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NFPA 86C
Industrial Furnaces Using a Special Processing Atmosphere
1987 Edition

NFPA

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NFPA 86C

Standard for

Industrial Furnaces Using a Special Processing Atmosphere

1987 Edition

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 Annual Meeting held May 18-21, 1987 in Cincinnati, Ohio. It was issued by the Standards Council on June 10, 1987, with an effective date of June 30, 1987, and supersedes all previous editions.

The 1987 edition of this standard has been approved by the American National Standards Institute.

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.

Origin and Development of NFPA 86C

The 1977 edition was introduced and adopted as a Tentative Standard in 1972. It was adopted, with editorial revisions, as an official standard in 1973, and amended in 1974.

The 1984 edition consisted of a complete rewrite to more closely follow the NFPA *Manual of Style*. This latest edition includes requirements for programmable controller use for control and operation of the furnace system. New recommendations for personnel safety have been included in the Appendix.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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.

Contents

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 safe operation of this type of equipment.

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

Causes of practically all failures can be traced back to human failure. The most significant failures have been found to be:

(a) Inadequate training of operators.

(b) Lack of proper maintenance.

(c) 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. The standard for furnaces is set forth under classifications as follows:

Class A furnaces are heat utilization equipment operating at approximately atmospheric pressure wherein there is a potential explosion and/or fire hazard which may be occasioned by the presence of flammable volatiles or combustible material processed or heated in the furnace. Such flammable volatiles and/or combustible material may, for instance, originate from paints, powder, or finishing processes, including dipped, coated, sprayed, impregnated materials or wood, paper and plastic pallets, spacers or packaging materials. Polymerization or similar molecular rearrangements and resin curing are processes which may produce flammable residues and/or volatiles. Potentially flammable materials, such as quench oil, water-borne finishes, cooling oil, etc., in sufficient quantities to present a hazard are ventilated according to Class A standards.

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

Class C 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 may use any type of heating system and includes the special atmosphere supply system(s). Also included in the Class C standard are integral quench and molten salt bath furnaces.

Class D furnaces are vacuum furnaces which operate at temperatures above ambient to over 5000°F (2760°C) and at pressures below atmospheric using any type of heating system. These furnaces may include the use of special processing atmospheres.

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Standard for

Industrial Furnaces Using a Special Processing Atmosphere

1987 Edition

Information on referenced publications can be found in Chapter 16 and Appendix B.

Chapter 1 General

1-1 Scope.

(a) This standard refers to Class C industrial furnaces, atmosphere generators and atmosphere supply systems, and shall apply to new installations, alterations, or extensions to existing equipment.

Coal (or other solid fuel) firing systems are not included in this standard. Heating systems for furnaces having a liquid heat transfer medium are also not included in this standard.

(b) Within the scope of this standard, a Class C furnace shall be any heated enclosure, operating at approximately atmospheric pressure, which utilizes a special atmosphere within the furnace.

(c) Within the scope of this standard, an integral quench shall be a container that holds a quench medium into which metal work is immersed for various heat treating processes.

(d) 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 which form a liquid-like medium into which metal work is immersed for various processes which include, but are not limited to, heat treating, brazing, stripping, and descaling.

1-2 Purpose. Since the heat processing of materials may involve a serious fire and explosion hazard endangering 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 This entire standard shall apply to new installations or alterations or extensions to existing equipment.

Exception: Section 1-6 and Chapter 14.

NOTE: 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 which are considered applicable and reasonable for existing installations.

1-3.2 Chapter 14, Inspection and Maintenance, and Section 1-6, Operator and Maintenance Personnel Training, shall apply to all operating furnaces.

1-4 Definitions. For the purpose of this standard, the following definitions shall apply:

Afterburner System. See Fume Incinerator.

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

Air Flow Switch. See Switch, Air Flow.

Air Fuel Gas Mixer. See Mixer, Air Fuel Gas.

Air Jet Mixer. See Mixer, Air Jet

Air, Primary. All air supplied through the burner, including atomizing and combustion air.

Air Purge. See Purge Air.

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

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

Air System, High Pressure [air pressure 5 psig (34 kPa) or higher]. A system using the kinetic energy of a jet of high pressure air to entrain fuel gas, or air and fuel gas to produce a combustible mixture.

Air System, Low Pressure [air pressure up to 5 psig (34 kPa)]. A system using the kinetic energy of a jet of low pressure air to entrain fuel gas to produce a combustible mixture, where all, or nearly all, of the air required for combustion is supplied by separate means such as a combustion air blower.

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

Approved. Acceptable to the "authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Atmosphere Furnace. See Furnace, Atmosphere.

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

See Special Atmosphere, Carrier Gas; Special Atmosphere, Nonflammable; Special Atmosphere, Flammable; Special Atmosphere, Indeterminate; or Special Atmosphere, Inert (Purge Gas).

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: 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, 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 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."

Bath, Molten Salt. See Furnaces, Molten Salt Bath.

Blower, Mixing. See Mixers.

Branch Circuit—Individual. A branch circuit that supplies only one utilization equipment.

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.

Burners.

Burner (or Nozzle). A device through which combustion air and fuel are released into the combustion zone. If the fuel gas and air are introduced separately, the burner is said to be "nozzle-mixing"; otherwise, an air-gas mixing device is used to supply the nozzle, which then is said to be of the (partial) premixing type. Either way, additional means are required to control or limit the flow of the fuel and air. Oil burners are always "nozzle-mixing," even if air is used for atomization.

Burner-Air or Steam Atomizing Type. A burner where oil is divided into a fine spray by an atomizing agent, such as steam or air.

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

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

Burner, Blast Tip. A small metallic or ceramic burner nozzle so made that flames will not blow away from it.

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

Burner, Diaphragm. A burner which utilizes a porous refractory diaphragm at the port so that the combustion takes place over the entire area of this refractory diaphragm.

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

Burner, Enclosed Combustion. A burner which confines the combustion in a small chamber of a furnace and only the high temperature completely combusted gases, in the form of high velocity jets or streams, are used for heating.

Burner, Excess Air. A nozzle mixing burner delivering a fixed volume of air and a variable volume of fuel gas such that complete combustion of fuel gas occurs at all rates of firing, to provide relatively uniform flow of air and products regardless of firing rates.

Burner, Flame Retaining Nozzle. Any burner nozzle with built-in features to hold the flame at high mixture pressures.

Burner, Line. A burner whose flame is a continuous "line" from one end to the other (normally applied to a blast burner).

Burner, Luminous Flame. A burner which discharges nonturbulent parallel strata of air and fuel gas to produce an extended flame of high luminosity.

Burner, Luminous Wall. A porous refractory liner to permit fuel gas-air mixtures to flow through, forming a luminous wall.

Burner, Multijet. A form of burner which generally consists of fuel gas manifolds with a large number of jets arranged to fire horizontally through openings in a vertical refractory plate.

Burner, Multiport. A burner having two or more separate discharge openings or ports. (These ports may be either flush or raised.)

Burner, Nozzle Mixing. A burner in which the fuel gas and air are kept separate until discharged from the burner into the combustion chamber or tunnel. Generally used with low pressure fuel gas [up to ½ psig or 14 in. w.c. (3.5 kPa) and low pressure air (up to 5 psig (34 kPa)].

Burner, Open Port. Any type of burner that fires across a gap into an opening in the furnace or combustion chamber wall and is not sealed into the wall.

Burner, Pipe. Any type of atmospheric or blast burner in the form of a tube or pipe with ports or tips spaced over its length.

Burner, Power. A fuel gas burner in which either fuel gas or air, or both, are supplied at pressure exceeding for fuel gas, the line pressure, and for air, the atmospheric pressure. Examples are fuel gas burners having zero governor inspirator mixers, those supplied by blower mixers or an approved gas mixing machine and those supplied with air by a blower, compressor, or forced-draft fan.

Burner, Premixed. A burner that utilizes a positive and dependable air-fuel gas mixer to furnish the air needed for complete combustion of the fuel supplied to the burner independently of the concentration or pressure of the atmosphere inside the enclosure where the burner fires. The zero governor inspirator mixer, the high-pressure [fuel gas pressure 1.0 psi (7 kPa) or higher] atmospheric inspirator mixer, the blower mixer, and the approved fuel gas mixing machine are examples of such a mixer.

Burner, Pressure. Same as Burner, Blast.

Burner, Pressure Atomizing. A burner where oil under high pressure is forced through small orifices.

Burner, Radiant. A burner designed to transfer a significant part of the combustion heat in the form of radiation from surfaces of various shapes which are usually of refractory material.

Burner, Radiant Tube. A burner of the atmospheric, premix or nozzle mixing type specially designed to provide a long flame within a tube to assure substantially uniform radiation from the tube surface.

Burner, Ribbon. A burner having many small closely spaced ports usually made up by pressing corrugated metal ribbons in a slot or other shaped opening.

Burner, Ring. A burner made with one or more concentric rings. Combustion air may be supplied by natural, induced, or forced draft.

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

Burner, Self-Piloted. A burner where the pilot fuel is issued from the same ports as the main flame and/or merge with the main flame to form a common flame envelope with a common flame base. In effect, the pilot flame is simply enlarged to become the main flame.

Burner, Single Port. A burner having only one discharge opening or port.

Burner, Tunnel. A burner sealed in the furnace wall in which combustion takes place mostly in a refractory tunnel or tuyere which is really part of the burner.

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

Burner, Vaporizing. A burner where oil is vaporized by heat.

Carrier Gas Special Atmosphere. See Special Atmosphere, Carrier Gas.

Catalytic Combustion System (Direct or Indirect Heater). A furnace heater of any construction that employs catalysts to accelerate the oxidation or combustion of fuel-air mixtures for eventual release of heat to a furnace process.

Check, Safe-Start. A checking circuit incorporated in a safety control circuit that prevents lighting-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 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 full closed position.

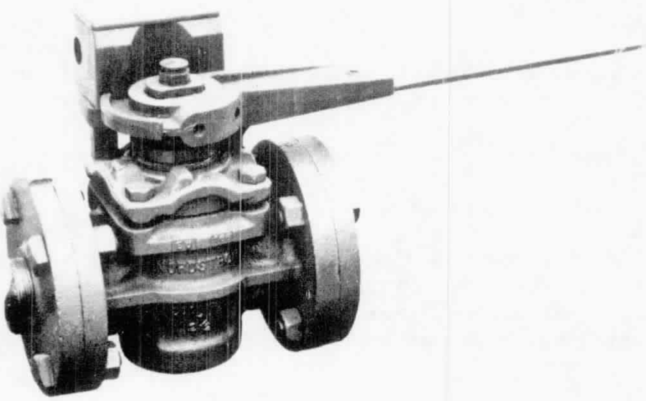


Figure 1-4.1 Supervising Cock.

Cock, Supervising, Electric-Interlocking. A conventional straight-through cock with a special built-in switch assembly protected against tampering, and arranged so that switch contacts are closed only when the cock is in the fully closed position.

NOTE: This type of supervising cock is suitable for both gas or oil fuels. The switch contacts of all cocks are wired in series in the safety control circuit so that all supervising cocks must be closed before the main fuel safety shutoff valve can be opened.

Cock, Supervising, Pneumatic-Type. A special approved cock similar to the usual burner fuel gas cock, except that it has two side outlets which furnish a small independent passageway which is opened only after the main fuel gas passage is completely closed.

NOTE: The key way width is narrow enough in respect to size and proportions of the main fuel gas ports to ensure positive closure of the main fuel gas way before opening the side outlets. This particular type of supervising cock is not suitable for fuel oil.

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

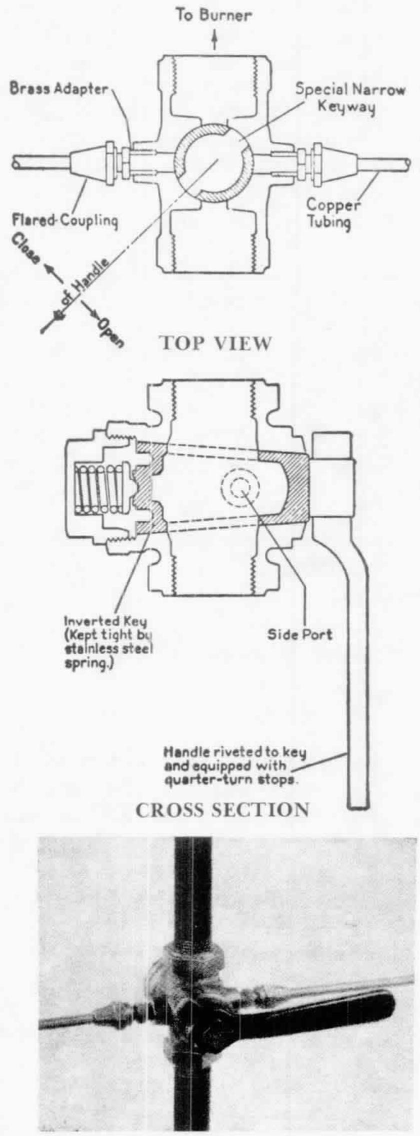


Figure 1-4.2 Pneumatic-type Supervising Cock.

Combustion Safeguard. See Safeguard, Combustion.

Controller, Continuous Vapor Concentration. Devices which measure and indicate, directly or indirectly, in percentage of the lower explosive limit, the concentration of a flammable vapor-air mixture.

Controls, Fuel Safety. Devices such as safety shutoff valves, flame detection units, fuel pressure switches (high and low), combustible gas detectors, flowmeters, firechecks, reliable ignition sources, and supervisory cocks.

Controls, Ventilation. Devices such as flow switches, pressure switches, fan shaft rotation detectors, dampers, position limit-switches, time delay and electrical interlocks which are placed in the system to ensure adequate ventilation prior to establishing the source of heat and during the operation of the heating equipment.

Cryogenic Fluid. A fluid produced or stored at very low temperatures. In 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).

Damper Cut-Away. A restricting air flow device that, when placed in the maximum closed position, will permit a minimum amount of airflow past the restriction. Cut-away dampers are normally placed in the exhaust and/or fresh air intake ducts to ensure that the required minimum amount of exhaust and/or fresh air is handled by the ventilating fans to keep the solvent vapor concentration in the furnace below the designed concentration level.

Device, Flame Detection. A device which will detect the presence or absence of flame. Flame detection devices may be based on:

(a) Flame rectification
(b) Ultraviolet radiation
(c) Infrared radiation
(d) Heat actuation.

Device, Photoelectric, Infrared and Ultraviolet Detecting. A detector based on the radiant energy of specific wave lengths of the flame, and the current passing through the detector is amplified by the combustion safeguard to actuate suitably arranged relays to make or interrupt the power to the fuel safety shutoff valves.

Dielectric Heater. See Heater, Dielectric.

Direct Fired. Any heating system where the products of combustion enter the furnace chamber and come in contact with the work in process.

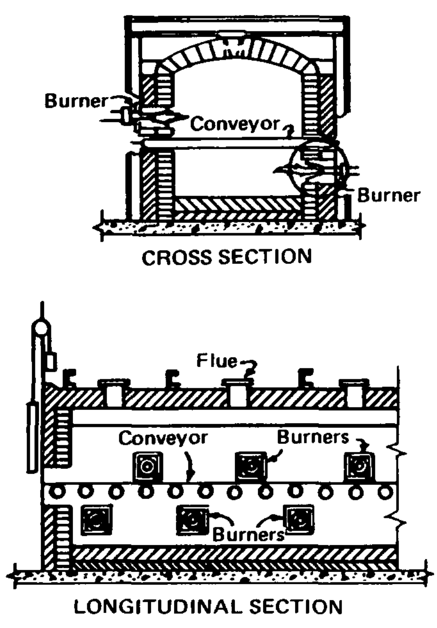


Figure 1-4.3 Direct-Fired Heating System.

Direct-Fired Internal Heater. See Heater, Direct-Fired Internal.

Dustproof. So constructed or protected that dust will not interfere with its successful operation.

Explosive Range (Limits of Flammability). See Range, Explosive.

Excess Temperature Limit. See Limit, Excess Temperature.

Firing, High-Low. Provision for two firing rates, high and low, according to load demand.

Flame Detection Device. See Device, Flame Detection.

Flame Propagation (Rate of). See Propagation, Flame (Rate of).

Flame Rod. See Rod, Flame.

Flame, Supervised. A flame whose presence is detected by a combustion safeguard.

Flammable Special Atmosphere. See Special Atmosphere, Flammable.

Flow Switch. See Switch, Flow.

Fluid. Gas or liquid.

Fuel Air Ratio Control System, Two Valve. A system using separate control of air and gas, both of which are under pressure. The valves controlling the air and fuel gas flow may or may not be mechanically linked or interlocked.

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, Analyzer. See Analyzer, Fuel Gas.

Fuel Gas, Atmospheric Regulator. See Zero Governor.

Fuel Gas, Commercial Manufactured. A mixture of gases usually composed of various proportions of some of the following gases:

(a) Coal gas, formed by distillation or "cracking" of bituminous coal.

(b) Coke-furnace gas, produced in a similar manner as a by-product in manufacture of coke.

(c) Carbureted water gas, formed by flowing steam through incandescent carbon. It has a low heat content which is increased by bringing the hot gas into contact with oil so that some of the oil is broken down or "cracked" into a gas. This product is sometimes mixed with coke-furnace gas.

(d) Oil gas, made by "cracking" petroleum oils, is used occasionally in manufactured gases.

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

Fuel Gas, Liquefied Petroleum. Any material which is composed predominantly of any of the following hydrocarbons, or mixtures of them: propane, propylene, butanes (normal butane or isobutane), and butylenes.

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

Fuel Gas, Natural. A mixture of gases, principally methane and ethane, obtained from gas wells and from which less volatile hydrocarbons such as propane and butane have been removed, leaving a mixture of gases which will remain in the gaseous state at all pressures and temperatures encountered in a gas distribution system.

Fuel Gas Pressure Regulator. See Regulator, Fuel Gas Pressure.

Fuel Gas, Producer. Any gas formed by blowing air and/or steam through incandescent coal, coke or charcoal.

Fuel Oil. No. 2, 4, 5 or 6 in accordance with ASTM D396, *Specifications for Fuel Oils*.

Fuel Safety Controls. See Controls, Fuel Safety.

Fume Incinerator. A fume incinerator is any separate or independent combustion equipment or device which entrains the process exhaust (particulate matter, dust, fumes, gas, mist, smoke or vapor, or any combination thereof) for the purpose of thermal decomposition and/or heat recovery.

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

Furnace, Batch Process. A furnace into which the work is introduced all at one time.

Furnace, Continuous Process. 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. The passage of an electric current between either a pair of electrodes or between electrodes and the work causing an arc which releases energy in the form of heat under the influence of an ionized gas, such as argon.

Gas, Reaction. All of the gas which, when reacted with air in an endotheric generator by the addition of heat, becomes the special atmosphere gas.

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

Hazardous Material. Any material possessing a relatively high potential for harmful effects on persons, property, or process. A material having one or more of the following characteristics.

(a) Has a closed-cup flash point below 140°F (60°C) or is subject to spontaneous heating.

(b) Has a threshold limit value below 500 parts per million in the case of a gas or vapor or below 500 mg/cu M for fumes, and below 25 mppcf in the case of a dust.

(c) Has a single dose oral LD 50 below 500 mg/kg.

(d) Is subject to polymerization with the release of large amounts of energy.

(e) Is a strong oxidizing or reducing agent.

(f) Causes first-degree burns to skin in short-time exposure, or is systemically toxic by skin contact; or

(g) In the course of normal operations, may produce dusts, gases, fumes, vapors, mists, or smokes which have one or more of the above characteristics.

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

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

Heater, Indirect-Fired. Any heating system where the products of combustion do not enter the work chamber, heating being accomplished by radiation or convection from the tubes or muffles.

Heater, 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 Article 665 of NFPA 70, National Electrical Code®*.)

Heater, Radiant Tube. Tubular elements open at one or both ends, constructed gastight of suitable heat-resistant material, and capable of withstanding explosion pressure from ignition of fuel-air mixture. The tube has an inlet and/or burner arrangement where combustion is initiated, a suitable length where combustion occurs, and an outlet for the combustion products formed. The fuel-air mixture can be mixed before, during, or after introduction into the tube. The introduction can be accomplished under high pressure, under slight pressure, or under suction. Ignition can be accomplished at either the inlet or the outlet of the tube.

Radiant tubes can be located in the actual heating chamber of the furnace or remotely in another chamber. In the latter instance, heat transfer is accomplished by recirculation of heated gases.

Heater, Resistance. Any heater in which heat is produced by current flow through a resistive conductor and utilizing the heat generated as a result. Resistance heaters may be of the "open" type with bare heating conductors or "insulated sheath" type with conductors covered by a protecting sheath which may be filled with electrical insulating material.

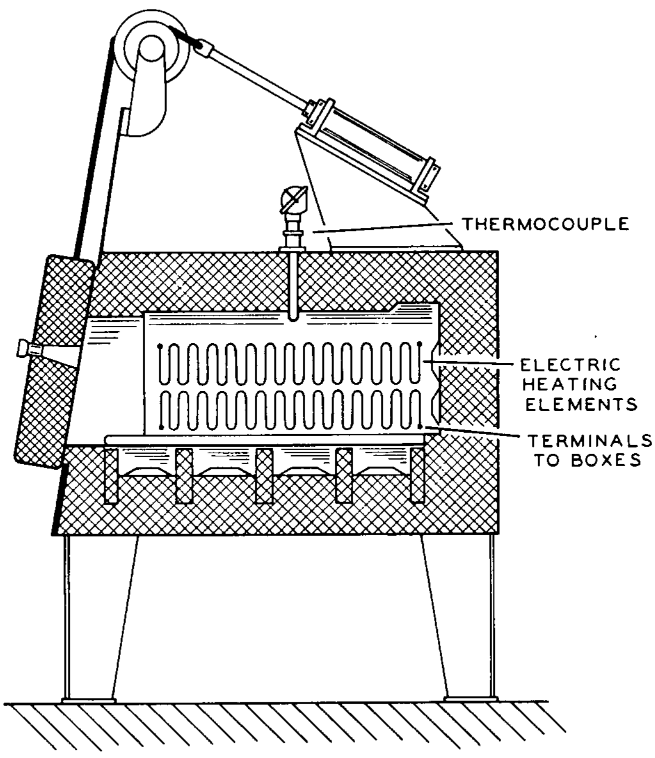


Figure 1-4.4 Cross Section of a Resistance Heater.

Heater, Tubular. A form of resistance heater in which the resistive conductors are enclosed in glass, quartz, or ceramic envelopes that may or may not contain a special gas atmosphere.

High-Low Firing. See Firing, High-Low.

High Pressure Air System. See Air System, High Pressure.

Ignition Systems.

Automatic-Ignited Burner. A burner ignited by direct electric ignition, or by an electric-ignited or continuous pilot.

Automatic-Lighted Industrial Heating Equipment. Fuel gas- or oil-fired industrial heating equipment such as a furnace where fuel to the main burner(s) is turned on automatically and ignited automatically (*see Automatic-Ignited Burner*).

Direct Electric Ignition. Ignition of an oil flame (and in some cases a fuel-gas flame) by an electric-ignition source such as a high-voltage spark or hot wire.

Manual-Ignited Burner. A burner ignited by a portable fuel gas- or oil-burner torch or by an oil-soaked swab torch, placed in proximity to the burner nozzle by the operator.

Manual-Lighted Industrial Heating Equipment. Fuel gas- or oil-fired equipment such as a furnace where fuel to the main burner(s) can be turned on only by hand and is manually or semiautomatically ignited under the supervision of the operator (*see Manual-Ignited Burner and Semiautomatic-Ignited Burner*).

Modulated Firing. Provision for gradually varying the firing rate between high-fire and low-fire, according to load demand.

Proved Low-Fire Start Interlock. A burner start in which a control sequence ensures that a high-low or modulated burner is in the low-fire position before the burner can be started, as, for example, by means of an end switch mounted on the drive shaft of the modulating motor, which is wired into the safety-control circuit.

Semiautomatic-Ignited Burner. A burner ignited by direct electric ignition or by an electric-ignited pilot, electric ignition being manually activated.

Semiautomatic-Lighted Industrial Heating Equipment. The same as automatic-lighted except that on each lighting-off, placing the equipment in service from cold condition, fuel to the main burner(s) can be turned on only by hand and is manually or semiautomatically ignited under the supervision of the operator (*see Manual-Ignited Burner and Semiautomatic-Ignited Burner*).

Ignition Temperature. See Temperature, Ignition.

Indeterminate Special Atmosphere. See Special Atmosphere, Indeterminate.

Indicator, Continuous Vapor Concentration. See Controller, Continuous Vapor Concentration Indicator.

Indirect-Fired Heater. See Heater, Indirect-Fired.

Induction Heater. See Heater, Induction.

Inert Atmosphere Purge. See Purge, Inert Atmosphere.

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

Inspirator, Atmospheric (Venturi). A device which utilizes the kinetic energy of the fuel gas under pressure, to inject all or part of the combustion air required as primary air from the atmosphere. (*See Figure 1-4.5.*)

Inspirator, Proportioning. An inspirating tube which when supplied with air will draw into the air stream all the fuel gas necessary for combustion.

Inspirators, High Pressure. Operate in the approx-

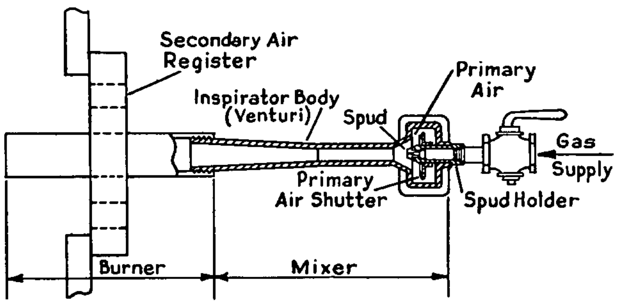


Figure 1-4.5 Atmospheric (Venturi) Inspirator.

imate range of 1 to 30 psig (7 to 207 kPa) fuel gas pressure, and may or may not inject 100 percent primary air.

Inspirators, Low Pressure. Operate at about 1 psig (7 kPa) fuel gas pressure, or less, and cannot inject 100 percent combustion air.

Interlock, Proved Low-Fire Start. A burner start in which a control sequence ensures that a high-low or modulated burner is in the low-fire position before the burner can be started, as for example, by means of an end switch mounted on the drive shaft of the modulating motor, which is wired into the safety-control circuit.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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.

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

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

Limit Switch. See Switch, Limit.

Limits of Flammability. See Range, Explosive.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

Low Pressure Air System. See Air System, Low Pressure.

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

Mixer, Air-Fuel Gas. A system which proportions air and fuel and mechanically compresses the mixture for combustion purposes. A central mixing unit may be used or individual appliances may each have its own mixer.

Mixers, 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 may be designed to entrain some of the air for combustion as well as the fuel gas.

Mixers, Automatic. A mixer that automatically maintains within its rated capacity a substantially constant air/fuel gas ratio at varying rates of flow. All types defined below can be designed to fit this classification.

Mixers, Gas Jet (Atmospheric Inspirator 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.

(a) The term "Atmospheric Inspirator (Venturi) Mixer" shall mean any mixer in which part or all of the combustion air (primary air) is drawn in by the inspirating effect of a fuel gas jet entering the inspirator, the remaining combustion air (secondary air), if needed, being supplied from the atmosphere in which the burner is located.

(b) If fuel gas for the jet is available at the orifice at pressures below 1 psig (7 kPa), the mixer is defined as "low pressure atmospheric inspirator" mixer; if at 1 psig (7 kPa) or above, the mixer is designated "high pressure atmospheric inspirator."

Mixers, Manual. A mixer that requires manual adjustments to maintain the desired air/fuel gas ratio as rates of flow are changed.

Mixers, Mechanical. A mixer using mechanical means to mix fuel and air, neglecting any kinetic energy in the fuel and air, and compressing 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. The proportioning device may be automatic or require manual adjustment to maintain the desired air/fuel ratio as rates of flow are changed.

Mixers, Proportioning. A mixer comprised of an inspirator which, when supplied with air, will draw into the air stream all of the fuel gas necessary for combustion and a governor, zero regulator, or ratio valve which reduces incoming fuel gas pressure to approximately atmospheric. (*See Figure 1-4.6.*)

Mixing Blower. A motor-driven blower to supply air-fuel 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.

Muffles. Enclosures within a furnace which separate

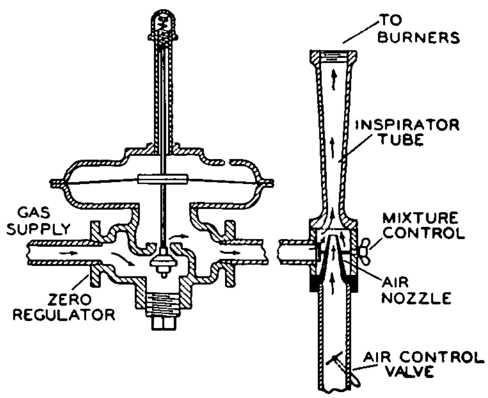


Figure 1-4.6 Proportioning Mixers.

the products of combustion from the work and from any special atmosphere which may be required for the process. Burners may be used for direct-firing of the space within the furnaces but outside the muffle, or heating of the muffle may be by indirect means using radiant tubes or external furnace heaters.

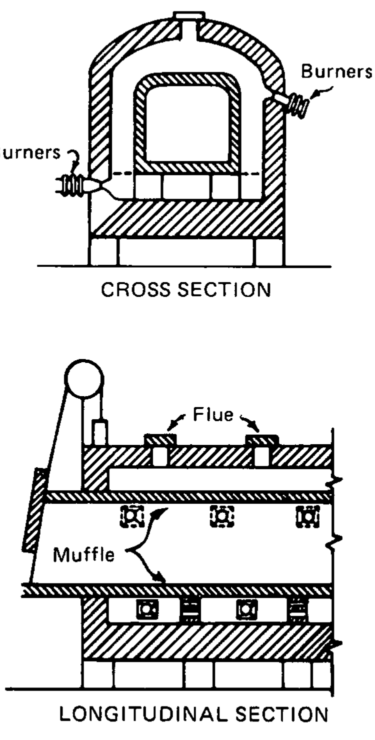


Figure 1-4.7 Muffles.

Nonflammable Special Atmosphere. See Special Atmosphere, Nonflammable.

Operator. The individual responsible for the light-up, operation, shutdown, and emergency handling of the furnace and its associated equipment.

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

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

Pilot Continuous. A pilot that burns continuously 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 whether or not the main burner is firing, but during lighting-off, it is expanded (burns without turndown) to ignite the main burner reliably.

Pilot, Flame-Establishing Period. The interval of time during lighting-off in which a safety-control circuit permits the pilot fuel safety shutoff valve to be open before the combustion safeguard is required to prove the presence of the pilot flame.

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

Pilot, Interrupted. A pilot which burns during the entire pilot-flame-establishing period and/or trial-for-ignition period, and which is cut off (interrupted) at the end of this period(s) or during firing.

Pilot, Proved. A pilot flame supervised by a combustion safeguard which senses the presence of the pilot flame and which is located where it will reliably ignite the main burner.

Plasma Arc Furnace. See Furnace, Plasma Arc.

Pressure Switch. See Switch.

Preventilation Time Delay Relay. See Relay, Preventilation Time Delay.

Primary Air. See Air, Primary.

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

Programmable Controller. A digitally operating electronic system designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control, through digital or analog inputs and outputs, various types of machines or processes.

Proven Ventilation. See Ventilation, Proper.

Proportioning System (Automatic). A combination of one or more burner tips, nozzles, or other firing heads and a proportioning device intended to supply a fuel-air mixture to the firing point in proper proportion for combustion.

Proved Low-Fire Start Interlock. See Interlock, Proved Low-Fire Start.

Proven Ventilation. See Ventilation, Proven.

Pump, Vacuum. Mechanical pump used to purge to a vacuum generally in the range of 100 microns (0.1 mmHg).

Purge. The replacement of a flammable or high-oxygen bearing atmosphere with an inert gas to a nonflammable state, i.e., 50 percent of the lower explosive limit (LEL) or <1 percent oxygen.

Purge Air. Positive removal and/or dilution of flammable vapors with air to a point below 25 percent of the lower explosive limit.

Purge, Inert Atmosphere. The replacement of a flammable or high-oxygen bearing atmosphere with an inert gas to a nonflammable state.

Quench Tank. See Tank, Integral or Open Liquid or Salt Media Quench Type.

Range, Explosive (Limits of Flammability). The range of concentration of a flammable gas in air within which flame is propagated. The lowest flammable concentration is the lower explosive limit (LEL). The highest flammable concentration is the upper explosive limit (UEL). See NFPA 325M, *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*

Reaction Air. See Air, Reaction.

Reaction Gas. See Gas, Reaction.

Regulator, Fuel Gas Atmosphere. See Zero Governor.

Regulator, Fuel Gas Pressure. A diaphragm-operated valving device that maintains a constant outlet pressure under varying flow.

Relay, Preventilation Time Delay. A switch which is operated automatically after a preset time interval usually measured by a timing device.

Rod, Flame. A detector which 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 of the burner, and the electrical current passing through the flame is rectified and this rectified current is detected and amplified by the combustion safeguard.

Room, Cutoff. A room separated from the rest of the building by fire-resistive barriers.

Rotational Switch. See Switch, Rotational.

Safeguard, Combustion. A safety control responsive directly to flame properties; it senses the presence and/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.

Safe-Start Check. See Check, Safe-Start.

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

Safety Shutoff Valve. See Valve, Safety Shutoff.

Secondary Air. See Air, Secondary.

Shall. Indicates a mandatory requirement.

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

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

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

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

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

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

Suction System. A system applying suction to a combustion chamber to draw in the air and/or fuel necessary to produce the desired combustible mixture.

Supervised Flame. See Flame, Supervised.

Supervising Cock. See Cock, Supervising.

Switch.

Switch, Air Flow. A device actuated by the flow of air in a duct system.

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 which is activated by the flow of a gaseous or liquid fluid by a pressure differential in a diaphragm measuring two different points which produces a pressure differential across a diaphragm measuring pressure at two different points.

Switch, Flow. A switch which 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 device consisting of a suitable connecting mechanism to a switch or a contact.

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

Switch, Rotational. A device which is usually 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 give a safe minimum air flow, 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 whereby work from the furnace is exposed to air before and upon entering the tank containing combustible, noncombustible or salt quench medium.

Temperature Controller. See Controller, Temperature.

Temperature, Ignition. The lowest temperature at which a gas-air mixture may ignite and continue to burn. This is also referred to as the auto-ignition temperature. When burners supplied with a gas-air mixture in the flammable range are heated above the auto-ignition temperature, flash backs may occur. In general, such temperatures range from 870°F (466°C) to 1300°F (704°C). A much higher temperature is needed to ignite gas dependably. The temperature necessary 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.

Trial-for-Ignition Period (Flame-Establishing Period). That interval of time during lighting-off which a safety control circuit permits the fuel safety shutoff valve to be open before the combustion safeguard is required to supervise the flame.

Two-Valve Fuel Air Ratio Control System. A system using separate control of air and gas, both of which are under pressure. The valves controlling the air and fuel gas flow may or may not be mechanically linked or interlocked.

UEL (Upper Explosive Limit). See Range, Explosive.

Upper Explosive Limit (UEL). See Range, Explosive.

Vacuum Pump. See Pump, Vacuum.

Valve, Safety Shutoff. A normally closed (closed when de-energized) automatic valve installed in the piping to shut off the atmosphere gas or fuel in the event of abnormal conditions or during shutdown periods.

Valve, Electric, Manual-Opening, Automatic-Closing Safety Shutoff. A valve which can be opened only after the valve solenoid coil is energized and must be opened manually. Deenergizing the valve automatically closes the valve by means of a suitable "free-handle" and closes automatically when the solenoid coil is deenergized.

Valve, Electric-Opening, Automatic-Closing Safety Shutoff. A valve which opens automatically on energizing the valve actuating device, and closes automatically on deenergizing the actuating device.

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

Ventilation Controls. See Controls, Ventilation.

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 will be safely below the lower explosive limit at all times.

Zero Governor (*also called Atmospheric Regulator*). A diaphragm-type regulator that maintains the fuel gas pressure at atmospheric or zero gage pressure.

1-5 Approvals, Plans, and Specifications.

1-5.1 Before new equipment is installed or existing equipment remodeled, complete plans, sequence of operations, and specifications shall be submitted for approval to the authority having jurisdiction.

For application of programmable controllers, also see Section 4-2.

1-5.1.1 Plans shall be drawn and show all essential details as 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.

1-5.1.2 Wiring diagrams and sequence of operations for all safety controls shall be provided.

NOTE: Where applicable, ladder-type schematic diagrams are preferred.

1-5.2 Any deviation from this standard shall require special permission from the authority having jurisdiction.

1-5.3 All wiring in and around furnaces shall be in accordance with NFPA 70, *National Electrical Code*, and as described hereafter.

NOTE: The *National Electrical Code* is indicated as a reference source for safe practices and wiring methods. Where it is considered that variation of the commended wiring methods as currently specified in the *National Electrical Code* is necessary to provide greater safety of the installation, such variations are required to meet with the approval of all parties having jurisdiction and are required to be the sole responsibility of the parties initiating such variation.

1-6 Operator and Maintenance Personnel Training.

1-6.1 The selection of alert and competent personnel shall be required. It is recognized that their knowledge and training is vital to safe furnace operation and maintenance.

1-6.1.1 All personnel shall be thoroughly instructed and trained under supervision of experienced person(s), and shall be required to demonstrate understanding of the equipment and of its operation to assure knowledge of and practice of safe operating procedures.

1-6.2 Regular personnel shall receive scheduled retraining and testing to maintain a high level of proficiency and effectiveness.

1-6.3 Personnel shall have access to operating instructions at all times.

1-6.4 Operator training shall include, where applicable:

(a) Combustion of fuel-air mixtures.

(b) Explosion hazards.

(c) Sources of ignition including auto-ignition (for instance, by incandescent surfaces).

(d) Functions of control and safety devices.

(e) Handling of special atmospheres.

(f) Handling and processing of hazardous materials.

1-6.5 Operating instructions shall be provided by the equipment manufacturer. These shall include:

(a) Schematic piping and wiring diagrams.

(b) Start-up procedures.

(c) Shut-down procedures.

(d) Emergency procedures including those occasioned by loss of special atmospheres, electric power or other essential utilities.

(e) Maintenance procedures.

Chapter 2 Location and Construction

2-1 Location.

2-1.1 General. Furnaces and related equipment shall be located with consideration to the possibility of fire resulting from overheating, spillage of molten metal, quench tanks, ignition of hydraulic oil, overheating of material in furnace, etc., or from the escape of fuel and the possibility of building damage and personal injury resulting from an explosion.

2-1.2 Grade Location. Special consideration shall be given to the location of equipment using flammable fluids or when using fuels with a specific gravity greater than air.

2-1.3 Structural Members of the Building.

2-1.3.1 Furnaces shall be located and erected so that the building structural members will not be adversely affected by the maximum anticipated temperatures (*see 2-1.5*).

2-1.3.2 Structural building members shall not pass through or be enclosed within the furnaces.

2-1.4 Location in Regard to Stock and Other Processes.

2-1.4.1 Valuable Stock.

NOTE: Furnaces should be well separated from valuable stock, important power equipment, machinery and sprinkler risers, thereby securing a minimum interruption to production and protection in case of accidents to the furnace.

2-1.4.2 Personnel. Furnaces shall be located to minimize exposure to people from the possibility of injury from fire, explosion, asphyxiation, and toxic materials, and shall not obstruct personnel travel to exitways.

2-1.4.3 Industrial furnaces shall be safely located and protected from exposure by flammable coating dip tanks, spray booths, storage and mixing rooms for flammable liquids, storage areas used for readily flammable materials, or exposure by or to the diffusion of flammable vapor-air mixtures.

2-1.4.4 Corrosion Resistance. Equipment shall be safely located and protected from corrosive external processes and environment.

NOTE: Fumes or materials from adjacent processes or equipment which are not normally corrosive may produce corrosive conditions when introduced into the furnace environment. (*See NFPA 325M, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*)

2-1.5 Floors and Clearances.

2-1.5.1 Furnaces shall be located so as to be readily accessible with adequate space above to permit installation of automatic sprinklers, the proper functioning of explosion vents, inspection and maintenance. Roofs and floors of furnaces shall be insulated, and the space above and below ventilated, to keep temperatures at combustible ceilings and floors below 160°F (71°C).

2-1.5.2 If furnace locations on noncombustible floors are not available, then sufficient insulation and ventilation shall be provided to protect the combustible floor from damage by fire, and wood deterioration due to long-time heat exposure.

2-1.5.3 The following procedure shall be observed if the furnace is located in contact with a wood or other combustible floor and the operating temperature is above 160°F (71°C):

(a) Remove the wood or other combustible floor and replace it with a concrete slab extending at least 12 in. (305 mm) beyond the furnace outline.

(b) If the combustible floor is not removed, provide hollow tile or steel tunnels on top of floor extending to furnace outline and laid to form continuous air channels parallel with short axis of the furnace wherever possible, open at both ends, for air movement so that the surface temperature of the floor will not exceed 160°F (71°C). If the temperature at the combustible floor surface exceeds 160°F (71°C), then the air channels shall be connected on one end to a vent duct, of adequate size, leading to a stack discharging to the atmosphere and provided with mechanical ventilation.

(c) When the supporting floor is of concrete, steel channels, or hollow tile, for operating temperatures above 300°F (149°C), the furnace floor shall be further insulated with suitable material equivalent in insulating value to that used for furnace walls and roof, and suitably enclosed or covered for protection against mechanical damage or abrasion. The external temperature of the floor near the furnace shall not exceed 250°F (121°C).

NOTE: Insulating cement for 700°F (371°C) furnace heat may be diatomaceous earth or its equivalent mixed with cement, and the thicknesses used should be:

2 in. (51 mm) for 300°F (149°C) furnace heat

3 in. (76 mm) for 400°F (204°C) furnace heat

4 in.(102 mm) for 500°F (260°C) furnace heat

5 in.(127 mm) for 600°F (316°C) furnace heat

6 in.(152 mm) for 700°F (371°C) furnace heat

(d) Where electrical wiring will be present in the channels of certain types of floors, the wiring shall be installed in accordance with Article 356, Cellular Metal Floor Raceways, of NFPA 70, *National Electrical Code*.

(e) Combustible floors in the immediate area of oil burners shall be covered with noncombustible material in such a manner that the floor cannot become oil soaked. (*See NFPA 31, Standard for the Installation of Oil Burning Equipment, and/or the building code having jurisdiction.*)

(f) Adequate protection from heat and from fuel spillage shall be provided for combustible floors under heaters.

2-1.5.4 Combustible material shall be located as far as practical from a furnace, furnace heater, or ductwork.

2-1.6 Adequate plant lighting shall be provided to allow proper operation of the furnace and its associated equipment.

2-2 Furnace Design.

2-2.1 General. Furnaces and related equipment shall be designed with due regard to the fire hazard inherent in equipment operating at elevated temperatures.

2-2.2 Materials.

2-2.2.1 Furnace structures shall be constructed of noncombustible materials.

2-2.2.2 Furnace structural supports and conveyors shall be designed with adequate factors of safety at the maximum operating temperatures, consideration being given to the strains imposed by expansion.

2-2.2.3 Burners and heating elements of all types shall be substantially constructed or guarded to resist external mechanical damage from falling work, trucking, or other mechanical hazards inherent in industrial use.

2-2.2.4 Where refractory materials are used, they shall be adequately supported.

2-2.2.5 Accessibility and Mounting of Controls. Provision shall be made for the rigid attachment of control devices. Combustion safeguard mounts shall be arranged so that the electrode or other flame detecting element is correctly positioned. Valves and control panels shall be so located that all necessary observations and adjustments may be readily made.

2-2.2.6 All parts of equipment operating at elevated temperatures shall be installed in accordance with 2-1.5.

2-2.2.7 Where impractical to provide adequate shields or guards, warning signs or permanent floor markings shall be provided or mounted to be visible to personnel entering the area.

NOTE 1: Exterior of furnaces in excess of 160°F (71°C) should be guarded by location, guard rails, shields or insulation to prevent accidental contact by personnel.

NOTE 2: Bursting discs or panels, mixer openings, or other parts of the furnace from which flame or hot gases may be discharged should be located or guarded to prevent injury to personnel.

2-2.2.8 Properly located observation ports shall be provided to permit the operator to observe the lighting of individual burners.

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

2-2.2.9 Closed water cooling systems shall have relief valves to protect all portions of the cooling system, when its pressure may exceed the design pressure. In addition, waterflow devices with audible/visual alarms shall be furnished.

NOTE: Open cooling systems utilizing unrestricted sight drains installed for ready observation by the opertor do not require relief valves, waterflow devices, etc.

2-2.2.10 Fuel-fired heaters shall not be located directly under the product being heated where combustible materials may drop and accumulate. Neither shall they be located directly over readily ignitible materials unless for a controlled exposure period, as in continuous processes where further automatic provisions and/or arrangements of guard baffles preclude the possibility of ignition.

2-2.2.11 The metal frames of furnaces shall in all cases be electrically grounded.

2-2.3 Explosion Vents.

2-2.3.1 Furnaces which may contain flammable liquids, vapors, or gases shall be equipped with unobstructed relief vents for freely relieving internal explosion pressures (for additional information regarding relief of equipment and buildings housing the equip-

~~FACILITIES~~

~~COCKTAIL RECEPTION~~

~~2 Free cocktail ?~~

~~INTRODUCTIONS.~~

2.2.3.2 This is a "rule of thumb" used in the old days i.e. before test data (NFPA 68-1988) was made available. Recommend deletion of TP

Just make reference to NFPA 68.

Journal of Loss Prevention in the Process Industries

V1 N1 1-88 Design of Deflagration Protection Systems.

I. Smith

Explosion Propagation in non-spherical vessels; simplified equations & applications J. Singh

V1 N2 4-88

ment, see NFPA 68, *Guide for Explosion Venting*).

Exception: Explosion relief panels are not required on furnaces having the following characteristics: shell construction having 3/16-in. (4.8-mm) or heavier steel plate shells reinforced with structural steel beams and buckstays, which support and retain refractory and insulating materials required for temperature endurance, and thus are unsuitable for the installation therein of effective explosion vents.

2-2.3.2 Explosion relief panels shall be proportioned in the ratio of their area to the explosion-containing volume of the furnace due allowance being made for openings or hinged panels or access doors equipped with approved explosion-relieving hardware. The preferred ratio is 1:15, i.e., 1 sq ft (0.0929 m^2) of relief panel area to every 15 cu ft (0.4248 m^3) of furnace volume.

2-2.3.3 Arrangement of Explosion Vents.

2-2.3.3.1 Explosion venting panels or doors shall be arranged so that, when open, the full vent opening will be an effective relief area. The operation of relief vents to their full capacity shall not be obstructed by low ceilings, piping, building columns, or walls, instrument panels, or other fixed equipment.

NOTE 1: These vents should preferably be provided in the form of gravity retained roof panels designed to provide adequate insulation and possess the necessary structural strength.

NOTE 2: Guard rails may be needed to prevent movable equipment from being placed so as to obstruct such vents.

NOTE 3: Explosion relief vents should be placed in the top of the furnace, whenever possible, or in side walls and located so that employees will not be exposed to injury.

NOTE 4: Maximum weight per panel allowed by NFPA 68, *Guide for Explosion Venting*, is 2½ lb/sq ft (12.2 kg/m^2).

NOTE 5: Where practical, an explosion relief vent should be placed close to a source of ignition (*see NFPA 68, Guide for Explosion Venting*).

2-2.3.3.2 Explosion relief vents for a long furnace shall be reasonably distributed throughout the entire furnace length.

2-2.4 Ductwork.

2-2.4.1 Whenever 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).

2-2.4.2 Ducts shall be constructed entirely of sheet steel or other noncombustible material, and be of adequate strength and rigidity to meet the conditions of service and installation requirements, and shall be protected where subject to physical damage.

2-2.4.3 No rooms or portions of the building shall be used as an integral part of the system.

NOTE: The entire duct system should be self-contained.

2-2.4.4 All ducts shall be made tight throughout and shall have no openings other than those required for the operation and maintenance of the system.

2-2.4.5 All ducts shall be thoroughly braced where required and substantially supported by metal hangers or brackets.

NOTE: All laps in the duct joints should be made in the direction of the flow.

2-2.4.6 Where ducts pass through noncombustible walls, floors, or partitions, the space around the duct shall be sealed with noncombustible material to prevent the passage of flame and smoke.

NOTE: The passing of ducts through fire walls should be avoided.

2-2.4.7 Ducts handling fumes which leave a combustible deposit shall be provided with cleanout doors. Such ducts shall be constructed of not less than 16 gauge steel or equivalent.

2-2.4.8 Hand holes for damper, sprinkler, or fusible link inspection or resetting, and for purposes of residue cleanout shall be equipped with tight-fitting doors or covers provided with substantial latches, except in the case of vertical sliding doors held in place by gravity.

2-2.4.9 Dampers in the ducts which affect the volume of fresh air admitted to and vapors or gases exhausted from the furnace shall be designed so that, when in closed position, they will pass the volume required for safe ventilation. If electrically or mechanically controlled dampers are used, limit switches shall be utilized to assure proper position of the dampers, including those used as gas barriers on carbon dioxide extinguishing systems.

2-2.4.10 The furnace and its location shall be designed to prevent excessive emission of objectionable fumes into the building.

2-2.4.11 All exposed hot fan casings and hot ducts within 7 ft (2.1 m) of the building floor shall be protected to prevent injury to personnel [temperature not to exceed 160°F (71°C].

2-2.4.12 Exhaust ducts shall not discharge near doors, windows, or other air intakes in a manner that will permit re-entry of effluents into the building.

NOTE: All air inlets outside the furnace should be protected by coarse screens and so guarded that they cannot be obstructed.

2-2.4.13 A suitable collecting and venting system for the radiant tube-type heating systems shall be provided. The system shall be of sufficient capacity to render the total unburned input capacity of the radiant tubes noncombustible.

NOTE: For additional information pertaining to furnace duct work, reference is made to NFPA 54, *National Fuel Gas Code*; NFPA 91, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying*; and NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances*.

2-2.5 Access, Mountings, and Auxiliary Equipment.

2-2.5.1 Adequate facilities for access shall be provided to permit proper inspection and maintenance. Facilities shall include motion stops or lockout devices for vertical and/or horizontal movement of doors, elevators, or transfer mechanisms to minimize accidental movement.

2-2.5.2 Mountings for auxiliary equipment shall provide for mounting of control instruments and safety devices to protect against damage by heat, vibration, and mechanical equipment.

2-2.5.3 Where ladders or steps are needed to reach operating valves or other controls, they shall be noncombustible and provided as an integral part of the equipment.

2-2.5.4 Auxiliary equipment such as conveyors, racks, shelves, baskets, and hangers shall be noncombustible and designed to facilitate cleaning.

2-2.5.5 All external moving parts within 7 ft (2.1 m) of a working platform shall be guarded from mechanical accidents or possibilities of causing personal injury.

2-2.6 Hydraulic Systems.

2-2.6.1 Furnace hydraulic systems shall utilize fire-resistant fluids.

Exception: Other hydraulic fluids can be used if furnace casing temperatures are below the auto-ignition temperature of the fluid and no other sources of ignition are present.

NOTE: Drawings for fluid power diagrams should follow ANSI Standards Y14.17 and Y32.10.

Chapter 3 Heating Systems

3-1 Scope.

(a) For the purpose of this standard, the term "furnace and associated equipment heating system" shall include the heating source (and associated piping/wiring) used to heat the furnace and the work therein as well as for auxiliary quenches, atmosphere generator, etc.

(b) The source of heat may be either fuel firing or by electric heating.

3-2 Electrical Wiring. All electrical wiring, and applicable electrical components, shall be in accordance with NFPA 70, *National Electrical Code*, and as described hereafter.

3-3 Gas-Fired Units.

3-3.1 General.

(a) This section includes combustion systems for furnaces and associated equipment fired with commercially distributed fuel gases such as natural, mixed, manufactured, liquefied petroleum gas (LP-Gas) in the vapor phase and LP-Gas/air systems, and the gas burning portions of dual fuel or combination burners.

(b) Additional safety considerations which are beyond the scope of this standard shall be given to dirt-laden gases, sulfur-laden gases, high hydrogen gases, low Btu waste gases, etc., where used.

3-3.2 Burner System Selection. 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 for the temperatures to which they will be subjected.

3-3.3 Users Fuel Gas Supply Piping.

3-3.3.1 Emergency shutoff valves shall be provided to permit turning off the fuel in an emergency and shall be located so that fires, explosions, etc., at furnaces will not prevent access to these valves.

NOTE 1: Installation of LP-Gas storage and handling systems should comply with NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases.*

NOTE 2: Piping from the point of delivery to the equipment isolation valve should comply with NFPA 54, National Fuel Gas Code.

3-3.4 Equipment Fuel Gas Piping.

3-3.4.1 Manual Shutoff Valves and Cocks.

3-3.4.1.1 Individual manual shutoff valves (isolation) shall be provided for shut-off of the fuel to each piece of equipment — i.e., furnace, quenches, atmosphere generators, etc.

3-3.4.1.2 Valves and cocks shall be maintained in accordance with the manufacturer's instructions.

NOTE 1: Particular attention is directed to the need for proper lubrication of lubricated plug cocks.

NOTE 2: Quarter turn valves are recommended.

3-3.4.1.3 It shall be the user's responsibility to see that separate wrenches (handles) remain affixed to the valve, and that they are properly oriented with respect to the valve port.

3-3.4.2 Equipment Piping (Gas train piping). Equipment piping is defined as the piping which connects isolation valve equipment to the air-gas mixing device (or to the burner, if nozzle-mixing).

3-3.4.2.1 Material. Material for pipe and fittings shall comply with NFPA 54, *National Fuel Gas Code.*

3-3.4.2.2 Sizing. Pipe, fittings, and valving equipment shall be sized to prevent excessive pressure losses at the maximum rate of flow.

3-3.4.3 Pressure Regulator.

3-3.4.3.1 A pressure regulator shall be furnished wherever the plant supply pressure exceeds that required for proper burner operation or whenever the plant supply pressure is subject to excessive fluctuations.

3-3.4.3.2 Regulators 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 entry of water and insects. Vent pipe shall be of adequate size to avoid lengthening response time.

Exception: Regulators need not be vented when used with lighter-than-air fuel gases at 1 psig (7 kPa) inlet pressure or less, provided that the vent connection con-

tains a restricted orifice and discharges into a space large enough, or is ventilated well enough, so the gases escaping will not present a hazard.

3-3.4.3.3 Vent lines from multiple regulators, where manifolded together, shall be piped in such a manner that diaphragm rupture of one will not backload the others.

3-3.4.3.4 Vents from gas pressure switches, but from no other devices, may be vented into the regulator vent lines provided that switch failure shall not backload the regulator.

Exception: Regulators and zero governors may be backloaded from combustion air lines, air-gas mixture lines, and combustion chambers provided that gas escapement through the restricted vent opening will, in itself, create no additional hazard.

3-3.5 Gas Burners.

3-3.5.1 All burners shall maintain stability of the designed flame shape, with neither flashback nor blow-off, over the entire range of turndown that will be encountered during operation when supplied with combustion air and the designed fuels in the proper proportions and in the proper pressure ranges.

NOTE 1: Burner operation may be adversely affected when other than the designed fuels are used.

NOTE 2: Attention should be paid to the burner tile maintenance in order to maintain flame stability.

3-3.5.2 **Multiple-Port Burners.** Line-, ribbon-, pipe-, ring-, radiant- and diaphragm- type burners shall comply with the provisions of 3-3.5.1. In addition, they shall maintain stability of the designed flame shape throughout their entire connected length and/or area under the designed operating conditions.

3-3.5.3 **Burner Ignition.** Burners shall have the ignition source located in a position which will permit smooth and reliable ignition of the pilot/main flame over the complete stable firing range provided for in 3-3.5.1.

3-3.5.3.1 Burners having expanding pilots which are an integral part of the main burner flame shall have a reliable and smooth transition from pilot flame to main flame and vice-versa on increasing or decreasing burner firing rates.

3-3.5.3.2 For burners which cannot be safely ignited at all firing rates encountered, positive provision shall be made to reduce the burner firing rates during light-off to a lower level which will ensure a smooth and reliable ignition of the main flame (forced low fire start).

3-3.6 Air Gas Mixers.

3-3.6.1 Air-Gas Mixture Piping.

3-3.6.1.1 In the design, fabrication, and utilization of mixture piping, cognizance shall be given to the fact that the mixture is in the flammable range.

3-3.6.1.2 Piping shall be designed to provide uniformity of transverse velocity at the nozzle(s) to the degree required by the nozzle(s).

NOTE: This generally requires a minimum straight run of approximately four pipe diameters immediately upstream from the nozzle.

3-3.6.1.3 Piping shall be sized to prevent excessive pressure losses (and attendant capacity reduction) and to present essentially uniform mixture pressures at multiple nozzles.

3-3.6.1.4 Total length of mixture piping shall be as short as practical within the limits of established good practice.

3-3.6.1.5 Devices which can, or may, result in pressure loss or may adversely affect the flow velocity pattern shall not be installed in the mixture piping. Fixed balancing orifices shall be installed in the mixture piping only under the direction of the responsible manufacturer.

3-3.6.1.6 Flow control valves shall not be used in the air-gas mixture piping.

Exception: Individual control of one or more nozzles can be achieved as provided in 3-3.7 and 3-3.9.

3-3.6.2 **Mixer Adjustments.** If any field adjustable device is built into the mixer (gas orifice, air orifice, air shutter, etc.) an appropriate locking device to prevent unintentional changes in the setting shall be provided.

3-3.6.3 Mixing Blowers.

3-3.6.3.1 Mixing blowers shall not be used to function as gas mixing machines, which are covered in 3-3.9.

3-3.6.3.2 Air-gas piping and air-gas control adjustments for mixing blowers shall comply with 3-3.6.1 and 3-3.6.2. Mixing blowers shall be subject to the same limitations as are other air-gas mixers (*see 3-3.6.1.1 through 3-3.6.1.6*).

3-3.6.3.3 Mixing blowers shall not be used with fuel gases containing more than 10 percent free hydrogen (H_2).

3-3.6.3.4 Mixing blowers shall not be utilized where 10 in. w.c. (2.49 kPa) or more mixture pressure is required.

3-3.6.3.5 Mixing blowers shall be equipped with a permanent but adjustable inlet air limit stop to assure that a minimum mixture pressure can be field established to suit the requirements of the burners, the manifold, and the combustion environment.

3-3.7 Flow Control Valves.

3-3.7.1 Flow control valves of appropriate design shall be used to change the rate of flow of pressurized combustion air and/or the fuel gas where applicable.

3-3.7.2 Where the minimum and/or the maximum flow of combustion air and/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.

3-3.8 Combustion Air.

3-3.8.1 Whether supplied as primary or secondary air, and under positive, negative or atmospheric pressure, the quality and quantity of the combustion air shall be equal to, or greater than, that required for proper operation of the mixer and/or burner, and for the subsequent combustion.

3-3.8.2 Fuel burning system design shall provide for an adequate supply of combustion air. Inlet air filters shall be used on combustion blowers where required to screen out solid matter.

3-3.8.3 Precautions shall be taken to prevent insufficiently diluted products of combustion from short circuiting back into the combustion air inlet of the burner or mixer.

3-3.8.4 When primary and/or secondary air is mechanically provided, combustion air flow or pressure shall be proven and interlocked with the safety shutoff valve so that fuel gas cannot be admitted prior to establishment of combustion air, and the gas will be shut off in the event of combustion air failure.

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

3-3.8.4.1 Secondary Air Adjustment. When provided, adjustment shall include a locking device to prevent unintentional change in setting.

3-3.9 Gas Mixing Machines.

3-3.9.1 General. Any combination of proportioning control devices, blowers, or compressors which supply mixtures of fuel gas and air to burners where control devices or other obstructions are installed between the mixing device and burner is defined as a "gas mixing machine" and the provisions of 3-3.9.2, 3-3.9.3 and 3-3.9.4 shall apply.

NOTE 1: The essential difference between the mixing devices used with an air-gas mixer (3-3.6) and the gas mixing machines is the provision for a proportioning valve which responds to changes in rate of gas delivery controlled at any point between the machine and burner. There are several distinct types of gas mixing devices which come within the scope of this section and may supply premixed gas within the explosive range or with only part of the air required for complete combustion.

NOTE 2: A gas mixing machine usually consists of a pressure regulator which equalizes the gas supply pressure with air fed into a proportioning valve which in turn is connected to an air compressor.

NOTE 3: Gas mixing machines may deliver gas-air mixtures which are not within the explosive range, additional combustion air being secured at the burner, either from a burner mixer or directly from the combustion space. They also may supply mixtures within the explosive range and, when so installed, means to prevent flashbacks occurring in piping containing the flammable mixture or to prevent damage if flashback should occur, should also be provided.

3-3.9.2 Nonexplosive Mixtures (outside flammability limits). Gas mixing machines supplying gas-air mixtures which are above the upper explosive limit shall be installed as follows:

(a) A stop or other means shall be provided which will effectively prevent adjustment of the machine within or approaching the explosive range.

(b) If the machine is located in a small detached building or cut-off room, explosion vents shall be provided in the ratio of 1 sq ft (0.092 m^2) of vent area to each 20 cu ft (0.57 m^3) of room volume (*see NFPA 68, Guide for Explosion Venting*).

NOTE 1: The choice of location varies considerably in individual installation. In large, well-ventilated manufacturing areas there is relatively little chance of leakage accumulating in explosive gas-air mixtures and, under such conditions, the machine may well form an integral part of a furnace heating system.

NOTE 2: In considering small rooms where explosive gas-air mixtures could be formed, the machine is better located in a detached building or in a small room cut off by concrete walls bonded into the floor and ceiling and provided with explosion relief vents to outdoors. Entrance to this room should be directly from outdoors.

NOTE 3: Machines should, if practical, be constructed so that, in the event of an explosive mixture forming and flashback resulting, the machine casing will not be ruptured.

NOTE 4: Air intakes for gas mixing machines and blowers using compressors or blowers should be taken from outdoors wherever practical.

(c) When gas mixing machines are installed in well-ventilated areas, the type of electrical equipment shall be governed by NFPA 70, *National Electrical Code*, requirements for general service conditions unless other hazards in the area prevail.

(d) When gas mixing machines are installed in small detached buildings or cutoff rooms, the electrical equipment and wiring shall be installed in accordance with NFPA 70, *National Electrical Code*, requirements for hazardous (classified) locations (Article 500, Class 1, Division 2).

3-3.9.3 Explosive Mixtures (within flammability limits). Gas mixing machines supplying gas-air mixtures within the explosive range shall be installed in accordance with 3-3.9.2 (b), (c), and (d) and the following shall also apply:

(a) Automatic fire checks and safety blowouts shall be provided.

(b) Burners used with explosive mixtures shall be designed with port areas and length of gas passage through each port such that the possibility of backfire is largely eliminated.

NOTE: When necessary to secure stability of operation, water-cooled burners may be used.

3-3.9.4 Controls for gas mixing machines shall include interlocks and safety shutoff valves in the gas supply connection to each machine arranged to automatically shut off the gas supply in the event of air and/or gas supply failure (*see Chapter 5*).

3-3.10 Fuel Ignition.

3-3.10.1 Whenever filling of the combustion chamber with flammable air-fuel mixture can result in an explosive condition, the length of time allotted for flame ignition and the rate of fuel input at ignition shall be correlated so that the lower explosive limit with respect to the combustion chamber volume is not exceeded.

NOTE: Fuel-air mixtures of a ratio within the flammable range are ignited by means of electric arc, hot wire, pilot burner flame, hand-held torch, etc. A burner is suitably ignited when combustion of the fuel-air mixture is established and stable at the discharge port(s) of the nozzle(s) or in the contiguous combustion tunnel.

3-3.10.2 Ignition shall be effectively applied at the proper point with sufficient intensity to ignite the fuel-air mixture.

3-3.10.3 Pilot Burners. The provisions of 3-3.5, Gas Burners, shall also apply to pilot burners.

3-3.10.4 If pilot mixers are used, the provisions of 3-3.6, Air-Gas Mixers, shall also apply to pilot mixers.

3-3.10.5 Combustion Air. The provisions of 3-3.8, Combustion Air, shall apply.

3-3.10.6 Fixed Pilots.

3-3.10.6.1 The pilot burner shall be located as required to reliably ignite the main flame, and as directed by the manufacturer.

3-3.10.6.2 The pilot shall be so mounted to prevent unintentional changes in location, and in direction with respect to the main flame.

3-4 Oil-Fired Units.

3-4.1 Scope.

(a) This section includes combustion systems for furnaces fired with No. 2, No. 4, No. 5, and No. 6 industrial fuel oils as specified by ASTM D396, *Specifications for Fuel Oils*. It also includes the oil-burning portions of dual fuel and combination burners.

(b) Additional considerations which are beyond the scope of this standard shall be given to other combustible liquids not specified in 3-4.1(a).

3-4.2 In the design of, and the use of, oil-fired units, attention shall be given to the following:

(a) Unlike fuel gases, many important physical/chemical characteristics are not available for fuel oil which, being a complex mixture of hydrocarbons, is relatively unpredictable.

(b) Fuel oil must be vaporized prior to combustion. Heat generated by the combustion is commonly utilized for this purpose, and oil will remain in the vapor phase as long as sufficient temperature is present. Under these conditions, oil vapor can be treated like fuel gas.

(c) Unlike fuel gas, oil vapor will condense into liquid when the temperature falls too low; and will revaporize whenever the temperature rises to an indeterminate point. Therefore, oil in a cold furnace can lead to a hazardous condition for it cannot be purged out as fuel gas may, but oil may vaporize (to become a gas) when, or because, furnace operating temperature is reached.

(d) Unlike water, for example, there is no published relationship between temperature and vapor pressure for fuel oil. For purposes of comparison, a gallon of fuel oil is equivalent to 140 cu ft (4.0 m^3) of natural gas, hence 1 oz (0.03 kg) equals approximately 1 cu ft (0.03 m^3).

3-4.3 Burner System Selection. 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 will be subjected.

3-4.3.1 This shall not be interpreted to imply that a burner system selected for No. 2 fuel oil must be capable of handling No. 4, No. 5, or No. 6 fuel oil, or vice versa.

3-4.4 Oil Supply Piping.

3-4.4.1 Storage tank and its installation shall comply with NFPA 31, *Standard for the Installation of Oil Burning Equipment*.

3-4.4.2 Piping materials shall be wrought iron, steel, brass or copper. Pipe shall be connected with standard fittings, tubing with listed fittings. Connectors made of, or utilizing, combustible materials shall not be used. Unions requiring gaskets and sweat fittings employing solder having a melting point of less than 1000°F (537°C) shall not be used. Cast-iron fittings shall not be used.

3-4.4.3 Manual Shutoff Valves and Cocks.

3-4.4.3.1 Manual shutoff valves shall be installed to avoid oil spillage during servicing of supply piping and associated components.

3-4.4.3.2 Manual shutoff valves shall be provided for shutoff of the fuel to the pilot and/or burner for shutdown.

3-4.4.3.3 Valves shall be maintained in accordance with the manufacturer's instructions.

NOTE: Quarter turn valves are recommended.

3-4.4.3.4 It shall be the user's responsibility to see that separate wrenches (handles) remain affixed to the valve, and that they are properly oriented with respect to the valve's port.

3-4.4.4 Emergency Shutoff Valves. Valves shall be provided to permit turning off the fuel in an emergency and shall be located so that fires, explosions, etc., at furnaces will not prevent access to these valves.

NOTE: A positive displacement oil pump can serve as one valve by shutting off the power to it.

3-4.4.5 All air from the supply and return piping shall be initially purged and air entrainment in the oil shall be minimized.

NOTE 1: 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.

NOTE 2: Manual vent valves may be needed to bleed air from the high points of the oil supply piping.

3-4.4.6 Suction, supply and return piping shall be adequately sized with respect to oil pump capacity.

3-4.4.6.1 Oil shall be supplied to the furnace site properly conditioned by the user.

3-4.4.7 Whenever a section of oil piping can be shut off at both ends, consideration shall be given to the use of relief valves and/or expansion chambers to release the pressure caused by thermal expansion of the oil.

NOTE: The weight of the oil is always a consideration in vertical runs. When going up, pressure will be lost. One hundred psig (689 kPa) with a 100 ft (30.5 m) lift will net only 63 psig (434 kPa). When going down, pressure will be added. One hundred psig (689 kPa) with a 100 ft (30.5 m) drop will net 137 psig (945 kPa). This also occurs with fuel gas, but it is most often of no importance. However, it can never be overlooked when handling oil (*see Table 3-4.4.7*).

Table 3-4.4.7 Useful Conversion Data

(14.7 psig = 29.92 in. Hg = 33.9 ft H_2O = 39.89 ft .85 SG OIL)
psig = 6895 Pa; in. Hg = 3377 Pa; ft H_2O = 2986 Pa

NOTE: 14.7 psig and 29.92 in. Hg are sea level figures.

FROM TO	psig	in. Hg	ft. H_2O	ft. .85 SG OIL
One psig =	1	2.04	2.31	2.71
One in. Hg =	0.49	1	1.13	1.33
One ft. H_2O =	0.43	0.88	1	1.18
One ft. .85 SG OIL =	0.37	0.75	0.85	1

3-4.5 Equipment Oil Piping.

3-4.5.1 Equipment oil piping (oil train) means that piping which connects from the supply leg of the circulating loop to one or more furnace burner systems.

3-4.5.2 Piping shall connect to the bottom of the supply leg (to minimize air entrainment.).

3-4.5.3 Materials shall be in accordance with 3-4.4.2.

3-4.5.4 Piping shall be adequately sized for maximum flow rate.

3-4.5.5 Consideration shall be given to shutoff valves (refer to 3-4.4.3, 3-4.4.4 and 3-4.4.7).

3-4.6 Oil Train Piping.

3-4.6.1 Oil train piping means that piping which connects the equipment oil piping to the burner.

3-4.6.2 The provisions of 3-4.5.3 and 3-4.5.4 shall apply.

3-4.6.3 Manual Shutoff Valve. A manual shutoff valve having provision for position indication shall be located upstream from all other components to shutoff the flow of oil for servicing, and for other shutdowns.

3-4.6.4 Pressure Regulator.

3-4.6.4.1 A suitable pressure regulator shall be furnished whenever the plant supply pressure exceeds that required for proper burner system operation, or whenever the plant supply pressure is subject to excessive fluctuation.

3-4.6.5 Oil Filters and Strainers.

3-4.6.5.1 An oil filter shall be installed in the oil train piping to protect the downstream components.

3-4.6.5.2 The degree of filtration shall be compatible with the size of the most critical clearance being protected.

NOTE: Customarily, a filter/strainer is installed in the suction piping to protect the pump. A secondary filter/strainer is often installed in the discharge line. However, neither of these are usually fine-meshed to the point required for total burner and valving protection.

3-4.6.5.3 The filter housing and cartridge shall be suitable for the intended pressure, temperature, and service.

3-4.7 Oil Burners.

3-4.7.1 Oil burners shall be of a type and design suitable for the intended service.

3-4.7.1.1 The burner shall accept fuel oil of the proper grade which has been preconditioned properly for combustion.

3-4.7.1.2 The burner shall maintain self-sustained combustion.

3-4.7.2 Oil Atomization.

3-4.7.2.1 Oil shall be atomized to the droplet size as required for proper combustion throughout the firing range.

NOTE: The atomizing medium may be steam, compressed air, low-pressure air, air-gas mixture, fuel gas, or other gases. Atomization may also be mechanical (mechanical-atomizing tip or rotary cup).

3-4.7.2.2 The atomizing device shall be accessible for inspection, cleaning, repair, replacement, and other maintenance as required.

3-4.7.3 Burner Ignition.

3-4.7.3.1 Burners shall ignite completely, smoothly, and reliably from the ignition source presented. If a burner cannot be safely ignited at all firing rates encountered, positive provision shall be made to assure the existence of a firing rate suitable for safe light-off.

3-4.7.4 Burner Shutdown. If clearance 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 allied fans and blowers in operation.

3-4.7.5 All pressures involved in the safe operation of the combustion system shall be maintained within the proper ranges throughout the firing cycle.

3-4.8 Flow Control Valves.

3-4.8.1 Flow control valves of appropriate design shall be used to change the rate of flow of pressurized combustion air and/or the fuel oil where applicable.

3-4.8.2 Where the minimum and/or the maximum flow of combustion air and/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.

3-4.9 Combustion Air.

3-4.9.1 Whether supplied as primary, secondary, or atomizing air, under positive, negative or atmospheric pressure, the quality and quantity of the air shall be equal to, or greater than, that required for proper operation of the mixer and/or burner, and for the subsequent combustion.

3-4.9.2 Fuel burning systems shall be assured of an adequate supply of combustion air. Inlet air filters shall be used on combustion blowers where required to screen out solid matter.

3-4.9.3 Precautions shall be taken to prevent insufficiently diluted products of combustion from short-circuiting back into the combustion air inlet of the mixer.

3-4.9.4 When air pressure and/or flow is mechanically provided, it shall be proven electrically and/or pneumatically, and interlocked with the safety shutoff valve so that oil cannot be admitted prior to establishment of combustion air, and the oil will be shut off in the event of combustion air failure.

3-4.10 Dual-Fuel and Combination Burners.

3-4.10.1 When fuel gas and fuel oil are to be fired individually (dual-fuel) or simultaneously (combination) the provisions of Sections 3-3 and 3-4 shall apply equally to the respective fuels.

3-5 Electrically Heated Units.

3-5.1 General.

3-5.1.1 **Scope.** This section includes all types of heating systems where electrical energy is used as the source of heat.

3-5.1.2 **Safety Equipment.** Safety equipment including air flow interlocks, time relays, and temperature switches shall be in accordance with Chapter 5.

3-5.1.3 **Electrical Installation.** All parts of the electrical installation shall be in accordance with NFPA 70, *National Electrical Code*.

3-5.2 Resistance Heating Systems.

3-5.2.1 **General.** The following paragraphs shall apply to resistance heating systems including infrared lamp (quartz, ceramic, and tubular glass types).

3-5.2.2 Enclosure.

3-5.2.2.1 External electric heating systems shall be encased in a sufficiently insulated chamber to prevent injury to personnel and property.

3-5.2.2.2 The heater housing shall be so constructed as to provide easy accessibility to heating elements and wiring.

3-5.2.2.3 Heating elements shall be securely supported so that they will not easily become dislodged from their intended location. Heating elements, electrically insulated from and supported from a metallic frame, shall have the frame electrically grounded.

3-5.2.2.4 "Open"-type resistor heating elements shall be supported upon electrically insulated hangers and shall be constrained from motion induced by thermal stress which could result in adjacent segments of the elements touching one another or from touching a grounded surface.

3-5.2.3 Heater Locations.

3-5.2.3.1 Heaters shall not be located directly under the product being heated where combustible materials may drop and accumulate.

3-5.2.3.2 External parts of furnace heaters which operate at temperatures in excess of 160°F (71°C), or which are energized at voltages specified in Article 725 of NFPA 70, *National Electrical Code*, shall be guarded. Where impractical to guard, warning signs shall be mounted or permanent floor markings shall be provided, visible to personnel entering the area.

3-5.2.4 Construction.

3-5.2.4.1 Where insulators are used, they shall be supported so they will resist falling out of place.

3-5.2.4.2 All parts of equipment operating at elevated temperatures shall be installed in accordance with 2-1.5, *Floors and Clearances*.

3-5.2.5 Safety Devices for Resistance Heaters. (*Refer to Chapter 5.*)

3-5.3 Induction and Dielectric Heating Systems.

3-5.3.1 **General.** The following paragraphs shall apply to induction and dielectric heating systems. This type of heating shall be designed and installed in accordance with NFPA 70, *National Electrical Code*, with special reference to Article 665, Induction and Dielectric Heating Equipment.

NOTE: To prevent spurious radiation caused by this type of equipment and to ensure that the frequency spectrum is utilized equitably, the Federal Communications Commission (FCC) has established rules (*Code of Federal Regulations*, Title 47, Part 18) which govern the use of industrial heating equipment of this type operating above 10 kHz.

3-5.3.2 **Installation.** High-frequency induction equipment and dielectric heating systems shall not be installed in hazardous locations. (*See Article 665 of NFPA 70, National Electrical Code.*)

3-5.3.3 Construction.

3-5.3.3.1 Frames, enclosures, and shelves shall be of noncombustible construction and shall be sufficiently strong to resist physical damage.

3-5.3.3.2 Combustible electrical insulation shall be reduced to a minimum.

NOTE: Transformers should be of the dry, high fire point or nonflammable liquid type. Dry transformers should be in compliance with NEMA TR27-4.03, 150°C rise insulation.

3-5.3.3.3 Protection shall be installed to prevent overheating of any part of the equipment, in accordance with NFPA 70, *National Electrical Code.*

3-5.3.3.4 When 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 will not damage the electrical equipment. The cooling-water supply shall be interlocked with the power supply so that loss of water will cut off the power supply. Consideration shall be given to providing individual pressure flow interlocks for parallel water flow paths.

3-5.3.3.5 When 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.

3-5.3.3.6 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.

3-5.3.3.7 Dielectric heaters used for treating highly combustible materials shall be designed to prevent a disruptive discharge between the electrodes.

3-6 Afterburners and Heat Recovery Systems.

3-6.1 General. Afterburners are systems intended to convert furnace emissions by direct thermal oxidation.

3-6.2 Design and operation of combustion systems and controls shall comply with all parts of this standard pertaining to direct-fired furnaces.

3-6.3 Interlocks shall be provided to ensure that proper operation is maintained in conjunction with the fume-generating process and that sufficient operating temperatures are sustained for acceptable thermal destruction of fumes.

NOTE: Afterburner systems may or may not employ various heat exchange devices to reduce fuel usage.

3-6.4 Excess temperature protection shall be provided to prevent uncontrolled temperature rise. Forms of protection may include one or more of the following:

1. Excess temperature limit switches.
2. Interruption of the fume-generating process.
3. Dilution with fresh air or inert gas.
4. Partial emission stream bypass of heat exchanger.

NOTE: Structural supports, thermal expansion joints, and protective insulation for afterburner housings, stacks, related ductwork and/or heat recovery systems utilizing afterburner exhaust gases should be designed for high operating temperatures.

3-6.5 When heat recovery systems are employed and portions of the afterburner exhaust gases are utilized as the heat source for one or more of the zones of the fume-generating furnace, special precautions shall be taken to prevent recycling combustible vapors. An adequate supply of fresh air shall be introduced into the system to provide the oxygen necessary for combustion of any special atmosphere gas as well as primary burner fuel.

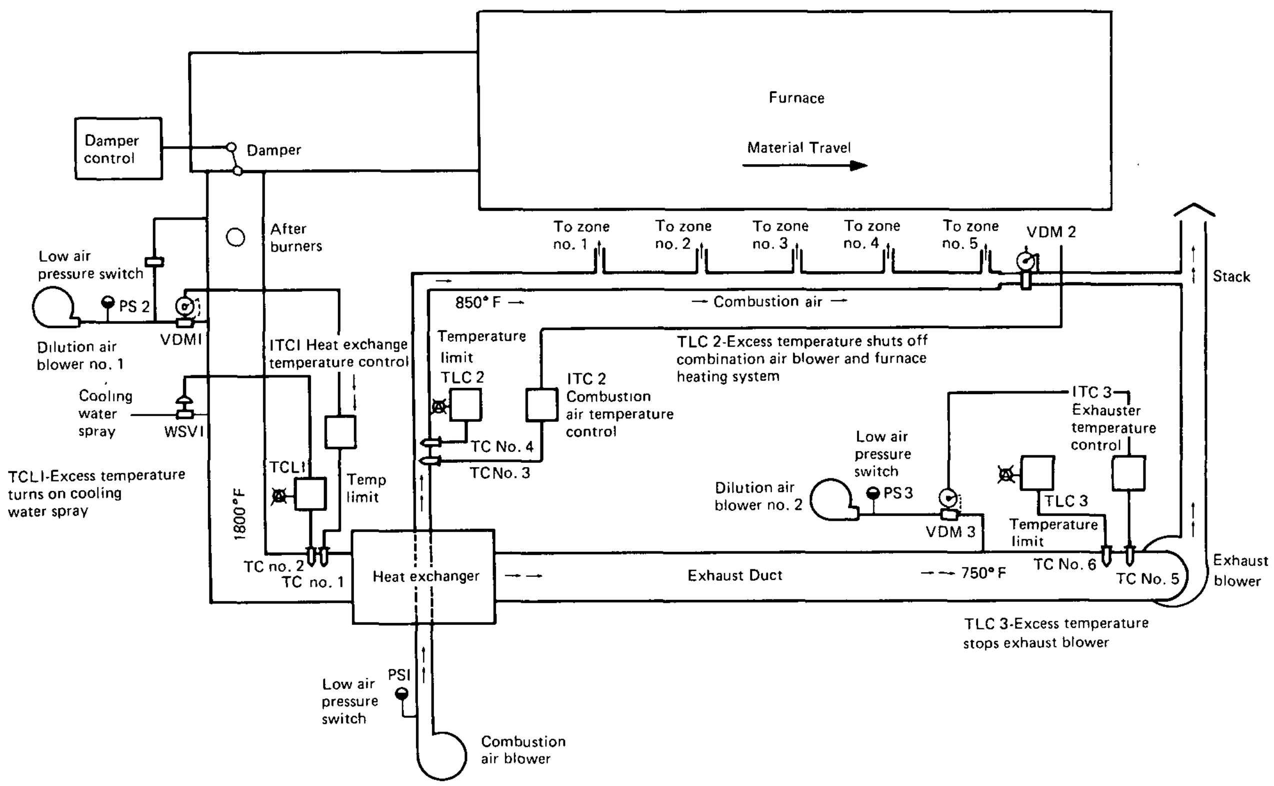


Figure 3-6 Typical Example of Afterburner and Heat Recovery System.

Chapter 4 Safety Equipment and Application

4-1 General.

4-1.1 This chapter includes heating systems for furnaces and quench tanks. Special atmosphere generators are excluded and are covered in Chapter 6. Section 4-2, concerning the application of programmable controllers, shall apply to all safety controls included in all chapters of this standard.

4-1.2 For the protection of personnel and property, careful consideration shall be given to the supervision and/or monitoring of conditions which may cause, or may lead to, a real or potential hazard on any given installation.

4-1.2.1 Fuel-fired units shall be provided with all safety devices in accordance with established safe practices.

4-1.2.2 Safety considerations shall extend to allied equipment, and to other proximate equipment, to avoid additional contributory hazards.

4-1.2.3 A safety shutdown of the heating system by any of the prescribed safety features or devices shall require manual intervention of an operator for re-establishment of normal operation of the system.

4-1.3 It shall be noted that:

(a) The mere presence of safety equipment on an installation cannot, in itself, assure absolute safety of operation.

(b) There is no substitute for a diligent, capable, well-trained operator.

(c) Highly repetitive operational cycling of any safety device may reduce its life span.

(d) Electric relays and fuel safety shutoff valves are not substitutes for main shutoff cocks (valves) and disconnects.

4-1.4 Regularly scheduled inspection and maintenance of all safety devices shall be performed by the user. (*See Chapter 14.*)

4-1.4.1 It shall be the sole responsibility of the user to establish, schedule and enforce the frequency of and the extent of the inspection/maintenance program (as well as the corrective action to be taken) because only the user can know the actual operating conditions.

4-1.4.2 It shall be the responsibility of the equipment manufacturer to provide suitable recommendations and/or suggestions on maintenance and inspection procedures.

4-1.5 Safety devices shall be properly installed, used and maintained in accordance with the manufacturer's instructions.

4-1.6 Safety devices shall be located to protect against physical damage and inadvertent tampering.

4-1.7 Safety devices shall not be shorted out nor shall they be bypassed.

4-2 Programmable Controllers.

4-2.1 When a programmable controller is used, the following requirements shall apply:

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

(b) The control system shall have a separate manual emergency switch, independent of the programmable controller, that will cause the system to revert to a safe condition.

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

(d) The programmable controller shall have the capability of detecting failures and unprogrammed logic changes of its safety-dependent inputs and outputs and, upon detection of same, shall annunciate and cause the system to revert to a safe condition.

(e) 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 also be separated from all other programming. Application software that contains safety logic or detection logic shall not be modified in any manner that does not comply with this standard. The authority having jurisdiction shall be notified, in writing for permanent documentation, of any changes.

(f) System operation shall be verified for compliance with this standard whenever the programmable controller is replaced, repaired, or updated.

(g) 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.

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

(i) The system access shall be limited by incorporating measures to prevent remote or local instructions to the programmable controller that could result in hazards to personnel or equipment.

(j) Only approved programmable controller-based systems meeting the above requirements shall be used to control the equipment as listed under 4-1.1.

NOTE: Other programmable controller-based systems may be used only to monitor.

4-2.2 When a programmable controller is used in conjunction with the combustion safeguard circuitry, the following additional requirements shall apply:

(a) Failures that create a hazard shall cause the system to revert to a safe condition.

(b) Combustion safety interlocks approved combustion safeguard and excess temperature limits shall be wired to directly de-energize the safety shutoff valve and their operation shall result in a safe system condition.

Exception: Programmable controller-based systems approved for flame safeguard application may be directly applied and utilized for combustion safety.

NOTE: Programmable controllers *not* approved for flame safety service may be used *only* to monitor equipment, except that isolated programmable controller contacts (not directly connected to a power source) may be wired in series with the above safety circuits.

4-3 Preignition (Prepurge, Purging Cycle).

4-3.1 Prior to each furnace start-up, provision shall be made for the removal of all flammable vapors and/or gases which may have entered during the shutdown period.

4-3.1.1 At least 4 standard cu ft (SCF) of fresh air per cu ft (4 m^3/m^3 at 20°C) of furnace volume shall be introduced during the purging cycle.

Exception: Inert-atmosphere furnaces may be purged with an inert gas (see Chapter 6).

4-3.1.2 Preignition purging of radiant tube-type heating systems is not required; however, special conditions may require purging of the furnace work chamber.

4-4 Flue Product Venting. A suitable collecting and venting system for the radiant tube-type heating systems shall be provided by the user. The system shall be of sufficient capacity to render the total unburned input capacity of the radiant tubes noncombustible.

4-4.1 The flue venting products system shall be considered part of the plant exhaust.

4-5 Combustion Air Safety Devices (Fuel-Fired Units).

4-5.1 When the air from the exhaust and/or recirculating fans is required for combustion of the fuel, air flow shall be proven prior to an ignition attempt and reduction of air flows to an unsafe level shall result in closure of the safety shutoff valve.

4-5.2 When a combustion air blower is used, the minimum combustion air pressure required for proper burner operation shall be proven prior to each attempt at ignition.

4-5.2.1 Motor starter shall be interlocked in the safety circuitry.

4-5.2.2 A low pressure switch shall be used to sense and monitor combustion air pressure or differential pressure, interlocked into the safety circuitry.

4-5.3 Whenever it is possible for combustion air pressure to exceed a maximum safe operating pressure, as might occur when compressed air is utilized, a pressure-reducing valve, a high pressure switch, and a low pressure switch shall be used.

4-6 Fuel Safety Devices.

4-6.1 General.

4-6.1.1 As with all safety devices, improper application and/or adjustment can result in repeated and unscheduled shutdowns. Improper corrective action (bypassing, jumpering-out, etc.) can lead to a hazardous condition, and shall not be taken to sustain production.

4-6.1.2 A manual reset feature shall be provided to prevent unintentional recycling of the safety system, or any portion of it.

4-6.2 Safety Shutoff Valves (Fuel Gas or Oil).

4-6.2.1 General.

4-6.2.1.1 The safety shutoff valve shall be the "Key Unit" of all safety controls used to protect against the explosion or fire hazards which could result from accidental interruption to various services or operations, such as flame failure, failure of fuel pressure, failure of combustion air pressure, failure of exhaust or recirculation fans, excessive temperatures, or power failure.

4-6.2.1.2 Safety shutoff valves shall automatically shut off the fuel to the burner system after interruption of the holding medium by any one of the interlocking safety devices or operating control where units cycle on and off. They shall be self-closing and not readily bypassed or blocked open. Safety shutoff valves shall not be used as modulating temperature control valves.

Exception No. 1: Installations requiring a valve 8 in. (200 mm) IPS or larger may employ such safety shutoff valves as a dual purpose valve, namely a temperature control valve.

Exception No. 2: Particulate matter or corrosive materials may impair the operation of the valve. For example, coke furnace gas service may employ such safety shutoff valve as a dual purpose valve for temperature and/or pressure control.

4-6.2.1.3 Valve components shall be of a material suitable for the fuel handled and ambient temperature.

4-6.2.1.4 Valves shall not be subjected to pressures in excess of manufacturer's ratings.

4-6.2.1.4.1 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 shall be vented to a safe location.

4-6.2.1.5 Position indication shall be provided for safety shutoff valves to main burners in excess of 150,000 BTU/hr (44 kw).

4-6.2.2 Fuel Gas Safety Shutoff Valves.

4-6.2.2.1 When main or pilot fuel gas burner system capacity exceeds 400,000 BTU/hr (117 kw), two approved safety shutoff valves (piped in series) shall be used. If the main or pilot fuel gas burner capacity is 400,000 BTU/hr (117 kw) or less, a single approved safety shutoff valve may be used in place of the double safety shutoff valves.

Exception No. 1: If main or pilot fuel gas burner capacity is 400,000 BTU/hr (117 kw) or less, a single approved safety shutoff valve may be used in place of the double safety shutoff valves.

Exception No. 2: When the pilot supply line is located downstream of the first safety shutoff valve, means shall be provided to prevent the introduction of gas to the main burners prior to energizing the pilot valve.

4-6.2.2.2 A permanent and ready means for making tightness checks of all main burners fuel gas safety shutoff valves shall be provided (*see Chapter 14, Inspection and Maintenance*).

4-6.2.3 Oil Safety Shutoff Valves.

4-6.2.3.1 An approved safety shutoff valve or valves shall be provided for shutting off fuel oil to the burner or burners being protected.

NOTE: Two approved safety shutoff valves should be provided under any one of the following conditions: (a) When the pressure is greater than 125 psi (862 kPa); (b) Whenever the fuel oil pump operates without main oil burner firing, regardless of the pressure; (c) With combination gas/oil burners when the fuel oil pump operates during the fuel gas burner operation.

4-6.3 Fuel Pressure Switches (Gas or Oil).

4-6.3.1 A low pressure switch shall be provided for, and interlocked with, each burner system's safety shutoff valve.

4-6.3.2 Whenever the normal fuel pressure to the pressure regulator immediately upstream from the safety shutoff valve exceeds the design limits of the burner system, a high pressure switch shall be provided, and interlocked with the burner system's safety shutoff valve, as in 4-6.3.1.

4-6.3.3 Pressure switch settings shall be made in accordance with design limits of the burner system and/or the heating unit.

4-6.4 Combustion Safeguards (Flame Supervision).

4-6.4.1 Each burner flame shall be supervised by an approved combustion safeguard, having a nominal flame response timing of 4 seconds or less, interlocked with the safety circuitry.

Exception No. 1: It is permissible to supervise flames at the intersection of the main burner flame and the pilot flame rather than provide supervision equipment for both.

Exception No. 2: Neither interrupted pilot nor second flame sensor are required for self-piloted burners, as defined in Section 1-4.

Exception No. 3: Supervision of the main burner flame may be accomplished by either a second sensor applied to the main flame only, or by interruption of the main burner ignition pilot.

Exception No. 4: Multiple burners, where combustion safeguards for each burner are too numerous to be practical, can use continuous line-burner-type pilots for groups of burners (see 3-3.5.2). An approved combustion safeguard shall be provided at the far end of each line-burner-type pilot, away from the pilot fuel source, with sensing element located at the junction of the flame paths of both pilot and last main burner. The pilot safety shutoff valve must be initially opened by a manual momentary push button.

Exception No. 5: Where two premix burners, which will reliably ignite one from the other, are used, it shall be permissible to use a single approved combustion safeguard, supervising one of the burners; the supervised

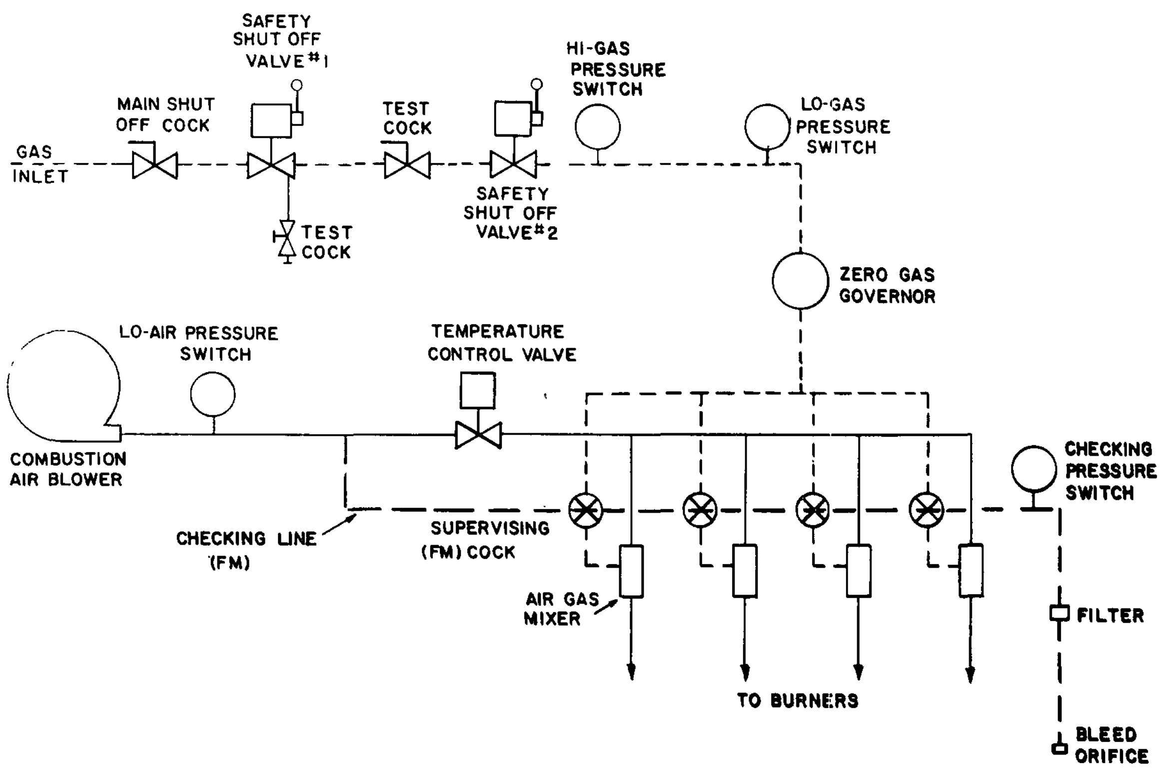


Figure 4-6.4.1(a) Piping.

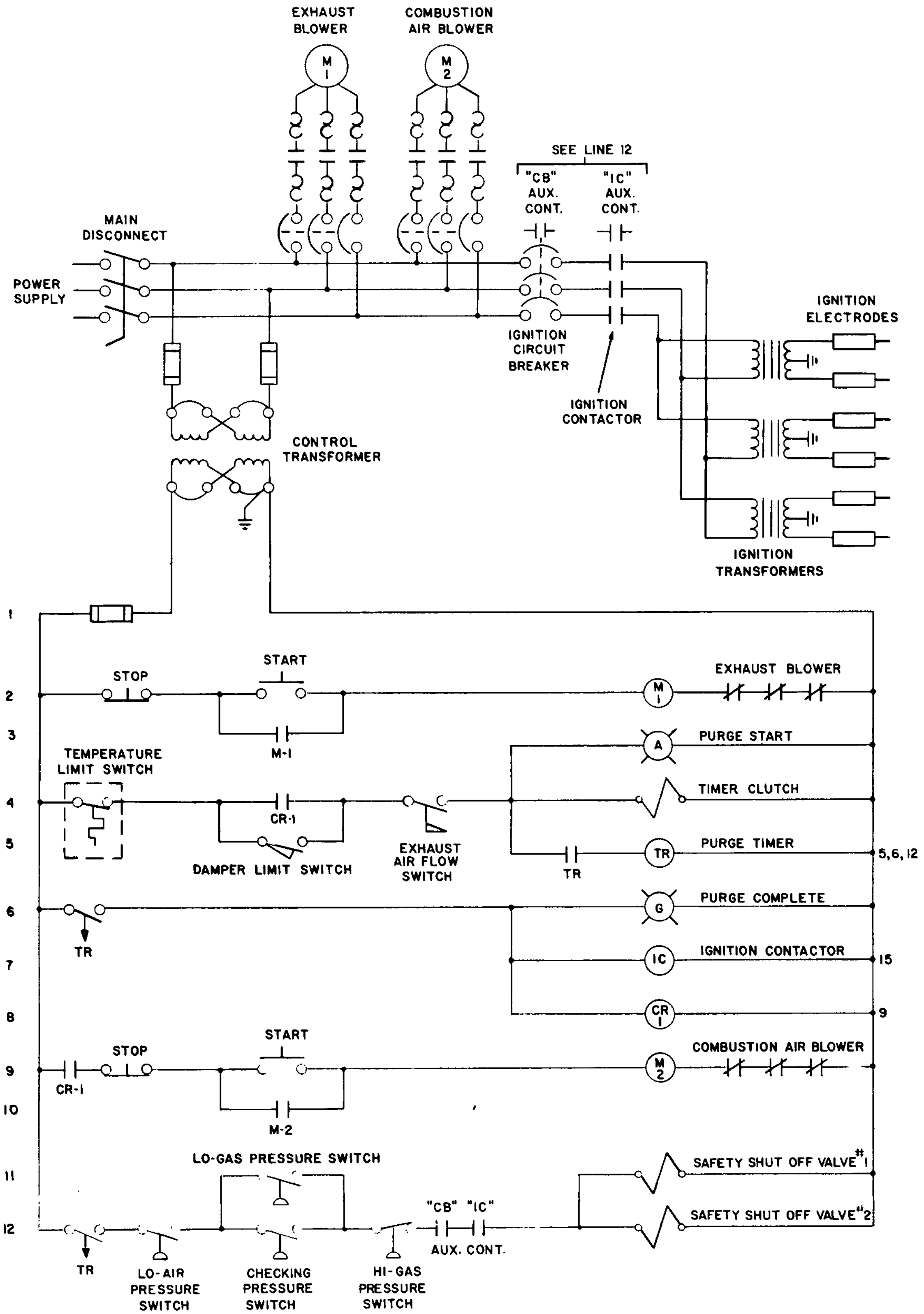


Figure 4-6.4.1(a) Electrical.

Figure 4-6.4.1(a) Examples of a Supervising Cock and Fuel Gas Safety Control System.

NOTE: A method of assuring closure of all individual fuel gas burner cocks before the main burner fuel gas safety shutoff valve can be opened is the supervising cock and fuel gas safety control system. A typical piping and wiring arrangement using the pneumatic-type supervising cock is illustrated in Figure 4-6.4.1(a). (*See Section 1-4, Supervising Cock.*) The number and location of pressure switches, arrangement of tubing and other details will vary with the individual installation. In the illustration, the main burner safety shutoff valve cannot be opened until the supervising cocks are closed, combustion air pressure is normal, and normal fuel gas pressure present in the pilot burner manifold. Power failure, loss of combustion air, and/or gas pressure failure during normal firing will shut and lock out the main burner and pilot safety shutoff valves. Once the initial check has been completed and the main burner safety shutoff valve is opened, the low fuel gas pressure switch downstream from the safety shutoff valve shunts the checking pressure switch so that, after lighting the pilots, the supervising cocks can be opened to light-off.

A typical piping and wiring arrangement for the electric interlocking-type supervising cock is also illustrated in Figure 4-6.4.1(b). The main burner safety shutoff valve cannot be opened until all supervising cocks are closed (cock switch contacts in series are all closed), ventilation fans operating, preventilation purge completed and other interlocks satisfied.

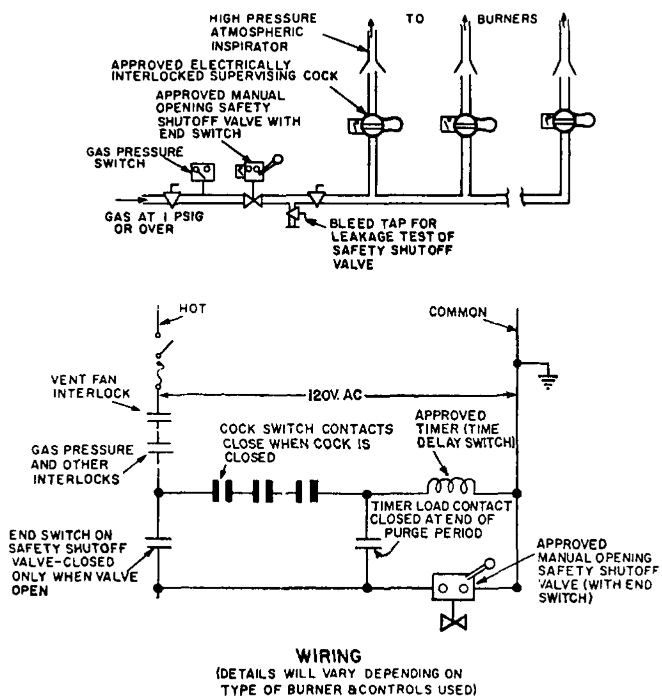


Figure 4-6.4.1(b) Example of a Safety Control System Piping and Wiring, Electric Interlock-type Supervising Cock.

burner shall burn continuously at a firing rate at all times sufficient to reliably ignite the unsupervised burner.

Exception No. 6: Burners for direct-fired heating systems which supply a furnace at a fuel rate not exceeding 150,000 BTU/hr (44 kw) may be equipped with heat-actuated combustion safeguards or safety pilots. For small equipment under constant attendance, approaching in size the household gas range or very small laboratory test furnace, combustion safeguards may be omitted, subject to approval of the authority having jurisdiction.

Exception No. 7: In general, for greatest security, all burners should be protected with combustion safeguards as outlined in the foregoing sections. When this is not practical from an engineering standpoint, the maximum practical protection shall be furnished by providing a reliable source of ignition at each burner, and/or operating burners on high-low flame, and by installing devices (pressure switches and safety shutoff valves) to assure, where practical, closure of all individual burner cocks [see Figures 4-6.4.1 (a) and (b)] before the main burner safety shutoff valve can be opened, and to shut off all fuel in case of high and low fuel pressure and low air pressure, where air pressure is necessary for operation of burners and controls, subject to the approval of the authority having jurisdiction.

Exception No. 8: Radiant tube heating systems utilizing explosion-resistant tube construction do not require combustion safeguards. However, a suitable means of ignition shall be provided.

Exception No. 9: On furnace zones, when a combination of burners with and without flame supervision exists, it is permissible to switch the flame supervision out of the safety circuit for that zone when the zone temperature is at or above 1400°F (760°C). The burners without flame supervision shall be interlocked to prevent their operation until the zone temperature is at or above 1400°F (760°C). The flame supervision shall become part of the safety circuit when the zone temperature drops below 1400°F (760°C).

4-6.4.2 Automatic relight after unintentional flame failure shall be prohibited.

4-6.4.3 Trial for ignition of pilots or main burners shall not exceed 15 seconds.

Exception: Longer time, up to a maximum of 60 seconds, may be permitted for ignition provided:

(a) Written request for extension of trial for ignition is filed with the authority having jurisdiction and

(b) It is determined that 25 percent of the lower explosive limit will not be exceeded in the extended time.

4-6.5 Fuel Oil Atomization, other than Mechanical Atomization.

4-6.5.1 Adequate pressure/flow of the atomizing medium shall be proven to exist before the fuel oil enters the burning zone.

4-6.5.2 If a low pressure switch is used to sense/supervise the atomizing medium, consideration shall be given to locating it downstream from all cocks, valves, and other obstructions which can shut off flow or cause excessive pressure drop of atomization medium.

4-6.6 Low Fuel Oil Temperature Limit Devices.

4-6.6.1 A low fuel oil temperature limit device shall be provided and interlocked to de-energize the oil safety shutoff valve(s) whenever fuel oil temperature falls below a safe predetermined level and under the following conditions:

(a) Whenever the temperature of the fuel oil can drop below a safe level for proper atomization.

(b) When a fuel oil preheater is used.

(c) With No. 2 and 4 fuel oil when its temperature may reach the congealing point, whether or not preheaters are used.

4-6.7 Multiple fuel systems require safety devices for the secondary fuel(s) that are equivalent to those devices used for the primary fuel; i.e., the fact that oil or gas may be considered to be a standby fuel for a dual fuel burner system shall not lessen the safety requirements for that portion.

4-6.7.1 When dual fuel burners are used, positive provision shall be made to prevent simultaneous introduction of both fuels.

NOTE: Not applicable to combination burners.

4-7 Fuel Gas Mixing Machines. Safety equipment and installation shall comply with NFPA 54, *National Fuel Gas Code*.

4-8 Ignition of Main Burners — Fuel Gas or Oil.

4-8.1 Burners shall be ignited by a manual torch or by a continuous, intermittent or interrupted pilot burner or by direct electrical means.

4-8.1.1 Sufficient energy shall be provided for safe and proper ignition of the burners.

4-8.1.2 If any specific input, or a limited range of inputs is required for safe ignition, the fuel control valve shall be properly positioned and interlocked prior to each and every attempt at ignition.

4-8.2 Electrical ignition energy for direct spark ignition systems shall be terminated after the main burner trial for ignition period.

Exception No. 1: Repetitive operation of a direct spark igniter for multiple burners is allowed where the input per burner does not exceed 150,000 BTU/hr (44 kw).

Exception No. 2: Repetitive operation of a direct spark igniter for radiant tubes is allowed.

4-8.3 If one or more main burners are to be ignited from another main burner, the burden for proof of reliability shall rest with the equipment manufacturer.

4-9 Excess Temperature Limit Controller.

4-9.1 An excess temperature limit controller shall be used on any heating unit where it is possible for the controlled temperature to exceed a safe limit.

Exception: A single/multipoint recorder with excess temperature switch capability may be used as an excess temperature controller providing it meets all the criteria listed in 4-9.1, 4-9.2, 4-9.3, and 4-9.4. This recorder shall not be used as the operating temperature controller. This instrument shall not have a switch that can void the high limit contact.

4-9.1.1 The thermal element of the excess temperature limit controller shall be suitable for the atmosphere to which it will be exposed.

4-9.2 The excess temperature limit controller shall be interlocked with the safety circuit to cut off the source of heat when safe temperature is exceeded and require operator attention before start-up of the furnace or affected furnace zone.

4-9.3 The thermal element of the excess temperature limit controller within the heating system shall supervise that temperature most critical to safe operation.

4-9.4 The operating temperature controller and/or its thermocouple shall not be used as an excess-temperature limit.

4-10 Automatic Fire Checks and Safety Blowouts.

4-10.1 Automatic fire checks and safety blowouts (sometimes called back-fire preventers) shall be provided in piping systems distributing flammable air-gas mixtures from gas-mixing machines (requirements) to protect the piping and the machines in event of explosions in accordance with the following requirements:

4-10.1.1 Automatic Fire Checks. Automatic fire checks shall be installed upstream as close as practicable to the burner inlets following the fire-check manufacturer's instructions. Two basic methods are generally used. One calls for a separate fire check at each burner, the other a fire check at each group of burners.

The second method is generally more practical if a system consists of many closely spaced burners.

4-10.1.2 Safety Blowout Devices. A safety blowout device (or back-fire preventer) shall be provided near the outlet of each gas-mixing machine where the size of the piping is larger than 2½ in. (63.5 mm) IPS or equivalent, to protect the machine in event of an explosion passing through an automatic fire check.

The manufacturer's instructions shall be followed when installing these devices. Acceptable safety blowouts are available from some manufacturers of approved gas-mixing machines. They incorporate the following components and design features:

1. Flame arrester.
2. A blowout disk.
3. Provision for automatically shutting off the supply of air-gas mixture to the burners in event of a flashback passing through an automatic fire check.

4-10.2 Separate Gas Cock at Each Automatic Fire Check. A separate manually operated gas cock shall be provided at each automatic fire check for shutting off the flow of air-gas mixture through the fire check after a flashback has occurred. The cocks shall be located upstream as close as practicable to the inlets of the automatic fire checks.

Caution: These cocks should 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.

4-11 Electrical Power. Safety control circuits shall be single phase, one side grounded, with all breaking contacts in the "Hot" ungrounded, fused (or circuit breaker) protected line, which shall not exceed 120-volt potential.

NOTE: This control circuit and its nonfurnace or furnace-mounted control and safety components should be housed in a dusttight panel or cabinet, protected by partitions or secondary barriers, or separated by sufficient spacing from electrical controls employed in the higher voltage furnace power system. Related instruments may or may not be installed in the same control cabinet.

The door providing access to this control enclosure may include means for mechanical interlock with the main disconnect device required in the furnace power supply circuit.

Temperatures within this control enclosure should be limited to 125°F (52°C) for suitable operation of plastic components, thermal elements, fuses, and various mechanisms as may be employed in the control circuit.

4-12 Safety Control Application for Electrical Heating Systems.

4-12.1 General. Safety control application for electrical heating systems shall provide protection from excess temperatures, loss of secondary system (cooling, material handling, etc.) essential to normal operation of the furnace.

4-12.2 Heating Equipment Controls.

4-12.2.1 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 which is affected by abnormal and unsafe operating conditions. Such disconnecting device(s) shall be capable of interrupting maximum available fault current as well as rated load current. (*See NFPA 70, National Electrical Code.*)

NOTE 1: Abnormal conditions which may occur and require automatic or manual de-energization of affected circuits are as follows:

(a) A system fault (short circuit) not cleared by normally provided branch-circuit protection. (*See NFPA 70, National Electrical Code.*)

(b) Occurrence of excess temperature in a portion of the furnace which has not been abated by normal temperature controlling devices.

(c) A failure of any normal operating controls when such failure can contribute to unsafe conditions.

(d) A loss of electric power which can contribute to unsafe conditions.

NOTE 2: Drives for equipment such as conveyors, ventilation or recirculating fans, cooling components, etc., should not be stopped when interruption of heating energy is adequate to provide protection to other components of the equipment. (*See 4-9.2, 4-10.1, and 4-12.2.2.*)

4-12.2.2 Automatic versus supervised operation of the "main heating system disconnect" shall be governed by the furnace size, design characteristics and the potential hazards involved.

NOTE: When operation of a multiple phase "main disconnect" is to be manually supervised, each phase of the power supply circuit should be equipped to show electrical potential on the protected or load side, as an indication of intended operation, and partial or complete loss of power.

4-12.2.3 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 when fully equipped for the location and type of service proposed.

NOTE: This may require de-rating some components as listed by manufacturers for other types of industrial service, motor control, etc. and shown in Table 4-12.2.3.

Table 4-12.2.3

Control Device	*Resistance Type Heating Devices* — *Rating in % of Actual Load*	*Resistance Type Heating Devices* — *Permissible Current in % of Rating*	*Infrared Lamp and Quartz Tube Heaters* — *Rating in % of Actual Load*	*Infrared Lamp and Quartz Tube Heaters* — *Permissible Current in % of Rating*
Fusible Safety Switch (% rating of Fuse employed)	125	80	133	75
Individually Enclosed Circuit Breaker	125	80	125	80
Circuit Breakers in Enclosed Panelboards	133	75	133	75
Magnetic Contactors				
0–30 Amperes	111	90	200	50
30–100 Amperes	111	90	167	60
150–600 Amperes	111	90	125	80

NOTE: The above applies to "maximum load" or open ratings for safety switches, circuit breakers, and industrial controls approved under current NEMA standards.

4-12.2.4 All controls, using thermal protection or trip mechanisms, shall be so located or protected as to preclude faulty operation due to normal temperatures.

4-12.2.5 Equipment using solid-state power controllers (SCRs) shall have warning signs attached stating that the main line disconnect switch and/or heater circuit breaker shall be turned "off" whenever the equipment is shut off or being serviced.

4-13 Excess Temperature Limit Controller.

4-13.1 An approved excess furnace temperature limit controller shall be used on any heating unit where it is possible for the controlled temperature to exceed a safe limit.

Exception: A single/multi-point recorder with excess temperature switch capability may be used as an excess temperature controller and cannot be used as a primary temperature controller providing it meets all the criteria listed in 4-9.1.1, 4-9.2, 4-9.3, and 4-9.4. This recorder shall not be used as the operating temperature controller. This instrument shall not have a switch that can void the high limit contact.

4-13.1.1 The thermal element of the excess temperature limit controller shall be suitable for the atmosphere to which it will be exposed.

4-13.2 The excess temperature limit controller shall be interlocked with the safety circuit to cut off the source of heat when safe temperature is exceeded and require operator attention before start-up of the furnace or affected furnace zone. The cut-off of this heat source shall be independent of the operational temperature controller.

4-13.3 The location of thermal element of the excess temperature limit controller within the heating system shall supervise that temperature most critical to safe operation.

4-13.4 The operating temperature controller and/or its thermocouple shall not be used as an excess-temperature limit.

4-14 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.*

Chapter 5 Safety Ventilation

NOTE: Reference is made to NFPA 86, *Standard for Ovens and Furnaces*, for units where combustible flammable volatiles and/or combustible material are involved.

Chapter 6 Special Atmospheres

6-1 General.

6-1.1 This chapter covers the equipment used to generate or to store special atmospheres, and to meter or control their flows to atmosphere furnaces. "Generated" and also "synthetic" special atmospheres are included. Furnaces and the means for safely using special atmospheres in them are covered in other chapters. For application of programmable controllers, also see Section 4-2.

6-1.2 For the purposes of this standard "generated" special atmospheres are those produced from the reaction of air with hydrocarbon fuels, air with ammonia, or the dissociation of ammonia or other chemicals in atmosphere generators. Generators may be separate from the furnaces they serve, or be combined with the furnace in that they utilize a common heat source.

6-1.3 "Synthetic" atmospheres are special atmospheres derived from chemical liquids or liquefied gases such as anhydrous ammonia, alcohols, or hydrocarbon liquids. These industrially supplied gases or chemicals are usually not chemically reacted nor burned prior to introduction to the furnace. However, they can react or decompose within the furnace. They are generally transported to the user and are stored at the user location in compressed gas cylinders or in bulk storage tanks.

6-1.3.1 A mixture of a generated and a synthetic atmosphere is considered a synthetic atmosphere.

6-1.3.2 Nitrogen made at the user site by cryogenic separation, by adsorption separation, or other means from air is also considered a synthetic atmosphere or synthetic atmosphere constituent.

6-1.4 The equipment used to produce special atmospheres shall be properly selected and operated.

6-1.4.1 Responsibility for selection of equipment to produce or store special atmospheres shall rest with the person or agency authorizing the equipment.

6-1.4.2 Responsibility for observing the operating instructions for special atmospheres generators and atmosphere flow control units shall rest with the person or agency that owns or operates the equipment.

6-1.4.3 Responsibility for operating compressed gas or liquefied gas cylinders leased to the user by an industrial gas company or by their distributor shall rest with the agency that operates the equipment.

6-1.4.4 Responsibility for properly filling or operating bulk gas or liquid storage cylinders and tanks shall rest with the owner of the cylinders and tanks.

6-1.5 Provision shall be made to safely dispose of unwanted atmosphere gas at the point of discharge from the generator. Depending upon the specific local circumstances and the analysis of the atmosphere gas, this shall be accomplished by one of the following:

(a) provide a vent line, properly controlled by valves, to permit venting of the unwanted atmosphere gas to a safe place outside the building, or

(b) arrange a suitable method of completely burning the atmosphere gas and properly disposing of the combustion products.

6-1.6 Provisions shall be made to dispose of atmosphere fluids vented from synthetic atmosphere storage tanks and flow control units. Depending on local circumstances and/or ordinances, and the nature of the fluids, this shall be accomplished by one of the following:

(a) Provide a vent line from the point of release at a bulk tank, compressed gas cylinder, or flow control unit to convey combustible, flammable, toxic, corrosive or otherwise hazardous fluids to a place where release will not threaten the safety of equipment, buildings or operating personnel.

(b) In the case of nonflammable fluids such as carbon dioxide and non-toxic fluids such as nitrogen, argon, etc., consideration shall be given to venting outside the building or some other safe place if venting at the maximum rate poses a hazard of asphyxiation to occupants of the building at or near the point of discharge.

6-1.7 The electrical power for the safety control circuits of special atmosphere generators, fluid storage systems, or special atmosphere flow control systems shall be single-phase with one side grounded. All safety circuit breaking contacts shall be in the ungrounded line. The maximum nominal voltage shall not exceed 120 volts, and the ungrounded line shall be protected against circuit overload.

6-1.8 Motor starters, wiring, lighting, and other electrical devices or controls situated in areas which may contain flammable gases or liquids shall conform to requirements of NFPA 70, *National Electrical Code*, Article 500.

6-1.9 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. In cooling systems that are open to the atmosphere, the water shall be discharged into an open sight funnel readily visible to the operator with no valves or restrictions installed in the discharge piping. In closed water cooling systems the water shall be discharged through individual sight flow indicators. Relief valves shall be installed on closed systems to prevent overpressurization due to obstructed discharge lines.

NOTE: Open systems may include equipment having an open sight drain feeding into a sump tank and pump, for connection to the users closed water system.

6-2 Exothermic Generators.

6-2.1 General.

6-2.1.1 Exothermic generators are those that convert a fuel gas to a special atmosphere gas by burning, completely or partially, the gas with air in a controlled ratio.

6-2.1.2 The combustion reaction is self-supporting and gives off heat (i.e., exothermic). The usual combustion range is from 60 percent to 100 percent of the stoichiometric ratio (aeration). In exothermic generators the combustion products become the atmosphere gas, and therefore the gaseous constituents supplied to exothermic generators will be called fuel gas and air.

6-2.2 Protective Equipment.

6-2.2.1 Protective equipment shall be selected and applied for the fuel gas and air separately, and interlocks shall be provided. The protective devices shall shut down the system and require manual resetting after any utility (fuel gas, air, power) or mechanical failure. Observation ports shall be provided to permit ready viewing of burner operation under all firing conditions.

Exception: Where observations are not practical, other means of verifying lighting of individual burners shall be provided.

6-2.2.2 Required protective equipment shall include:

1. A safety shutoff valve in the fuel gas supply piping, arranged to close in case of abnormally low fuel gas pressure, abnormally high fuel gas pressure, loss of air supply, power failure, or flame failure. A manual operation shall be required to open this valve.

Exception: A protective device on the air supply is not required when a gas/air mechanical mixer is employed.

2. A low pressure switch in the fuel gas supply piping. This device shall close the safety shutoff valve, and shut off the air supply or mechanical mixer in case of abnormally low fuel gas pressure.

3. A high pressure switch in the fuel gas supply piping when the system is such that abnormally high fuel gas pressures may create a dangerous situation. This device shall close the safety shutoff valve, and shut off the air supply or mechanical mixer in the case of abnormally high fuel pressure.

4. A low pressure switch in the air supply piping coming from an air blower or compressed air line. This device shall close the safety shutoff valve, and shut off the air supply in case of abnormally low air pressure.

5. A device that will shut off the air from a remote supply in case of power failure, abnormally low or abnormally high fuel gas pressure at the generator.

6. A flame safeguard device supervising the main burner(s) shall shut off the safety shutoff valve and air supply or mechanical mixer when a flame failure occurs.

7. A reliable method of ignition for each burner. Main burner ignition shall be by a supervised, interrupted gas pilot.

Exception: Certain conditions and designs may preclude the preferred main flame supervision under all operating conditions. Under these special conditions: (1) direct ignition, or (2) continuous pilot supervision with dual flame sensors for both pilot and main flame, or (3) a combination of supervised continuous pilot with generator chamber discharge temperature monitoring, shall be considered acceptable alternates.

8. Trial for ignition of pilots or main burners shall not exceed 15 seconds.

9. 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.

10. A manual cock or valve on the downstream side of the safety shutoff valve, with a tap in between to permit periodic checking of the tightness of closure of the safety shutoff valve.

11. An automatic fire check installed in the air-gas mixture line, as close as practicable to the generator burner inlet, whenever a mechanical mixer employing an automatic constant air-gas ratio device is used. Actuation of the fire check shall close the safety shutoff valve in the gas supply line and stop the mechanical mixer.

12. A manual shutoff valve, designated as "main fuel gas" shutoff valve in the gas supply line, located directly upstream from the safety shutoff valve. This valve shall be readily accessible to the operator for emergency and normal shutdown.

13. An atmosphere gas vent. (*See 6-1.5.*)

14. Visual and/or audible alarm devices.

6-2.2.2.1 Supplementary protective equipment may be applicable and the following shall be considered:

1. Cooling water failure protective devices.
2. Gas analyzing devices.
3. A supervisory cock system.
4. A preignition purge timer.
5. Excess temperature limit device.

6-2.3 Operating Procedures.

6-2.3.1 Operating instructions shall be provided by the manufacturer. They shall be followed during light-up, operation, normal shut-down and emergency shut-down.

NOTE: Of prime concern in the case of generator shutdown is the equipment in which the atmosphere gas is being used. Protection of this equipment, and the process material depending upon it, may require quick action by a competent operator.

6-2.3.1.1 Operating procedures shall include the following:

(a) *Light-up Procedure.*

1. Make certain that all fuel gas valves are closed and the air supply is off.

2. Make certain the atmosphere gas header is closed to points of use.

3. Make certain the atmosphere gas vent line is opened to a safe point of discharge.

4. Energize electrical circuits.

5. Purge generator with air if required by the manufacturer.

6. Activate cooling equipment.

7. Establish reliable ignition at each burner.

8. Light each burner immediately when it is supplied an air-fuel gas mixture. In the event of lighting difficulty, shut off all fuel valves and purge the system thoroughly after each lighting attempt.

9. Check each burner for satisfactory operation.

10. Vent the atmosphere gas to a safe location until proper generator temperature and atmosphere gas analysis are obtained.

(b) *Shutdown Procedure.*

1. Secure end-use equipment.

2. Open the atmosphere gas vent line to a safe point of discharge.

3. Close the atmosphere gas header to points of use.

4. Close the "main fuel gas" shutoff valve and check the operation.

(5) Close all remaining gas and air valves immediately.

(6) Turn off cooling equipment when safe to do so according to the manufacturer's instructions.

(7) De-energize the electrical equipment when it is no longer required.

(c) *Utility Failure Procedure.* The equipment and associated circuits shall be arranged to shut down the unit automatically in case of flame failure or supply failure of fuel gas, air, or electrical power. This type of shutdown shall be immediately followed by the shutdown procedure in 6-2.3.1.1 (b).

(d) *Emergency Procedure.* The person or agency responsible for selecting and operating atmosphere generators shall be familiar with the hazards that can occur in end use equipment. Methods and procedures shall be provided to the operators for dealing with these emergencies.

6-3 Endothermic Generators.

6-3.1 General.

6-3.1.1 Endothermic generators are those that require the addition of heat to complete the reaction of the gas and air generating the atmosphere. This standard includes the types of atmosphere generators in which the atmosphere being generated is separate at all times from the heating combustion products or other medium. The separation may be effected by use of retorts, tubes, pipes, or other special vessels. To simplify this standard, all gas used in the reaction with air to make the atmosphere will be called "reaction gas," and all air used in this reaction will be called "reaction air." Gas burned with air to supply heat will be called "fuel gas," and all air used with the fuel gas will be called "fuel air." The atmosphere produced in the generator from heating the mixture of "reaction gas" and "reaction air" will be called "special atmosphere gas."

NOTE: The reaction gas and the fuel gas may or may not be the same type of gas.

6-3.2 Protective Equipment.

6-3.2.1 Protective equipment shall be selected and applied for the reaction gas and fuel gas separately.

6-3.2.2 The protective devices shall shut down the system which would require manual resetting after any utility (fuel gas, fuel air, power) or mechanical failure. Observation ports shall be provided to permit ready viewing of burner operation under all firing conditions.

NOTE: In the case of common gas supply for the reaction and fuel gases, the same protective device may serve both.

6-3.2.3 Protective equipment for the reaction section of endothermic generators shall include the following:

1. A safety shutoff valve 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.

2. 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.

3. A high pressure switch in the reaction gas supply piping when the system is such that abnormally high reaction gas pressure may create a dangerous situation. This device shall close the safety shutoff valve and shut off the reaction air supply in case of abnormally high reaction gas pressures at the mixer.

4. A low pressure switch in the reaction air supply piping coming from 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.

5. A device to shut off reaction air in case of power failure, abnormally low or abnormally high reaction gas pressure at the mixer.

6. An atmosphere gas vent. (*See 6-1.5.*)

7. A manual cock or valve on the downstream side of the safety shutoff valve, with a tap in between, to permit periodic checking of the safety shutoff valve closure tightness.

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

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

10. Automatic fire check protection.

11. Visual and/or audible alarm devices.

6-3.2.3.1 Supplementary protective equipment may be applicable to the reaction section and the following shall be considered: flow indicators, meters, or pressure gages on the reaction gas and reaction air supplies.

6-3.2.4 Protective equipment for the heating section of units fired with atmospheric gas burners shall include the following:

1. A safety shutoff valve in the fuel gas supply piping arranged to close in case of abnormally low fuel gas pressure, abnormally high fuel gas presure, or power failure. A manual operation shall be required to open this valve.
2. A low pressure switch in the fuel gas supply piping to close the safety shutoff valve in case of abnormally low fuel gas pressure.
3. A high pressure switch in the fuel gas supply piping when the system is such that abnormally high fuel gas pressures may create a dangerous situation. This device shall close the safety shutoff valve in case of abnormally high fuel gas pressure.
4. A manual cock or valve on downstream side of the safety shutoff valve with a tap between these valves to permit periodic checking of the tightness of closure of the safety shutoff valve.
5. A manual shutoff valve, designated as the main shutoff valve in the fuel gas supply line, located directly upstream from the safety shutoff valve. This valve shall be readily accessible to the operator for emergency and normal shutdown.
6. A reliable method of ignition for each burner.
7. Excess temperature limit device.
8. Visual and/or audible alarm devices.

6-3.2.4.1 Supplementary protective equipment may be applicable to the heating section of endothermic generators fired with atmospheric gas burners. Consideration shall be given to providing the following:

1. Flame safeguard devices.
2. A supervisory cock system.

6-3.2.5 Protective equipment for the heating section of units fired with blast-type gas burners shall include the following:

1. A safety shutoff valve in the fuel gas supply piping arranged to close in case of abnormally low fuel gas pressure, abnormally high fuel gas pressure, loss of fuel air supply, or power failure. A manual operation shall be required to open this valve.
2. A low pressure switch in the fuel gas supply piping. This device shall close the safety shutoff valve, and shut off the fuel air supply or mechanical mixer in case of abnormally low fuel gas pressure.
3. A high pressure switch in the fuel gas supply piping when the system is such that abnormally high fuel gas pressures may create a dangerous situation. This device shall close the safety shutoff valve, and shut off the fuel air supply or mechanical mixer in case of abnormally high fuel gas pressure.
4. A pressure switch in the fuel air supply piping coming from an air blower or compressed air line. This device shall close the safety shutoff valve, and shut off the fuel air supply in case of loss of fuel air pressure.
5. A manual cock or valve on the downstream side of the safety shutoff valve with a tap between these valves to permit periodic checking of the tightness of closure of the safety shutoff valve.
6. Automatic fire check protection in the fuel gas and air mixture supply line as close as practicable to the burner or burners whenever a mechanical mixer employing an automatic constant air-gas ratio device is used. Actuation of the firecheck shall close the safety shutoff valve in the fuel gas line and shut off the mechanical fuel gas and fuel air mixer.
7. A manual shutoff valve, designated as the main shutoff valve in the fuel gas supply line, located directly upstream from the safety shutoff valve. This valve shall be readily accessible to the operator for emergency and normal shutdown.
8. A reliable method of ignition for each burner.
9. Excess temperature limit device.
10. Visual and/or audible alarm devices.

6-3.2.5.1 Supplementary protective equipment may be applicable to the heating section of endothermic generators fired with blast type gas burners. Consideration shall be given to providing the following:

1. Flame safeguard devices.
2. Supervisory cock systems.

6-3.2.6 Protective equipment for the heating section of units fired with oil burners shall include the following:

1. A safety shutoff valve in the fuel oil supply piping arranged to close in case of low oil pressure, low atomizing medium pressure, loss of combustion air supply, low oil temperature (for preheated oils), flame failure (when flame supervision is provided), and power failure. A manual operation shall be required to open this valve.
2. A low pressure switch in the fuel oil piping. This device shall close the safety shutoff valve and shut off the atomizing medium and combustion air supply in case of abnormally low fuel oil pressure.
3. A low pressure switch in the atomizing medium supply piping. This device shall close the safety shutoff valve in the fuel oil piping, and shut off the combustion air supply in case of abnormally low atomizing medium pressure.
4. A low pressure switch or flow switch in the combustion air supply piping. This device shall be interlocked to close the safety shutoff valve in the fuel oil piping and shut off the atomizing medium in case of abnormally low combustion air pressure or flow.
5. A low temperature switch in the fuel oil piping of preheated oils. This device shall close the safety shutoff valve and shut off the atomizing medium and combustion air supplies in case of abnormally low fuel oil temperatures.
6. A manual shutoff valve on the fuel oil supply piping. This valve shall be readily accessible to the operator for emergency and normal shutdown.
7. A reliable method of ignition for each burner.
8. Excess temperature limit device.

9. Visual and/or audible alarm devices.

6-3.2.6.1 Supplementary protective equipment may be applicable to the heating section of units fired with oil burners. Consideration shall be given to provide the following:

1. Flame safeguard devices.
2. High oil temperature limiting device.

6-3.2.7 Protective equipment for the heating section of units heated electrically shall include the following:

(a)1. A main disconnect device, capable of de-energizing the entire heating system under full load. This device shall de-energize the heating system in case of complete or partial loss of power, excess generator temperature, or failure of normal operating controls.

2. The interrupting capacity of the main disconnect device (*see Appendix D*) shall be adequate to clear the maximum fault current capability of the immediate power supply system (fault current shall be determined from the voltage and impedance of the furnace power supply circuit, not from the summation of the operating load currents). Other disconnect means in this power supply circuit may be used as the heating equipment "main disconnect" provided furnace operation can be terminated without affecting operation of other essential equipment. Automatic versus supervised operation of the "main disconnect" shall be governed by the furnace size, design characteristics and the potential hazards involved.

NOTE: When operation of a multiple phase "main disconnect" is to be manually supervised, each phase of the power supply circuit should be equipped to show electrical potential on the protected or load side, as an indication of intended operation, partial or complete loss of power.

(b) Excess temperature limit device. This device shall open the main heating system disconnect device in case of abnormally high generator temperature.

(c) The entire electrical installation shall conform to the requirements of NFPA 70, *National Electrical Code*.

(d) Visual and/or audible alarm devices.

6-3.3 Operating Procedures.

6-3.3.1 Operating instructions shall be provided by the manufacturer. They shall be followed during start-up, operation and normal and emergency shutdown.

NOTE: Of prime concern in the case of atmosphere generator failure is the equipment in which the atmosphere gas is being used. Protection of this equipment and the process material depending upon it may require quick action by a competent operator. The operation of endothermic generators requires careful coordination of the heating section with the reaction gas section.

6-3.3.1.1 Operating instructions shall include the following:

(a) *Light-up procedure for heating sections of endothermic generators fired by atmospheric or blast gas burners, or oil burners.*

1. Make certain that all fuel valves and reaction gas valves are closed and the reaction air supply is off.

2. Make certain the atmosphere gas header is closed to points of use.

3. Make certain the atmosphere gas vent line is opened to a safe point of discharge.

4. Energize electrical circuits.

5. Establish reliable ignition at each burner.

6. Light each burner immediately when it is supplied a fuel-air- mixture. In the event of lighting difficulty, shut off all fuel valves and purge the system thoroughly with air after each lighting attempt.

7. Check burners for satisfactory operation.

(b) *Start-up procedure for heating sections of endothermic generators heated electrically:*

1. Make certain electric power to heating section is off.

2. Make certain that all reaction gas valves are closed and the reaction air supply is off.

3. Make certain the atmosphere gas header is closed to points of use.

4. Make certain the atmosphere gas vent line is opened to a safe point of discharge.

5. Energize electrical circuits.

6. Verify satisfactory operation.

(c) *Operating instructions for reaction gas start-up for endothermic generators.*

1. When the retort operating temperature is reached, check to be sure the atmosphere gas vent line is open to a safe point of discharge and the atmosphere gas header is closed to points of use. The unit should now be ready to produce atmosphere gas. At this point the operating instructions based upon the manufacturer's design shall be followed. This is important because each manufacturer has developed procedures applicable to this particular design and general instructions cannot be listed.

(d) *Shutdown Procedure.*

1. Secure end-use equipment.

2. Open the atmosphere gas vent to a safe point of discharge.

3. Close the atmosphere gas header to points of use.

4. Close the main reaction gas shutoff valve and check the operation of reaction gas and reaction air safety devices.

5. Close all of the remaining reaction gas and reaction air valves immediately.

6. Close the "main fuel" shutoff valve and check the operation of the safety devices.

7. Close all of the remaining fuel air, fuel, and atomizing medium valves immediately.

8. De-energize the electrical equipment when its use is no longer required.

(e) *Utility Failure Procedure.* The equipment and associate circuits shall be arranged to shut down the unit automatically in case of supply failure of fuel, air, or power. This type of shutdown shall be followed immediately by the shutdown procedures of 6-3.3.1.1(d).

(f) *Emergency Procedure.* The person or agency responsible for selecting and operating atmosphere generators shall be familiar with the hazards that can occur in end use equipment. Methods and procedures shall be provided to the operators for dealing with these emergencies.

6-4 Ammonia Dissociators.

6-4.1 General.

6-4.1.1 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.

6-4.2 Construction.

6-4.2.1 Ammonia dissociators shall be designed and constructed to withstand the maximum pressures possible upon failure of reaction gas regulators at operating temperatures, taking into consideration all pressure relief venting.

6-4.2.2 All equipment, components, valves, fittings, etc., shall be suitable for ammonia service. Use of brass components in contact with ammonia or dissociated ammonia shall be prohibited.

6-4.3 Protective Equipment.

6-4.3.1 Protective equipment for the dissociation vessel shall include:

1. A relief valve in the high pressure ammonia supply line, ahead of the pressure reducing regulator. Relief shall be set at 100 percent of design pressure of the ammonia supply manifold.
2. A relief valve in the low pressure ammonia line, between the high pressure reducing regulator and the dissociation vessel. Relief shall be set at 100 percent of the design pressure of the dissociation vessel.
3. A manual shutoff valve between the pressure reducing regulator and the dissociator. This valve shall be readily accessible to the operator for emergency and normal shutdown.
4. An atmosphere gas vent. (*See 6-1.5*)
5. 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.
6. A safety shutoff valve in the ammonia supply line to the generator, arranged to close automatically when abnormal conditions of pressure and temperature are encountered.
7. A visual and/or audible alarm.

6-4.3.2 Consideration shall be given to providing the following supplementary protective devices: flow indicators, meters, or pressure gages on the reaction gas and reaction air supplies.

6-4.3.3 Protective equipment for the dissociator heating system shall conform to the requirements for endothermic generators, as outlined in Section 6-3.

6-5 Bulk Storage and Supply Systems for Special Atmospheres.

6-5.1 General. A supply of inert purge gas of defined and acceptable analysis shall be available when required by this standard. Usage of processing inert gas shall not deplete the adequacy of inert purge gas supply. The inert purge gas shall contain less than 1 percent oxygen, or the flammable constituents of the inert purge gas shall have a concentration less than 25 percent of its lower explosive limit in air. The contents of the inert purge gas shall be analyzed using a reliable method and confirmed on a routine basis.

NOTE: Inert purge gas supply may be either a stored supply or a generated supply, provided adequate volume of inert purge gas, as defined by this standard is assured.

6-5.1.1 All storage tanks and cylinders shall comply with local, state, and federal codes relating to the types of fluids stored, their pressures and temperatures. NFPA standards that are applicable shall be followed.

6-5.1.2 Vessels, controls, and piping shall be provided which will maintain their integrity under maximum and minimum design pressures and temperatures.

6-5.1.3 ASME tank relief devices provided shall be sized, constructed and tested in accordance with the ASME *Boiler and Pressure Vessel Code*, Section 8, Division I.

6-5.1.4 Locations for tanks and cylinders containing flammable or toxic fluids shall be selected with adequate consideration given to exposure to buildings, processes, personnel, and other storage facilities. Tables of distances specified in the various NFPA standards shall be followed.

6-5.1.5 Storage tanks and their associated piping and controls shall comply with the following standards:

(a) Liquefied petroleum gas systems shall be in accordance with NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

(b) Fuel gas systems shall be in accordance with NFPA 54, *National Fuel Gas Code*.

(c) 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*.

(d) Flammable or combustible liquid systems shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*. Piping for flammable, combustible, or toxic liquids shall be in accordance with ANSI B31.3, *Code for Chemical Plant and Petroleum Refinery Piping*.

NOTE: For additional information see the following Compressed Gas Association guidelines:

1. G2 — Anhydrous Ammonia
2. G2.1 — *Storage and Handling of Anhydrous Ammonia* (ANSI-K61.1)
3. G5 — Hydrogen
4. G6 — Carbon Dioxide
5. G6.1 — Carbon Dioxide Systems at Consumer Sites
6. P-1 — Safe Handling of Compressed Gases in Containers.

6-5.1.6 Bulk storage systems shall be rated and installed so as to provide assured and noninterrupted flow of special atmospheres to the user equipment if an interruption of the flow can create an explosion hazard.

6-5.1.7 In the case of inert gases which may be used as safety purge media, the volume stored shall always be sufficient to purge all connected special atmosphere furnaces with at least five furnace volume changes whenever the flammable atmospheres are being used.

6-5.2 Vaporizers Used for Purging.

6-5.2.1 Vaporizers utilized to convert cryogenic liquids to the gas state shall be ambient air heated units so flow from them is unaffected by the loss of power.

Exception: Use of powered vaporizers shall be permissible, provided:

(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, or

(b) Reserve ambient vaporizers are provided that are piped to the source of supply so as to be 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 fulfills requirements of 6-5.1.6, 6-5.1.7, 6-5.2.2, 6-5.2.4, and 6-5.2.5.

6-5.2.2 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. Wintertime temperature extremes in the locale shall be taken into consideration by the agency responsible for rating them.

6-5.2.3 It shall be the user's responsibility to inform the industrial gas supplier of additions to the plant which will materially increase inert gas consumption rate, so vaporizer and storage capacity may be resized for the changed requirements.

6-5.2.4 A temperature indicator shall be installed in the vaporizer outlet piping for use in evaluating its evaporation performance at any time.

6-5.2.5 A device shall be installed which will prevent 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. Whenever a critical flow orifice is utilized to fulfill this requirement, the inlet pressure used to rate it shall not be lower than the safety relief pressure of the supply tank.

NOTE: A break in downstream pipeline or failure (open) of supply pressure regulator could cause excessive flow.

6-5.3 Storage Systems.

6-5.3.1 If the fluid is a purge medium, an audible or visual alarm shall be provided which will signal a low quantity of the fluid. The alarm shall be situated in the area normally occupied by furnace operators.

6-5.3.2 Contents of the tank at the time of low quantity alarm shall be sufficient to permit an orderly shutdown of the affected furnace(s). Contents of a tank containing a purge fluid shall be sufficient at the alarm setpoint to purge all connected atmosphere furnaces with at least five volume changes.

6-5.3.3 Pressurized inert gas in the vapor space above flammable liquids in storage tanks may be used to propel the liquids in lieu of mechanical pumps.

6-5.3.3.1 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.

6-5.3.3.2 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.

6-5.3.4 Liquid withdrawal connections on pressurized aboveground flammable liquid tanks shall contain steel excess flow shutoff valves that will close automatically in the event of a pipe break or other mishap which would cause an unchecked outflow of liquid.

6-6 Flow Control of Special Atmospheres.

6-6.1 Special Atmospheres Flowrates.

6-6.1.1 Processes and equipment for controlling flows of special atmospheres shall be designed, installed, and operated to maintain a positive pressure within connected furnaces.

NOTE: The object of this is to prevent infiltration of air which may be detrimental to the work being processed, or may result in the creation of flammable gas-air mixtures within the furnace. The flowrates may be varied during the course of a heat treatment cycle.

6-6.1.1.1 The flowrates used shall rapidly restore positive internal pressure without excessive infiltration of air during atmosphere contractions when furnace chamber doors close, or work loads are quenched.

6-6.1.2 When the atmosphere is flammable, its flow rate shall be sufficient to provide stable and reliable burn-off flames at vent ports.

NOTE: After closure of an outer vestibule door of a batch-type or pusher furnace a delay usually occurs before burn off resumes at the vent opening. The duration of the delay depends on the special atmosphere flowrate, its combustibles content, the vestibule volume, and other factors.

6-6.1.2.1 The party responsible for commissioning of furnace and/or atmosphere process shall prescribe atmosphere flow rates that will reliably cause burning to resume at the burn off port before further cycling of the furnace can take place (i.e. door, elevator movements).

6-6.1.3 Reliable means shall be provided for metering and controlling the flowrates of all fluids comprising the special atmosphere for a furnace.

6-6.1.3.1 Devices with visible indication of flow shall be used to meter the flows of carrier gases, carrier gas component fluids, inert purge gases, and enrichment gases, or air.

6-6.1.3.2 The flow control equipment may be installed at the furnace, the generator, or in a separate flow control unit. In either case it shall be accessible and in an illuminated area so that an operator can readily monitor its operation.

6-6.1.4 Synthetic atmosphere flow control units shall have the additional capabilities delineated in 6-6.1.4.1 through 6-6.1.4.7.

6-6.1.4.1 An atmosphere flow control unit equipped with an inert purge mode shall have a manually operated switch which will actuate the purge, located prominently on the face of the unit.

6-6.1.4.2 Automatic means for preventing the introduction of flammable fluids into a furance before the furnace temperature has risen to 1400°F (760°C), when the furnace is being started up from a cold or idle air-filled condition, or from other conditions (such as a prolonged power failure) which may have caused it to fill with air.

6-6.1.4.3 Means 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.

NOTE 1: Inadequate dissociation results in lessened atmosphere expansion which causes a reduction in furnace pressure, and thereby creates an air infiltration hazard.

NOTE 2: Insufficient temperature may also create a condition where unvolatized atmosphere fluid will be carried into the quench tank, changing the physical characteristics of the quench oil, such as increasing the vapor pressure and lowering the flash point.

6-6.1.4.3.1 When the flammable gas flow is interrupted in this way the flow control unit shall automatically admit a flow of inert gas that will restore positive pressure without delay, and signal this flow by means of an audible alarm. The party responsible for commissioning the furnace and/or atmosphere process shall prescribe the temperature at which flammable gas flow will be interrupted.

Exception: Manual inert gas purge may be provided for furnaces where operators are present and able to effect timely shutdown procedures.

6-6.1.4.4 Automatically operated flow control valves shall halt flows of combustible fluids and permit continued or augmented flows of inert gas in event of a power failure. Resumption of combustible fluid flow shall require manual intervention (reset) by an operator after power is restored.

6-6.1.4.5 Means to test for leak-free operation of safety shutoff valves for flammable or toxic fluids.

6-6.1.4.6 Safety relief valves to prevent overpressurizing of glass tube flowmeters and all other system components. 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.

6-6.1.4.7 Alternate valves for manually shutting off the flow of flammable fluids into a furnace, separate from the atmosphere flow control unit. These valves shall be readily accessible to operators and located remotely from the furnace and control unit.

6-6.1.5 Pipes feeding atmosphere flow control units shall contain isolation valves. Consideration shall be given to provision of filters or strainers to assure reliable functioning of pressure regulators, flow meters, flow monitors, control valves, and other components.

6-7 Piping System for Special Atmospheres.

6-7.1 Piping shall be sized to permit the full flow of special atmosphere to all connected furnaces at maximum demand rates.

6-7.2 Design, materials of construction, fabrication and tests on pipes containing flammable and/or toxic liquids shall conform to the applicable sections of ANSI B31.3, *Code for Pressure Piping, Chemical Plant and Petroleum Refinery Piping*.

6-7.3 Piping which contains cryogenic liquids, or is installed downstream of a cryogenic gas vaporizer and is used to convey safety purge gases, shall be constructed of metals which retain adequate strength at cryogenic temperatures.

Caution: 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 of a vaporizer running beyond its rated vaporization capacity, or at very low ambient temperatures.

6-7.4 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 are connected into piping supplied from cryogenic vaporizers, means shall be provided for automatically halting the flow of excessively cold liquid or gas into them.

6-7.4.1 A low temperature shutoff device used as prescribed in 6-7.4 shall not be installed so that closure of the device can interrupt the main flow of inert safety purge gas to connected furnaces containing flammable special processing atmospheres.

6-7.4.2 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.

6-7.4.3 In consultation with the industrial gas supplier, the user shall select the low temperature shutoff device, its placement, and a shutoff setpoint temperature that is appropriate for the purpose intended.

6-7.5 Flammable liquid piping shall be routed so as to avoid locations where it will 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, etc.). Pipes shall be supported, isolated from vibration sources that could damage them, and allowance for expansion and contraction due to temperature changes shall be made.

6-7.6 Pipes conveying flammable liquids shall contain hydrostatic relief valves that will protect them from damage due to expansion of contained liquids that are heated. Discharge from the relief valves shall be piped to a safe disposal location such as the fluid supply area.

6-7.7 Liquid withdrawal connections on pressurized aboveground flammable liquid tanks shall contain steel excess flow shutoff valves that will close automatically in the event of a pipe break or other mishap which would cause an unchecked outflow of liquid.

6-7.8 Means shall be provided for automatically releasing accumulations of inert pressurizing gas from elevated sections of piping, which would otherwise inhibit or disrupt the flow of the liquid. Gas vented from such gas relief devices shall be disposed of in a manner that will not cause fire, explosion, or personnel hazards.

6-7.9 Use of aluminum or lead components or other incompatible materials in tanks, piping, valves, fittings, filters, strainers or controls which may be contacted with methanol (methyl alcohol) liquid or vapor shall not be permitted. Lead-containing solders shall not be used.

6-7.10 Lead-containing solders shall not be used to join pipes containing flammable liquids.

6-7.11 Use of brass components in tanks, piping, filters, strainers or controls which may be contacted with ammonia shall not be permitted.

6-8 Maintenance.

6-8.1 Responsibility.

6-8.1.1 An essential safety aid is an established maintenance program which determines that the equipment is in working order. The equipment manufacturer shall impress upon the user the need for adequate operational checks and maintenance and shall issue complete and clear maintenance instructions.

6-8.1.1.1 The final responsibility of establishing a maintenance program which determines that the equipment is in working order shall rest with the user.

6-8.1.1.2 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.

6-8.2 Check Lists. The user's operational and maintenance program shall include any listed procedures which are applicable to the atmosphere generator or flow control unit and that may be recommended by the authority having jurisdiction and the equipment supplier. An operational and maintenance check list is essential to the safe operation of the equipment. (*See Appendix C.*)

Chapter 7 Special Atmospheres and Furnaces as Classified in Chapters 8, 9, and 10

7-1 General.

7-1.1 The following are definitions of carrier gas and the four types of Special Atmospheres used in Class C furnaces:

Carrier Gas. Any gas or liquid component of the special atmosphere which represents a sufficient portion of the special atmosphere gas volume in the furnace such that if the flow of this component gas or liquid ceases, the total flow of the special atmosphere in the furnace would not be sufficient to maintain a positive pressure in that furnace.

Nonflammable. Gases which are known to be nonflammable at any temperature.

Flammable. Gases which are known to be flammable and are reliably and predictably ignitible when mixed with air.

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

Inert (Purge Gas). Nonflammable gases which are free of oxygen (less than 1 percent oxygen).

7-1.2 Indeterminate atmospheres shall be treated as flammable atmospheres as defined in 7-1.1 with the following consideration: When a special atmosphere is replaced with another (for example, flammable by nonflammable) which will cause the atmosphere to become indeterminate at some stage, burn in or burn out procedures shall not be used.

7-1.2.1 In any case for indeterminate atmospheres, inert gas purge in and purge out procedures alone shall be used for admittance and removal of special processing atmospheres.

NOTE: Appendix E, *Indeterminate Special Gas Atmospheres* also elaborates on key points of concern relating to indeterminate special atmospheres.

7-1.3 Automatic cycling of a furnace (i.e., quenching, load transfer from a heated zone to a cold vestibule, etc.) shall not be permitted when 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.

7-1.4 Nonflammable atmospheres shall be admitted or removed from a furnace utilizing the purge in or purge out techniques as listed in each chapter (8, 9, 10).

7-1.5 The type of furnace shall be determined by the normal operating temperature within the heating chamber, certain features of the furnace and type of atmosphere in use. In Chapters 8, 9 and 10, the furnaces using flammable atmospheres shall be determined as follows:

(a) Chapter 8 — Furnace in which at least one zone operates at or above 1400°F (760°C). The chamber(s) operating below 1400°F (760°C) is (are) separated by doors from those at or above 1400°F (760°C).

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

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

(b) Chapter 9 — Furnace in which at least one zone operates at or above 1400°F (760°C) and which has no inner doors which separate zones operating above and below 1400°F (760°C).

Type III. Both inlet and outlet ends of the furnace are open, and there are no external doors or covers.

Type IV. Only one end of the furnace is open, and there are no external doors or covers.

Type V. Outer doors or covers are provided.

(c) Chapter 10 — Furnace in which no zones are consistently operated at or above 1400°F (760°C).

Type VI. At least one heating zone can be heated above 1400°F (760°C) before introduction and removal of the special atmosphere gas.

Type VII. No furnace zone can be heated to 1400°F (760°C); therefore the special atmosphere gas must be introduced and removed using the inert gas purge procedures.

NOTE 1: Virtually all types of furnaces may fall into the classification of Type VI or VII furnaces in Chapter 10. The tabular listing that follows, 7-1.5 (e), provides some common examples.

NOTE 2: Sketches of five types of furnaces appear in Chapters 8 and 9.

(d) Chapter 11 — Furnaces wherein a heating cover and inner cover (if applicable) are separated from a base which supports the work being processed.

Type VIII. A heating cover furnace with an inner sealed cover.

Type IX. A heating cover furnace without an inner cover or with a non-sealed inner cover.

(e) Table of furnaces (common examples) and chapter location (for flammable atmospheres):

NOTE: IQ = Integral Quench.

Description of Furnace	Chapter	Corresponding Furnace Type
Batch Integral Quench (one or more cold chambers, IQ)	8	II
	10	VI or VII
Bell (with or without retort)	See Chapter 11	VIII or IX
Belt (both ends open)	9	III
	10	VI or VII
Belt, Cast Link (with IQ, entry end open)	9	IV
	10	VI or VII
Belt, Mesh (with IQ, entry end open)	9	IV
	10	VI or VII
Box (exterior door)	9	V
	10	VI or VII
Car	11	IX
Gantry (exterior cover)	9	V
	10	VI or VII
Humpback (both ends open, cold chambers on each end)	9	III
	10	VI or VII
Pit (with exterior cover)	9	V
	10	VI or VII
Pusher Tray (cold chambers at each end, inner doors and external doors, with or without IQ)	8	I
	10	VI or VII
Roller Hearth (both ends open)	9	III
	10	VI or VII
Roller Hearth (inner doors separating cold chambers at each end from hot zones, external doors)	8	I
	10	VI or VII
Rotary Hearth (with or without exterior doors)	9	III, IV, V
	10	VI or VII
Rotary Retort, Batch (no IQ, entry end open)	9	IV
	10	VI or VII
Rotary Retort, Continuous (with IQ, entry end open)	9	IV
	10	VI or VII
Rotary Retort, Continuous (with IQ, entry end having a door)	9	V
	10	VI or VII
Shaker Hearth (with IQ, entry end open)	9	IV
	10	VI or VII
Shuffle Hearth (with IQ, entry end open)	9	IV
	10	VI or VII
Tip-up	11	IX
Tube (both ends open)	9	III
	10	VI or VII
Walking Beam (open at each end)	9	III
	10	VI or VII

Chapter 8 Furnace in Which at Least One Zone Operates at or Above 1400°F (760°C).

8-1 General. The chamber operating below 1400°F (760°C) is separated by door(s) from those at or above 1400°F (760°C).

8-1.1 Scope. This chapter covers controls and procedures relating to the admittance and removal of flammable special processing atmospheres for indirectly heated atmosphere type furnaces. Two general types of furnaces are covered:

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

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

For application of programmable controllers, also see Section 4-2.

8-1.2 Special Atmosphere Flow Requirements.

8-1.2.1 Atmosphere processes and the equipment for controlling the flows of special atmospheres shall be installed and operated so as to minimize the infiltration of air into a furnace which could result in the creation of flammable gas-air mixtures within.

8-1.2.2 The special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits from the furnace. Atmosphere burn-off is often interrupted at exit ports as a result of furnace door openings and closings. The person or agency commissioning the furnace and/or atmosphere process shall prescribe a flow rate.

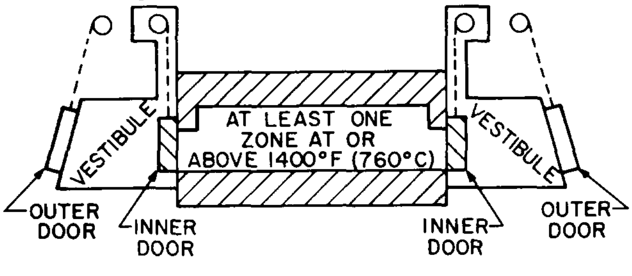
8-1.2.3 The flow rate of an inert gas being used as a purge shall be controlled. It must be introduced to the furnaces through one or more inlets as necessary to assure that all chambers shall be purged.

8-2 Atmosphere Introduction and Removal.

8-2.1 Flammable liquids shall be introduced only in zones operating above 1400°F (760°C).

8-2.2 Introduction of Special Atmosphere Gas into Furnace Type I by Purge (8-2.2.1) or Burn-in (8-2.2.2) Procedure.

8-2.2.1 Purge with an Inert Gas.



TYPE I

Figure 8-2.2 Example of Type I Special Processing Atmosphere Furnace.

8-2.2.1.1 The following 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) Verify that there is an adequate supply of inert purge gas. 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 Type I sketch shall be closed.

(d) Verify that all flammable atmosphere gas, flame curtain, etc., valves are closed.

(e) Heat furnace to operating temperature.

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

(g) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(h) At least one zone of the furnace shall be above 1400°F (760°C).

(i) Ignite pilots at outer doors and effluent lines (special atmosphere vents). Pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(j) After determining the special atmosphere gas supply is adequate, introduce the atmosphere gas. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(k) When flame appears at vestibule effluent lines, the atmosphere introduction is complete.

(l) Turn on flame curtain (if provided) and verify ignition.

(m) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

8-2.2.2 Burning in the Type I Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

8-2.2.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of special atmosphere gas.

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

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

(e) Open outer doors.

(f) Open inner doors.

(g) Introduce the carrier gas(es) components of the special atmosphere gas into furnace heating chamber and observe that ignition takes place.

(h) Close inner doors. A reliable source of ignition is 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 has been burned in.

(i) Turn on flame curtain (if provided) and verify ignition.

(j) Close outer doors.

(k) When flame appears at vestibule effluent lines, the vestibule has been burned-in.

(l) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

8-2.3 Removal of Special Atmosphere Gas from Furnace Type I by Purge (8-2.3.1) or Burn-out (8-2.3.2) Procedure.

8-2.3.1 Purge with an Inert Gas.

8-2.3.1.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of purge gas.

(c) All inner and outer doors as shown in Type I sketch shall remain closed.

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

(e) Immediately shut off all special atmosphere gas, process gas, flame curtain, etc., valves.

(f) Begin sampling the furnace atmosphere. Continue until two consecutive analyses of all chambers indicate the atmosphere is below 50 percent of its lower explosive limit. When this condition is reached, the furnace is purged.

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

(h) Turn off the inert gas supply to the furnace.

(i) Follow furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmosphere is inert; it will NOT sustain life. Persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

8-2.3.2 Burning-out the Type I Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

8-2.3.2.1 The following procedure shall be performed in sequence.

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

(b) Verify that at least one heating chamber is above 1400°F (760°C).

(c) Open all outer doors and shut off flame curtain (if provided).

(d) Open all inner doors to allow air to enter heating chamber and burn out the gas.

(e) Shut off all of the special atmosphere gas and process gas supply valves.

(f) After furnace is burned out, close inner doors.

(g) Follow the furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

8-2.4 Introduction of Special Atmosphere Gas into Furnace Type II by Purge (8-2.4.1) or Burn-in (8-2.4.2) Procedures.

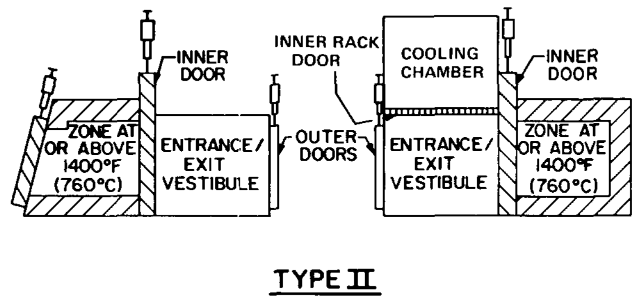


Figure 8-2.4 Example of Type II Special Processing Atmosphere Furnace.

8-2.4.1 Purge with an Inert Gas.

8-2.4.1.1 The following 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) Verify that there is an adequate supply of inert purge gas of acceptable analysis. 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 Type II sketch shall be closed.

(d) Verify that all flammable atmosphere gas, flame curtain, etc., valves are closed.

(e) Heat furnace to operating temperature.

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

(g) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(h) Heating chamber shall be above 1400°F (760°C).

(i) Ignite pilots at outer doors and effluent lines (special atmosphere vent) and pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(j) After determining the special atmosphere gas supply is adequate, introduce the atmosphere gas. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(k) When flame appears at vestibule effluent lines, the atmosphere introduction is complete.

(l) Turn on flame curtain (if provided) and verify ignition.

(m) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

8-2.4.2 Burning-in the Type II Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures rest with the person or agency authorizing the purchase of the equipment. Before proceeding, read item (k) below.

8-2.4.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of flammable special atmosphere gas.

(c) Verify that the heating chamber is above 1400°F (760°C).

(d) Ignite pilots at outer doors and effluent lines.

(e) Open outer door(s).

(f) Open all inner door(s) — heating chamber and cooling chamber (if provided) — and shut off cooling chamber and heat zone fans (if provided).

(g) Introduce special atmosphere gas into heating chamber and observe that ignition takes place.

(h) Close inner and outer doors (if provided) to heating chamber only. A reliable source of ignition is required in 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 has been burned-in.

(i) Flame curtain (if provided) shall be turned on and outer door closed.

(j) When flame appears at vestibule effluent line, the vestibule is burned-in.

(k) If there is an atmosphere cooling chamber attached to the quench vestibule (*see sketch of Type II furnace with attached cooling chamber*), the following steps shall be included, provided the gases introduced directly into the cooling chamber are reliably and predictably flammable when mixed with air at ambient temperature. If they are not reliably and predictably flammable, (e.g., nitrogen or inert gas or methanol) a burn-in procedure shall not be used.

1. Provide reliable source of ignition for the special atmosphere gas inlet in cooling section and introduce gas atmosphere into the cooling section. Observe that ignition takes place and continues.

2. Turn on flame curtain and verify ignition.

3. Close outer door.

4. When flame appears at the vestibule effluent line, the vestibule and cooling chamber have been burned-in.

5. Close cooling chamber door.

(l) Follow furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

8-2.5 Removal of Special Atmosphere Gas From Furnace Type II by Purge (8-2.5.1) or Burn-out (8-2.5.2) Procedures.

8-2.5.1 Purge with an Inert Gas.

8-2.5.1.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of purge gas.

(c) All doors shall remain closed.

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

(e) Immediately shut off all special atmosphere gas, flame curtains, etc., valves.

(f) Begin sampling the furnace atmosphere. Continue until two consecutive analyses of all chambers indicate the atmosphere is below 50 percent of its lower explosive limit. When this condition is reached, the furnace is purged.

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

(h) Turn off the inert gas supply to the furnace.

(i) Shut off cooling chamber fan (if provided).

(j) Open cooling chamber door (if provided).

(k) Follow furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmosphere is inert; it will NOT sustain life. Persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

8-2.5.2 Burning-out the Type II Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures rest with the person or agency authorizing the purchase of the equipment.

8-2.5.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that the heating chamber is above 1400°F (760°C).

(c) Shut off cooling chamber fan (if provided).

(d) Open inner door to cooling chamber (if provided).

(e) Open outer door to vestibule only.

(f) Shut off atmosphere gas to cooling chamber only (if provided).

(g) Shut off flame curtain (if provided).

(h) Open inner door to heating chamber.

(i) Shut off special atmosphere gas supply to heating chamber.

(j) When all burning inside of heating chamber, cooling chamber (if provided), and furnace vestibule has ceased, the special atmosphere gas has been burned out.

(k) Follow furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

8-3 Emergency Procedures for Furnace Types I and II.

8-3.1 Emergency Procedures in Case of Interruption of Special Atmosphere Gas Supply (Carrier Gas Component).

8-3.1.1 In case of interruption of any carrier gas component, one of the following shut-down procedures shall be used:

(a) If inert purge gas is available, immediately initiate purge-out procedure as outlined in 8-2.3.1 or 8-2.5.1.

(b) In case an inert purge gas supply is not available, immediately follow standard burn-out procedures, as outlined in 8-2.3.2 or 8-2.5.2.

8-3.2 Procedures in Case of Interruption of Heating System(s) that Create an Emergency.

8-3.2.1 Immediately initiate a shutdown procedure as outlined in 8-2.3 or 8-2.5.

8-4 Protective Equipment for Furnace Types I and II.

8-4.1 The following safety equipment shall be provided in conjunction with the special atmosphere gas system.

(a) Safety shutoff valves on all flammable fluid supplies to the furnace. These valve(s) shall be opened only when furnace temperature is above 1400°F (760°C). Operator's action shall be required to initiate flow.

(b) Low flow switch(es) on all carrier gas supplies to assure that atmosphere gas supply is flowing at proper rates. Low flow shall be indicated by audible and/or visual alarms.

(c) A sufficient number of furnace temperature monitoring devices to determine temperature in all heating chambers. These shall be interlocked to prevent opening of the flammable gas supply safety shut-off valve(s) until at least one heating zone is at or above 1400°F (760°C).

Exception: In case of the Type II furnace, a bypass of the 1400°F (760°C) temperature contact after the initial gas introduction is permissible, so long as a flow monitor such as a flow switch is provided to assure atmosphere flow. When 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 interlock) shall be provided if flow of the liquid is continued below 1400°F. The person or agency responsible for commissioning the atmosphere process shall specify for the user an interlock temperature setpoint and atmosphere flowrate that will provide adequate positive furnace pressure at all temperatures above the setpoint. This interlock shall not be bypassed and its set point temperature shall not be less than 800°F (427°C).

(d) Inert gas purge automatically actuated by:

1. Temperature less than 800°F (427°C) when liquid carrier gas is used.
2. Power failure.
3. Loss of flow of any carrier gas.

Exception No. 1: Inert gas purge is not 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 may be provided for furnaces where operators are present and able to 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 operator.

(f) Pilots at effluents.

(g) Manual shutoff valves and capability for checking leak tightness of safety shutoff valves.

(h) Safety relief valves when overpressurizing of glass tube flowmeters is possible.

(i) Provisions for explosion relief in vestibule.

(j) Visual and/or audible 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, 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 permit operator control in the event of power failure and/or carrier gas flow failure.

(n) Purge system, when provided, shall include:

1. Visual and/or audible alarms to alert operator of abnormal purge flow rate.
2. Gas analyzing equipment for assuring furnace is purged.
3. Monitoring devices to permit the operator to visually determine the adequacy of the inert purge flow at all times.
4. Operator's actuation station having necessary hand valves, regulators, relief valves, flow and pressure monitoring devices.

NOTE: Separate furnace inlets should be considered for introduction of inert gas if the special atmosphere is of a type that can deposit soot in the atmosphere supply pipe.

Chapter 9 Furnace in Which at Least One Zone Operates at or Above 1400°F (760°C) and Which Has no Inner Doors Which Separate Zones Operating Above and Below 1400°F (760°C)

9-1 General.

9-1.1 Scope. This chapter covers controls and procedures relating to the admittance and removal of flammable special processing atmospheres. Three general types of furnaces are covered:

Type III. Both inlet and outlet ends of the furnace are open and there are no external doors or covers.

Type IV. One end only is open.

Type V. Outer doors or covers are provided.

For application of programmable controllers, also see Section 4-2.

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 so as to minimize the infiltration of air into a furnace which could result in the creation of flammable gas-air mixtures within.

9-1.2.2 The special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits from the furnace. Atmosphere burn-off is often interrupted at exit ports as a result of furnace door openings and closings. The person or agency commissioning the furnace and/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. It must be introduced to the furnaces through one or more inlets as necessary to assure that all chambers will be 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 Furnace Type III by Purge (9-2.2.1) or Burn-in (9-2.2.2) Procedure.

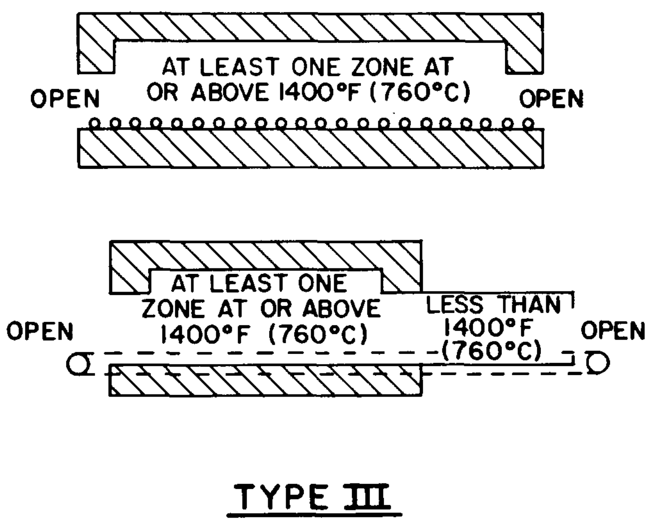


Figure 9-2.2 Examples of Type III Special Processing Atmosphere Furnace.

9-2.2.1 Purge with an Inert Gas.

9-2.2.1.1 The following procedure shall be performed before or during heatings or after the furnace is at operating temperature:

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

(b) Verify that there is an adequate supply of inert purge gas. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

(c) Verify that all flammable atmosphere gas, flame curtain, etc., valves are closed.

(d) Heat furnace to operating temperature.

(e) Actuate the inert gas purge system to purge the furnace at a rate to maintain a positive pressure in all chambers.

(f) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(g) At least one zone of the furnace shall be above 1400°F (760°C).

(h) Ignite pilots at charge and discharge end of the furnace and pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(i) After determining the special atmosphere gas supply is adequate, introduce the atmosphere gas. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(j) When flame appears at both charge and discharge end of furnace, the atmosphere introduction is complete.

(k) Turn on flame curtain (if provided) and verify ignition.

(l) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.2.2 Burning-in the Type III Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

9-2.2.2.1 The following procedures shall be performed in sequence:

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

(b) Verify that there is an adequate supply of flammable special atmosphere gas.

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

(d) Ignite pilots at charge and discharge end of the furnace and pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(e) Introduce the carrier gas(es) components of the special atmosphere gas into furnace heating chamber and observe that ignition takes place.

(f) Turn on flame curtain (if provided) and verify ignition.

(g) When flame appears at both charge and discharge end of furnace, the furnace has been burned-in.

(h) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.3 Removal of Special Atmosphere Gas from Furnace Type III by Purge (9-2.3.1) and Burn-out (9-2.3.2) Procedure.

9-2.3.1 Purge with an Inert Gas.

9-2.3.1.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of inert purge gas.

(c) Actuate the inert purge gas system to purge the furnace at a rate to maintain a positive pressure in all chambers.

(d) Immediately shut off all special atmosphere gas, process gas, flame curtain, etc., valves.

(e) Begin sampling the furnace atmosphere. Continue until two consecutive analyses of all chambers indicate the atmosphere is below 50 percent of its lower explosive limit. When this condition is reached, the furnace is purged.

(f) All pilots at charge and discharge end of furnace shall be turned off.

(g) Turn off the inert gas supply to the furnace.

(h) Follow furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmosphere is inert; it will NOT sustain life. persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

9-2.3.2 Burning-out the Type III Furnace Special Atmosphere. Responsibility for use of burn-in and burnout procedures shall rest with the person or agency authorizing the purchase of the equipment.

9-2.3.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that at least one heating chamber is above 1400 °F (760 °C).

(c) Shut off flame curtain (if provided).

(d) Shut off all special atmosphere gas and process gas supply to furnace valves.

(e) Follow the furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.4 Introduction of Special Atmosphere Gas into Furnace Type IV by Purge (9-2.4.1) or Burn-in (9-2.4.2) Procedure.

9-2.4.1 Purge with an Inert Gas.

9-2.4.1.1 The following 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) Verify that there is an adequate supply of inert purge gas. The inert gas requirements for the normal process shall not deplete the adequacy of the emergency purge gas supply.

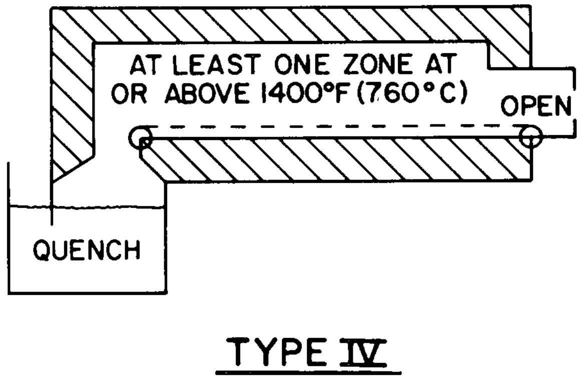


Figure 9-2.4 Example of Type IV Special Processing Atmosphere Furnace.

(c) Verify that all flammable atmosphere gas, flame curtain, etc., valves are closed.

(d) Heat furnace to operating temperature.

(e) Actuate the inert gas purge system to purge the furnace at a rate to maintain a positive pressure in all chambers.

(f) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(g) At least one zone of the furnace shall be above 1400 °F (760 °C).

(h) Ignite pilots at open end of the furnace and effluent lines and/or ports (special atmosphere vents). The pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(i) After determining the special atmosphere gas supply is adequate, introduce the atmosphere gas. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(j) When flame appears at open end of furnace, the atmosphere introduction is complete.

(k) Turn on flame curtain (if provided) and verify ignition.

(l) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.4.2 Burning-in the Type IV Furnace Special Atmosphere. Responsibility for use of burn-in and burnout procedures shall rest with the person or agency authorizing the purchase of the equipment.

9-2.4.2.1 The following procedures shall be performed in sequence:

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

(b) Verify that there is an adequate supply of flammable special atmosphere gas.

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

(d) Ignite pilots at open end of furnace and effluent lines and/or ports (special atmosphere vent).

(e) Introduce the carrier gas(es) components of the special atmosphere gas into furnace heating chamber and observe that ignition takes place.

(f) Turn on flame curtain (if provided) and verify ignition.

(g) When flame appears at open end of furnace, the furnace has been burned-in.

(h) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.5 Removal of Special Atmosphere Gas from Furnace Type IV by Purge (9-2.5.1) or Burn-out (9-2.5.2) Procedures.

9-2.5.1 Purge with an Inert Gas.

9-2.5.1.1 The following procedure shall be performed in sequence:

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

(b) Verify that an adequate supply of inert purge gas is available.

(c) Actuate inert gas purge system to purge the furnace to maintain a positive pressure in the furnace.

(d) Immediately shut off all special atmosphere gas, process gas, flame curtain, etc., valves.

(e) Begin sampling the furnace atmosphere. 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 is purged.

(f) All pilots at open end of furnace and effluent pilots (if provided) shall be turned off.

(g) Turn off the inert gas supply to the furnace.

(h) Follow manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmosphere is inert; it will NOT sustain life. Persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

9-2.5.2 Burning-out the Type IV Furnace Special Atmosphere. Responsibility for use of burn-in and burnout procedures shall rest with the person or agency authorizing the purchase of the equipment.

9-2.5.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that at least one heating chamber is above 1400°F (760°C).

(c) Shut off flame curtain (if provided).

(d) Shut off all special atmosphere and process gas supply valves.

(e) Follow the furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.6 Introduction of Special Atmosphere Gas into Furnace Type V by Purge (9-2.6.1) or Burn-in (9-2.6.2) Procedure.

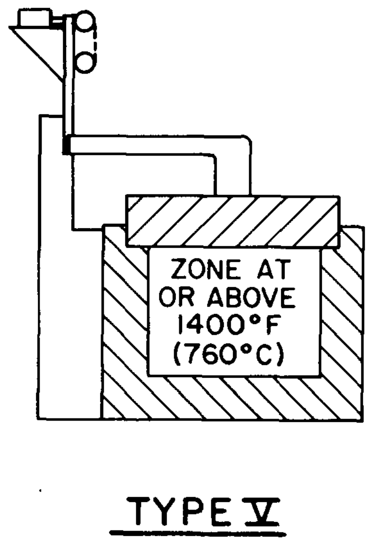


Figure 9-2.6 Example of Type V Special Processing Atmosphere Furnace.

9-2.6.1 Purge with an Inert Gas.

9-2.6.1.1 The following 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) Verify that there is an adequate supply of inert purge gas. 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 Type V sketch shall be closed.

(d) Verify that all flammable atmosphere gas, flame curtain, etc., valves are closed.

(e) Heat furnace to operating temperature.

(f) Actuate the inert gas purge system at a rate to maintain a positive pressure in all chambers.

(g) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(h) At least one zone of the furnace shall be above 1400°F (760°C).

(i) Ignite pilots at outer doors or covers and effluent lines (special atmosphere vents, if provided) and/or ports. Pilots shall be of the type that remain lit when subjected to an inert atmosphere.

(j) After determining the special atmosphere gas supply is adequate, introduce the atmosphere gas. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(k) When flame appears at effluent lines and/or ports, the atmosphere introduction is complete.

(l) Turn on flame curtain (if provided) and verify ignition.

(m) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.6.2 Burning-in the Type V Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

9-2.6.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of special atmosphere gas.

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

(d) Ignite pilots at outer doors or covers and effluent lines and/or ports (special atmosphere vent, if provided).

(e) Open outer doors.

(f) Introduce the carrier gas(es) components of the special atmosphere gas into furnace heating chamber and observe that ignition takes place.

(g) Turn on flame curtain (if provided).

(h) Close outer doors.

(i) When flame appears at effluent lines and/or ports, the furnace has been burned-in.

(j) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-2.7 Removal of Special Atmosphere Gas from Furnace Type V by Purge (9-2.7.1) or Burn-out (9-2.7.2).

9-2.7.1 Purge with an Inert Gas.

9-2.7.1.1 The following procedure shall be performed in sequence:

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

(b) Verify that an adequate supply of inert purge gas is available.

(c) All doors shall remain closed.

(d) Actuate inert gas purge system to purge the furnace to maintain a positive pressure in the furnace.

(e) Immediately shut off all special atmosphere gas, process gas, flame curtain, etc., valves.

(f) Begin sampling the furnace atmosphere. 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 is purged.

(g) All door, cover and effluent pilots (if provided) shall be turned off.

(h) Turn off the inert gas supply to the furnace.

(i) Follow manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmospere is inert; it will NOT sustain life. Persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

9-2.7.2 Burning-out the Type V Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

9-2.7.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that at least one heating chamber is above 1400°F (760°C).

(c) Open all doors or covers to allow air to enter the furnace and burn out the special atmosphere.

(d) Shut off flame curtain (if provided).

(e) Shut off all special atmosphere and process gas supply valves.

(f) Follow the furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

9-3 Emergency Procedures for Furnace Types III, IV, and V.

9-3.1 Emergency Procedures in Case of Interruption of Special Atmosphere Gas Supply (Carrier Gas Component).

9-3.1.1 In case of interruption of any carrier gas component, one of the following shutdown procedures shall be used:

(a) If inert purge gas is available, immediately initiate purge procedure as outlined in 9-2.3.1, 9-2.5.1, or 9-2.7.1.

(b) In case an inert purge gas supply is not available, immediately follow standard burnout procedures, as outlined in 9-2.3.2, 9-2.5.2, or 9-2.7.2.

9-3.2 Procedures in Case of Interruption of Heating System(s) that Create an Emergency.

9-3.2.1 Immediately initiate shutdown procedure as outlined in 9-2.3 or 9-2.5.

9-4 Protective Equipment for Furnace Types III, IV, and V.

9-4.1 The following safety equipment shall be provided in conjunction with the special atmosphere gas system:

(a) A safety shutoff valve on all flammable fluid supplies to the furnace. These valve(s) shall be energized to open only when furnace temperature is above 1400°F (760°C). Operator's action shall be required to initiate flow.

(b) Low flow switch(es) on all carrier gas supplies to assure that atmosphere gas supply is flowing at proper rates. Low flow shall be indicated by visual and/or audible alarms.

(c) A sufficient number of furnace temperature monitoring devices to determine temperature in all heating chambers. These 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 the Type V furnace, a bypass of the 1400°F (760°C) temperature contact after the initial gas introduction is permissible, so long as a flow monitor such as a flow switch is provided to assure atmosphere flow. When 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 for the user an interlock temperature setpoint and atmosphere flowrate that will provide adequate positive furnace pressure at all temperatures above the setpoint. This interlock shall not be bypassed and its set point temperature shall not be less than 800°F (427°C).

(d) Safety shutoff valve for the flame curtain burner gas supply.

(e) Visual and/or audible alarms.

(f) Manual door opening facilities to permit operator control in the event of power failure and/or carrier gas flow failure.

(g) Inert gas purge automatically actuated by:

1. Temperature less than 800°F (427°C) when liquid carrier gas is used.
2. Power failure.
3. Loss of flow of any carrier gas.

Exception No. 1: Inert gas purge is not 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 may be provided for furnaces where operators can effect timely shutdown procedures.

(h) Pilots at effluents.

(i) Manual shutoff valves and capability for checking leak tightness of safety shutoff valves.

(j) Safety relief valves when overpressurizing of glass tube flowmeters is possible.

(k) Valves for manually shutting off the flow of flammable liquids into a furnace, 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) Purge system, when provided, shall include:

1. Visual and/or audible alarms to alert operator of abnormal purge flow rate.
2. Gas analyzing equipment for assuring furnace is purged.
3. Monitoring devices to permit the operator to visually determine the adequacy of the inert purge flow at all times.
4. Operator's actuation station having necessary hand valves, regulators, relief valves, flow and pressure monitoring devices.

NOTE: Separate furnace inlets should be considered for introduction of inert gas if the special atmosphere is of a type that can deposit soot in the atmosphere supply pipe.

Chapter 10 Furnace in Which no Zones Are Consistently Operated at or Above 1400°F (760°C)

10-1 General.

10-1.1 Scope. This chapter covers controls and procedures relating to the admittance and removal of flammable special atmospheres. Two general types of furnaces are covered:

Type VI. At least one zone can be heated above 1400°F (760°C) before introduction and removal of the flammable special atmosphere gas.

Type VII. No zones can be heated to 1400°F (760°C); therefore, the flammable special atmosphere gas must be introduced and removed, using the inert gas purge procedures.

NOTE: Virtually all types of furnaces may fall into the classification of Type VI or VII. The tabular listing in 7-1.5(e) provides some common examples. Refer to sketches of Types I, II, III, IV and V in Chapters 8 and 9.

For application of programmable controllers, also see Section 4-2.

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 so as to minimize the infiltration of air into a furnace which could result in the creation of flammable gas-air mixtures within.

10-1.2.2 The special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits from the furnace. Atmosphere burn-off is often interrupted at exit ports as a result of furnace door openings and closings. The person or agency commissioning the furnace and/or atmosphere process shall prescribe a flowrate.

10-1.2.3 The flow rate of an inert gas being used as a purge shall be controlled. It must be introduced to the furnaces through one or more inlets as necessary to assure that all chambers shall be purged.

10-2 Atmosphere Introduction and Removal.

10-2.1 Introduction of Special Atmosphere Gas into Furnace Type VI by Purge (10-2.1.1) or Burn-in (10-2.1.2) Procedures.

10-2.1.1 Purge in with an Inert Gas.

10-2.1.1.1 The following 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) Verify that there is an adequate supply of inert purge gas. 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) Verify that all flammable atmosphere gas, flame curtain, etc., valves, if provided, are closed.

(e) Heat furnace to operating temperature.

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

(g) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(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. Pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(j) After determining the special atmosphere gas supply is adequate, the atmosphere gas may be introduced. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(k) When flame appears at vestibule effluent lines and/or ports, the atmosphere introduction is complete.

(l) Turn on flame curtain (if provided) and verify ignition.

(m) See furnace manufacturer's instructions for further mechanical operation and supplier of special atmosphere for process and safety instructions.

10-2.1.2 Burning-in the Type VI Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

10-2.1.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that there is an adequate supply of special atmosphere gas.

(c) Verify 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) Ignite pilots at outer doors (if provided) and effluent lines (special atmosphere vent, if provided).

(f) Open outer doors (if provided).

(g) Open inner doors (if provided).

(h) Introduce the carrier gas(es) components of the special atmosphere gas into furnace heating chamber and observe that ignition takes place.

(i) Close inner doors (if provided). A reliable source of ignition is 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 has been burned in.

(j) Turn on flame curtain (if provided) and verify ignition.

(k) Close outer doors (if provided).

(l) When flame appears at vestibule effluent lines and/or ports, the vestibule is burned-in.

(m) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

10-2.2 Removal of Special Atmosphere Gas from Furnace Type VI by Purge (10-2.2.1) or Burn-out (10-2.2.2) Procedures.

10-2.2.1 Purge with an Inert Gas.

10-2.2.1.1 The following procedure shall be performed in sequence:

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

(b) Verify that an adequate supply of inert gas is available.

(c) All doors (if provided) shall remain closed.

(d) Actuate inert gas purge system to purge the furnace at a rate to maintain a positive pressure in the furnace.

(e) Immediately shut off all special atmosphere gas, process gas, flame curtain, etc., valves (if provided).

(f) Begin sampling the furnace atmosphere. 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 is purged.

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

(h) Turn off the inert gas supply to the furnace.

(i) Follow manufacturer's instructions for further mechanical operation and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmosphere is inert; it will NOT sustain life. Persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

10-2.2.2 Burning-out the Type VI Furnace Special Atmosphere. Responsibility for use of burn-in and burn-out procedures shall rest with the person or agency authorizing the purchase of the equipment.

10-2.2.2.1 The following procedure shall be performed in sequence:

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

(b) Verify that at least one heating chamber is above 1400°F (760°C).

(c) Open all outer doors (if provided) and shut off flame curtain (if provided).

(d) Open all inner doors (if provided) to allow air to enter heating chamber and burn out the gas.

(e) Immediately shut off all components of the special atmosphere gas and other process gases to furnace.

(f) After furnace is burned-out, close inner doors (if provided).

(g) Follow the furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

10-2.3 Introduction of Special Atmosphere Gas into Furnace Type VII.

10-2.3.1 Purge with an Inert Gas.

10-2.3.1.1 The following 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) Verify that there is an adequate supply of inert purge gas of the following analysis: The inert purge gas must be free of oxygen (less than one percent oxygen) and contain less than four 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) Verify that all flammable atmosphere gas, flame curtain, etc. (if provided) valves are closed.

(e) Heat furnace to operating temperature.

(f) Actuate the inert gas purge system at a rate to maintain a positive pressure in all chambers.

(g) Begin sampling the furnace atmosphere. Continue the inert gas purge until two consecutive analyses of all chambers indicate that the oxygen content is below one percent. When this condition is reached, the furnace is purged.

(h) Ignite pilots at outer doors (if provided) and effluent lines and/or ports (special atmosphere vents, if provided).

(i) After determining the special atmosphere gas supply is adequate, introduce the atmosphere gas. After the special atmosphere gas is flowing, the inert gas purge shall be immediately turned off.

(j) When flame appears at vestibule effluent lines and/or ports, the atmosphere introduction is complete.

(k) Turn on flame curtain (if provided) and verify ignition.

(l) See furnace manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

10-2.4 Removal of Special Atmosphere Gas from Furnace Type VII by Purge (10-2.4.1).

10-2.4.1 Purge with an Inert Gas.

10-2.4.1.1 The following procedure shall be performed in sequence:

(a) Verify that an adequate supply of inert purge gas is available.

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

(c) All doors (if provided) shall remain closed.

(d) Initiate inert gas purge and assure that flow is sufficient to maintain a positive pressure in the furnace by itself.

(e) Immediately shut off all special atmosphere gas, process gas, flame curtain, etc. (if provided) valves.

(f) Begin sampling the furnace atmosphere. 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 is purged.

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

(h) Turn off the inert gas supply to the furnace.

(i) Follow manufacturer's instructions for further mechanical operations and supplier of special atmosphere for process and safety instructions.

DANGER: The furnace atmosphere is inert; it will NOT sustain life. Persons must not enter the furnace until it has been ventilated and tested to ensure safe entry conditions exist.

10-3 Emergency Procedures for Furnace Types VI and VII.

10-3.1 Emergency Procedures in Case of Interruption of Special Atmosphere Gas Supply (Carrier Gas Component).

10-3.1.1 In case of interruption of any carrier gas component, immediately initiate purge procedure as outlined in 10-2.2.1 or 10-2.4.1.

10-3.2 Procedures in Case of Interruption of Heating System(s) that Create an Emergency.

10-3.2.1 Immediately initiate shutdown procedure as outlined in 10-2.2 or 10-2.4.

10-4 Protective Equipment.

10-4.1 The following safety equipment shall be provided for furnace Type VI in conjunction with the special atmosphere gas system.

(a) Safety shutoff valves on all flammable fluid supplies to the furnace. These valve(s) may only be opened when furnace temperature is above 1400°F (760°C). Operator's action shall be required to initiate flow.

NOTE: Some operating procedures for Type VI furnaces using exothermic generated gas supplied for both purging and process may not require safety shutoff valves.

(b) Low flow switch(es) on all carrier gas supplies to assure that atmosphere gas supply is flowing at proper rates. Low flow shall be indicated by audible and/or visual alarms.

(c) Inert gas purge initiated by:

1. Temperature less than 800°F (427°C) when liquid carrier gas is used.

2. Power failure.

3. Loss of flow of any carrier gas.

Exception: Manual inert gas purge may be provided 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, shut off fuel gas to the curtain burners (if provided), and alert operator.

(e) Pilots at effluent ports.

(f) Manual shutoff valves and capability for checking leak tightness of safety shutoff valves.

(g) Safety relief valves when overpressurizing of glass tube flowmeters is possible.

(h) Provisions for explosion relief in vestibule (if provided).

(i) Audible and/or visual alarms.

(j) Safety shutoff valve for the flame curtain burner gas supply.

(k) Valves for manually shutting off the flow of flammable liquids into a furnace, 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 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 permit operating 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. When 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 interlock) shall be provided if flow of the liquid is continued below 1400°F. The person or agency responsible for commissioning the atmosphere process shall specify for the user an interlock temperature setpoint and atmosphere flowrate that will provide adequate positive furnace pressure at all temperatures above the setpoint. This interlock shall not be bypassed and its set point temperature shall not be less than 800°F (427°C).

NOTE: Furnaces using electrical heating elements that are deleteriously affected by oxygen at elevated temperatures should be purged with inert gas while the furnace is cold. Refer to manufacturers' instructions for proper procedures.

(m) Purge system shall include:

1. Audible and/or visual alarms to alert operator of abnormal purge flow rate.

2. Gas analyzing equipment for assuring furnace is purged.

3. Monitoring devices to permit the operator to visually determine the adequacy of the inert purge flow at all times.

4. Operators actuation station having necessary hand valves, regulators, relief valves, flow and pressure monitoring devices.

NOTE: Separate furnace inlets should be considered for introduction of inert gas if the special atmosphere is of a type that can deposit soot in the atmosphere supply pipe.

10-4.2 Protective devices for Type VII furnaces shall be installed and interlocked as described in (a) through (l):

(a) Inert purge gas and carrier gas flow monitoring devices shall be provided to permit the operator to visually determine the adequacy of inert purge and special atmosphere gas flow at all times.

(b) An automatic flame curtain safety shutoff valve shall be provided for flame curtain gas supply. This shall be interlocked so that the special atmosphere supply must be established prior to opening 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 vestibule door, shut off gas to curtain burners (if provided), and alert operator.

(d) Visual and/or audible alarms.

(e) Safety shutoff valve(s) shall be provided in the flammable gas components of the special atmosphere gas supply to the furnace. These valve(s) shall be interlocked with the carrier gas flows and shall require operator attention when opening. Closure of these safety shutoff valve(s) shall be immediately followed by introduction of inert gas purging.

NOTE 1: Exothermic generated gas supplies used for both purging and process do not require safety shutoff valves and low flow interlocks. Refer to manufacturers' instructions for proper procedures.

NOTE 2: Furnaces using electrical heating elements that are deleteriously affected by oxygen at elevated temperatures should be purged with inert gas while the furnace is cold. (Refer to manufacturers' instructions for proper procedures.)

(f) Low flow switch(es) on all carrier gas supplies to assure that atmosphere gas supply is flowing at proper rates. Loss of flow shall cause closure of the safety shutoff valve(s). Loss of flow shall be indicated by visual and/or audible alarms.

(g) The furnace shall be equipped with automatic inert gas purge initiated by:

1. Temperature less than 800°F (427°C) when liquid carrier gas is used.

2. Power failure.

3. Loss of flow of any carrier gas.

(h) Inert purging system shall include:

1. Visual and/or audible alarms to alert operator of abnormal purge flow rate.

2. Gas analyzing equipment to assure that the furnace is purged.

3. Monitoring devices to permit the operator to visually determine the adequacy of the inert purge flow at all times.

4. Operator's actuation station having necessary hand valves, regulators, relief valves, flow and pressure monitoring devices.

NOTE: Separate furnace inlets should be considered for introduction of inert gas if the special atmosphere is of a type that can deposit soot in the atmosphere supply pipe.

(i) Safety relief valves to prevent overpressurizing of glass tube flowmeters.

(j) Provisions shall be made for explosion relief in vestibule (if provided).

(k) Valves for manually shutting off the flow of flammable liquids into a furnace, 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) When 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 for the user an interlock temperature setpoint and atmosphere flow rate that will provide adequate positive furnace pressure at all temperatures above the set point.

Chapter 11 Class C — Heating Cover Furnaces

11-1 General.

11-1.1 Scope. This chapter describes procedures and protecting equipment which shall be used for introduction and removal of flammable special atmospheres from heating cover-type furnaces. Chapters 1 through 7 shall be used in conjunction with this chapter wherever applicable. For application of programmable controllers, also see Section 4-2. The scope shall be limited to furnaces wherein the heating cover and inner cover (if applicable) is separated from a base which also supports the work processed.

NOTE: The cover and base are closed together in order to contain the work and unavoidably a volume of air is entrapped. The heating cover may be lifted up by a self-contained mechanism as in the case of the "Tip-up"-type furnace, by factory crane as used with "Bell"-type furnaces, or the base may be mobile as in "Car Bottom"-type furnaces.

11-1.2 Types of Heating Cover Furnaces.

11-1.2.1 Type VIII. A heating cover furnace with an inner sealed cover. The work is indirectly heated. The heat source is in the space between the outer heating cover and sealed inner cover (retort). The inner cover encloses the work. (*See Figure 11-1.2.1.*)

11-1.2.2 Type IX. A heating cover furnace without an inner cover or with a non-sealed inner cover. The work may be directly or indirectly heated. (*See Figure 11-1.2.2.*)

11-1.3 Special Atmosphere Flow Requirements.

11-1.3.1 Atmosphere process and the equipment for controlling the flows of special atmospheres shall be installed and operated so as to minimize the infiltration of air into a furnace which could result in the creation of flammable gas-air mixtures within.

11-1.3.2 The flammable special atmosphere flow rate shall be sufficient to enable reliable burning of the atmosphere as it exits from the furnace. The person or agency commissioning the furnace and/or atmosphere process shall prescribe a flow rate.

11-1.3.3 The flow rate of an inert gas being used as a purge shall be controlled. It must be introduced to the furnaces through one or more inlets as necessary to assure that the entire chamber(s) shall be purged.

11-2 Flammable Special Atmoshere Introduction and Removal.

11-2.1 Flammable special atmosphere introduction and removal to/from a Type VIII heating cover furnace must be accomplished using purge procedures as listed in 11-2.3 and 11-2.4.

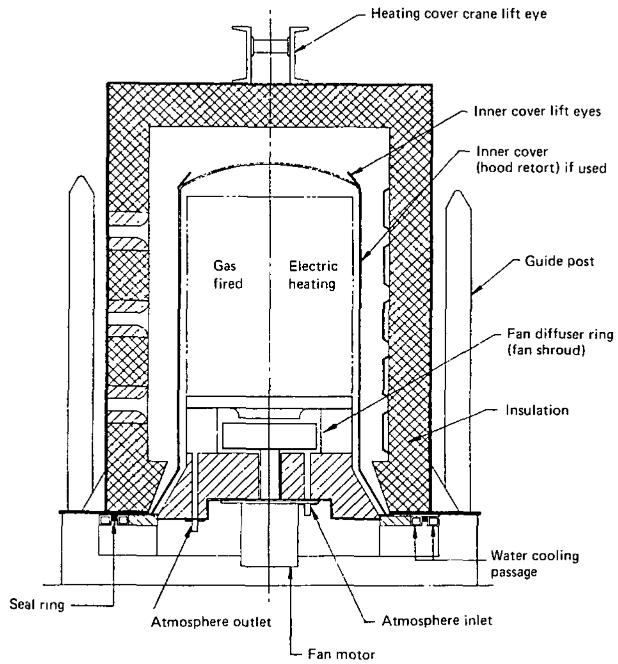


Figure 11-1.2.1 Example of a Bell-Type Furnace.

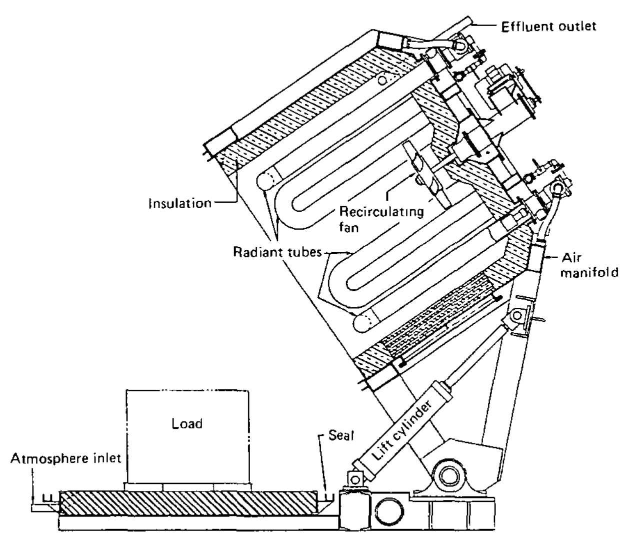


Figure 11-1.2.2 Example of a Tip-up-Type Furnace.

11-2.2 The selection of the proper procedure to be used for introduction and removal of atmosphere to/from a Type IX heating cover furnace shall be determined by the normal operating temperature of the work chamber when atmosphere is to be admitted or removed.

Exception: The procedures used to introduce or remove flammable special atmosphere from a Type IX heating cover furnace with a non-sealed inner cover shall be those listed in 11-2.5 and 11-2.6, Purge Procedures.

11-2.2.1 The procedures used to introduce or remove flammable special atmosphere to/from a Type IX heating cover furnace work chamber at or above 1400°F (760°C) shall be those listed in 11-2.7 and 11-2.8, *Burn-in Procedures*.

11-2.2.2 The procedures used to introduce or remove a flammable special atmosphere to/from a Type IX heating cover furnace work chamber below 1400°F (760°C) shall be those listed in 11-2.5 and 11-2.6, *Purge Procedures*.

11-2.3 Introduction of Flammable Special Atmosphere Gas into Heating Cover Furnace Type VIII by Purge Procedure.

11-2.3.1 Air trapped inside the inner cover (retort) shall be purged by means of inert gas or vacuum pump, prior to admitting a flammable special atmosphere.

11-2.3.1.1 The following procedure shall be performed in sequence and in accordance with manufacturer's instructions.

NOTE: Starting condition: Furnace base is loaded with work. Both base and work load are below 1400°F (760°C). Inner cover (retort) not in position over work.

(a) Verify that there is an adequate supply of inert purge gas. The inner purge gas requirements for the normal process shall not deplete the adequacy of the emergency gas supply.

(b) Close atmosphere gas valves on all bases which do not have a workload and inner cover in position, and the atmosphere gas valves on all bases which have an unpurged inner cover in position.

(c) Place the inner cover over work and seal to furnace base.

(d) Check and refill, when necessary, the liquid level in manometers and/or bubbler bottles (if so equipped) on the vent line and ignite the effluent gas pilot(s). Pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(e) Start the circulating fan, if so equipped.

(f) Actuate the inert gas purge system to purge the inner cover at a rate to maintain a positive pressure. This shall be indicated by the bubbler, vent manometer or similar device.

(g) Begin sampling the inner cover atmosphere. Continue the inert gas purge until two consecutive analyses indicate that the oxygen content is below one percent by volume.

NOTE: Alternate to (f) and (g): A vacuum purge is acceptable if the initial room air within the inner cover is pumped out with a mechanical pump to a vacuum generally in the range of 100 microns (1×10^{-1} torr).

(h) After determining the flammable special atmosphere gas supply is adequate, turn off the inert gas supply, and immediately introduce the flammable special atmosphere.

(i) Adjust the flammable special atmosphere flow to the inner cover.

(j) Check that manometers, bubbler bottles, or similar devices indicate proper pressure before continuing.

(k) When flame appears at the effluent lines, the atmosphere introduction is complete.

(l) The base with load and inner cover is now ready for the heat treating cycle. Place the outer heating cover over the inner cover and apply heat.

11-2.4 Removal of Flammable Special Atmosphere Gas from Heating Cover Furnace Type VIII by Purge Procedure.

11-2.4.1 Combustible gases within the inner cover (retort) shall be purged before the inner cover is removed.

11-2.4.1.1 The following procedure shall be performed in sequence and in accordance with manufacturer's instructions.

(a) Verify an adequate amount of inert gas is available.

(b) Remove the outer heating cover from over inner cover.

(c) Close the flammable special atmosphere gas safety shutoff valve. This should automatically cause the inert gas to flow into the inner cover. See 11-4.2.1. Verify that the inert gas flow is sufficient to maintain the manufacturer's required minimum pressure as indicated by bubbler, vent manometer, or similar device. Continue purge until the total combustible content of the special atmosphere inside the inner cover (retort) is below 50 percent of its lower explosive limit on two consecutive readings.

(d) Shut off pilot flame at each effluent vent line.

(e) Stop or reduce the speed of the circulating fan (if required).

(f) Remove the inner cover from over the work.

(g) Shut off inert purge gas flow.

11-2.5 Introduction of Flammable Special Atmosphere Gas into Heating Cover Furnace Type IX by Purge Procedure.

11-2.5.1 Air trapped inside the heating cover, and non-sealed inner cover if applicable, shall be purged by means of inert gas or vacuum pump, prior to admitting a flammable special atmosphere.

11-2.5.1.1 The following procedure shall be performed in sequence and in accordance with manufacturer's instructions.

NOTE: Starting condition: Furnace base is loaded with work. Both base and work load are below 1400°F (760°C). Heating cover not covering work.

(a) Verify that there is an adequate supply of inert gas.

The inert purge gas requirements for normal process shall not deplete the adequacy of the emergency gas supply.

(b) Verify that the atmosphere gas valves are closed on all bases which do not have a workload under process.

(c) Place the heating cover over work and seal it in the base.

(d) Check and refill, when necessary, the liquid level in manometers and/or bubbler bottles (if so equipped) on the vent line and ignite the effluent gas pilot(s). Pilots shall be of the type that will remain lit when subjected to an inert atmosphere.

(e) Start the circulating fan, if required.

(f) Actuate the inert gas purge system to purge the work chamber at a rate to maintain a positive pressure. This shall be indicated by the bubbler, vent manometer, or similar device.

(g) Begin sampling the work chamber atmosphere. Continue the inert gas purge until two consecutive analyses indicate that the oxygen content is below one percent by volume.

NOTE: Alternate to (f) and (g): A vacuum purge is acceptable if the initial room air within the heating cover is pumped out with a mechanical pump to a vacuum generally in the range of 100 microns (1×10^{-1} torr).

(h) After determining the flammable special atmosphere gas supply is adequate, turn off the inert gas supply and immediately introduce the flammable special atmosphere gas.

(i) Adjust the special atmosphere flow to the work chamber.

(j) Check that manometers, bubbler bottles, or similar devices indicate proper pressure before continuing.

(k) When flame appears at the effluent lines, the atmosphere introduction is complete.

11-2.6 Removal of Flammable Special Atmosphere Gas from Heating Cover Furnace Type IX by Purge Procedure.

11-2.6.1 Combustible gases within the heating cover, and non-sealed inner cover if applicable, shall be purged before the heating cover is opened or removed.

11-2.6.1.1 The following procedure shall be performed in sequence and in accordance with the manufacturer's instructions:

(a) Verify an adequate amount of inert gas is available.

(b) Close the flammable special atmosphere gas safety shutoff valve. This should automatically cause the inert gas to flow into the work chamber. See 11-4.2.1. Verify that the inert gas flow is sufficient to maintain manufacturer's required minimum pressure as indicated by bubbler, vent manometer or similar device. Continue purge until the total combustible content of the special atmosphere inside the work chamber is below 50 percent of its lower explosive limit on two consecutive readings.

(c) Shut off pilot flame at effluent vent line.

(d) Stop or reduce the speed of the circulating fan if required.

(e) Remove the heating cover from over the work.

(f) Shut off inert purge gas flow.

11-2.7 Introduction of Flammable Special Atmosphere Gas into a Heating Cover Furnace Type IX by Burn-in Procedure.

11-2.7.1 The procedure listed in 11-2.7.2 shall only be used if the work chamber is at or above 1400°F (760°C).

11-2.7.2 The following procedure shall be performed in sequence and in accordance with manufacturer's instructions.

NOTE: Starting condition: Furnace base is loaded with work. Both base and work load are below 1400°F (760°C). Heating cover not covering work.

(a) Verify that there is an adequate supply of flammable special atmosphere gas.

(b) Verify that the emergency inert safety purge system contains an adequate supply of inert purge gas.

(c) Verify that the atmosphere valves are closed on all bases which do not have a workload under process.

(d) Place the heating cover over workload and seal it to the base.

(e) Start the circulating fan if required.

(f) Check and refill, when necessary, the liquid level in manometers and/or bubbler bottles (if so equipped) on the vent line(s).

(g) Start-up heating system and bring work chamber temperature up to 1400°F (760°C) or greater.

NOTE: A temperature of 1400°F (760°C) or greater throughout the entire chamber is necessary for positive ignition of flammable gas upon being introduced into the furnace.

(h) Ignite the effluent gas pilots at all vents where gases may be discharged from the furnace. Pilots shall be the type that will remain lit when subjected to an inert atmosphere.

(i) Introduce the flammable special atmosphere gas and adjust the flow.

(j) Check that manometers, bubbler bottles, or similar devices indicate proper pressure before continuing.

(k) When flame appears at the effluent lines, the atmosphere introduction is complete.

11-2.8 Removal of Flammable Special Atmosphere Gas from a Heating Cover Furnace Type IX by Burn-out Procedure.

11-2.8.1 The procedure listed in 11-2-8.2 shall only be used if the work chamber is at or above 1400°F (760°C).

11-2.8.2 The following procedure shall be completed in sequence and in accordance with manufacturer's instructions, before the work chamber temperature falls below 1400°F (760°C).

(a) Where required, ignite pilots or torches and place in position or have ready for ignition of the flammable atmosphere gas at the heating cover to base seal as soon as the seal is broken.

(b) Turn off the heat source.

(c) Stop or reduce the speed of the circulating fan, if required.

(d) Release any mechanical clamping devices (if used) which hold the heating cover to the base.

(e) Gradually separate the heating cover from the base. The flammable atmosphere gas should ignite or be ignited as soon as the heating cover breaks its seal with the base.

NOTE: This procedure is required to prevent the possible formation of an explosive mixture inside the heating cover after it has been separated from the base.

(f) Close the flammable special atmosphere gas inlet valve.

11-3 Emergency Shutdown for Heating Cover-Type Furnace.

11-3.1 In the event of electric power failure or loss of flammable special atmosphere flow, the following actions will occur:

(a) An inert gas safety purge system as prescribed in 11-4.1(e) shall be immediately actuated.

(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 rate of the inert gas safety purge shall be 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 lower explosive limit on two consecutive readings.

11-4 Protective Equipment for Heating Cover-Type Furnaces.

11-4.1 The following protective equipment shall be provided in conjunction with the special atmosphere gas system.

(a) A safety shutoff valve on the flammable special atmosphere gas supply line to furnace.

(b) An atmosphere gas flow indicator(s) to permit the operator to visually determine the adequacy of atmosphere gas flow at all times.

(c) A sufficient number of furnace temperature monitoring devices to determine temperature in all zones. These shall be interlocked to prevent opening of the atmosphere gas safety shutoff valve until all zones are at, or above, 1400°F (760°C) when inert gas or vacuum purging of oxygen from the initial room air within the work chamber is not employed.

(d) Visual and/or audible alarms to alert the furnace operator of abnormal furnace temperature or atmosphere flow conditions detected by the monitoring devices as recommended, giving the operator the opportunity to safely perform any required shutdown procedure.

(e) Emergency Safety Purge. A nonflammable safety purge system, conforming to Section 6-5, to immediately purge the flammable or indeterminate atmosphere gas from the furnace 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 supervised with an approved combustion safeguard to alert the operator on pilot failure.

11-4.2 The inert purge system(s) shall include:

(a) Visual and/or audible alarms to alert the operator of abnormal purge flow rates.

(b) Gas analyzing equipment to assure that the furnace is purged.

(c) Monitoring devices to permit the operator to visually determine the adequacy of the inert purge flow at all times.

(d) Provision so that the operator may manually start the inert purge whenever desired.

11-4.2.1 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.

11-4.3 All piping and wiring connections to removable heating covers shall be painted, keyed, or otherwise marked to minimize the possibility of misconnections.

11-4.4 Automatic pressure makeup of the work chamber shall be provided on furnace equipment where reliable operator monitoring of pressure, flow rates, etc. cannot be assured.

11-5 Operating Precautions for Heating Cover-Type Furnaces.

11-5.1 The rate of separation or rejoining a heating cover from/to the inner cover shall not exceed a rate which will cause rapid expansion or contraction of the atmosphere gas inside the inner cover.

NOTE: Rapid expansion of the atmosphere gas can cause the seals to blow and rapid contraction can cause air to be drawn in the effluent line(s).

Chapter 12 Integral Quench Furnaces

12-1 Scope.

12-1.1 General.

12-1.1.1 This chapter 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 a flammable and/or nonflammable atmosphere from the time the work enters the furnace until it has been quenched and removed from the furnace. For application of programmable controllers, also see Section 4-2.

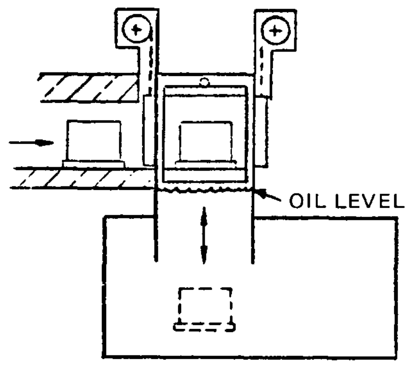
12-1.1.2 The integral quench section consists of a gastight quench vestibule and a quench tank. An additional cooling chamber may be provided, and is elevated above the quench tank or located to one side of the quench.

12-1.1.3 The atmosphere used will depend on the metallurgical requirements of work being processed.

12-1.1.4 The integral quench tank may utilize any combination of heating and cooling depending on the metallurgical requirements of the work to be processed.

TYPE Q I

DUNK TYPE ELEVATOR QUENCH



TYPE QII

DUNK TYPE ELEVATOR QUENCH WITH UNDER OIL TRANSFER

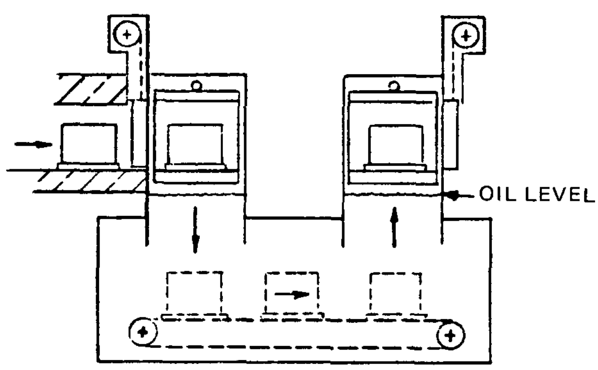


Figure 12-2 Examples of Integral Quench Furnaces.

12-1.2 Hazards.

12-1.2.1 The integral quench tank, using a combustible liquid, may be subject to the introduction or accumulation of water from a number of sources which, when exposed to the heat released from quenching of work, flashes to steam. The resulting increase in volume causes overflow of the quench tank, or over-pressurization of the quench vestibule, and expulsion of the quench medium.

12-1.3 This standard does not cover salt quench tanks or central quench medium cooling systems.

12-2 Types of Integral Quench Furnaces (*See Figure 12-2.*)

12-2.1 Type QI. Dunk-type elevator quench.

12-2.2 Type QII. Dunk-type elevator quench with under coil transfer.

(a) Type QI: Dunk-Type Elevator Quench.

(b) Type QII: Dunk-Type Elevator Quench with Oil Transfer.

12-3 Quench Vestibule.

12-3.1 The quench vestibule shall be gastight and constructed of noncombustible materials with due regard to the fire and explosion hazards inherent to such equipment.

NOTE 1: Attention to mechanical functions and corrosive conditions is vital to ensuring reliable, safe operation.

NOTE 2: The quench vestibule's design and size are dependent upon end use. If the quench vestibule doubles as atmosphere gas cooling chamber, forced cooling is normally required, provided by either water- or oil-filled jackets, plate coils, or tubing tracing. (*See Section 12-4.*)

12-3.2 The inner door between furnace and quench shall close the opening to serve as an insulated baffle to block heat loss to the quench vestibule.

12-3.3 Emergency or service openings shall be provided with gastight closures.

12-3.4 All outer load and unload doors shall be properly fitted with adequately sized and stable pilots.

12-3.5 The quench vestibule shall be supplied with adequate atmosphere gas supply to maintain safe conditions during the entire process cycle. The admittance and maintenance of this atmosphere shall conform to Chapters 8 and 10.

12-3.6 An effluent line (flammable atmosphere vent) shall be provided to control pressure equilibrium in chamber and be so located that operators will not be exposed to injury upon pressure eruption.

12-3.7 An adequately sized stable pilot shall be provided at the effluent line to ignite the vented gases.

12-3.8 Manual facilities shall be provided to permit opening of the outer quench vestibule door. Opening of this door under emergency conditions shall be an operating personnel decision.

12-4 Cooling Chamber Design.

NOTE: This section is intended to cover any design utilizing water as a cooling medium, where, by means of leakage or condensation, the quench medium is exposed to an accumulation of water.

12-4.1 With the use of hot rolled steel plate, oil or other non-waterbased coolants shall be used in place of water.

Exception: Jacketed stainless steel plate may be used, with water as a coolant, to eliminate the hazards of corrosion of hot rolled steel. However, unless all of the stainless steel is of the stabilized type, such as Columbium or Titanium or the low carbon L-series type, corrosion can take place faster than in hot rolled steel due to carbide precipitation in the steel at the welds. If used, a careful study shall be made as to compatibility of materials and welding techniques employed.

12-4.2 When quench medium temperature is excessive for desired jacket cooling, a separate heat exchanger shall be employed.

12-4.3 When 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 shall always exceed that of the cooling water.

12-4.4 When 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 a possibility of a water leak into the quench reservoir.

NOTE: Steel plate coils used with either water- or oil-type coolants are subject to eventual plugging of the passages with rust and mineral deposits. When water is used as a coolant, the use of stainless steel plate coils will considerably reduce the possibility of plugging of the water passages.

12-4.5 When 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.

12-4.6 Automatic temperature controls shall be installed in pressure-type water-cooling and oil-cooling systems to ensure the desired jacket temperature.

12-5 Elevator Design.

NOTE: The elevator's function is to immerse the work charge into the quench medium with minimum splash. At termination of the timed quench cycle, the elevator is raised to drain position at hearth level.

12-5.1 The elevating mechanism shall be substantially supported by structural members to handle the maximum rated loads.

12-5.2 Elevator guides or ways shall be provided to ensure uniform stabilized movement of the elevator in the confined areas of the quench tank.

12-5.3 Tray guides and/or stops shall be provided to ensure tray is properly positioned on the elevator.

12-5.4 Outer door operation shall be interlocked so that it cannot be opened unless the elevator is in its full "up" or "down" position, or on outage of the flame-supervised outer door pilot, except through action of manual override in emergencies.

12-6 Lower Quench Chamber or Tank.

12-6.1 The quench tank shall be designed and constructed to:

(a) Contain the quench medium capacity at the expected operating temperature and with maximum work load volume.

(b) Operate with a maximum quench medium level, when elevator and work load are submerged, of not less than 6 in. (152 mm) below door or any opening into the furnace.

12-6.2 The quench tank shall be tested to leaks prior to use.

12-6.3 The quench tank shall have sufficient capacity to quench a maximum gross load with a maximum temperature rise that will not exceed 50F° (28C°) below the flash point and cooling capabilities to recover quench medium temperature between minimum design quench cycles.

12-6.4 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 loss of quench chamber atmosphere gas and prevent siphon effect.

12-7 Overflow Drains.

12-7.1 Quench tanks of over 150 gal (0.57 m^3) in liquid capacity or 10 sq ft (0.9 m^2) in liquid surface area shall be equipped with a properly trapped overflow pipe leading to a safe location outside buildings.

NOTE: Smaller quench tanks should also be so protected, where practical.

12-7.1.1 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.

12-7.1.2 If the liquid surface area of quench tank is 75-150 sq ft (7-14 m^2), diameter of overflow pipe shall be not less than 4 in. (102 mm); if 150-225 sq ft (14-21 m^2), not less than 5 in. (127 mm); if 225-235 sq ft (21-30 m^2), not less than 6 in. (152 mm).

NOTE: On large quench tanks, multiple overflow connections are preferable to a single large pipe, provided the aggregate cross-sectional area is equivalent.

12-7.2 Overflow pipes shall be connected to quench tanks through an outlet where the accumulation of caked or dried material will not clog the overflow opening.

12-7.3 Piping connections on drains and overflow lines shall be designed so as to permit ready access for inspection and cleaning.

12-7.3.1 The bottom of the overflow connection shall be not less than 6 in. (152 mm) below the top of the tank.

12-8 Quench Medium Cooling Systems.

NOTE: Quench medium tanks generally utilize a cooling system to maintain the general quench medium at an operating temperature to reduce the quantity of quench medium required. Three basic cooling systems are in general use, consisting of:

(a) Internal cooler, where heat transfer medium is circulated through heat exchanger within quench tank.

DANGER: Water shall not be used as a cooling medium within a quench tank utilizing a combustible liquid quench medium.

(b) External cooler, where quench medium is withdrawn from quench tank, circulated through a liquid-cooled heat exchanger, and returned.

(c) External cooler, where quench medium is withdrawn from quench tank, circulated through an air-cooled heat exchanger, and returned.

12-8.1 Heat Exchanger Within Quench Tank.

12-8.1.1 The heat exchanger shall be constructed of materials that are not corroded by either cooling medium or quench medium.

12-8.1.2 The heat exchanger shall be subjected to a minimum pressure test of 150 percent of maximum designed working pressure after installation in quench tank.

NOTE: The heat exchanger should be subjected to similar test prior to being placed in service, and at periodic intervals thereafter, to ascertain that it is free of leaks.

12-8.1.3 The heat exchanger shall be located within the quench tank in such a manner as not to be subject to mechanical damage by the elevator or load to be quenched.

12-8.1.4 The cooling medium flow should be controlled by an automatic temperature control.

12-8.1.5 A pressure relief shall be provided to protect the heat exchanger. Relief shall be piped to a safe location.

12-8.2 External Liquid-Cooled Heat Exchanger.

12-8.2.1 Tubes of the heat exchanger which are exposed to contact with water shall be constructed of noncorrosive materials.

12-8.2.2 The heat exchanger, after fabrication, shall be subjected to a minimum pressure test of 150 percent of the maximum design working pressure.

NOTE: The heat exchanger should be subjected to similar test prior to being placed in service, and at periodic intervals thereafter, to ascertain that it is free of leaks.

12-8.2.3 The pressure of the quench medium through the heat exchanger shall be greater than the coolant pressure applied.

12-8.2.4 A pressure relief shall be provided to protect the heat exchanger. Relief shall be piped to a safe location.

12-8.3 External Air-Cooled Heat Exchanger.

12-8.3.1 External air-cooled heat exchangers installed out-of-doors shall be structurally reinforced to withstand anticipated wind forces without damage at elevation at which it is mounted.

12-8.3.2 External air-cooled heat exchangers installed out-of-doors or which utilize supplemental water cooling shall be of materials suitably protected against corrosion.

12-8.3.3 An external heat exchanger installed out-of-doors shall be provided with lightning protection if located in an exposed, rooftop location.

12-8.3.4 If the air-cooled heat exchanger is installed in a rooftop location, it shall be installed in a curbed or diked area, drained to a safe location outside of the building.

12-9 Quench Tank Protective Features.

12-9.1 Quench reservoir shall be equipped with a reliable quench medium level indicator.

12-9.1.1 If of the sight glass type, the level indicator shall be of heavy duty construction and protected from mechanical damage.

12-9.2 Quench tank shall be equipped with a low level device arranged to sound an alarm, prevent start of quenching, and shut off heating medium in case of a low level condition.

12-9.3 Quench tank shall be equipped with an excess temperature limit control device arranged to:

(a) Sound an alarm.

(b) Automatically shut off the quench heating medium.

(c) Prevent start of a quench.

12-9.4 When agitation of the quench medium is required to prevent overheating, the agitation shall be interlocked to prevent quenching until agitator has been started. (*See also 12-9.5.*)

12-9.4.1 The agitation shall be running a minimum of 5 minutes before quenching to aid in the detection of water in the oil.

12-9.5 When a combustible liquid quench medium is used, a water detector shall be provided for the quench tank to sound an audible alarm, and interlocked to prevent quenching in the event that water content of the quench medium exceeds 0.50 percent by volume.

12-10 Quench Tank Heating Controls.

12-10.1 Fuel-fired Immersion Heaters.

12-10.1.1 Fuel-fired immersion burners shall have fuel supplies and pilots and main burners installed and protected in accordance with Chapter 4.

12-10.1.2 Burner control systems shall be interlocked with quench medium agitation or recirculating system to prevent localized overheating of the quench medium.

12-10.1.3 The immersion tubes shall be installed so that the entire tube within the quench tank is covered with quench medium at all times.

12-10.1.4 A quench level and excess temperature supervision shall be interlocked to shut off immersion heating when low quench level or over-temperature is detected.

12-10.2 Electric Immersion Heaters.

12-10.2.1 Electric heaters shall be of a sheath-type construction.

12-10.2.2 Heater shall be installed with its sheath fully submerged in the quench medium at all times.

12-10.2.3 The quench medium shall be supervised by:

(a) A temperature controller arranged to maintain quench medium at proper temperature.

(b) A quench medium level control and excess temperature supervision shall be interlocked to shut off the immersion heating when low quench level or over-temperature is detected.

12-10.2.4 The electrical control system shall be interlocked with the quench medium agitation system to prevent localized overheating of the quench medium.

Chapter 13 Molten Salt Bath Furnaces

13-1 General.

13-1.1 Scope. This chapter covers molten salt bath furnaces, internal quench molten salt bath furnaces, and associated equipment. Molten salt bath furnaces will include any heated container that holds a melt or fusion of one or more relatively stable salts as a fluid medium into which metal work is immersed.

For application of programmable controllers, also see Section 4-2.

13-1.2 Responsibility. Molten salt bath furnaces shall be properly selected and operated for a specific process.

(a) Responsibility for selection shall rest with the person or agency authorizing the equipment, and with the manufacturer supplying the equipment.

(b) Responsibility for observing the operating instructions shall rest with the person or agency operating the equipment.

13-2 Location and Construction.

13-2.1 Location.

13-2.1.1 A liberal area shall be allocated for the installation of each salt bath furnace and the zone of operation shall be spaced off immediately around the bath to prevent congestion and to prevent interference with normal operations.

13-2.1.2 Every salt bath furnace shall be located either inside of 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: Furnaces with outer walls constructed and maintained in a manner to be salttight to prevent leakage should the inner wall fail, do not need curbing.

13-2.1.3 All salt bath furnaces shall be located so that the bath will not be exposed to leakage from overhead liquid conveying piping (service piping, steam piping, sprinkler piping, oil piping, etc.), liquid entry through wall openings (windows, air intakes, etc.), or anticipated leakage or seepage through roofs or floors above. When it is not possible to protect against possible liquid leakage entering the salt bath because of location, then the salt bath shall be provided with a noncombustible hood that is designed and installed so that leakage into the molten salt is impossible.

13-2.1.4 Where adjacent equipment (oil or water quench tanks, etc.) are located so that potential "splash over" could expose a molten salt bath, then the adjacent equipment shall be provided with deflecting baffles or guards to prevent the "splash over" from entering the salt bath.

13-2.2 Construction.

13-2.2.1 All molten salt bath furnaces shall be constructed of noncombustible materials.

13-2.2.2 All molten salt bath furnaces shall be constructed of materials that are resistant to the corrosive action of the chemical salts at the maximum design operating temperature.

13-2.2.3 The design of molten salt baths, and the materials selected for construction, shall minimize the possible effects of explosions, fires, spattering and leakage, both as regards protection of property as well as safety to operating personnel.

13-2.2.4 All requirements outlined in Chapter 2, *Location and Construction,* shall also apply for the construction of salt bath furnaces except as specified in 13-2.1.2.

13-3 Salts.

13-3.1 General. For the purpose of this section, a salt shall be considered to be any chemical compound, or mixture of compounds, that may be utilized to form a melt or fluid medium into which metal parts are immersed for processing.

13-3.2 Storage and Handling.

13-3.2.1 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).

13-3.2.2 All storage and shipping containers shall be prominently marked with the identification of the salt (or salt mixture) it contains, so that the possibility of accidentally mixing noncompatible salts will be minimized.

13-3.2.3 The supply of nitrate salts shall be stored in a separated, fireproof and damp-free room or area that is away from heat, liquids and reactive chemicals. This room or area shall be secured against entry by unauthorized personnel at all times. Only the required amount of nitrate salt shall be removed from the storage room or area that is required for make-up or full bath charges. When nitrate salts have been transported to the furnace area, they shall be immediately added to the salt bath. Excess salt shall not be permitted in the furnace area.

13-3.2.4 All furnace chargings (full charge or make-up) shall be from drums or metal containers. The use of fabric or paper sacks or bags shall be avoided.

13-3.2.5 All restrictions applying to nitrate/nitrite salts shall apply as well to cyanide salts.

WARNING: Mixing of cyanide and nitrate/nitrite salts will cause an explosion.

13-4 Heating Systems.

13-4.1 General.

13-4.1.1 For the purpose of this section, the term "salt bath furnace heating system" shall include the heating source and all associated piping, electrodes, radiant tubes, and all other equipment or devices necessary to safely convey the heat to the bath that is required to create the salt melt or fusion.

13-4.1.2 The heat source may be externally applied or may be by direct immersion of radiant tubes or electrical heating elements.

13-4.1.3 All of the requirements outlined in Chapter 3, *Heating Systems,* and Chapter 4, *Safety Control Equipment,* will apply.

13-4.2 Gas and Oil Heating Systems.

13-4.2.1 The design of a salt bath furnace shall never permit direct flame impingement upon the wall of the salt container.

13-4.2.2 Whenever burner immersion tubes or radiant tubes are used, the design shall prevent any products of combustion from entering the salt bath.

13-4.2.3 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.

13-4.2.4 All immersion tubes shall be designed so that the tube outlet is above the salt level and the inlet shall be below the salt bath level. The burner shall be sealed at tube entry to prevent salt leakage outside of the bath upon tube failure. Wherever the tube inlet or outlet is located below the salt level, it shall be sealed to prevent salt leakage outside of the furnace.

13-4.2.5 The design of a molten salt bath furnace shall eliminate (or minimize) the potential build up of sludge and foreign materials that can result in "hot spots" on immersion tubes.

13-4.2.6 For control equipment requirements, see Section 13-6.

13-4.3 Electrical Heating Systems.

13-4.3.1 Whenever 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 metal work in process.

13-4.3.2 When 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 build-up on the element that can result in damage from "hot spots."

13-4.3.3 Whenever immersed or submerged electrodes or internal resistance heating elements are used, they shall be positioned in the bath so that all heat transfer surfaces will be below the salt level at all times.

13-4.3.4 For control equipment requirements, see Section 13-6.

13-5 Ventilation.

13-5.1 **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 which are resistant to the maximum design temperature of the salt bath and the corrosive action of the salt being used.

13-5.2 Exhaust.

13-5.2.1 Salt bath furnace hoods shall be provided with exhaust ductwork and a blower (mounted external to the hood) for the continuous evacuation of fumes.

13-5.2.2 When required for the reduction of pollution by exhaust emissions, an air washer, chemical scrubber, or fume destructor, shall be installed that will perform the required altering of the exhaust without reducing the exhaust system effectiveness.

13-6 Safety Control Equipment.

13-6.1 General.

13-6.1.1 A molten salt bath furnace shall be equipped with control instrumentation and interlock systems that provide protection against the various and known types of potential equipment malfunctions.

13-6.1.2 Gas- and oil-fired salt bath furnaces shall be provided with controls as specified in Chapter 5 of this standard. In addition, an approved flame supervisory device shall be provided for each burner which shall be interlocked to shut off the fuel supply to the affected burner and activate the alarms.

13-6.1.3 All salt bath furnaces shall be provided with a temperature control instrument that will maintain the set temperature of the furnace. The temperature control instrument shall be of the "fail safe" type. Any failure of the instrument or failure of the circuit to the temperature sensing device shall immediately drive the instrument upscale and automatically open the safety contacts or shunt trip. This shall shut down the furnace and activate the alarms.

13-6.1.4 An excess temperature control instrument shall be provided, which shall have its own temperature sensing element, and shall be interlocked to shut off the heating system and activate the alarms when an excess temperature condition is detected.

NOTE 1: When a salt bath is operating in a temperature range close to the melting point of the metal work in process, or when nitrate salts are being used, it is recommended that an over-temperature control instrument be provided to open a separate disconnect device, not the temperature control contactor. As possible alternates, a preset timer which limits the "on" time of the heating system may be used, or the original instrument may be of a "fail safe" design.

NOTE 2: When nitrate salts are being used (regardless of the type of heating system), a "heat rate" controller should be installed to prevent a too rapid heat-up, thus preventing localized overheating and ignition of the salt.

13-6.1.5 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.

13-6.1.6 All electrical wiring, control cabinets and cubicles shall conform to the requirements of NFPA 70, *National Electrical Code*.

13-6.1.7 Each salt bath furnace shall be provided with visual and audible alarms. These alarms shall be interlocked with the operating and safety control instrumentation.

13-6.2 Electrically Heated Salt Bath Furnaces.

13-6.2.1 Positive control of the heating load shall be provided.

NOTE 1: When the salt bath furnace is idled over long periods, left unattended, or when not operating, and when a step-switch transformer is used, the lower voltage taps should be used.

NOTE 2: The current and voltage input should be measured by ammeters and voltmeters. These instruments should read out amperes and voltage for each phase.

13-6.2.2 If a multi-tap 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 of changing secondary voltage taps under load.

13-6.2.3 Whenever transformers are forced-air cooled, a transformer air flow switch shall be provided. This air flow switch shall be interlocked to open the safety control contactor or actuate the shunt trip in the event of loss of air flow.

13-6.2.4 Whenever 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. This instrumentation may be a waterflow switch or a thermal detector on the drain side, or both.