NFPA 306

Standard for the Control of Gas Hazards on Vessels

2003 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 306

Standard for the

Control of Gas Hazards on Vessels

2003 Edition

This edition of NFPA 306, *Standard for the Control of Gas Hazards on Vessels*, was prepared by the Technical Committee on Gas Hazards and acted on by NFPA at its May Association Technical Meeting held May 18–21, 2003, in Dallas, TX. It was issued by the Standards Council on July 18, 2003, with an effective date of August 7, 2003, and supersedes all previous editions.

This edition of NFPA 306 was approved as an American National Standard on July 18, 2003.

Origin and Development of NFPA 306

The original standard on this subject was developed by the NFPA Committee on Marine Fire Hazards in 1922 in cooperation with the NFPA Committee on Flammable Liquids. It was adopted by the Association and published as Appendix A of the "Regulations Governing Marine Fire Hazards." Further editions with minor changes were published in 1923, 1926, and 1930. In 1947, a completely revised standard was prepared by a joint committee of the American Bureau of Shipping and the National Fire Protection Association. A revised edition was developed by the NFPA Sectional Committee on Gas Hazards, approved by the Committee on Marine Fire Protection, and adopted in 1962, amended in 1963, 1969, 1971, 1972, 1975, 1980, and 1984.

In 1988, a complete revision was prepared by the Committee. It added a new safety designation, a safe condition for vessels in lay-up, and a section on military unique vessels. Chapters 2, 3, and 4 were restructured to present the sequence for obtaining a Marine Chemist Certificate.

The 1993 edition contained amendments to the 1988 edition.

The 1997 edition, which marked the 75th year for these requirements, incorporated a new standard safety designation that reflected a common approach to an industry practice. That new designation was also supported by other changes to the document, including expanded inspection of vessel piping systems.

The 2001 edition incorporated a revised standard safety designation, and several changes that reflect safe, commonly used industry practices. Several new definitions were also included. For the first time in this document, the well-established relationship between the Marine Chemist and the competent person (as defined by U.S. Department of Labor, Occupational Safety and Health Administration regulations), and the frequency of retesting confined spaces, was provided.

The 2003 edition was completed on an expedited schedule to further revise requirements in the standard that must complement those shipyard safety requirements defined by OSHA. The Committee has clarified the standard and the Marine Chemist role by further defining the atmospheric hazards associated with safe entry and hot work as the standard's primary focus. The standard also clarifies the intent for defining "permissible concentrations," by stating that the most conservative value for the various exposure limits should always be used.

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

Committee Scope: This Committee shall have primary responsibility for documents on the prevention of fire and explosion of flammable vapors in compartments or in spaces on board vessels and within shipyards and on the conditions that must exist in those compartments or spaces in order that workers can safely enter them and perform work.

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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 technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard applies to vessels that carry or burn as fuel, flammable or combustible liquids. It also applies to vessels that carry or have carried flammable compressed gases, chemicals in bulk, or other products capable of creating a hazardous condition.

1.1.2 This standard describes the conditions required before a space can be entered or work can be started, continued, or started and continued on any vessel under construction, alteration, or repair, or on any vessel awaiting shipbreaking.

1.1.3 This standard applies to cold work, application or removal of protective coatings, and work involving riveting, welding, burning, or similar fire-producing operations.

1.1.4 This standard applies to vessels while in the United States, its territories and possessions, both within and outside of yards for ship construction, ship alteration, ship repair, or shipbreaking.

1.1.5 This standard applies specifically to those spaces on vessels that are subject to concentrations of combustible, flammable, and toxic liquids, vapors, gases, and chemicals as hereinafter described. This standard is also applicable to those spaces on vessels that might not contain sufficient oxygen to permit safe entry.

1.1.6 This standard applies to land-side confined spaces, whether stationary or mobile, or other dangerous atmospheres located within the boundaries of a shipyard or ship repair facility.

1.1.7 This standard applies to Marine Chemists performing activities related to inspection and certification procedures described in this standard and consulting services connected therewith on board any vessel.

1.1.8* This standard does not apply to physical hazards of tanks and confined or enclosed spaces on a vessel or vessel sections, or in the shipyard. For the purposes of this standard, physical hazards do not include fire and explosion hazards.

1.2 Purpose. The purpose of this standard is to provide minimum requirements and conditions for use in determining that a space or area on a vessel, or in a shipyard or ship repair facility, is safe for entry or work.

1.3* Emergency Exception. Nothing in this standard shall be construed as prohibiting the Marine Chemist from allowing the immediate drydocking or emergency repair of a vessel whose safety is imperiled or which presents the potential of a serious release, discharge, or disbursement into the environment of combustible, flammable, or toxic liquids, vapors, gases, or solid chemicals (the vessel is sinking or is seriously damaged), making it impracticable to clean and to gas-free in advance. This emergency exception shall be subject to the approval of any authority having jurisdiction.

1.4* Governmental Regulations. Nothing in this standard shall be construed as superseding existing requirements of any governmental or local authority. Attention of owners, repairers, and Marine Chemists is directed to the Rules and Regulations for Tank Vessels and other rules and regulations for vessel inspection of the United States Coast Guard and the Occupational Safety and Health Administration standards (OSHA) of the United States Department of Labor, which prescribe an inspection prior to making repairs involving riveting, welding, burning, or similar fire-producing operations and prior to entering spaces where oxygen deficiency can exist. Those standards provide, under the conditions stated therein, for inspection by a Marine Chemist certificated by the National Fire Protection Association or, alternatively, for inspection by certain other persons.

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 Publication. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 312, *Standard for Fire Protection of Vessels During Construction, Repair, and Lay-Up,* 2000 edition.

2.3 Other Publications. (Reserved)

Chapter 3 Definitions

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

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3.2 NFPA Official Definitions.

3.2.1* 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.

3.2.2 Shall. Indicates a mandatory requirement.

3.2.3 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an 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 Adjacent Spaces. Those spaces in all directions from subject space, including all points of contact, corners, diagonals, decks, tank tops, and bulkheads. [**326:**1.4]

3.3.2 Certificate. See 3.3.12, Marine Chemist's Certificate.

3.3.3 Chemical. Any compound, mixture, or solution in the form of a solid, liquid, or gas that may be hazardous by virtue of its properties other than or in addition to flammability or by virtue of the properties of compounds that might be evolved from hot work or cold work.

3.3.4 Coiled Vessels. See 3.3.17.1.

3.3.5* Combustible Material. Material made of or surfaced with wood, compressed paper, plant fibers, plastics, or other material that will ignite and burn, whether flame-proofed or not, or whether plastered or unplastered.

3.3.6* Competent Person. A person who is designated in writing by their employer in accordance with 29 CFR 1915.7.

3.3.7 Facility. A shoreside location such as a shipyard, cleaning plant, naval base, dock, pier complex, etc. that is under the ownership or control of the same party and has the same continuous shoreline under their ownership or operation.

3.3.8 Flammable Compressed Gas. Any flammable gas that has been compressed, liquefied, or compressed and liquefied for the purpose of transportation and has a Reid vapor pressure exceeding 2.76×10^5 Pa (40 psia).

3.3.9 Hollow Structures. Rudders, rudder stocks, skegs, castings, masts and booms, rails, lapped plates, and other attachments to a vessel that enclose a void space.

3.3.10 Liquids.

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

3.3.10.2 *Cryogenic Liquid.* See 3.5.3.

3.3.10.3* *Flammable Liquid.* Any liquid that has a closed-cup flash point below 37.8°C (100°F).

3.3.11 Marine Chemist. The holder of a valid Certificate issued by the National Fire Protection Association in accordance with the "Rules for the Certification and Recertification of Marine Chemists," establishing the person's qualifications to determine whether construction, alteration, repair, or shipbreaking of vessels can be undertaken with safety. Activities of a Marine Chemist, as defined in this section, are limited to the inspection and certification procedures described in this standard and consulting services connected therewith.

3.3.12 Marine Chemist's Certificate (Certificate). A written statement issued by a Marine Chemist, stating the conditions that the Marine Chemist found at the time of inspection.

3.3.13* Secured. Closed in a manner to prevent opening or operation.

3.3.14 Shipbreaking. The breaking down of a vessel's structure for the purpose of scrapping the vessel.

3.3.15 Tank Barge. See 3.3.17.2.

3.3.16 Tank Ship. See 3.3.17.3.

3.3.17 Tank Vessel. Any vessel especially constructed or converted to carry liquid bulk cargo in tanks.

3.3.17.1 *Coiled Vessels.* Tank vessels using a closed system of heating coils that use thermal oil as the heating medium.

3.3.17.2 *Tank Barge.* Any tank vessel not equipped with a means of self-propulsion.

3.3.17.3 *Tank Ship.* Any tank vessel propelled by power or sail.

3.3.18 Toxic. Any material whose properties contain the inherent capacity to produce injury to a biological system, which is dependent on concentration, rate, method, and site of absorption.

3.3.19 Vessel. Includes every description of watercraft used, or capable of being used, as a means of transportation on water.

3.3.20 Visual Inspection. The physical survey of the space or compartment and surroundings in order to identify potential atmospheric and fire hazards.

3.4 Repair Classifications.

3.4.1 Cold Work. Any construction, alteration, repair, or shipbreaking that does not involve heat-, fire-, or spark-producing operations.

3.4.2* Hot Work. Any activity involving riveting, welding, burning, the use of powder actuated tools or similar fire producing operations as well as grinding, drilling, abrasive blasting, or similar operations not isolated physically from any atmosphere containing more than 10 percent of the lower explosive limit of a flammable or combustible substance.

3.4.3 Work Below Deck. Work in or on enclosed spaces surrounded by shell, bulkheads, and overheads.

3.4.4 Work in the Open. Work performed from open decks or in spaces from which the overhead has been completely removed.

3.5 Flammable Cryogenic Liquid Carriers.

3.5.1* Cargo Area. That part of the ship that contains the cargo containment system, cargo pump room, and compressor room and that includes the deck areas over both the full beam and the length of the ship located above the aforementioned.

3.5.2* Cargo Containment System. The arrangement for containment of cargo including, where applicable, a primary and secondary barrier, associated insulation, and any intervening spaces and adjacent structures if necessary for the support of these elements.

3.5.3 Cryogenic Liquid. A refrigerated liquefied gas having a boiling point lower than –90°C (–130°F).

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3.5.4 Hold Space. The space enclosed by the ship's structure in which a cargo containment system is situated.

3.5.5 Interbarrier Space. That space between a primary and secondary barrier, whether or not completely or partially occupied by insulation or other material.

3.5.6 Primary Barrier. The inner element designed to contain the cargo when the cargo containment system includes two boundaries.

3.5.7 Secondary Barrier. The liquid-resisting outer element of a cargo containment system designed to afford temporary containment of any envisaged leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level.

Chapter 4 Minimum Requirements for Issuance of Marine Chemist's Certificate and Maintenance Conditions

4.1 Determination of Conditions. The Marine Chemist shall personally determine conditions, and shall be permitted to issue a Marine Chemist's Certificate setting forth in writing that the prescribed work to a vessel can be undertaken with safety. The Marine Chemist shall, whenever possible, physically enter each compartment or space and conduct a visual inspection to the extent necessary to determine the atmospheric or fire hazards that exist. The Marine Chemist shall carry out tests within each compartment or space, ensuring compliance with the minimum applicable requirements prior to issuing a Certificate.

4.2 Procedures Prior to Issuance of a Certificate.

4.2.1 The calibration of all instruments used by the Marine Chemist shall be verified before each day's use by using a known concentration of test gas in a manner consistent with the manufacturer's recommendations. A record shall be maintained for at least three months.

4.2.2 The Marine Chemist's determinations shall include a visual inspection and tests of the spaces to be certified; and for repair or alterations involving hot work, all adjacent cargo tanks, spaces adjacent to cargo tanks, and other adjacent spaces containing or having contained flammable or combustible materials in accordance with 4.3.4(4). The determinations also shall include the following:

(1) The three previous cargo loadings
(2) Nature and extent of the work
(3) Starting time and duration of the work
(4) Tests of cargo and vent lines at manifolds and accessible openings
(5) Verification that pipelines that could release hazardous materials into spaces that will be certified ATMOSPHERE SAFE FOR WORKERS or SAFE FOR HOT WORK are either disconnected, blanked off, or otherwise blocked by a positive method, or the valves are positioned and tagged in such a manner to prevent, or by written notice restrict, operation
(6) Tests of cargo heating coils

4.3 Standard Safety Designations and Conditions Required. The following standard safety designations shall be used where applicable in preparing Certificates, cargo tank labels, and other references.

4.3.1* ATMOSPHERE SAFE FOR WORKERS requires that in the compartment or space so designated the following criteria shall be met at the time the permit is issued:

(1)*The oxygen content of the atmosphere is at least 19.5 percent and not greater than 22 percent by volume.
(2)*The concentration of flammable materials is below 10 percent of the lower explosive limit.
(3)*Any toxic materials in the atmosphere associated with cargo, fuel, tank coatings, inerting mediums, adjacent spaces, or fumigants are within permissible concentrations at the time of the inspection.

Exception: Further testing for toxic materials shall not be required if previous testing indicates that these materials have been eliminated or are not capable of regeneration to hazardous levels while maintained as directed on the Marine Chemist's Certificate.

(4)*The residues or materials associated with the work authorized by the Certificate are not capable of producing uncontrolled toxic materials under existing atmospheric conditions while maintained as directed on the Certificate.

4.3.1.1 If any of the conditions of 4.3.1(1), (2), (3), or (4) do not exist, then the designation NOT SAFE FOR WORKERS or ENTER WITH RESTRICTIONS shall be used.

4.3.2 NOT SAFE FOR WORKERS indicates that the compartment or space so designated shall not be entered by personnel.

4.3.3* ENTER WITH RESTRICTIONS indicates that in all spaces so designated, entry for work shall be permitted only if conditions of proper protective equipment, clothing, or time, or all of the aforementioned, as appropriate, are as specified.

4.3.4 SAFE FOR HOT WORK requires that in the compartment or space so designated the following criteria shall be met at the time the permit is issued:

(1)*The oxygen content of the atmosphere is not greater than 22 percent by volume.
(2)*The concentration of flammable materials in the atmosphere is less than 10 percent of the lower explosive limit.
(3) The residues, scale, or preservative coatings are cleaned sufficiently to prevent the spread of fire and are not capable of producing a higher concentration than permitted by 4.3.4(1) or (2) under existing atmospheric conditions in the presence of hot work and while maintained as directed on the Certificate; or, in the case of the engine room or fire room bilges, or other machinery spaces, are treated in accordance with the Marine Chemist's requirements.
(4) All adjacent spaces, containing or having contained flammable or combustible materials, are sufficiently cleaned of residues, scale, or preservative coatings to prevent the spread of fire; or are inerted; or, in the case of the ship's fuel tanks, lube tanks, or engine room or fire room bilges, or other machinery spaces, are treated in accordance with the Marine Chemist's requirements.

4.3.4.1 If any of the conditions of 4.3.4(1), (2), (3), or (4) do not exist, the designation NOT SAFE FOR HOT WORK shall be used.

4.3.5 NOT SAFE FOR HOT WORK indicates that in the compartment so designated, hot work shall not be permitted.

4.3.6 SAFE FOR LIMITED HOT WORK indicates that all of the following criteria shall be met at the time the permit is issued:

(1) Any compartment or space so designated meets the requirements of 4.3.4(1) and 4.3.4(2) (unless inerted in accordance with 4.3.8).

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(2) The Certificate shall include a statement describing the specific location of the hot work and the type of the hot work. The Marine Chemist shall also be permitted to list any areas to be excluded from hot work. These areas shall be listed on the Certificate under the heading "limitations."
(3) The space meets one of the following conditions:
   (a) The space or compartment is inerted in accordance with 4.3.8, adjacent spaces shall be treated in accordance with 4.3.4(4), and the hot work shall be limited to the specific location or locations described in the "limitations" in 4.3.6(2).
   (b) The space or compartment meets the requirements of 4.3.4(1), (2), (3), and (4); the hot work shall not be allowed on adjacent spaces or pipelines, or both as applicable; and the hot work limitations shall be described in the "limitations" in 4.3.6(2).
   (c) Portions of the space or compartment meet the requirements of 4.3.4(3) and (4), as well as the applicable portions of 5.1.3, and the hot work shall be limited to the location or locations described in the "limitations" in 4.3.6(2).

4.3.7 SAFE FOR SHIPBREAKING requires that the compartment so designated shall meet the criteria of 4.3.4(1) through (4). The residual combustible materials designated shall not be capable of producing fire beyond the extinguishing capabilities of the equipment on hand.

4.3.8 INERTED requires that one of the following procedures shall have been completed in the compartment or space so designated:

(1)*Carbon dioxide or other nonflammable gas acceptable to the Marine Chemist shall have been introduced into the space in sufficient volume to maintain the oxygen content of the atmosphere of the enclosed space at or below 6 percent or 50 percent of the amount required to support combustion, whichever is less. *(See Annex E.)*
(2) The kind of gas and the safe disposal and securing of gas inerting media shall be noted on the Certificate by the Marine Chemist upon completion of repairs. Closing and securing of hatches and other openings, except vents, shall be permitted to be used as a "safe disposal" method by the Marine Chemist.
(3) The space is flooded with water, and that level shall be maintained throughout the intended work by securing valves and lines to the space, and provided that any hot work shall be performed against the water layer and at least 0.9 m (3 ft) below the level of the water inside the space. The gas content of the atmosphere or head space above the liquid level inside the space shall not exceed 10 percent of the lower explosive limit. Any such procedure shall be approved by the Marine Chemist.

4.3.9 INERTED FOR FLAMMABLE COMPRESSED GAS requires that individual pressure tanks with a working pressure of 3.45×10^5 Pa (50 psi) or more shall constitute a safe condition for such work not directly involving these tanks or their pipelines when a positive pressure is maintained on the tanks by the flammable vapors, and when special precautions are observed under carefully controlled conditions as specified on the Certificate.

4.3.10 SAFE FOR LAY-UP requires that the tank ship so designated shall meet any of the following conditions at the time the permit is issued:

(1) The vessel is cleaned in accordance with the provisions in Section 5.1, and the vessel is inspected weekly by the responsible owner's representative to ensure that no change in conditions occurs.
(2) All the cargo tanks are discharged of cargo, the residues are not capable of producing more than 10 percent of the lower explosive limit, and the vessel is inspected weekly by the responsible owner's representative to ensure that no change in conditions occurs.
(3) All the cargo tanks are inerted to less than 8 percent oxygen, or 50 percent of the amount of oxygen required to support combustion, whichever is less. Thereafter, the responsible owner's representative shall be in constant attendance, and the vessel shall be reinspected daily until stabilized; and, thereafter, the responsible owner's representative shall maintain daily inspections and records of oxygen content.

4.3.10.1 Preparation of vessels for lay-up shall be in accordance with NFPA 312, *Standard for Fire Protection of Vessels During Construction, Repair, and Lay-Up.*

4.3.10.2 Failure to comply with the requirements of 4.3.10 shall void the Certificate.

4.4 Preparation of Certificates. When the Marine Chemist is satisfied that the related requirements necessary for the safe conduct of the work have or have not been met, a Certificate shall be prepared in form and manner prescribed by this standard. The Certificate shall be written legibly. If ink stamps are used, all copies of the Certificate shall be stamped and legible.

4.4.1* The Certificate shall include instrument test results of the Marine Chemist's inspections and tests, including required adjacent spaces.

4.4.2 Any additional requirements or qualifications issued by the Marine Chemist shall be specified on the Certificate, including the following:

(1) Frequency and type of such additional tests, inspections, qualifications, and other instructions as the Marine Chemist specifies
(2) Conditions under which the Marine Chemist shall be consulted or recalled

4.4.3* Such qualifications and requirements shall include precautions, including protective equipment and devices, necessary to eliminate or minimize hazards that could be present from protective coatings or residues from cargoes. These qualifications also shall include limitations or restrictions, if any, on the areas where work is to be done.

4.5 Issuance of Certificates. The Certificate shall be completed, and a signature for receipt of the Certificate shall be obtained, signifying the understanding of the conditions and limitations and the requirements for maintaining conditions under which it is issued. Any additions to or deletions from such a Certificate after obtaining a signature for receipt shall void the Certificate and require reissuance.

4.5.1 If the Certificate is issued in connection with commencement of repair work, it shall be delivered to and signed for by the ship repairer or his authorized representative.

4.5.2 If the Certificate is issued for purposes other than the commencement of repair work, it shall be delivered to and signed for by the person who authorized the inspection or an authorized representative.

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4.6 Responsibility for Obtaining Certificate and Maintaining Conditions.

4.6.1 Obtaining the Certificate.

(A) It is the responsibility of the vessel repairer, shipbreaker, or vessel builder to retain the services of the Marine Chemist, to secure copies of the Certificate, and to provide the master of the vessel and the representatives of the vessel owner with copies of such Certificate. Receipt and understanding of the Certificate shall be acknowledged by signature of the person designated in 4.5.1 or 4.5.2, as applicable.

(B) It is the responsibility of the person signing for receipt of the Certificate to securely post the Certificate in a conspicuous place aboard the vessel before a space is entered or work is started.

(C) It is the responsibility of the vessel repairer, shipbreaker, vessel builder, owner, or their representative to ensure that all access openings to spaces designated NOT SAFE FOR WORKERS, including inerted spaces, shall be appropriately labeled with a warning sign, which reads "NOT SAFE FOR WORKERS" and which shall remain in place unless recertified.

(D) Under no circumstances shall the Certificate be represented by the Certificate holder to be transferable to any other vessel repairer, shipbreaker, or vessel builder unless authorized by the Marine Chemist on the Certificate.

4.6.2 Maintaining the Certificate. In order for the Certificate to be maintained, the following conditions shall be met by the vessel repairer, shipbreaker, vessel builder, or owner or their representative:

(1) Work authorized by the Certificate shall commence within 24 hours unless otherwise noted on the Certificate.
(2) Throughout the course of repairs or alterations, conditions on the Certificate shall be maintained on the vessel by testing and visually inspecting all certified spaces, including all adjacent spaces, accessory piping, valves, coils, and so on, that were part of the original inspection.
(3)* Unless otherwise stated on the Certificate, all spaces and affected adjacent spaces shall be reinspected daily by the competent person or authority having jurisdiction as applicable or more often as necessary, in support of work prior to entry or recommencement work.
(4) Certificates not maintained according to the requirements in 4.6.2(1) through (5) shall be void.
(5) It is the responsibility of the vessel repairer, shipbreaker, vessel builder, owner, or their representative to ensure that the prescribed work is carried out at the original location within the facility for which the Certificate was issued, unless movement is authorized within that facility by the Marine Chemist on the Certificate. If movement is authorized within the facility, a reinspection shall be performed by a competent person. The Marine Chemist shall include on the Certificate the nature of any tests to be performed after the move is complete and prior to beginning work.
(6) The calibration of all instruments used by a competent person to maintain a Marine Chemist's Certificate shall be verified by either the competent person, another qualified individual, or metrology laboratory, before each day's use by using a known concentration of test gas in a manner consistent with the manufacturer's recommendations. A record shall be maintained for at least 3 months.

Chapter 5 Preparing Vessels for Issuance of a Marine Chemist's Certificate Involving Hot Work

5.1 Where a Safe Condition Is to Be Obtained Entirely by Cleaning. *[See Figure B.1 Part (b) in Annex B.]*

5.1.1 All cargo pumps, cargo lines, inert gas lines, crude oil wash lines, piped cargo fire-extinguishing lines, vapor control and recovery lines, and vent lines shall have been flushed with water, blown with steam or air, or inerted.

5.1.2 Compartments concerned shall be cleaned so that the atmosphere in all cargo compartments and adjacent spaces, including those diagonally adjacent to the cargo compartments, is in accordance with 4.3.1, 4.3.4, or 4.3.6, or with both 4.3.1 and 4.3.6, or with both 4.3.1 and 4.3.4, as applicable.

5.1.3 Partial Cleaning for Limited Hot Work. Tanks or compartments containing combustible residues or preservative coatings shall be permitted to be partially cleaned for limited hot work as described by 5.1.3(A) and (B). Areas to be cleaned shall be cleaned a sufficient distance from the hot work to prevent the spread of fire and shall be cleaned in such a manner as to prevent sparks or slag from the hot work operations from being thrown or dropped into the other portions of the space. A fire watch shall not be used in lieu of cleaning to establish a safe condition. The nature, location, and extent of the hot work shall be listed on the Marine Chemist's Certificate.

(A) Tanks or compartments that have not been washed or steamed and have residues or preservative coatings whose flash point is 82.2°C (180°F) or above, and are free of flowing residues or coatings shall be permitted to be partially cleaned for limited hot work. The area to be cleaned shall meet the requirements of 4.3.4. The flash point of the residues or preservative coatings shall be verified by the Marine Chemist prior to issuing a Certificate.

(B)* Tanks or compartments that have been washed or steamed as thoroughly as practicable and are free of flowing residues or preservative coatings shall be permitted to be partially cleaned for limited hot work. The area to be cleaned shall meet the requirements of 4.3.4. An ignitability test shall be performed on the residues or preservative coatings prior to issuing a Certificate.

5.1.4 The residues or preservative coatings in all compartments concerned (with the exception of tanks described in 5.1.3) shall be such that the conditions of either 4.3.1 or 4.3.4, or both 4.3.1 and 4.3.4, as applicable, shall be met.

5.2 Where a Safe Condition Is to Be Obtained by Both Cleaning and Inerting or Entirely by Inerting. *[See Figure B.1 Parts (c) and (d) in Annex B.]*

5.2.1 The Marine Chemist shall approve the use of the inerting medium and shall personally supervise introduction of the inerting medium into the space to be inerted, except in situations where an inerting medium has been introduced prior to the vessel's arrival at the repair facility. A Marine Chemist, in all cases, shall personally conduct tests to determine that the oxygen content of the inerted space is at or below 6 percent or 50 percent of the amount required to support combustion, whichever is less. The Marine Chemist shall be readily available during the entire period of work and shall determine that the oxygen level in the inerted space is maintained at or below 6 percent or 50 percent of the amount required to support combustion, whichever is lower. On vessels not utilizing cargo space–inerting systems, a Marine Chemist shall specify the safe disposal and securing of the inerting medium following completion of the repair work on the inerted space and adjacent spaces.

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5.2.2 All piped cargo fire-extinguishing systems within the cargo tanks and vent lines, except those in the inerted spaces, shall have been flushed with water, blown with steam or air, or inerted. (All valves to the inerted spaces shall be tagged and secured in such a manner as to prevent or, by written notice, restrict opening or operation.) All cargo pumps and cargo lines, inert gas lines, and crude oil wash lines shall have been flushed with water, blown with steam or air, or inerted.

5.2.3 All spaces to be inerted shall be sufficiently intact, and remain sufficiently intact, to retain the inerting medium. All valves, hatches, and other openings to the inerted spaces, except those controlling the inerting medium, shall be closed and secured.

5.2.4 Compartments or spaces in which internal repairs or alterations are to be undertaken shall be cleaned to comply with the requirements of Section 5.3, and all other spaces (with the exception of tanks described in 5.1.3) shall be inerted in accordance with the requirements of 4.3.8 or 4.3.9, as applicable.

5.2.5 Compartments or spaces on which external repairs or alterations are to be undertaken on the external boundaries (deck or shell) shall be permitted to be inerted by gas instead of being cleaned as described in Section 5.2, and all other spaces (with the exception of tanks described in 5.1.3) shall be inerted in accordance with the requirements of 4.3.8 or 4.3.9, as applicable.

5.3 Where a Safe Condition Is to Be Obtained by Cleaning Certain Compartments and by Securing the Other Compartments. *[See Figure B.1 Part (e) in Annex B.]*

5.3.1 Nonadjacent spaces containing atmospheres exceeding 10 percent of the lower explosive limit shall be closed and secured, and those spaces shall be noted on the Certificate.

5.3.2 All piped cargo fire-extinguishing systems and vent lines to the spaces involved shall have been flushed with water, blown with steam or air, or inerted; and the valves to all other compartments shall have been closed and secured. All cargo pumps and cargo lines, inert gas lines, and crude oil wash lines shall have been flushed with water, blown with steam or air, or inerted; and the valves shall have been closed and secured in a manner to prevent or, by written notice, restrict opening or operation.

5.3.3 Compartments or spaces in which internal repairs or alterations are to be undertaken and all adjacent compartments, including those diagonally adjacent thereto, shall be cleaned to comply with the applicable requirements of Section 5.1. All other applicable spaces shall be closed and secured in a manner to prevent or, by written notice, restrict opening or operation.

5.4 Where a Safe Condition Is to Be Obtained by Cleaning Some Compartments, by Inerting Some Compartments, and by Securing Some Compartments. *[See Figure B.1 Part (f) in Annex B.]*

5.4.1 All piped cargo fire-extinguishing systems and vent lines to the spaces involved, except those to the inerted spaces, shall have been flushed with water, blown with steam or air, or inerted; and the valves to all other compartments shall have been closed and secured in a manner to prevent or, by written notice, restrict opening or operation. All cargo pumps and cargo lines, inert gas lines, and crude oil wash lines shall have been flushed with water, blown with steam or air, or inerted; and the valves shall have been closed and secured in such a manner as to prevent or, by written notice, restrict opening or operation.

5.4.2 Nonadjacent spaces containing atmospheres exceeding 10 percent of the lower explosive limit shall be closed and secured in a manner to prevent or, by written notice, restrict opening or operation, and those spaces shall be noted on the Certificate.

5.4.3 Compartments or spaces in which internal repairs or alterations are to be undertaken shall be cleaned to comply with the requirements of Section 5.1; and all adjacent compartments, including those diagonally adjacent thereto, shall be inerted to comply with the applicable requirements of 4.3.8 and Section 5.2. All other compartments shall be closed and secured in compliance with 5.3.1. With respect to inerted spaces, the requirements of 5.2.1 shall apply.

5.4.4 Compartments or spaces on which external repairs or alterations are to be undertaken on the external boundaries (deck or shell) shall be permitted to be inerted by gas instead of being cleaned as described in Section 5.1. All adjacent compartments, including those diagonally adjacent thereto, shall be inerted or cleaned to comply with applicable requirements of 4.3.8 and Sections 5.1 and 5.2. All other applicable spaces shall be closed and secured in compliance with 5.3.1.

5.5 Cargo Heater Coils.

5.5.1 All steam-supplied cargo heater coils to the spaces involved, except those to the inerted spaces, shall have been made safe by one of the following means:

(1) Steaming
(2) Flushing with water
(3) Blowing with air
(4) Inerting

5.5.2 Coils in cargo tanks that have been used for chemicals that could react with water or steam shall be cleaned in accordance with the requirements of 7.3.2.

5.5.3 On coiled vessels using thermal heating oils [260°C (500°F) or greater], the Marine Chemist shall be satisfied as to the integrity of the heater coils in the prescribed work areas.

5.6 Electric Welding Operations. When determined to be necessary by the Marine Chemist, electrical welding ground cables shall be connected to the ship's structure, as close as possible to the point of welding, with a safe current-carrying capacity equal to or exceeding the specified maximum output capacity of the unit that it services.

5.7 Requirements for Use of a Designated Berthing Area for Cleaning, Gas Freeing, or Inerting.

5.7.1 Vessels that have not been cleaned, gas freed, or inerted shall proceed to a designated berth, selected and set apart with due regard to the hazards of the location and to the hazards to adjacent property.

5.7.2 The degassing, cleaning, or inerting of vessels at such designated berths shall be carried out in accordance with the requirements of Section 5.1 or Section 5.2, as appropriate, before they are shifted to other berths. No repairs involving hot work, other than in boiler or machinery spaces when specifically certified by a Marine Chemist, shall be undertaken on any vessel in such designated berth until it has been degassed and cleaned or inerted in accordance with the requirements of Section 5.1 or Section 5.2, as appropriate, nor shall such repairs be then undertaken if another vessel that has not complied with these requirements is in the designated berth at the same time.

5.8 Vessel Fuel Oil Tanks. No hot work shall be permitted adjacent to any vessel's fuel oil tanks unless the work has been authorized by the Marine Chemist.

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Chapter 6 Vessels Required to Have Marine Chemist's Certificate

6.1 Tank Vessels. Tank vessels shall be permitted to be repaired in accordance with the provisions of Chapter 5. A Certificate to this effect shall be required. Repairs or alterations involving hot work shall not be undertaken unless specifically authorized by the Certificate.

Exception No. 1: Tank vessels shall be permitted to enter a repair yard — while afloat or in dry dock — for examination, provided that all bulk cargo compartments and cofferdams are kept closed.

Exception No. 2: Tank vessels shall be permitted to enter a repair yard — while afloat or in dry dock — for scraping, washing down, and painting, provided that all bulk cargo compartments and cofferdams are kept closed.

Exception No. 3: Tank vessels shall be permitted to enter a repair yard — while afloat or in dry dock — for cold work to be performed outside of the vessel on the propeller, tailshaft, or rudder, or for hot work to be performed off the vessel, such as on the anchors or chains, provided that all bulk cargo compartments and cofferdams are kept closed.

Exception No. 4: Tank vessels shall be permitted to enter a repair yard — while afloat or in dry dock — for work within boiler and machinery spaces and other locations provided that, where hot work is to be undertaken, a Certificate shall be required. This Certificate shall set forth each specific location for which hot work is approved. All bulk cargo compartments, cofferdams, and other areas where the flammable content of the atmosphere is above 10 percent of the lower explosive limit shall be kept closed and secured. The securing of the compartments, cofferdams, and other areas shall be noted on the Certificate.

6.2 Vessels Other Than Tank Vessels. On any vessels that have carried flammable or combustible liquid in bulk as fuel or cargo, or that have carried cargoes that can produce hazardous atmospheres (including, but not limited to, those caused by decomposition or reaction with oxygen from the atmosphere), no repairs involving hot work shall be made in or on the external boundaries (shell, tank top, or deck) of cargo tanks, fuel tanks, oil pipelines, heating coils or hollow structures, and machinery spaces, unless such compartments and pipelines, as deemed necessary by the Marine Chemist, have been cleaned or inerted to meet the appropriate designation requirements of 4.3.4 and 4.3.8. Repairs and alterations shall not be undertaken until a Certificate is obtained.

6.3 Military Unique Vessels (i.e., U.S. Navy, Coast Guard, Army).

6.3.1 Oilers and tank barges shall be treated as tank vessels in accordance with Section 6.1.

6.3.2 All ammunition shall be removed from any space requiring hot work. Adjacent spaces containing ammunition shall be treated in accordance with the Marine Chemist's requirements. Adjacent spaces containing flammable or combustible liquids shall be treated in accordance with 4.3.4.

6.3.3 Adjacent tanks used for radiation shielding on nuclear-powered vessels shall be treated in accordance with the Marine Chemist's requirements.

6.3.4 All tanks, confined spaces, and machinery compartments in which internal repairs or alterations are to be undertaken shall be cleaned to comply with the requirements of either 4.3.1 or 4.3.3. For repair or alteration involving hot work, these spaces shall meet the requirements of 4.3.4 or 4.3.6, and adjacent compartments shall be cleaned to meet the requirements of 4.3.4 or shall be permitted to be inerted to meet the requirements of 4.3.8.

Exception: Spaces covered by 5.1.3, Section 5.8, and 6.3.3.

6.3.5 All tanks, confined spaces, and machinery compartments in which external repairs or alterations are to be undertaken shall be either cleaned to comply with the requirements of 4.3.4 or 4.3.6, or shall be inerted to comply with the requirements of 4.3.8. All adjacent compartments shall be cleaned to meet the requirements of 4.3.4 or shall be permitted to be inerted to meet the requirements of 4.3.8.

Exception: Spaces covered by 5.1.3, Section 5.8, and 6.3.3.

6.3.6 All other types of military vessels shall be treated in accordance with Section 6.2.

6.4 Vessels in Lay-Up. A tank ship in lay-up shall be treated in accordance with Section 6.1. No repairs or alterations involving hot work shall be made unless authorized by the Marine Chemist in accordance with the provisions of 4.3.10.

6.5 Vessels Carrying Flammable Compressed Gas. On any vessels that have carried flammable compressed gas in bulk, no repairs or alterations involving hot work shall be made unless the provisions of Section 6.1 have been complied with, provided individual pressure tanks (inerted in accordance with 4.3.9) are considered in a safe condition for such work not directly involving these tanks or their pipelines.

Chapter 7 Additional Requirements for Bulk Chemical Cargo Tanks

7.1 Scope.

7.1.1 This section describes the conditions required before repairs can be made in spaces that have carried or have been exposed to chemicals in bulk. The remaining spaces in the vessel shall comply with the applicable provisions in Chapter 6.

7.1.2 The definitions set forth in Section 3.5 shall apply to this chapter.

7.2 Minimum Requirements.

7.2.1 All minimum requirements for issuance of the Certificate set forth in Chapter 4 of this standard are applicable to spaces that have carried or have been exposed to chemicals in bulk.

7.2.2 The designation NOT SAFE FOR WORKERS shall be used for spaces that have carried material of unknown chemical hazards. *(See 4.4.3.)*

7.2.3 Results of any chemical hazard tests shall be permitted to be noted on the Certificate.

7.3 Minimum Conditions.

7.3.1 Minimum conditions that shall prevail prior to the issuance of a Certificate for spaces that have contained chemicals in bulk shall be as set forth in Chapter 5, insofar as they are applicable, and as set forth in this section.

7.3.2 All pipelines, including heating coils, fire-extinguishing systems, and vents, together with the cargo pumps and cargo lines serving the chemical-carrying spaces, shall be initially dealt with to the satisfaction of the Marine Chemist. Care shall be exercised in the selection of methods and materials used for cleaning or inerting to avoid noncompatibility with previous cargoes.

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7.3.3 Compartments having carried chemicals in bulk and that are to be cleaned shall be cleaned so that the atmosphere in those compartments is in accordance with 4.3.1 and 4.3.4, as applicable.

7.3.4 The residues in the compartments concerned shall be such that the conditions of 4.3.1 and 4.3.4, as applicable, will be met.

Chapter 8 Additional Requirements for Flammable Cryogenic Liquid Carriers

8.1 Scope.

8.1.1* The design and operational characteristics of tank, cargo-handling, and related systems on vessels carrying flammable cryogenic liquid cargoes shall be fully appreciated by the Marine Chemist in making the determinations required by Section 4.1 of this standard. This chapter describes the conditions required before repairs can be made in spaces that have carried or have been exposed to flammable cryogenic liquid cargoes in their liquid or vapor form.

8.1.2 This chapter supplements the factors to be considered prior to issuance of the Certificate in accordance with Section 4.1.

8.1.3 Only those Marine Chemists who have evidenced the required additional experience, training, and knowledge shall be authorized to issue Certificates under the requirements of Chapter 8. Such Marine Chemists shall receive a special endorsement on the Marine Chemist's Certificate issued them by the National Fire Protection Association.

8.2 Definitions. The following terms related to flammable cryogenic liquid carriers and defined in Chapter 3 shall apply to this chapter:

(1) Cargo Area *(3.5.1)*
(2) Cargo Containment System *(3.5.2)*
(3) Cryogenic Liquid *(3.5.3)*
(4) Hold Space *(3.5.4)*
(5) Interbarrier Space *(3.5.5)*
(6) Primary Barrier *(3.5.6)*
(7) Secondary Barrier *(3.5.7)*

8.3 Minimum Requirements.

8.3.1 All minimum requirements for issuance of the Certificate as set forth in Chapter 4 of this standard shall be met prior to commencement of hot work or entry in spaces that have carried or been exposed to flammable cryogenic liquids or their vapors.

8.3.2 The special safety designation SAFE FOR REPAIR YARD ENTRY shall apply only to flammable cryogenic liquid carriers and describes vessels whose compartments and spaces either have been tested by sampling at remote sampling stations, with results indicating that the atmosphere tested is above 19.5 percent oxygen and less than 10 percent of the lower explosive limit, or have been inerted in accordance with 4.3.8.

8.3.3 Vessels whose cargo containment systems have not met the criteria of 8.3.2 shall be permitted to undergo specific limited repairs in locations outside those spaces. However, such repairs or alterations shall not be undertaken until a Certificate is obtained. When undergoing such repairs, the vessel shall be berthed in a special location selected with due regard to the hazards of the location and to hazards to adjacent property. Should the Marine Chemist have reason to question the safety of any aspect of the site selection, he or she shall consult the proper governmental authorities.

8.3.4 Because interbarrier spaces or insulation could contain pockets of cargo vapors that can be released over varying time periods, the Marine Chemist shall inspect for gas concentration and combustible materials before work in or on the boundaries of such places is begun.

8.3.5 The following information shall be used by the Marine Chemist as a guide for making his or her inspection:

(1) Description and schematic arrangement of provisions for inerting cargo tanks, hold spaces, or interbarrier spaces, as applicable
(2) Description and instruction manual for calibration of the cargo leak detector equipment
(3) Schematic plan showing locations of leak detector(s) and sampling points
(4) Schematic plan(s) of liquid and vapor cargo piping
(5) U.S. Coast Guard Letter of Compliance and Certificate of Fitness for foreign flag vessels, or the Certificate of Inspection and Certificate of Fitness for U.S. flag vessels
(6) The recent history of cargoes handled with special reference to outturn and any pertinent unusual incidents encountered

8.4 Minimum Conditions.

8.4.1 Minimum conditions that shall prevail prior to the issuance of a Certificate for spaces that have contained or been exposed to flammable cryogenic liquids or their vapors shall be as set forth in Chapter 5, insofar as they are applicable, and as set forth in Section 8.4.

8.4.2 When vessels are undergoing repairs, no venting of cargo tanks, systems, or other spaces that could contain inert gas or flammable vapors shall take place without approval of the Marine Chemist. Any other activity that could similarly alter the atmosphere in the vicinity of the repair work shall be permitted to be undertaken only with such approval.

8.4.3 Vessels that are capable of burning cargo boil-off as a fuel for their main propulsion system or for other purposes shall be inspected to ensure that gas supply lines to the fire room or other spaces have been properly secured, inerted, or otherwise properly treated prior to repairs to this system.

8.4.4 Prior to the opening of cargo machinery or systems for repairs, such equipment shall have been purged and ventilated to remove cargo vapor or inert gas.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.8 The Marine Chemist, as a shipyard safety professional, should take note of any observed physical hazards in a tank or confined or enclosed space, and convey that information to those individuals who are empowered and qualified to correct such hazards. Some examples of physical hazards are, among others, broken or rusted ladder rungs, engulfment, entrapment, obvious electrical hazards, and noise hazards.

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A.1.3 In all emergency situations, all necessary precautionary measures should be undertaken as soon as is practical to provide safe conditions satisfactory to the Marine Chemist.

A.1.4 All applicable regulations, requirements, and standards should be consulted.

A.3.2.1 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.3.5 Combustible Material. See 29 CFR 1915.52 for guidance when doing hot work near these materials, and NFPA 312, *Standard for Fire Protection of Vessels During Construction, Repair, and Lay-Up*, for additional information on doing hot work around combustible material.

A.3.3.6 Competent Person. In accordance with OSHA's Shipyard Industry standard (29 CFR 1915.7), competent persons are required to be designated by their employer. The employer also has to ensure that the designated competent person has specific skills, knowledge, and abilities based on the criteria set forth in 29 CFR 1915.7. Maritime confined space safety training is available from NFPA, many Marine Chemists, and other safety or training professionals.

In addition to the criteria outlined in 29 CFR 1915.7, the following content is suggested as a minimum for competent person training:

(1) *Hazard Description and Recognition*
   (a) Relevant terms, fire and explosion theory, relevant chemistry (including concepts of flash point, explosive range, the role of oxygen, classification of fuels, and solvent vapor pressure)
   (b) Relevant shipboard structures, locations, and systems
   (c) Toxicity of materials and concepts of exposure guidance
   (d) Toxicity resources, guidance, and standards: the ACGIH TLVs, OSHA's Maritime Standards
   (e) MSDS information and skills

(2) *Hazard Evaluation and Measurement*
   (a) Instrumentation theory, operation, maintenance, calibration, and hands-on training (including the workings and limitations of the combustible gas meter, the oxygen meter, colorimetric detector tube systems, and specific gas electrochemical sensors)
   (b) Preparation for and execution of shipboard confined space testing

(3) *Hazard Prevention, Control, and Elimination*
   (a) Regulations: Scope and Application of 29 CFR 1915 and NFPA 306
   (b) The responsibilities and interactions of the competent person and NFPA Certificated Marine Chemist
   (c) NFPA Marine Chemist's standard safety designations
   (d) Control of ignition sources
   (e) Ventilation theory and application
   (f) Key aspects of respiratory protection
   (g) The fire watch
   (h) Written competent person records
   (i) The Marine Chemist's Certificate

(4) *Practical Application Simulation*
   (a) Hands-on actual or simulated exercises, using instruments involving the students, as guided by the instructors
   (b) Practice and reviewed exercises in recordkeeping and certifications

(5) *Examination*

A.3.3.10.1 Combustible Liquid. Definition applies as determined by the test procedures and apparatus set forth in 1.7.4 of NFPA 30, *Flammable and Combustible Liquids Code*. Combustible liquids are classified as Class II or Class III as follows:

(1) Class II Liquid — Any liquid that has a flash point at or above 37.8°C (100°F) and below 60°C (140°F)
(2) Class IIIA — Any liquid that has a flash point at or above 60°C (140°F), but below 93°C (200°F)
(3) Class IIIB — Any liquid that has a flash point at or above 93°C (200°F)

A.3.3.10.3 Flammable Liquid. Definition applies as determined by the test procedures and apparatus set forth in Section 1.7.4 of NFPA 30, *Flammable and Combustible Liquids Code*. Flammable liquids are classified as Class I as follows:

(1) Class I Liquid — Any liquid that has a closed-cup flash point below 37.8°C (100°F) and a Reid vapor pressure not exceeding 2068.6 mm Hg (40 psia) at 37.8°C (100°F), as determined by ASTM D 323, *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method)*.

Class I liquids are further classified as follows:

(1) Class IA — Those liquids that have flash points below 22.8°C (73°F) and boiling points below 37.8°C (100°F)
(2) Class IB — Those liquids that have flash points below 22.8°C (73°F) and boiling points at or above 37.8°C (100°F)
(3) Class IC — Those liquids that have flash points at or above 22.8°C (73°F), but below 37.8°C (100°F)

A.3.3.13 Secured. Examples of a secured condition include dogged down, bolted down, removing or locking the valve handwheel, and labeled.

A.3.4.2 Hot Work. Grinding, drilling, abrasive blasting, or similar spark-producing operations are considered hot work unless deemed otherwise by a Marine Chemist and stated in writing on a Marine Chemist's Certificate.

A.3.5.1 Cargo Area. Where applicable, the cofferdams, ballast tanks, or void spaces located at the after end of the aftermost hold space, or at the forward end of the forwardmost hold space, are excluded from the cargo area.

A.3.5.2 Cargo Containment System. If the secondary barrier is part of the hull structure, it can be a boundary of the hold space.

A.4.3.1 Spaces adjacent to spaces that are certified by the Marine Chemist might or might not be open at the time of inspection. It is generally recognized that adjacent spaces pose a reduced risk to workers performing cleaning or other cold work in certified spaces. The Marine Chemist should consider

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those risks presented by adjacent spaces at the time of the inspection and prepare the Certificate based upon the knowledge of work described to the Marine Chemist by the vessel repairer, shipbreaker, or vessel builder. See statement on Certificate that highlights ". . . spaces not listed on the Certificate are not to be entered unless authorized on another Certificate and/or maintained in accordance with Subpart B, 29 CFR 1915."

A.4.3.1(1) It is important that any change from ambient air, either above or below, should be investigated. Even though any change from ambient air is undesirable, the range of 19.5 percent to 22 percent has been selected for reasons of the accuracy of the meter and the precision with which it can be read. The setting of the instrument for 20.8 percent should be made in ambient air under the conditions of temperature and humidity within the compartment or space to be tested.

A.4.3.1(2) The level of 10 percent of the lower explosive limit should not be used to determine the toxic level. It is to be used in those instances where a fire hazard would be present, such as with propane, methane, and so forth, but not be a toxic hazard.

A.4.3.1(3) Permissible concentrations can be found in the latest version of *Threshold Limit Values for Chemical Substances and Physical Agents,* published by the American Conference of Governmental Industrial Hygienists, in Subpart Z of 29 CFR 1915.1000, "Permissible Exposure Limit Value," or the value listed in the Manufacturers' Safety Data Sheet (MSDS).

In situations where a permissible exposure limit (PEL) and a threshold limit value (TLV) exist for a substance, it is recommended that the more conservative limit value be used when evaluating spaces for entry.

A.4.3.1(4) See A.4.3.1(3).

A.4.3.3 The ENTER WITH RESTRICTIONS designation is not intended to apply to spaces with immediately dangerous to life or health (IDLH) atmospheres except to install ventilation equipment or for emergency rescue. Other precautions that would apply to IDLH atmospheres are found in 29 CFR 1915, Subpart I.

A.4.3.4(1) See A.4.3.1(1).

A.4.3.4(2) The terms *lower flammable limit* and *lower explosive limit* are used synonymously. Refer to *Fire Protection Guide to Hazardous Materials.*

It is important that any change from the levels found by the Marine Chemist be investigated. A positive change in the lower explosive limit would indicate the presence of flammable contaminants in the atmosphere.

A.4.3.8(1) The improper introduction of an inerting gas can generate sufficient static electricity for ignition. Refer to NFPA 69, *Standard on Explosion Prevention Systems*, for level of oxygen to support combustion.

A.4.4.1 Due to the different methods of conducting tests for toxic materials, the results should be listed as "None detected" along with the limit of detection (LOD) or less than (<) the LOD when appropriate:

(1) Example 1: Benzene — None Detected LOD = 0.5 ppm.
(2) Example 2: Benzene <0.5 ppm.

A result listed as zero (0) does not provide enough information to the end user of the certificate. Some limits of detection can exceed established exposure limits.

A.4.4.3 If there is no additional statement regarding the scope of the work on the Certificate, any hot work or cold work can proceed as indicated by the standard safety designation. If all types of work cannot be conducted safely under a standard safety designation, then the authorized work or prohibited work should be listed on the Certificate.

A.4.6.2(3) The Marine Chemist can recognize a facility's procedures and infrastructure used to minimize risk and hazards to people and equipment through engineering controls supplemented by administrative controls. As an example, mechanical exhaust ventilation for the space has been installed and will operate continuously. OSHA, in 29 CFR 1915.13, notes that the frequency of retesting the atmospheric conditions of a space should be a function of several factors, including temperature, work in the tank, period of time elapsed, unattended tanks, work breaks, or ballasting.

A.5.1.3(B) This test can be performed by exposing a sample of the residue or preservative coating to a strong open flame and observing the ease with which it ignites or burns. This test should be performed off the vessel or in an area approved for hot work.

A.8.1.1 Flammable cryogenic liquid carriers present hazards due to the presence of gas-dangerous spaces. The following are examples of gas-dangerous spaces:

(1) A space in the cargo area that is not arranged or equipped in an approved manner to ensure that its atmosphere is at all times maintained in a gas-free condition.
(2) An enclosed space outside the cargo area through which any piping that could contain liquid or gaseous products passes, or within which such piping terminates, unless approved arrangements are installed to prevent any escape of product vapor into the atmosphere of that space.
(3) A cargo containment system and cargo piping.
    (a) A hold space where cargo is carried in a cargo containment system requiring a secondary barrier.
    (b) A hold space where cargo is carried in a cargo containment system not requiring a secondary barrier.
(4) A space separated from a hold space described in A.8.1.1(3)(a), above, by a single gastight steel boundary.
(5) A cargo pump room and cargo compressor room.
(6) A zone on the open deck or semienclosed space on the open deck within 3 m (9.84 ft) of any cargo tank outlet, gas or vapor outlet, cargo pipe flange, cargo valve, or entrance and ventilation opening to cargo pump rooms and cargo compressor rooms.
(7) The open deck over the cargo area and 3 m (9.84 ft) forward and aft of the cargo area on the open deck up to a height of 2.4 m (7.88 ft) above the weather deck.
(8) A zone within 2.4 m (7.88 ft) of the outer surface of a cargo containment system where such surface is exposed to the weather.
(9) An enclosed or semienclosed space in which pipes containing product are located.
(10) A compartment for cargo hose.
(11) An enclosed or semienclosed space having a direct opening into any gas-dangerous space or zone.

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Annex B Examples of Safe Conditions

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 The illustrations in Figure B.1 Parts (a) through (f) are examples of safe conditions discussed in Chapter 5 of this standard. The conditions shown in the drawings correspond to Sections 5.1 through 5.4 of this standard. Although the single plane drawings show horizontal separations only, vertical compartmentation should be similarly treated.

Annex C Sample Marine Chemist's Certificate

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 The certificate shown in Figure C.1 is a sample of the form that is to be filled out by the Marine Chemist at the completion of the inspection.

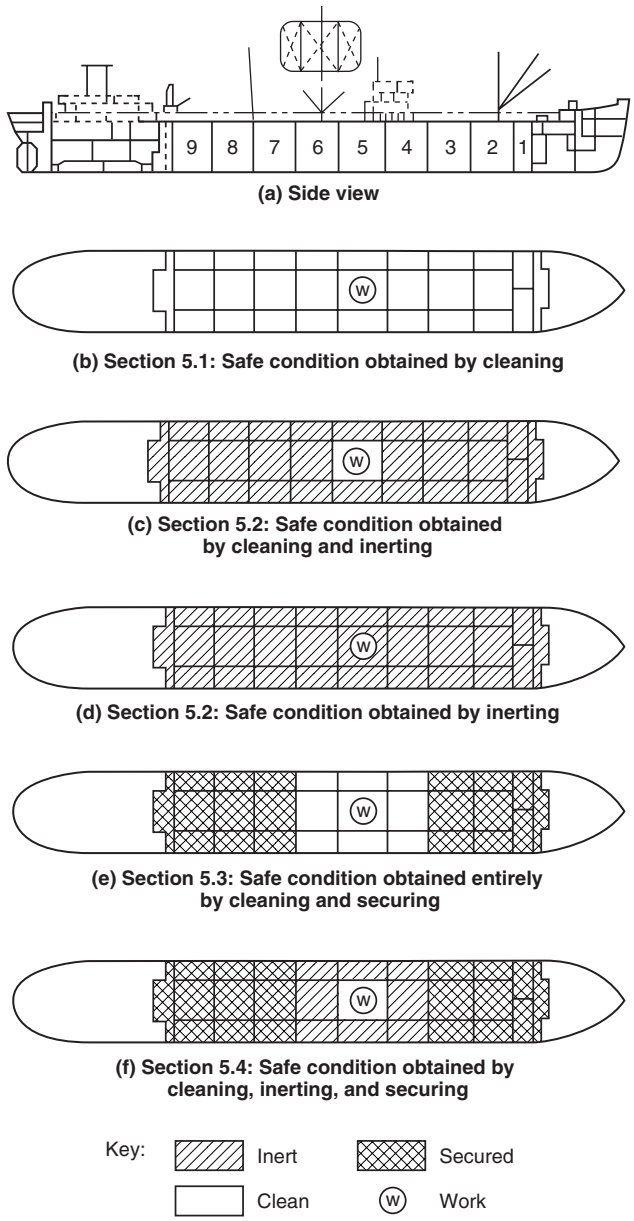
Annex D Guidance to Vessel Owners and Operators When Hot Work and/or Enclosed/Confined Space Entry Is Conducted on a Vessel at Sea and a Marine Chemist Is Not Required

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 This standard is not written to specifically address how to perform atmospheric monitoring that is necessary to achieve safe conditions related to gas freeing, tank entry, and hot work. This standard contains guidance on the criteria for a safe condition for entry and hot work. For guidance on performance of atmospheric testing by tank vessel personnel at sea when a Marine Chemist is not required, tank vessel owners and operators can reference the following documents:

(1) API 1141, *Guidelines for Confined Space Entry On Board Tank Ships in the Petroleum Industry*
(2) *International Safety Guide for Oil Tankers and Terminals* (ISGOTT)
(3) *Recommendations for Entering Enclosed Spaces Aboard Ships*
(4) *Tanker Handbook for Deck Officers*
(5) *Tanker Safety Guide* (Liquid or Chemical)
(6) 29 CFR 1915, Subpart B
(7) Individual company safety policies and practices

Training is viewed by the Committee as a very important aspect of a successful program for entering and working in confined or enclosed spaces. Specifying "how to" perform atmospheric monitoring in the context of this document is not appropriate but should be included in the training that all responsible personnel should receive.



(a) Side view

(b) Section 5.1: Safe condition obtained by cleaning

(c) Section 5.2: Safe condition obtained by cleaning and inerting

(d) Section 5.2: Safe condition obtained by inerting

(e) Section 5.3: Safe condition obtained entirely by cleaning and securing

(f) Section 5.4: Safe condition obtained by cleaning, inerting, and securing

FIGURE B.1 Illustrations of Safe Conditions.

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MARINE CHEMIST'S CERTIFICATE

MARINE CHEMIST CERTIFICATE
SERIAL NO. A 00000

Survey Requested by	Vessel Owner or Agent	Date
Vessel	Type of Vessel	Specific Location of Vessel
Last Three (3) Loadings	Tests Performed	Time Survey Completed

SAMPLE

In the event of physical or atmospheric changes affecting the STANDARD SAFETY DESIGNATIONS assigned to any of the above spaces,this certificate is voided; spaces not listed on the Certificate are not to be entered unless authorized on another Certificate and/or maintained in accordance with OSHA 29 CFR 1915; or if in any doubt, immediately stop all work and contact the undersigned Marine Chemist. Unless otherwise stated on the Certifcate, all spaces and affected adjacent spaces are to be reinspected daily or more often as necessary by the competent person or the authority having jurisdiction as applicable in support of work prior to entry or recommencement of work.

QUALIFICATIONS: Transfer of ballast, cargo, fuel, or manipulation of valves or closure equipment tending to alter conditions in pipelines, tanks, or compartments subject to gas accumulation, unless specifically approved in this certificate, requires inspection and a new certificate for spaces so affected. All lines, vents, heating coils, valves, and similar enclosed appurtenances are considered "not safe" unless otherwise specifically designated. Movement of the vessel from its specific location voids the certificate unless shifting of the vessel within the facility has been specifically authorized on this certificate.

STANDARD SAFETY DESIGNATIONS (partial list, paraphrased from NFPA 306, 4.3.1 through 4.3.6):

ATMOSPHERE SAFE FOR WORKERS: In the compartment or space so designated (a) the oxygen content of the atmosphere is at least 19.5 percent and not greater than 22 percent by volume; (b) the concentration of flammable materials is below 10 percent of the lower explosive limit; (c) any toxic materials in the atmosphere associated with cargo, fuel, tank coatings, inerting mediums, or fumigants are within permissible concentrations at the time of the inspection.

NOT SAFE FOR WORKERS: In the compartment or space so designated, entry is not permitted.

ENTER WITH RESTRICTIONS: In the compartment or space so designated, entry for work is permitted only if conditions of proper protective equipment, or clothing, or time, or all of the aforementioned, as appropriate, are as specified.

SAFE FOR HOT WORK: In the compartment or space so designated (a) the oxygen content of the atmosphere is not greater than 22 percent by volume; (b) the concentration of flammable materials in the atmosphere is less than 10 percent of the lower explosive limit; (c) the residues, scale, or preservative coatings are cleaned sufficiently to prevent the spread of fire and are not capable of producing a higher concentration than permitted by (a) or (b); (d) all adjacent spaces containing or having contained flammable or combustible materials are sufficiently cleaned of residues, scale, or preservative coatings to prevent the spread of fire, or they are to be inerted. Ship's fuel tanks, lube tanks, or engine room or fire room bilges, or other machinery spaces, are to be treated in accordance with the Marine Chemist's requirements.

NOT SAFE FOR HOT WORK: In the compartment or space so designated, hot work is not permitted.

SAFE FOR LIMITED HOT WORK: In the compartment or space so designated (a) portions of the space are to meet the requirements for Safe for Hot Work and Partial Cleaning, as applicable; (b) the space is to be inerted, adjacent spaces are to meet the requirements for Safe for Hot Work, and hot work is restricted to specific locations; (c) portions of the space are to meet the requirements for Safe for Hot Work, as applicable, and the nature or type of hot work is to be limited or restricted.

CHEMIST'S ENDORSEMENT: This is to certify that I have personally determined that all spaces in the foregoing list are in accordance with NFPA 306, *Standard for the Control of Gas Hazards on Vessels*, and have found the condition of each to be in accordance with its assigned designation.

The undersigned acknowledges receipt of this Certificate under NFPA 306 and understands conditions and limitations under which it was issued, and the requirements for maintaining its validity.

This Certificate is based on conditions existing at the time the inspection herein set forth was completed and is issued subject to compliance with all qualifications and instructions.

Signed _____
Name Company Date

Signed _____
Marine Chemist Certificate No.

VESSEL POSTING

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FIGURE C.1 Sample of the Form to be Filled Out after Inspection for Certification.

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Annex E Limiting Oxidant Concentrations

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 Limiting Oxidant Concentration for Flammable Gases When Using Nitrogen or Carbon Dioxide as Diluents. Table E.1(a) through Table E.1(c) will enable Marine Chemists to quickly reference certain inert gases and the corresponding limiting oxygen concentrations.

Table E.1(a) Limiting Oxidant Concentrations for Flammable Gases When Using Nitrogen or Carbon Dioxide as Diluents

Gas or Vapor	Limiting Oxidant Concentration (Volume % O_2 Above Which Deflagration Can Take Place) N_2/Air	CO_2/Air	Reference (See Table Note 3)
Methane	12.0	14.5	1
Ethane	11.0	13.5	1
Propane	11.5	14.5	1
n-Butane	12.0	14.5	1
Isobutane	12.0	15.0	1
n-Pentane	12.0	14.5	1
Isopentane	12.0	14.5	2
n-Hexane	12.0	14.5	1
n-Heptane	11.5	14.5	2
Ethylene	10.0	11.5	1
Propylene	11.5	14.0	1
1-Butene	11.5	14.0	1
Isobutylene	12.0	15.0	4
Butadiene	10.5	13.0	1
3-Methyl-1-butene	11.5	14.0	4
Benzene	11.4	14.0	1, 7
Toluene	9.5	—	7
Styrene	9.0	—	7
Ethylbenzene	9.0	—	7
Vinyltoluene	9.0	—	7
Divinylbenzene	8.5	—	7
Diethylbenzene	8.5	—	7
Cyclopropane	11.5	14.0	1
Gasoline			
(73/100)	12.0	15.0	2
(100/130)	12.0	15.0	2
(115/145)	12.0	14.5	2
Kerosene	10.0 (150°C)	13.0 (150°C)	5
JP-1 fuel	10.5 (150°C)	14.0 (150°C)	2
JP-3 fuel	12.0	14.5	2
JP-4 fuel	11.5	14.5	2
Natural gas (Pittsburgh)	12.0	14.5	1
n-Butyl chloride	14.0	—	3
	12.0 (100°C)	—	3
Methylene chloride	19.0 (30°C)	—	3
	17.0 (100°C)	—	3
Ethylene dichloride	13.0	—	3
	11.5 (100°C)	—	3
1,1,1-Trichloroethane	14.0	—	3
Trichloroethylene	9.0 (100°C)	—	3
Acetone	11.5	14.0	4
n-Butanol	NA	16.5 (150°C)	4
Carbon disulfide	5.0	7.5	4
Carbon monoxide	5.5	5.5	4
Ethanol	10.5	13.0	4
2-Ethyl butanol	9.5 (150°C)	—	4
Ethyl ether	10.5	13.0	4
Hydrogen	5.0	5.2	4
Hydrogen sulfide	7.5	11.5	4
Isobutyl formate	12.5	15.0	4
Methanol	10.0	12.0	4
Methyl acetate	11.0	13.5	4
Propylene oxide	7.8	—	8
Methyl ether	10.5	13.0	4
Methyl formate	10.0	12.5	4
Methyl ethyl ketone	11.0	13.5	4
UDMH (dimethylhydrazine)	7.0	—	6
Vinyl chloride	13.4	—	7
Vinylidene chloride	15.0	—	7

Notes:

1. See 2.7.2 from the 1997 edition of NFPA 69 for the required oxygen level in equipment.

2. Data were determined by laboratory experiment conducted at atmospheric temperature and pressure. Vapor–air–inert gas samples were placed in explosion tubes and ignited by electric spark or pilot flame.

3. References for Table E.1(a):

1. H. F. Coward and G. W. Jones, "Limits of Flammability of Gases and Vapors," Bulletin 503, U.S Bureau of Mines, 1952, 155 pp.

2. G. W. Jones, M. G. Zabetakis, J. K. Richmond, G. S. Scott, and A. L. Furno, "Research on the Flammability Characteristics of Aircraft Fuels," Wright Air Development Center, Wright-Patterson AFB, OH, Technical Report 52-35, Supplement I, 1954, 57 pp.

3. J. M. Kuchta, A. L. Furno, A. Bartkowiak, and G. H. Martindill, "Effect of Pressure and Temperature on Flammability Limits of Chlorinated Combustibles in Oxygen-Nitrogen and Nitrogen Tetroxide-Nitrogen Atmospheres," *Journal of Chemical and Engineering Data*, Vol. 13, No. 3, July 1968, p. 421.

4. M. G. Zabetakis, "Flammability Characteristics of Combustible Gases and Vapors," Bulletin 627, U.S Bureau of Mines, 1965, 121 pp.

5. M. G. Zabetakis and B. H. Rosen, "Considerations Involved in Handling Kerosine," *Proceedings API*, Vol. 37, Sec. III, 1957, p. 296.

6. Unpublished data, U.S. Bureau of Mines.

7. Unpublished data, Dow Chemical Co.

8. U.S. Bureau of Mines.

Source: NFPA 69, *Standard on Explosion Prevention Systems*, 1997 edition.

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Table E.1(b) Limiting Oxidant Concentrations for Combustible Dust Suspensions When Using Nitrogen or Carbon Dioxide as Diluents

Dust	Limiting Oxidant Concentration (Volume % O_2 Above Which Deflagration Can Take Place) N_2/Air	CO_2/Air
Agricultural		
Coffee	—	17
Cornstarch	—	11
Dextrin	11.0	14
Soy flour	—	15
Starch	—	12
Sucrose	10.0	14
Chemical		
Ethylene diamine tetra-acetic acid	—	13
Isatoic anhydride	—	13
Methionine	—	15
Ortazol	—	19
Phenothiazine	—	17
Phosphorus pentasulfide	—	12
Salicylic acid	15.0	17
Sodium lignosulfate	—	17
Stearic acid and metal stearates	10.6	13
Carbonaceous		
Charcoal	—	17
Coal, bituminous	—	17
Coal, sub-bituminous	—	15
Lignite	—	15
Metal		
Aluminum	5.0*	2
Antimony	—	16
Chromium	—	14
Iron	—	10
Magnesium	0	0
Manganese	—	14
Silicon	11.0	12
Thorium	2.0	0
Titanium	4.0	0
Uranium	1.0	0
Vanadium	—	14
Zinc	9.0	10
Zirconium	0	0
Miscellaneous		
Cellulose	—	13
Paper	—	13
Pitch	—	11
Sewage sludge	—	14
Sulfur	—	12
Wood flour	—	16
Plastics Ingredients		
Azelaic acid	—	14
Bisphenol A	—	12
Casein, rennet	—	17
Hexamethylene tetramine	13.0	14
Isophthalic acid	—	14
Paraformaldehyde	8.0	12
Pentaerythritol	13.0	14
Phthalic anhydride	—	14
Terephthalic acid	—	15
Plastics — Special Resins		
Coumarone- indene resin	—	14
Lignin	—	17
Phenol, chlorinated	—	16
Pinewood residue	—	13
Rosin, DK	—	14
Rubber, hard	—	15
Shellac	—	14
Sodium resinate	13.0	14
Plastics — Thermoplastic Resins		
Acetal	—	11
Acrylonitrile	—	13
Butadiene-styrene	—	13
Carboxymethyl cellulose	—	16
Cellulose acetate	9.0	11
Cellulose triacetate	—	12
Cellulose acetate butyrate	—	14
Ethyl cellulose	—	11
Methyl cellulose	—	13
Methyl methacrylate	—	11
Nylon	—	13
Polycarbonate	—	15
Polyethylene	—	12
Polystyrene	—	14
Polyvinyl acetate	—	17
Polyvinyl butyrate	—	14
Plastics — Thermosetting Resins		
Allyl alcohol	—	13
Dimethyl isophthalate	—	13
Dimethyl terephthalate	—	12
Epoxy	—	12
Melamine formaldehyde	—	15
Polyethylene terephthalate	—	13
Urea formaldehyde	—	16

Notes:

1. Data in this table were obtained by laboratory tests conducted at room temperature and pressure, using a 24-watt continuous-spark ignition source and were reported in U.S. Bureau of Mines, Report of Investigation 6543.

2. Where nitrogen is used as the diluent and no data are listed in the table, the following equation should be used to calculate the oxygen value for carbonaceous dusts:

$$O_n = 1.3(O_c - 6.3)$$

where:

O_n = the limiting oxygen concentration for dilution by nitrogen (N)

O_c = the limiting oxygen concentration for dilution by carbon dioxide (CO_2)

3. See 2.7.2 of NFPA 69, *Standard on Explosion Prevention Systems*, 1997 edition, for the required oxygen level in equipment.

4. Data on the use of dry powders or water as inerting materials and on the effects of inerting on pressure development in a closed vessel are given in U.S. Bureau of Mines, Reports of Investigations 6549, 6561, and 6811.

5. The values in this table can differ from those in Table E.1(c) because of differences in test methods and dust characteristics, such as particle size, and other factors.

*Determined by test; see R. K. Eckhoff, *Dust Explosions in the Process Industries*, p. 586. Also see NFPA 484, *Standard for the Combustible Metals, Metal Powders, and Metal Dusts*, which addresses the passivation of freshly produced aluminum surfaces in the presence of low concentrations of oxygen.

Source: NFPA 69, *Standard on Explosion Prevention Systems*, 1997 edition.

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Table E.1(c) Limiting Oxidant Concentrations for Combustible Dust Suspensions When Using Nitrogen as a Diluent

Dust	Median Particle Diameter by Mass (μm)	Limiting Oxidant Concentration (Volume % O_2 Above Which Deflagration Can Take Place) N_2/Air
Cellulosic Materials		
Cellulose	22	9
Cellulose	51	11
Wood flour	27	10
Food and Feed		
Pea flour	25	15
Corn starch	17	9
Waste from malted barley	25	11
Rye flour	29	13
Starch derivative	24	14
Wheat flour	60	11
Coals		
Brown coal	42	12
Brown coal	63	12
Brown coal	66	12
Brown coal briquette dust	51	15
Bituminous coal	17	14
Plastics, Resins, Rubber		
Resin	<63	10
Rubber powder	95	11
Polyacrylonitrile	26	10
Polyethylene, h.p.	26	10
Pharmaceuticals, Pesticides		
Aminophenazone	<10	9
Methionine	<10	12
Intermediate Products, Additives		
Barium stearate	<63	13
Benzoyl peroxide	59	10
Bisphenol A	34	9
Cadmium laurate	<63	14
Cadmium stearate	<63	12
Calcium stearate	<63	12
Methyl cellulose	70	10
Dimethyl terephthalate	27	9
Ferrocene	95	7
Bistrimethylsilyl-urea	65	9
Naphthalic acid anhydride	16	12
2-Naphthol	<30	9
Paraformaldehyde	23	6
Pentaerythritol	<10	11
Metals, Alloys		
Aluminum	22	5
Calcium/aluminum alloy	22	6
Ferrosilicon magnesium alloy	17	7
Ferrosilicon alloy	21	12
Magnesium alloy	21	3
Other Inorganic Products		
Soot	<10	12
Soot	13	12
Soot	16	12
Others		
Bentonite derivative	43	12

Notes:
1. The data came from 1 m^3 and 20 L chambers using strong chemical igniters.
2. See R. K. Eckhoff, *Dust Explosions in the Process Industries*, 1991.
Source: NFPA 69, *Standard on Explosion Prevention Systems*, 1997 edition.

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Annex F Informational References

F.1 Referenced Publications. The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

F.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

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NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, 1999 edition.

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▼

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▼

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▼

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NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP or ROC).

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