NFPA 86C

Standard for Industrial Furnaces Using a Special Processing Atmosphere

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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This edition of NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere*, was prepared by the Technical Committee on Ovens and Furnaces and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 86C was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 86C

NFPA 86C was first introduced as a tentative standard in 1972. It was adopted with editorial revisions as an official standard in 1973.

Following its adoption in 1973, NFPA 86C was amended in 1974, 1984, and 1987. The 1984 edition was rewritten completely to follow the NFPA *Manual of Style* more closely. The 1987 edition included new requirements for programmable logic controllers along with new personnel safety recommendations in the appendix.

The 1991 edition included a complete revision of Chapter 4 on safety equipment and application, new requirements for fuel mixing machines, a new chapter on open liquid quench tanks, a new chapter on alternative purge methods, and a common Appendix A in accordance with the NFPA *Manual of Style*.

The 1995 edition of NFPA 86C provided correlation with NFPA 86, *Standard for Ovens and Furnaces*, and NFPA 86D, *Standard for Industrial Furnaces Using Vacuum as an Atmosphere*. It also refined and updated the standard to more current technologies, provided increased requirements in several areas, and expanded the explanatory material in the appendixes.

This edition of NFPA 86C includes changes to the technical requirements in several areas. Also included are many refinements to clarify the technical requirements. Changes are also provided to more clearly distinguish mandatory requirements from nonmandatory recommendations and explanatory material. Nonmandatory notes have been relocated to the appendixes.

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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 control of fire and explosion hazards in drying ovens for japan, enamel, and other finishes, bakery ovens, core ovens, annealing and heat treating furnaces, and other special atmosphere furnaces, including equipment for other special atmospheres.

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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 Appendix A.

Information on referenced publications can be found in Chapter 19 and Appendix D.

FOREWORD

Explosions and fires in fuel-fired and electric heat utilization equipment constitute a loss potential in life, property, and production. This standard is a compilation of guidelines, rules, and methods applicable to the safe operation of this type of equipment.

There are other conditions and regulations not covered in this standard, such as toxic vapors; hazardous materials; noise levels; heat stress; and local, state, and federal regulations (EPA and OSHA), that should be considered when designing and operating furnaces.

Causes of practically all failures can be traced to human error. The most significant failures include inadequate training of operators, lack of proper maintenance, and improper application of equipment.

Users and designers must utilize engineering skill to bring together that proper combination of controls and training necessary for the safe operation of the equipment. This standard classifies furnaces as follows.

Class A ovens and furnaces are heat utilization equipment operating at approximately atmospheric pressure wherein there is a potential explosion or fire hazard that could be occasioned by the presence of flammable volatiles or combustible materials processed or heated in the furnace.

Such flammable volatiles or combustible materials can, for instance, originate from any of the following: (1) paints, powders, inks, and adhesives from finishing processes, such as dipped, coated, sprayed, and impregnated materials; (2) substrate material; (3) wood, paper, and plastic pallets, spacers, or packaging materials; or (4) polymerization or other molecular rearrangements.

Potentially flammable materials, such as quench oil, waterborne finishes, cooling oil, or cooking oils, that present a hazard are ventilated according to Class A standards.

Class B ovens and furnaces are heat utilization equipment operating at approximately atmospheric pressure wherein there are no flammable volatiles or combustible materials being heated.

Class C ovens and furnaces are those in which there is a potential hazard due to a flammable or other special atmosphere being used for treatment of material in process. This type of furnace can use any type of heating system and includes a special atmosphere supply system(s). Also included in the Class C classification are integral quench furnaces and molten salt bath furnaces.

Class D furnaces are vacuum furnaces that operate at temperatures above ambient to over 5000°F (2760°C) and at pressures from vacuum to several atmospheres during heating using any type of heating system. These furnaces can include the use of special processing atmospheres. During gas quenching, these furnaces may operate at pressures from below atmospheric to over 100 psig.

Chapter 1 General

1-1 Scope.

1-1.1 This standard shall apply to Class C industrial furnaces, atmosphere generators, and atmosphere supply systems. Also included are furnaces with integral quench tanks or molten salt baths.

1-1.2 Within the scope of this standard, an oven shall be any heated enclosure operating at approximately atmospheric pressure and used for commercial and industrial processing of materials.

1-1.3 Within the scope of this standard, an integral quench tank shall be a container that holds a quench medium into which metalwork is immersed for various heat treatment processes. The work load remains under a protective atmosphere from the time it leaves the heating zone until it enters the quench medium.

1-1.4 Within the scope of this standard, a molten salt bath furnace shall be any heated container that holds a melt or fusion composed of one or more relatively stable chemical salts that form a liquid-like medium into which metalwork is immersed for various processes that include, but are not limited to, heat treating, brazing, stripping, and descaling.

1-1.5 This standard shall not apply to the following:

(1) Coal or other solid fuel-firing systems
(2) Listed equipment with a heating system(s) that supplies a total input not exceeding 150,000 Btu/hr (44 kW). *(See definition of Listed.)*

1-2 Purpose. Because the heat processing of materials can involve a serious fire and explosion hazard that can endanger the furnace and the building in which the process is located and possibly the lives of employees, adequate safeguards shall be provided as appropriate for the location, equipment, and operation of such furnaces.

1-3 Application.

1-3.1 The requirements of Chapters 1 through 5 shall apply to equipment described in subsequent chapters except as modified by those chapters.

1-3.2* This entire standard shall apply to new installations or alterations or extensions to existing equipment.

1-3.3 Section 1-5 and Chapter 17 shall apply to all operating furnaces.

1-3.4 No standard can guarantee the elimination of furnace fires and explosions. Technology in this area is under constant development, which is reflected in fuel, special processing atmospheres, flammable vapors, and quench systems, with regard to the type of equipment and the characteristics of the various fluids. Therefore, the designer is cautioned that the standard is not a design handbook. The standard does not eliminate the need for the engineer or competent engineering judgment. It is intended that a designer capable of applying more complete and rigorous analysis to special or unusual problems shall have latitude in the development of furnace designs. In such cases, the designer shall be responsible for demonstrating and documenting the safety and validity of the design.

1-4* Approvals, Plans, and Specifications.

1-4.1 Before new equipment is installed or existing equipment is remodeled, complete plans, sequence of operations, and specifications shall be submitted for approval to the authority having jurisdiction.

1-4.1.1 Plans shall be drawn and shall show all essential details with regard to location, construction, ventilation, piping, and electrical safety equipment. A list of all combustion, control, and safety equipment giving manufacturer and type number shall be included.

1-4.1.2 Wiring diagrams and sequence of operations for all safety controls shall be provided. Ladder-type schematic diagrams are recommended.

1-4.2 Any deviation from this standard shall require special permission from the authority having jurisdiction.

1-4.3 Electrical.

1-4.3.1* All wiring shall be in accordance with NFPA 70, *National Electrical Code*®, NFPA 79, *Electrical Standard for Industrial Machinery*, and as described hereafter.

1-4.3.2 Wiring and equipment installed in hazardous (classified) locations shall comply with the applicable requirements of NFPA 70, *National Electrical Code.*

1-4.3.3* The installation of an oven in accordance with the requirements of this standard shall not in and of itself require a change to the classification of the oven location.

1-5 Operator and Maintenance Personnel Training.

1-5.1 All operating, maintenance, and appropriate supervisory personnel shall be thoroughly instructed and trained under the direction of a qualified person(s) and shall be required to demonstrate understanding of the equipment and its operation to ensure knowledge of and practice of safe operating procedures.

1-5.2 All operating, maintenance, and appropriate supervisory personnel shall receive regularly scheduled retraining and testing to maintain a high level of proficiency and effectiveness.

1-5.3 Personnel shall have access to operating instructions at all times.

1-5.4 Operator training shall include the following, where applicable:

(1) Combustion of fuel–air mixtures
(2) Explosion hazards
(3) Sources of ignition, including autoignition (e.g., by incandescent surfaces)
(4) Functions of control and safety devices
(5) Handling of special atmospheres
(6) Handling of low-oxygen atmospheres
(7) Handling and processing of hazardous materials
(8) Confined space entry procedures
(9) Operating instructions *(see 1-5.5)*

1-5.5 Operating instructions shall be provided by the equipment manufacturer and shall include all of the following:

(1) Schematic piping and wiring diagrams
(2) Start-up procedures
(3) Shutdown procedures
(4) Emergency procedures, including those occasioned by loss of special atmospheres, electric power, inert gas, or other essential utilities
(5) Maintenance procedures

1-6 Equipment Maintenance. All equipment shall be maintained in accordance with the manufacturer's instructions.

1-7 Safety Labeling.

1-7.1 A suitable, clearly worded, and prominently displayed safety design data form or manufacturer's nameplate shall be provided that states the safe operating conditions for which the furnace system was designed, built, altered, or extended.

1-7.2 A warning label shall be provided by the manufacturer stating that the equipment shall be operated and maintained according to instructions. This label shall be permanently affixed to the furnace.

Chapter 2 Definitions

2-1 Definitions. The following definitions shall apply to NFPA 86, *Standard for Ovens and Furnaces;* NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere;* and NFPA 86D, *Standard for Industrial Furnaces Using Vacuum as an Atmosphere.*

Afterburner. See *Incinerator, Fume.*

Air, Combustion. All the air introduced with fuel to supply heat in a furnace.

Air, Primary. All air supplied through the burner.

Air, Reaction. All the air that, when reacted with gas in an endothermic generator by the indirect addition of heat, becomes a special atmosphere gas.

Air, Secondary. All the combustion air that is intentionally allowed to enter the combustion chamber in excess of primary air.

Air Makeup Unit, Direct-Fired. A Class B fuel-fired heat utilization unit operating at approximately atmospheric pressure used to heat outside replacement air for the process.

Analyzer, Gas. A device that measures concentrations, directly or indirectly, of some or all components in a gas or mixture.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Backfire Arrester. A flame arrester installed in fully premixed air–fuel gas distribution piping to terminate flame propagation therein, shut off fuel supply, and relieve pressure resulting from a backfire.

Bath, Molten Salt. See *Furnace, Molten Salt Bath.*

Burn-In. The procedure used in starting up a special atmosphere furnace to replace air within the heating chamber(s) and vestibule(s) with flammable special atmosphere.

Burn-Out. The procedure used in shutting down or idling a special atmosphere to replace flammable atmosphere within the heating chamber(s) and vestibule(s) with a nonflammable atmosphere.

Burner. A device or group of devices used for the introduction of fuel, air, oxygen, or oxygen-enriched air into a furnace at the required velocities, turbulence, and concentration to maintain ignition and combustion of fuel.

Burner, Atmospheric. A burner used in the low-pressure fuel gas or atmospheric system that requires secondary air for complete combustion.

Burner, Atomizing. A burner in which oil is divided into a fine spray by an atomizing agent, such as steam or air.

Burner, Blast. A burner delivering a combustible mixture under pressure, normally above 0.3 in. w.c. (75 kPa), to the combustion zone.

Burner, Combination Fuel Gas and Oil. A burner that can burn either fuel gas or oil, or both simultaneously.

Burner, Dual-Fuel. A burner designed to burn either fuel gas or oil, but not both simultaneously.

Burner, Line. A burner whose flame is a continuous line.

Burner, Multiple-Port. A burner having two or more separate discharge openings or ports.

Burner, Nozzle Mixing. A burner in which the fuel and air are introduced separately to the point of ignition.

Burner, Premix. A burner in which the fuel and air are mixed prior to the point of ignition.

Burner, Pressure Atomizing. A burner in which oil under high pressure is forced through small orifices to emit liquid fuel in a finely divided state.

Burner, Radiant. A burner designed to transfer a significant part of the combustion heat in the form of radiation.

Burner, Radiant Tube. A burner designed to provide a long flame within a tube to ensure substantially uniform radiation from the tube surface.

Burner, Rotary Atomizing. A burner in which oil is atomized by applied centrifugal force, such as by a whirling cone or plate.

Burner, Self-Piloted. A burner in which the pilot fuel is issued from the same ports as the main flame or merges with the main flame to form a common flame envelope with a common flame base.

Burner System. One or more burners operated as a unit by a common safety shutoff valve(s).

Check, Safe-Start. A checking circuit incorporated in a safety-control circuit that prevents light-off if the flame-sensing relay of the combustion safeguard is in the unsafe (flame-present) position due to component failure within the combustion safeguard or due to the presence of actual or simulated flame.

Cock, Supervising. A special approved cock incorporating in its design a means for positive interlocking with a main fuel safety shutoff valve so that, before the main fuel safety shutoff valve can be opened, all individual burner supervising cocks must be in the fully closed position.

Combustion Safety Circuitry. That portion of the oven control circuitry that contains the contacts for the required safety interlocks and the excess temperature limit controller(s). These contacts are arranged in series ahead of the safety shutoff valve(s) holding medium.

Controller, Continuous Vapor Concentration. A device that measures, indicates, and directly or indirectly controls the concentration of a flammable vapor–air mixture as expressed in percentage of the lower explosive limit (LEL).

Controller, Excess Temperature Limit. A device designed to cut off the source of heat if the operating temperature exceeds a predetermined temperature set point.

Controller, Programmable. A digital electronic system designed for use in an industrial environment that uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions to control, through digital or analog inputs and outputs, various types of machines or processes.

Controller, Temperature. A device that measures the temperature and automatically controls the input of heat into the furnace.

Cryogenic Fluid. A fluid produced or stored at very low temperatures. In the context of this standard, cryogenic fluid generally refers to gases made at low temperatures and stored at the user site in an insulated tank for use as an atmosphere or atmosphere constituent (e.g., nitrogen, argon, carbon dioxide, hydrogen, oxygen).

Damper, Cut-Away. A restricting airflow device that, when placed in the maximum closed position, allows a minimum amount of airflow past the restriction. Cut-away dampers normally are placed in the exhaust or fresh air intake ducts to ensure that the required minimum amount of exhaust or fresh air is handled by the ventilating fans.

Explosion-Resistant (Radiant Tube). The ability of a radiant tube, or radiant tube heat recovery system to withstand the overpressure developed by the combustion of a stoichiometric ratio of approximately 10 volumes of combustion air to one volume of natural gas (or the stoichiometric ratio of other gaseous fuel). The radiant tube or the radiant tube heat recovery system may experience bulging and distortion but should not fail catastrophically.

Fire Check, Automatic. A flame arrester equipped with a check valve to shut off the fuel gas supply automatically if a backfire occurs.

Flame, Supervised. A flame whose presence or absence is detected by a flame sensor connected to a combustion safeguard.

Flame Arrester. A device installed in the small branch piping of a fully premixed air–fuel gas mixture to retard a flame front originating from a backfire.

Flame Propagation Rate. The speed at which a flame progresses through a combustible fuel–air mixture. This rate is a function of the temperature and the mixture conditions existing in the combustion space, burner, or piping under consideration.

Flame Rod. A detector that employs an electrically insulated rod of temperature-resistant material that extends into the flame being supervised, with a voltage impressed between the rod and a ground connected to the nozzle or burner. The resulting electrical current, which passes through the flame, is rectified, and this rectified current is detected and amplified by the combustion safeguard.

Fluid, Pump. The operating fluid used in diffusion pumps or in liquid-sealed mechanical pumps (sometimes called *working medium, working fluid,* or *pump oil*).

Fuel Gas. Gas used for heating, such as natural gas, manufactured gas, undiluted liquefied petroleum gas (vapor phase only), liquefied petroleum gas–air mixtures, or mixtures of these gases.

Fuel Gas System, High Pressure. A system using the kinetic energy of a jet of 1 psig (7 kPa) or higher gas pressure to entrain from the atmosphere all, or nearly all, the air required for combustion.

Fuel Gas System, Low Pressure or Atmospheric. A system using the kinetic energy of a jet of less than 1 psig (7 kPa) gas pressure to entrain from the atmosphere a portion of the air required for combustion.

Fuel Oil. Grades 2, 4, 5, or 6 fuel oils as defined in ASTM D 396, *Standard Specifications for Fuel Oils.*

Furnace, Atmosphere. A furnace built to allow heat processing of materials in a special processing atmosphere.

Furnace, Batch. A furnace into which the work charge is introduced all at once.

Furnace, Class A. An oven or furnace that has heat utilization equipment operating at approximately atmospheric pressure wherein there is a potential explosion or fire hazard that could be occasioned by the presence of flammable volatiles or combustible materials processed or heated in the furnace. Flammable volatiles or combustible materials can include, but are not limited to, any of the following: (1) paints, powders, inks, and adhesives from finishing processes, such as dipped, coated, sprayed, and impregnated materials; (2) substrate material; (3) wood, paper, and plastic pallets, spacers, or packaging materials; or (4) polymerization or other molecular rearrangements. In addition, potentially flammable materials, such as quench oil, water-borne finishes, cooling oil, or cooking oils, that present a hazard are ventilated according to Class A standards.

Furnace, Class B. An oven or furnace that has heat utilization equipment operating at approximately atmospheric pressure wherein there are no flammable volatiles or combustible materials being heated.

Furnace, Class C. An oven or furnace that has a potential hazard due to a flammable or other special atmosphere being used for treatment of material in process. This type of furnace can use any type of heating system and includes a special atmosphere supply system(s). Also included in the Class C classification are integral quench furnaces and molten salt bath furnaces.

Furnace, Class D. An oven or furnace that operates at temperatures above ambient to over 5000°F (2760°C) and at pressures from vacuum to several atmospheres during heating using any type of heating system. These furnaces can include the use of special processing atmospheres. During inert gas-quenching, these furnaces may operate at pressures from below atmospheric to over 100 psig.

Furnace, Continuous. A furnace into which the work charge is more or less continuously introduced.

Furnace, Molten Salt Bath. A furnace that employs salts heated to a molten state. These do not include aqueous alkaline baths, hot brine, or other systems utilizing salts in solution.

Furnace, Plasma Arc. A furnace that employs the passage of an electric current between either a pair of electrodes or between electrodes and the work, and ionizing a gas (such as argon) and transferring energy in the form of heat.

Gas, Ballast. Atmospheric air or a dry gas that is admitted into the compression chamber of rotary mechanical pumps to prevent condensation of vapors in the pump oil by maintaining the partial pressure of the condensable vapors below the saturation value (also called *vented exhaust*).

Gas, Inert. See *Special Atmosphere, Inert (Purge Gas)*.

Gas, Reaction. A gas that, when reacted with air in an endothermic generator by the addition of heat, becomes a special atmosphere gas.

Gas Quenching. The introduction of a gas, usually nitrogen or argon (in certain situations helium or hydrogen may be used), into the furnace to a specific pressure [usually between –2.5 psig to 15 psig (0.85 bar to 2.05 bar)] for the purpose of cooling the work. The gas is recirculated over the work and through a heat exchanger by means of a fan or blower.

Gas Quenching, High Pressure. Gas-cooling at pressures greater than 15 psig.

Gauge, Vacuum. A device that indicates the absolute gas pressure in a vacuum system.

Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by such means as suitable covers or casings, barriers, rails or screens, mats, or platforms.

Heater, Dielectric. A heater similar to an induction heater, but using frequencies that generally are higher (3 MHz or more) than those used in induction heating. This type of heater is useful for heating materials that commonly are thought to be nonconductive. Examples of uses include heating plastic preforms before molding, curing glue in plywood, drying rayon cakes, and other similar applications.

Heater, Direct-Fired External. A heating system in which the burners are in a combustion chamber effectively separated from the work chamber and arranged so that products of combustion from the burners are discharged into the work chamber by a circulating fan or blower.

Heater, Direct-Fired Internal. A heating system in which the burners are located within the work chamber.

Heating System, Direct-Fired.* A heating system in which the products of combustion enter the work chamber.

Heating System, Indirect-Fired. A heating system in which the products of combustion do not enter the work chamber.

Heating System, Indirect-Fired Internal. A heating system of gastight radiators containing burners not in contact with the oven atmosphere. Radiators might be designed to withstand explosion pressures from ignition of air–fuel mixtures in the radiators.

Heating System, Induction. A heating system by means of which a current-carrying conductor induces the transfer of electrical energy to the work by eddy currents. *(See NFPA 70, National Electrical Code, Article 665.)*

Heating System, Radiant Tube. A heating system with tubular elements open at one or both ends. Each tube has an inlet burner arrangement where combustion is initiated, a suitable length where combustion occurs, and an outlet for the combustion products formed.

Heating System, Resistance. A system in which heat is produced by current flow through a resistive conductor. Resistance heaters can be of the open type, with bare heating conductors, or insulated sheath type, with conductors covered by a protecting sheath that can be filled with electrical insulating material.

Heating System, Tubular. A form of radiant heater in which resistive conductors are enclosed in glass, quartz, or ceramic envelopes that can contain a special gas atmosphere.

Implosion. The rapid inward collapsing of the walls of a vacuum component or device as the result of failure of the walls to sustain the atmospheric pressure. This can be followed by an outward scattering of pieces of the wall if the wall material is not ductile, thus causing possible danger to nearby equipment and personnel.

Incinerator, Fume. Any separate or independent combustion equipment or device that entrains the process exhaust for the purpose of direct thermal or catalytic destruction, which can include heat recovery.

Insulation, Vacuum-Type. A highly reflective double-wall structure with high vacuum between the walls; used as insulation in cryogenic systems for the reduction of heat transfer.

Interlock, Proved Low-Fire Start. A burner start interlock in which a control sequence ensures that a high–low or modulated burner is in the low-fire position before the burner can be ignited.

Interlock, Safety. A device required to ensure safe start-up and safe operation and to cause safe equipment shutdown.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Limiting Oxidant Concentration (LOC). The concentration of oxidant below which a deflagration cannot occur. Materials other than oxygen can act as oxidants.

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.

LOC. See *Limiting Oxidant Concentration.*

Lower Explosive Limit (LEL). See *Range, Explosive.*

Mixer, Air Jet. A mixer using the kinetic energy of a stream of air issuing from an orifice to entrain the fuel gas required for combustion. In some cases, this type of mixer can be designed to entrain some of the air for combustion as well as the fuel gas.

Mixer, Air–Fuel Gas. A system that combines air and fuel gas in the proper proportion for combustion.

Mixer, Gas Jet [Atmospheric Inspirator (Venturi) Mixer]. A mixer using the kinetic energy of a jet of fuel gas issuing from an orifice to entrain all or part of the air required for combustion.

Mixer, Proportional. A mixer comprised of an inspirator that, when supplied with air, draws all the fuel gas necessary for combustion into the airstream, and a governor, zero regulator, or ratio valve that reduces incoming fuel gas pressure to approximately atmospheric.

Mixing Blower. A motor-driven blower to supply air–fuel gas mixtures for combustion through one or more fuel burners or nozzles on a single-zone industrial heating appliance or on each control zone of a multizone installation. Mixing machines operated at 10 in. w.c. (2.49 kPa) or less static pressure are considered mixing blowers.

Mixing Machine. A mixer using mechanical means to mix fuel and air and to compress the resultant mixture to a pressure suitable for delivery to its point of use. Mixers in this group utilize either a centrifugal fan or some other type of mechanical compressor with a proportioning device on its intake through which fuel and air are drawn by the fan or compressor suction.

Muffles. Enclosures within a furnace to separate the source of heat from the work and from any special atmosphere that might be required for the process.

Operator. An individual trained and responsible for the start-up, operation, shutdown, and emergency handling of the furnace and associated equipment.

Outgassing. The release of adsorbed or occluded gases or water vapor, usually by heating, such as from a vacuum tube or other vacuum system.

Oven. See *Furnace* definitions.

Oven, Low-Oxygen. An oven that utilizes a low-oxygen atmosphere to evaporate solvent to facilitate solvent recovery. These ovens normally operate at high solvent levels and can operate safely in this manner by limiting the oxygen concentration within the oven enclosure.

Pilot. A flame that is used to light the main burner.

Pilot, Burn-off. A pilot that ignites the flame curtain or special processing atmosphere discharging from the furnace or generator.

Pilot, Continuous. A pilot that burns throughout the entire period that the heating equipment is in service, whether or not the main burner is firing.

Pilot, Expanding. A pilot that burns at a set turndown throughout the entire period that the heating equipment is in service, but burns without turndown during light-off of the main burner.

Pilot, Intermittent. A pilot that burns during light-off and while the main burner is firing.

Pilot, Interrupted. A pilot that is ignited and burns during light-off and is automatically shut off at the end of the trial-for-ignition period of the main burner(s).

Pilot, Proved. A pilot flame supervised by a combustion safeguard that senses the presence of the pilot flame.

Pilot Flame Establishing Period. The interval of time during light-off that a safety control circuit allows the pilot fuel safety shutoff valve to remain open before the combustion safeguard proves the presence of the pilot flame.

Pressure, Partial. The pressure that is exerted by one component of a mixture of gases if it is present alone in a container.

Pressure, Ultimate. The limiting pressure approached in the vacuum system after sufficient pumping time to establish that further reductions in pressure would be negligible (sometimes called the *ultimate vacuum*).

Pump, Diffusion. A vacuum pump in which a stream of heavy molecules, such as those of mercury or oil vapor, carries gas molecules out of the volume being evacuated.

Pump, Gas Ballast. A mechanical pump (usually of the rotary type) that uses oil to seal the clearances between the stationary and rotating compression members. The pump is equipped with an inlet valve through which a suitable quantity of atmospheric air or "dry" gas (ballast gas) can be admitted into the compression chamber to prevent condensation of vapors in the pump oil by maintaining the partial pressure of the condensable vapors in the oil below the saturation value (sometimes called a *vented-exhaust mechanical pump*).

Pump, Holding. A backing (fore) pump used to hold a diffusion pump at efficient operating conditions while a roughing pump reduces the system pressure to a point at which a valve between the diffusion pump and the system can be opened without stopping the flow of vapor from the nozzles.

Pump, Rotary Blower. A pump without a discharge valve that moves gas by the propelling action of one or more rapidly rotating members provided with lobes, blades, or vanes, such as a roots blower. It is sometimes called a *mechanical booster pump* where used in series with a mechanical backing (fore) pump.

Pump, Roughing.* The pump used to reduce the system pressure to the level at which a diffusion or other vacuum pump can operate.

Pump, Vacuum. A compressor for exhausting air and noncondensable gases from a space that is to be maintained at subatmospheric pressure.

Pump-Down Factor. The product of the time to pump down to a given pressure and the displacement (for a service factor of 1) divided by the volume of the system ($F = t\,D/V$).

Purge. The replacement of a flammable, indeterminate, or high-oxygen-bearing atmosphere with another gas that, when complete, results in a nonflammable final state.

Range, Explosive.* The range of concentration of a flammable gas in air within which a flame can be propagated. The lowest flammable concentration is the lower explosive limit (LEL). The highest flammable concentration is the upper explosive limit (UEL).

Regulator, Pressure. A device that maintains a constant outlet pressure under varying flow.

Roughing Line. A line running from a mechanical pump to a vacuum chamber through which preliminary pumping is conducted to a vacuum range at which a diffusion pump or other high vacuum pump can operate.

Safeguard, Combustion. A safety control directly responsive to flame properties; it senses the presence or absence of flame and de-energizes the fuel safety valve in the event of flame failure within 4 seconds of the loss of flame signal.

Safety Device. An instrument, control, or other equipment that acts, or initiates action, to cause the furnace to revert to a safe condition in the event of equipment failure or other hazardous event. Safety devices are redundant controls, supplementing controls utilized in the normal operation of a furnace system. Safety devices act automatically, either alone or in conjunction with operating controls, when conditions stray outside of design operating ranges and endanger equipment or personnel.

Separator, Oil. An oil reservoir with baffles used to minimize the discharge of oil mist from the exhaust of a rotary mechanical vacuum pump.

Shall. Indicates a mandatory requirement.

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

Special Atmosphere. Prepared gas or gas mixtures that are introduced into the work chamber of a furnace to replace air, generally to protect or intentionally change the surface of the material undergoing heat processing (heat treatment).

Special Atmosphere, Carrier Gas. Any gas or liquid component of the special atmosphere that represents a sufficient portion of the special atmosphere gas volume in the furnace so that, if the flow of this component gas or liquid ceases, the total flow of the special atmosphere in the furnace is not sufficient to maintain a positive pressure in that furnace.

Special Atmosphere, Flammable. Gases that are known to be flammable and predictably ignitible where mixed with air.

Special Atmosphere, Generated. Atmospheres created in an ammonia dissociator, exothermic generator, or endothermic generator by dissociation or chemical reaction of *reaction air* and *reaction gas*.

Special Atmosphere, Indeterminate. Atmospheres that contain components that, in their pure state, are flammable but that, in the mixtures used (diluted with nonflammable gases), are not reliably and predictably flammable.

Special Atmosphere, Inert (Purge Gas). Nonflammable gases that contain less than 1 percent oxygen.

Special Atmosphere, Nonflammable. Gases that are known to be nonflammable at any temperature.

Special Atmosphere, Synthetic. Those atmospheres such as anhydrous ammonia, hydrogen, nitrogen, or inert gases obtained from compressed gas cylinders or bulk storage tanks and those derived by chemical dissociation or mixing of hydrocarbon fluids. Synthetic atmospheres include mixtures of synthetic and generated atmospheres.

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, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Switch, Atomizing Medium Pressure. A pressure-activated device arranged to effect a safety shutdown or to prevent the burner system from being actuated in the event of inadequate atomizing medium pressure.

Switch, Combustion Air Pressure. A pressure-activated device arranged to effect a safety shutdown or to prevent the burner system from being actuated in the event the combustion air supplied to the burner or burners falls below that recommended by the burner manufacturer.

Switch, Differential Flow. A switch that is activated by the flow of a gaseous or liquid fluid. This flow is detected by measuring pressure at two different points to produce a pressure differential across the sensor.

Switch, Flow. A switch that is activated by the flow of a fluid in a duct or piping system.

Switch, High Fuel Pressure. A pressure-activated device arranged to effect a safety shutdown of the burner system in the event of abnormally high fuel pressure.

Switch, Limit. A switching device that actuates when an operating limit has been reached.

Switch, Low Fuel Pressure. A pressure-activated device arranged to effect a safety shutdown of the burner system in the event of abnormally low fuel pressure.

Switch, Rotational. A device that usually is driven directly by the fan wheel or fan motor shaft. When the speed of the fan shaft or drive motor reaches a certain predetermined rate to provide a safe minimum airflow, a switch contact closes.

Tank, Integral Liquid or Salt Media Quench Type. A tank connected to the furnace so that the work is under a protective atmosphere from the time it leaves the heating zone until it enters the tank containing a combustible, noncombustible, or salt quench medium.

Tank, Open Liquid or Salt Media Quench Type. A tank in which work from the furnace is exposed to air before and upon entering the tank containing a combustible, noncombustible, or salt quench medium.

Temperature, Ignition. The lowest temperature at which a gas–air mixture can ignite and continue to burn. This also is referred to as the autoignition temperature.

Time, Evacuation. The time required to pump a given system from atmospheric pressure to a specified pressure (also known as *pump-down time* or *time of exhaust*).

Time, Roughing. The time required to pump a given system from atmospheric pressure to a pressure at which a diffusion pump or other high vacuum pump can operate.

Trial-for-Ignition Period (Flame-Establishing Period). The interval of time during light-off that a safety control circuit allows the fuel safety shutoff valve to remain open before the combustion safeguard is required to supervise the flame.

Turndown, Burner. The ratio of maximum to minimum burner fuel-input rates.

Vacuum. A space in which the pressure is far below atmospheric pressure so that the remaining gases do not affect processes being carried out in the space.

Vacuum, High. A vacuum with a pressure between 1×10^{-3} torr and 1×10^{-5} torr (millimeters of mercury).

Vacuum, Low. A vacuum with a pressure between 760 torr and 1×10^{-3} torr (millimeters of mercury).

Vacuum System. A chamber or chambers having walls capable of withstanding atmospheric pressure and having an opening through which the gas can be removed through a pipe or manifold to a pumping system. A complete vacuum system contains all pumps, gauges, valves, and other components necessary to carry out a particular process.

Valve, Air Inlet. A valve used for letting atmospheric air into a vacuum system. The valve also is called a vacuum breaker.

Valve, Safety Shutoff. A normally closed (closed when deenergized) valve installed in the piping that closes automatically to shut off the fuel, atmosphere gas, or oxygen in the event of abnormal conditions or during shutdown. The valve can be opened either manually or automatically, but only after the solenoid coil or other holding mechanism is energized.

Ventilated. A system provided with a method to allow circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Ventilation, Proven. A sufficient supply of fresh air and proper exhaust to outdoors with a sufficiently vigorous and properly distributed air circulation to ensure that the flammable vapor concentration in all parts of the furnace or furnace enclosure is safely below the lower explosive limit at all times.

Chapter 3 Location and Construction

3-1 Location.

3-1.1 General.

3-1.1.1 Furnaces and related equipment shall be located so as to protect personnel and buildings from fire or explosion hazards. Hazards to be considered include molten metal or other molten material spillage, quench tanks, hydraulic oil ignition, overheating of material in the furnace, and escape of fuel, processing atmospheres, or flue gases.

3-1.1.2 Furnaces shall be located so as to protect them from damage by external heat, vibration, and mechanical hazards.

3-1.1.3 Furnaces shall be located so as to make maximum use of natural ventilation, to minimize restrictions to adequate explosion relief, and to provide sufficient air supply for personnel.

3-1.1.4* Where furnaces are located in basements or enclosed areas, sufficient ventilation shall be supplied so as to provide required combustion air and to prevent the hazardous accumulation of vapors.

3-1.1.5 Furnaces designed for use with special atmospheres or fuel gas with a specific gravity greater than air shall be located at or above grade and shall be located so as to prevent the escape of the special atmosphere or fuel gas from accumulating in basements, pits, or other areas below the furnace.

3-1.2 Structural Members of the Building.

3-1.2.1 Furnaces shall be located and erected so that the building structural members are not affected adversely by the maximum anticipated temperatures *(see 3-1.4)* or by the additional loading caused by the furnace.

3-1.2.2 Structural building members shall not pass through or be enclosed within a furnace.

3-1.3 Location in Regard to Stock, Processes, and Personnel.

3-1.3.1 Furnaces shall be located so as to minimize exposure to power equipment, process equipment, and sprinkler risers. Unrelated stock and combustible materials shall be maintained at a fire-safe distance but not less than 2.5 ft (0.76 m) from a furnace, a furnace heater, or ductwork.

3-1.3.2 Furnaces shall be located so as to minimize exposure of people to the possibility of injury from fire, explosion, asphyxiation, and hazardous materials and shall not obstruct personnel travel to exitways.

3-1.3.3* Furnaces shall be designed or located so as to prevent an ignition source to flammable coating dip tanks, spray booths, storage and mixing rooms for flammable liquids, or exposure to flammable vapor or combustible dusts.

Exception: This requirement shall not apply to integral quench systems.

3-1.3.4 Equipment shall be protected from corrosive external processes and environments, including fumes or materials from adjacent processes or equipment that produce corrosive conditions when introduced into the furnace environment.

3-1.4 Floors and Clearances.

3-1.4.1 Furnaces shall be located with adequate space above and on all sides to allow inspection and maintenance. Provisions also shall be included for the installation of automatic sprinklers and the proper functioning of explosion vents, if applicable.

3-1.4.2* Furnaces shall be constructed and located to keep temperatures at combustible floors, ceilings, and walls below 160°F (71°C).

3-1.4.3 Where electrical wiring is present in the channels of certain types of floors, the wiring shall be installed in accordance with NFPA 70, *National Electrical Code*, Article 356.

3-1.4.4 Floors in the area of mechanical pumps, oil burners, or other equipment using oil shall be provided with a noncombustible, nonporous surface to prevent floors from becoming soaked with oil.

3-2 Furnace Design.

3-2.1 Furnaces and related equipment shall be designed so as to minimize the fire hazard inherent in equipment operating at elevated temperatures.

3-2.2 Furnace components exposed simultaneously to elevated temperatures and air (oxygen) shall be constructed of noncombustible material.

3-2.3 Furnace structural supports and material-handling equipment shall be designed with adequate factors of safety at the maximum operating conditions, including temperature. Furnaces shall withstand the strains imposed by expansion and contraction, as well as static and dynamic mechanical load.

3-2.4 Heating devices and heating elements of all types shall be constructed or located so as to resist mechanical damage from falling work, material handling, or other mechanical hazards.

3-2.5 Furnace and related equipment shall be designed and located so as to allow access for required inspection and maintenance.

3-2.5.1 Ladders, walkways, and access facilities, where provided, shall be designed in accordance with 29 *CFR* 1910.24 through 29 *CFR* 1910.29 and ANSI A14.3, *Safety Requirements for Fixed Ladders*.

3-2.5.2 Means shall be provided to allow for safe entry by maintenance and other personnel. *(See also Section 17-2.)*

3-2.6 Radiation shields, refractory material, and insulation shall be retained or supported so they do not fall out of place under designed use and with proper maintenance.

3-2.7 External parts of furnaces that operate at temperatures in excess of 160°F (71°C) shall be guarded by location, guard rails, shields, or insulation to prevent accidental contact with personnel. Bursting discs or panels, mixer openings, or other parts of the furnace from which flame or hot gases could be discharged shall be located or guarded to prevent injury to personnel.

Exception: Where impractical to provide adequate shields or guards, warning signs or permanent floor markings shall be provided to be visible to personnel entering the area.

3-2.8 Properly located observation ports shall be provided so the operator can observe the lighting and operation of individual burners. Observation ports shall be protected properly from radiant heat and physical damage.

Exception: Where observation ports are not practical, other means of visually verifying the lighting and operation of individual burners shall be provided.

3-2.9 Closed cooling systems shall have a means of relief to protect all portions of the system, if the system pressure can exceed the design pressure. Flow switches shall be provided with audible and visual alarms.

3-2.10 Open cooling systems utilizing unrestricted sight drains readily observable by the operator shall not require flow switches.

3-2.11 Where a cooling system is critical to continued safe operation, the cooling system shall continue to operate after a safety shutdown or power failure.

3-2.12* Furnaces shall be designed to minimize fire hazards due to the presence of combustible products or residue in the furnace.

3-2.13 Furnace hydraulic systems shall utilize fire-resistant fluids.

Exception: Other hydraulic fluids shall be permitted to be used if failure of hydraulic system components cannot result in a fire hazard, subject to approval by the authority having jurisdiction.

3-2.14 The metal frames of furnaces shall be electrically grounded.

3-3 Explosion Relief.

3-3.1* Fuel-fired furnaces and furnaces that contain flammable liquids, gases, or combustible dusts shall be equipped with unobstructed explosion relief for freely relieving internal explosion pressures.

Exception: Explosion relief shall not be required on furnaces with shell construction having $^3/_{16}$-in. (4.8-mm) or heavier steel plate shells reinforced with structural steel beams and buckstays that support and retain refractory or insulating materials required for temperature endurance, which make them unsuitable for the installation of explosion relief.

3-3.2 Explosion relief shall be designed as a ratio of relief area to furnace volume. The minimum design shall be at least 1 ft^2 (0.093 m^2) of relief area for each 15 ft^3 (0.424 m^3) of furnace volume. Hinged panels, openings, or access doors equipped with approved explosion-relief hardware shall be permitted to be included in this ratio of 1:15.

3-3.3 Explosion-relief vents shall be arranged so that, when open, the full vent opening provides an effective relief area. The operation of vents to their full capacity shall not be obstructed. Warning signs shall be posted on the vents.

3-3.4* Explosion-relief vent(s) shall be located as close as practicable to each known source of ignition to minimize damage.

3-3.5 Explosion-relief vents shall be located or retained so that personnel are not exposed to injury by operation of the vents.

3-3.6* Where explosion relief is required, explosion-relief vents shall activate at a surge pressure that does not exceed the design pressure of the oven enclosure.

3-3.7* Explosion-relief vents for a long furnace shall be reasonably distributed throughout the entire furnace length. However, the maximum distance between explosion-relief vents shall not exceed five times the oven's smallest inside dimension (width or height).

3-4* Ventilation and Exhaust System.

3-4.1 Building Makeup Air. A sufficient quantity of makeup air shall be admitted to oven rooms and buildings to provide the air volume required for oven safety ventilation and adequate combustion air.

3-4.2 Fans and Motors.

3-4.2.1 Electric motors that drive exhaust or recirculating fans shall not be located inside the oven or ductwork.

Exception: Electric motors shall be permitted to be used in vacuum furnaces.

3-4.2.2 Oven recirculation and exhaust fans shall be designed for the maximum oven temperature and for material and vapors being released during the heating process.

3-4.3 Ductwork.

3-4.3.1 Ventilating and exhaust systems, where applicable, shall be installed in accordance with Chapters 1, 2, and 3 of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, unless otherwise noted.

3-4.3.2 Rectangular and square ducts shall be permitted.

3-4.3.3 Wherever furnace ducts or stacks pass through combustible walls, floors, or roofs, noncombustible insulation or clearance, or both, shall be provided to prevent combustible surface temperatures from exceeding 160°F (71°C).

3-4.3.4* Where ducts pass through noncombustible walls, floors, or partitions, the space around the duct shall be sealed with noncombustible material to maintain the fire rating of the barrier.

3-4.3.5 Ducts shall be constructed entirely of sheet steel or other noncombustible material capable of meeting the intended installation and conditions of service. The installation shall be of adequate strength and rigidity and shall be protected where subject to physical damage.

3-4.3.6 Ducts handling fumes that leave a combustible deposit shall be provided with clean-out doors.

3-4.3.7 No portions of the building shall be used as an integral part of the duct.

3-4.3.8* All ducts shall be made tight throughout and shall have no openings other than those required for the operation and maintenance of the system.

3-4.3.9 All ducts shall be thoroughly braced where required and substantially supported by metal hangers or brackets.

3-4.3.10 Ducts handling flammable vapors shall be designed to minimize the condensation of the vapors out of the exhaust airstream onto the surface of the ducts.

3-4.3.11 Ducts handling combustible solids shall be designed to minimize the accumulation of solids within the ducts.

3-4.3.12 Hand holes for damper, sprinkler, or fusible link inspection or resetting and for purposes of residue clean-out shall be equipped with tight-fitting doors or covers.

3-4.3.13 Exposed hot fan casings and hot ducts [temperature exceeding 160°F (71°C)] shall be guarded by location, guard rails, shields, or insulation to prevent injury to personnel.

3-4.3.14 Exhaust ducts shall not discharge near openings or other air intakes where effluents can re-enter the building.

3-4.3.15 A suitable collecting and venting system for radiant tube heating systems shall be provided. *(See Section 4-5.)*

3-5 Mountings and Auxiliary Equipment.

3-5.1 Pipes, valves, and manifolds shall be mounted so as to provide protection against damage by heat, vibration, and mechanical hazard.

3-5.2 Furnace systems shall have provisions to prevent injury to personnel during maintenance or inspection. Such equipment shall be permitted to be motion stops, lockout devices, or other safety mechanisms.

3-5.3 To the extent practical, instrumentation and control equipment shall be brought to a common location and mounted for ease of observation, adjustment, and maintenance. Protection from physical and temperature damage and ambient hazards shall be provided.

3-5.4 Auxiliary equipment such as conveyors, racks, shelves, baskets, and hangers shall be noncombustible and designed to facilitate cleaning.

Chapter 4 Furnace Heating Systems

4-1 General.

4-1.1 For the purpose of this chapter, the term *furnace heating system* shall include the heating source, the associated piping and wiring used to heat the furnace, and the work therein as well as the auxiliary quenches, atmosphere generator, and other components.

4-1.2 All components of the furnace heating system and control cabinet shall be grounded.

4-2 Fuel Gas–Fired Units.

4-2.1 Scope.

4-2.1.1* Section 4-2 shall apply to furnace heating systems fired with commercially distributed fuel gases such as natural gas, mixed gas, manufactured gas, liquefied petroleum gas (LP-Gas) in the vapor phase, and LP-Gas/air systems. Section 4-2 also shall apply to the gas-burning portions of dual-fuel or combination burners.

4-2.1.2 Burners, along with associated mixing, valving, and safety controls and other auxiliary components, shall be properly selected for the intended application, suitable for the type and pressure of the fuel gases to be used, and suitable for the temperatures to which they are subjected.

4-2.2* Combustion Air.

4-2.2.1 The fuel-burning system design shall provide for an adequate supply of clean combustion air for proper burner operation.

4-2.2.2 Precautions shall be taken to prevent insufficiently diluted products of combustion from short-circuiting back into the combustion air. This requirement shall not prevent the use of properly designed flue gas recirculation systems.

4-2.2.3 Where primary or secondary combustion air is provided mechanically, combustion airflow or pressure shall be proven and interlocked with the safety shutoff valves so that fuel gas cannot be admitted prior to establishment of combustion air and so that the gas is shut off in the event of combustion air failure.

4-2.2.4 In the case of an exothermic generator, loss of fuel gas shall cut off the combustion air.

4-2.2.5 Where a secondary air adjustment is provided, adjustment shall include a locking device to prevent an unintentional change in setting.

4-2.3 Fuel Gas Supply Piping.

4-2.3.1 A remotely located shutoff valve shall be provided to allow the fuel to be turned off in an emergency and shall be located so that fire or explosion at a furnace does not prevent access to this valve.

4-2.3.2 Installation of LP-Gas storage and handling systems shall comply with NFPA 58, *Liquefied Petroleum Gas Code.*

4-2.3.3 Piping from the point of delivery to the equipment isolation valve shall comply with NFPA 54, *National Fuel Gas Code. (See 4-2.4.2.)*

4-2.4 Equipment Fuel Gas Piping.

4-2.4.1 Manual Shutoff Valves and Cocks.

4-2.4.1.1 Individual manual shutoff valves for equipment isolation shall be provided for shutoff of the fuel to each piece of equipment.

4-2.4.1.2 Manual shutoff valves shall have permanently affixed visual indication of the valve position.

4-2.4.1.3 Quarter-turn valves with removable wrenches shall not allow the wrench handle to be installed perpendicular to the fuel gas line when the valve is open.

4-2.4.1.4 It shall be the user's responsibility to ensure that separate wrenches (handles) remain affixed to the valve and that they are oriented properly with respect to the valve port.

4-2.4.1.5 Valves and cocks shall be maintained and lubricated in accordance with the manufacturer's instructions.

4-2.4.2 Piping and Fittings.

4-2.4.2.1 Material for the piping and fittings that connect the equipment manual isolation valve to the burner shall meet the requirements of NFPA 54, *National Fuel Gas Code.*

4-2.4.2.2 Piping, fittings, and valves shall be sized to provide proper flow rates and pressure so as to maintain a stable flame over the burner operating range.

4-2.4.3* Fuel Filters and Strainers. For new installations, a gas filter or strainer shall be installed in the fuel gas piping to protect the downstream safety shutoff valves.

4-2.4.4* Drip Legs. A drip leg or sediment trap shall be installed for each fuel gas supply line prior to any piping devices. The drip leg shall be at least 3 in. (76 mm) long and the same diameter as the supply piping.

4-2.4.5 Pressure Regulators and Pressure Switches.

4-2.4.5.1 A pressure regulator shall be furnished wherever the plant supply pressure exceeds that required for proper burner operation or wherever the plant supply pressure is subject to excessive fluctuations.

Exception: An automatic flow control valve shall be permitted to meet this requirement, provided it can compensate for the full range of expected source pressure variations.

4-2.4.5.2 Regulators and switches shall be vented to a safe location where vented gas cannot re-enter the building without extreme dilution. The terminating end shall be protected against water entry and shall be bug-screened. Vent piping shall be of adequate size to allow normal regulator and switch operation.

Exception No. 1: Vent piping from regulators and switches shall be permitted to terminate within a building where used with lighter-than-air fuel gases, provided the vent contains a restricted orifice and discharges into a space large enough and with sufficient natural *ventilation so that the escaping gases do not present a hazard and cannot re-enter the work area without extreme dilution.*

Exception No. 2: Vent piping shall not be required for regulators and switches where used with lighter-than-air fuel gases at 1 psig (7 kPa) inlet pressure or less, provided the vent connection contains a restricted orifice and discharges into a space large enough, or is ventilated well enough, so that the escaping gases do not present a hazard.

Exception No. 3: Fuel gas regulators and zero governors shall not be required to be vented if backloaded from combustion air lines, air–gas mixture lines, or combustion chambers, provided that gas leakage through the backload connection does not create a hazard.

4-2.4.5.3 Fuel gas regulators and zero governors shall not be backloaded from oxygen or oxygen-enriched air lines.

4-2.4.5.4 Vent lines from multiple furnaces shall not be manifolded together.

4-2.4.5.5 Vent lines from multiple regulators and switches of a single furnace, where manifolded together, shall be piped in such a manner that diaphragm rupture of one vent line does not backload the others. The size of the vent manifold shall be not less than the area of the largest vent line plus 50 percent of the additional vent line area.

4-2.5 Flow Control Valves. Where the minimum or the maximum flow of combustion air or the fuel gas is critical to the safe operation of the burner, flow valves shall be equipped with an appropriate limiting means and with a locking device to prevent an unintentional change in the setting.

4-2.6 Air–Fuel Gas Mixers.

4-2.6.1* General. Subsection 4-2.6 shall apply only to mixtures of fuel gas with air and not to mixtures of fuel gas with oxygen or oxygen-enriched air. Oxygen shall not be introduced into air–fuel gas mixture piping, fuel gas mixing machines, or air–fuel gas mixers.

4-2.6.2 Proportional Mixing.

4-2.6.2.1 Piping shall be designed to provide a uniform mixture flow of proper pressure and velocity as needed for stable burner operation.

4-2.6.2.2 Valves or other obstructions shall not be installed between a proportional mixer and burners. Fixed orifices shall be permitted for purposes of balancing.

4-2.6.2.3 Any field-adjustable device built into a proportional mixer (e.g., gas orifice, air orifice, ration valve) shall be arranged with an appropriate locking device to prevent unintentional changes in the setting.

4-2.6.2.4 Where a mixing blower is used, an approved safety shutoff valve shall be installed in the fuel gas supply connection that shuts off the fuel gas supply automatically when the blower is not in operation and in the event of a fuel gas supply failure.

4-2.6.2.5 Mixing blowers shall not be used with fuel gases containing more than 10 percent free hydrogen (H_2).

4-2.6.2.6 Mixing blowers having a static delivery pressure of more than 10 in. w.c. (2.49 kPa) shall be considered mixing machines.

4-2.6.3 Mixing Machines.

4-2.6.3.1* Automatic fire checks shall be provided in piping systems that distribute flammable air–fuel gas mixtures from a mixing machine. The automatic fire check shall be installed as close as practical to the burner inlet(s), and the manufacturer's installation guidelines shall be followed.

4-2.6.3.2 A separate, manually operated gas valve shall be provided at each automatic fire check for shutting off the flow of air-fuel mixture through the fire check after a flashback has occurred. The valves shall be located upstream as close as practicable to the inlets of the automatic fire checks.

CAUTION

These valves shall not be reopened after a flashback has occurred until the fire check has cooled sufficiently to prevent reignition of the flammable mixture and has been properly reset.

4-2.6.3.3* A backfire arrester with a safety blowout device shall be provided near the outlet of each mixing machine that produces a flammable air–fuel gas mixture. The manufacturer's installation guidelines shall be followed.

4-2.6.3.4 A listed safety shutoff valve shall be installed in the fuel gas supply connection of any mixing machine. This valve shall be arranged to shut off the fuel gas supply automatically when the mixing machine is not in operation or in the event of an air or fuel gas supply failure.

Exception: Where listed safety shutoff valves are not available for the service intended, the selected device shall require approval by the authority having jurisdiction.

4-2.7 Fuel Gas Burners.

4-2.7.1 All burners shall maintain the stability of the designed flame shape, without flashback or blow-off, over the entire range of turndown that is encountered during operation where supplied with combustion air (oxygen-enriched air or oxygen) and the designed fuels in the proper proportions and in the proper pressure ranges. Burners shall only be used with the fuels for which they are designed.

4-2.7.2 All pressures required for safe operation of the combustion system shall be maintained within the proper ranges throughout the firing cycle.

4-2.7.3 Burners shall have the ignition source sized and located in a position that provides safe and reliable ignition of the pilot or main flame.

4-2.7.3.1 Self-piloted burners shall have a safe and reliable transition from pilot flame to main flame.

4-2.7.3.2 For burners that cannot be ignited safely at all firing rates, positive provision shall be made to reduce the burner firing rates during light-off to a lower level, which ensures a safe and reliable ignition of the main flame (forced low-fire start).

4-2.7.4* Explosion resistance of nonmetallic radiant tubes shall be determined by test.

4-2.8 Fuel Ignition.

4-2.8.1* The ignition source (e.g., electric spark, hot wire, pilot burner, handheld torch) shall be applied effectively at the proper point and with sufficient intensity to ignite the air–fuel mixture.

4-2.8.2 Fixed ignition sources shall be mounted to prevent unintentional changes in location and in direction with respect to the main flame.

4-2.8.3 Pilot burners shall be considered burners, and all provisions of Section 4-2 shall apply.

4-2.9 Dual-Fuel and Combination Burners. Where fuel gas and fuel oil are to be fired individually (dual-fuel) or simultaneously (combination), the provisions of Sections 4-2, 4-3, and 5-12 shall apply equally to the respective fuels.

4-3 Oil-Fired Units.

4-3.1 Scope.

4-3.1.1* Section 4-3 shall apply to combustion systems for furnaces fired with No. 2, No. 4, No. 5, and No. 6 industrial fuel oils as specified by ASTM D 396, *Standard Specifications for Fuel Oils*. It also includes the oil-burning portions of dual-fuel and combination burners.

4-3.1.2 Additional considerations that are beyond the scope of this standard shall be given to other combustible liquids not specified in 4-3.1.1.

4-3.1.3 Burners, along with associated valving, safety controls, and other auxiliary components, shall be suitable for the type and pressure of the fuel oil to be used and for the temperatures to which they are subjected.

4-3.2* Combustion Air.

4-3.2.1 The fuel-burning system design shall provide for an adequate supply of clean combustion air for proper burner operation.

4-3.2.2 Precautions shall be taken to prevent insufficiently diluted products of combustion from short-circuiting back into the combustion air. This requirement shall not prevent the use of properly designed flue gas recirculation systems.

4-3.2.3 Where primary or secondary combustion air is provided mechanically, combustion airflow or pressure shall be proven and interlocked with the safety shutoff valves so that oil cannot be admitted prior to establishment of combustion air and so that the oil is shut off in the event of combustion air failure.

4-3.2.4 Where a secondary air adjustment is provided, adjustment shall include a locking device to prevent an unintentional change in setting.

4-3.3 Oil Supply Piping.

4-3.3.1 Storage tanks, their installation, and their supply piping materials shall comply with NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.

4-3.3.2 A remotely located shutoff valve shall be provided to allow the fuel to be turned off in an emergency and shall be located so that fire or explosion at a furnace does not prevent access to this valve. A positive displacement oil pump shall be permitted to serve as a valve by shutting off its power.

4-3.3.3 Where a shutoff is installed in the discharge line of an oil pump that is not an integral part of a burner, a pressure-relief valve shall be connected to the discharge line between the pump and the shutoff valve and arranged to return surplus oil to the supply tank or to bypass it around the pump, unless the pump includes an internal bypass.

4-3.3.4* All air from the supply and return piping shall be purged initially, and air entrainment in the oil shall be minimized.

4-3.3.5 Suction, supply, and return piping shall be adequately sized with respect to oil pump capacity.

4-3.3.6* Wherever a section of oil piping can be shut off at both ends, relief valves or expansion chambers shall be used to release the pressure caused by thermal expansion of the oil.

4-3.4 Equipment Oil Piping.

4-3.4.1 Manual Shutoff Valves and Cocks.

4-3.4.1.1 Individual manual shutoff valves for equipment isolation shall be provided for shutoff of the fuel to each piece of equipment.

4-3.4.1.2 Manual shutoff valves shall be installed to avoid oil spillage during servicing of supply piping and associated components.

4-3.4.1.3 Manual shutoff valves shall display a permanently affixed visual indication of the valve position.

4-3.4.1.4 Quarter-turn valves with removable wrenches shall not allow the wrench handle to be installed perpendicular to the fuel oil line when the valve is open.

4-3.4.1.5 It shall be the user's responsibility to ensure that separate wrenches (handles) remain affixed to the valve and that they are oriented properly with respect to the valve port.

4-3.4.1.6 Valves and cocks shall be maintained and lubricated in accordance with the manufacturer's instructions.

4-3.4.2 Piping and Fittings.

4-3.4.2.1 Equipment piping shall be in accordance with NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.

4-3.4.2.2 Piping, fittings, and valves shall be sized to provide proper flow rates and pressure so as to maintain a stable flame over the burner operating range.

4-3.4.3 Oil Filters and Strainers.

4-3.4.3.1 An oil filter or strainer shall be installed in the oil piping to protect the downstream components.

4-3.4.3.2* The degree of filtration shall be compatible with the size of the most critical clearance being protected.

4-3.4.3.3 The filter or strainer shall be suitable for the intended pressure, temperature, and service.

4-3.4.4 Pressure Regulators. A pressure regulator shall be furnished wherever the plant supply pressure exceeds that required for proper burner operation or wherever the plant supply pressure is subject to excessive fluctuations.

Exception: An automatic flow control valve shall be permitted to meet this requirement, provided it can compensate for the full range of expected source pressure variations.

4-3.4.5* Pressure Gauges. Pressure gauges shall be isolated or protected from pulsation damage during operation of the burner system.

4-3.5 Flow Control Valves. Where the minimum or the maximum flow of combustion air or the fuel oil is critical to the safe operation of the burner, flow valves shall be equipped with an appropriate limiting means and with a locking device to prevent an unintentional change in the setting.

4-3.6 Oil Atomization.

4-3.6.1* Oil shall be atomized to droplet size as required for proper combustion throughout the firing range.

4-3.6.2 The atomizing device shall be accessible for inspection, cleaning, repair, replacement, and other maintenance as required.

4-3.7 Oil Burners.

4-3.7.1 All burners shall maintain the stability of the designed flame shape over the entire range of turndown that is encountered during operation where supplied with combustion air (oxygen-enriched air or oxygen) and the designed fuels in the proper proportions and in the proper pressure ranges.

4-3.7.2 All pressures required for the safe operation of the combustion system shall be maintained within the proper ranges throughout the firing cycle.

4-3.7.3 The burner shall be supplied with fuel oil of the proper grade that has been preconditioned to the required viscosity.

4-3.7.4 Burners shall have the ignition source sized and located in a position that provides safe and reliable ignition of the pilot or main flame.

4-3.7.4.1 Self-piloted burners shall have a safe and reliable transition from pilot flame to main flame.

4-3.7.4.2 For burners that cannot be ignited safely at all firing rates, positive provision shall be made to reduce the burner firing rates during light-off to a lower level, which ensures a safe and reliable ignition of the main flame (forced low-fire start).

4-3.7.5 If purging of oil passages upon normal termination of a firing cycle is required, it shall be done prior to shutdown with the initial ignition source present and with all associated fans and blowers in operation.

4-3.8 Fuel Ignition.

4-3.8.1* The ignition source (e.g., electric spark, hot wire, pilot burner, handheld torch) shall be applied effectively at the proper point and with sufficient intensity to ignite the air–fuel mixture.

4-3.8.2 Fixed ignition sources shall be mounted so as to prevent unintentional changes in location and in direction with respect to the main flame.

4-3.8.3 Pilot burners shall be considered burners, and all provisions of Section 4-2 shall apply.

4-3.9 Dual-Fuel and Combination Burners. Where fuel gas and fuel oil are to be fired individually (dual-fuel) or simultaneously (combination), the provisions of Sections 4-2, 4-3, and 5-12 shall apply equally to the respective fuels.

4-4 Oxygen-Enhanced Fuel-Fired Units.

4-4.1* Scope. Section 4-4 shall apply to combustion systems using oxygen (oxy-fuel) or oxygen-enriched air with gas or liquid fuels. The requirements shall be in addition to those in Sections 4-2 and 4-3 and Chapter 5.

4-4.2 Combustion Systems Utilizing Oxygen.

4-4.2.1 Oxygen storage and delivery systems shall comply with NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites.*

4-4.2.2 Oxygen shall not be introduced into inlet or discharge piping of air compressors or blowers that are internally lubricated with petroleum oils, greases, or other combustible substances.

4-4.3 Oxygen Piping and Components.

4-4.3.1 Design, materials of construction, installation, and tests of oxygen piping shall comply with the applicable sections of ASME B31.3, *Process Piping.*

4-4.3.2* Materials and construction methods used in the installation of the oxygen piping and components shall be compatible with oxygen.

4-4.3.3* Piping and components that come in contact with oxygen shall be cleaned prior to admitting gas.

4-4.3.4* Air introduced into oxygen passages in burners, such as cooling air, shall be free of particulate matter, oil, grease, and other combustible materials.

4-4.3.5 A remotely located shutoff valve shall be provided to allow the oxygen to be turned off in an emergency and shall be located so that fire or explosion at a furnace does not prevent access to this valve.

4-4.3.6 Oxygen from pressure-relief devices and purge outlets shall not be released into pipes or manifolds where it can mix with fuel.

4-4.3.7 Oxygen from pressure-relief devices and purge outlets shall be released to a safe location.

4-4.3.8 Means shall be provided to prevent oxygen, fuel, or air to intermix in burner supply lines due to valve leakage, burner plugging, or other system malfunctions.

4-4.3.9* Oxygen piping and components shall be inspected and maintained.

4-4.3.10 If glass tube flowmeters are used in oxygen service, safeguards against personnel injury from possible rupture shall be provided.

4-4.3.11* The piping fed from a cryogenic supply source shall be protected from excessive cooling by means of an automatic low-temperature shutoff device.

4-4.3.12 Piping and controls downstream of an oxygen pressure-reducing regulator shall be able to withstand the maximum potential upstream pressure or shall be protected from overpressurization by means of a suitable pressure-relief device.

4-4.4 Oxygen Flow Control Valves.

4-4.4.1 Where the minimum or the maximum flow of oxygen or oxygen-enriched air is critical to safe operation of the burner, flow control valves shall be equipped with an appropriate limiting means and locking device to prevent an unintentional change in the setting.

4-4.4.2 An oxygen pressure regulator shall be furnished wherever the source oxygen pressure exceeds that required for proper burner operation or wherever the source pressure is subject to excessive fluctuations.

Exception: An automatic flow control valve shall be permitted to meet this requirement, provided it can compensate for the full range of expected source pressure variations and complies with 4-4.4.1.

4-4.5 Oxygen-Enriched Combustion Air.

4-4.5.1 Filters shall be installed in the air blower intake to minimize contamination of the oxygen-enriched air piping.

4-4.5.2* Devices, such as diffusers, used to disperse oxygen into an airstream shall be designed to prevent jet impingement of oxygen onto interior surfaces of the air piping.

4-4.5.3 Oxygen-enriched combustion air shall not be introduced into a burner before the oxygen has been uniformly mixed into the airstream.

4-4.5.4 Branching of the enriched-air piping shall not be permitted before a uniform mixture of oxygen and air has been attained.

4-5 Flue Product Venting.

4-5.1 A means shall be provided to ensure adequate ventilation for the products of combustion on fuel-fired equipment.

4-5.2 Collecting and venting systems for radiant tube–type heating systems shall be of sufficient capacity to prevent an explosion or fire hazard due to the flow of unburned fuel through the radiant tubes. The system shall be capable of dilution of the rated maximum input capacity of the system to a noncombustible state.

Exception: These requirements shall not apply to radiant tube–type heating systems provided with two safety shutoff valves interlocked with combustion safeguards.

4-6 Electrically Heated Units.

4-6.1 Scope. Section 4-6 includes all types of heating systems where electrical energy is used as the source of heat.

4-6.2 Safety Equipment. Safety equipment including airflow interlocks, time relays, and temperature switches shall be in accordance with Chapter 5.

4-6.3 Electrical Installation. All parts of the electrical installation shall be in accordance with NFPA 70, *National Electrical Code.*

4-6.4 Resistance Heating Systems.

4-6.4.1 The provisions of 4-6.4 shall apply to resistance heating systems, including infrared lamps, such as quartz, ceramic, and tubular glass types.

4-6.4.2 Construction.

4-6.4.2.1 The heater housing shall be constructed so as to provide access to heating elements and wiring.

4-6.4.2.2 Heating elements and insulators shall be supported securely or fastened so that they do not become easily dislodged from their intended location.

4-6.4.2.3 Heating elements that are electrically insulated from and supported by a metallic frame shall have the frame electrically grounded.

4-6.4.2.4 Open-type resistor heating elements shall be supported by electrically insulated hangers and shall be secured to prevent the effects of motion induced by thermal stress, which could result in adjacent segments of the elements touching one another, or the effects of touching a grounded surface.

4-6.4.2.5 External parts of furnace heaters that are energized at voltages that could be hazardous as specified in NFPA 70, *National Electrical Code*, shall be guarded.

4-6.4.3 Heater Locations. Heaters shall not be located directly under the product being heated where combustible materials can drop and accumulate.

4-6.5 Induction and Dielectric Heating Systems.

4-6.5.1 Induction and dielectric heating systems shall be designed and installed in accordance with NFPA 70, *National Electrical Code*, with special reference to Article 665.

4-6.5.2 Construction.

4-6.5.2.1* Combustible electrical insulation shall be reduced to a minimum.

4-6.5.2.2 Protection shall be installed to prevent overheating of any part of the equipment in accordance with NFPA 70, *National Electrical Code.*

4-6.5.2.3 Where water-cooling is used for transformers, capacitors, electronic tubes, spark gaps, or high-frequency conductors, cooling coils and connections shall be arranged so that leakage or condensation does not damage the electrical equipment. The cooling-water supply shall be interlocked with the power supply so that loss of water cuts off the power supply. Consideration shall be given to providing individual pressure flow interlocks for parallel waterflow paths.

4-6.5.2.4 Where forced ventilation by motor-driven fans is necessary, the air supply shall be interlocked with the power supply. An air filter shall be provided at the air intake.

4-6.5.2.5 The conveyor motor and the power supply of dielectric heaters of the conveyor type used to heat combustible materials shall be interlocked to prevent overheating of the material being treated.

4-6.5.2.6 Dielectric heaters used for treating highly combustible materials shall be designed to prevent a disruptive discharge between the electrodes.

4-7 Fluid-Heated Systems.

4-7.1* Scope. Section 4-7 shall apply to all types of systems where water, steam, or other heat transfer fluids are the source of heat through the use of heat exchangers. Section 4-7 covers the heat transfer fluid system between the oven supply and return isolation valves for the oven being served.

4-7.2 General.

4-7.2.1* Piping and fittings shall be in accordance with ASME B31.1, *Power Piping.*

4-7.2.2 Piping containing combustible heat transfer fluid that is insulated shall use closed-cell, nonabsorptive insulation. Fibrous or open-cell insulation shall not be permitted.

4-7.2.3* Oven isolation valves shall be installed in the fluid supply and return lines. If a combustible heat transfer fluid is used, the oven isolation valves shall be installed within 5 ft (1.5 m) of the oven.

4-7.2.4 Enclosures or ductwork for heat exchanger coils shall be of noncombustible construction with suitable access openings provided for maintenance and cleaning.

4-7.2.5 Heat exchangers or steam coils shall not be located on the floor of an oven or in any position where paint drippage or combustible material can accumulate on the coils.

4-7.3 Safety Devices.

4-7.3.1 System equipment shall be operated within the temperature and pressure limits specified by the supplier or manufacturer of the heat transfer medium and by the manufacturer of the equipment.

4-7.3.2 If the oven atmosphere is recirculated over the heat exchanger coils, a noncombustible filtration system shall be used if combustible particulates can deposit on the heat exchanger surface. The filtration system and heat exchanger shall be cleaned on a regular schedule.

Chapter 5 Safety Equipment and Application

5-1 Scope.

5-1.1 Chapter 5 shall apply to safety equipment and its application to furnace heating and ventilation systems. Section 5-3 shall apply to all safety controls included in this standard.

5-1.2* For the purpose of this chapter, the term *furnace heating system* shall include the heating source, associated piping and wiring used to heat the furnace, auxiliary quenches, and the work therein.

5-2 General.

5-2.1 All safety devices shall be listed for the service intended. Safety devices shall be applied and installed in accordance with this standard and the manufacturer's instructions.

Exception: Where listed devices are not available for the service intended, the selected device shall require approval by the authority having jurisdiction.

5-2.2 Electric relays and safety shutoff valves shall not be used as substitutes for electrical disconnects and manual shutoff valves.

5-2.3 Purge, ignition trials, and other burner safety sequencing shall be performed only by devices listed for such service.

5-2.4 A shutdown of the heating system by any safety feature or safety device shall require manual intervention of an operator for re-establishment of normal operation of the system.

5-2.5 Regularly scheduled inspection, testing, and maintenance of all safety devices shall be performed. *(See Chapter 17.)*

5-2.5.1 It shall be the responsibility of the equipment manufacturer to provide operating instructions that cover start-up, shutdown, emergencies, and procedures for inspection, testing, and maintenance.

5-2.5.2 It shall be the responsibility of the user to establish, schedule, and enforce the frequency and extent of the inspection, testing, and maintenance program, as well as the corrective action to be taken. Documented safety inspections and testing shall be performed at least annually.

5-2.6 Safety devices shall be installed, used, and maintained in accordance with the manufacturer's instructions.

5-2.7 All combustion safety circuitry contacts for required safety interlocks and excess temperature limit controllers shall be arranged in series ahead of the safety shutoff valve holding medium.

Exception No. 1: Devices specifically listed for combustion safety service shall be permitted to be used in accordance with the listing requirements and the manufacturer's instructions.

Exception No. 2: Interposing relays shall be permitted where the conditions of (a), (b), and (c) are met:

(a) Required connected load exceeds the rating of available safety interlock devices or where necessary to perform required safety logic functions

(b) Interposing relay is configured to revert to a safe condition upon loss of power

(c) Each interposing relay serves no more than one safety interlock device

5-2.8 Safety devices shall be located or guarded to protect them from physical damage.

5-2.9 Safety devices shall not be removed or rendered ineffective.

5-2.10 Safety devices shall not be bypassed electrically or mechanically. This requirement shall not prohibit safety device testing and maintenance in accordance with 5-2.5. When a system includes a "built-in" test mechanism that bypasses any safety device, it shall be interlocked to prevent operation of the system while the device is in the test mode, unless listed for that purpose.

5-2.11* Electrical power for safety control circuits shall be single-phase, one-side grounded, with all breaking contacts in the "hot" ungrounded, fuse-protected, or circuit breaker–protected line, and shall not exceed 120-volt potential.

5-3 Programmable Controllers for Safety Service.

5-3.1 General.

5-3.1.1 The supplier of the application software for the programmable controller shall provide the end user and the authority having jurisdiction with the documentation needed to verify that all related safety devices and safety logic are functional before the programmable controller is placed in operation.

5-3.1.2 In the event of a power failure, the programmable controller (hardware and software) shall not prevent the system from reverting to a safe default condition. A safe condition shall be maintained upon the restoration of power.

5-3.1.3 The control system shall have a separate manual emergency switch, independent of the programmable controller, that initiates a safe shutdown.

CAUTION

For some applications, additional manual action might be required to bring the process to a safe condition.

5-3.1.4 Any changes to hardware or software shall be documented, approved, and maintained in a file on the site.

5-3.1.5 The internal status of the programmable controller shall be monitored. In the event of a programmable controller failure, the system shall annunciate and cause the system to revert to a safe condition.

5-3.1.6 The system access shall be limited by incorporating measures to prevent unauthorized access to the programmable controller or its logic that could result in hazards to personnel or equipment.

CAUTION

Modems and networks require special measures to provide the necessary security.

5-3.2 Combustion Safety Functions.

5-3.2.1 Programmable controller–based systems specifically listed for combustion safety service shall be permitted where applied in accordance with the listing requirements and the manufacturer's instructions.

5-3.2.2 A programmable controller not listed for combustion safety service shall be permitted to monitor safety interlocks, or to provide burner control functions, provided that its use complies with both of the following:

(1) The programmable controller shall not interfere with or prevent the operation of the safety interlocks.
(2) Only isolated programmable controller contacts (not directly connected to a power source) shall be permitted to be wired in series with the safety interlocks to permit burner control functions.

5-3.2.3 The requirements of 5-2.3 shall apply to programmable controller–based systems.

5-3.3 Hardware.

5-3.3.1* A failure of programmable controller hardware shall cause the system to revert to a safe default condition.

5-3.3.2 A programmable controller shall be provided with a watchdog timer external to the CPU and memory. Failures detected by the watchdog timer shall cause the system to revert to a safe default condition.

5-3.3.3 System operation shall be tested and verified for compliance with this standard and the original design criteria whenever the programmable controller is replaced, repaired, or updated.

5-3.4 Software.

5-3.4.1 Whenever application software that contains safety logic or detection logic is modified, system operation shall be verified for compliance with this standard and the original design criteria.

5-3.4.2 The software for the programmable controller shall reside in some form of nonvolatile storage (memory that retains information on loss of system power).

5-3.4.3 Application software that contains safety logic shall be separated from all other programming. Application software that interacts with safety logic or detection logic for input/output devices shall be separated from all other programming.

5-3.4.4 Unauthorized change or corruption of software shall cause the system to revert to a safe default condition.

5-4 Safety Control Application for Fuel-Fired Heating Systems.

5-4.1 Preignition (Prepurge, Purging Cycle).

5-4.1.1* Prior to each furnace heating system start-up, provision shall be made for the removal of all flammable vapors and gases that might have entered the heating chambers during the shutdown period.

5-4.1.2 A timed preignition purge shall be provided. At least 4 standard cubic feet (scf) of fresh air or inert gas per cubic foot (4 m^3/m^3) of heating chamber volume shall be introduced during the purging cycle.

5-4.1.2.1 To begin the timed preignition purge interval, both of the following conditions shall be satisfied:

(1) The minimum required preignition airflow shall be proven *(see Sections 5-5 and 5-6 for proof of airflow requirements).*
(2) The safety shutoff valve(s) shall be closed *(see 5-7.2.2 and 5-7.3.2 for proof of closure requirements).*

5-4.1.2.2 The minimum required preignition purge airflow shall be proven and maintained throughout the timed preignition purge interval.

5-4.1.2.3 Failure to maintain the minimum required preignition purge airflow shall stop the preignition purge and reset the purge timer.

5-4.1.3 A furnace heating system, either alone or as part of multiple furnaces feeding into one fume incinerator, shall not be purged into an operating incinerator.

Exception: A furnace heating system shall be permitted to be purged into an operating incinerator if it can be demonstrated that the flammable vapor concentration entering the fume incinerator cannot exceed 50 percent of the LEL.

5-4.1.4 Preignition purging of radiant tube–type heating systems shall be provided.

Exception: Preignition purging of radiant tube–type heating systems shall not be required where the systems are arranged and designed such that the conditions of (a) or (b) are satisfied.

(a) The tubes are of metal construction and open at one or both ends with heat recovery systems, if used, that are of explosion-resistant construction.

(b) The entire radiant tube heating system, including any associated heat recovery system, is of explosion-resistant construction.

5-4.1.5 Prior to the reignition of a burner after a burner shutdown or flame failure, a preignition purge shall be accomplished.

Exception: Repeating the preignition purge shall not be required where the following conditions of (a), (b), or (c) are satisfied.

(a) The heating chamber temperature exceeds 1400°F (760°C).

(b) For any fuel-fired system, all of the following conditions are satisfied: (1) each burner and pilot is supervised by a combustion safeguard in accordance with Section 5-9; (2) each burner system is equipped with safety shutoff valves in accordance with Section 5-7; and (3) at least one burner remains operating in the common combustion chamber of the burner to be reignited.

(c) All of the following conditions are satisfied (does not apply to fuel oil systems): (1) each burner and pilot is supervised by a combustion safeguard in accordance with Section 5-9; (2) each burner system is equipped with gas safety shutoff valves in accordance with Section 5-7; and (3) it can be demonstrated that the combustible concentration in the heating chamber cannot exceed 25 percent of the LEL.

CAUTION

Repeated ignition attempts can result in a combustible concentration greater than 25 percent of the LEL. Liquid fuels can accumulate, causing additional fire hazards.

5-4.2 Trial-for-Ignition Period.

5-4.2.1 The trial-for-ignition period of the pilot burner shall not exceed 15 seconds.

5-4.2.2 The trial-for-ignition period of the main gas burner shall not exceed 15 seconds.

Exception: The trial-for-ignition period of the main gas burner shall be permitted to exceed 15 seconds where both of the following conditions are satisfied.

(a) A written request for an extension of the trial-for-ignition period is approved by the authority having jurisdiction.

(b) It is determined that 25 percent of the LEL cannot be exceeded in the extended time.

5-4.2.3 The trial-for-ignition period of the main oil burner shall not exceed 15 seconds.

5-5 Ventilation Safety Devices.

5-5.1 Wherever a fan is essential to the operation of the oven or allied equipment, fan operation shall be proven and interlocked into the safety circuitry.

5-5.1.1 Electrical interlocks and flow switches shall be arranged in the safety control circuit so that loss of ventilation or airflow immediately shuts down the heating system of the affected section, or, if necessary, loss of ventilation shall shut down the entire heating system as well as the conveyor.

5-5.1.2 Air pressure switches shall not be used to prove airflow where dampers downstream of the pressure switch can be closed to the point of reducing flow to an unsafe operating level.

5-5.1.3 Air suction switches shall not be used to prove airflow where dampers upstream of the pressure switch can be closed to the point of reducing flow to an unsafe operating level.

5-5.1.4 Switches used to prove airflow on systems where the air is contaminated with any substance that might condense or otherwise create a deposit shall be selected and installed to prevent interference with the performance of the switch.

5-5.2 Dampers capable of being adjusted to a position that can result in an unsafe condition shall be equipped with mechanical stops, cut-away dampers, or limit switches interlocked into the safety circuitry to ensure that dampers are in a proper operating position.

5-6 Combustion Air Safety Devices.

5-6.1 Where the air from the exhaust or recirculating fans is required for combustion of the fuel, airflow shall be proven prior to an ignition attempt. Reduction of airflows to an unsafe level shall result in closure of the safety shutoff valves.

5-6.2 Where a combustion air blower is used, the minimum combustion air needed for proper burner operation shall be proven prior to each attempt at ignition.

5-6.3 Motor starters on equipment required for the combustion of the fuel shall be interlocked into the combustion safety circuitry.

5-6.4* A low pressure switch shall be used to sense and monitor combustion air pressure or differential pressure and shall be interlocked into the combustion safety circuitry.

Exception: Alternative methods of verification of minimum combustion air required for burner operation shall be permitted where both of the following conditions are satisfied.

(a) The burner can reliably operate at a combustion air pressure that is lower than the available range of pressure switches listed for this service.

(b) The alternative method is acceptable to the authority having jurisdiction.

5-6.5 Wherever it is possible for combustion air pressure to exceed a maximum safe operating pressure, as might occur where compressed air is utilized, a high pressure switch interlocked into the combustion safety circuitry shall be used.

5-7 Safety Shutoff Valves (Fuel Gas or Oil).

5-7.1 General.

5-7.1.1 Safety shutoff valves shall be utilized as a key safety control to protect against explosions and fires.

5-7.1.2 Each safety shutoff valve required in 5-7.2.1 and 5-7.3.1 shall automatically shut off the fuel to the burner system after interruption of the holding medium (such as electric current or fluid pressure) by any one of the interlocking safety devices, combustion safeguards, or operating controls.

Exception: For fuel gas systems, where multiple burners or pilots operate as a burner system firing into a common heating chamber, the loss of flame signal at one or more burners shall be permitted to shut off those burner(s) by closing a single safety shutoff valve, provided the following conditions in both (a) and (b) are satisfied.

(a) For the individual burner safety shutoff valve: (1) it is demonstrated based on available air flow that failure of the valve to close will result in a fuel concentration not greater than 25 percent of the LEL; or (2) the safety shutoff valve has proof of closure acceptable to the authority having jurisdiction; or (3) the fuel to the burner is monitored to verify that there is no fuel flow following operation of the burner safety shutoff valve.

(b) The safety shutoff valve upstream of the individual burner safety shutoff valves shall close for any of the following conditions: (1) activation of any operating control or interlocking safety device other than the combustion safeguard; or (2) when the individual burner valves do not have proof of closure or fuel monitoring as described in (a) and the number of failed burners are capable of exceeding 25 percent of the LEL if their single safety shutoff valves should fail in the open position; or (3) when individual burner valves have proof of closure or fuel monitoring as described in (a) and verification that the individual burner safety shutoff valve has closed following loss of flame signal at the burner is not present; or (4) loss of flame signal at all burners in the burner system or at a number of burners in the burner system that will result in unsafe operation.

5-7.1.3 Safety shutoff valves shall not be used as modulating control valves.

Exception: The use of listed safety shutoff valves designed as both a safety shutoff valve and a modulating valve, and tested for concurrent use, shall be permitted.

5-7.1.4 Valve components shall be of a material suitable for the fuel handled and for ambient conditions.

5-7.1.5 Safety shutoff valves in systems containing particulate matter or highly corrosive fuel gas shall be operated regularly in accordance with the manufacturer's instructions to assure their proper operation.

5-7.1.6 Valves shall not be subjected to pressures in excess of the manufacturer's ratings.

5-7.1.7 If normal inlet pressure to the fuel pressure regulator immediately upstream from the valve exceeds the valve's pressure rating, a relief valve shall be provided and it shall be vented to a safe location.

5-7.1.8 Local visual position indication shall be provided at each safety shutoff valve to burners or pilots in excess of 150,000 Btu/hr (44 kW). This indication shall directly indicate the physical position, closed and open, of the valve. Where lights are used for position indication, the absence of light shall not be used to indicate open or closed position. Indirect indication of valve position, such as by monitoring operator current voltage or pressure, shall not be permitted.

5-7.2 Fuel Gas Safety Shutoff Valves.

5-7.2.1 Each main and pilot fuel gas burner system shall be separately equipped with two safety shutoff valves piped in series.

Exception: A single safety shutoff valve shall be permitted on a radiant tube–fired burner system where the following conditions of (a) or (b) are satisfied.

(a) The tubes are of metal construction and open at one or both ends with heat recovery systems, if used, that are of explosion-resistant construction.

(b) The entire radiant tube heating system, including any associated heat recovery system, is of explosion-resistant construction.

5-7.2.2 Where the main or pilot fuel gas burner system capacity exceeds 400,000 Btu/hr (117 kW), at least one of the safety shutoff valves required by 5-7.2.1 shall be proved closed and interlocked with the preignition purge interval. *(See 5-4.1.2.1.)*

5-7.2.3* A permanent and ready means for making tightness checks of all fuel gas safety shutoff valves shall be provided.

5-7.2.4 Tightness checks shall be performed in accordance with the manufacturer's instructions. Testing frequency shall be at least annually.

5-7.3 Oil Safety Shutoff Valves.

5-7.3.1 Two safety shutoff valves shall be provided under any one of the following conditions:

(1) Where the pressure is greater than 125 psi (862 kPa)
(2) Wherever the fuel oil pump operates without the main oil burner firing, regardless of the pressure
(3) For combination gas and oil burners, where the fuel oil pump operates during the fuel gas burner operation

Where none of the conditions of 5-7.3.1(1) through (3) apply, a single safety shutoff valve shall be permitted.

5-7.3.2 Where two safety shutoff valves are required by 5-7.3.1, at least one of the two safety shutoff valves shall be proved closed and interlocked with the preignition purge interval.

5-8 Fuel Pressure Switches (Gas or Oil).

5-8.1 A low pressure switch shall be provided and shall be interlocked into the combustion safety circuitry.

5-8.2 A high gas pressure switch shall be provided and interlocked into the combustion safety circuitry. The switch shall be located downstream of the final pressure-reducing regulator.

Exception: For an oil system, a high pressure switch shall not be required where the fuel supply pressure to the burners cannot exceed the operating limits of the system.

5-8.3 Pressure switch settings shall be made in accordance with the operating limits of the burner system.

5-9 Combustion Safeguards (Flame Supervision).

5-9.1 Each burner flame shall be supervised by a combustion safeguard having a maximum flame failure response time of 4 seconds or less, that performs a safe-start check, and is interlocked into the combustion safety circuitry.

Exception No. 1: The flame supervision shall be permitted to be switched out of the combustion safety circuitry for a furnace zone when that zone temperature is at or above 1400°F (760°C). When the zone temperature drops below 1400°F (760°C), the burner shall be interlocked to allow its operation only if flame supervision has been re-established. A 1400°F (760°C) bypass controller shall be used for this purpose.

Exception No. 2: Combustion safeguards on radiant tube–type heating systems shall not be required where a suitable means of ignition is provided and the systems are arranged and designed such that the following conditions of (a) or (b) are satisfied.

(a) The tubes are of metal construction and open at one or both ends with heat recovery systems, if used, that are of explosion-resistant construction.

(b) The entire radiant tube heating system, including any associated heat recovery system, is of explosion-resistant construction.

Exception No. 3: Burners without flame supervision shall be permitted, provided these burners are interlocked to prevent their operation when the zone temperature is less than 1400°F (760°C). A 1400°F (760°C) bypass controller shall be used for this purpose.

5-9.2* Flame Supervision.

5-9.2.1 Each pilot and main burner flame shall be supervised independently.

Exception No. 1: One flame sensor shall be permitted to be used to supervise the main burner and pilot flames if an interrupted pilot is used.

Exception No. 2: One flame sensor shall be permitted to be used to supervise self-piloted burners, as defined in Chapter 2.

5-9.2.2* Line burners, pipe burners, and radiant burners, where installed immediately adjacent to one another or connected with suitable flame-propagating devices, shall be considered to be a single burner and shall have at least one flame safeguard installed to sense burner flame at the end of the assembly farthest from the source of ignition.

5-10 Fuel Oil Atomization (Other than Mechanical Atomization).

5-10.1 Adequate pressure of the atomizing medium shall be proven and interlocked into the combustion safety circuitry.

5-10.2 The low pressure switch used to supervise the atomizing medium shall be located downstream from all cocks, valves, and other obstructions that can shut off flow or cause excessive pressure drop of atomization medium.

5-11* Fuel Oil Temperature Limit Devices. Fuel oil temperature limit devices shall be provided and interlocked into the combustion safety circuitry if conditions allow the fuel oil temperature to rise above or fall below a predetermined safe level.

5-12 Multiple Fuel Systems.

5-12.1 Safety equipment in accordance with the requirements of this standard shall be provided for each fuel used. The fact that oil or gas is considered a standby fuel shall not reduce the safety requirements for that fuel.

5-12.2 Where dual-fuel burners are used, positive provision shall be made to prevent the simultaneous introduction of both fuels.

Exception: This requirement shall not apply to combination burners.

5-13 Air–Fuel Gas Mixing Machines.

5-13.1 A safety shutoff valve shall be installed in the fuel gas supply connection of any mixing machine.

5-13.2 The safety shutoff valve shall be arranged to shut off the fuel gas supply automatically when the mixing machine is not in operation or in the event of an air or fuel gas supply failure.

5-14 Oxygen Safety Devices.

5-14.1 Two oxygen safety shutoff valves in series shall be provided in the oxygen supply line.

5-14.2 A filter or fine-mesh strainer shall precede the upstream safety shutoff valve.

5-14.3 There shall be a high oxygen flow or pressure limit interlocked into the combustion safety circuitry. The switch shall be located downstream of the final pressure regulator or automatic flow control valve.

5-14.4 There shall be a low oxygen flow or pressure limit interlocked into the combustion safety circuitry.

5-14.5 The oxygen safety shutoff valves shall shut automatically after interruption of the holding medium by any one of the interlocking safety devices.

5-14.6 Safety shutoff valves shall not be used as modulating control valves.

Exception: The use of listed safety shutoff valves designed as both a safety shutoff valve and a modulating valve, and tested for concurrent use, shall be permitted.

5-14.7 A permanent and ready means for making tightness checks of all oxygen safety shutoff valves shall be provided.

5-14.8 Local visual position indication shall be provided for each oxygen safety shutoff valve to burners or pilots in excess of 150,000 Btu/hr (44 kW). This indication shall directly indicate the physical position, closed and open, of the valve. Where lights are used for position indication, the absence of light shall not be used to indicate open or closed position. Indirect indication of valve position, such as by monitoring operator current voltage or pressure, shall not be permitted.

5-14.9 Oxygen-Enriched Burners.

5-14.9.1 Where oxygen is added to a combustion air line, an interlock shall be provided to permit oxygen flow only when airflow is proven continuously. Airflow shall be proven in accordance with the requirements of Section 5-5.

5-14.9.2 Upon loss of oxygen flow, the flow of fuel shall be permitted to continue where there is no interruption in the flow of combustion air, provided the control system can revert automatically to a safe air–fuel ratio before a hazard due to a fuel-rich flame is created.

5-14.10 Burner systems employing water or other liquid coolants shall be equipped with a low coolant flow limit switch located downstream of the burner and interlocked into the combustion safety circuitry.

5-14.10.1 A time delay shall be permitted that allows the operator to take corrective action, provided an alarm is activated and it can be proved to the authority having jurisdiction that such a delay cannot create a hazard.

5-14.10.2 Coolant piping systems shall be protected from freezing and overpressurization.

5-15 Ignition of Main Burners — Fuel Gas or Oil.

5-15.1 If a reduced firing rate is required for safe and reliable ignition of the burner (forced low-fire start), an interlock shall be provided to prove the control valve is properly positioned prior to each attempt at ignition.

5-15.2 Electrical ignition energy for direct spark ignition systems shall be terminated after the main burner trial-for-ignition period.

Exception: Continuous operation of direct spark igniters shall be permitted for radiant tube–type heating systems that do not require combustion safeguards.

5-16* Excess Temperature Limit Controller.

5-16.1 An excess temperature limit controller shall be provided and interlocked into the combustion safety circuitry, unless it can be demonstrated that a safe temperature limit cannot be exceeded.

5-16.2 Operation of the excess temperature limit controller shall cut off the source of heat before the safe temperature is exceeded.

5-16.3 Operation of the excess temperature limit controller shall require manual reset before restart of the furnace or affected furnace zone.

5-16.4 Failure of the temperature-sensing element of the excess temperature limit controller shall cause the same response as an excess temperature condition.

CAUTION

Where a thermocouple is used with an excess temperature limit controller, ruggedly constructed and conservatively rated thermocouples and extension wires shall be used to minimize the probability of a short circuit in the thermocouple or thermocouple extension wires. Thermocouple short circuits should not result in the action required by 5-16.4.

5-16.5 The temperature-sensing element of the excess temperature limit controller shall be suitable for the temperature and atmosphere to which it is exposed.

5-16.6 The temperature-sensing element of the excess temperature limit controller shall be located to sense the temperature most critical to safe operation.

5-16.7 The excess temperature limit controller set point shall be displayed or clearly marked in units of temperature (°F or °C).

5-16.8 The operating temperature controller and its temperature-sensing element shall not be used as the excess temperature limit controller.

5-17 1400°F (760°C) Bypass Controller.

5-17.1 Where permitted in accordance with 5-9.1 to switch the flame supervision out of the combustion safety circuitry or to bring unsupervised burners on-line, a 1400°F (760°C) bypass controller shall be used.

5-17.2 Failure of the temperature-sensing element shall cause the same response as an operating temperature less than 1400°F (760°C).

5-17.3 The temperature-sensing element of the 1400°F (760°C) bypass controller shall be suitable for the temperature and atmosphere to which it is exposed.

5-17.4 The temperature-sensing element of the 1400°F (760°C) bypass controller shall be located to sense the temperature most critical to safe operation.

5-17.5 The 1400°F (760°C) bypass controller set point shall not be set below 1400°F (760°C), and the set point shall be displayed or clearly marked in units of temperature (°F or °C).

5-17.6 Visual indication shall be provided to indicate when the 1400°F (760°C) bypass controller is in the bypass mode.

5-17.7 The operating temperature controller and its temperature-sensing element shall not be used as the 1400°F (760°C) bypass controller.

5-18 Electrical Heating Systems.

5-18.1 Heating Equipment Controls.

5-18.1.1* Electric heating equipment shall be equipped with a main disconnect device or with multiple devices to provide back-up circuit protection to equipment and to persons servicing the equipment. Such a disconnecting device(s) shall be made capable of interrupting maximum available fault current as well as rated load current. *(See NFPA 70, National Electrical Code.)*

5-18.1.2 Shutdown of the heating power source shall not inadvertently affect the operation of equipment such as conveyors, ventilation or recirculation fans, cooling components, and other auxiliary equipment.

5-18.1.3 Branch Circuits. Branch circuits and branch circuit protection for all electrical circuits in the furnace heating system shall be provided in accordance with NFPA 70, *National Electrical Code*, and with NFPA 79, *Electrical Standard for Industrial Machinery.*

Exception: The requirements for resistance heaters larger than 48 amperes to be broken down into subdivided circuits not to exceed 48 amperes shall not apply to industrial ovens and furnaces.

5-18.1.4* The capacity of all electrical devices used to control energy for the heating load shall be selected on the basis of continuous duty load ratings where fully equipped for the location and type of service proposed.

5-18.1.5 All controls using thermal protection or trip mechanisms shall be located or protected to preclude faulty operation due to ambient temperatures.

5-18.2* Excess Temperature Limit Controller.

5-18.2.1 An excess temperature limit controller shall be provided and interlocked into the heating control circuitry.

Exception: Where it can be demonstrated that a safe temperature limit cannot be exceeded.

5-18.2.2 Operation of the excess temperature limit controller shall cut off the source of heat before the safe temperature is exceeded.

5-18.2.3 Operation of the excess temperature limit controller shall require manual reset before restart of the furnace or affected furnace zone.

5-18.2.4 Failure of the temperature-sensing element of the excess temperature limit controller shall cause the same response as an excess temperature condition.

CAUTION

Where a thermocouple is used with an excess temperature limit controller, ruggedly constructed and conservatively rated thermocouples and extension wires shall be used to minimize the probability of a short circuit in the thermocouple or thermocouple extension wires. Thermocouple short circuits should not result in the action required by 5-18.2.4.

5-18.2.5 The temperature-sensing element of the excess temperature limit controller shall be suitable for the temperature and atmosphere to which it is exposed.

5-18.2.6 The temperature-sensing element of the excess temperature limit controller shall be located to sense the temperature most critical to safe operation.

5-18.2.7 The excess temperature limit controller set point shall be displayed or clearly marked in units of temperature (°F or °C).

5-18.2.8 The operating temperature controller and its temperature-sensing element shall not be used as the excess temperature limit controller.

5-19* Fluid-Heated Systems — Excess Temperature Limit Controller.

5-19.1 Where a fluid-heated system can cause an excess temperature condition within the oven served, an excess temperature limit controller shall be provided and interlocked to interrupt the supply of heat transfer fluid to the oven.

5-19.2* Interrupting the supply of heat transfer fluid to an oven shall not cause an unsafe condition to the remainder of the heat transfer system.

5-19.3 Operation of the excess temperature limit controller shall cut off the source of heat before the safe temperature is exceeded.

5-19.4 Operation of the excess temperature limit controller shall require manual reset before re-establishing the flow of heat transfer fluid.

5-19.5 Failure of the temperature-sensing element of the excess temperature limit controller shall cause the same response as an excess temperature condition.

CAUTION

Where a thermocouple is used with an excess temperature limit controller, ruggedly constructed and conservatively rated thermocouples and extension wires shall be used to minimize the probability of a short circuit in the thermocouple or thermocouple extension wires.

5-19.6 The temperature-sensing element of the excess temperature limit controller shall be suitable for the temperature and atmosphere to which it is exposed.

5-19.7 The temperature-sensing element of the excess temperature limit controller shall be located to sense the temperature most critical to safe operation.

5-19.8 The excess temperature limit controller set point shall be displayed or clearly marked in units of temperature (°F or °C).

5-19.9 The operating temperature controller and its temperature-sensing element shall not be used as the excess temperature limit controller.

Chapter 6 Fume Incinerators

6-1 General.

6-1.1* The design and construction of fume incinerators shall comply with all requirements of Class A ovens in NFPA 86, *Standard for Ovens and Furnaces.*

Exception: The requirements for explosion relief shall not apply to fume incinerators.

6-1.2 Special precautions shall be taken to reduce the fire hazards where the relative location of equipment or the type of fumes generated are such that combustible liquids can condense or solids can be deposited between the generating process and the afterburner. *(See Chapters 3 and 18.)*

6-2* Direct-Fired Fume Incinerators.

6-2.1* The design and operation of combustion systems and controls shall comply with all parts of this standard pertaining to direct-fired ovens.

6-2.2* An excess temperature limit controller shall be provided to prevent the uncontrolled temperature rise in the fume incinerator. Operation of the excess temperature limit controller shall interrupt fuel to the fume incinerator burner and shall interrupt the source of fumes to the incinerator.

6-3 Direct Heat Recovery Systems.

6-3.1 An adequate supply of proven fresh air shall be introduced into the system to provide the oxygen necessary for combustion of hydrocarbons as well as primary burner fuel. Fresh air shall be introduced through openings that supply air directly to each zone circulating system.

6-3.2 Where direct heat recovery systems are employed and portions of the incinerator exhaust gases are utilized as the heat source for one or more of the zones of the fume-generating oven, special precautions shall be taken to prevent recycling unburned solvent vapors.

6-4* Catalytic Fume Incinerators.

6-4.1 The requirements in Section 6-2 for direct-fired fume incinerators shall apply to catalytic fume incinerators.

6-4.2* An additional excess temperature limit controller shall be located downstream from the discharge of the catalyst bed for thermal protection of the catalyst elements. Operation of the excess temperature limit controller shall interrupt fuel to the burner and shall interrupt the source of fumes.

6-4.3* Sufficient process exhaust ventilation shall be provided to maintain vapor concentrations that cannot generate temperatures at which thermal degradation of the catalyst can occur.

6-4.4* A differential pressure (ΔP) high limit switch, measuring across the catalyst bed, shall be used to detect particulate contamination. Operation of the high limit differential pressure switch shall interrupt fuel to the fume incinerator burner and shall interrupt the source of fumes to the incinerator.

6-4.5* Where catalysts are utilized with direct heat recovery, a maintenance program shall be established, and frequent tests of catalyst performance shall be conducted so that unburned or partially burned vapors are not reintroduced into the process oven.

Chapter 7 Special Atmospheres

7-1* General.

7-1.1 Chapter 7 shall apply to the equipment used to generate or to store special atmospheres and to meter or control their flows to atmosphere furnaces. Generated and synthetic special atmospheres are included. All the requirements in this standard for furnace heating systems shall apply to generator heating systems, unless otherwise specified in this chapter.

7-1.2 The selection and operation of the equipment used to produce or store special atmospheres shall be the responsibility of the user and shall be subject to the authority having jurisdiction.

7-1.3 Unwanted, normal operating, and emergency releases of fluids (gases or liquids) from special atmosphere generators, storage tanks, gas cylinders, and flow control units shall be disposed of to a safe location. Depending upon specific local circumstances and ordinances, the nature of the fluids, and the composition of the gas, then one or more of the following methods shall be employed:

(1) If the fluid is flammable, toxic, corrosive, or otherwise hazardous, a vent line controlled by an automatic valve, safety relief valve, or shutoff valve shall be provided from the point of discharge of a generator, bulk tank, compressed gas cylinder, or flow control unit.
(2) For nonflammable fluids such as carbon dioxide and nontoxic fluids such as nitrogen and argon, if venting at the maximum rate poses a hazard of asphyxiation to personnel in a building at or near the point of discharge, then the gases shall be vented outside the building.
(3) If a vented gas is burned, a suitable method of completely burning the gas and disposing of the combustion products shall be vented to a safe location.

7-1.4 Water-cooled atmosphere generators shall be provided with valves on the cooling-water inlet. Piping shall be arranged to ensure that equipment jackets are maintained full of water. Closed cooling-water systems shall comply with 3-2.9. Open cooling-water systems shall comply with 3-2.10.

7-2 Exothermic Generators.

7-2.1* General.

7-2.1.1 For the purpose of Chapter 7, exothermic generators shall be those that convert a fuel gas to a special atmosphere gas by completely or partially burning the gas with air in a controlled ratio.

7-2.1.2* Copper and copper alloy components or materials shall not be used in exothermic atmosphere gas generators, cooling systems, heat exchangers, and distribution systems where they will be exposed to the make-up, reacting, or final product exothermic atmosphere gas.

7-2.2 Protective Equipment.

7-2.2.1 Protective equipment shall be selected and applied separately for the fuel gas and air, and interlocks shall be provided. The protective devices shall shut down the system and shall require manual resetting after any utility (fuel gas, air, power) or mechanical failure. Observation ports or other means of verifying lighting of individual burners shall be provided.

7-2.2.2 The required protective equipment shall include the following:

(1) Those required in Chapters 1 through 5.
(2) The air supply or mechanical mixer shall be shut off in the event of loss of fuel gas for any reason.
(3) A device that shuts off the air from a remote supply in case of power failure or abnormally low or abnormally high fuel gas pressure at the generator.
(4) Flow indicators, meters, or differential pressure devices on the fuel gas and air supply piping, or a test burner with suitable flashback protection in the air–gas mixture line, to aid a trained operator in checking the air–gas ratio.
(5) Visual and audible alarm when the safety shutoff valve is closed.

7-3 Endothermic Generators.

7-3.1* General. Endothermic generators are those that require the addition of heat to complete the reaction of the gas and air generating the atmosphere. Section 7-3 shall apply to those types of atmosphere generators in which the atmosphere being generated is separated at all times from the heating combustion products or other heating medium.

7-3.2 Protective Equipment.

7-3.2.1 Protective equipment shall be selected and applied separately for the reaction gas and the fuel gas. In the case of a common gas supply for both the reaction and fuel gases, the same high gas pressure switch shall be permitted to serve both.

7-3.2.2 The protective devices shall shut down the system, which shall require manual resetting after any utility (fuel gas, fuel air, power) or mechanical failure.

7-3.2.3 Observation ports shall be provided to allow viewing of burner operation under all firing conditions.

7-3.2.4* Protective equipment for the reaction section of endothermic generators shall include the following.

(a) A safety shutoff valve(s) in the reaction gas supply piping arranged to close in case of abnormally low reaction gas pressure, abnormally high reaction gas pressure, loss of reaction air supply, low generator temperature, or power failure. A manual operation shall be required to open this valve.

(b) A low pressure switch in the reaction gas supply piping. This device shall close the safety shutoff valve and shut off the reaction air supply in case of abnormally low reaction gas pressure at the mixer.

(c) A high pressure switch in the reaction gas supply piping where the system is subject to abnormally high reaction gas pressure. This device shall close the safety shutoff valve and shut off the reaction air supply in the case of abnormally high reaction gas pressures at the mixer.

(d) A low pressure switch in the reaction air supply piping connected to an air blower or compressed air line. This device shall close the safety shutoff valve and shut off the reaction air supply in case of abnormally low reaction air pressure.

(e) A device that shuts off reaction air in case of power failure or abnormally low or abnormally high reaction gas pressure at the mixer.

(f) A permanent and ready means for making tightness checks of all reaction gas safety shutoff valves shall be provided.

(g) A manual shutoff valve(s), designated as the main shutoff valve, in the reaction gas supply line, located directly upstream from the safety shutoff valve. This valve shall be accessible to the operator for emergency and normal shutdown.

(h) A generator temperature control to prevent the flow of reaction air and reaction gas unless the generator is at the proper temperature. The minimum generator temperature shall be specified by the generator manufacturer.

(i) Automatic fire check protection.

(j) Visual and audible alarm when the reaction gas safety shutoff valve is closed.

7-3.2.5* The requirements of Chapters 1 through 5 shall apply to the heating system of endothermic generators.

Exception: Sections 5-4 and 5-9 shall not apply.

7-3.2.6 Visual and audible alarms shall be provided to indicate when the heating system is shut down.

7-4 Ammonia Dissociators.

7-4.1 General. An ammonia dissociator is a heated vessel in which ammonia decomposes into its component elements (25 percent nitrogen and 75 percent hydrogen) by the action of heat in the presence of a catalyst. Section 7-4 shall apply to those types of ammonia dissociators in which the ammonia being dissociated is separated at all times from the heating combustion products or other heating medium.

7-4.2 Construction.

7-4.2.1 Ammonia dissociators shall be designed and constructed to withstand the maximum attainable pressure.

7-4.2.2 All equipment, components, valves, fittings, and other related items shall be chemically compatible with ammonia. Use of brass or other copper alloy components in contact with ammonia or dissociated ammonia shall be prohibited.

7-4.3 Protective Equipment.

7-4.3.1* Protective equipment for the dissociation vessel shall include the following.

(a) A relief valve in the high pressure ammonia supply line, ahead of the pressure-reducing regulator vented to a safe location. Relief shall be set at 100 percent of the design pressure of the ammonia supply manifold. The relief devices provided shall be sized, constructed, and tested in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

(b) A relief valve in the low pressure ammonia line, between the high-pressure reducing regulator and the dissociation vessel vented to a safe location. Relief shall be set at 100 percent of the design pressure of the dissociation vessel. The relief devices provided shall be sized, constructed, and tested in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

(c) A manual shutoff valve between the pressure-reducing regulator and the dissociator. This valve shall be accessible to the operator for emergency and normal shutdown.

(d) A generator temperature control to prevent flow of ammonia unless the dissociation vessel is at proper temperature. The minimum dissociation vessel temperature shall be specified by the ammonia dissociator manufacturer.

(e) A safety shutoff valve in the ammonia supply line to the generator shall be located downstream of the manual shutoff valve and arranged to close automatically when abnormal conditions of pressure and temperature are encountered.

(f) A visual and audible alarm when the ammonia supply safety shutoff valve is closed.

7-4.3.2 Protective equipment for the dissociator heating system shall conform to the requirements for endothermic generators as specified in Section 7-3.

7-5 Bulk Storage and Generated Supply Systems for Special Atmospheres.

7-5.1 General.

7-5.1.1 All storage tanks and cylinders shall comply with local, state, and federal codes relating to the types of fluids stored, their pressures, and their temperatures. The applicable NFPA standards shall be followed.

7-5.1.2 Piping and piping components shall be in accordance with ASME B31.3, *Process Piping*.

7-5.1.3 When an ASME tank is used, the tank relief devices provided shall be sized, constructed, and tested in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

7-5.1.4 Locations for tanks and cylinders containing flammable or toxic fluids shall comply with the applicable NFPA standards.

7-5.1.5 Storage tanks and their associated piping and controls shall comply with the following standards:

(1) Liquefied petroleum gas systems shall be in accordance with NFPA 58, *Liquefied Petroleum Gas Code*.
(2) Fuel gas systems shall be in accordance with NFPA 54, *National Fuel Gas Code*.
(3) Hydrogen storage systems shall be in accordance with NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, or NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*.
(4) *Flammable or combustible liquid systems shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

7-5.1.6 A supply of inert purge gas of known and acceptable analysis shall be available where required by this standard. The processing of inert gas shall not deplete the adequacy of the inert purge gas supply. The inert purge gas shall contain less than 1 percent oxygen. If the inert purge gas contains flammable constituent gases, their combined concentration in the purge gas mixture shall be less than 25 percent of the lower flammable limit (LFL). Mixed inert purge gases shall be analyzed on a continuous basis to ensure that the oxygen and combustible gas concentrations remain within the limits specified in this paragraph.

Exception: Continuous analysis shall not be required if the inert purge gas is stored.

7-5.1.7 Bulk storage systems shall be rated and installed to provide adequate and reliable flow of special atmospheres to the user equipment if an interruption of the flow can create an explosion hazard.

7-5.1.8 In the case of inert gases that might be used as safety purge media, the volume stored always shall be sufficient to purge all connected special atmosphere furnaces with at least five furnace volume changes wherever the flammable atmospheres are being used.

7-5.2 Vaporizers Used for Safety Purging.

7-5.2.1 Vaporizers utilized to convert cryogenic liquids to the gas state shall be ambient air heat transfer units so that flow from such vaporizers is unaffected by the loss of power.

Exception: Use of powered vaporizers shall be permitted, provided that one of the following conditions is satisfied.

(a) The vaporizer has reserve heating capacity sufficient to continue vaporizing at least five furnace volumes at the required purge flow rate immediately following power interruption.

(b) Reserve ambient vaporizers are provided that are piped to the source of supply so that they are unaffected by a freeze-up or flow stoppage of gas from the powered vaporizer. The reserve vaporizers shall be capable of evaporating at least five furnace volumes at the required purge flow rate.

(c) Purge gas is available from an alternate source that is capable of supplying five volume changes after interruption of the flow of the atmosphere gas to the furnace.

7-5.2.2 Vaporizers shall be rated by the industrial gas supplier or the owner to vaporize at 150 percent of the highest purge gas demand for all connected equipment. Winter temperature extremes for the locale shall be taken into consideration by the agency responsible for rating the vaporizers.

7-5.2.3 It shall be the user's responsibility to inform the industrial gas supplier of additions to the plant that materially increase the inert gas consumption rate so that vaporizer and storage capacity can be resized for the revised requirements.

7-5.2.4 A temperature indicator shall be installed in the vaporizer outlet piping for use in evaluating its evaporation performance at any time.

7-5.2.5* A device shall be installed that prevents the flow rate of gas from exceeding the vaporizer capacity and thereby threatening the integrity of downstream equipment or control devices due to exposure to cryogenic fluids.

7-5.3 Storage Systems.

7-5.3.1 If the fluid is a purge medium, an audible and visual alarm shall be provided that signals a low quantity of the fluid. The alarm shall be situated in the area normally occupied by furnace operators.

7-5.3.2 If the fluid is the purge medium contained in the tank at the time of low quantity, the alarm shall be sufficient to allow an orderly shutdown of the affected furnace(s). The contents of a tank containing a purge fluid shall be sufficient at the alarm set point to purge all connected atmosphere furnaces with at least five volume changes.

7-5.3.3 Where pressurized inert gas in the vapor space above liquids in storage tanks is employed to pump flammable liquids, means shall be provided for isolating the tank remotely by closing valves on the pressurization supply line and the effluent pipe. Pressurized inert gas in the vapor space above flammable liquids in storage tanks shall be permitted to be used to propel the liquids in lieu of mechanical pumps.

7-5.3.4 The pipe connecting the flammable liquid storage tank to the inert gas supply shall contain a backflow check to prevent backflow of the liquid into the inert gas.

7-5.3.5 Liquid withdrawal connections on pressurized aboveground flammable liquid tanks shall contain steel excess flow shutoff valves that close automatically in the event of a pipe break or other mishap that could cause an unchecked outflow of liquid.

7-6 Special Processing Gas Atmosphere Gas Mixing Systems.

7-6.1* General. Section 7-6 shall apply to gas mixing systems that incorporate a surge tank mixing scheme that cycles between upper and lower set pressure limits.

7-6.2 Gas Atmosphere Mixing System Requirements.

7-6.2.1* Pipes feeding gas atmosphere mixing systems shall contain manual isolation valves.

7-6.2.2 Pressure-relief devices shall be used to prevent overpressurization of system components. Surge tank gas atmosphere mixing systems shall be sized, constructed, and tested in accordance with the ASME *Boiler and Pressure Vessel Code,* Section VIII, Division 1. The effluents from the relief devices used to protect a gas atmosphere mixing system containing flammable gases shall be piped to a safe disposal location.

7-6.2.3 Piping and components shall be in accordance with ASME B31.3, *Process Piping.*

7-6.2.4 The use of liquids shall not be permitted in gas atmosphere mixing systems.

7-6.2.5 Reliable means shall be provided for metering and controlling the flow rates of all gases.

7-6.2.6 Flow control of the blended atmosphere gas shall be in compliance with each furnace's applicable special atmosphere flow requirements and protective equipment as specified in Chapters 9 through 12.

7-6.2.7 Atmosphere gas mixers that create nonflammable or indeterminate gas mixtures shall be provided with gas analyzers or other equipment for continuously monitoring and displaying the flammable gas composition. Automatic controls shall be provided to shut off the flammable gas flow when the flammable component concentration rises above the operating limit.

7-6.2.8 If the creation of a gas mixture with a flammable gas content that is higher than intended results in the risk of explosions where none previously existed, then controls shall be provided to shut off the flammable gas flow automatically when the flammable gas concentration rises above the operating limit.

7-6.2.9 When the flammable gas concentration in a mixed gas exceeds the established high limit, an alarm shall be actuated to alert the operator. Such an alarm shall annunciate in an area occupied by persons operating the furnaces served.

7-6.2.10 Restart of flammable gas flow after a high concentration limit interruption shall require manual intervention by the operator at the site of the gas mixer.

7-6.2.11 Safety shutoff valves used to admit combustible gases to the gas mixer shall be valves that normally are closed and are capable of closing against maximum supply pressure.

7-6.2.12 Atmosphere gas mixers installed outdoors shall be furnished by the manufacturer for outdoor service or placed in a shelter that provides suitable weather protection. If a gas mixer is sited in a shelter, the temperature within shall be maintained in accordance with the manufacturer's recommendations.

7-6.2.13 Gas mixers shall be built and installed in accordance with NFPA 70, *National Electrical Code,* Articles 500 and 501, which cover installation of electrical equipment in hazardous (classified) locations.

7-7 Flow Control of Special Atmospheres.

7-7.1* Processes and equipment for controlling flows of special atmospheres shall be designed, installed, and operated to maintain a positive pressure within connected furnaces.

7-7.2 The flow rates used shall restore positive internal pressure rapidly without excessive infiltration of air during atmosphere contractions when furnace chamber doors close or work loads are quenched.

7-7.3* Where the atmosphere is flammable, its flow rate shall be sufficient to provide stable and reliable burn-off flames at vent ports.

7-7.4 The party responsible for commissioning the furnace or atmosphere process shall prescribe atmosphere flow rates that reliably cause burning to resume at the burn-off port before further cycling of the furnace can take place (e.g., door, elevator movements).

7-7.5 Reliable means shall be provided for metering and controlling the flow rates of all fluids comprising the special atmosphere for a furnace.

7-7.5.1 Devices with visible indication of flow shall be used to meter the flows of carrier gases, carrier gas component fluids, inert purge gases, enrichment gases, or air.

7-7.5.2 The flow control equipment shall be permitted to be installed at the furnace, the generator, or in a separate flow control unit. In any case, it shall be accessible and located in an illuminated area so that an operator can readily monitor its operation.

7-7.6 Synthetic atmosphere flow control units shall have the additional capabilities specified in 7-7.6.1 through 7-7.6.8.

7-7.6.1 An atmosphere flow control unit equipped with an inert purge mode shall have a manually operated switch located prominently on the face of the unit that actuates the purge.

7-7.6.2 An automatic means shall be provided for preventing the introduction of flammable fluids into a furnace before the furnace temperature has risen to 1400°F (760°C) or when the furnace is being started up from a cold or idle air-filled condition, and shall furnish protection from other conditions (such as a prolonged power failure) that can cause it to fill with air.

7-7.6.3* A means shall be provided for interrupting the flow of methanol (methyl alcohol) or other flammable liquid atmospheres into a furnace when the temperature inside is insufficient to provide vaporization and adequate dissociation of the fluid.

7-7.6.4 Where the flammable gas flow is interrupted as specified in 7-7.6.3, the flow control unit automatically shall admit a flow of inert gas that restores positive pressure without delay and shall signal this flow by means of an audible and visual alarm. The party responsible for commissioning the furnace or atmosphere process shall prescribe the temperature at which flammable gas flow is interrupted.

Exception: Manual inert gas purge shall be permitted to be provided for furnaces where operators are present and able to effect timely shutdown procedures subject to the authority having jurisdiction.

7-7.6.5 Automatically operated flow control valves shall halt flows of combustible fluids and allow continued or augmented flows of inert gas in the event of a power failure. Resumption of combustible fluid flow shall require manual intervention (reset) by an operator after power is restored.

7-7.6.6 Means shall be provided to test for leak-free operation of safety shutoff valves for flammable or toxic fluids.

7-7.6.7 Safety relief valves to prevent overpressurizing of glass tube flow meters and all other system components shall be in accordance with ASME B31.3, *Process Piping*. The effluents from relief valves used to protect control unit components containing flammable or toxic fluids shall be piped to a safe disposal location, such as the fluid supply area.

7-7.6.8 Alternate valves, separate from the atmosphere flow control unit, shall be provided for manually shutting off the flow of flammable fluids into a furnace. These valves shall be readily accessible to operators and located remotely from the furnace and control unit.

7-7.7* Pipes feeding atmosphere flow control units shall contain isolation valves.

7-8 Piping Systems for Special Atmospheres.

7-8.1 Piping shall be sized to allow the full flow of special atmospheres to all connected furnaces at maximum demand rates.

7-8.2 Design, materials of construction, fabrication, and tests on all pipes and piping components shall conform to the applicable sections of ASME B31.3, *Process Piping*.

7-8.3* Piping that contains cryogenic liquids shall be constructed of metals that retain adequate strength at cryogenic temperatures.

7-8.4 If carbon steel vessels or pressurized receivers are utilized to contain special processing atmospheres, or if other equipment that is adversely affected by extremely cold liquids or gases is connected to piping supplied from cryogenic vaporizers, means shall be provided for automatically halting the flow of excessively cold liquid or gas into such vessels, receivers, or piping.

7-8.4.1 A low temperature shutoff device used as prescribed in 7-8.4 shall not be installed so that closure of the device can interrupt the main flow of inert safety purge gas to connected furnaces containing indeterminate special processing atmospheres.

7-8.4.2 If closure of a low temperature shutoff device creates any other hazard, an alarm shall be provided to alert furnace operators or other affected persons of this condition.

7-8.4.3 In consultation with the industrial gas supplier, the user shall select the low temperature shutoff device, its placement, and a shutoff set point temperature that is appropriate for the purpose intended.

7-8.5 Flammable liquid piping shall be routed to avoid locations where it can be subjected to extreme temperature changes (e.g., directly above furnaces), accidental contact with power lines, or mechanical injury from shop machinery (e.g., lift trucks, cranes, conveyors). Pipes shall be supported and isolated from vibration sources that could damage them, and allowance for expansion and contraction due to temperature changes shall be made.

7-8.6 Pipes conveying flammable liquids shall contain pressure-relief valves that protect them from damage due to expansion of such liquids when heated. Discharge from the relief valves shall be piped to a safe disposal location, such as the fluid supply area.

7-8.7 Liquid withdrawal connections on pressurized aboveground flammable liquid tanks shall contain steel excess flow shutoff valves that close automatically in the event of a pipe break or other mishap that could cause an unchecked outflow of liquid.

7-8.8 Means shall be provided for automatically releasing accumulations of inert pressurizing gas from elevated sections of piping that otherwise could inhibit or disrupt the flow of the liquid. Gas vented from such gas relief devices shall be disposed of in a manner that cannot cause fire, explosion, or personnel hazards.

7-8.9 Use of aluminum or lead components or other incompatible materials in tanks, piping, valves, fittings, filters, strainers, or controls that might have contact with methanol liquid or vapor shall not be permitted. Solders that contain lead shall not be used.

7-8.10 Solders that contain lead shall not be used to join pipes containing flammable liquids.

7-8.11 Use of brass or other copper alloy components in tanks, piping, filters, strainers, or controls that might have contact with ammonia shall not be permitted.

7-9 Maintenance.

7-9.1 Responsibility. An essential safety aid is an established maintenance program that determines that the equipment is in working order. The equipment manufacturer shall advise the user of the need for adequate operational checks and maintenance.

7-9.1.1 The user shall be responsible for establishing a maintenance program that determines that the equipment is in working order.

7-9.1.2 Maintenance on gas atmosphere generators, flow control units, and associated equipment shall be undertaken only under the jurisdiction of a supervisor familiar with the safety and proper functioning of the equipment.

7-9.2 Checklists. The user's operational and maintenance program shall include any procedures that are applicable to the atmosphere generator or flow control unit and that are recommended by the authority having jurisdiction and the equipment supplier. An operational and maintenance checklist is essential to the safe operation of the equipment. *(See Appendix B.)*

Chapter 8 Special Atmospheres and Furnaces as Classified in Chapters 9 through 12

8-1 General. Refer to the definitions for *Special Atmosphere* in Section 2-1.

8-2* Indeterminate Atmospheres. Indeterminate atmospheres shall be treated as flammable atmospheres with the following consideration: where one special atmosphere is replaced with an atmosphere (e.g., flammable with nonflammable) that can cause the atmosphere to become indeterminate at some stage, burn-in or burn-out procedures shall not be used.

In the case of any indeterminate atmosphere, inert gas purge procedures alone shall be used for introduction and removal of special processing atmospheres.

8-3 Automatic Cycling. Automatic cycling of a furnace (e.g., quenching, load transfer from a heated zone to a cold vestibule) shall not be permitted where the special atmosphere has become indeterminate during the replacement of a flammable atmosphere with a nonflammable or an inert atmosphere (or vice versa) until the special atmosphere in all furnace chambers has been verified as either flammable, nonflammable, or inert.

8-4 Furnace Type. The type of furnace shall be determined by the following criteria:

(1) Normal operating temperature within the heating chamber
(2) Certain features of the furnace
(3) Type of atmosphere in use

In Chapters 9 through 12, the specifications for furnaces using flammable atmospheres are as follows.

(a) *Chapter 9.* Furnaces in which at least one zone operates at or above 1400°F (760°C). The chamber(s) operating below 1400°F (760°C) is separated by doors from those at or above 1400°F (760°C).

(1) Type I. The high temperature zone is always operated at or above 1400°F (760°C).
(2) Type II. The high temperature zone could indicate a temperature of less than 1400°F (760°C) after the introduction of a cold load.

(b) *Chapter 10.* Furnaces in which at least one zone operates at or above 1400°F (760°C) and that have no inner doors that separate zones operating above and below 1400°F (760°C).

(1) Type III. Both inlet and outlet ends of the furnace are open, and there are no external doors or covers.
(2) Type IV. Only one end of the furnace is open, and there are no external doors or covers.
(3) Type V. Outer doors or covers are provided.

(c) **Chapter 11.* Furnaces in which no zones are consistently operated at or above 1400°F (760°C).

(1) Type VI. At least one heating zone can be heated above 1400°F (760°C) before introduction and removal of the special atmosphere gas.
(2) Type VII. No furnace zone can be heated to 1400°F (760°C); therefore, the special atmosphere gas shall be introduced and removed using the inert gas purge procedures.

(d) *Chapter 12.* Furnaces in which a heating cover and inner cover (if applicable) are separated from a base that supports the work being processed.

(1) Type VIII. A heating cover furnace with an inner sealed cover.
(2) Type IX. A heating cover furnace without an inner cover or with a nonsealed inner cover.

Table 8-4 provides cross-reference examples of furnace types and features.

Chapter 9 Type I and Type II Furnaces

9-1 General. The chamber operating below 1400°F (760°C) is separated by a door(s) from chambers operating at or above 1400°F (760°C).

9-1.1 Scope. This chapter shall apply to controls and procedures relating to the introduction and removal of flammable special processing atmospheres for indirectly heated atmosphere–type furnaces. The following two general types of furnaces are covered.

(a) *Type I.* The high temperature zone is always operated at or above 1400°F (760°C).

(b) *Type II.* The high temperature zone could indicate a temperature less than 1400°F (760°C) after the introduction of a cold load.

For application of programmable controllers, also see Section 5-3.

Table 8-4 Table Furnace Cross-Reference

		Ref. Furnace Type									Ref. Chap.			
Item No.	**Furnace Description**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**9**	**10**	**11**	**12**
1	Batch IQ (one or more cold chambers, IQ)		X				X	X			X		X	
2	Bell (with or without retort)								X	X				X
3	Belt (both ends open)			X			X	X				X	X	
4	Belt, cast link (with IQ, entry end open)				X		X	X				X	X	
5	Belt, mesh (with IQ, entry end open)				X		X	X				X	X	
6	Box, (exterior door)					X	X	X				X	X	
7	Car									X				X
8	Gantry (exterior cover)					X	X	X				X	X	
9	Humpback (both ends open, cold chambers on each end)			X			X	X				X	X	
10	Pit (with exterior cover)					X	X	X				X	X	
11	Pusher tray (cold chambers at each end, inner doors and exterior doors, with and without IQ)	X					X	X			X		X	
12	Roller hearth (both ends open)			X			X	X				X	X	
13	Roller hearth (inner doors separating cold chambers at each end from hot zones, external doors)	X					X	X			X		X	
14	Rotary hearth (without or without exterior doors)			X	X	X	X	X				X	X	
15	Rotary retort, batch (no IQ, entry end open)				X		X	X				X	X	
16	Rotary retort, continuous (with IQ, entry end open)				X		X	X				X	X	

(continues)

Table 8-4 Table Furnace Cross-Reference *(Continued)*

		Ref. Furnace Type									Ref. Chap.			
Item No.	**Furnace Description**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**9**	**10**	**11**	**12**
17	Rotary retort, continuous (with IQ, entry end having a door)					X	X	X				X	X	
18	Shaker hearth (with IQ, entry end open)				X		X	X				X	X	
19	Shuffle hearth (with IQ, entry end open)				X		X	X				X	X	
20	Tip-up									X				X
21	Tube (both ends open)			X			X	X				X	X	
22	Walking beam (open at each end)			X			X	X				X	X	

Note: IQ = integral quench.

9-1.2 Special Atmosphere Flow Requirements.

9-1.2.1 Atmosphere processes and the equipment for controlling the flows of special atmospheres shall be installed and operated to minimize the infiltration of air into a furnace, which could result in the creation of flammable gas–air mixtures within the furnace.

9-1.2.2 The special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits the furnace. Atmosphere burn-off often is interrupted at exit ports as a result of the opening and closing of furnace doors. The person or agency commissioning the furnace or atmosphere process shall prescribe a flow rate.

9-1.2.3 The flow rate of an inert gas being used as a purge shall be controlled. The inert gas shall be introduced to the furnaces through one or more inlets as necessary to ensure that all chambers are purged.

9-2 Atmosphere Introduction and Removal.

9-2.1 Flammable liquids shall be introduced only in zones operating above 1400°F (760°C).

9-2.2 Introduction of Special Atmosphere Gas into a Type I Furnace by Purge or Burn-in Procedure.

9-2.2.1 Purge with an Inert Gas. In addition to the requirements of 9-2.2.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.2.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas of acceptable analysis shall be made. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All inner and outer furnace doors, as shown in Figure 9-2.2.1, shall be closed.

(d) All valves such as flammable atmosphere gas valves and flame curtain valves shall be closed.

(e) The furnace shall be heated to operating temperature.

(f) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(g) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(h) At least one heating chamber shall be operating above 1400°F (760°C).

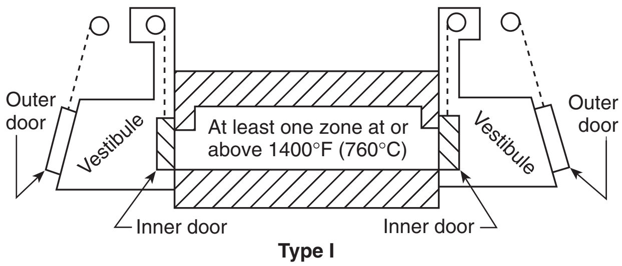
(i) Pilots at outer doors and effluent lines (special atmosphere vents) shall be ignited.

(j) After it has been determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(k) When flame appears at the vestibule effluent lines, the atmosphere introduction shall be considered to be complete.

(l) The flame curtain (if provided) shall be turned on and ignition shall be verified.

Figure 9-2.2.1 Example of Type I special processing atmosphere furnace.



9-2.2.2 Burn-in Procedures for Type I Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 9-2.2.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.2.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-in procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the burn-in procedure.

(b) Verification of an adequate supply of special atmosphere gas shall be made.

(c) At least one heating chamber shall be operating above 1400°F (760°C).

(d) Pilots at outer doors and effluent lines (special atmosphere vents) shall be ignited.

(e) The outer doors shall be opened.

(f) The inner doors shall be opened.

(g) The carrier gas(es) components of the special atmosphere gas shall be introduced into the furnace heating chamber and ignition shall be verified by observation.

(h) Inner doors shall be closed. A reliable source of ignition shall be required in the vestibule to ignite flammable gas flowing from the heating chamber into the vestibule. When gas leaving the heating chamber is ignited, the heating chamber shall be considered to have been burned-in.

(i) The flame curtain (if provided) shall be turned on and ignition shall be verified.

(j) The outer doors shall be closed.

(k) When flame appears at the vestibule effluent lines, the vestibule shall be considered to have been burned-in.

9-2.3 Removal of Special Atmosphere Gas from Type I Furnace by Purge or Burn-out Procedure.

9-2.3.1 Purge with an Inert Gas. In addition to the requirements of 9-2.3.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.3.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedures.

(b) Verification of an adequate supply of purge gas shall be made.

(c) All inner and outer doors as shown in Figure 9-2.2.1 shall be closed.

(d) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(e) All valves such as special atmosphere gas valves, process gas valves, and flame curtain valves shall be closed immediately.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its LEL. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) All door and effluent vent pilots shall be turned off.

(h) The inert gas supply to the furnace shall be turned off.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

9-2.3.2 Burn-out Procedures for Type I Furnace Special Atmosphere. Responsibility for the use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 9-2.3.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.3.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-out procedure.
(2) At least one heating chamber shall be operating above 1400°F (760°C).
(3) All outer doors shall be opened and the flame curtain (if provided) shall be shut off.
(4) All inner doors shall be opened to allow air to enter the heating chamber and burn out the gas.
(5) All special atmosphere gas and process gas supply valves shall be closed.
(6) After the furnace is burned out, the inner doors shall be closed.

9-2.4 Introduction of Special Atmosphere Gas into Type II Furnace by Purge or Burn-in Procedure.

9-2.4.1 Purge with an Inert Gas. In addition to the requirements of 9-2.4.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.4.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas of acceptable analysis shall be made. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All inner and outer doors, as shown in Figure 9-2.4.1, shall be closed.

(d) All valves such as flammable atmosphere gas valves and flame curtain valves shall be closed.

(e) The furnace shall be heated to operating temperature.

(f) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(g) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(h) The heating chamber shall be above 1400°F (760°C).

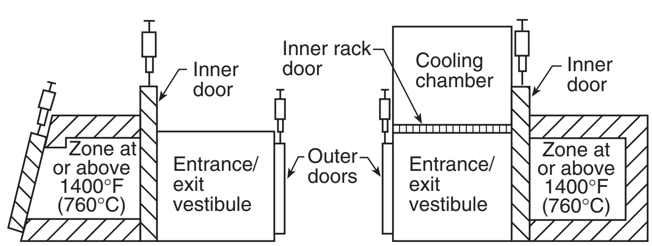
(i) Pilots at outer doors and effluent lines (special atmosphere vents) shall be ignited.

(j) After it has been determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(k) When flame appears at vestibule effluent lines, the atmosphere introduction shall be considered to be complete.

(l) The flame curtain (if provided) shall be turned on and ignition shall be verified.

Figure 9-2.4.1 Example of Type II special processing atmosphere furnace.



9-2.4.2 Burn-in Procedures for Type II Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 9-2.4.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.4.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction. *[See 9-2.4.2(k) before proceeding.]*

The following burn-in procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the burn-in procedure.

(b) Verification of an adequate supply of flammable special atmosphere gas shall be made.

(c) The heating chamber shall be operating above 1400°F (760°C).

(d) Pilots at outer doors and effluent lines (special atmosphere vents) shall be ignited.

(e) The outer doors shall be opened.

(f) All inner doors shall be opened. The heating chamber and cooling chamber (if provided), and the cooling chamber and heat zone fans (if provided), shall be shut off.

(g) The special atmosphere gas shall be introduced into the heating chamber and ignition shall be verified by observation.

(h) Inner and outer doors to the heating chamber only (if provided) shall be closed. A reliable source of ignition shall be required in the vestibule to ignite the flammable gas flowing from the heating chamber into the vestibule. When gas leaving the heating chamber is ignited, the heating chamber shall be considered to have been burned-in.

(i) The flame curtain (if provided) shall be turned on and the outer door closed.

(j) When flame appears at the vestibule effluent lines, the vestibule shall be considered to have been burned-in.

(k) If there is an atmosphere cooling chamber attached to the quench vestibule *(see Figure 9-2.4.1)*, the following steps shall be included, provided the gases introduced directly into the cooling chamber are predictably flammable when mixed with air at ambient temperature. If they are predictably flammable (e.g., nitrogen with methanol or inert gas with methanol), a burn-in procedure shall not be required.

(1) A reliable source of ignition for the special atmosphere gas inlet in the cooling section shall be provided and the gas atmosphere shall be introduced into the cooling section. It shall be verified by observation that ignition takes place and continues.

(2) The flame curtain (if provided) shall be turned on and ignition shall be verified.

(3) The outer doors shall be closed.

(4) When flame appears at the vestibule effluent lines, the vestibule and cooling chamber shall be considered to have been burned-in.

(5) The cooling chamber door shall be closed.

9-2.5 Removal of Special Atmosphere Gas from Type II Furnace by Purge or Burn-out Procedure.

9-2.5.1 Purge with an Inert Gas. In addition to the requirements of 9-2.5.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.5.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of purge gas shall be made.

(c) All doors shall be closed.

(d) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(e) All valves such as special atmosphere gas valves and flame curtain valves shall be closed immediately.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its lower explosive limit. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) All door and effluent vent pilots shall be turned off.

(h) The inert gas supply to the furnace shall be turned off.

(i) The cooling chamber fan (if provided) shall be shut off.

(j) The cooling chamber door (if provided) shall be opened.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

9-2.5.2 Burn-out Procedures for Type II Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 9-2.5.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 9-2.5.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-out procedure.
(2) The heating chamber shall be operating above 1400°F (760°C).
(3) The cooling chamber fan (if provided) shall be shut off.
(4) The inner door to the cooling chamber (if provided) shall be opened.
(5) The outer door to the vestibule only shall be opened.
(6) The atmosphere gas to the cooling chamber only (if provided) shall be shut off.
(7) The flame curtain (if provided) shall be shut off.
(8) The inner door to the heating chamber shall be opened.
(9) The special atmosphere gas supply to the heating chamber shall be shut off.
(10) When all burning inside of the heating chamber, cooling chamber (if provided), and furnace vestibule has ceased, the special atmosphere gas shall be considered to have been burned-out.

9-3 Emergency Procedures for Type I and Type II Furnaces.

9-3.1 Emergency Procedures in Case of Interruption of Special Atmosphere Gas Supply (Carrier Gas Component). In case of interruption of any carrier gas component, one of the following shutdown procedures shall be used:

(1) If inert purge gas is available, the purge procedure outlined in 9-2.3.1 or 9-2.5.1 shall be initiated immediately.
(2) If an inert purge gas supply is not available, the standard burn-out procedure outlined in 9-2.3.2 or 9-2.5.2 shall be initiated immediately.

9-3.2 Procedures in the Case of Interruption of a Heating System(s) that Creates an Emergency. The shutdown procedure outlined in 9-2.3 or 9-2.5 shall be initiated immediately.

9-4 Protective Equipment for Type I and Type II Furnaces.

9-4.1 The following safety equipment and procedures shall be required in conjunction with the special atmosphere gas system.

(a) A safety shutoff valve(s) on all flammable fluids that are part of special atmospheres supplied to the furnace. This valve(s) shall be energized to open only when the furnace temperature is above 1400°F (760°C). Operator action shall be required to initiate flow.

(b) A low flow switch(es) on all carrier gas supplies to ensure that the atmosphere gas supply is flowing at the proper rates. Low flow shall be indicated by audible and visual alarms.

(c) A sufficient number of furnace temperature monitoring devices to determine temperature in all heating chambers. These devices shall be interlocked to prevent opening of the flammable gas supply safety shutoff valve(s) until at least one heating zone is at or above 1400°F (760°C).

Exception: In the case of a Type II furnace, a bypass of the 1400°F (760°C) temperature contact after the initial gas introduction shall be permitted, provided that a flow monitor, such as a flow switch, is provided to ensure atmosphere flow. Where an alcohol or other liquid is used as a carrier gas and introduced in the liquid state, a second low temperature safety interlock [independent of the 1400°F (760°C) interlock] shall be provided if flow of the liquid is continued below 1400°F (760°C). The person or agency responsible for commissioning the atmosphere process shall specify an interlock temperature set point and atmosphere flow rate that provides adequate positive furnace pressure at all temperatures above the set point. This interlock shall not be bypassed, and its set point temperature shall not be less than 800°F (427°C).

(d) The inert gas purge shall be automatically actuated by the following:

(1) A temperature less than 800°F (427°C) where liquid carrier gas is used
(2) Power failure
(3) Loss of flow of any carrier gas

Exception No. 1: An inert gas purge shall not be required where burn-in and burn-out procedures are permitted by the person or agency authorizing the purchase of the equipment.

Exception No. 2: Manual inert gas purge shall be permitted to be provided for furnaces where operators can effect timely shutdown procedures.

(e) Pilots at outer doors; one pilot at each outer door shall be supervised with an approved combustion safeguard interlocked to prevent automatic opening of the vestibule door, shut off fuel gas to the curtain burners (if provided), and alert the operator. Pilots shall be of the type that remain lit when subjected to an inert or indeterminate atmosphere.

(f) Pilots located at effluents.

(g) Manual shutoff valves and capability for checking leak tightness of the safety shutoff valves.

(h) Safety relief valves where overpressurizing of glass tube flow meters is possible.

(i) Provisions for explosion relief in the vestibule.

(j) Audible and visual alarms.

(k) A safety shutoff valve for the flame curtain burner gas supply.

(l) Valves for manually shutting off the flow of flammable liquids into a furnace that are separate from the atmosphere flow control unit. These valves shall be readily accessible to operators and remotely located from the furnace and control unit.

(m) Manual door-opening facilities to allow operator control in the event of power failure or carrier gas flow failure.

(n) *The purge system, where provided, shall include the following:

(1) Visual and audible alarms to alert the operator of low purge flow rate
(2) Gas analyzing equipment for ensuring that the furnace is purged
(3) Monitoring devices to allow the operator to determine the adequacy of the inert purge flow visually at all times
(4) An operator's actuation station equipped with the necessary hand valves, regulators, relief valves, and flow and pressure monitoring devices

9-4.2 All the following protective equipment for furnaces utilizing timed flow purges shall be provided:

(1) Purge timer(s)
(2) Purge gas flow meter(s)
(3) Purge flow monitoring device(s)
(4) Fan rotation sensor(s)

Chapter 10 Furnace Types III, IV, and V

10-1 General.

10-1.1 Scope. This chapter shall apply to controls and procedures relating to the introduction and removal of flammable special processing atmospheres. The following three general types of furnaces are covered.

(a) *Type III.* Both inlet and outlet ends of the furnace are open, and there are no external doors or covers.

(b) *Type IV.* One end only is open.

(c) *Type V.* Outer doors or covers are provided.

For application of programmable controllers, also see Section 5-3.

10-1.2 Special Atmosphere Flow Requirements.

10-1.2.1 Atmosphere processes and the equipment for controlling the flows of special atmospheres shall be installed and operated to minimize the infiltration of air into a furnace, which could result in the creation of flammable gas–air mixtures within the furnace.

10-1.2.2 The special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits the furnace. Atmosphere burn-off often is interrupted at exit ports as a result of the opening and closing of furnace doors. The person or agency commissioning the furnace or atmosphere process shall prescribe a flow rate.

10-1.2.3 The flow rate of an inert gas being used as a purge shall be controlled. The inert gas shall be introduced to the furnaces through one or more inlets as necessary to ensure that all chambers are purged.

10-2 Atmosphere Introduction and Removal.

10-2.1 Flammable liquids shall be introduced only in zones operating above 1400°F (760°C).

10-2.2 Introduction of Special Atmosphere Gas into Type III Furnace by Purge or Burn-in Procedure.

10-2.2.1 Purge with an Inert Gas. In addition to the requirements of 10-2.2.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.2.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All valves such as flammable atmosphere gas valves and flame curtain valves shall be closed.

(d) The furnace shall be heated to operating temperature.

(e) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) At least one zone of the furnace shall be above 1400°F (760°C). *(See Figure 10-2.2.1.)*

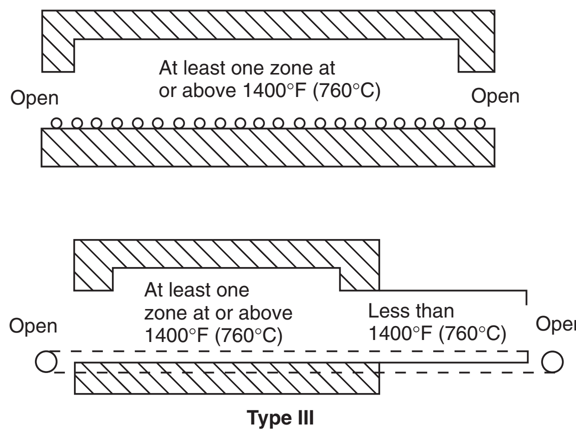
(h) Pilots at charge and discharge ends of the furnace shall be ignited.

(i) After it has been determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(j) When flame appears at both the charge and discharge ends of the furnace, the atmosphere introduction shall be considered to be complete.

(k) The flame curtain (if provided) shall be turned on and ignition shall be verified.

Figure 10-2.2.1 Examples of Type III special processing atmosphere furnace.



10-2.2.2 Burn-in Procedures for Type III Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 10-2.2.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.2.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-in procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-in procedure.

(2) Verification of an adequate supply of flammable special atmosphere gas shall be made.

(3) At least one heating chamber shall be operating above 1400°F (760°C).

(4) Pilots at the charge and discharge ends of the furnace shall be ignited, and pilots shall be of the type that remain lit when subjected to an inert atmosphere.

Exception: Pilots shall not be required for Type III humpback furnaces utilizing dissociated ammonia for an atmosphere.

(5) The carrier gas(es) components of the special atmosphere gas shall be introduced into the furnace heating chamber, and ignition shall be verified by observation.

(6) The flame curtain (if provided) shall be turned on and ignition shall be verified.

(7) When flame appears at both the charge and discharge ends of the furnace, the furnace shall be considered to have been burned-in.

10-2.3 Removal of Special Atmosphere Gas from Type III Furnace by Purge and Burn-out Procedure.

10-2.3.1 Purge with an Inert Gas. In addition to the requirements of 10-2.3.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.3.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made.

(c) The inert purge gas system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(d) All valves such as special atmosphere gas valves, process gas valves, and flame curtain valves shall be closed immediately.

(e) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its LEL. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(f) All pilots at the charge and discharge ends of the furnace shall be turned off.

(g) The inert gas supply to the furnace shall be turned off.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

10-2.3.2 Burn-out Procedures for Type III Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 10-2.3.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.3.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-out procedure.

(2) At least one heating chamber shall be operating above 1400°F (760°C).
(3) The flame curtain (if provided) shall be shut off.
(4) All special atmosphere gas and process gas supplies to furnace valves shall be shut off.
(5) When all burning inside of the heating chamber, cooling chamber (if provided), and furnace vestibule has ceased, the special atmosphere gas shall be considered to have been burned-out.

10-2.4 Introduction of Special Atmosphere Gas into Type IV Furnace by Purge or Burn-in Procedure.

10-2.4.1 Purge with an Inert Gas. In addition to the requirements of 10-2.4.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.4.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All valves such as flammable atmosphere gas valves and flame curtain valves shall be closed.

(d) The furnace shall be heated to operating temperature.

(e) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) At least one heating chamber shall be operating above 1400°F (760°C). *(See Figure 10-2.4.1.)*

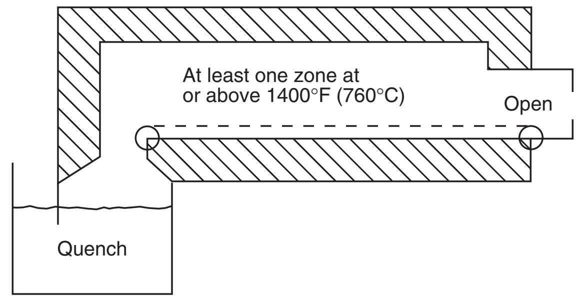
(h) Pilots at the open ends of the furnace and effluent lines or ports (special atmosphere vents) shall be ignited.

(i) After it has been determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(j) When flame appears at the open end of furnace, the atmosphere introduction shall be considered to be complete.

(k) The flame curtain (if provided) shall be turned on and ignition shall be verified.

Figure 10-2.4.1 Example of Type IV special processing atmosphere furnace.



10-2.4.2 Burn-in Procedures for Type IV Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 10-2.4.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.4.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-in procedures shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-in procedure.
(2) Verification of an adequate supply of flammable special atmosphere gas shall be made.
(3) At least one heating chamber shall be operating above 1400°F (760°C).
(4) Pilots at the open end of the furnace and effluent lines or ports (special atmosphere vents) shall be ignited.
(5) The carrier gas(es) components of the special atmosphere gas shall be introduced into the furnace heating chamber, and ignition shall be verified by observation.
(6) The flame curtain (if provided) shall be turned on and ignition shall be verified.
(7) When flame appears at the open end of the furnace, the furnace shall be considered to have been burned-in.

10-2.5 Removal of Special Atmosphere Gas from Type IV Furnace by Purge or Burn-out Procedure.

10-2.5.1 Purge with an Inert Gas. In addition to the requirements of 10-2.5.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.5.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made.

(c) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(d) All valves such as special atmosphere gas valves, process gas valves, and flame curtain valves shall be closed immediately.

(e) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its LEL. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(f) All pilots at the open end of furnace and effluent pilots (if provided) shall be turned off.

(g) The inert gas supply to the furnace shall be turned off.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

10-2.5.2 Burn-out Procedures for Type IV Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 10-2.5.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.5.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the purging procedure.
(2) At least one heating chamber shall be operating above 1400°F (760°C).
(3) The flame curtain (if provided) shall be shut off.
(4) All special atmosphere and process gas supply valves shall be shut off.
(5) When all burning inside of the heating chamber, cooling chamber (if provided), and furnace vestibule has ceased, the special atmosphere gas shall be considered to have been burned-out.

10-2.6 Introduction of Special Atmosphere Gas into Type V Furnace by Purge or Burn-in Procedure.

10-2.6.1 Purge with an Inert Gas. In addition to the requirements of 10-2.6.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.6.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All furnace doors, as shown in Figure 10-2.6.1, shall be closed.

(d) All valves such as flammable atmosphere gas valves and flame curtain valves shall be closed.

(e) The furnace shall be heated to operating temperature.

(f) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(g) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(h) At least one heating chamber shall be operating above 1400°F (760°C).

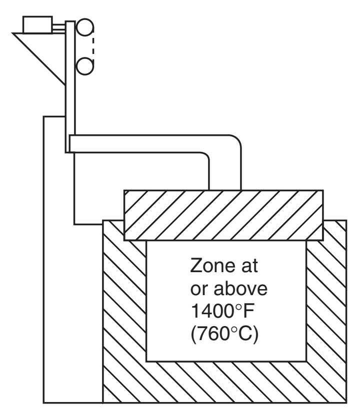
(i) Pilots at outer doors or covers and effluent lines or ports (special atmosphere vents, if provided) shall be ignited.

(j) After it has been determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(k) When flame appears at effluent lines or ports, the atmosphere introduction shall be considered to be complete.

(l) The flame curtain (if provided) shall be turned on and ignition shall be verified.

Figure 10-2.6.1 Example of Type V special processing atmosphere furnace.



Type V

10-2.6.2 Burn-in Procedures for Type V Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 10-2.6.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.6.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-in procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-in procedure.
(2) Verification of an adequate supply of special atmosphere gas shall be made.
(3) At least one heating chamber shall be operating above 1400°F (760°C).
(4) Pilots at outer doors or covers and effluent lines or ports (special atmosphere vents, if provided) shall be ignited.
(5) The outer doors shall be opened.
(6) The carrier gas(es) components of the special atmosphere gas shall be introduced into the furnace heating chamber and ignition shall be verified by observation.
(7) The flame curtain (if provided) shall be turned on.
(8) The outer doors shall be closed.
(9) When flame appears at effluent lines or ports, the furnace shall be considered to have been burned in.

10-2.7 Removal of Special Atmosphere Gas from Type V Furnace by Purge or Burn-out Procedure.

10-2.7.1 Purge with an Inert Gas. In addition to the requirements of 10-2.7.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.7.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made.

(c) All doors shall be closed.

(d) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(e) All valves such as special atmosphere gas valves, process gas valves, and flame curtain valves shall be closed immediately.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its LEL. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) All door, cover, and effluent pilots (if provided) shall be turned off.

(h) The inert gas supply to the furnace shall be turned off.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

10-2.7.2 Burn-out Procedures for Type V Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 10-2.7.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 10-2.7.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-out procedure.
(2) At least one heating chamber shall be operating above 1400°F (760°C).
(3) All doors or covers shall be opened to allow air to enter the furnace and burn out the special atmosphere.
(4) The flame curtain (if provided) shall be shut off.
(5) All special atmosphere and process gas supply valves shall be shut off.
(6) When all burning inside of the heating chamber, cooling chamber (if provided), and furnace vestibule has ceased, the special atmosphere gas shall be considered to have been burned-out.

10-3 Emergency Procedures for Types III, IV, and V Furnaces.

10-3.1 Emergency Procedures in Case of Interruption of Special Atmosphere Gas Supply (Carrier Gas Component). In case of interruption of any carrier gas component, one of the following shutdown procedures shall be used:

(1) If inert purge gas is available, the purge procedure outlined in 10-2.3.1, 10-2.5.1, or 10-2.7.1 shall be initiated immediately.
(2) If inert purge gas supply is not available, the standard burn-out procedure outlined in 10-2.3.2, 10-2.5.2, or 10-2.7.2 shall be initiated immediately.

10-3.2 Procedures in the Case of Interruption of a Heating System(s) that Creates an Emergency. The shutdown procedure outlined in 10-2.3 or 10-2.5 shall be initiated immediately.

10-4 Protective Equipment for Types III, IV, and V Furnaces.

10-4.1 The following safety equipment and procedures shall be required in conjunction with the special atmosphere gas system.

(a) A safety shutoff valve(s) on all flammable fluids that are part of special atmospheres supplied to the furnace. This valve(s) shall be energized to open only when the furnace temperature is above 1400°F (760°C). Operator action shall be required to initiate flow.

(b) A low flow switch(es) on all carrier gas supplies to ensure that the atmosphere gas supply is flowing at the proper rates. Low flow shall be indicated by visual and audible alarms.

(c) A sufficient number of furnace temperature monitoring devices to determine temperature in all heating chambers. These devices shall be interlocked to prevent opening of the flammable gas supply safety shutoff valve(s) until at least one heating zone is at or above 1400°F (760°C).

Exception: In the case of a Type V furnace, a bypass of the 1400°F (760°C) temperature contact after the initial gas introduction shall be permitted, provided that a flow monitor, such as a flow switch, is provided to ensure atmosphere flow. Where an alcohol or other liquid is used as a carrier gas and introduced in the liquid state, a second low temperature safety interlock [independent of the 1400°F (760°C) interlock] shall be provided if flow of the liquid is continued below 1400°F (760°C). The person or agency responsible for commissioning the atmosphere process shall specify an interlock temperature set point and atmosphere flow rate that provides adequate positive furnace pressure at all temperatures above the set point. This interlock shall not be bypassed, and its set point temperature shall not be less than 800°F (427°C).

(d) A safety shutoff valve for the flame curtain burner gas supply.

(e) Audible and visual alarms.

(f) Manual door-opening facilities to allow operator control in the event of power failure or carrier gas flow failure.

(g) The inert gas purge shall be automatically actuated by the following:

(1) A temperature less than 800°F (427°C) where liquid carrier gas is used
(2) Power failure
(3) Loss of flow of any carrier gas

Exception No. 1: An inert gas purge shall not be required where burn-in and burn-out procedures are permitted by the person or agency authorizing the purchase of the equipment.

Exception No. 2: Manual inert gas purge shall be permitted for furnaces where operators can effect timely shutdown procedures.

(h) Pilots at outer doors; one pilot at each outer door shall be supervised with an approved combustion safeguard interlocked to prevent automatic opening of the vestibule door, shut off fuel gas to the curtain burners (if provided), and alert the operator. Pilots shall be of the type that remain lit when subjected to an inert or indeterminate atmosphere.

(i) Pilots located at effluents.

(j) Manual shutoff valves and capability for checking leak tightness of the safety shutoff valves.

(k) Safety relief valves where overpressurizing of glass tube flow meters is possible.

(l) Valves for manually shutting off the flow of flammable liquids into a furnace that are separate from the atmosphere flow control unit. These valves shall be readily accessible to operators and remotely located from the furnace and control unit.

(m) *The purge system, where provided, shall include the following:

(1) Audible and visual alarms to alert the operator of low purge flow rate
(2) Gas analyzing equipment for ensuring that the furnace is purged
(3) Monitoring devices to allow the operator to determine the adequacy of the inert purge flow visually at all times
(4) An operator's actuation station equipped with the necessary hand valves, regulators, relief valves, and flow and pressure monitoring devices

10-4.2 All the following protective equipment for furnaces utilizing timed flow purges shall be provided:

(1) Purge timer(s)
(2) Purge gas flow meter(s)
(3) Purge flow monitoring device(s)
(4) Fan rotation sensor(s)

Chapter 11 Type VI and Type VII Furnaces

11-1 General.

11-1.1* Scope. This chapter shall apply to controls and procedures relating to the introduction and removal of flammable special atmospheres. The following two general types of furnaces are covered.

(a) *Type VI.* At least one zone can be heated above 1400°F (760°C) before introduction and removal of the flammable special atmosphere gas.

(b) *Type VII.* No zones can be heated to 1400°F (760°C); therefore, the flammable special atmosphere gas shall be introduced and removed using the inert gas purge procedures.

For application of programmable controllers, also see Section 5-3.

11-1.2 Special Atmosphere Flow Requirements.

11-1.2.1 Atmosphere processes and the equipment for controlling the flows of special atmospheres shall be installed and operated to minimize the infiltration of air into a furnace, which could result in the creation of flammable gas–air mixtures within the furnace.

11-1.2.2 The special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits the furnace. Atmosphere burn-off often is interrupted at exit ports as a result of the opening and closing of furnace doors. The person or agency commissioning the furnace or atmosphere process shall prescribe a flow rate.

11-1.2.3 The flow rate of an inert gas being used as a purge shall be controlled. The inert gas shall be introduced to the furnaces through one or more inlets as necessary to ensure that all chambers are purged.

11-2 Atmosphere Introduction and Removal.

11-2.1 Introduction of Special Atmosphere Gas into Type VI Furnace by Purge or Burn-in Procedure.

11-2.1.1 Purge with an Inert Gas. In addition to the requirements of 11-2.1.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 11-2.1.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All furnace doors (if provided) shall be closed.

(d) All valves such as flammable atmosphere gas valves and flame curtain valves shall be closed.

(e) The furnace shall be heated to operating temperature.

(f) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(g) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(h) At least one zone of the furnace shall be above 1400°F (760°C).

(i) Pilots at outer doors (if provided) and effluent lines (special atmosphere vents) shall be ignited.

(j) After it has been determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(k) When flame appears at the vestibule effluent lines or ports, the atmosphere introduction shall be considered to be complete.

(l) The flame curtain (if provided) shall be turned on and ignition shall be verified.

11-2.1.2 Burn-in Procedures for Type VI Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 11-2.1.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 11-2.1.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-in procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the burn-in procedure.

(b) Verification of an adequate supply of special atmosphere gas shall be made.

(c) It shall be verified that the inert gas storage system contains sufficient purge gas.

(d) At least one heating chamber shall be operating above 1400°F (760°C).

(e) Pilots at the outer doors (if provided) and effluent lines (special atmosphere vents, if provided) shall be ignited.

(f) The outer doors (if provided) shall be opened.

(g) The inner doors (if provided) shall be opened.

(h) The carrier gas(es) components of the special atmosphere gas shall be introduced into the furnace heating chamber and ignition shall be verified by observation.

(i) The inner doors (if provided) shall be closed. A reliable source of ignition shall be required in the vestibule to ignite flammable gas flowing from the heating chamber into the vestibule. When gas leaving the heating chamber is ignited, the heating chamber shall be considered to have been burned in.

(j) The flame curtain (if provided) shall be turned on and ignition shall be verified.

(k) The outer doors (if provided) shall be closed.

(l) When flame appears at the vestibule effluent lines or ports, the vestibule shall be considered to be burned-in.

11-2.2 Removal of Special Atmosphere Gas from Type VI Furnace by Purge or Burn-out Procedures.

11-2.2.1 Purge with an Inert Gas. In addition to the requirements of 11-2.2.1, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 11-2.2.1 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made.

(c) All doors (if provided) shall be closed.

(d) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(e) All valves such as special atmosphere gas valves, process gas valves, and flame curtain valves (if provided) shall be closed immediately.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its LEL. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) All door and effluent pilots (if provided) shall be turned off.

(h) The inert gas supply to the furnace shall be turned off.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

11-2.2.2 Burn-out Procedures for Type VI Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall be that of the person or agency authorizing the purchase of the equipment. In addition to the requirements of 11-2.2.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 11-2.2.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be performed in the given sequence:

(1) The furnace shall not be automatically cycled during the burn-out procedure.
(2) At least one heating chamber shall be operating above 1400°F (760°C).
(3) All outer doors (if provided) shall be opened and the flame curtain (if provided) shall be shut off.
(4) All inner doors (if provided) shall be opened to allow air to enter the heating chamber and burn out the gas.
(5) All components of the special atmosphere gas system and other process gas systems connected to the furnace shall be shut off immediately.
(6) When all burning inside of the heating chamber, cooling chamber (if provided), and furnace vestibule has ceased, the special atmosphere gas shall be considered to have been burned-out.
(7) After the furnace is burned out, the inner doors (if provided) shall be closed.

11-2.3 Introduction of Special Atmosphere Gas into Type VII Furnace by Purge Procedure with an Inert Gas. In addition to the requirements of 11-2.3, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 11-2.3 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence before or during heating or after the furnace is at operating temperature.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas of the following analysis shall be made: The inert purge gas shall contain less than 1 percent oxygen and shall contain less than 4 percent total flammables. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) All furnace doors (if provided) shall be closed.

(d) All valves such as flammable atmosphere gas valves and flame curtain valves (if provided) shall be closed.

(e) The furnace shall be heated to operating temperature.

(f) The inert gas purge system shall be actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

(g) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the oxygen content is below 1 percent. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(h) Pilots at the outer doors (if provided) and effluent lines or ports (special atmosphere vents, if provided) shall be ignited.

(i) After it is determined that the special atmosphere gas supply is adequate, the atmosphere gas shall be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be turned off immediately.

(j) When flame appears at the vestibule effluent lines or ports, the atmosphere introduction shall be considered to be complete.

(k) The flame curtain (if provided) shall be turned on and ignition shall be verified.

11-2.4 Removal of Special Atmosphere Gas from Type VII Furnace by Purge Procedure with an Inert Gas. In addition to the requirements of 11-2.4, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 11-2.4 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) The furnace shall not be automatically cycled during the purging procedure.

(b) Verification of an adequate supply of inert purge gas shall be made.

(c) All doors (if provided) shall be closed.

(d) The inert gas purge shall be initiated and a flow sufficient to maintain a positive pressure in the furnace by itself shall be ensured.

(e) All valves such as special atmosphere gas valves, process gas valves, and flame curtain valves (if provided) shall be closed immediately.

(f) Sampling of the furnace atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses of all chambers indicate that the atmosphere is below 50 percent of its LEL. When this condition is reached, the furnace shall be considered to be purged. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(g) All door and effluent pilots (if provided) shall be turned off.

(h) The inert gas supply to the furnace shall be turned off.

CAUTION

The furnace atmosphere is inert and CANNOT sustain life. Persons shall not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist. *(See A-17-2.)*

11-3 Emergency Procedures for Type VI and Type VII Furnaces.

11-3.1 Emergency Procedures in Case of Interruption of Special Atmosphere Gas Supply (Carrier Gas Component). In case of interruption of any carrier gas component, the purge procedure outlined in 11-2.2.1 or 11-2.4 shall be initiated immediately.

11-3.2 Procedures in the Case of Interruption of a Heating System(s) that Creates an Emergency. The shutdown procedure outlined in 11-2.2 or 11-2.4 shall be initiated immediately.

11-4 Protective Equipment for Type VI and Type VII Furnaces.

11-4.1 The following safety equipment and procedures shall be required for furnace Type VI in conjunction with the special atmosphere gas system.

(a) A safety shutoff valve(s) on all flammable fluids that are part of special atmospheres supplied to the furnace. This valve(s) shall be energized to open when the furnace temperature is above 1400°F (760°C). Operator action shall be required to initiate flow.

Exception: Type VI furnaces using exothermic-generated special atmosphere gas supplied for both purging and process shall not be required to include safety shutoff valves in the exothermic gas supply line.

(b) A low flow switch(es) on all carrier gas supplies to ensure that the atmosphere gas supply is flowing at the proper rates. Low flow shall be indicated by visual and audible alarms.

(c) The inert gas purge shall be automatically actuated by the following:

(1) A temperature less than 800°F (427°C) where liquid carrier gas is used
(2) Power failure
(3) Loss of flow of any carrier gas

Exception: Manual inert gas purge shall be permitted for furnaces where operators can effect timely shutdown procedures.

(d) Pilots at outer doors; one pilot at each outer door shall be supervised with an approved combustion safeguard interlocked to prevent automatic opening of the vestibule door (if provided), shut off fuel gas to the curtain burners (if provided), and alert the operator. Pilots shall be of the type that remain lit when subjected to an inert or indeterminate atmosphere.

(e) Pilots located at effluents.

(f) Manual shutoff valves and capability for checking leak tightness of safety shutoff valves.

(g) Safety relief valves where overpressurizing of glass tube flow meters is possible.

(h) Provisions for explosion relief in the vestibule (if provided).

(i) Visual and audible alarms.

(j) A safety shutoff valve for the flame curtain burner gas supply.

(k) Valves for manually shutting off the flow of flammable liquids into a furnace that are separate from the atmosphere flow control unit. These valves shall be readily accessible to operators and remotely located from the furnace and control unit.

(l) A sufficient number of furnace temperature monitoring devices to determine temperatures in zones. These devices shall be interlocked to prevent opening of the flammable gas supply safety shutoff valve(s) until all hot zones are at, or above, 1400°F (760°C). Temperature monitoring devices shall be provided with a gas flow bypass device to allow operation of the furnace below 1400°F (760°C) after initial introduction of atmosphere. All carrier gas flow switches shall be wired in series to complete the bypass. Where an alcohol or other liquid is used as a carrier gas and introduced in the liquid state, a second low temperature safety interlock [independent of the 1400°F (760°C) interlock] shall be provided if flow of the liquid is continued below 1400°F (760°C). The person or agency responsible for commissioning the atmosphere process shall specify an interlock temperature set point and atmosphere flow rate that provides adequate positive furnace pressure at all temperatures above the set point. This interlock shall not be bypassed, and its set point temperature shall not be less than 800°F (427°C).

(m) *The purge system shall include the following:

(1) Audible and visual alarms to alert the operator of low purge flow rate
(2) Gas analyzing equipment for ensuring that the furnace is purged
(3) Monitoring devices to allow the operator to determine the adequacy of the inert purge flow visually at all times
(4) An operator's actuation station equipped with the necessary hand valves, regulators, relief valves, and flow and pressure monitoring devices

11-4.2 Protective devices for Type VII furnaces shall be installed and interlocked as described in 11-4.2(a) through (l).

(a) Inert purge gas and carrier gas flow monitoring devices shall be provided to allow the operator to determine visually the adequacy of the inert purge and special atmosphere gas flow at all times.

(b) An automatic flame curtain safety shutoff valve shall be provided for the flame curtain gas supply. This shall be interlocked so that the special atmosphere supply is established prior to opening the flame curtain safety shutoff valve.

(c) Pilots at outer doors and vent lines; one pilot at each outer door shall be supervised with an approved combustion safeguard interlocked to prevent automatic opening of the vestibule door (if provided), shut off fuel gas to the curtain burners (if provided), and alert the operator. Pilots shall be of the type that remain lit when subjected to an inert or indeterminate atmosphere.

(d) Audible and visual alarms.

(e) A safety shutoff valve(s) shall be provided in the flammable gas components of the special atmosphere gas supply to the furnace. This valve(s) shall be interlocked with the carrier gas flows and shall require operator action when opening. Closure of this safety shutoff valve(s) shall be followed immediately by introduction of inert gas purging.

Exception: Exothermic-generated special atmosphere gas supplies used for both purging and process shall not require safety shutoff valves and low flow interlocks. Refer to the manufacturer's instructions for proper procedures.

(f) A low flow switch(es) on all carrier gas supplies to ensure that the atmosphere gas supply is flowing at the proper rates. Loss of flow shall cause closure of the safety shutoff valve(s). Loss of flow shall be indicated by visual or audible alarms.

(g) The inert gas purge shall be automatically actuated by the following:

(1) A temperature less than 800°F (427°C) where liquid carrier gas is used
(2) Power failure
(3) Loss of flow of any carrier gas

(h) *The inert purging system shall include the following:

(1) Audible and visual alarms to alert the operator of low purge flow rate
(2) Gas analyzing equipment for ensuring that the furnace is purged
(3) Monitoring devices to allow the operator to determine the adequacy of the inert purge flow visually at all times
(4) An operator's actuation station equipped with the necessary hand valves, regulators, relief valves, and flow and pressure monitoring devices

(i) Safety relief valves where overpressurizing of glass tube flow meters is possible.

(j) Provisions for explosion relief in the vestibule (if provided).

(k) Valves for manually shutting off the flow of flammable liquids into a furnace that are separate from the atmosphere flow control unit. These valves shall be readily accessible to operators and remotely located from the furnace and control unit.

(l) Where an alcohol or other liquid is used as a carrier gas and introduced in the liquid state, a low temperature safety interlock shall be provided. The person or agency responsible for commissioning the atmosphere process shall specify an interlock temperature set point and atmosphere flow rate that provides adequate positive furnace pressure at all temperatures above the set point.

11-4.3 All the following protective equipment for furnaces utilizing timed flow purges shall be provided:

(1) Purge timer(s)
(2) Purge gas flow meter(s)
(3) Purge flow monitoring device(s)
(4) Fan rotation sensor(s)

Chapter 12 Class C — Heating Cover Furnaces

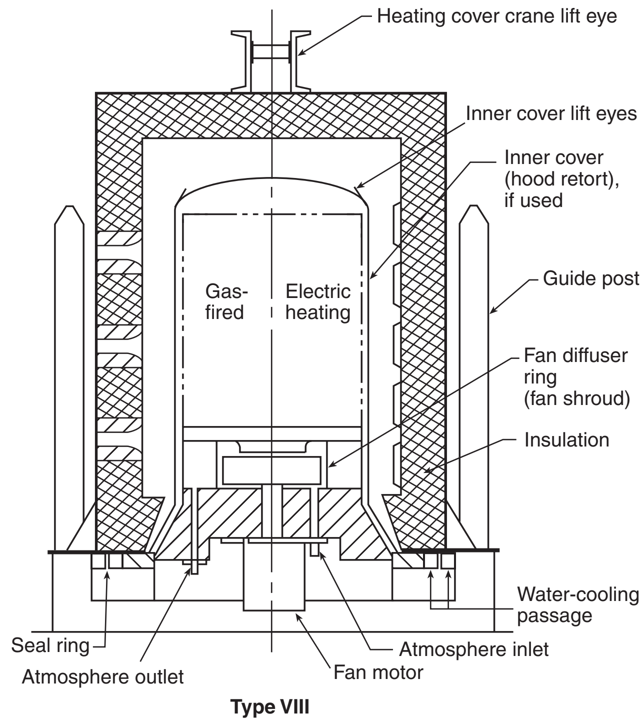
12-1 General.

12-1.1* Scope. This chapter describes procedures and protecting equipment that shall be used for the introduction and removal of flammable special atmospheres from heating cover–type furnaces. Chapters 1 through 7 shall be used in conjunction with Chapter 12 wherever applicable. For application of programmable controllers, also see Section 5-3. The scope shall be limited to furnaces in which the heating cover and inner cover (if applicable) are separated from a base that also supports the work processed.

12-1.2 Types of Heating Cover Furnaces. The following are two types of heating cover furnaces.

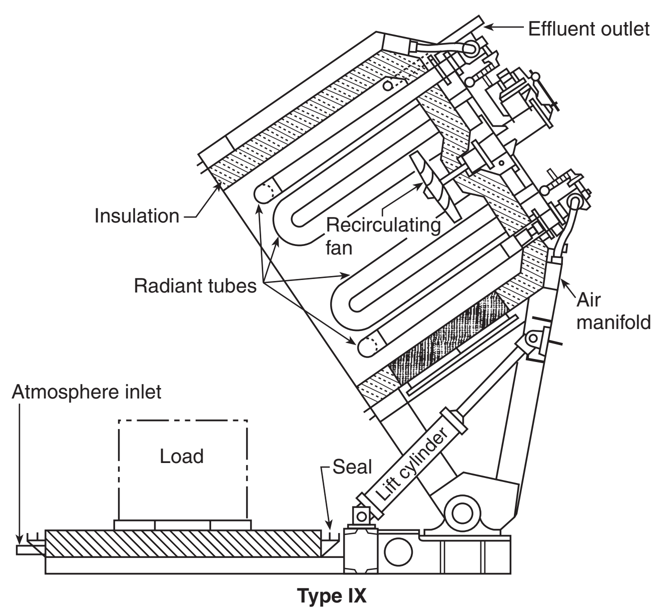
(a) *Type VIII.* A heating cover furnace with an inner sealed cover. The work is indirectly heated. The heat source is located in the space between the outer heating cover and the sealed inner cover (retort). The inner cover encloses the work. *[See Figure 12-1.2(a).]*

Figure 12-1.2(a) Example of a bell-type furnace.



(b) *Type IX.* A heating cover furnace without an inner cover or with a nonsealed inner cover. The work can be directly or indirectly heated. *[See Figure 12-1.2(b).]*

Figure 12-1.2(b) Example of a tip-up-type furnace.



12-1.3 Special Atmosphere Flow Requirements.

12-1.3.1 Atmosphere process and the equipment for controlling the flows of special atmospheres shall be installed and operated to minimize the infiltration of air into a furnace, which could result in the creation of flammable gas–air mixtures within the furnace.

12-1.3.2 The flammable special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits the furnace. The person or agency commissioning the furnace or atmosphere process shall prescribe the flow rate.

12-1.3.3 The flow rate of an inert gas being used as a purge shall be controlled. The inert gas shall be introduced to the furnaces through one or more inlets as necessary to ensure that the entire chamber(s) is purged.

12-2 Flammable Special Atmosphere Introduction and Removal.

12-2.1 Flammable special atmosphere introduction and removal to or from a Type VIII heating cover furnace shall be accomplished using the purge procedures in 12-2.3 and 12-2.4.

12-2.2 The selection of the proper procedure to be used for introduction and removal of atmosphere for a Type IX heating cover furnace shall be determined by the normal operating temperature of the work chamber when atmosphere is to be introduced or removed.

Exception: The procedures used to introduce or remove flammable special atmosphere for a Type IX heating cover furnace with a nonsealed inner cover shall be in accordance with 12-2.5 and 12-2.6.

12-2.2.1 The procedures used to introduce or remove flammable special atmosphere for a Type IX heating cover furnace work chamber at or above 1400°F (760°C) shall be in accordance with 12-2.7 and 12-2.8.

12-2.2.2 The procedures used to introduce or remove a flammable special atmosphere for a Type IX heating cover furnace work chamber below 1400°F (760°C) shall be in accordance with 12-2.5 and 12-2.6.

12-2.3 Introduction of Flammable Special Atmosphere Gas into Heating Cover Type VIII Furnace by Purge Procedure.

12-2.3.1 Air trapped inside the inner cover (retort) shall be purged by means of inert gas or vacuum pump prior to introducing a flammable special atmosphere.

12-2.3.2 In addition to the requirements of 12-2.3.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 12-2.3.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) All of the following starting conditions shall be satisfied:

(1) Furnace base is loaded with work
(2) Both base and workload are below 1400°F (760°C)
(3) Inner cover (retort) is not covering the work

(b) Verification of an adequate supply of inert purge gas shall be made. The inert purge gas requirements for the normal process shall not deplete the adequacy of the emergency gas supply.

(c) The atmosphere gas valves on all bases that do not have a workload and inner cover in position and the atmosphere gas valves on all bases that have an unpurged inner cover in position shall be closed.

(d) The inner cover shall be placed over the work and sealed to the furnace base.

(e) The liquid level in manometers or bubbler bottles (if provided) on the vent line shall be checked and refilled when necessary, and the effluent gas pilot(s) shall be ignited. Pilots shall be of the type that remains lit when subjected to an inert atmosphere.

(f) The circulating fan, if provided, shall be started.

(g) The inert gas purge system shall be actuated to purge the inner cover at a rate to maintain a positive pressure. This pressure shall be indicated by the bubbler, vent manometer, or similar device.

Exception: A vacuum purge shall be permitted if the initial room air within the inner cover is pumped out to a vacuum of 100 microns (1×10^{-1} torr) (13.3 Pa) or less.

(h) Sampling of the inner cover atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses indicate that the oxygen content is below 1 percent by volume. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

Exception: A vacuum purge shall be permitted if the initial room air within the inner cover is pumped out to a vacuum of 100 microns (1×10^{-1} torr) (13.3 Pa) or less.

(i) After it has been determined that the flammable special atmosphere gas supply is adequate, the inert gas supply shall be turned off and the flammable special atmosphere shall be introduced.

(j) The flammable special atmosphere flow to the inner cover shall be adjusted.

(k) Manometers, bubbler bottles, or similar devices shall indicate proper pressure before the procedure is continued.

(l) When flame appears at the effluent lines, the atmosphere introduction shall be considered to be complete.

(m) The base with load and inner cover then is ready for the heat-treating cycle. The outer heating cover shall be placed over the inner cover and heat shall be applied.

12-2.4 Removal of Flammable Special Atmosphere Gas from Heating Cover Type VIII Furnace by Purge Procedure.

12-2.4.1 Combustible gases within the inner cover (retort) shall be purged before the inner cover is removed.

12-2.4.2 In addition to the requirements of 12-2.4.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 12-2.4.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) Verification of an adequate supply of inert purge gas shall be made.

(b) The outer heating cover shall be removed from over the inner cover.

(c) The flammable special atmosphere gas safety shutoff valve shall be closed, causing the inert gas to flow into the inner cover *(see 12-4.2)*. The inert gas flow shall be sufficient to maintain the manufacturer's required minimum pressure as indicated by the bubbler, vent manometer, or similar device. The purge shall continue until the total combustible content of the special atmosphere inside the inner cover (retort) is below 50 percent of its LEL for two consecutive readings. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(d) The pilot flame at each effluent vent line shall be shut off.

(e) The speed of the circulating fan (if required) shall be stopped or reduced.

(f) The inner cover shall be removed from over the work.

(g) The inert purge gas flow shall be shut off.

12-2.5 Introduction of Flammable Special Atmosphere Gas into Heating Cover Type IX Furnace by Purge Procedure.

12-2.5.1 Air trapped inside the heating cover, and nonsealed inner cover if applicable, shall be purged by means of inert gas or vacuum pump prior to introducing a flammable special atmosphere.

12-2.5.2 In addition to the requirements of 12-2.5.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 12-2.5.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) All of the following starting conditions shall be satisfied:

(1) Furnace base is loaded with work

(2) Both base and workload are below 1400°F (760°C)

(3) Heating cover is not covering the work

(b) Verification of an adequate supply of inert purge gas shall be made. The inert purge gas requirements for the normal process shall not deplete the adequacy of the emergency gas supply.

(c) The atmosphere gas valves shall be closed on all bases that do not have a workload under process.

(d) The heating cover shall be placed over the work and sealed to the furnace base.

(e) The liquid level in manometers or bubbler bottles (if provided) on the vent line shall be checked and refilled when necessary, and the effluent gas pilot(s) shall be ignited. Pilots shall be of the type that remains lit under all operating and emergency conditions.

(f) The circulating fan, if provided, shall be started.

(g) The inert gas purge system shall be actuated to purge the work chamber at a rate to maintain a positive pressure. This pressure shall be indicated by the bubbler, vent manometer, or similar device.

Exception: A vacuum purge shall be permitted if the initial room air within the inner cover is pumped out to a vacuum of 100 microns (1×10^{-1} torr) (13.3 Pa) or less.

(h) Sampling of the work chamber atmosphere shall begin. The inert gas purge shall continue until two consecutive analyses indicate that the oxygen content is below 1 percent by volume. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

Exception: A vacuum purge shall be permitted if the initial room air within the inner cover is pumped out to a vacuum of 100 microns (1×10^{-1} torr) (13.3 Pa) or less.

(i) After it has been determined that the flammable special atmosphere gas supply is adequate, the inert gas supply shall be turned off and the flammable special atmosphere gas shall be introduced.

(j) The special atmosphere flow to the work chamber shall be adjusted.

(k) Manometers, bubbler bottles, or similar devices shall indicate proper pressure before the procedure is continued.

(l) When flame appears at the effluent lines, the atmosphere introduction shall be considered to be complete.

12-2.6 Removal of Flammable Special Atmosphere Gas from Heating Cover Type IX Furnace by Purge Procedure.

12-2.6.1 Combustible gases within the heating cover, and nonsealed inner cover if applicable, shall be purged before the heating cover is opened or removed.

12-2.6.2 In addition to the requirements of 12-2.6.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 12-2.6.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following purge procedure shall be performed in the given sequence.

(a) Verification of an adequate supply of inert purge gas shall be made.

(b) The flammable special atmosphere gas safety shutoff valve shall be closed, causing the inert gas to flow into the work chamber *(see 12-4.2)*. The inert gas flow shall be sufficient to maintain the manufacturer's required minimum pressure as indicated by the bubbler, vent manometer, or similar device. The purge shall continue until the total combustible content of the special atmosphere inside the work chamber is below 50 percent of its LEL for two consecutive readings. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

(c) The pilot flame at effluent vent line shall be shut off.

(d) The speed of the circulating fan (if required) shall be stopped or reduced.

(e) The heating cover shall be removed from over the work.

(f) The inert purge gas flow shall be shut off.

12-2.7 Introduction of Flammable Special Atmosphere Gas into a Heating Cover Type IX Furnace by Burn-in Procedure.

12-2.7.1 The procedure in 12-2.7.2 shall be used only if the work chamber is at or above 1400°F (760°C).

12-2.7.2 In addition to the requirements of 12-2.7.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 12-2.7.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-in procedure shall be performed in the given sequence.

(a) All of the following starting conditions shall be satisfied:

(1) Furnace base is loaded with work
(2) Both base and workload are below 1400°F (760°C)
(3) Heating cover is not covering the work

(b) Verification of an adequate supply of flammable special atmosphere gas shall be made.

(c) The atmosphere gas valves shall be closed on all bases that do not have a workload under process.

(d) The heating cover shall be placed over the workload and sealed to the furnace base.

(e) The circulating fan (if provided) shall be started.

(f) The liquid level in manometers or bubbler bottles (if provided) on the vent line(s) shall be checked and refilled when necessary.

(g) The heating system shall be started and the work chamber temperature shall be raised to 1400°F (760°C) or greater.

(h) The effluent gas pilots shall be ignited at all vents where gases might be discharged from the furnace. Pilots shall be of the type that remains lit under all operating and emergency conditions.

(i) The flammable special atmosphere gas shall be introduced and the flow shall be adjusted.

(j) Manometers, bubbler bottles, or similar devices shall indicate proper pressure before the procedure is continued.

(k) When flame appears at the effluent lines, the atmosphere introduction shall be considered to be complete.

12-2.8 Removal of Flammable Special Atmosphere Gas from a Heating Cover Type IX Furnace by Burn-out Procedure.

12-2.8.1 The procedure in 12-2.8.2 shall be used only if the work chamber is at or above 1400°F (760°C).

12-2.8.2 In addition to the requirements of 12-2.8.2, the furnace manufacturer's instructions shall be referenced for further mechanical operations, and the supplier of the special atmosphere shall be consulted for process and safety instructions. It shall be permitted for the manufacturer or user to modify the procedures of 12-2.8.2 if required to improve operational and emergency safety. These modifications shall be approved by the authority having jurisdiction.

The following burn-out procedure shall be completed in the given sequence before the work chamber temperature falls below 1400°F (760°C).

(a) Where required, pilots or torches shall be ignited and placed in position or shall be ready for ignition of the flammable atmosphere gas at the heating cover to the base seal as soon as the seal is broken.

(b) The heat source shall be turned off.

(c) The speed of the circulating fan (if provided) shall be stopped or reduced.

(d) Any mechanical clamping devices (if used) that hold the heating cover to the base shall be released.

(e) *The heating cover shall be separated gradually from the base. The flammable atmosphere gas shall ignite or shall be ignited as soon as the heating cover breaks its seal with the base.

(f) The flammable special atmosphere gas inlet valve shall be closed.

12-3 Emergency Shutdown for Heating Cover–Type Furnaces.

12-3.1 In the event of electric power failure or loss of flammable special atmosphere flow, all the following actions shall be initiated.

(a) An inert gas safety purge system, as prescribed in 12-4.1(e), shall be actuated immediately.

(b) The flammable atmosphere safety shutoff valve shall be closed.

(c) All manual flammable atmosphere gas valves shall be closed.

(d) The inert gas safety purge shall be continued as long as necessary to purge the flammable gas from the work chamber.

(e) The flow of the inert gas safety purge shall be actuated at a rate to maintain a positive pressure in the work chamber for the duration of the purge.

(f) The inert gas safety purge shall be continued until the total combustible content of the special atmosphere in the work chamber is below 50 percent of its LEL for two consecutive readings. Chapter 13 specifies timed flow alternative methods for determining that the purge is complete under normal operating conditions. However, timed flow purging methods shall not be used in the case of emergency purges.

12-3.2* In the event of a disruption in atmosphere circulation, atmosphere flow into the furnace shall be continued on an emergency basis to maintain positive pressure until fan operation is restored or until the heating cover is removed from the base and all remaining flammable atmosphere can be removed by other means, such as by burning out and thereby retarding air infiltration. Neither timed flow purging methods nor analyses of purge vent gas shall be used to determine when purging can be stopped.

12-4 Protective Equipment for Heating Cover–Type Furnaces above 1400°F (760°C).

12-4.1 The following protective equipment and procedures shall be required in conjunction with the special atmosphere gas system.

(a) A safety shutoff valve on the flammable special atmosphere gas supply line to the furnace.

(b) An atmosphere gas flow indicator(s) to allow the operator to determine the adequacy of atmosphere gas flow visually at all times.

(c) A sufficient number of furnace temperature monitoring devices to determine the temperature in all zones. These devices shall be interlocked to prevent opening of the atmosphere gas safety shutoff valve until all zones are at, or above, 1400°F (760°C) where inert gas or vacuum purging of oxygen from the initial room air within the work chamber is not employed.

(d) Audible and visual alarms to alert the furnace operator of abnormal furnace temperature or low atmosphere flow conditions detected by the monitoring devices as recommended, giving the operator the opportunity to perform any required shutdown procedure safely.

(e) An emergency safety purge. A nonflammable safety purge system, in accordance with Section 7-5, to purge the flammable or indeterminate atmosphere gas from the furnace immediately when an emergency situation occurs, such as power failure, loss of flammable special atmosphere, or loss of normal inert purge gases.

(f) Valves for manually shutting off the flow of flammable special atmosphere to the furnace. These valves shall be readily accessible to the operator and remotely located from the furnace.

(g) Pilots at all effluent vent lines. These pilots shall be monitored to alert the operator of pilot failure.

12-4.2 The inert purge system(s) shall include all of the following:

(1) Audible and visual alarms to alert the operator of low purge flow rate
(2) Gas analyzing equipment for ensuring that the furnace is purged
(3) Monitoring devices to allow the operator to determine the adequacy of the inert purge flow visually at all times
(4) A provision to allow the operator to start the inert purge manually whenever desired

The inert purge piping system shall be arranged so that whenever the control valve in the inert gas line is open, the flammable special atmosphere gas line is closed.

12-4.3 All piping and wiring connections to removable heating covers shall be painted, keyed, or otherwise marked to minimize the possibility of misconnections.

12-4.4 Automatic pressure makeup of the work chamber shall be provided on furnace equipment where reliable operator monitoring of indicators such as pressure and flow rates cannot be ensured.

12-4.5 All the following protective equipment for furnaces utilizing timed flow purges shall be provided:

(1) Purge timer(s)
(2) Purge gas flow meter(s)
(3) Purge flow monitoring device(s)
(4) Fan rotation sensor(s)

12-5* Operating Precautions for Heating Cover–Type Furnaces. The rate of separating a heating cover from or rejoining a heating cover to the inner cover shall not exceed a rate that causes rapid expansion or contraction of the atmosphere gas inside the inner cover.

Chapter 13 Timed Flow Purge Method for Type I–IX Furnaces

13-1* General.

13-1.1 Inert gas purges are used for either of the following purposes:

(1) To remove oxygen (contained in air) from a furnace before introducing a flammable or indeterminate carrier gas
(2) To remove a flammable or indeterminate atmosphere from the furnace before it is opened to the air

Such purges are required to avoid creating explosive atmosphere-air mixtures inside the furnace when combustible gases are introduced or withdrawn or when a furnace is opened to the air.

13-1.2 Chapter 13 prescribes a method for purging a furnace that avoids the use of gas analysis measurements in routine operations after commissioning of the furnace system.

13-1.3* Emergency Purging after Failure of Atmospheric Circulation. The timed purge method described in Chapter 13 shall not be used to determine when an emergency purge has been completed satisfactorily in the event of a failure of atmosphere circulation inside a furnace.

13-2 Timed Flow Purging Trials.

13-2.1 At the time of commissioning or initial start-up, the equipment supplier, or the agency authorizing purchase of the furnace, shall perform trials that confirm the adequacy and effectiveness of a timed flow purge. The test data and results shall be recorded and maintained as a permanent record and made available to the authority having jurisdiction.

13-2.2 The trial shall be conducted using ambient temperature purge gas flowed into an unheated furnace. The work chamber shall not contain work or any objects that reduce its normal volume of gas. Atmosphere circulation fans inside the furnace shall have proven operation during the entire purge period.

13-2.3 The trials shall incorporate all of the following.

(a) Verification that the purge gas flow rate or cumulative volume measurement is correct.

(b) Verification that the measured purge gas flow rate or volume is undiminished at the furnace atmosphere outlet or inlet to each individual furnace. In the latter case, there shall be no further downstream branching, tees, valves, or openings in the pipeline—only the inlet to the furnace.

(c) Use of a gas analyzing instrument(s) that is listed and calibrated in accordance with the manufacturer's instructions.

13-2.4 Where oxygen is being purged out of a furnace using an inert gas, verification testing shall be considered acceptable if, after five furnace volume changes of flow, two consecutive gas analyses of the effluent gas indicate less than 1 percent oxygen by volume.

13-2.5 Where a combustible atmosphere is being purged out of a furnace using an inert gas, verification testing shall be conducted at the normal purging temperature and considered acceptable if, after five furnace volume changes of flow, two consecutive gas analyses of the effluent gas indicate less than 50 percent of the LEL.

13-3* Future Purge Verifications. Trials prescribed in Section 13-2 shall be repeated periodically, as specified in the furnace manufacturer's instructions, to verify that future alterations to the furnace or atmosphere piping have not diminished the effectiveness of the purge. The user shall perform the retests and retain written records of the results for review by the authority having jurisdiction.

13-4 Failure to Verify Timed Flow Purge Effectiveness. In the event that the trials in Sections 13-2 and 13-3 fail to verify the effectiveness of the purge process, procedures utilizing gas analyzers to prove completeness of purges shall be utilized until the cause of the failure is found and remedied and successful trials are completed.

Chapter 14 Integral Quench Furnaces

14-1* Scope.

14-1.1 General.

14-1.1.1 Chapter 14 prescribes procedures and protective equipment of heat treatment furnaces of special design having an integral quench generally consisting of a Class C furnace to which is added an enclosed quench tank. Work in process is under special atmosphere from the time the work enters the furnace until it has been quenched and removed from the furnace. For application of programmable controllers, see Section 5-3.

14-1.1.2 The integral quench section consists of an enclosed quench vestibule and a quench tank. An additional cooling chamber shall be permitted to be provided and shall be elevated above the quench tank or located to one side of the quench.

14-1.1.3 The atmosphere used shall depend on the metallurgical requirements of the work being processed.

14-1.1.4 The integral quench tank shall be permitted to utilize any combination of heating and cooling, depending on the metallurgical requirements of the work to be processed.

14-1.2 This chapter does not cover salt quench tanks or central quench medium cooling systems.

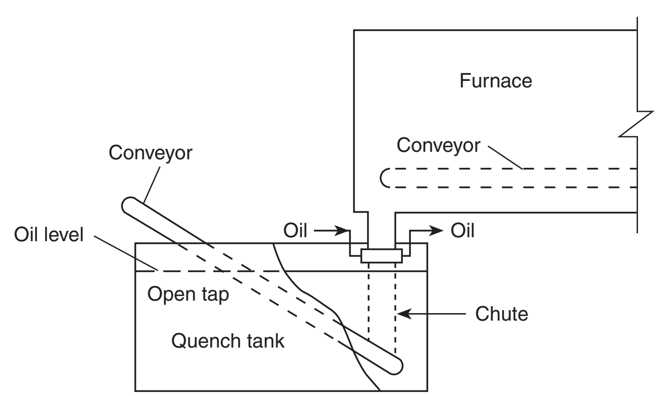
14-2 Types of Integral Quench Furnaces. The following are three types of integral quench furnaces.

(a) *Type QI.* Dunk-type elevator quench.

(b) *Type QII.* Dunk-type elevator quench with under-oil transfer.

(c) *Type QIII.* Conveyor-type quench *(see Figure 14-2).*

Figure 14-2 Example of integral quench furnace Type QIII.



14-3 Quench Vestibule.

14-3.1 The quench vestibule shall be constructed of noncombustible materials with due regard to the fire and explosion hazards inherent to such equipment.

14-3.2 The inner door between the furnace and quench shall seal the opening in order to serve as an insulated baffle to block heat loss to the quench vestibule.

14-3.3 Emergency or service access shall be provided.

14-3.4 All outer load and unload doors shall be fitted properly with adequately sized and stable pilots under all operating conditions.

14-3.5 The quench vestibule shall be supplied with an atmosphere gas supply adequate to maintain safe conditions during the entire process cycle. The introduction and maintenance of this atmosphere shall be in accordance with Chapters 9 and 11.

14-3.6 An effluent line (flammable atmosphere vent) shall be provided to control the pressure equilibrium in the chamber. The vent opening shall be located so that operators are not exposed to injury upon pressure release.

14-3.7 An adequately sized stable pilot shall be provided at the effluent line to ignite the vented gases.

14-3.8 Manual facilities shall be provided to allow opening of the outer quench vestibule door. Opening of this door under emergency conditions shall be the decision of operating personnel.

14-4 Cooling Chamber Design.

14-4.1 Base materials, weld filler materials, and welding procedures used for the cooling chamber shall be selected to provide resistance to corrosion by the cooling medium.

14-4.2 Where the quench medium temperature is excessive for desired jacket cooling, a separate heat exchanger shall be employed.

14-4.3 Where a water-cooled heat exchanger is used, the quench oil circulating pump shall be installed on the inlet side of the heat exchanger and the quench medium pressure always shall exceed that of the cooling water. A differential pressure switch shall be required and interlocked with the quench cycle.

14-4.4 Where steel plate coils are attached by thermal contact cement to the external surfaces of the quench chamber, fabricated of hot-rolled steel plate, the junction shall not cause the possibility of a water leak into the quench reservoir.

14-4.5 Where serpentine coils formed from a noncorrosive tubing material are brazed or welded to the exterior surfaces of a cooling chamber fabricated of hot-rolled steel plate, the junction shall not cause the possibility of a water leak into the quench tank.

14-4.6 Automatic temperature controls shall be installed in pressure-type water-cooling and oil-cooling systems to ensure the desired jacket temperature.

14-5* Elevator Design.

14-5.1 The elevating mechanism shall be supported substantially by structural members in order to handle the maximum rated loads.

14-5.2 Elevator guides or ways shall be provided to ensure uniform stabilized movement of the elevator in the confined areas of the quench tank.

14-5.3 Tray guides or stops shall be provided to ensure the tray is positioned properly on the elevator.

14-5.4 Outer door operation shall be interlocked in the automatic mode so that it cannot open unless the elevator is in its full up or down position or upon extinguishment of the flame-supervised outer door pilot, except through action of manual override in emergencies. *(See 14-3.8.)*

14-6 Lower Quench Chamber or Tank.

14-6.1 The quench tank shall be designed and constructed to do the following:

(1) Contain the quench medium capacity at the expected operating temperature and with maximum workload volume
(2) Operate with a maximum quench medium level, where the elevator and work load are submerged, of not less than 6 in. (152 mm) below the door or any opening into the furnace

14-6.2 The quench tank shall be tested for leaks prior to use.

14-6.3 The quench tank shall have sufficient capacity to quench a maximum gross load with a maximum temperature rise that cannot exceed 50°F (28°C) below the flash point and shall have cooling capabilities to return the quench medium to a satisfactory temperature range between minimum quench cycles.

14-6.4 The quench tank shall be provided with an adequately sized overflow directed to a safe location outside of the building or to a salvage tank. Overflow shall be trapped or otherwise arranged to prevent the loss of quench chamber atmosphere gas and to prevent a siphon effect.

14-7 Overflow Drains.

14-7.1* Quench tanks of over 150 gal (568 L) in liquid capacity or 10 ft^2 (0.9 m^2) in liquid surface area shall be equipped with a properly trapped overflow pipe leading to a safe location.

14-7.1.1 Overflow pipes shall be of sufficient capacity to overflow the maximum delivery of quench tank liquid fill pipes, but shall not be less than 3 in. (76 mm) in diameter, and shall be increased in size, depending upon the area of the liquid surface and the length and pitch of pipe.

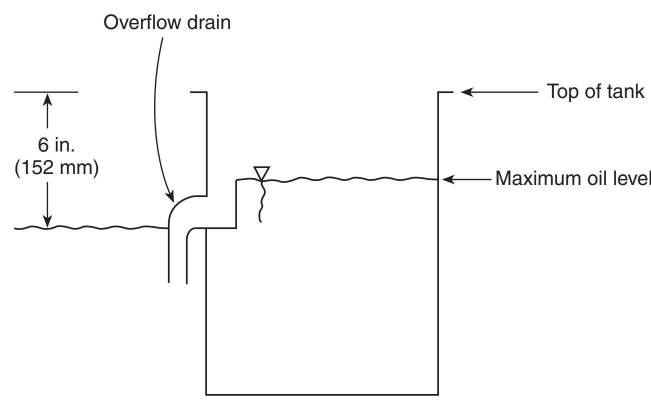
14-7.1.2* If the liquid surface area of a quench tank is 75 ft^2 to 150 ft^2 (7 m^2 to 14 m^2), the diameter of the overflow pipe shall be not less than 4 in. (102 mm); if 150 ft^2 to 225 ft^2 (14 m^2 to 21 m^2), not less than 5 in. (127 mm); if 225 ft^2 to 235 ft^2(21 m^2 to 30 m^2), not less than 6 in. (152 mm).

14-7.2 Overflow pipes shall be connected to quench tanks through an outlet where the accumulation of caked or dried material cannot clog the overflow opening.

14-7.3 Piping connections on drains and overflow lines shall be designed to allow ready access for inspection and cleaning.

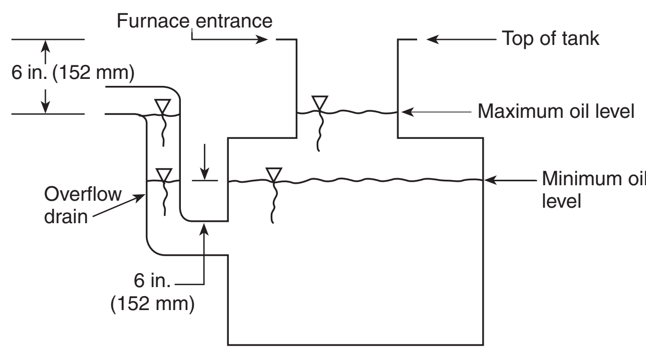
14-7.3.1 The bottom of the overflow connection shall be not less than 6 in. (152 mm) below the top of the tank for open integral quench tanks. *(See Figure 14-7.3.1.)*

Figure 14-7.3.1 Example of overflow drains for open integral quench tanks.



14-7.3.2 The bottom of the overflow connection shall be not less than 6 in. (152 mm) below the lowest operating oil level for closed integral quench tanks. *(See Figure 14-7.3.2.)*

Figure 14-7.3.2 Example of overflow drains for closed integral quench tanks.



14-8* Quench Medium Cooling Systems.

14-8.1 Heat Exchanger within Quench Tank.

14-8.1.1 The heat exchanger shall be constructed of materials that cannot be corroded by either cooling medium or quench medium.

14-8.1.2 The heat exchanger shall be subjected to a minimum pressure test of 150 percent of the maximum designed working pressure after installation in the quench tank.

14-8.1.3 The heat exchanger shall be located within the quench tank in a manner that prevents mechanical damage by the elevator or by the load to be quenched.

14-8.1.4 The cooling medium flow should be controlled by an automatic temperature control.

14-8.1.5 A pressure-relief device shall be provided to protect the heat exchanger. Relief shall be piped to a safe location.

14-8.1.6 Water shall not be used as a cooling medium within a quench tank utilizing a combustible liquid quench medium.

14-8.2 External Liquid-Cooled Heat Exchanger.

14-8.2.1 Heat exchanger tubes that are exposed to water shall be constructed of corrosion-resistant materials.

14-8.2.2 After fabrication, the heat exchanger shall be subjected to a minimum pressure test of 150 percent of the maximum designed working pressure.

14-8.2.3 The pressure of the quench medium through the heat exchanger shall be greater than the coolant pressure applied. A differential pressure switch shall be required and interlocked with the quench cycle.

14-8.2.4 A pressure-relief device shall be provided to protect the heat exchanger. Relief shall be piped to a safe location.

14-8.3 External Air-Cooled Heat Exchanger.

14-8.3.1 External air-cooled heat exchangers installed outdoors shall be reinforced structurally to withstand anticipated wind forces without damage at the elevation at which they are mounted.

14-8.3.2 External air-cooled heat exchangers that are installed outdoors or that utilize supplemental water-cooling shall be constructed of materials that are able to withstand corrosion.

14-8.3.3 An external heat exchanger installed outdoors shall be provided with lightning protection if located in an exposed, rooftop location.

14-8.3.4 If the air-cooled heat exchanger is installed in a rooftop location, it shall be installed in a curbed or diked area and drained to a safe location outside of the building.

14-9* Quench Tank Protective Features.

14-9.1 The quench reservoir shall be equipped with a reliable quench medium level indicator.

14-9.2 If of the sight-glass type, the level indicator shall be of heavy-duty construction and protected from mechanical damage.

14-9.3 The quench tank shall be equipped with a low-level device arranged to sound an alarm, to prevent the start of quenching, and to shut off the heating medium in case of a low-level condition.

14-9.4 The quench tank shall be equipped with an excess temperature limit control device arranged to do the following:

(1) Sound an alarm
(2) Automatically shut off the quench heating medium
(3) Prevent the start of a quench

14-9.5 Where agitation of the quench medium is required to prevent overheating, the agitation shall be interlocked to prevent quenching until the agitator has been started.

14-9.6 A reliable means shall be used to test for water in quench oil.

14-9.6.1* Laboratory testing shall be permitted to be used to determine the existence of water in quench oil.

14-9.6.2* A representative sample of quench oil shall be obtained.

14-9.6.3* Quench oil shall be tested for water content whenever there is a possibility that water has contaminated the quench oil system.

14-9.6.4 Quenching operations shall be prohibited until the water contamination is corrected and confirmed by test.

14-10 Quench Tank Heating Controls.

14-10.1 Fuel-Fired Immersion Heaters.

14-10.1.1 Fuel-fired immersion heaters shall be installed in accordance with Chapters 3, 4, and 5.

14-10.1.2 Burner control systems shall be interlocked with the quench medium agitation system or the recirculating system, or both, to prevent localized overheating of the quench medium.

14-10.1.3 The immersion tubes shall be installed so that the entire tube within the quench tank is covered with quench medium at all times.

14-10.1.4 A quench medium level control and excess temperature supervision shall be interlocked to shut off immersion heating when low quench level or overtemperature is detected.

14-10.2 Electric Immersion Heaters.

14-10.2.1 Electric immersion heaters shall be of sheath-type construction.

14-10.2.2 Heaters shall be installed so that the hot sheath is fully submerged in the quench medium at all times.

14-10.2.3 The quench medium shall be supervised by both of the following:

(1) A temperature controller arranged to maintain the quench medium at the proper temperature
(2) A quench medium level control and excess temperature supervision that are interlocked to shut off the immersion heating when low quench level or overtemperature is detected.

14-10.2.4 The electrical heating system shall be interlocked with the quench medium agitation system to prevent localized overheating of the quench medium.

Chapter 15 Open Liquid Quench Tanks

15-1 Scope.

15-1.1 This chapter shall apply to the open tank quenching of heated metals in combustible quench media. Pure mineral oils are the most common of these media, the majority of which have flash points above 300°F (150°C). The quench is separate from the furnace, with the tank and work exposed to air.

15-1.2 This chapter shall not apply to salt quench tanks or central quench medium cooling systems.

15-2 Location. Tanks shall be located as far as practicable from furnaces and shall not be located on or near combustible floors. Combustible materials shall not be stored in the vicinity of the quench tank.

15-3* Hazards. Fire is the principal hazard in oil quenching. When hot metal is quenched in oil, an envelope of vapors forms around the piece. Large vapor bubbles, which can have temperatures above autoignition temperature, rise to the surface and sometimes flash into flame momentarily. Additional localized surface flashing also occurs around the work as it enters the oil but is extinguished readily by normal agitation of the oil.

15-4 Quench Tank Construction.

15-4.1 The tank shall be constructed of noncombustible material and shall be supported securely and rigidly. Supports for tanks over 500 gal (1893 L) in capacity or 10 ft^2 (1 m^2) in liquid surface area shall have a minimum fire resistance rating of 1 hour.

15-4.2 The top of the tank shall be at least 6 in. (152 mm) above the floor.

15-4.3 In the event of a fire in the tank, automatic sprinkler discharge can collect in the tank and float the flaming liquid out of the tank. This condition shall be prevented by one or more of the following:

(1) Oil drain boards shall be arranged so sprinkler discharge cannot be conducted into the tank.
(2) Tanks shall be equipped with automatically closing covers.
(3) Tanks shall be equipped with overflow pipes. *(See 15-4.5.)*

15-4.4 The level of liquid in the tanks shall be maintained at 6 in. (152 mm) or greater below the top of the tank to allow effective application of extinguishing agents in the event of fire.

15-4.5* Overflow Pipes.

15-4.5.1 Tanks of over 150 gal (570 L) in capacity, or 10 ft^2 (1 m^2) in liquid surface area, shall be equipped with a properly trapped overflow pipe leading to a safe location.

15-4.5.2 Depending upon the area of the liquid surface and the length and pitch of the pipe, overflow pipes for quench tanks over 150 gal (570 L) in capacity, or 10 ft^2 (1 m^2) in area, shall be capable of handling the maximum delivery of quench tank liquid fill pipes, or automatic sprinkler discharge, but shall not be less than 3 in. (76 mm) in diameter.

15-4.5.3 Piping connections on drains and overflow lines shall be designed to allow ready access for inspection and cleaning of the interior.

15-4.5.4 Overflow pipes installed in quench tanks shall have a minimum liquid entry level of 6 in. (152 mm) below the top of the tank.

15-4.5.5 Overflow pipes shall not contain any valves or other restrictions.

15-4.6 Emergency Drains. Drain facilities from the bottom of a tank shall be permitted to be combined with the oil-circulating system or arranged independently to drain the oil to a safe location. Unless the viscosity of the liquid at normal atmospheric temperatures makes this impractical, tanks over 500 gal (1900 L) in liquid capacity shall be equipped with bottom drains arranged to drain the tank quickly, both manually and automatically, in the event of fire. Manual operation shall be from a safe, accessible location. Where gravity flow is not practicable, automatic pumps shall be required. Such drain facilities shall be trapped and shall discharge to a closed, properly vented salvage tank or to a safe location outside. The provisions of this section shall not apply to integral quench furnaces.

15-5 Equipment.

15-5.1 Transfer. Controls of transfer equipment shall be installed in a safe location so that the operator can be protected in the event of oil flash while the work is being lowered.

15-5.2 Temperature Control of Liquids.

15-5.2.1 To prevent overheating the oil, the tank and cooling system shall be designed with sufficient capacity to keep the oil temperature at least 50°F (28°C) below its flash point under maximum work load conditions.

15-5.2.2 The cooling system shall be constructed with an external heat exchanger and shall be controlled so that any leakage is from the oil to the water. Water-cooling coils shall not be installed within the quench tank. Loss of the controlled condition shall be alarmed.

15-5.2.3 On open tanks with heating systems, automatic temperature control shall be provided to maintain the oil at the desired working temperature. This temperature shall be more than 50°F (28°C) below the flash point of the oil. Controls shall be interlocked to prevent starting the heating system, unless the tank agitator or recirculation pump is in operation.

15-5.2.4 An excess temperature limit switch that is independent of operating temperature controls shall be provided on all quench tanks where any of the following conditions exist:

(1) The liquid surface area exceeds 10 ft^2 (1 m^2).
(2) Incoming or outgoing work is handled by conveyor.
(3) Artificial cooling is required to maintain the oil temperature at least 50°F (28°C) below the flash point.
(4) The tank is equipped with a heating system.

15-5.2.5* The excess temperature limit switch shall be set at least 50°F (28°C) below the flash point of the oil. On operation, the excess temperature limit switch shall actuate an audible and visual alarm, shut down any quench oil heating system, and, if not in operation, start up oil recirculation or agitation and the tank cooling system. Where sudden stoppage cannot result in partial submergence of work, the excess temperature limit switch also shall shut down the conveyor.

15-5.3 Low Oil Level Sensor. A low oil level sensor shall be provided to sound an alarm in the event that the oil level is below safe limits where any of the following conditions exist:

(1) The liquid surface area exceeds 10 ft^2 (1 m^2).
(2) Incoming or outgoing work is handled by a conveyor.
(3) The tank is equipped with a heating system.

15-5.4 Hoods. Tanks shall be provided with a noncombustible hood and vent or other equally effective means to facilitate removal of vapors from the process and to prevent condensate from forming on roof structures. All such vent ducts shall be treated as flues and shall be kept well-separated from combustible roofs or materials. Hoods and ducts shall be protected with an approved automatic extinguishing system and shall be located so as not to interfere with fire protection facilities for the quench tank.

15-6 Protection. Protection requirements for open quench tanks are included in Chapter 18.

Chapter 16 Molten Salt Bath Equipment

16-1* General.

16-1.1 Scope.

16-1.1.1 Chapter 16 covers molten salt bath furnaces, internal salt quench tanks, and associated equipment. Molten salt bath furnaces shall include any heated container that holds a melt or fusion of one or more relatively stable salts used as a fluid medium into which metalwork is immersed.

16-1.1.2 For application of programmable controllers, see Section 5-3.

16-1.2 Responsibility. Molten salt bath equipment shall be selected properly and operated for a specific process.

16-1.2.1 Responsibility for selection shall be that of the person or agency authorizing the purchase of the equipment and that of the manufacturer supplying the equipment.

16-1.2.2 Responsibility for observing the operating instructions shall be that of the person or agency operating the equipment.

16-2 Location and Construction.

16-2.1 Location.

16-2.1.1 An adequate area shall be allocated for the installation of all salt bath equipment, and the zone of operation immediately around the bath shall be kept clear to prevent congestion and to prevent interference with normal operations.

16-2.1.2 Salt bath equipment shall be located either inside a shallow, cement-lined pit or within a curbed area. In either case, the pit or curbed area shall be designed to contain the contents of the molten salt in the furnace.

Exception: Equipment with outer walls constructed and maintained in a manner to be salt-tight to prevent leakage if the inner wall fails shall not require curbing.

16-2.1.3 Salt bath equipment shall be located so that the bath is not exposed to leakage from overhead liquid-conveying piping (e.g., service piping, steam piping, sprinkler piping, oil piping), liquid entry through wall openings (e.g., windows, air intakes), or anticipated leakage or seepage through the roofs or floors above. Where it is not possible to protect against possible liquid leakage entering the salt bath because of location, the salt bath shall be provided with a noncombustible hood that is designed and installed so that leakage into the molten salt is impossible.

16-2.1.4 Where adjacent equipment (e.g., oil or water quench tanks) are located so that potential splashover could expose a molten salt bath, the adjacent equipment shall be provided with deflecting baffles or guards to prevent the splashover from entering the salt bath.

16-2.2 Construction.

16-2.2.1 Molten salt bath equipment shall be constructed of noncombustible materials.

16-2.2.2 Molten salt bath equipment shall be constructed of materials that are resistant to the corrosive action of chemical salts at the maximum design operating temperature.

16-2.2.3 The design of molten salt baths, and the materials selected for their construction, shall minimize the possible effects of explosions, fires, spattering, and leakage, with regard for the protection of property and the safety of operating personnel.

16-2.2.4 The requirements of Chapter 3 also shall apply for the construction of salt bath equipment.

Exception: As specified in 16-2.1.2.

16-3 Salts.

16-3.1 General. For the purpose of this section, a salt shall be considered to be any chemical compound, or mixture of compounds, that is utilized to form a melt or fluid medium into which metal parts are immersed for processing.

16-3.2 Storage and Handling.

16-3.2.1 All salts shall be stored in tightly covered containers that are designed to prevent the possible entrance of liquids or moisture (most salts are hygroscopic).

16-3.2.2 All storage and shipping containers shall be marked prominently with the identification of the salt (or salt mixture) they contain to minimize the possibility of accidentally mixing noncompatible salts.

16-3.2.3 The supply of nitrate salts shall be stored in a separated, fireproof, and damp-free room or area located away from heat, liquids, and reactive chemicals. This room or area shall be secured against entry by unauthorized personnel at all times. Only the amount of nitrate salt needed shall be removed from the storage room or area that is required for makeup or full-bath charges. Where nitrate salts have been transported to the equipment area, they shall be added to the salt bath immediately. Excess salt shall not be permitted in the equipment area.

16-3.2.4 The salt bath area shall be kept clear of paper sacks or bags to avoid fires.

16-3.2.5 All restrictions applying to nitrate/nitrite salts also shall apply to cyanide salts. Operating procedures shall be implemented to ensure that mixing of cyanide and nitrate/nitrite salts cannot occur.

CAUTION

Mixing of cyanide and nitrate/nitrite salts can cause an explosion.

16-4 Heating Systems.

16-4.1 General.

16-4.1.1 For the purpose of Section 16-4, the term *salt bath heating system* shall include the heating source and all associated piping, electrodes, radiant tubes, and all other equipment or devices used to convey the heat safely to the bath that are necessary to create the salt melt or fusion.

16-4.1.2 The requirements of Chapters 4 and 5 shall apply.

16-4.2 Gas and Oil Heating Systems.

16-4.2.1 The design of salt bath equipment shall not permit direct flame impingement upon the wall of the salt container.

16-4.2.2 Wherever burner immersion tubes or radiant tubes are used, the design shall prevent any products of combustion from entering the salt bath.

16-4.2.3 All immersion or radiant tubes shall be fabricated of materials that are resistant to the corrosive action of the salt, or salt mixture, being used.

16-4.2.4 All immersion tubes shall be designed so that the tube outlet is above the salt level. Where the tube inlet is located below the salt bath level, the burner shall be sealed to prevent salt leakage outside of the furnace. Where the tube inlet is located below the salt level, the tube shall be sealed to the tank to prevent salt leakage outside of the furnace.

16-4.2.5 The design of molten salt bath equipment shall minimize the potential buildup of sludge and foreign materials that can result in hot spots on immersion tubes.

16-4.3 Electrical Heating Systems.

16-4.3.1 Wherever immersed or submerged electrodes are used, the design shall prevent the possibility of stray current leakage (which could result in electrolytic corrosion and subsequent perforation of the wall of the salt container), and the electrodes shall be fixed or restrained to prevent possible arcing to the salt bath container or metalwork in process.

16-4.3.2 Where internal resistance heating elements are used, they shall be fabricated of materials that are resistant to the corrosive action of the salt, and the salt bath shall be designed to prevent sludge buildup on the element that can result in damage from hot spots.

16-4.3.3 Wherever immersed or submerged electrodes or internal resistance heating elements are used, they shall be positioned in the bath so that all heat transfer surfaces are below the salt level at all times.

16-5 Ventilation.

16-5.1 Hoods. In order to remove, and appropriately control, the emission of heat and toxic (or otherwise deleterious) fumes, molten salt bath furnaces shall be provided with vented hoods that are constructed of noncombustible materials that are resistant to the maximum design temperature of the salt bath and the corrosive action of the salt being used.

16-5.2 Exhaust.

16-5.2.1 Salt bath furnace hoods shall be provided with exhaust ductwork and a blower (mounted external to the hood) for the continuous evacuation of fumes.

16-5.2.2 Where necessary for the reduction of pollution by exhaust emissions, an air washer, chemical scrubber, or fume destructor shall be installed that shall perform the required altering of the exhaust without reducing the exhaust system effectiveness.

16-6 Safety Control Equipment.

16-6.1 General.

16-6.1.1 Where nitrate salts are being used (regardless of the type of heating system), a control system shall be provided to prevent an excessively rapid heat-up, thus preventing localized overheating and ignition of the salt.

16-6.1.2 Gas- and oil-fired salt bath furnaces shall be provided with controls as specified in Chapter 5.

16-6.1.3 All immersion-type temperature-sensing elements or devices shall be resistant to damage from the maximum design temperature and the corrosive action of the salt being used.

16-6.1.4 Salt bath equipment shall be provided with visual and audible alarms. These alarms shall be interlocked with the safety control instrumentation.

16-6.2 Electrically Heated Salt Bath Equipment.

16-6.2.1 Automatic temperature control of the heating system shall be provided.

16-6.2.2 If a step-switch transformer is used, a transformer switch interlock shall be provided and shall be interlocked to shut off power to the transformer to protect against the hazard posed by changing secondary voltage taps under load.

16-6.2.3 Wherever transformers are cooled by forced air, a transformer airflow switch shall be provided. This airflow switch shall be interlocked to open the safety control contactor or actuate the shunt trip in the event of loss of airflow.

16-6.2.4 Wherever water-cooled furnace electrodes are used, safety control instrumentation shall be provided to detect failure of the cooling-water system and shall be interlocked to open the safety control system contactor or actuate the shunt trip or undervoltage trip. This instrumentation shall be permitted to be a waterflow switch on the drain side.

16-7 Internal Quenching Salt Tanks.

16-7.1 General. Wherever a salt tank is utilized for internal quenching in an internal quench furnace, the requirements of Section 16-7 shall apply in addition to the requirements of Chapter 16. Chapter 16 covers all three types of furnaces shown in Figure 16-7.1 and listed as follows.

(1) *Type SI.* Dunk-type elevator quench.
(2) *Type SII.* Dunk-type elevator quench with under-salt transfer.
(3) *Type SIII.* Bottom chute–type quench.

16-7.2 Safety Control Equipment — Type SI and Type SII.

16-7.2.1* The composition of the atmosphere in the furnace shall be controlled and monitored by a reliable means to prevent free carbon originating in the furnace atmosphere from being transferred into the quench tank.

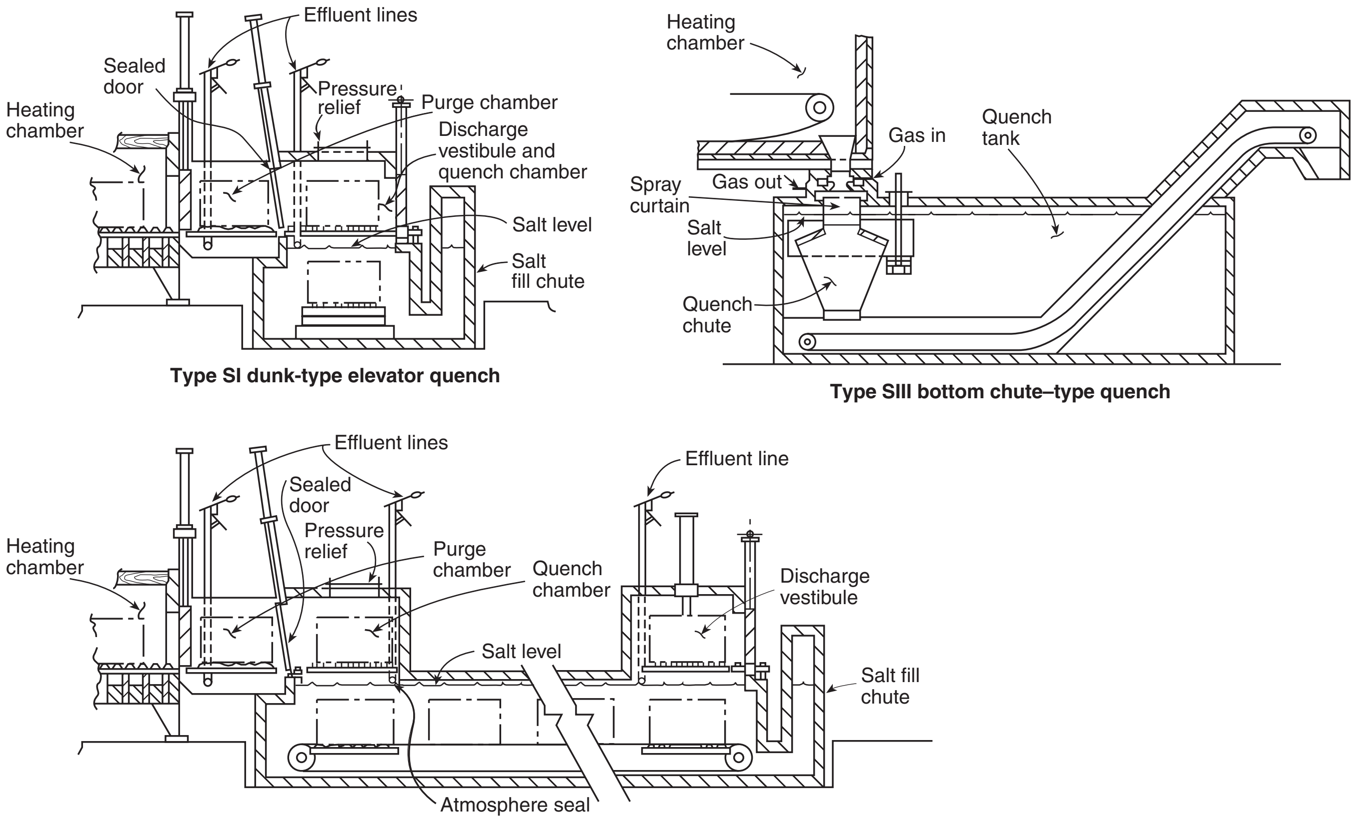
16-7.2.2 Adequate circulation shall be provided to ensure that the maximum temperature of the salt in contact with the hot work is below the decomposition temperature of the salt as specified by the salt manufacturer by a minimum of 200°F (111°C).

16-7.2.3 A means shall be provided to ensure that salt cannot enter the heating chamber by capillary action on the side wall of the chute or tank.

16-7.2.4 Condensation and freezing of the salt at the atmosphere interface shall be prevented by the following:

(1) Insulating or heating the salt fill to maintain a temperature above the freezing point of the salt *(see Figure 16-7.1)*
(2) Insulating the vestibule to maintain the temperature above the freezing point of the salt. *(see Figure 16-7.1)*

Figure 16-7.1 Examples of integral quench tanks.



Type SI dunk-type elevator quench

Type SIII bottom chute–type quench

Type SII dunk-type elevator quench with under-salt transfer

16-7.2.5 The design shall be such that horizontal shelves or ledges are minimized to prevent carbon, salt, or particulates from accumulating.

16-7.2.6 Each transfer chamber and discharge vestibule shall be provided with a separate atmosphere vent(s). The vent(s) shall be located so that the operators are not exposed to injury when pressure relief takes place. A pilot shall be provided at the vent outlets to ignite vented gases.

16-7.2.7 In addition to the vent(s) required in 16-7.2.6, a pressure-relief device shall be provided for the quench chamber in order to do both of the following:

(1) Keep the internal pressure from exceeding the design limits of the equipment
(2) Prevent salt overflow from the fill chute

16-7.2.8 The fill chute shall have sufficient freeboard to prevent salt overflow at peak vestibule pressure.

16-7.3 Safety Control Equipment — Type SIII.

16-7.3.1* The composition of the atmosphere in the furnace shall be controlled and monitored by a reliable means to prevent free carbon originating in the furnace atmosphere from being transferred into the quench tank.

16-7.3.2 Adequate circulation shall be provided to ensure that the maximum temperature of the salt in contact with the hot work is below the decomposition temperature of the salt as specified by the salt manufacturer by a minimum of 200°F (111°C).

16-7.3.3 Circulation of the liquid in the chute shall be provided to ensure that the salt does not become stagnant at the liquid surface.

16-7.3.4 A means shall be provided to ensure that salt cannot enter the heating chamber by capillary action on the side wall of the chute or tank.

16-7.3.5 Condensation and freezing of the salt at the liquid surface shall be prevented by heating or insulating the quench chute and salt fill to maintain a temperature above the freezing point of the salt.

16-7.3.6 The design shall be such that horizontal shelves or ledges are minimized to prevent carbon, salts, or particulates from accumulating.

16-7.4 High Temperature Salt Bath Quench Tanks. Salt bath quench tanks that operate between 700°F and 1300°F (371°C and 704°C) shall utilize salts, or salt mixtures, that are chemically and physically stable at the operating temperatures and are nonreactive to the furnace atmospheres.

16-7.5 Low Temperature Salt Quench Tanks. Salt quench tanks operating at 350°F to 750°F (177°C to 399°C), and utilizing a combination of sodium or potassium nitrites and nitrates in conjunction with a combustible atmosphere above all or part of the salt quench surface, shall be designed to provide adequate circulation of salt in the area in which hot parts enter to prevent temperature rise on the surface of the salt.

16-8 Cooling. Internal water-cooled coils and jackets shall not be used. The salt bath shall be cooled by natural means (i.e., direct radiation and conduction to the ambient surroundings). If these means are insufficient to maintain operating temperatures, then forced cooling shall be promoted by several proven means, using air as the cooling medium.

16-9* Operator Precautions.

16-9.1 Each molten salt bath operator shall be trained thoroughly, as specified in Section 1-5. Only trained, qualified operators shall be permitted to operate or service molten salt bath furnaces.

16-9.2 Each molten salt bath installation shall be furnished with a prominently displayed wall chart, which shall be supplied by the salt manufacturer. This wall chart shall state which salt or salt mixtures shall be used and shall identify the maximum design operating temperature.

16-9.3 A complete operation and service manual shall be available at each salt bath furnace, and the operator shall have access to the operation manual at all times.

16-9.4 Since emergency procedures are not utilized on a daily basis, all emergency procedures shall be reviewed with the operators on a regular schedule.

16-10 Precautions.

16-10.1 All items such as fixtures, tools, baskets, and parts that are to be immersed in a molten salt bath shall be made of solid bar materials and shall be completely dry.

16-10.2* No attempt shall be made to break freezing crust manually while the furnace is in operation. Instead, the temperature of the bath shall be raised gradually until the crust melts. The bath temperature shall not exceed the maximum design operating temperature at any time.

16-10.3 All salt bath covers shall be in the closed position whenever the equipment is not in use or is being idled over prolonged periods.

16-10.4 All public fire department and plant emergency organizations that respond to fires and explosions within the plant shall be familiar with the nature of the chemical salts being used, the location and operation of each molten salt bath, and the extinguishing and control methods that can be employed safely.

Chapter 17 Inspection, Testing, and Maintenance

17-1* Responsibility of the Manufacturer and the User. The equipment manufacturer shall inform the user regarding the need for adequate operational checks and maintenance and shall provide complete and clear inspection, testing, and maintenance instructions. The final responsibility for establishing an inspection, testing, and maintenance program that ensures that the equipment is in proper working order shall be that of the user.

17-2* Equipment Entry. The user's operational and maintenance program shall include procedures that apply to the proper entry of the specific equipment.

17-3* Checklist. The user's operational and maintenance program shall include all procedures that apply to the specific equipment. An operational maintenance checklist shall be maintained and is essential to safe operation of the equipment.

Chapter 18 Fire Protection

18-1 Sprinklers, Water Spray, and Special Extinguishing Systems.

18-1.1 General. Furnaces can present fire hazards to the surrounding area in which they are installed. Fixed fire extinguishing systems shall be provided to protect against such hazards as overheating, spillage of molten salts or metals, quench tanks, ignition of hydraulic oil, and escape of fuel. This chapter is not intended to specify the design of fire protection systems or cover all fire hazards. It shall be the responsibility of the user to consult with the authority having jurisdiction concerning the necessary requirements for such protection as outlined elsewhere in this chapter.

Exception: The integral furnace quench vestibule shall not be required to be equipped with a fixed extinguishing system.

18-1.2 Subject to the authority having jurisdiction, one or more of the following protection features shall be implemented.

(a) *Sprinklers.* Roof-level automatic sprinkler protection installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

(b) *Hoods.* Automatic sprinkler protection provided under all hoods in areas having roof-level sprinkler protection. Sprinklers under these hoods shall be of extra high–temperature rating [325°F to 650°F (163°C to 343°C)] to avoid premature operation from localized flashing.

(c) *Water Spray.* Automatic water spray systems in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* to protect the quench oil tank(s) and the surrounding areas.

(d) *Carbon Dioxide.* Automatic carbon dioxide protection systems in accordance with NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems.*

(e) **Dry Chemical.* Automatic dry chemical systems in accordance with NFPA 17, *Standard for Dry Chemical Extinguishing Systems.*

(f) *Automatic-Closing Process Tank Covers.* Automatic-closing process tank covers for open tanks under 150 gal (570 L) in capacity or 10 ft^2 (1 m^2) in liquid surface area. Automatic-closing process tank covers shall be actuated by approved automatic devices and also shall be arranged for manual operation.

18-1.3 Fixed-temperature actuation devices for automatic carbon dioxide or dry chemical systems shall be rated at least one temperature rating lower than the temperature rating of the water sprinklers over the quench tank.

18-2 Portable Protection Equipment.

18-2.1 Extinguishers. Approved portable extinguishing equipment shall be provided near the furnace and related equipment. Such installations shall be in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

18-2.2 Inside Hose Connections. Where small hose streams are required, they shall be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems,* or NFPA 14, *Standard for the Installation of Standpipe and Hose Systems.*

Chapter 19 Referenced Publications

19-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix D.

19-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers,* 1998 edition.
NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 1998 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1999 edition.
NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 1996 edition.
NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 1996 edition.
NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 1998 edition.
NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.
NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 1997 edition.
NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites,* 1996 edition.
NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites,* 1999 edition.
NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites,* 1999 edition.
NFPA 54, *National Fuel Gas Code,* 1999 edition.
NFPA 58, *Liquefied Petroleum Gas Code,* 1998 edition.
NFPA 70, *National Electrical Code®,* 1999 edition.
NFPA 79, *Electrical Standard for Industrial Machinery,* 1997 edition.
NFPA 86, *Standard for Ovens and Furnaces,* 1999 edition.
NFPA 86D, *Standard for Industrial Furnaces Using Vacuum as an Atmosphere,* 1999 edition.
NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 1999 edition.

19-1.2 Other Publications.

19-1.2.1 ANSI Publication. American National Standards Institute, Inc., 11 West 42nd Street, 13th floor, New York, NY 10036.

ANSI A14.3, *Safety Requirements for Fixed Ladders,* 1992.

19-1.2.2 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME *Boiler and Pressure Vessel Code,* 1998.
ASME B31.1, *Power Piping,* 1995.
ASME B31.3, *Process Piping,* 1996.

19-1.2.3 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 396, *Standard Specifications for Fuel Oils,* 1998.

19-1.2.4 U.S. Government Publication. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Code of Federal Regulations, Title 29, Parts 1910.24 through 1910.29, 1998.

Appendix A Explanatory Material

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

A-1-3.2 Because this standard is based on the present state of the art, application to existing installations is not mandatory. Nevertheless, users are encouraged to adopt those features of this standard that are considered applicable and reasonable for existing installations.

A-1-4 Section 1-4 includes requirements for complete plans, sequence of operations, and specifications to be submitted to the authority having jurisdiction for approval. Application forms such as those in Figure A-1-4(a) and (b) can be used or might be requested to help the authority having jurisdiction in this approval process. (Variations of the forms can depend on the type of furnace or oven being furnished, its application, and the authority having jurisdiction.) Figures A-1-4(a) and (b) are two historical examples of application forms that are based on older editions of the standard. Forms consistent with current requirements should be used.

Figure A-1-4(a) Sample 1: furnace or oven manufacturer's application for acceptance.

SHEET 1 OF 2

MFR'S. JOB OR CONTRACT NO.	DATE

PART A — PLANS

NAME OF CUSTOMER (name of owner)		
ADDRESS (St. & No.)	CITY	STATE
NAME OF MANUFACTURER		
ADDRESS (St. & No.)	CITY	STATE
DRAWINGS SUBMITTED, NOS.		NO. OF SETS

INSTALLA-TION	TYPE	BATCH ☐	CONTINUOUS ☐	
	CONSISTS OF			
RATED HEAT INPUT	BTU/HR	☐ GAS BTU/FT^3	☐ FUEL OIL NO. GAL/HR	☐ ELECTRIC KW
SIZE (EXTERNAL IN FT)	LENGTH	WIDTH	HEIGHT	OPERATING TEMP. °F
LOCATION OF EQUIPMENT	BLDG. NO. OR NAME		NO. OF FLOOR OR STORY	
FUEL SHUTOFF	ACCESSIBLE IN EVENT OF FIRE YES ☐ NO ☐	SEPARATE EXCESS TEMPERATURE LIMIT SWITCH SHUTS OFF HEAT YES ☐ NO ☐	SET FOR °F	
FIRE PROTECTION OF OIL QUENCH TANK	☐ NONE ☐ AUTOMATIC SPRINKLERS	☐ OPEN SPRINKLERS	☐ AUTOMATIC WATER SPRAY	☐ AUTOMATIC FIXED FOAM
	☐ IF OTHER, DESCRIBE			
TYPE OF WORK	HEAT TREATING METALS ☐ WITH SPECIAL FLAMMABLE ATMOSPHERE		☐ WITH SPECIAL INERT ATMOSPHERE	
	IF OTHER, DESCRIBE			
HEATING ARRANGE-MENT	☐ INTERNAL DIRECT-FIRED NONRECIRCULATING	☐ INTERNAL DIRECT-FIRED RECIRCULATING	☐ EXTERNAL DIRECT-FIRED RECIRCULATING	☐ EXTERNAL INDIRECT-FIRED
	☐ IF OTHER, DESCRIBE	MUFFLE YES ☐ NO ☐	RADIANT TUBES YES ☐ NO ☐	
	TYPE OF ELECTRIC HEATING ELEMENTS AND LOCATION			
	NO. OF MAIN BURNERS		NO. OF PILOT BURNERS	
METHOD OF LIGHTING–OFF	☐ PORTABLE TORCH ☐ FIXED	☐ PILOT	☐ OIL ☐ GAS	☐ SPARK IGNITOR
METHOD OF FIRING	☐ HI–LOW	☐ MODULATING	☐ ON–OFF	☐ CONTINUOUS

MIXER TYPE	☐ GAS	NO. OF MAIN BURNER INSPIRATORS	☐ ZERO-GOVERNOR TYPE	☐ ATMOSPHERIC INSPIRATOR	☐ HIGH PRESSURE 1.0 PSIG OR OVER	☐ LOW PRESSURE	☐ OTHER
		NO. OF PILOT INSPIRATORS	☐ ZERO-GOVERNOR TYPE	☐ ATMOSPHERIC INSPIRATOR	☐ HIGH PRESSURE 1.0 PSIG OR OVER	☐ LOW PRESSURE	☐ OTHER
	☐ OIL	☐ AIR (16–32 OZ) ATOMIZING		☐ ROSS OR DRY SYSTEM AIR ATOMIZING			☐ OTHER
	IF OTHER, DESCRIBE (MFR. & TYPE)						

Printed in U.S.A.

Figure A-1-4(a) ***(Continued)***

SHEET 2 OF 2

PROTECTION AGAINST FUEL EXPLOSION

LIGHTING-OFF

OPENINGS INTO ROOM ☐ TOP ☐ BOTTOM

NO FUEL & IGNITION UNTIL: ☐ TIMED PREVENTILATION BY EXH. & RECIRCULATING FANS | TIMER SETTING ___ MIN. | ☐ DOORS WIDE OPEN | ☐ BURNER (F.M.) COCKS CLOSED | ☐ MEANS PROVIDED FOR CHECK OF MAIN SAFETY SHUTOFF VALVE TIGHTNESS

PILOT-FLAME ESTABLISHING PERIOD AUTOMATICALLY LIMITED ☐ YES ☐ NO ___ SEC. | TRIAL-FOR-IGNITION PERIOD AUTOMATICALLY LIMITED ☐ YES ☐ NO ___ SEC. | OIL TEMP. INTERLOCK ☐ YES ☐ NO SET FOR ___ °F | PROVED LOW-FIRE INTERLOCK ☐ YES ☐ NO

MFR. & TYPE NO. OF F.M. COCKS AND TIMER | ☐ COMB. AIR BLOWER CANNOT BE STARTED UNTIL END OF PREVENT. (IF TIMER USED) | ☐ COMB. SAFEGUARD PROVES PILOT BEFORE MAIN SAFETY SHUTOFF VALVE OPENS

FIRING

HEAT CUTOFF AUTOMATICALLY, REQUIRING MANUAL OPERATION TO RESTORE, ON FAILURE OF ☐ COMBUSTION AIR ☐ RECIRCULATING FAN ☐ EXHAUST FAN ☐ FUEL PRESSURE ☐ FLAME (combustion safeguard)

☐ ROD OR SCANNER LOCATION ENSURES PILOT IGNITES MAIN FLAME | MANDATORY PURGE AFTER FLAME FAILURE ☐ YES ☐ NO

MFR. & TYPE N0.

MAIN SAFETY SHUTOFF VALVE ___ IPS. ___ IN. | PILOT SAFETY SHUTOFF VALVE ___ IPS. ___ IN.

COMBUSTION SAFEGUARD | PRESSURE SWITCHES | AUTOMATIC FIRE CHECKS

PROTECTION AGAINST SPECIAL ATMOSPHERE EXPLOSION

ATMOSPHERE FIRST TURNED ON INTO: ☐ HEATED WORK SECTION ☐ COOLING SECTION

IF COOLING SECTION, EXPLAIN HOW HAZARD AVOIDED

TEMPERATURE OF THIS SECTION WHEN ATMOSPHERE TURNED ON ___ °F | SHUTOFF ___ °F | ☐ ATMOSPHERE INTERLOCKED WITH FURNACE TEMPERATURE CONTROLLER

PRECAUTIONS WHEN TURNING ON AND SHUTTING OFF ATMOSPHERE ☐ INERT GAS PURGE ☐ BURN-OUT ☐ NO IGNITION SOURCE WHILE FURNACE ATMOSPHERE EXPLOSIVE

IF LATTER CASE, CHECK FOR NONEXPLOSIVE ATMOSPHERE IS BY ☐ GAS ANALYZER ☐ BURNING TEST SAMPLE ☐ TIME–VOLUME MEASURE ☐ NONE

SPECIAL ATMOSPHERE GENERATOR

MANUFACTURER AND TYPE | ☐ ATMOSPHERE GENERATOR OUTPUT VENTED TO OUTDOORS UNTIL GENERATOR BURNER STABLE

ALARM AND AUTOMATIC LOCKOUT OF FUEL & COMBUSTION AIR IF FAILURE OF: ☐ FUEL ☐ COMBUSTION AIR ☐ POWER ☐ FLAME ☐ ATMOSPHERE TEMPERATURE AT GENERATOR

MFR. & TYPE NO.

SAFETY SHUTOFF VALVES | PRESSURE SWITCHES

TEMPERATURE SWITCHES | COMBUSTION SAFEGUARDS

PART A ACCEPTED BY ☐ AS SUBMITTED ☐ SUBJECT TO ANY CHANGES INDICATED | DATE

PART B — MANUFACTURER'S INSPECTION & TEST (completed installation)

BURNERS: ☐ LIGHTED ☐ MIXERS ADJUSTED ☐ TEMP. CONTROL SET ☐ ADJ. FOR STABLE LOW FLAME

SAFETY CONTROLS: ☐ ADJUSTED ☐ TESTED FOR PROPER RESPONSE

INSTRUCTIONS: ☐ CUSTOMER'S OPERATOR INSTRUCTED ☐ PRINTED OPERATING INSTRUCTIONS LEFT ☐ APPLICATION FOR ACCEPTANCE POSTED ON CONTROL PANEL

SIGNATURES: MFRS. FIELD REP. | TEST WITNESSED BY ___ FOR CUSTOMER | DATE

PART B ACCEPTED BY ☐ AS SUBMITTED ☐ SUBJECT TO ANY CHANGES INDICATED | DATE

PART C — FIELD EXAMINATION OF COMPLETED INSTALLATION

☐ PART A CHECKED ☐ PART B CHECKED ☐ SAFETY CONTROLS TESTED ☐ ROD OR SCANNER LOCATION ASSURES PILOT IGNITES MAIN FLAME

INSTALLATION ACCEPTABLE BY | DATE

Printed in U. S. A.

Figure A-1-4(b) Sample 2: furnace or oven manufacturer's application for acceptance.

SHEET 1 of 2

MFR'S. JOB OR CONTRACT NO.	DATE

PART A — PLANS

NAME & ADDRESS OF CUSTOMER (OWNER)	NAME & ADDRESS OF MANUFACTURER
DRAWINGS SUBMITTED, NOS.	NO. OF SETS

INSTALLATION	ERECTION & ADJUSTMENTS (SEE PART B) BY: MANUFACTURER / CUSTOMER — IF OTHER, DESCRIBE SAFETY VENTILATION AIR FLOW TESTS (SEE PART B) TO BE MADE AFTER ERECTION BY: MANUFACTURER / CUSTOMER — IF OTHER, DESCRIBE TYPE: BATCH / CONTINUOUS — TYPE NO. OR OTHER INFORMATION
CON-STRUCTION	SHEET STEEL ON STEEL FRAME NONCOMBUSTIBLE INSULATION — IF OTHER, DESCRIBE
RATED HEAT INPUT	GAS ___ BTU/HR — FUEL OIL NO. ___ GAL/HR — ELECTRIC ___ KW — STEAM ___ PRESS, psig
SIZE	LENGTH (External) ___ FT — WIDTH (External) ___ FT — HEIGHT (External) ___ FT — VOLUME (Internal) ___ FT^3 — OPERATING TEMP. ___ °F
LOCATION OF EQUIPMENT	BLDG. NO. OR NAME — BUILDING FLOOR CONSTRUCTION AND NO. OF FLOOR OR STORY AIR SPACE BETWEEN OVEN & WOOD FLOOR ___ IN. — IF OTHER, DESCRIBE AIR SPACE BETWEEN STACKS, DUCTS, & WOOD BLDG. CONST. ___ IN. — IF OTHER, DESCRIBE EXHAUST STACKS — DIAM. OR SIZE ___ IN. — METAL GAUGE (USS) — INSULATED — NO. OF CLEANOUT (ACCESS) DOORS
EXPLOSION VENTING AREA	OPEN ENDS ___ FT^2 — LOOSE ROOF PANELS ___ FT^2 — ACCESS DOORS WITH EXPLOSION LATCHES ___ FT^2 MANUFACTURER AND TYPE LATCH — TOTAL AREA ___ FT^2 — VENT RATIO $\frac{\text{VENT AREA}}{\text{INTERNAL VOLUME}} =$
FUEL SHUTOFF	ACCESSIBLE IN EVENT OF FIRE: YES / NO
FIRE PROTECTION IN OVEN	NONE / AUTOMATIC SPRINKLERS / OPEN SPRINKLERS / CO_2 / STEAM — DRAWINGS SUBMITTED: YES / NO OTHER (DESCRIBE) — SEPARATE EXCESS TEMPERATURE LIMIT SWITCH WITH MANUAL RESET — SET FOR ___ °F
FIRE PROTECTION FOR DIP TANK & DRAINBOARD	DRAWINGS SUBMITTED: YES / NO — FIXED AUTO. CO_2: YES / NO — OTHER (DESCRIBE) OVERFLOW VALVES: YES / NO — DUMP VALVES: YES / NO — SALVAGE TANK: YES / NO — IS HEAT SHUTOFF AUTOMATICALLY ON FAILURE OF CONVEYOR: YES / NO
TYPE OF WORK	IMPREGNATED-COATED ABSORBENT MATERIAL: PAPER / CLOTH — LITHOGRAPH COATING — VARNISH ELECT. COILS — GRAVURE PRESS — FOOD BAKING — CORES OR MOLDS METAL: DIPPED / FLOW-COATED / SPRAYED — OTHER (DESCRIBE)
SOLVENTS EN-TERING OVEN	NAME OF SOLVENT USED — LENGTH OF BAKE ___ MIN. — MAX. SOLVENT FOR WHICH OVEN DESIGNED: CONTINUOUS ___ GAL/HR — BATCH ___ GAL/BATCH
DESIGNED SAFETY VENTILATION	ARRANGEMENT: SEPARATE CENTRI-FUGAL EXHAUSTER / RECIRCULATING FAN WITH SPILL / NATURAL DRAFT STACK / OPENINGS INTO ROOM — FILTERS ON FRESH AIR INTAKE: YES / NO FRESH AIR ADMITTED INTO OVEN CFM REFERRED TO 70° F — OPENING WITH DAMPER CLOSED: FRESH AIR INLET ___ % EXHAUST OUTLET ___ % — DOES CONVEYOR STOP AUTOMATICALLY ON FAILURE OF SAFETY EXHAUST FANS: YES / NO FAN MFR. SIZE, TYPE — WHEEL DESIGN (BLADE TIP): RADIAL TIP / BACKWARD INCLINED / FORWARD CURVED — DIAM. ___ IN. — TIP SPEED ___ FT/MIN

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Figure A-1-4(b) ***(Continued)***

SHEET 2 OF 2

HEATING ARRANGE-MENT	☐ INTERNAL DIRECT-FIRED NONRECIRCULATING ☐ INTERNAL DIRECT-FIRED RECIRCULATING ☐ EXTERNAL DIRECT-FIRED RECIRCULATING ☐ EXTERNAL INDIRECT-FIRED
	☐ OTHER (DESCRIBE)
	TYPE OF ELECTRIC HEATING ELEMENTS AND LOCATION
	NO. OF MAIN BURNERS / NO. OF PILOT BURNERS / CAN DRIPPINGS OFF WORK FALL ON HEATING ELEMENTS ☐ YES ☐ NO
METHOD OF LIGHTING–OFF	☐ PORTABLE TORCH ☐ FIXED ☐ PILOT ☐ OIL ☐ GAS ☐ SPARK IGNITOR
METHOD OF FIRING	☐ HI–LOW ON–OFF ☐ ☐ MODULATING CONTINUOUS ☐ ☐ AUTOMATIC-LIGHTED MANUAL-LIGHTED ☐ ☐ SEMI-AUTOMATIC-LIGHTED
	TYPE OF PILOT ☐ CONTINUOUS ☐ INTERRUPTED ☐ INTERMITTENT ☐ OTHER (DESCRIBE)
MIXER TYPE	☐ GAS — NO. MAIN BURNER INSPIRATORS ☐ ZERO-GOVERNOR TYPE ☐ ATMOSPHERIC INSPIRATOR ☐ HIGH PRESSURE ☐ LOW PRESSURE
	NO. PILOT INSPIRATORS ☐ ZERO-GOVERNOR TYPE ☐ ATMOSPHERIC INSPIRATOR ☐ HIGH PRESSURE ☐ LOW PRESSURE
	☐ OIL ☐ AIR (16–32 OZ) ATOMIZING
	☐ OTHER — OTHER TYPE MIXERS OR OIL BURNERS INCLUDING PILOTS (MFR. & TYPE)
PROTECTION AGAINST FUEL EXPLOSION — LIGHTING-OFF	NO FUEL AND IGNITION UNTIL: ☐ TIMED PREVENTILATION BY EXHAUST AND RECIRC. FANS / TIMER SETTING MIN. / ☐ DOORS WIDE OPEN / ☐ BURNER (F.M.) COCKS CLOSED / ☐ MEANS PROVIDED FOR CHECK OF MAIN SAFETY SHUTOFF VALVE TIGHTNESS
	PILOT-FLAME-ESTABLISHING PERIOD AUTOMATICALLY LIMITED ☐ YES ☐ NO SEC. / TRIAL-FOR-IGNITION PERIOD AUTOMATICALLY LIMITED ☐ YES ☐ NO SEC. / OIL TEMP. INTERLOCK ☐ YES ☐ NO SET FOR °F / PROVED LOW-FIRE INTERLOCK ☐ YES ☐ NO
	MFR. AND TYPE NO. OF F.M. COCKS & TIMER / ☐ COMBUSTION AIR BLOWER CANNOT BE STARTED UNTIL END OF PREVENT. (IF TIMER USED) / ☐ COMBUSTION SAFEGUARD PROVES PILOT BEFORE MAIN SAFETY SHUTOFF VALVE OPENS
FIRING	HEAT CUTOFF AUTOMATICALLY, REQUIRING MANUAL OPERATION TO RESTORE, ON FAILURE OF ☐ COMBUSTION AIR ☐ RECIRCULATING FAN ☐ SAFETY EXHAUST FAN ☐ HIGH AND LOW GAS PRESSURE ☐ LOW OIL PRESSURE ☐ FLAME (Combustion Safeguard)
	☐ ROD OR SCANNER LOCATION ENSURES PILOT IGNITES MAIN FLAME / MANDATORY PURGE AFTER FLAME FAILURE ☐ YES ☐ NO
MANU-FACTURER & TYPE NO.	MAIN SAFETY SHUTOFF VALVE IPS. IN. / PILOT SAFETY SHUTOFF VALVE IPS. IN.
	COMBUSTION SAFEGUARD / PRESSURE SWITCHES / AIRFLOW SWITCHES
PART A ACCEPTED	☐ AS SUBMITTED ☐ SUBJECT TO ANY CHANGES INDICATED / DATE / BY

PART B — MANUFACTURER'S INSPECTION & TEST

SAFETY VENTILATION	CFM REF. TO 70° F / MEASURED BY (SPECIFY) ☐ PITOT ☐ OTHER / MEASURED WITH FRESH AIR INLET & EXHAUST OUTLET DAMPERS IN MAXIMUM CLOSED POSITION ☐ YES ☐ NO
BURNERS	☐ LIGHTED ☐ MIXERS ADJUSTED ☐ TEMP. CONTROL SET ☐ ADJ. FOR STABLE LOW FLAME
SAFETY CONTROLS	☐ ADJUSTED ☐ TESTED FOR PROPER RESPONSE
INSTRUCTIONS	☐ CUSTOMER'S OPERATOR INSTRUCTED ☐ PRINTED OPERATING INSTRUCTIONS LEFT ☐ APPLICATION FOR ACCEPTANCE POSTED ON CONTROL PANEL
SIGNATURES	MFR'S. FIELD REP. / TEST WITNESSED BY FOR CUSTOMER / DATE
PART B ACCEPTED	☐ AS SUBMITTED ☐ SUBJECT TO ANY CHANGES INDICATED / DATE / BY

PART C — FIELD EXAMINATION OF COMPLETED INSTALLATION

☐ PART A CHECKED	☐ PART B CHECKED	☐ SAFETY CONTROLS TESTED	☐ ROD OR SCANNER LOCATION ASSURES PILOT IGNITES MAIN FLAME
ENGINEER'S SIGNATURE			DATE

A-1-4.3.1 The proximity of electrical equipment and flammable gas or liquid in an electrical enclosure or panel is a known risk and would be considered a classified area. Article 500 of NFPA 70, *National Electrical Code*®, should be consulted.

Conduit connecting devices handling flammable material might carry this material to an electrical enclosure if the device fails, creating a classified area in that enclosure. Sealing of such conduits should be considered.

A-1-4.3.3 Unless otherwise required by the local environment, ovens and furnaces and the surrounding area are not classified as a hazardous (classified) location. The primary source of ignition associated with an oven installation is the oven heating system or equipment or materials heated. The presence of these ignition sources precludes the need for imposing requirements for wiring methods appropriate for a hazardous (classified) location. Refer to Section 3-3 of 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*, and Section 3-3 of NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, regarding equipment with open flames or other ignition sources. In addition, ovens or furnaces are considered unclassified internally because safety depends upon ventilation.

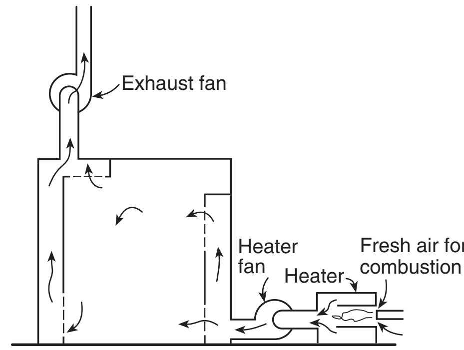
A-2-1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-2-1 Authority Having Jurisdiction. The phrase "authority having jurisdiction" 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-2-1 Heating System, Direct-Fired. The following are different types of direct-fired heating systems.

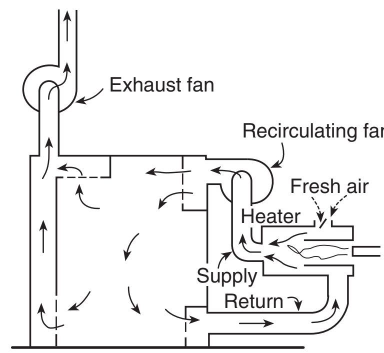
Heater: Direct-Fired, External, Nonrecirculating. A direct-fired, external heater arranged so that products of combustion are discharged into the oven chamber without any return or recirculation from the oven chamber. *[See Figure A-2-1(a).]*

Figure A-2-1(a) Example of a direct-fired, external, nonrecirculating heater.



Heater: Direct-Fired, External, Recirculating-Through. A direct-fired, external heater arranged so that oven atmosphere is recirculated to the oven heater and is in contact with the burner flame. *[See Figure A-2-1(b).]*

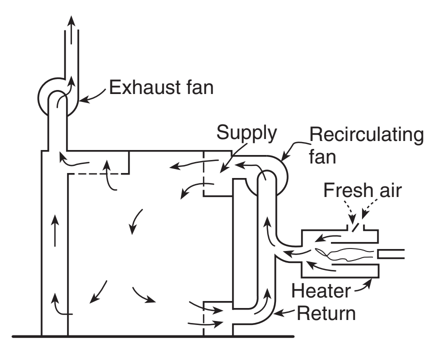
Figure A-2-1(b) Example of a direct-fired, external, recirculating-through heater.



Heater: Direct-Fired, Internal, Nonrecirculating. A combustion chamber of a recirculating oven heater that may be permitted to be built within an oven chamber not substantially separated from the oven atmosphere by gastight construction.

Heater: Direct-Fired, External, Recirculating-Not-Through. A heating system constructed so that the oven atmosphere circulates through a blower with products of combustion admitted to the recirculating ductwork, but without the oven atmosphere actually passing through the combustion chamber. *[See Figure A-2-1(c).]*

Figure A-2-1(c) Example of a direct-fired, external, recirculating-not-through heater.



A-2-1 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-2-1 Pump, Roughing. The roughing pump also can be used as the backing (fore) pump for the diffusion pump, or the roughing pump can be shut off and a smaller pump can be used as the backing (fore) pump where the gas load is relatively small.

A-2-1 Range, Explosive. See NFPA 325, *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*

A-3-1.1.4 For additional information, refer to NFPA 31, *Standard for the Installation of Oil-Burning Equipment;* NFPA 54, *National Fuel Gas Code;* and NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

A-3-1.3.3 The hazard is particularly severe where vapors from dipping operations could flow by means of gravity to ignition sources at or near floor level.

See NFPA 30, *Flammable and Combustible Liquids Code;* NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials;* and NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids.*

A-3-1.4.2 The following procedure should be followed if the furnace is located in contact with a wood floor or other combustible floor and the operating temperature is above 160°F (71°C).

Combustible floor members should be removed and replaced with a monolithic concrete slab that extends a minimum of 3 ft (1 m) beyond the outer extremities of the furnace.

Air channels, either naturally or mechanically ventilated, should be provided between the floor and the equipment (perpendicular to the axis of the equipment or noncombustible insulation, or both). This should be adequate to prevent surface temperatures of floor members from exceeding 160°F (71°C).

A-3-2.12 Fuel-fired or electric heaters should not be located directly under the product being heated where combustible materials could drop and accumulate. Neither should they be located directly over readily ignitible materials such as cotton unless for a controlled exposure period, as in continuous processes where additional automatic provisions or arrangements of guard baffles, or both, preclude the possibility of ignition.

A-3-3.1 For additional information regarding relief of equipment and buildings housing the equipment, see NFPA 68, *Guide for Venting of Deflagrations.*

A-3-3.4 The location for explosion relief is a critical concern and needs to be close to the ignition source.

The heater box is part of the oven system and needs to have explosion relief provided. Personnel considerations and proximity to other obstructions can impact the location selected for these vents.

A-3-3.6 Industry experience indicates that a typical oven enclosure built to withstand a minimum of 0.5 psig (3.45 kPa) surge overpressure with explosion-relief panels having a maximum weight per area of 5 lb/ft^2 (24.4 kg/m^2) meets the requirements of 3-3.6.

A-3-3.7 The intent of providing explosion relief in furnaces is to limit damage to the furnace and to reduce the risk of personnel injury due to explosions. To achieve this, relief panels and doors should be sized so that their inertia does not preclude their ability to relieve internal explosion pressures.

A-3-4 For additional information, refer to NFPA 31, *Standard for the Installation of Oil-Burning Equipment;* NFPA 54, *National Fuel Gas Code;* and NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

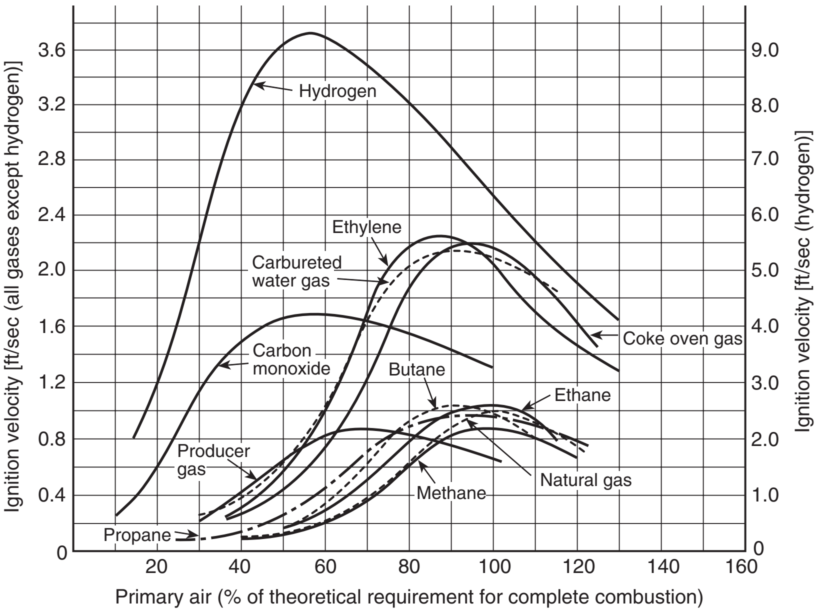
A-3-4.3.4 Ducts that pass through fire walls should be avoided.

A-3-4.3.8 All interior laps in the duct joints should be made in the direction of the flow.

A-4-2.1.1 The term *ignition temperature* means the lowest temperature at which a gas–air mixture can ignite and continue to burn. This is also referred to as the *autoignition temperature.* Where burners supplied with a gas–air mixture in the flammable range are heated above the autoignition temperature, flashbacks can occur. In general, such temperatures range from 870°F to 1300°F (465°C to 704°C). A much higher temperature is needed to ignite gas dependably. The necessary temperature is slightly higher for natural gas than for manufactured gases, but for safety with manufactured gases, a temperature of about 1200°F (649°C) is needed, and for natural gas, a temperature of about 1400°F (760°C) is needed. Additional safety considerations should be given to dirt-laden gases, sulfur-laden gases, high-hydrogen gases, and low-Btu waste gases.

Flame Propagation and Explosive Range. The term *rate of flame propagation* means the speed at which a flame progresses through a combustible gas–air mixture under the pressure, temperature, and mixture conditions existing in the combustion space, burner, or piping under consideration. *(See Figure A-4-2.1.1 and Table A-4-2.1.1.)*

Figure A-4-2.1.1 Ignition velocity curves for typical flammable gases.



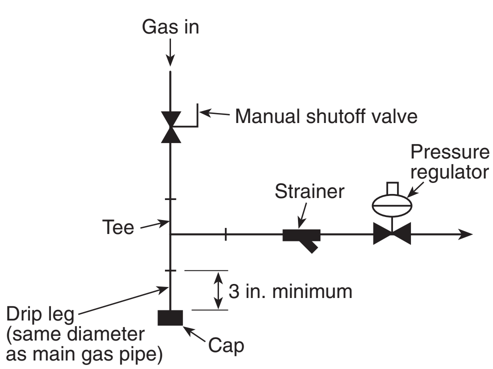
A-4-2.2 For additional information, refer to NFPA 54, *National Fuel Gas Code*.

A-4-2.4.3 Whenever the fuel train is opened for service, the risk of dirt entry exists. It is not required that existing piping be opened for the sole purpose of the addition of a filter or strainer.

A-4-2.4.4 A typical piping arrangement for a drip leg or sediment trap and gas filter or strainer is shown in Figure A-4-2.4.4.

A-4-2.6.1 In the design, fabrication, and utilization of mixture piping, it should be recognized that the air–fuel gas mixture might be in the flammable range.

Figure A-4-2.4.4 Typical piping arrangement for a drip leg and strainer.



A-4-2.6.3.1 Two basic methods generally are used. One uses a separate fire check at each burner, the other a fire check at each group of burners. The second method generally is more practical if a system consists of many closely spaced burners.

A-4-2.6.3.3 Acceptable safety blowouts are available from some manufacturers of air–fuel mixing machines. They incorporate all the following components and design features:

(1) Flame arrester
(2) Blowout disk
(3) Provision for automatically shutting off the supply of air–gas mixture to the burners in the event of a flashback passing through an automatic fire check

A-4-2.7.4 Testing of radiant tubes should include subjecting them to thermal cycling typical for the furnace application and then verifying their ability to withstand overpressure developed by a fuel–air explosion. Overpressure testing can be done in one of the following two ways.

(a) Statically pressurize the tube until it fails. Compare this pressure to the maximum pressure (from literature) that can be developed in a contained deflagration of an optimum fuel–air mixture.

(b) After partially blocking the open end of the tube to simulate a heat exchanger, fill the tube with a well-mixed stoichiometric fuel–air mixture (10 volumes of air to one volume of fuel for natural gas). Ignite the mixture at the closed end of the tube. Measure the pressure developed. Compare this pressure to the maximum pressure (from literature) that can be developed in a contained deflagration of an optimum fuel–air mixture.

A-4-2.8.1 A burner is suitably ignited when combustion of the air–fuel mixture is established and stable at the discharge port(s) of the nozzle(s) or in the contiguous combustion tunnel.

A-4-3.1.1 In the design and use of oil-fired units, the following should be considered.

(a) Unlike fuel gases, data on many important physical/chemical characteristics are not available for fuel oil, which, being a complex mixture of hydrocarbons, is relatively unpredictable.

(b) Fuel oil has to be vaporized prior to combustion. Heat generated by the combustion commonly is utilized for this purpose, and oil remains in the vapor phase as long as sufficient

Table A-4-2.1.1 Properties of Typical Flammable Gases

Flammable Gas	Molecular Weight	Btu/ft^3	Autoignition (°F)	LEL% by Volume	UEL% by Volume	Vapor Density (Air=1)	ft^3 Air Req'd To Burn 1 ft^3 of Gas
Butane	58	3200	550	1.9	8.5	2	31
CO	28	310	1128	12.5	74	0.97	2.5
Hydrogen	2	311	932	4	74.2	0.07	2.5
Natural gas (high Btu–type)	18.6	1115	—	4.6	14.5	0.64	10.6
Natural gas (high methane–type)	16.2	960	—	4	15	0.56	9
Natural gas (high inert–type)	20.3	1000	—	3.9	14	0.70	9.4
Propane	44	2500	842	2.1	9.5	1.57	24

temperature is present. Under these conditions, oil vapor can be treated as fuel gas.

(c) Unlike fuel gas, oil vapor condenses into liquid when the temperature falls too low and revaporizes whenever the temperature rises to an indeterminate point. Therefore, oil in a cold furnace can lead to a hazardous condition, because, unlike fuel gas, it cannot be purged. Oil can vaporize (to become a gas) when, or because, the furnace operating temperature is reached.

(d) Unlike water, for example, there is no known established relationship between temperature and vapor pressure for fuel oil. For purposes of comparison, a gallon of fuel oil is equivalent to 140 ft^3 (4.0 m^3) of natural gas; therefore, 1 oz (0.03 kg) equals approximately 1 ft^3 (0.03 m^3).

A-4-3.2 For additional information, refer to NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.

A-4-3.3.4 A long circulating loop, consisting of a supply leg, a back-pressure regulating valve, and a return line back to the storage tank, is a means of reducing air entrainment.

Manual vent valves might be needed to bleed air from the high points of the oil supply piping.

A-4-3.3.6 The weight of fuel oil is always a consideration in vertical runs. When going up, pressure is lost. One hundred psig (689 kPa) with a 100-ft (30.5-m) lift nets only 63 psig (434 kPa). When going down, pressure increases. One hundred psig (689 kPa) with a 100-ft (30.5-m) drop nets 137 psig (945 kPa). This also occurs with fuel gas, but it usually is of no importance. However, it should never be overlooked where handling oils.

A-4-3.4.3.2 Customarily, a filter or strainer is installed in the supply piping to protect the pump. However, this filter or strainer mesh usually is not sufficiently fine for burner and valve protection.

A-4-3.4.5 Under some conditions, pressure sensing on fuel oil lines downstream from feed pumps can lead to gauge failure when rapid pulsation exists. A failure of the gauge can result in fuel oil leakage. The gauge should be removed from service after initial burner start-up or after periodic burner checks. An alternative approach would be to protect the gauge during service with a pressure snubber.

A-4-3.6.1 The atomizing medium might be steam, compressed air, low pressure air, air–gas mixture, fuel gas, or other gases. Atomization also might be mechanical (mechanical-atomizing tip or rotary cup).

A-4-3.8.1 A burner is suitably ignited when combustion of the air–fuel mixture is established and stable at the discharge port(s) of the nozzle(s) or in the contiguous combustion tunnel.

A-4-4.1 Oxy-fuel burners often are utilized in conjunction with arc melting furnaces to augment electric heating. Some of these burners utilize air as well. Stationary burners are attached to the furnace shell or cover, or both. Movable burners that normally are not attached to the furnace are suspended from structural members outside a furnace door. They are manipulated from the operating floor, and the oxygen and fuel are introduced into the furnace through long, concentric pipes.

Conventional flame safeguards are impractical in conjunction with oxy-fuel burners in arc furnaces because of the radio frequency noise associated with the arcs. The electric arc is a reliable means of ignition for the burners, once it has been established. After the arc has been established, the high temperatures inside an arc furnace cause the ignition of significant accumulations of oxygen and fuel.

Using oxygen to augment or to substitute for combustion air in industrial furnace heating systems presents new safety hazards for users acquainted only with air–fuel burners.

One group of hazards arises from the exceptional reactivity of oxygen. It is a potent oxidizer; therefore, it accelerates burning rates. It also increases the flammability of substances that generally are considered nonflammable in air. A fire fed by oxygen is difficult to extinguish.

Special precautions are needed to prevent oxygen pipeline fires — that is, fires in which the pipe itself becomes the fuel. Designers and installers of gaseous oxygen piping should familiarize themselves with standards and guidelines referenced in this standard on pipe sizing, materials of construction, and sealing methods. Gaseous oxygen should flow at relatively low velocity in pipelines built of ferrous materials, because friction created by particles swept through steel pipe at a high speed can ignite a pipeline. For this reason, copper or copper-based alloy construction is customary where the oxygen velocity needs to be high, such as in valves, valve trim areas, and in orifices.

Oxygen pipelines should be cleaned scrupulously to rid them of oil, grease, or any hydrocarbon residues before oxygen is introduced. Valves, controls, and piping elements that come in contact with oxygen should be inspected and certified as "clean for oxygen service." Thread sealants, gaskets and seals, and valve trim should be oxygen-compatible; otherwise they could initiate or promote fires. Proven cleaning and inspection methods are described in the Compressed Gas Association guidelines provided in Appendix D.

Furnace operators and others who install or service oxygen piping and controls should be trained in the precautions and safe practices for handling oxygen. For example, smoking or striking a welding arc in an oxygen-enriched atmosphere could start a fire. Gaseous oxygen has no odor and is invisible, so those locations in which there is a potential for leaks are off-limits to smokers and persons doing hot work. The location of such areas should be posted. Persons who have been in contact with oxygen should be aware that their clothing is extremely flammable until it has been aired. Equipment or devices that contain oxygen should never be lubricated or cleaned with agents that are not approved for oxygen service.

Oxygen suppliers are sources of chemical material safety data sheets (MSDS) and other precautionary information for use in employee training. Users are urged to review the safety requirements in this standard and adopt the recommendations.

Another group of hazards is created by the nature of oxy-fuel and oxygen-enriched air flames. Because they are exceptionally hot, these flames can damage the burners, ruin work in process and furnace internals, and even destroy refractory insulation that was intended for air–fuel heating. Oxygen burner systems and heating controls should have quick-acting, reliable means for controlling heat generation.

Air that has been enriched with oxygen causes fuel to ignite very easily, because added oxygen increases the flammability range of air–fuel mixtures. Therefore, preignition purging is critical where oxygen is used.

Oxygen is also a hazard for persons entering furnaces to perform inspections or repairs. Strict entry procedures for confined spaces should be implemented. They should include analyses for excess oxygen (oxygen contents in excess of 20.9 percent) in addition to the usual atmosphere tests for oxygen deficiency and flammability.

A-4-4.3.2 CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems*, specifies maximum gas velocity criteria, materials of construction, installation methods, joining methods, metering methods, use of filters, and specifications for oxygen-compatible sealing materials, gasket materials, and thread sealants.

A-4-4.3.3 See CGA G-4.1, *Cleaning Equipment for Oxygen Service.*

A-4-4.3.4 This requirement is intended to prevent the contamination of surfaces that must be clean for oxygen service from the oil normally present in plant compressed air.

A-4-4.3.9 See CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems.*

A-4-4.3.11 Commercial-grade carbon steel pipe exhibits a marked reduction in impact strength when cooled to sub-zero temperatures. Consequently, it is vulnerable to impact fracture if located downstream from a liquid oxygen vaporizer running beyond its rated vaporization capacity or at very low ambient temperatures.

A-4-4.5.2 Diffusers commonly are used to disperse oxygen into an airstream, effecting rapid and complete mixing of the oxygen into the air. High-velocity impingement of oxygen is a potential fire hazard.

A-4-6.5.2.1 Transformers should be of the dry, high fire–point, or less flammable liquid type. Dry transformers should have a 270°F (150°C) rise insulation in compliance with Section 4.03 of NEMA TR 27, *Commercial, Institutional and Industrial Dry-Type Transformers.*

A-4-7.1 Fluid heating systems are used to heat lumber dry kilns, plywood veneer dryers, carpet ranges, textile ovens, and chemical reaction vessels. A fluid heating system typically consists of a central heat exchanger to heat the thermal fluid. Firing can be by conventional gas or oil burners. The hot gases then pass through a heat exchanger to indirectly heat the thermal fluid. The heat exchanger can be a separate, stand-alone unit or an integral part of the heater. Conventional water-tube boilers have been used as heaters, with thermal fluid replacing the water.

In addition to steam and water, special oils have been developed for this type of application, with flash points of several hundred degrees Fahrenheit. For maximum thermal efficiency, they are usually heated above their flash points, making an oil spill especially hazardous. Also, because of the high oil temperatures, it is usually necessary to keep the oil circulation through the heat exchanger at all times to prevent oil breakdown and tube fouling. Diesel-driven pumps or emergency generators are usually provided for this purpose in case of a power outage. Oil circulation can even be needed for a period of time after burner shutdown due to the residual heat in the heater.

A-4-7.2.1 Suitable relief valves should be provided where needed. Where relief valves are provided, they should be piped to a safe location. See design criteria in API RP 520 Pt I, *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part I — Sizing and Selection,* and API RP 520 Pt II, *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part II — Installation.*

A-4-7.2.3 If a combustible heat transfer fluid is used, consideration should be given to the use of automatic-actuating fire-safe isolation valves. The actuating mechanism should operate even if exposed to high temperatures. Fireproofing of the mechanism to maintain operational integrity could be necessary.

A fire-safe valve is one that provides a relatively tight valve-seat shutoff during temperatures that are high enough to destroy seals. The stem packing and gasketed body joints must also be relatively liquidtight during exposure to high temperatures.