideline for Process Liquid Heating Systems*, 2011.

2.3.7 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials*, 2011.

ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2008, revised 2013.

ANSI/UL 900, *Standard for Air Filter Units*, 2015.

ANSI/UL 2360, *Standard Test Method for Determining the Combustibility Characteristics of Plastics Used in Semiconductor Tool Construction*, 2013.

2.3.8 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code*, 2018 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2015 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2016 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 400, *Hazardous Materials Code*, 2016 edition.

NFPA 1670, *Standard on Operations and Training for Technical Search and Rescue Incidents*, 2017 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 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* 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.

3.2.4 Shall. Indicates a mandatory requirement.

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

3.2.6 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Bulk Gas System. A system in which compressed gas is delivered, stored, and discharged in the gaseous form to a piping system. The threshold quantity used to define a bulk gas system is determined based on material-specific requirements. The compressed gas system terminates at the point where compressed gas at service pressure first enters the distribution piping system.

3.3.2 Clean Zone. A defined space in which the concentration of airborne particles is controlled to specified limits.

3.3.3 Cleanroom. A room in which the concentration of airborne particles is controlled to specified limits, including areas below the raised floor and above the ceiling grid if these areas are part of the air path and within the rated construction.

3.3.4 Compressed Gas. A material, or mixture of materials, that (1) is a gas at 68°F (20°C) or less at an absolute pressure of

14.7 psi (101.3 kPa) and (2) has a boiling point of 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and that is liquefied, nonliquefied, or in solution, except those gases that have no other health or physical hazard properties are not considered to be compressed gases until the pressure in the packaging exceeds an absolute pressure of 40.6 psi (280 kPa) at 68°F (20°C). [55, 2016]

3.3.5 Compressed Gas Container. A pressure vessel designed to hold compressed gas at an absolute pressure greater than 1 atmosphere at 68°F (20°C) that includes cylinders, containers, and tanks. [5000, 2018]

3.3.6* Corrosive Material. A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. [1, 2018]

3.3.7 Dopant Gas. A dopant gas is a molecule that will insert a trace impurity element into a substance in order to alter the electrical properties or the optical properties of the substance.

3.3.8 Exhausted Enclosure. In semiconductor fabrication facilities, exhausted enclosures provide secondary containment for pieces of equipment, mechanical fittings, or valves, providing a means of local exhaust for capturing potential gases, fumes, vapors, and mists resulting from abnormal conditions.

3.3.9 Explosion. The bursting or rupture of an enclosure or a container due to the development of internal pressure from a deflagration. [69, 2014]

3.3.10 Fabrication Area (Fab Area). An area within a semiconductor fabrication facility and related research and development areas in which there are processes using hazardous production materials; such areas include cleanrooms, process equipment support areas, parts clean and ancillary rooms that are directly related to the fab area processes.

3.3.11 Facility Sub-fab. A support area, used for facility equipment and services, located below the fabrication cleanroom level, but which is separated from the cleanroom air flow by a fire-rated barrier. Typically located one level below the Clean Sub-fab, which is directly below the fabrication cleanroom level, and is within the air return path. Sometimes referred to as the "Dirty Sub-fab."

3.3.12 Flammable Degradation Temperature (FDT). The temperature at which a liquid degrades producing a flammable byproduct. [SEMI S3-0306] [Definition republished with permission from Semiconductor Equipment and Materials International, Inc. (SEMI) © 2012]

3.3.13 Flammable Vapors or Fumes. The concentration of flammable constituents in air that exceed 25 percent of their flammability limit.

3.3.14 Gas Cabinet. A fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use. Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are allowed to be included.

3.3.15 Grade Plane. A reference plane upon which vertical measurements of a building are based.

3.3.16 Hazardous Production Material. In semiconductor fabrication facilities, any solid, liquid, or gas that has a degree-of-hazard rating in health, flammability, or reactivity of Class 3 or 4 as ranked by NFPA 704.

3.3.17 Immediately Dangerous to Life or Health (IDLH). Any condition that would pose an immediate or delayed threat to life, cause irreversible adverse health effects, or interfere with an individual's ability to escape unaided from a hazardous environment. [1670, 2017]

3.3.18 Incompatible Materials. Materials that, when making contact with each other in an upset condition, can react in a manner that generates heat, fumes, gases, or by-products that could cause damage to life or property.

3.3.19 Interface. That place at which independent systems meet and act on or communicate with each other.

3.3.20 Interlock. A device, or an arrangement of devices, in which the operation of one part or one mechanism of the device or arrangement controls the operation of another part of another mechanism.

3.3.21 Limit.

3.3.21.1* Permissible Exposure Limit (PEL). The maximum permitted 8-hour, time-weighted average concentration of an airborne contaminant. [5000, 2018]

3.3.22 Liquid. A material that has a melting point that is equal to or less than 68°F (20°C) and a boiling point that is greater than 68°F (20°C) at 14.7 psia (101.3 kPa). When not otherwise identified, the term liquid shall mean both flammable and combustible liquids. [1, 2018]

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

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

3.3.23 Noncombustible. In semiconductor fabrication facilities, a material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

3.3.24 Normal Temperature and Pressure (NTP). A temperature of 21.1°C (70°F) and a pressure of 1 atmosphere [101.3 kPa (14.7 psia)]. [5000, 2018]

3.3.25 Pass-Through. An enclosure, installed in a wall and with a door on each side, that allows chemicals, production materials, equipment, and parts to be transferred from one side of the wall to the other.

3.3.26 Pyrophoric. A chemical with an autoignition temperature in air at or below 54.4°C (130°F).

3.3.27 Restricted Flow Orifice (RFO). A device located in the gas cylinder valve body that restricts the maximum flow rate to 30 L/min (1.06 ft³/min).

3.3.28 Room.

3.3.28.1 Gas Room. A separately ventilated, fully enclosed room in which only compressed gases and associated equipment and supplies are stored or used.

3.3.28.2 Hazardous Chemical Storage and Dispensing Room. A room used in conjunction with or serving a fabrication area where hazardous chemicals are stored, used, or transferred from vessels in the room through piping systems to a fabrication area.

3.3.29 Semiconductor Fabrication Facility. Buildings or portions thereof used for the fabrication of semiconductors and related research containing quantities of hazardous materials exceeding the maximum allowable quantities of Level 5 contents permitted in control area.

3.3.30 Service Corridor. A fully enclosed passage used for transporting HPM and for purposes other than required means of egress. [5000, 2018]

3.3.31 Smoke. The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, together with the quantity of air that is entrained or otherwise mixed into the mass.

3.3.32 Source Valve. A shutoff valve on the piping system serving a bulk gas supply system where the gas supply, at service pressure, first enters the supply line. [55, 2016]

3.3.33 Standby Mode. A mode wherein all flow of flammable gas or liquid ceases and heaters have power removed.

3.3.34 System.

3.3.34.1 Access Floor System. An assembly consisting of panels mounted on pedestals to provide an under-floor space for the installations of mechanical, electrical communication, or similar systems or to serve as an air supply or return-air plenum.

3.3.34.2 Compressed Gas System. An assembly of equipment designed to contain, distribute, or transport compressed gases.

3.3.34.3 Continuous Gas Detection System. A gas detection system where the instrument is maintained in continuous operation and the interval between sampling of any point does not exceed 30 minutes. [5000, 2018]

3.3.34.4 Emergency Alarm System. A system to provide indication and warning of emergency situations involving hazardous materials and to summon appropriate aid.

3.3.35 Subatmospheric Gas Source (SAGS).

3.3.35.1 Subatmospheric Gas Storage and Delivery Source (Type 1 SAGS). A gas source package that stores and delivers gas at subatmospheric pressure and includes a container (e.g., gas cylinder and outlet valve) that stores and delivers gas at a pressure of less than absolute pressure of 14.7 psi at NTP.

3.3.35.2 Subatmospheric Gas Delivery Source (Type 2 SAGS). A gas source package that stores compressed gas and delivers gas at subatmospheric pressure and includes a container (e.g., gas cylinder and outlet valve) that stores gas at a pressure greater than absolute pressure of 14.7 psi at NTP and delivers gas at a pressure of less than absolute pressure of 14.7 psi at NTP.

3.3.36 Third Party. A professional, qualified as the result of training, education, and experience, who can perform a compliance and hazardous analysis of process equipment in accordance with this standard.

3.3.37 Tool. Any device, storage cabinet, workstation, or process machine used in the cleanroom.

3.3.38* Toxic Material. A material that produces a lethal dose or a lethal concentration within any of the following categories: (1) a chemical or substance that has a median lethal dose (LD50) of more than 50 mg/kg but not more than 500 mg/kg of body weight when administered orally to albino rats weighing between 200 g and 300 g each; (2) a chemical or substance that has a median lethal dose (LD50) of more than 200 mg/kg but not more than 1000 mg/kg of body weight when administered by continuous contact for 24 hours, or less if death occurs within 24 hours, with the bare skin of albino rabbits weighing between 2 kg and 3 kg each; (3) a chemical or substance that has a median lethal concentration (LC50) in air of more than 200 parts per million but not more than 2000 parts per million by volume of gas or vapor, or more than 2 mg/L but not more than 20 mg/L, of mist, fume, or dust when administered by continuous inhalation for 1 hour, or less if death occurs within 1 hour, to albino rats weighing between 200 g and 300 g each. [1, 2018]

3.3.38.1* Highly Toxic Material. A material that produces a lethal dose or lethal concentration that falls within any of following categories: (1) a chemical that has a median lethal dose (LD50) of 50 mg/kg or less of body weight when administered orally to albino rats weighing between 200 g and 300 g each; (2) a chemical that has a median lethal dose (LD50) of 200 mg/kg or less of body weight when administered by continuous contact for 24 hours, or less if death occurs within 24 hours, with the bare skin of albino rabbits weighing between 2 kg and 3 kg each or albino rats weighing 200 g to 300 g each; (3) a chemical that has a median lethal concentration (LC50) in air of 200 parts per million by volume or less of gas or vapor, or 2 mg/L or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour, or less if death occurs within 1 hour, to albino rats weighing between 200 g and 300 g each. [1, 2018]

3.3.39* Water-Reactive Material. A material that explodes, violently reacts; produces flammable, toxic, or other hazardous gases; or evolves enough heat to cause self-ignition or ignition of nearby combustibles upon exposure to water or moisture. [1, 2018]

3.3.40* Workstation. A defined space or an independent, principal piece of equipment using hazardous chemicals within a cleanroom or clean zone, where a specific function, a laboratory procedure, or a research activity occurs.

Chapter 4 Building Construction and Related Services

4.1 General.

4.1.1 Occupied Levels of Fabrication Areas. Normally, occupied levels of fabrication areas handling HPM shall be located at or above grade.

4.1.2 Fabrication Areas. Floors of fabrication areas separating fabrication areas from other uses shall be liquid-tight. [5000:34.3.7.2.1.4(B)]

Δ 4.2 Classification of Occupancy. Semiconductor manufacturing facilities containing cleanrooms and associated support facilities shall be considered to be general- or special-purpose industrial occupancies as defined in NFPA 101.

4.3* Noncombustible Construction Components. Cleanrooms rated ISO Class 5 or cleaner in accordance with ISO 14644-1, *Cleanrooms and Associated Controlled Environments — Part 1: Classification of Air Cleanliness*, or cleanrooms having clean zones rated ISO Class 5 or cleaner shall have approved, noncombustible components for walls, floors, ceilings, and partitions.

4.4 Fire Resistance Rating.

N 4.4.1 Fire resistance ratings shall be determined in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, or ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials*.

4.4.2 Fabrication areas shall be separated from each other by 1-hour fire resistance-rated construction.

Δ 4.4.3 Fabrication areas shall be separated from adjacent occupancies by not less than 1-hour fire resistance-rated construction and not less than the fire resistance rating required in NFPA 5000.

4.5 Pass-Throughs in Existing Exit Access Corridors.

4.5.1 Self-closing doors having a fire protection rating of not less than 1 hour shall separate pass-throughs from existing exit access corridors.

4.5.2 Pass-throughs shall be constructed as required for exit access corridors.

4.6 Vertical Openings.

4.6.1 Openings through floors of fabrication areas shall be permitted to be unprotected, in accordance with 4.5.2, where the interconnected levels are used solely for mechanical equipment directly related to the fabrication areas. [5000:34.3.7.2.1.5]

4.6.1.1 Mechanical, duct, and piping penetrations within a fabrication area shall not extend through more than two floors. [5000:34.3.7.2.1.5(A)]

4.6.1.2 The annular space around equipment passing through the penetrations shall be sealed at the floor level to restrict the movement of air. [5000:34.3.7.2.1.5(B)]

4.6.1.3 The fabrication area, including levels interconnected with ductwork and piping, shall be regulated as a single conditioned environment. [5000:34.3.7.2.1.5(C)]

4.6.2 Unenclosed vertical openings not contained within fire-rated construction shall be permitted as follows:

- (1) Such openings shall connect not more than two adjacent stories (one floor pierced only).
- (2) Such openings shall be separated from unprotected vertical openings serving other floors by a barrier.
- (3) Such openings shall be separated from corridors.
- (4)* Such openings shall be separated from other fire or smoke compartments on the same floor.
- (5) In new construction, the convenience opening shall be separated from the corridor referenced in 8.12.5.1(3) of NFPA 5000 by a smoke partition, unless Chapters 15 through 31 and 33 through 34 of NFPA 5000 require the corridor to have a fire resistance rating.
- (6)* Such openings shall not serve as a required means of egress.

4.7 Air Supply and Recirculation Systems.

4.7.1 The location of outside air intakes shall be chosen to avoid drawing in hazardous chemicals or products of combustion coming either from the building itself or from other structures and devices.

4.7.2 High-efficiency particulate air (HEPA) modules, ultra-low penetration air (ULPA) filter modules, and pre- or final filters in makeup and recirculation air-handling units shall meet ANSI/UL 900, *Standard for Air Filter Units*.

4.7.3 Air supply and recirculation ducts shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*.

4.7.4 A manually operated remote switch(es) to shut off the affected areas of the cleanroom air recirculation system(s) shall be provided at an approved location(s).

4.7.5 Testing.

Δ **4.7.5.1** Testing of automatic detection devices shall be conducted in accordance with the requirements of Chapter 12.

4.8* Electrical Classification.

Δ **4.8.1 General.** The fabrication area or cleanroom shall be considered unclassified electrically with respect to Article 500 of NFPA 70, where all of the following requirements are met:

- (1) Chemical storage and handling meet the requirements of Chapters 5, 6, and 7 of this standard.
- (2) Ventilation and exhaust systems meet the requirements of this chapter and Chapter 9 of this standard.
- (3) The average ventilation flow rate is not less than 0.176 L/sec·m² (4 ft³/min·ft²) of floor area, and the ventilation flow rate at any location is not less than 0.132 L/sec·m² (3 ft³/min·ft²) of floor area. The use of recirculated air shall be allowed.

4.8.2 Workstations. Workstations shall be in accordance with 8.4.2.

Δ **4.9 Emergency Power System.** An emergency power system shall be provided for electrically operated equipment and connected control circuits for the following systems:

- (1) Hazardous chemical exhaust ventilation systems
- (2) Hazardous chemical gas cabinet ventilation systems
- (3) Hazardous chemical exhausted enclosure ventilation systems
- (4) Hazardous chemical gas room ventilation systems
- (5) Hazardous chemical room ventilation systems
- (6) Hazardous chemical gas-detection systems
- (7) Emergency alarm systems
- (8) Manual fire alarm systems
- (9) Automatic fire sprinkler system monitoring and alarm systems
- (10) Electrically operated systems required elsewhere in this standard, NFPA 1, or NFPA 5000 applicable to the use, storage, or handling of hazardous chemicals

Δ **4.9.1** Diesel generators shall be installed in accordance with the requirements of NFPA 37.

4.10 Means of Egress.

Δ **4.10.1** Means of egress shall be provided in accordance with NFPA 101.

4.10.2 Service Corridors.

4.10.2.1 Service corridors shall be provided with two or more exits, and not more than one-half of the required number of exits shall lead to the fabrication area.

4.10.2.2 The travel distance within a service corridor to an exit or to a door into a fabrication area shall not exceed 23 m (75 ft). Dead ends shall not exceed 1.22 m (4 ft).

4.10.2.3 Doors from service corridors shall swing in the direction of exit travel and shall be self-closing.

Chapter 5 Hazardous Materials — General Provisions

5.1* Hazardous Chemicals.

Δ **5.1.1 Materials Classification.** Hazardous production materials (HPM) shall be classified in accordance with NFPA 704 and shall be defined by the classes of chemicals or substances in 5.1.1.1 and 5.1.1.2.

5.1.1.1 Physical Hazards. The following material categories shall be classified as physical hazards, and a material with a primary classification as a physical hazard can pose a health hazard:

- (1) Flammable and combustible liquids
- (2) Flammable solids and gases
- (3) Oxidizer materials
- (4) Pyrophoric liquids, gases, and solids
- (5) Unstable (reactive) materials
- (6) Water-reactive solids and liquids
- (7) Cryogenic fluids
- (8) Compressed gases

5.1.1.2 Health Hazards. The following material categories shall be classified as health hazards, and a material with a primary classification as a health hazard can pose a physical hazard:

- (1) Highly toxic and toxic materials
- (2) Corrosive materials

5.2 HPM Risk Assessment.

5.2.1 This section shall apply to the management methodology used to identify, evaluate, and control the hazards involved in the processing and handling of flammable and combustible liquids. These hazards include, but are not limited to, preparation; separation; purification; and change of state, energy content, or composition.

5.2.2 Operations involving flammable and combustible liquids shall be reviewed to ensure that fire and explosion hazards are addressed by fire prevention, fire control, and emergency action plans. [30:6.4.1]

Exception No. 1: Operations where liquids are used solely for on-site consumption as fuels.

Exception No. 2: Operations where Class II or Class III liquids are stored in atmospheric tanks or transferred at temperatures below their flash points.

Table 5.5 Minimum Separation of Hazardous Production Materials (HPMs)

Material	Highly Toxic	Toxic	Acid	Base	Flammable	Oxidizer	Water-Reactive	Pyrophoric	Unstable (Reactive)	Organic Peroxide
Highly toxic		NR	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
Toxic	NR		S	S	S	S	S	S	S	S
Acid	1 hr	S		S	S*	S	S	S*	S	S
Base	1 hr	S	S		S	S	S	S	S	S
Flammable	1 hr	S	S*	S		S	R	S	S	S
Oxidizer	1 hr	S	S	S	S		S	S*	S	S
Water-reactive	1 hr	S	S	S	R	S		S	S	S
Pyrophoric	1 hr	S	S*	S	S	S*	S		S	S
Unstable (reactive)	1 hr	S	S	S	S	S	S	S		S
Organic peroxide	1 hr	S	S	S	S	S	S	S	S	

NR = Not required.

1 hr = 1-hour fire resistance-rated construction.

S = Separation by a partial noncombustible partition extending not less than 457 mm (18 in.) above and to the sides of the stored material.

R = Separate rooms, which are not required to have a fire resistance rating.

Note: HPM gases are required to be separated from HPM liquids and solids by 1-hour fire resistance-rated construction or are required to be kept in approved gas cabinets. HPM gases also are required to be separated from gases in other HPM hazard categories as required by Table 5.5, or are required to be kept in approved gas cabinets.

*Separation by not less than 6 m (20 ft) is permitted in lieu of a noncombustible partition.

5.2.3 The fire hazards management review shall be repeated whenever the hazards leading to a fire or explosion change significantly. Conditions that shall require repeating a review shall include, but are not limited to, the following:

- (1) When changes occur in the materials in process
- (2) When changes occur in process equipment
- (3) When changes occur in process control
- (4) When changes occur in operating procedures or assignments

5.2.4 A written emergency action plan that is consistent with available equipment and personnel shall be established to respond to fires and related emergencies. This plan shall include the components contained in 6.8.1 of NFPA 30.

5.3 Container Delivery.

5.3.1* In new buildings, a service corridor shall be provided when necessary to transport hazardous chemicals from a liquid storage room, hazardous chemical room, or gas room or from the outside of a building to the perimeter wall of a fabrication area.

5.3.1.1 Hazardous chemicals shall be transported in approved chemical carts.

5.3.2 Hazardous chemicals shall not be dispensed or stored in exit access corridors.

5.3.3* Chemical carts transporting or containing hazardous chemicals shall be designed so that the contents will be fully enclosed.

5.3.3.1 Chemical carts shall be capable of containing a spill from the largest single container transported, with a maximum individual container size of 20 L (5.3 gal) for liquids.

5.3.3.2 The capacity of carts used for the transportation of hazardous chemicals shall not exceed the following:

- (1) Liquids: 208 L (55 gal)
- (2) Solids: 227 kg (500 lb)
- (3) Compressed gases: 7 cylinders, up to 18 kg (40 lb) each
- (4) SAGS: 7 cylinders, up to 18 kg (40 lb) each

5.3.4 Incompatible chemicals shall not be transported simultaneously on the same hazardous chemical cart.

5.3.5 The minimum clear width of a service corridor shall be 1524 mm (5 ft) or 838 mm (33 in.) wider than the widest cart or truck used in the service corridor, whichever is greater.

5.3.6 Service corridors shall not be used as a required means of egress.

5.3.7 The maximum quantities of hazardous chemicals transported in a service corridor at one time shall not exceed two times that set forth in 6.3.3.

5.4 Storage and Handling of Hazardous Chemicals. Storage and handling of hazardous chemicals shall comply with applicable NFPA standards, including the following:

- (1) NFPA 30
- (2) NFPA 55
- (3) NFPA 70
- (4) NFPA 385
- (5) NFPA 400

5.5* Separation of Hazardous Chemicals. Hazardous chemicals stored in hazardous chemical rooms shall be separated from incompatible materials in accordance with Table 5.5.

▲ **5.5.1** Hazardous chemical rooms and gas rooms shall be separated from the fabrication area by not less than 2-hour fire resistance-rated construction, with the fire resistance rating in accordance with *NFPA 5000*, Chapter 8.

▲ **5.5.2** Hazardous chemicals in the fabrication area shall be limited to those needed for operations and maintenance and as required by 5.5.2.1 through 5.5.2.3, with quantities not exceeding the limitations specified in Table 5.5.2. The limits of Table 5.5.2 shall be permitted to be exceeded, provided a submittal using alternative methods and materials is approved by the authority having jurisdiction (AHJ).

■ **5.5.2.1** The amount of hazardous material allowed to be stored, used, or handled in a control area shall be the exempt amount set forth in *NFPA 1* and *NFPA 5000*, and it shall be based on the material state (solid, liquid, or gas) and the material storage or use conditions.

▲ **5.5.2.2** Quantities of hazardous chemicals shall be limited to those in use within the tool or the daily (24-hour) supply of chemicals needed, with quantities not exceeding the limitations specified in Table 5.5.2.2 unless a risk assessment determines that a significant fire is unlikely to take place.

5.5.2.2.1* The amounts in Table 5.5.2.2 shall be permitted to be exceeded if a risk assessment is performed and approved by the AHJ.

5.5.2.3 Storage of hazardous chemicals in the fabrication area shall be within approved or listed storage cabinets, gas cabinets, or exhausted enclosures, or within a tool.

5.5.3 Hazardous chemical storage and dispensing rooms shall have mechanical exhaust ventilation as follows:

- (1) Mechanical exhaust ventilation shall be at a minimum rate of $0.31 \text{ m}^3/\text{min}\cdot\text{m}^2$ ($1 \text{ ft}^3/\text{min}\cdot\text{ft}^2$) of floor area.
- (2) Exhaust and inlet openings shall be arranged to prevent accumulation of vapors.

5.5.4 Incompatible Storage.

▲ **5.5.4.1** Incompatible hazardous materials shall be separated from each other in accordance with *NFPA 1*.

5.5.4.2 Only inert gas shall be used for pressurization of gas-over-liquid delivery systems.

5.5.4.3 Containers of chemicals shall be labeled to identify their contents.

5.6 Systems, Equipment, and Processes. Systems, equipment, and processes utilized for storage, dispensing, use, or handling of hazardous materials shall be in accordance with 5.6.1 through 5.6.2.

5.6.1 Design and Construction of Containers, Cylinders, and Tanks.

5.6.1.1 Containers, cylinders, and tanks shall be designed and constructed in accordance with approved standards.

5.6.1.2 Containers, cylinders, tanks, and other means used for containment of hazardous materials shall be of an approved type.

5.6.2 Piping, tubing, valves, and fittings conveying hazardous materials shall be designed and installed in accordance with approved standards and shall be in accordance with 5.6.2.1.

▲ **5.6.2.1* Design and Construction.** Piping, tubing, valves, fittings, and related components used for hazardous materials shall be in accordance with the following:

- (1) Piping, tubing, valves, fittings, and related components shall be designed and fabricated from materials that are compatible with the material to be contained and shall be of adequate strength and durability to withstand the pressure, structural, and seismic stress and exposure to which they are subject.
- (2) Piping and tubing shall be identified in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems*, to indicate the material conveyed.
- (3) Readily accessible manual valves or automatic remotely activated fail-safe emergency shutoff valves shall be installed on supply piping and tubing at the following locations:
 - (a) The point of use
 - (b) The tank, cylinder, or bulk source
- (4) Manual emergency shutoff valves and controls for remotely activated emergency shutoff valves shall be identified and the location shall be clearly visible, accessible, and indicated by means of a sign.
- (5) Backflow prevention or check valves shall be provided when the backflow of hazardous materials could create a hazardous condition or cause the unauthorized discharge of hazardous materials.
- (6) Where gases or liquids have a hazard ranking of health hazard Class 3 or 4, flammability Class 4, reactivity Class 3 or 4 in accordance with *NFPA 704* and are carried in pressurized piping above gauge pressure of 103 kPa (15 psi), an approved means of leak detection and emergency shutoff or excess flow control shall be provided. Where the piping originates from within a hazardous material storage room or area, the excess flow control shall be located within the storage room or area.

5.6.3 Hazard Chemical Storage Cabinets. Hazardous chemicals shall be stored within enclosed storage cabinets or workstations.

5.6.3.1 Within hazardous materials storage or dispensing rooms, enclosures shall not be required.

5.6.3.2 Incompatible chemicals shall not be stored in the same cabinet.

5.6.3.3 Storage cabinets shall be constructed of not less than 1.2 mm (18 gauge) steel.

5.6.3.4 Doors shall be self-closing and shall be provided with a latching device.

5.6.3.5 Approved safety containers shall be used to store flammable liquids.

5.6.3.5.1 Where needed for purity, glass or plastic containers shall be permitted for quantities of 4 L (1 gal) or less per individual container.

5.7 Supply Piping.

5.7.1 Supply piping for hazardous chemical liquids and gases shall be welded throughout, except for connections to the systems that are located within a ventilated enclosure if the material is a gas, or an approved method of drainage or containment shall be provided for connections if the material is a liquid.