NFPA

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INDUSTRIAL FURNACES

SPECIAL ATMOSPHERE

1977

NATIONAL FIRE PROTECTION ASSOCIATION

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Standard for

Industrial Furnaces Using

A Special Processing Atmosphere

NFPA 86C — 1977

1977 Edition of 86C

This Standard was prepared by the Sectional Committee on Class C Furnaces. It was approved by the Committee on Ovens and Furnaces, was adopted at the 1977 Fall Meeting and supersedes the 1974 edition. The principal revision is the addition of a new chapter covering molten salt bath furnaces.

Origin and Development of 86C

This Standard 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.

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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.

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Standard for

Industrial Furnaces Using A Special Processing Atmosphere

NFPA 86C — 1977

Foreword

The standard for the location, design, and construction of ovens and furnaces is set forth under classifications as follows:

Class A ovens or furnaces are those operating at approximately atmospheric pressures and temperatures below 1400° F (760° C) where there is an explosion hazard from either, or a combination of, the fuel in use; or flammable volatiles from material in the oven or catalytic combustion system; i.e., flammable volatiles from paints and other finishing processes such as dipped or sprayed material, impregnated material, coated fabrics, etc.

Class B ovens or furnaces are those operating at or above atmospheric pressure and temperatures exceeding approximately 1400° F (760° C).

Class C furnaces are those in which there is an explosion hazard due to a flammable special atmosphere being used for treatment of material in process. This type of furnace may use any type of heating system and includes the atmosphere generator.

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

CHAPTER 1. GENERAL

ARTICLE 100. GENERAL INFORMATION

100-1. Scope. (a) This standard refers to Class C industrial furnaces and atmosphere generators, only, and shall apply to new installations, major alterations, or extensions to existing equipment.

(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 processing atmosphere within the furnace.

(c) 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.

100-2. Definitions. (a) For the purpose of this standard, BATCH PROCESS FURNACES include all furnaces into which the work is introduced all at one time.

(b) CONTINUOUS PROCESS FURNACES are furnaces into which the work charge is more or less continuously introduced.

(c) OPERATORS are the individuals responsible for the light-up, operation, shutdown, and emergency handling of the specific installation, consisting of the atmosphere gas generator and/or furnace and the associated equipment through or into which the atmosphere gas flows.

(d) MOLTEN SALT BATH FURNACES are furnaces that employ salts heated to the molten state. These do not include aqueous alkaline baths, hot brine, or other systems utilizing salts in solution.

(e) 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 standards 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 delegated agent assumes the role of the "authority having jurisdiction," at government installations, the commanding officer, or a departmental official may be the "authority having jurisdiction."

100-3. Approvals, Plans, and Specifications. (a) Before new equipment is installed or existing equipment remodeled, complete plans and specifications shall be submitted for approval to the authority having jurisdiction. Plans shall be drawn to an indicated scale, and show all essential details as to location, construction, heating equipment, fuel piping, heat input, and safety control wiring diagrams. The plans shall include a list of equipment giving manufacturer and type number.

(b) Any deviation from this standard will require special permission from the authority having jurisdiction.

(c) Wiring diagrams and sequence of operations for all safety controls, including "ladder type" schematic diagrams, shall be provided (see Fig. 1).

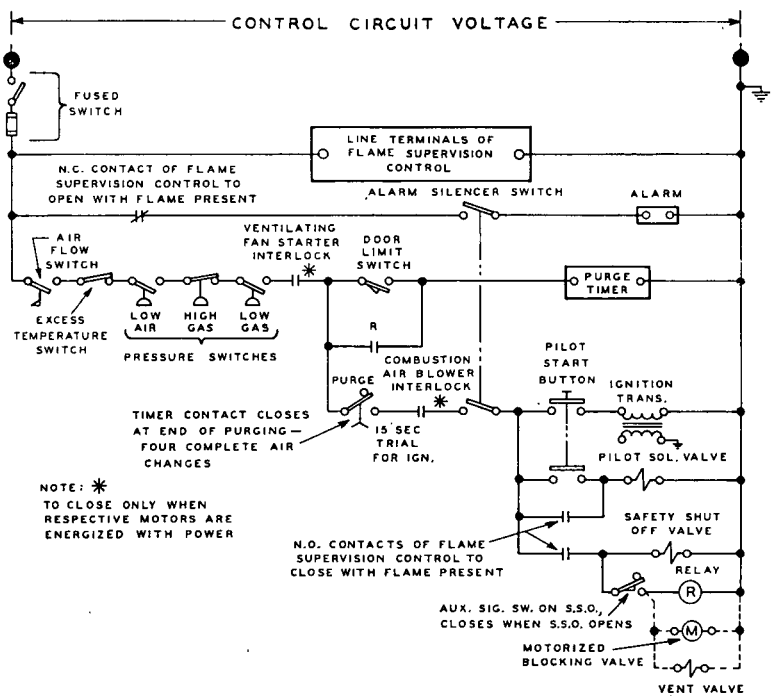


Fig. 1. Typical "ladder-type" schematic diagram

100-4. Electrical. All wiring in and around furnaces and generators shall be in accordance with the National Electrical Code (NFPA No. 70–1978) and as described in Fig. 1.

100-5. Operator Training.

(a) It is fully recognized that the most essential safety consideration is the selection of alert and competent operators. Their knowledge and training are vital to continued safe operation.

(b) New operators shall be thoroughly instructed and shall demonstrate an adequate understanding of the equipment and its operations.

(c) Regular operators shall receive scheduled retraining to maintain a high level of proficiency and effectiveness.

(d) Operators shall have access to operating instructions at all times. An outline of these instructions shall be posted at the furnace.

(e) Operating instructions shall be provided by the equipment manufacturer. These instructions shall include schematic piping and wiring diagrams. All instructions shall also include:

1. Light-up procedures.
2. Shutdown procedures.
3. Emergency procedures.
4. Maintenance procedures.

(f) Operator training shall include:

1. Combustion of air-gas mixtures.
2. Explosion hazards.
3. Sources of ignition and ignition temperature.
4. Atmosphere gas analysis.
5. Handling of flammable atmosphere gases.
6. Handling of toxic atmosphere gases.
7. Functions of control and safety devices.
8. Purpose and basic principles of the gas atmosphere generators.

CHAPTER 2. LOCATION AND CONSTRUCTION

ARTICLE 200. LOCATION OF FURNACES, GENERATORS AND RELATED EQUIPMENT

A. General

200-1. Furnaces, generators, and related eqdipment shall be located with consideration to the possibility of fire resulting from overheating, molten metal, ignition of quench oil, ignition of hydraulic oil, overheating of material in the furnace, etc., or from escaping fuel or processing atmosphere, with the resulting possibility of building and equipment damage and injury to personnel.

B. Grade Location

200-2. (a) Class C furnaces and special atmosphere generators should be located at or above grade to make maximum use of natural ventilation and to minimize restrictions to adequate explosion relief.

(b) Special consideration shall be given when a flammable special atmosphere is used or when using fuels with a specific gravity greater than air. When basements, or other confining areas, must be used, additional consideration must be given to ventilation and the ability to safely provide the required explosion relief.

C. Structural Members of Buildings

200-3. Class C furnaces and generators shall be located so that there will not be any adverse temperature effect on building structural members.

D. Location in Regard to Stock, Processes, and Personnel

200-4. Stock and Processes. Class C furnaces and special atmosphere generators should be well separated from valuable stock, important power equipment, important process equipment, and fire protection facilities, in order to minimize interruption of production, and to provide protection in the event of accidents.

200-5. Personnel. (a) Furnaces and generators shall be located to minimize exposure to groups of persons from the possibility of injury from fire, explosion, or asphyxiation.

(b) Furnaces shall not adjoin personnel assembly areas, such as recreational areas, locker rooms, lunch rooms, etc., and shall not obstruct personnel travel to exitways.

200-6. Finishing Operations. Class C furnaces and generators shall be safely located and protected from exposure to flammable liquid dip tanks, spray booths, flow coaters, or storage and mixing rooms or areas. The hazard is particularly severe when vapors from dipping operations may flow by gravity to heating units at, or near, floor level. This section should not be construed to include quenching, which imparts metallurgical properties to the product.

E. Floors and Clearances

200-7. Class C furnaces and generators shall be located for ready accessibility, with adequate space above, and on all sides, to permit inspection and maintenance. The space above, below and around the equipment shall be properly ventilated to keep temperatures at combustible floors, ceilings and walls below 160°F (71°C).

200-8. (a) Furnaces and generators shall be located on, or above, noncombustible floors. If such a location is not possible, then one of the following procedures shall be employed:

1. Remove combustible floor members and replace with a monolithic concrete slab which extends a minimum of 3 ft. beyond the outer extremities of the furnace or generator.

2. Provide air channels between the floor and the equipment (perpendicular to the axis of the equipment) and/or noncombustible insulation. This shall be adequate to prevent surface temperatures of floor members from exceeding 160°F (71°C).

(b) Where electrical wiring will be present in the channels of certain types of floors, the wiring shall be installed in accordance with Article 356 of the National Electrical Code (NFPA No. 70 — 1978).

(c) Floors beneath oil burners shall be provided with a noncombustible, nonporous surface to prevent the floors from becoming oil soaked.

200-9. Where furnace or generator ducts or stacks penetrate combustible walls, floors or roofs, clearances and insulation shall be provided to prevent surface temperatures of combustible members from exceeding 160°F (71°C).

200-10. Combustible stock, stock fixtures, equipment, etc., shall not be located near any furnace or generator or high temperature ducts or stacks.

ARTICLE 210. CONSTRUCTION OF FURNACES AND GENERATORS

A. General

210-1. Furnaces and related equipment shall be built in a substantial manner with due regard to the fire hazard inherent in equipment operating at elevated temperatures, the hazard to operators from high temperatures, open flames and mechanical equipment and the need of ensuring reliable, safe operation over the expected maximum life of the equipment.

B. Materials

210-2. (a) Furnaces shall be constructed of noncombustible materials.

(b) 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.

(c) Adequate facilities for access shall be provided to permit proper inspection and maintenance.

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

(e) Where refractory materials are used, they shall be supported so that they will not fall out of place.

(f) Corrosion resistance. Where subject to corrosion, metal parts shall be adequately protected.

(g) 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 panel shall be so located that all necessary observation and adjustment may be readily made.

(h) Parts of furnaces which operate at temperatures in excess of 160° F should be guarded by location, guard rails, shields or insulation to prevent accidental contact with personnel. All parts of equipment operating at elevated temperatures shall be installed in accordance with Article 200, Section E, Floors and Clearances.

(i) 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.

(j) Properly located observation ports shall be provided to permit the operator to observe the lighting of individual burners.

(k) Devices such as relief valves, open sight drains, and water flow switches from water cooling systems shall be designed and installed for ready observation by operator.

ARTICLE 220. FURNACE AND GENERATOR EXHAUST SYSTEMS

220-1. The need for a furnace chimney or furnace exhaust system for removal of products of combustion, heat, toxic gases, and other objectional gases will depend on the heating process, type of combustion, hazard to personnel, and all applicable air pollution control regulations.

220-2. When furnace venting is required, care shall be exercised so that excess draft is not imposed upon the furnace by the draft hood, barometric damper, or exhaust hood.

220-3. Before exhausting products of combustion directly into the area in which the furnace is located, the following factors regarding the ability of the building ventilation system to dilute these vapors and gases shall be considered:

(a) The quantity of the contaminants discharged into the area must not be too great or the air volume necessary for dilution will be impractical.

(b) Workers must not be exposed to concentrations of harmful contaminants in excess of the established threshold limit values.

220-4. In all cases where contaminants are exhausted from a furnace and related equipment into a room, the room should have mechanical ventilation consisting of an air intake system bringing in air from the outside and an exhaust system exhausting an equal amount of air to the outside. The supply air should be uniformly distributed within the area, and the exhaust duct should be arranged to eliminate all pockets and dead air areas at either floor or ceiling levels, depending on the type of contaminant being evolved.

220-5. Furnaces and related equipment requiring outside exhaust of flue gases or other combustion by-products may use direct connected, dilution, or recuperative-type exhaust systems. Size, insulation and auxiliary equipment employed shall be suitable for the maximum temperature and volume of gases to be discharged under peak conditions. The design shall otherwise conform to 200-9 and 210-2(h).

ARTICLE 230. ACCESS, MOUNTINGS, AND AUXILIARY EQUIPMENT

A. General

230-1. Adequate facilities for access shall be provided to permit proper inspection and maintenance.

230-2. When such openings are intended to permit persons to climb inside for inspection and cleaning, there should be provided such additional equipment as ladders, steps, and grab-rails to permit safe and easy access and egress.

B. Mountings

230-3. Mountings for auxiliary equipment, such as control instruments and safety devices, shall provide protection against damage by heat, vibration, and mechanical hazards.

C. Ladders or Steps

230-4. Where ladders or steps are needed to reach valves or other controls, they shall be noncombustible and provided as a permanent part of the installation.

D. Auxiliary Equipment

230-5. Auxiliary equipment such as conveyors, racks, shelves, baskets, and hangers shall be noncombustible and designed to facilitate cleaning.

ARTICLE 240. FURNACE HYDRAULIC SYSTEMS

240-1. Hydraulic systems for furnace door operation, lifts for work loads, and conveyor systems should not use petroleum or other combustible hydraulic fluids. The use of fire resistant hydraulic fluids is recommended.

240-2. When petroleum oils or other combustible fluids must be used, the system shall be designed to minimize the possibility of fluid release which may result in a fire or explosion.

240-3. All components of the hydraulic system shall conform to the standards of the National Fluid Power Association and/or ANSI Standards in the B-93 series.

240-4. Drawings for fluid power diagrams should follow ANSI Standards Y-14.17, 1966, and Y-32.10, 1967.

CHAPTER 3. HEATING SYSTEMS

ARTICLE 300. GENERAL REQUIREMENTS

300-1. Scope. (a) For the purpose of this standard the term "furnace heating system" shall include the heating source and associated ductwork and circulating fans used to convey heat to the furnace or work therein.

(b) Other heating systems such as coal or other solid fuel firebox and firing equipment, and hot oil or other liquid circulating systems are not included in this section.

(c) The source of heat may be internal, i.e., within the furnace, external, i.e., outside the furnace and the means of transfer of heat may be direct, i.e., the products of combustion enter the furnace and contact the work in process, or indirect if the products of combustion do not contact the materials in process.

(d) The transfer of heat into and throughout the furnace may be by convection, radiation, or conduction; also combinations of these means.

300-2. Control Equipment. For control equipment requirements, including combustion safeguards, air flow switches, time relays and temperature controls, see Chapter 4.

300-3. Fuel Supplies. For the handling of fuel supplies up to the point of connection with the furnace, see Section C, Articles 310 and 320 of this standard and the following NFPA standards: Oil Burning Equipment (No 31–1974), Liquefied Petroleum Gases (No. 58–1976) and National Fuel Gas Code (No. 54–1974).

300-4. Electrical Equipment. Electrical installation shall be in accordance with the National Electrical Code (NFPA No. 70–1978) and as described hereafter.

ARTICLE 310. GAS HEATING SYSTEMS

A. General

310-1. Scope. This section includes heating systems fired with natural gas, commercial manufactured gas, mixed gases, liquefied petroleum gases, and producer gas.

310-2. Gas burners and associated mixing and control equipment shall be of a proper type for safe operation and construction suitable for:

(a) The Btu content and specific gravity of the gas used.

(b) The operating pressures available.

(c) The maintenance of an adequate air supply to fuel-air mixers for reliable combustion throughout the burner operating range.

(d) In the case of excess air burners, a correct air-gas ratio for the particular burner shall be maintained throughout the turndown range. Sufficient air and gas pressures or mixture pressures depending on the type of burner shall be maintained throughout the turndown range so that safe conditions of pressure and secondary air will prevail in the combustion space.

(e) The use of safety interlocks. See Chapter 4, Safety Control Equipment.

(f) A stable pilot flame, either manually or spark ignited, if required. (See 410-8).

(g) Temperature exposure, air movement and flame propagation as may prevail.

B. Installation of Fuel Gas Systems

310-3. A description of the types of commercial gases, the properties of these gases, and a glossary with interpretation of terms as they apply to gas combustion systems and equipment is found in the Appendix.

C. Gas Piping and Valves

310-4. Other Standards Applicable. (a) Gas piping and valves for natural and manufactured gases shall be installed in accordance with the following paragraphs. Where high pressure services (above 0.5 psig (3.4 kPa) are utilized, the installation requirements shall comply specifically to the following paragraphs and to the applicable provisions of the National Fuel Gas Code (NFPA No. 54–1974).

(b) Installation of liquefied petroleum gas storage and handling systems used to supply furnace heating systems shall be made in accordance with the Standard for Liquefied Petroleum Gases (NFPA No. 58–1976).

310-5. Pipe Material. Gas piping shall be so constructed and installed in accordance with the National Fuel Gas Code (NFPA No. 54–1974).

310-6. Size of Piping. Piping shall be of a size and so installed as to provide a supply of gas sufficient to meet the maximum demand at the point of use.

310-7. Emergency Manual Shutoff Valves. Manually operated shutoff valves, operated separately from any automatic valve, shall be provided to permit turning off the fuel in emergency and shall be located so that fires, explosions, etc., at furnaces will not prevent access to these valves.

310-8. Pressure Regulator. Where a pressure regulator or governor is used as part of a furnace heating system, including gas mixing blowers and gas mixing machines, the air space of the diaphragm or bellows housing shall be vented outdoors, or to a safe location unless construction does not require a vent. The vent is not required when the diaphragm discharges through a restricted orifice into space large enough so that escaping gas would not present a hazard (not to be used on high pressure gas lines or an LP-Gas System). Also, the vent is not required for regulators having the diaphragm space connected to discharge piping from mixers through a restricted orifice. The foregoing does not apply to zero governors or loaded ratio regulators.

D. Burners and Mixers

310-9. General. There are numerous variations, combinations, and trade names for mixers and burners. A description and definition of the various types of burners and mixers may be found in the Appendix.

310-10. Burner Air Adjustment shall be fixed or provided with a locking device which will prevent accidental change of setting and shall be so located that adjustments may be readily made.

310-11. Multiple Port Burners. (a) Burners having many individual ports shall maintain a stable flame over the entire length (or surface) of the burner under all draft conditions which may arise in the operation of the furnace. They shall light easily, flash across the entire burner surface and not blow off or flash back when the burner is at operating temperatures.

Such burners must be carefully maintained and shall be so located that foreign material cannot enter ports.

(b) Multiple port burners shall be so designed that ignition of gas from every port shall result rapidly from the ignition of gas at any single port when gas is supplied to the burner at the highest and lowest rates of the control device.

(c) When "modulating" or "proportional" control is used, the low rate must be set so that burners will light dependably over their entire length or area from the ignition source provided.

310-12. Tunnel, Nozzle Mix or Torch Burners shall be so constructed that a stable flame condition without tendency to flash back or blow off will be maintained over the entire range of turndown and under all operating conditions which may be encountered in furnace operations.

Where a number of nozzle burners are supplied from a single inspirator, the provisions of 310-14, Grouped Burners, shall apply.

310-13. Special Burner Types. Specialized burner designs shall ignite reliably over the entire area of the burner from a single ignition source. Stable flame conditions without flash back or blow off shall be maintained over the entire range of turndown. Examples of special burner types are radiant and luminous wall burners.

310-14. Grouped Burners. When a number of separate burners having a single mixing inspirator are supplied, such inspirators shall be capable of inspirating all air needed for combustion and shall be installed in accordance with Section E governing proportioning burners.

310-15. Eduction Burners. When an atmospheric inspirating burner fires into a combustion space maintained at less than atmospheric pressure, it shall operate reliably under normal draft conditions and controls shall be provided to shut off the burner in event of suction failure.

310-16. Turndown. The burner shall maintain stable operation over the entire operating range and shall ignite reliably over the entire burner (at low flame) from the pilot location. Stops to limit the travel of automatic control devices shall be provided. The use of cocks or valves provided with fixed bypasses where manual control is used, is recommended.

E. Automatic Proportioning Systems

310-17. General. For definitions and descriptions of the various types of proportioning mixers, burners, inspirators, etc., see Appendix A.

310-18. Gas Burner Systems shall be equipped with a proportioning device or other device which will insure a correct gas-air ratio over the entire range of turndown. (See 310-2(c) and 2(d).)

310-19. Burner Limitations. (a) In any single gas mixing burner assembly when only one burner is used, no valve or control device except a fixed orifice for balancing purposes shall be inserted in piping between the proportioning device and any firing point.

(b) The burner head, tip or line burner shall maintain a stable flame when supplied with correct gas-air mixture over the full range of turndown.

(c) Line burners (including blast tip burners, radiant types, "infrared burners," and other grouped burners) shall light over their entire length when an ignition source is applied to any point on the burner over the entire operating range of the burner. Line burners shall not be used where ports may be subject to obstruction without adequate protection to eliminate the possibility of such obstruction.

(d) All burners shall be regulated to light reliably.

310-20. Proportioning Inspirators. (a) Valves or other obstructions shall not be installed between a proportioning mixer and burner except a fixed orifice for purposes of balancing.

(b) Each proportioning inspirator shall have a gas adjustment consisting of a fixed, replaceable orifice or an adjustable orifice. When an adjustable orifice is used, the adjustment screw shall be protected against tampering.

(c) The gas-air adjustment shall be provided with a device for locking in place.

310-21. Proportioning Mixers. (a) Valves or other obstructions shall not be installed between a proportioning mixer and burner except a fixed orifice for purposes of balancing.

(b) Each proportioning mixer shall be equipped with an adjustment means for setting the air-gas ratio which shall be equipped with locking no other means of effectively securing the setting.

310-22. Mixing Blowers. (See Appendix A, 2 for definition.)

(a) The blower shall be equipped with a gas control valve at its entrance so arranged that gas is admitted to the air stream entering the blower in proper proportions for correct combustion

by the type of burner or burners employed; the said gas control shall be of either the "zero governor" or "mechanical ratio valve" types which control the gas and air adjustments simultaneously, and no valves, control devices, or other obstructions which will change overall manifold pressure during operation, will be permitted between the blower discharge and the burner or burners.

(b) An approved safety shutoff valve of the manual opening, automatic closing type shall be installed in the gas supply connection to each mixing blower which will shut off the gas supply automatically when the blower is not in operation and in the event of gas pressure failure (see 510-2).

(c) Proper gas-air mixtures shall be supplied to the burner over the entire turndown range.

(d) The total length of air-gas mixture pipe from a mixing blower to the farthest removed gas burner inlet on the manifold shall be as short as possible.

(e) The size or sizes of pipe used in fabricating an air-gas mixture manifold shall conform with the instructions of the manufacturer of the mixing blower; but, in any event, the diameter of main manifold shall be at least the size of the discharge of the mixer.

(f) Only mixing blowers having a static delivery pressure of 10 inch w.c. or less and otherwise meeting the definition should be so classed; blowers of higher pressure being subject to the limitations of gas mixing machines under Article 310-F.

(g) The air-gas control or ratio valve on the inlet of a mixing blower shall be equipped with a permanent but adjustable limit stop to assure that a minimum mixture pressure can be established in the field to suit the requirements of the burners, the manifold, and the combustion environment.

(h) Mixing blowers should not be used with manufactured gas or other fuels containing more than 10 per cent hydrogen.

310-23. Pressure-Loaded Regulator Systems usually involve a "Zero Governor" which is cross-connected by means of an Impulse Line to a source of varying pressure for which compensation is desired. Examples include (1) Proportioning Mixers with sealed-in nozzles, with varying furnace pressure, and (2) Nozzle Mixing Burners with single (air) valve control.

(a) If a shutoff valve or an adjustment device is installed in the impulse line, it shall be done only at the direction of the equipment manufacturer.

310-24. Mechanical Air-Gas Proportioning Valves consist of (1) an air valve and (2) an adjustable gas valve and are essentially an interlocked Two Valve System with one valve in the air line and the other in the gas line.

The two valves may depend upon approximately equivalent inlet pressures and flow characteristics for maintaining proper gas-air ratios throughout the range, or their movement may be synchronized by adjustment of a flexible cam to give desired gas-air ratios at multiple positions in the range.

(a) If any adjustment device is located downstream from the Air-Gas Valve it shall be done only at the direction of the mixer manufacturer and should be protected against tampering.

F. Gas Mixing Machines

310-25. General. Any combination of proportioning control devices, blowers or compressors which supply mixtures of 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 310-26, 310-27, and 310-28 shall apply.

NOTE: The essential difference between the mixing devices used with automatic proportioning burners, Section E, and the gas mixing machines is the provision of 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.

A gas mixing machine usually comprises a pressure regulator or "zero governor" which reduces the gas supply pressure ot atmospheric and a proportioning valve and compressor.

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 mixre or directly from the combustion space. They also may supply mixtures within the explosive range and, when so installed, means to prevent flash backs occurring in piping containing the flammable mixture or to prevent damage if flash back should occur should also be provided.

310-26. 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 prevent effectively adjustment of the machine within or approaching the explosive range.

(b) The machine should be located in a large, well-ventilated

area. If the machine is in a small detached building or cut-off room, explosion vents shall be provided in the ratio of 1 square foot of vent area to each 20 cubic feet (0.57 m^3) of room volume (see NFPA No. 68–1974, Guide for Explosion Venting).

The choice of location varies considerably in individual installations. In large, well-ventilated manufacturing areas there is relatively little chance of leakage accumulating in dangerous proportions and, under such conditions, the machine may well form an integral part of a furnace heating system.

In considering small rooms where dangerous gas-air mixtures could be formed, the machine is better located in a detached building or in 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.

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

When gas mixing machines are installed in small detached buildings or cut-off rooms, the electrical equipment and wiring shall be installed in accordance with the National Electrical Code (NFPA No. 70–1978) requirements for hazardous locations (Article 500, Class I, Division 2).

(d) Machines should, if practical, be constructed so that in the event of an explosive mixture forming and flash back resulting that the machine casing will not be ruptured.

(e) Air intakes for gas mixing machines and blowers using compressors or blowers should be taken from outdoors wherever practical.

310-27. Explosive Mixtures (within flammability limits). Gas mixing machines supplying gas-air mixtures within the explosive range shall be installed in accordance with paragraph 310-26 b, c, and e, and the following paragraphs shall also apply.

(a) Automatic fire checks and safety blowouts shall be provided as called for in 410-7.

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

310-28. Controls for gas mixing machines shall include interlocks and safety shutoff valve of the manually opening automatic closing type in the gas supply connection to each machine arranged to automatically shut off the gas supply in event of air and/or gas supply failures. (See Article 410.)

G. Furnace Heating Systems

310-29. General. Furnace heating systems are of two general types, direct fired and indirect fired.

310-30. Direct Fired shall mean any heating system in which the burners fire within the work chamber. Such a system may have multiple burners (see Fig. 2).

310-31. Indirect Heating Systems are so arranged that the products of combustion do not enter the work chamber, heating being accomplished by radiation or convection from tubes or muffles.

(a) RADIANT TUBES are defined as tubular elements open at one or both ends, constructed gas-tight of suitable heat-resistant material, and capable of withstanding explosion pressure from ig-

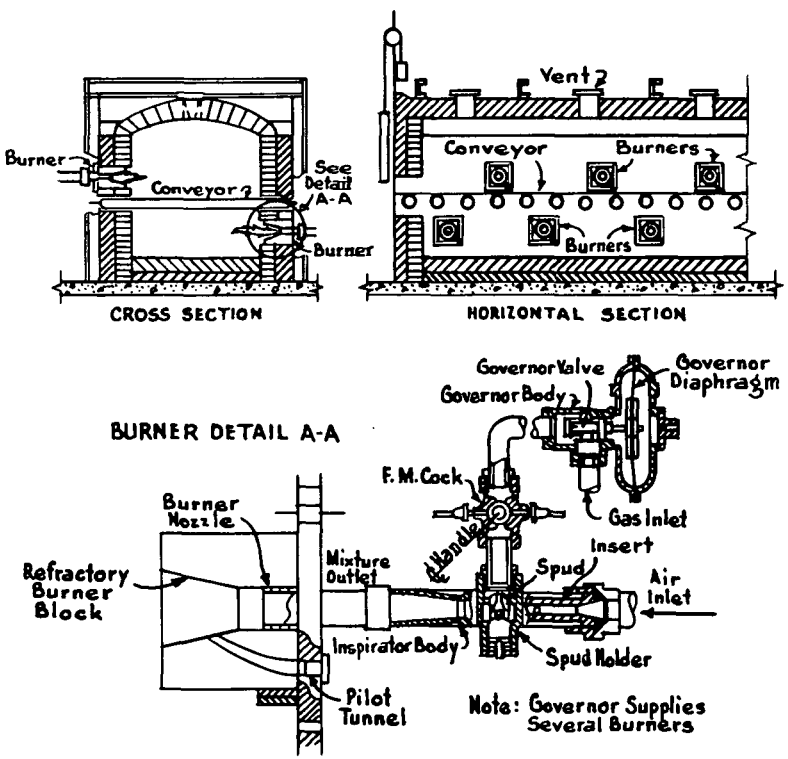
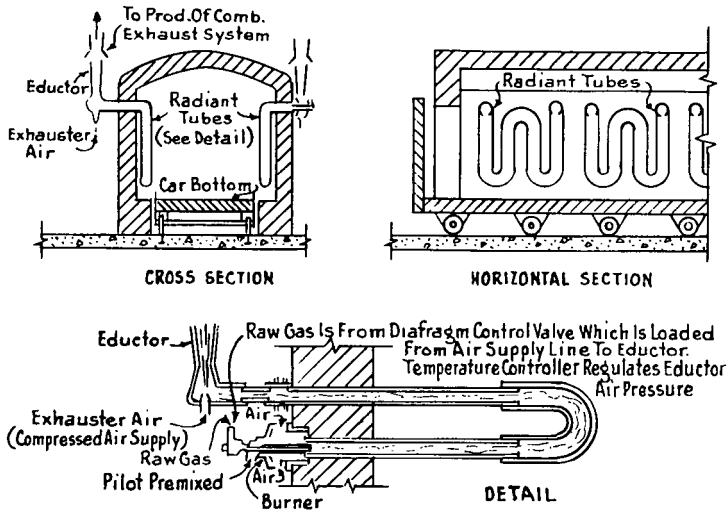


Fig. 2. Typical piping, direct fired multiburner furnace.

nition of fuel-air mixtures. 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



TYPICAL PULL-THROUGH RADIANT-TUBE BURNER

Fig. 3. Typical indirect fired radiant-tube furnace (car-bottom type)

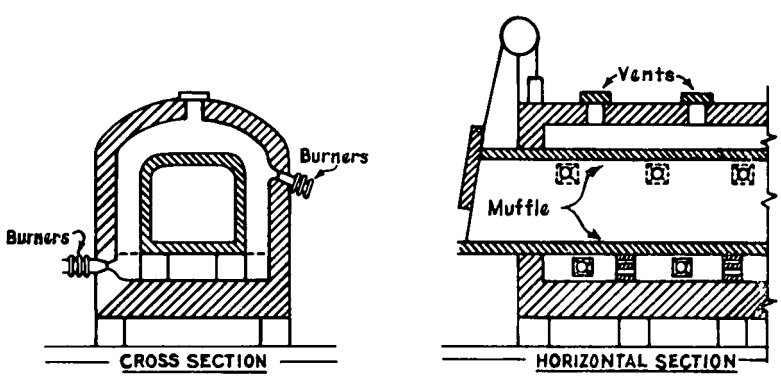


Fig. 4. Muffle-type internal-fired multiburner furnace.

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 (see Fig. 3).

(b) MUFFLES are enclosures within a furnace which separate 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 furnace but outside the muffle, or heating of the muffle may be by indirect means using radiant tubes or external furnace heaters (see Fig. 4).

ARTICLE 320. OIL-FIRED HEATING SYSTEMS

A. General

320-1. Scope. This section includes furnace heating systems fired with fuel oil and the oil burning portions of combination systems of oil and other fuels. When dual fuel heaters are used, this section shall apply to such heaters when fuel oil is being used.

B. Fuel Oil

320-2. Fuel oil as used in this Standard shall mean Nos. 2, 4, 5 or 6 in accordance with Specification for Fuel Oils, ASTM D396-73.

C. Fuel Supply

320-3. The installation of fuel storage tanks, piping, and valves shall be in accordance with the NFPA Standard for the Installation of Oil Burning Equipment (No. 31–1974).

D. Oil Burners

320-4. (a) Burners and control devices shall be acceptable to the authority having jurisdiction (see 400-1).

(b) Adequate safety protection shall be provided to prevent spillage to the building floor or to the inside floor of the combustion chamber.

320-5. Oil burners shall be of a type suitable for the service intended, as follows:

(a) Oil shall be delivered by the burner in a readily combustible condition, by proper preheating to a gas or vapor, or by atomization using preheating if necessary.

(b) Proper methods of main burner ignition in their order of preference for safety are gas pilots, electric ignition and manual ignition (see 510-8).

(c) OIL BURNER TYPES:

1. Air or stream atomizing: oil divided into a fine spray by an atomizing agent, such as steam or air.

2. Rotary: oil atomized by centrifugal force, such as applied by a whirling cone or plate.

3. Pressure atomizing: oil under high pressure forced through small orifices.

4. Vapor: oil vaporized by heat.

(d) COMBINATION — GAS AND OIL BURNERS. This type unit shall conform in safety, design and operating characteristics with the requirements specified for gas or oil burners as would be the case if they were not being used in combination.

320-6. Fuel Burning Equipment.

(a) MAIN BURNER

1. The atomizing equipment for oil burners shall be designed for convenient removal, cleaning and maintenance.

2. If an oil burner is equipped with a single atomizer and if provisions for clearing the passages of the atomizer into the furnace are included, such clearing should be done after a normal shutdown with the pilot ignited and the fan operating.

3. Clearing of the oil passages of the atomizer into the furnace immediately after a safety shutdown shall be prohibited.

(b) ATOMIZING MEDIUM FOR OIL BURNERS

1. When the fuel is to be atomized with the assistance of another medium, this atomizing medium shall be supplied free of contaminants that could cause an interruption of service.

2. The atomizing medium shall be provided at the pressures required for proper operation.

3. Provisions shall be made to insure that fuel cannot enter the main air and atomizing medium line during or after operation.

320-7. Oil Burner Controls. See Chapter 4.

E. Furnace Heating Systems — Oil Fired

(See 310-29, 30 and 31)

ARTICLE 330. ELECTRIC HEATING SYSTEMS

A. General

330-1. Scope. This section includes all types of heating systems where electrical energy is used as the source of heat.

330-2. Definitions. The following definitions apply to the several types of electrical heating systems included under Article 330.

(a) RESISTANCE HEATER — any electric heater in which heat is produced by current flow through a resistive conductor. (See Fig. 5.)

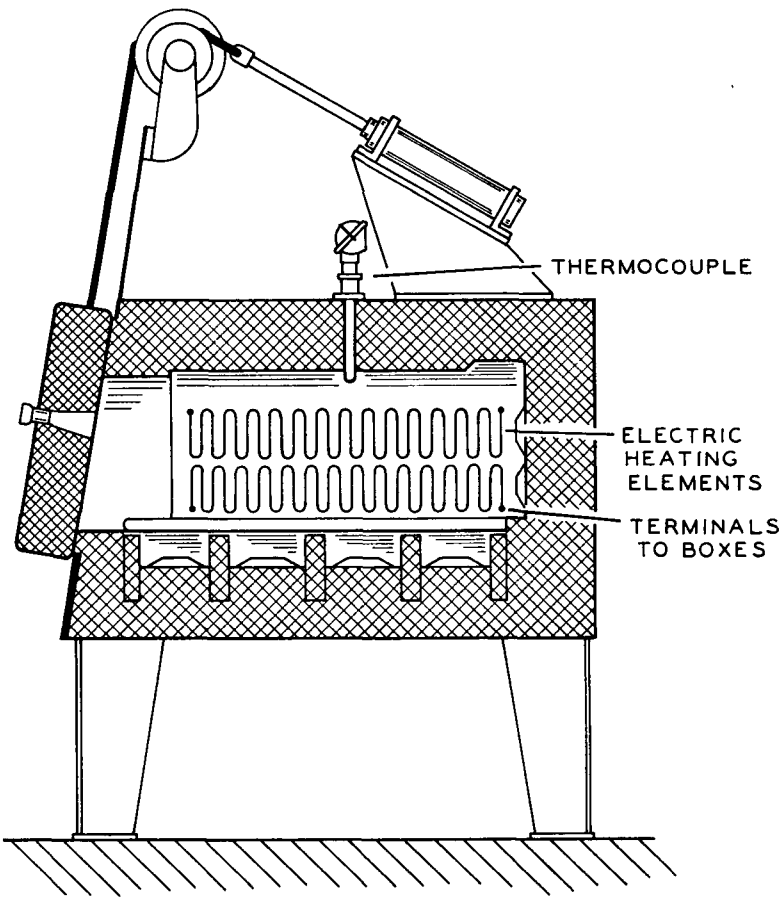


Fig. 5. Electric furnace.

(b) INDUCTION HEATER — 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 No. 70–1978.)

(c) ARC AND SKULL CASTING FURNACES — 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.

(d) PLASMA ARC FURNACE — 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.

330-3. Control Equipment. For control equipment requirements, including air flow interlocks, time relays and temperature switches, see Chapter 4.

330-4. Electrical Installation. All parts of the electrical installation shall be in accordance with the National Electrical Code, NFPA No. 70–1978.

B. Resistance Heating Systems

330-5. General. The following paragraphs apply to resistance heating systems. This category includes, but is not limited to, metallic resistors, refractory metals, cermet, silicon carbide, carbon, metal sheath, and quartz lamp heat sources.

330-6. Enclosure. (a) All parts of heaters operating within a furnace at elevated temperatures and all energized parts shall be protected to prevent accidental contact by work in process and metal objects.

(b) Unenclosed electric heating systems shall have the electric elements insulated and/or shielded to prevent injury to personnel and property.

(c) Furnaces, shells, and chambers containing heaters shall be grounded.

330-7. Protection to Personnel.

(a) Parts of furnace heaters shall be so guarded by location or enclosure as to prevent accidental contact with personnel.

330-8. Construction. (a) Resistance heaters of all types shall be located, protected, and constructed to resist damage from falling work, or other mechanical hazards inherent in industrial use.

(b) Where refractory materials or insulators are used, they shall be supported so that they will not fall out of place.

(c) Corrosion Resistance. Where subject to corrosion, metal parts shall be protected.

(d) Accessibility and Mounting of Controls. Provision shall be made for the rigid attachment of control devices. All control devices shall be located so that all necessary observation and adjustment may be readily made.

(e) All parts of equipment operating at elevated temperatures shall be installed in accordance with Article 200, Section E, Floors and Clearances.

330-9. Controls for Resistance Heaters. Refers to Article 460-B.

C. Induction Heating Systems

330-10. General. The following paragraphs apply to induction heating systems. This type of heating shall be designed and installed in accordance with the National Electrical Code (NFPA No. 70–1978) with special reference to Article 665 entitled, Inductive and Dielectric Heating Equipment:

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 (FCC, Part 18) which govern the use of industrial heating equipment of this type operating above 10 kHz.

330-11. Installation. High frequency induction equipment heating systems shall not be installed in hazardous locations. (See Article 665 of NFPA No. 70–1978.)

330-12. Construction. (a) Frames, enclosures, and shelves shall be of noncombustible construction and shall be sufficiently strong to resist physical damage.

(b) Combustible electrical insulation shall be reduced to a minimum. Transformers should be of the dry or nonflammable liquid type. Dry transformers should be in compliance with NEMA TR27–4.03, 150° C rise insulation.

(c) Protection shall be installed to prevent overheating of any part of the equipment, in accordance with the National Electrical Code, NFPA 70–1978.

(d) 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. Parallel water paths should have their own pressure or flow interlock.

(e) When forced ventilation, by motor-driven fans is necessary, the air supply shall be interlocked with the power supply. Noncombustible air filter shall be provided at the air intake.

330-13. Controls for Induction Heating Systems shall be as required in Article 665 of NFPA No. 70–1978.

D. Plasma Arc Furnaces

330-14. General. A plasma arc installation will in general consist of a furnace, an ionizing gas supply system, water cooling, a high current low voltage power supply, and a control system which integrates the system operation and protects the equipment and operating personnel.

330-15. Construction. (a) Furnace shell, control enclosure and power supply enclosure shall be made of noncombustible material and sufficiently strong to resist physical damage. Crucible and insulation material shall be compatible with required process temperatures.

(b) Furnace support arms and/or frame shall be strong enough to securely support the furnace in all possible loading, heating, and pouring positions.

330-16. Controls. (a) Furnace controls shall be located so that the operator can give attention to the electrical features of the furnace operation. An ammeter and voltmeter are essential. Also recommended are a gas flow meter and water flow meter, with operating and emergency controls convenient to the operator.

(b) Exterior furnace and control enclosure surfaces shall be grounded. Other safety control equipment will be as required in Chapter 4, where applicable.

(c) The cooling water supply shall be interlocked with the power supply.

(d) Provisions should be included for positioning and securely clamping molds to prevent moving with respect to the pouring spout during operation.

(e) Provisions shall be provided for tilting furnace to pouring position without exposure to sparks or molten metal.

(f) Since the arc generated radiates intensely at various wave lengths, particularly in the ultra violet, eyes and skin surface of the furnace operator, and other personnel near the furnace shall be properly protected. Clothing and eye protection normally associated with electric arc welding has been found to be adequate. Sight glasses should have, in addition to the usual heavy-duty high temperature glass, a filter lens in a range of No. 6 to No. 10.

CHAPTER 4. SAFETY CONTROL EQUIPMENT

ARTICLE 400. GENERAL REQUIREMENTS

A. General

400-1. (a) For safety of personnel and protection of property against fire or explosion, careful consideration shall be given to all hazards peculiar to each individual project. All furnaces heated with combustible fuels shall be provided with adequate safety devices to guard against these hazards. It is also essential that all auxiliary apparatus in close proximity to the furnace shall be safeguarded properly to avoid additional hazards.

(b) Adequate safety devices shall be used which will provide:

1. sufficient preventilation
2. control of fuel combustion
3. overtemperature protection where furnace is self-destructive

(c) Proper inspection and maintenance of safety devices shall be performed to insure that protection against the hazard is available at all times. Partial protection caused by failure of any one safety device could be more dangerous than no protection at all. Safety devices shall be properly designed and installed where prescribed in this standard. Safety devices shall not be shorted out or by-passed in the systems. All safety devices, including the oven or furnace, shall be inspected and maintained in accordance with the typical maintenance check list in Appendix C–C. Where special maintenance and inspection procedures are required due to the nature of the equipment plant management and the authority having jurisdiction shall prescribe the time interval at which the equipment and controls shall be tested for service reliability based on recommendations of the equipment manufacturer.

B. Fuel Hazards

400-2. Since a source of ignition will inevitably be present, any accumulation of flammable gases from unburned or incompletely burned fuel gas or oil in a furnace that may come within the explosive range may result in an explosion and serious fire.

(a) In order to cope with the fuel hazard, it is necessary to recognize three different conditions when operating a fuel gas or fuel oil heating system and these are discussed in 400-3, 4 and 5:

400-3. Lighting Off. Before torches, sparks, or other ignition sources are introduced, and until all burners are properly lighted, the operator shall exercise every precaution, backed up by such

automatic safety controls as are practical, to eliminate or to avoid producing dangerous unburned fuel-air accumulations.

400-4. Firing. (a) Safety requires burning of the fuel before it passes beyond its normal combustion zone at the burner. The mixer and burner assembly must proportion the particular fuel and air properly throughout the combustion zone, to the correct concentration, and the mixture velocity through the combustion zone must be neither too high, causing extinguishment by blowoff, nor too low, causing flame to flash back or "go out," at any firing rate within the turn down range. It is thus obvious that good burner-mixer design and proper application to the particular heating equipment operating conditions will be one of the main factors in safety during "firing."

(b) Air for combustion is obtained from the primary and/or secondary air supplied at the burner. Total or partial failure of combustion air supply can result in unstable flame which/may lead to flame failure, and introduction of unburned fuel into the combustion chamber. When too little combustion air is supplied, the result is an overrich mixture and incomplete combustion. The resultant flammable incomplete products of combustion are passing out of those parts of the system at temperatures high enough for prompt ignition, may later become diluted with air down into the explosion range in the furnace and after a dangerous accumulation has built up, ignition from a number of sources may produce an explosion. Overrich combustion may also produce rapid smothering and extinguishment of the burner flame, and the flammable products of incomplete combustion followed by raw gas may likewise become explosive when diluted by air later or in another part of the system. Therefore, it is essential that precautions be taken to cut off the fuel in event of failure of combustion air.

(c) Liquid fuels, such as fuel oil, must be broken up into fine globules by atomization for easy ignition and quick complete combustion. This can be accomplished by ejecting the liquid fuel at high pressure, as well as by directing a steam or air jet into the oil stream or by other means. Improper oil temperature preventing proper flow, partial obstructions in burner tips, and loss of oil or atomizing medium pressures can cause improper atomization. Failure to atomize properly will usually result in unstable flame which can lead to flame failure. Other factors leading to flame failure are stoppage of fuel supply by improperly closed fuel valve or other pipe obstruction, and presence of a slug of water in a fuel oil line.

400-5. Shutting Down. A dangerous accumulation of unburned fuel may occur in a furnace and heating system following a shutdown if any manual fuel valves are left open or leaking and/or safety shutoff valves are not tight closing. Subsequent ignition by hot refractory or ignition source when starting up may produce an explosion. All fuel valves including individual burner valves shall be closed. When practical, all safety devices should be shut down.

ARTICLE 410. SAFETY CONTROLS FOR FUEL-FIRED FURNACES

410-1. Fuel safety controls are devices such as safety shutoff valves, flame detection units, pressure switches, combustible gas detectors, flowmeters, firechecks, reliable ignition sources, and supervisory cocks. See Appendix A for a description of the items not described below.

410-2. Safety Shutoff Valves are normally closed (closed when de-energized) automatic valves installed in the fuel piping to shut off the fuel in the event of unsafe conditions or during shutdown periods. The safety shutoff valve is the "Key Unit" of all the 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. Component parts of a safety shutoff valve shall be of material suitable for the fuel handled and the design of the valve such as to assure positive shutoff under the maximum operating pressure and temperature of the fuel handled. Safety shutoff valves shall be of such design that they cannot be readily bypassed or blocked in the open position. A safety shutoff valve should be reserved for safety shutoff service only, and not subjected to the additional wear and tear of temperature control operation. See Appendix A for types of safety shutoff valves.

On continuously operating furnaces, i.e., those that are not shut down for long periods of time, the safety shutoff valves may be installed so that they can be readily tested while the furnaces are in operation.

410-3. Safety Shutoff Valve Tightness Test. A permanent and ready means for making tightness checks of all main burner gas safety shutoff valves shall be provided. (See Appendix C.)

410-4. Flame Detection Devices detect the presence or absence of flame and are used to interrupt the fuel supply in event of flame outage. Flame detection devices may be based on:

1. Flame rectification and conductivity by burning gases.

2. Ultra-violet radiation produced by burning gases.
3. Infrared radiation produced by burning gases.

NOTE: Not recommended for refractory furnaces.

A complete description of these devices may be found in Appendix A.

410-5. Pressure Limit or Supervisory Switches shall be provided to prove fuel, atomizing medium and combustion air pressures are within design limits for the burner or furnace. These pressure limit or supervisory switches are, but not necessarily limited to:

(a) HIGH GAS PRESSURE SWITCH. A pressure activated device arranged to effect a safety shutdown of the burner or burners or prevent the burner or burners from starting in the event of abnormally high gas pressures. The attention of qualified personnel shall be required before restart.

(b) LOW GAS PRESSURE SWITCH. A pressure activated device arranged to effect a safety shutdown of the burner or burners or prevent the burner or burners from starting in the event of abnormally low gas pressure. The attention of qualified personnel shall be required before restart.

(c) LOW OIL PRESSURE SWITCH. A pressure activated device arranged to effect a safety shutdown of the oil burner or burners or to prevent it or them from starting when the oil pressure falls below that recommended by the burner manufacturer. The attention of qualified personnel should be required before restart.

(d) ATOMIZING MEDIUM PRESSURE SWITCH. A pressure activated device arranged to effect a safety shutdown or to prevent the oil burner or burners from starting in the event of inadequate atomizing medium pressure. Differential pressure sensing between the atomizing medium and oil is the preferred supervisory method when system design permits.

(e) COMBUSTION AIR PRESSURE SWITCH. A pressure activated device arranged to effect a safety shutdown or to prevent the burner or burners from starting in the event the combustion air supplied to the burner or burners falls below that recommended by the burner manufacturer.

410-6. Flowmeters. Properly calibrated flowmeters are available to monitor proper flow rates of air and combustible gases for special processing.

410-7. Automatic Fire Checks and Safety Blowouts. Automatic fire checks and safety blowouts (sometimes called backfire

preventers) shall be provided in piping systems distributing flammable air-gas mixtures from gas-mixing machines (as required in 310-27) to protect the piping and the machines in event of explosions in accordance with the following recommendations:

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.

SAFETY BLOWOUT DEVICES. Safety blowout device (or backfire preventer) shall be provided near the outlet of each gas-mixing machine where the size of the piping is larger than 2½ in. 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 flash back passing through an automatic fire check.

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 flash back 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 flash back has occurred until the fire check has cooled sufficiently to prevent reignition of the flammable mixture and has been properly reset.

410-8. Pilots. A reliable ignition source for the main burner is one of the best safety controls. Properly constructed pilot burners of adequate capacity and properly located to insure ignition of the main burner, reduce the hazard associated with burning of fuel.

1. FIXED PREMIXED PILOTS FOR MANUAL-LIGHTED FURNACES. The main burners of gas- and oil-fired manual-lighted furnaces should have fixed premixed pilots. These pilots shall have suf-

ficiently large capacities to insure ignition of the main burners, and their flames shall be stable even during substantial fluctuations in draft or back pressure. Each pilot-mounting assembly shall be designed and installed so that the pilot cannot be moved out of the position and will furnish reliable ignition for the burner.

Exception (a): The main burners of gas- and oil-fired manual-lighted furnaces do not require premixed pilots but may be ignited by gas- or oil-fired portable burner pilots or by oil-soaked swabs placed in proximity to the burner nozzles by the burner man, provided approved combustion safeguards are wired into the safety-control circuit as described under Combustion Safeguards, Section 450-10, or they are indirect-fired with radiant tubes.

Exception (b): The main burners of gas- and light (Nos. 1, 2, and 4) oil-fired manual-lighted furnaces do not require premixed pilots but may have direct electric ignition, if the burner design makes premixed pilots impractical.

2. FIXED PREMIXED PILOTS FOR SEMIAUTOMATIC-LIGHTED FURNACES. The main burners of gas- and oil-fired semiautomatic-lighted furnaces should have fixed premixed pilots. These pilots shall have sufficiently large capacities to insure ignition of the main burners, and their flames shall be stable even during substantial fluctuations in draft or back pressure. Each pilot-mounting assembly shall be designed and installed so that the pilot cannot be moved out of the position and it will furnish reliable ignition for the burner.

Exception (a): The main burners of light (No. 4 or lighter) oil-fired semiautomatic-lighted furnaces do not require premixed pilots but may have direct electric ignition if the design of the burners makes gas pilots impractical.

Exception (b): The main burners of gas-fired semiautomatic-lighted furnaces do not require premixed pilots but may have direct electric ignition if the number of burners or their design makes premixed pilots impractical.

Exception (c): The main burners of oil-fired automatic- and semiautomatic-lighted furnaces do not require premixed pilots but may have oil-fired portable burner pilots. Such pilots should have sufficiently large capacities to insure provision of reliable ignition for the main burners, and their flames should be stable even under conditions of substantial fluctuations in draft or back pressure.

410-9. The Supervising Cock is 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 burners supervising cocks must be in the full closed position. Proper application of super-

vising cocks in a safety control system will minimize the type of explosion which could result where one or more standard burner cocks are accidentally left open when the main fuel supply is turned on and there is a delay in applying a proper ignition source. For application and detailed description, see 450-10(b), Exception 4(d) and Appendix A-12.

410-10. Programming Combustion Safeguard. A programming combustion safeguard is comprised of a flame-detecting assembly, an ignition-timing assembly, and one or more flame-sensing elements. The flame-detecting assembly and the ignition-timing assembly are usually in the same enclosure and complement each other.

This device may be wired into a safety-control circuit so that in addition to providing flame-failure protection during firing, it will also furnish protection against fuel explosions during lighting-off by automatically limiting the pilot-flame-establishing period and/or the trial-for-ignition period. For example, it may be arranged so that it will activate the electric ignition automatically and determine the length of time it is on and when the pilot and the main fuel safety shutoff valves can be opened. Further, a programming combustion safeguard may provide other features such as timed preventilation period and a timed post-firing-purge period.

Approved programming combustion safeguards may be of either the recycling or the nonrecycling type, depending on whether or not they automatically make one attempt to re-ignite and prove a pilot flame before permitting the main fuel safety shutoff valve to be reopened following accidental flame failure during firing.

The nonrecycling type causes all fuel to be shut off and the electric ignition to be de-activated in event the pilot flame is not proved at the end of the pilot-flame establishing period or the main flame is not established and proved at the end of the trial-for-ignition period, or if accidental flame failure occurs during firing. In all these events, the attention of an operator is required before the next pilot-flame-establishing period or trial-for-ignition period can start.

The recycling type causes all fuel to be shut off and the electric ignition to be de-activated in event the pilot flame is not proved at the end of the pilot-flame-establishing period or the main flame is not proved at the end of the trial-for-ignition period. The attention of an operator is required before the next pilot-flame-establishing period or trial-for-ignition period can start. In case of accidental flame failure during firing, this device causes the main fuel safety shutoff valve to be tripped closed, but it automatically

recycles, that is, it makes one attempt to re-ignite and prove the presence of the pilot flame before permitting the main fuel safety shutoff valve to be reopened. If the pilot is not ignited during this attempt, it causes fuel to the pilot to be shut off and the electric ignition to be de-activated. The attention of an operator is required before the next pilot-flame-establishing period or trial-for-ignition period can start.

Approved programming combustion safeguards of either the recycling or the nonrecycling type provide the following desirable lighting-off programs:

(a) GAS MAIN BURNER. A pilot flame is proved by the combustion safeguard prior to permitting the main gas safety shutoff valve to open, and where an interrupted or expanding pilot is used, the trial-for-ignition period is limited to 15 seconds and the pilot-flame-establishing period to 15 seconds.

(b) OIL MAIN BURNER. When a pilot flame is proved by the combustion safeguard prior to permitting the main oil safety shutoff valve to open, the trial-for-ignition period is limited to 30 seconds when using heavy oil and 15 seconds when using light oil. With either direct electric ignition or an unproved pilot, the trial-for-ignition period is limited to 15 seconds. The pilot-flame-establishing period is limited to 30 seconds when using heavy oil and 15 seconds when using light oil.

ARTICLE 420. TEMPERATURE CONTROLLERS

420-1. (a) Temperature controllers are devices which measure the temperature automatically and control the heat input of the burner. Excess temperature controllers are similar units designed to cut off the source of heat if the temperature controllers fail to operate properly. On failure of the primary sensing element, the controller shall fail safe.

(b) Excess temperature limit switches shall be arranged to cut off the fuel supply when the temperature exceeds a safe limit; they shall not automatically reopen the fuel valve or turn on the power. The device shall be suitable for the atmosphere in which the thermal element is located, and temperature service to which it will be subjected, its design shall be such that eventual failure at the end of its service life will not close the electric circuit causing it to "fail" unsafe. The exact location of the thermal element in the heating system shall be carefully chosen so as to supervise that temperature which most directly affects safety.

ARTICLE 430. COMBUSTIBLE GAS INDICATORS AND CONTROLLERS

A. General

430-1. (a) Continuous vapor concentration indicators and controls are devices which measure and indicate, directly or indirectly in percentage of the lower explosion limit, the concentration of a flammable vapor-air mixture. They may be of the portable or fixed location continuous operating type. The continuous indicators are mostly used throughout the period of operation of a process wherein flammable vapor is evolved. In addition to indicating or recording concentrations to aid in safe and efficient process control, they can be arranged through suitable controls automatically to sound an alarm, open or close dampers, start or stop motors, conveyors, and ventilating fans, when the concentration of a flammable vapor-air mixture has reached a predetermined dangerous level.

(b) When a continuous vapor concentration indicator and controller is arranged to shut down or operate auxiliary equipment at a predetermined dangerous level of vapor concentration, the operation point shall be set to not exceed 50 percent of the lower explosive limit.

430-2. These devices are ordinarily used with continuous process ovens and dryers or coating machines evaporating relatively large amounts of flammable liquids where the character of the process is such that evaporation rates may fluctuate widely or the normal working vapor concentration level is unusually high. Ovens connected to solvent recovery systems are frequently equipped with these instruments.

430-3. Only approved devices should be used and plans covering the application of the instrument to the process in question should be submitted to the authority having jurisdiction.

430-4. Flammable vapor concentration indicators shall be used to test flammable vapors having a flash point below 70°F (21°C) unless it is possible to maintain the sampling line and measuring assembly at the temperature of the vapors, so that condensation will not occur.

430-5. Maintenance of continuous flammable vapor indicators and controls shall be done periodically, through a maintenance service by the instrument manufacturer or equivalent. Properly trained personnel, competent to make necessary daily adjustments in accordance with the manufacturer's exact instructions or equivalent shall be made responsible for reliable operation.

A reliable auxiliary means for checking indicator calibrations frequently is imperative. It should be noted that some flammable vapor indicators are designed for use on specific materials, and that new calibrations must be made for each change in material tested. Maintaining sampling lines clean and airtight and prompt renewal of filaments when necessary are essential.

ARTICLE 440. GENERAL APPLICATION OF SAFETY CONTROLS

A. General

440-1. Safety controls are provided to aid the operator and to protect against various conditions which could result in a fire and explosion such as:

1. Accumulations of dangerous mixtures of unburned fuel or flammable vapors with air.
2. Ventilation, recirculation, or exhaust system failures.
3. Combustion air failure.
4. Abnormal fuel pressures and fuel failure.
5. Ignition and flame failure.
6. Electric power failure.
7. Excessive temperatures.

B. Operating Procedure

In general, to provide protection against fuel hazard, the operating procedure of operators and application of safety control equipment shall cover the following:

440-2. Lighting Off. (a) First, all fuel valves shall be checked for closure before any main valve is opened; and second, to remove any possible accumulation of fuel leakage during shutdown, furnace shall be preventilated before introducing an ignition source.

(b) A reliable ignition source shall be provided before the main burner fuel is supplied. It shall be kept in place until stable flame is obtained over the entire burner.

(c) Before fuel can be turned on, the fuel supply pressure and necessary air supply for reliable combustion shall be present.

440-3. Firing. (a) In event of flame failure with furnace under 1400°F (760°C) the fuel shall be shut off immediately. When applicable, flame failure combustion safeguards should be used to provide automatic fuel shutoff on flame failure (see 410-2 and 450-5).

(b) In event of excess furnace temperature, the main burner fuel should be shut off with manual restart required and shall sound an alarm.

440-4. Shutting Down. (a) All fuel valves, including individual burner cocks, shall be closed.

(b) When practical, all safety devices should be tested during the shutting down operation.

ARTICLE 450. SPECIFIC APPLICATION OF SAFETY CONTROLS

A. General

450-1. Application of safety controls and safeguards to protect against fuel hazards in furnaces shall be provided in accordance with the following sections. The safety control circuit shall be arranged so that proper operating sequence is obtained. All electrical wiring shall be in accordance with the National Electrical Code and as described hereafter.

450-2. Operation. A manual system of lighting of pilots and burners shall be accomplished by trained personnel. A programmed combustion safeguard system shall be used for semiautomatic control which governs the sequence of events in the lighting off and shutting down of the burner. See 410-10 for details of a programmed combustion safeguard.

450-3. 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 volts potential. Where possible this control circuit and its "non-furnace mounted control and safety components" should be housed in a reasonably dust-tight panel or cabinet, protected by partitions or secondary barriers 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 (see 460-3). 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.

450-4. Pilots (does not apply to radiant tubes — see 450-14).

(a) Gas pilots should be provided for ignition of main gas and oil burners. These pilots shall be:

1. Stable under all operating conditions of the equipment.
2. Properly sized to give a reliable ignition of the main burner.
3. Properly positioned to give a smooth lightoff of the main burner.
4. Fixed in position in relation to the main burner.

(b) Ignition of pilot burners may be either manual or electrical. If manual ignition is employed, either a supervising cock system or a flame detection system shall be provided to insure that the fuel to the main and pilot burners is shut off before ignition can be attempted.

(c) Ignition of pilot burners shall not be attempted unless the furnace is in the preventilated condition relating to fan operations, open doors, and full open dampers.

(d) Where main burners operate continuously, and/or flame supervisory equipment is provided, interrupted pilots may be employed. Continuous burning pilots may be used where main burner operations so dictate.

(e) Spark ignition of main gas and oil burners is permitted provided that the burner is provided with proper combustion safeguard equipment (see 450-10).

450-5. If several flame failure combustion safeguard systems are used to monitor a multiple burner heating system having only one safety shutoff valve, the combustion safeguard system shall be so interconnected that a flame failure of any burner will result in the shutting off of all fuel to the heating system. When multiple safety shutoff valves are used for individual burner or zone control, the combustion safeguard controlling the burner(s) shall be interconnected so that flame failure will result in shutting off fuel to the burner or zone involved.

450-6. Purging Cycle or Preventilation. (a) Ventilation for an appropriate time is required for all furnaces in which fuel can accumulate during a shutdown period. Radiant tube systems may or may not require ventilation controls.

(b) Only furnaces with natural ventilation shall have an electrical interlock arranged so that furnace doors must be open fully before burners can be lighted or heat can be turned on.

(c) Where preventilation is required, an approved time delay relay shall be arranged in the safety control circuit and set so as to require operation of exhaust and recirculating fans for sufficient time to provide a minimum of four complete furnace volume air changes with fresh air before the burner ignition system may be operated or fuel turned on. Distribution of fresh air introduced into the furnace during the preventilation period should be such that all internal areas of the furnace are purged.

(d) Furnace doors and/or dampers in fresh air inlets or safety exhaust outlets may require limit switch interlocks, to insure that before the time delay relay can be energized, doors or dampers must be opened sufficiently to move the amount of air required for preventilation within a reasonable time period. These switches may be shunted after the completion of the preventilation purge by suitable bypass switches, such as a fuel low-cutout pressure switch or extra "flame-on" contact of a combustion safeguard.

450-7. Combustion Air Blowers shall be interlocked in the safety control circuit so that they cannot be started until the preventilation purge period has been completed, unless provision is made by the addition of a second supervised valve to minimize the leakage when the aspirating effect of a blower can increase the leakage of gas through the burners during the purge period.

B. Safety Control Application — Direct Fired Gas Heating Systems

450-8. These heating systems are defined in 310-30. Each furnace equipped with a gas-fired (direct fired) heating system shall be provided with the control devices and safety control circuit with proper operating sequence as covered in 450-9 to 450-13 inclusive.

450-9. Ventilation Controls shall be as outlined in 450-6.

450-10. Combustion Safeguards. In general, each burner should be equipped with an approved instantaneous (flame sensing) combustion safeguard (410-4) arranged through suitable approved safety shutoff valves to shut off fuel to the burner and its pilot in the event of flame failure.

NOTE: Combustion safeguards are recommended on multipurpose multiburner furnaces which process different types of work requiring operating temperatures both above and below 1400°F (760°C). This also applies to those zones of a multizone furnace where zone operating temperatures are under 1400°F (760°C).

It is recognized that properly applied and applicable combustion safeguards can also give valuable protection on higher temperature furnaces during the initial lighting-off and warm-up periods where temperatures can be under 1400°F (760°C). for considerable lengths of time.

The flame-sensing element of the combustion safeguard should be located so as to prove the pilot flame and monitor at the intersection of the main and pilot burner flame paths, so that prompt reliable ignition by the pilot is assured before the main fuel valves can be opened. In addition, these approved combustion safeguards shall be wired into the safety control circuits to provide an acceptable sequence of operation during lighting off, firing, and relighting as follows:

(a) Gas-fired semiautomatic lighted furnaces with fixed gas pilots.

1. Before permitting the main gas safety shutoff valves to be energized and opened, the existence of a gas pilot flame should be proven at locations where they will reliably ignite the main burners.

2. The main burners shall be immediately ignited by the pilots even when they are reduced to a minimum flame that will barely hold the flame-sensing relay of the combustion safeguard in the energized (flame) position.

3. There shall be no automatic recycling after accidental flame failure; all fuel shall be shut off (safety shutoff valves tripped closed) and electric ignition deactivated.

4. The pilot flame establishing period and/or the main burner trial for ignition period shall be automatically limited to not more than 15 seconds unless the authority having jurisdiction grants an extension. If the authority having jurisdiction considers such an extension, the following conditions must be met:

(4a) A written justification must be submitted for the extension.

(4b) The time period shall not exceed 60 seconds.

(4c) An extension for the timing will be granted only after it has been determined that no more than 25 per cent of L.E.L. is the maximum permitted under the most extreme operating conditions.

At continuous-line burners, including those composed of a limited number of individual radiant burners or line-burner sections located directly adjacent to one another, supplied from a common burner manifold and having reliable flame propagation between the consecutive individual burners without special external flame-propagation devices, the length of burner supervised by a single approved combustion safeguard shall not be more than 50 ft. At burners where the total length exceeds 20 ft., the trial-for-ignition periods should be automatically limited to not more than 15 seconds after fuel is available at the burner head.

At continuous-line burners composed of a number of individual radiant-cup burners that are not located directly adjacent to one another but are supplied from a common burner manifold and have reliable flame-propagation devices, the maximum number of individual burners in a group supervised by a single approved combustion safeguard shall be 50. The total distance of the single-flame path from the first burner ignited to the last in the group, where the flame-sensing element should be located, shall not exceed 50 ft. (15.2 m), the individual burners should not be spaced more than 30 in. (762 mm), the trial-for-ignition periods should be automatically limited to not more than 15 sec., and it is not

necessary during lighting-off to prove the pilots before permitting the main safety shutoff valve to be energized and opened.

(b) Gas-Fired Manual Lighted Furnaces.

1. At main gas burners ignited by pilots or portable torches, the existence of the pilot or torch flames should be proven at locations where they will reliably ignite the main burners before permitting the main gas safety shutoff valves to be energized and opened.

2. There should be no automatic recycling after accidental flame failure.

3. The pilot flame establishing or main burner trial-for-ignition periods shall be automatically limited to not more than 15 seconds.

4. When using fixed pilots, the 15 second flame establishing period shall apply to pilot ignition only. When using portable torches, the 15 second trial-for-ignition period shall apply to main burner ignition only.

Exception (a): Multiple burners where combustion safeguards for each burner are too numerous to be practical, but continuous line-burner type pilots for groups of burners can be used: An approved practically instantaneous 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 (b): Where two burners, which will reliably ignite one from the other, are used, it shall be permissible to use a single approved instantaneous combustion safeguard supervising one of the burners; the supervised burner shall burn continuously at a firing rate at all times sufficient to reliably ignite the unsupervised burner.

Exception (c): Burner for direct fired gas heating systems which supply a furnace at a fuel rate not exceeding 150,000 Btu–hr may be equipped with heat actuated combustion safeguards or safety pilots. (See Article 410.) 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 (d): In general, for greatest security, all burners should be protected with combustion safeguards as outlined in the foregoing sections. When this is impractical the maximum practical protection should be furnished by providing a reliable continuous pilot at each burner, and/or operating burners on high-low flame, and by installing devices (pressure switches and safety shutoff valves) (see Article 410) to assure, where practical, closure of all individual burner cocks before the main burner safety shutoff valve can be opened, and to shut off all gas in case of high and low gas 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.

A method of assuring closure of all individual gas burner cocks before the main burner gas safety shutoff valve can be opened is the supervising cock and gas safety control system. A typical piping and wiring arrangement using the pneumatic type supervising cock is

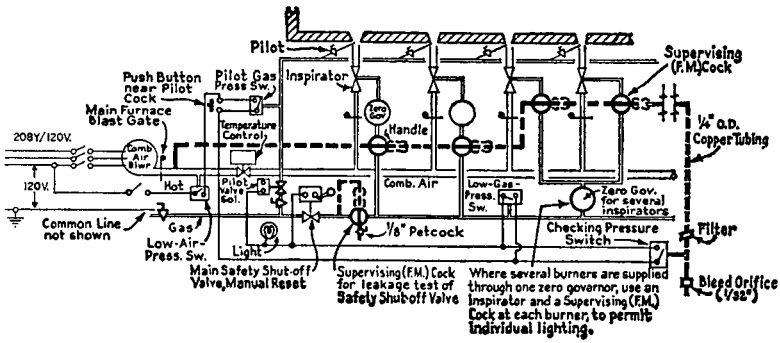


Fig. 6. Supervising Cock and Gas Safety Control System.

illustrated in Fig. 6. (See 410-9 for details of 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 all supervising cocks are closed, combustion air pressure is normal, and normal 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 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 Fig. 15. 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.

450-11. Safety Shutoff Valves. (See 410-2.) (a) When the main heating system input of the furnace is greater than 400,000 Btu's per hour, and the furnace exceeds a volume of 64 cu. ft. (1.8 m^3), an approved safety shutoff valve shall be provided in the main gas line to the burner. A second approved safety shutoff valve shall be provided in the main gas line to the burner. The second approved safety

shutoff valve shall be provided downstream from the first safety shutoff valve. An appropriately sized normally open electrically operated valve shall be provided in a vent line between the two safety shutoff valves. The vent pipe line shall be run to a safe location, preferably outdoors, and shall be accessible for inspection.

The safety shutoff valves shall be arranged to close and the vent valve shall be arranged to open in the event of failure of combustion air, excessive combustion air pressure, flame failure, excessive temperature, excessive gas pressure, too low a gas pressure and failure of electric current.

When recirculating and/or exhaust fans are used and are essential to the proper operation and safety of the furnace, the failure of the recirculating fan and/or exhaust fan shall also close the safety shutoff valves and open the vent valves.

(b) When gas pilot systems are piped up stream from the main line gas burner safety shutoff valves and the pilot system capacity is greater than 400,000 Btu's per hour (117,228 W), this same double safety shutoff valve system with a vent valve shall be used.

(c) When the main heating system input of the furnace is 400,000 Btu's per hour or less, or the volume of the furnace is less than 64 cu. ft., a single approved safety shutoff valve without a vent line may be used in place of the double safety shutoff valve and vent valve system described in 450-11 (a) and 450-11 (b).

1. Spring load solenoid valves may be used as the primary safety shutoff valve with fuel flow up to 400,000 Btu's per hour (117,228 W), or as the secondary safety shutoff valve with the double safety shutoff valve and vent system described in 450-11 (a) provided:

   a. The seating force of the spring is a minimum of five pounds, exclusive of "dead weight" of the assembly and fuel pressure exerted.
   b. Their use does not necessitate any abnormal settings of either the high or low gas pressure switches to counter any transient pressure fluctuations created by sudden operations of the valve.

2. Other solenoid valves, not meeting the above specifications may be used when all three of the following conditions prevail:

   a. The flow is less than 150,000 Btu's per hour (43,961 W).
   b. The valve size and pipe size is ¾ in. (19 mm) or less.
   c. The gas pressure is five (5) Psig (34.5 kPa), or less.

(d) The attention of the operator shall always be required before restart.

(e) A leak test facility shall be provided downstream of each safety shutoff valve. See Fig. 16 in Appendix C for proper location and procedure.

(f) Vent lines where specified above shall be as follows:

1. For fuel line diameters larger than 8 in., the vent pipe shall be at least 15 percent of the cross sectional area of the main gas pipe. If the main line is less than ¾ in., then the vent line shall be equal to the cross sectional area of the main line.
2. Vent valve ports shall have a cross sectional area equal to the specified vent line.
3. Vent lines should have a maximum length of 40 feet and discharge to outside atmosphere. If longer runs are unavoidable, or an unusual number of fittings are necessary, an increase in vent size may be necessary.
4. Manifolding of vent lines should be avoided. If manifolding is absolutely necessary, then the cross sectional area of the manifold pipe must be equal or greater than the sum of the cross sectional areas of all individual vents involved.
5. See Figure 17 in Appendix C.

Vent Pipe Size Table

FUEL LINE DIAMETER	VENT LINE DIAMETER
up to 1½ in.	¾ in.
2 in.	1 in.
2½ in.	1¼ in.
3 in.	1¼ in.
3½ in.	1½ in.
4 in.	2 in.
4½ in.	2 in.
5 in.	2 in.
5½ in.	2½ in.
6 in.	2½ in.
6½ in.	3 in.
7 in.	3 in.
7½ in.	3 in.
8 in.	3½ in.

450-12. Excess Temperature Limit Switches of the Fail Safe Type (see 420-1(b)) should be provided and suitably interlocked with the safety control circuit so that all main burners controlled by the circuit will be shut off in event of excessive temperatures in the furnace, and shall sound an alarm. They shall not automatically reopen the fuel valve. These controls shall be in addition to any normal temperature control devices used.

450-13. Auxiliary Interlocks. (a) Interlocks shall be provided for protection of the furnace. Some items that should be considered are:

1. Water-cooled walls, rolls, fan bearings, etc.
2. Conveyors.
3. Doors.

(b) An audible and/or visible alarm shall be provided in the safety circuit to give warning of unsafe conditions and interruption of the safety circuit by these interlocks.

C. Safety Control Application — Indirect Fired Gas Heating Systems — Using Radiant Tubes

450-14. These systems are defined in 310-31(a). Each radiant tube heating system or combination of systems (when two or more are combined into a single processing line with a common combustion system) shall have the following safeguards, as covered in 450-15 through 450-21.

450-15. The main fuel supply shall be supervised by means of suitable pressure switches. Both automatic and manual reset types are acceptable. Switches shall be arranged to detect abnormally high or low fuel pressure. They shall be interlocked with a safety shutoff valve to stop the flow of fuel when abnormal pressure occurs. The low pressure switch shall be set below, but still within the operable range of the combustion system. The high pressure switch shall be set above, but still within, the operable range of the combustion system.

The safety shutoff valve used in the main fuel supply line shall be a manually opened, automatically closed type. This valve shall be properly interlocked to shut down upon any abnormal operating condition or failure of the safety control circuit.

A leak test facility shall be provided downstream of the fuel supply safety shutoff valve.

Pilots should be piped upstream of the main gas safety shutoff valve with a separate safety shutoff valve and low gas pressure switch. If the manufacturer decides to locate pilot supply line downstream of the main gas safety shutoff valve, means shall be provided to prevent the introduction of gas to the main burners prior to energizing pilot valve.

450-16. On units utilizing a pressurized combustion air supply, a suitable pressure switch shall be provided to supervise this supply. Both automatic and manual reset types are acceptable. The low pressure setting shall be within the operable range of the combustion system. This switch shall be interlocked to shut off the main flow of fuel when low air pressure is detected. This switch shall be satisfied before the safety shutoff valve can be opened.

On combustion systems requiring pressure reduction, a high pressure combustion air switch shall also be provided. It shall be

interlocked to shut off main flow of fuel when excessive air pressure is detected. This setting shall be above but still within operable range of the combustion system.

Radiant tube installation employing pull-through or induced draft for induction of combustion air shall provide suitable interlocks to close fuel valve upon loss of adequate combustion air.

450-17. Purging of Radiant Tube-Type Heating Systems. Preignition purging of radiant tube-type heating systems is not required; however, special conditions may require purging of furnace work chamber.

450-18. Flame Supervision and Burner Ignition. Flame supervision of the radiant tube burners is not required; however, a suitable means of ignition shall be provided. Initial ignition can be manual or automatic. Subsequent ignition can be by auxiliary pilot, by continuous self-piloted burner, or by direct spark ignition.

450-19. 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.

The flue venting products system is to be considered as part of the plant exhaust system.

450-20. An Excess Temperature Limit Switch or Switches should be provided as outlined in 450-12.

450-21. Auxiliary Interlocks shall be provided as outlined in 450-13.

D. Safety Control Application — Indirect Fired Gas Heating Systems — Muffle Type

450-22. These heating systems are defined in 310-31 (b). Each muffle furnace gas heating system shall be equipped with control devices and safety control circuit with proper operating sequence as covered in 450-23 through 450-27.

450-23. Ventilation Controls shall be as outlined in 450-6.

450-24. Combustion Safeguards shall be provided on the burners as outlined in Section 450-10.

450-25. Safety Shutoff Valves shall be provided for indirect fired internal nonexplosion resisting heating systems as outlined in 450-11.

450-26. An Excess Temperature Limit Switch shall be provided as outlined in 450-12.

450-27. Auxiliary Interlocks shall be provided as outlined in 450-13.

E. Safety Control Application — Oil Fired Heating Systems

450-28. For description of these heating systems refer to Article 320. Control devices shall be in accordance with the Standard for Oil Burning Equipment (NFPA No. 31–1974) and approved by the authority having jurisdiction. Each furnace equipped with an oil fired heating system shall be provided with control devices and safety control circuit with proper operating sequence, as covered in 450-29 through 450-33.

450-29. Ventilation Controls shall be as outlined in 450-6.

Exception (a): Preventilation of an indirect heating system is not required when the oil burners are of the aspirating type which utilize air pressure to create a suction and draw oil from a reservoir. The fan used to draw products of combustion out of the radiant tubes should be interlocked with the furnace ventilation controls and will, therefore, operate during the furnace preventilation period.

450-30. Combustion Safeguards. In general, oil burners shall be equipped with approved instantaneous combustion safeguards to supervise burner flames and to prevent dangerous accumulations of unburned fuel and air mixtures in the furnace work chambers in the event of accidental flame failure.

Combustion safeguards shall be wired into safety-control circuits to provide an acceptable sequence of operations during lighting off, firing, and relighting as follows:

(a) Heavy-oil-fired semiautomatic lighted furnaces (Nos. 5 and 6 oil) with fixed gas pilots.

1. At main oil burners having fixed gas or oil pilots, prove the existence of the pilot flames at locations where they will reliably ignite the main burners before permitting the main oil safety shutoff valves to be energized and opened.

2. The pilot flame establishing or main burner trial-for-ignition periods shall be automatically limited to 30 seconds.

3. The safety shutoff valves shall be interlocked with the following devices to detect:

(a) Low oil temperature

(b) Low fire start

(c) Low oil pressure

(d) Supervision of atomizing medium.

4. There shall be no automatic recycling following accidental flame failure.

(b) Light oil-fired semiautomatic lighted furnaces (Nos. 1, 2, and 4 oil).

1. At light-oil burners having fixed gas pilots, prove the existence of the pilot flames at locations where they will reliably ignite the main burners before permitting the main oil safety shutoff valves to be energized and opened.

2. The pilot flame establishing or main burner trial-for-ignition periods shall be automatically limited to 15 seconds.

3. The safety shutoff valve shall be interlocked with the following devices to detect:

(a) Low fire start

(b) Low oil pressure

(c) Supervision of atomizing medium.

4. There should be no automatic recycling after flame failure.

(c) Oil-fired manual-lighted furnaces with pilots or portable torches.

1. At main light and heavy oil fired burners ignited by pilots or portable torches, the existence of the pilot or torch flames should be proven at locations where they will reliably ignite the main burners before permitting the main oil safety shutoff valves to be energized and opened.

2. There should be no automatic recycling after accidental flame failure.

3. The pilot flame establishing or the main burner trial-for-ignition periods shall be automatically limited to 30 seconds when using "heavy oil" and 15 seconds when using "light oil."

4. When using fixed pilots, the flame establishing period shall apply to pilot ignition only. When using portable torches, the flame establishing period shall apply to main burner ignition only.

Exception (a): Subject to the approval of the authority having jurisdiction, direct supervision of the oil flame by a combustion safeguard may not be required when a continuous burning reliable gas pilot flame ignition source is provided for an oil burner, providing that the pilot flame is supervised by an approved instantaneous combustion safeguard (see 410-4) arranged to shut off the fuel to the main burner and pilot in event of pilot flame failure through suitable approved safety shutoff valves. The safety control circuit should be so arranged that the fuel safety shutoff valve cannot be opened until the combustion safeguard senses a strong pilot flame.

Exception (b): When two oil burners will reliably ignite one from each other, it may be permissible to use a single approved instantaneous combustion safeguard supervising one of the burners, provided that the supervised burner burns continuously at a firing rate at all times sufficient to reliably ignite the unsupervised burner.

Exception (c): Combustion safeguards may be omitted on radiant tube burners (see 450-18).

450-31. Safety Shutoff Valves (see 410-2). Each oil heating system shall be provided with an approved safety shutoff valve or valves for shutting off fuel to the burner or burners being protected. An approved safety shutoff valve shall also be provided on the gas pilot lines to the burners, if gas pilots are used. These valves shall be arranged to close in event of failure of ventilation, air flow, flame failure, failure of fuel pressure, failure of atomizing air or steam pressure (if used), and failure of electric current. For small furnaces not equipped with mechanical ventilation, the safety shutoff valve, in addition to the foregoing, shall be connected so that it will close when the furnace is shut down and require opening of the furnace before it can be reopened.

450-32. Excess Temperature Limit Switch shall be provided as outlined in 450-12.

450-33. Auxiliary Interlocks shall be provided as outlined in 450–13.

ARTICLE 460. SAFETY CONTROL APPLICATION FOR ELECTRIC FURNACES

A. General

460-1. Safety control application for furnaces lacking fuel hazards shall provide protection from excess temperatures, loss of secondary systems (cooling, material handling, etc.) essential to normal operation of the furnace. Controls and arrangement shall be as outlined in the safety control application for electric furnaces. Instruments shall be of the fail-safe type. (See Appendix A–6.)

B. Safety Control Application for Electric Furnaces

460-2. For a description of these systems refer to Article 330. Each furnace, or heat processing system (including resistance, induction, electric arc or plasma device) shall be provided with the following control devices and safety control circuits for proper operation.

460-3. Heating Equipment Controls. (a) Electric heating equipment of other than the portable type shall be equipped with a main disconnect device, capable of de-energizing the entire heating system under load to provide safety for secondary measures necessitated by one or more of the following conditions:

1. A system short circuit not cleared by supplemental branch circuit protection.
2. Excess furnace temperature.
3. Failure of normal operating controls.
4. Complete or partial loss of power such as single phasing of a multiple phase power system.

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 heating system 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.

Portable furnaces may be equipped with main disconnect devices to meet the above requirements, but if not, the power supply circuit to the furnace shall be so equipped. Supplemental electrical controls (contactors, circuit breakers, relays, signaling devices, etc.) shall be provided in accord with safety, temperature control, branch circuit and auxiliary system requirements.

(b) 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. This may require de-rating some components as listed by manufacturers for other types of industrial service, motor control, etc., and shown in Table I.

TABLE I

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

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

(c) All controls, using thermal protection or trip mechanisms, shall be so located or protected as to preclude faulty operation due to abnormal temperatures or other furnace hazards.

460-4. Ventilation Controls. When removal of by-product vapors is essential to the safe operation of the furnace, controls and interlocks shall be provided as outlined in 450-6.

460-5. Material handling or positioning controls should be arranged for proper sequence of operation with other furnace (special atmosphere and safety controls), and also to assure emergency action as may be needed in the event of malfunction of the material handling system.

Exception: It is permissible to install provision for operating conveyors manually or by means of a constant pressure pushbutton for the purpose of removing material from the furnace in event of malfunction in the automatic system.

460-6. Where a furnace is subject to damage, an excess furnace temperature limit control should be provided for annunciation and interruption of power supply to the furnace heating system.

Manual reset shall be provided to prevent automatic restoration of power.

These controls shall be in addition to any normal operating temperature control devices.

460-7. Branch circuits and branch circuit protection for all electrical circuits in the furnace heating system shall be provided in accordance with the National Electrical Code (NFPA No. 70–1978).

460-8. Main Disconnect to Power. See Appendix D.

CHAPTER 5

GAS ATMOSPHERE GENERATORS AND BULK STORAGE SYSTEMS

ARTICLE 500. GENERAL

500-1. This chapter covers special processing atmosphere generating and bulk storage equipment, only. Ovens and furnaces are covered in other chapters.

While liquid fuels for atmosphere generation are not covered, the same basic principles of safety and operating procedures will apply.

500-2. Atmosphere generators and auxiliary equipment must be properly selected and operated.

(a) Responsibility for selection shall rest with the person or agency authorizing the equipment.

(b) Responsibility for observing the operating instructions shall rest with the person or agency operating the equipment.

500-3. 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 for completely burning the atmosphere gas and properly disposing of the combustion products.

500-4. The electrical power for the safety control circuit 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.

500-5. (a) Water cooled equipment shall have valving provided on the cooling water inlet. Piping shall be arranged to insure that equipment jackets are maintained full of water.

(b) For open water cooling systems, the water shall be discharged to an open sight funnel with no valves in the discharge piping.

(c) For closed water cooling systems, the water shall be discharged through individual sight flow indicators. A relief valve shall be installed on such systems to relieve obstructed discharge lines.

ARTICLE 510. EXOTHERMIC GENERATORS

510-1. Definition. 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.

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

510-2. Protective Equipment. Protective equipment shall be selected and applied for the gas and air separately, and interlocks shall be provided. The protective devices shall shut down the system, which would require manual resetting after any utility (gas, air, power) or mechanical failure. Observation ports shall be provided to permit ready viewing of burner operation under all firing conditions.

(a) Required Protective Equipment shall include:

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

2. A low gas pressure device in the 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 gas pressure.

3. A high gas pressure device in the gas supply piping, when the system is such that abnormally high 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 gas pressure.

4. A low pressure device 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 suitable device to shut off the air from a remote supply in case of power failure, abnormally low or abnormally high gas pressure at the generator.

6. A flame safeguard device to shut off the safety shutoff valve and air supply or mechanical mixer when a flame failure occurs.

7. Certain conditions and designs may preclude the preferred main flame supervision under all operating conditions. Under these special conditions, continuous pilot supervision, with dual flame sensors for both pilot and main flame, or a combination of supervised continuous pilot with generator chamber discharge temperature monitoring, could be considered acceptable alternates.

8. Flow indicators, meters of differential pressure devices on the 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.

9. 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.

10. 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.

11. A manual shutoff valve, designated as "main 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.

12. A reliable method of ignition for each burner. Main burner ignition should be by a supervised, interrupted gas pilot. If direct ignition of main burner is required, trial for ignition should not exceed 15 seconds.

13. An atmosphere gas vent. (See 500-3.)

(b) Supplementary Protective Equipment may be applicable and the following should be considered:

1. Visible and/or audible alarm devices to indicate abnormal conditions.

2. High temperature limiting devices.

3. Cooling water failure protective devices.

4. Gas analyzing devices.

5. A supervisory cock system.

6. A preignition purge timer.

510-3. Operating Procedures. Operating instructions shall be followed during light-up, operation, normal shutdown, and emergency

shutdown. 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. Operating instructions shall include the following:

(a) Light-up Procedure.

1. Make certain that all gas valves are closed and the sir 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 as 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-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 Procedures.

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

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

3. Close the "main gas" shutoff valve and check the operation.

4. Close all remaining gas and air valves immediately.

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

6. De-energize the electrical equipment when it is no longer required.

(c) Utility Failure Procedures. The equipment and associated circuits shall be arranged to shut down the unit automatically in case of flame failure or supply failure of gas, air, or electrical power. This type of shutdown shall be immediately followed by the shutdown procedure in 510-3(b).

(d) Emergency Procedure. Plant safety personnel should recognize the hazards that can occur in end use equipment and should develop methods for meeting these emergencies.

ARTICLE 520. ENDOTHERMIC GENERATORS

520-1. 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 "Atmosphere Gas."

It should be noted that the Reaction Gas and the Fuel Gas may or may not be the same type of gas.

520-2. Protective Equipment.

In general protective equipment will be selected and applied for the reaction gas and fuel gas separately. In some cases the reaction gas and fuel gas will be interlocked.

Under some conditions, the same device may serve both reaction gas and fuel gas. The protective devices shall shut down the system which would require manual resetting after any utility (gas, air, power) or mechanical failure. Observation ports shall be provided to permit ready viewing of burner operation under all firing conditions.

(a) The required protective equipment for the reaction section of endothermic generators shall include at least the following:

1. A safety shutoff valve in the reaction gas supply piping arranged to close in case of abnormally low gas pressure, abnormally high gas pressure, loss of air supply, low generator temperature (see 520-2.(a)9), or power failure. A manual operation shall be required to open this valve.

2. A low pressure device 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 device in the reaction gas supply piping when the system is such that abnormally high 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 device 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. If an air blower has its impeller mounted on the blower motor shaft and supplies a single generator, a starter interlock contact may be permitted instead of the low air pressure device.

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

6. An atmosphere vent. (See 500-3.)

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 maufacturer.

(b) Supplementary protective equipment may be applicable to the reaction section and the following should be considered:

1. Automatic fire check protection.

2. Visible or audible alarm devices, or both, to indicate abnormal conditions.

3. High temperature limiting devices.

4. Flow indicators, meters, or pressure gauges on the reaction gas and reaction air supplies.

(c) Protective equipment for the heating section of units fired with atmospheric gas burners shall include at least 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, or power failure. A manual operation shall be required to open this valve.

2. A low pressure device in the fuel gas supply piping to close the safety shutoff valve in case of abnormally low fuel gas pressure.

3. A high pressure device in the fuel gas supply piping when the system is such that abnormally high fuel gas pressures may create a dangerous situation. This device will 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.

(d) Supplementary protective equipment may be applicable to the heating section of endothermic generators fired with atmospheric gas burners, and the following should be considered:

1. Visible or audible alarm devices, or both, to indicate abnormal conditions.

2. High temperature limiting devices.

3. Flame safeguard devices.

4. A supervisory cock system.

e. Protective equipment for the heating section of units fired with blast-type gas burners shall include at least 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 device 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 device 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 low pressure device 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 beween 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 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.

(f) Supplementary protective equipment may be applicable to the heating section of endothermic generators fired with blast type gas burners, and the following should be considered:

1. Visible or audible alarm devices, or both, to indicate abnormal conditions.

2. High temperature limiting devices.

3. Flame safeguard devices.

4. Supervisory cock systems.

5. A suitable device to shut off fuel gas from remote supply in case of power failure, abnormally low or abnormally high fuel gas pressures at the generator.

(g) Protective equipment for the heating section of units fired with oil burners shall include at least 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 device 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 device 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 or flow monitoring device in the combustion air supply piping. This device shall 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 device 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.

(h) Supplementary protective equipment may be applicable to the heating section of units fired with oil burners, and the following should be considered:

1. Flame safeguard devices.

2. High oil temperature limiting device.

3. High generator temperature limiting device.

4. A suitable device to permit shutoff of fuel oil from a remote supply in case of power failure or abnormal operating conditions.

(i) Protective equipment for the heating section of units heated electrically shall include at least the following:

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.

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.

2. A generator temperature limiting device. This device shall open the main heating system disconnect device in case of abnormally high generator temperature.

NOTE: The entire electrical installation shall conform to the requirements of the National Electrical Code, NFPA No. 70–1978.

520-3. Operating Procedures.

Operation instructions shall be followed during light-up, operation and normal and emergency shutdown. 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 Fuel Gas heating section with the Reaction Gas atmosphere gas section. Operating instructions shall include the following:

(a) Light-up procedure for heating sections of endothermic generators fired by atmosphere 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) Operating instructions for reaction gas start-up for endothermic generators.

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.

(c) Temporary Shutdown Procedure.

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

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

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

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

(d) Permanent Shutdown Procedure. Follow the steps for temporary shutdown and add the following:

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

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

3. 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 520-3.(c) and 520-3.(d).

(f) Emergency Procedure.

Plant personnel should recognize the hazards that can occur in end use equipment and shall develop methods for meeting emergencies. (See 100-5.)

ARTICLE 530. AMMONIA DISSOCIATORS

530-1. Definition. An ammonia dissociator is a heated vessel in which ammonia is broken down into its component parts (25 percent nitrogen and 75 percent hydrogen) by temperature in the presence of a suitable catalyst.

530-2. Construction. Ammonia dissociators shall be designed and constructed to withstand the maximum pressures possible upon failure of regulation at operating temperatures, taking into consideration all pressure relief venting. All equipment, components, valves, fittings, etc., must be suitable for ammonia service.

530-3. Protective Equipment.

(a) 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 is to 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 is to be set at 100 percent of the design pressure of the dissociation vessel.

3. A high temperature limiting device to shut off the heat source when temperatures exceed the designated temperature rating of the vessel.

4. 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.

5. An atmosphere gas vent. (See 500-3.)

(b) Protective equipment for the dissociator heating system shall conform to the requirements for endothermic generators, as outlined in Article 520.

(c) Operational equipment shall be provided as recommended by the manufacturers. Consideration should be given to the following:

1. A high pressure gauge in the ammonia supply line ahead of the high pressure reducing regulator.

2. A low pressure gauge in the ammonia supply line after the high pressure reducing regulator.

3. A suitable flow measuring device.

4. A reducing regulator valve in the ammonia supply line, set to reduce the high ammonia pressure to that required by equipment design.

5. A suitable pyrometer for dissociator temperature control within manufacturers recommended limits.

(d) Supplementary protective devices that should be considered are:

1. A visible and/or audible alarm to indicate abnormal or unsafe conditions.

2. A suitable temperature control device to prevent introduction of ammonia to the dissociation vessel if the unit is not up to operating temperature.

3. A suitable safety shutoff valve in the ammonia supply line to the generator, arranged to close automatically when abnormal conditions of pressure and temperature are encountered.

ARTICLE 540. BULK ATMOSPHERE GAS STORAGE SYSTEMS

540-1. Construction.

All storage tanks and cylinders shall comply with local, state, and federal codes relating to pressures and type of gas. NFPA standards shall also be followed.

Vessels, controls and piping shall be designated to maintain their integrity under maximum possible pressures and temperatures.

540-2. Location.

Locations for tanks and cylinders containing flammable or toxic gases 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.

540-3. Storage systems shall comply with the following NFPA standards:

(a) Liquefied petroleum gas systems shall be in accordance with the Standard for Liquefied Petroleum Gases, NFPA No. 58–1976.

(b) Gas piping shall be in accordance with the National Fuel Gas Code, NFPA No. 54–1974.

(c) Hydrogen storage systems shall be in accordance with the Standard for Gaseous Hydrogen Systems at Consumer Sites, NFPA No. 50A–1973.

(d) Oxygen storage systems shall be in accordance with the Standard for Bulk Oxygen Systems at Consumer Sites, NFPA No. 50–1974.

(e) Processing atmosphere gas storage systems not covered by an NFPA standard (i.e., Anhydrous Ammonia) shall be installed in accordance with recommendations from the supplier and all applicable local, state and federal codes.

NOTE: Special reference is made to the ANSI Standard K61.1-1972 "Storage and Handling of Anhydrous Ammonia."

ARTICLE 550. MAINTENANCE

550-1. Responsibility.

An essential safety aid is an established maintenance program which determines that the equipment is in perfect 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. The final responsibility of establishing a maintenance program which determines that the equipment is in perfect working order shall rest with the user. Maintenance on gas atmosphere generators and associated equipment shall be undertaken only under the jurisdiction of a supervisor familiar with the safety and proper functioning of the equipment.

550-2. Check Lists.

The user's operational and maintenance program shall include any listed procedures which are applicable to his generator and that may be recommended by the authority having jurisdiction and his equipment supplier. An operational and maintenance check list is essential to the safe operation of the equipment. (See Appendix E.)

CHAPTER 6. CLASS C FURNACES WITH ZONES ABOVE AND BELOW 1400°F (760°C) ATMOSPHERE INTRODUCTION AND REMOVAL BY BURNING

ARTICLE 600. GENERAL INFORMATION

600-1. Scope. Procedures for "burn in" and "burn out" of indirectly heated atmosphere type furnaces having zones both above and below 1400°F (760°C), but where "burn in" and "burn out" procedures of flammable atmosphere gas may be safely used.

600-2. Type of Furnaces. The three general types of furnaces covered in this chapter (see Fig. 7) are as follows:

TYPE I. All zones within furnace chambers above 1400°F (760°C), having vestibules with doors. (Vestibule chamber utilized to prevent air infiltration into furnace chamber proper.)

TYPE II. All zones within furnace chambers above 1400°F (760°C), having vestibules without doors.

TYPE III. Batch-type furnace where temperature indication is below 1400°F (760°C), upon the introduction of a new load, having vestibules with doors and separate cooling section.

ARTICLE 610. ATMOSPHERE INTRODUCTION AND REMOVAL

610-1. Introduction of flammable atmosphere gas into furnace Type I.

(a) Furnace temperature must be above 1400°F (760°C).

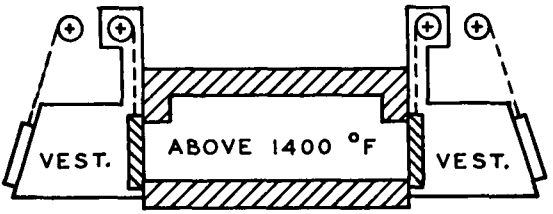
(b) Pilots at outer doors and effluent lines (flammable atmosphere vent) should be lighted.

(c) All outer doors are open.

(d) All inner doors are open.

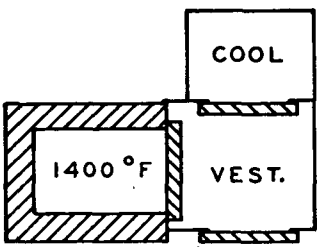
(e) Introduce flammable atmosphere gas into furnace and observe that ignition takes place.

(f) Close inner doors. A reliable source of ignition is required in vestibule to ignite flammable gas fed into the vestibule. When gas leaving furnace chamber is ignited, the air in the furnace chamber has been replaced by the flammable gas atmosphere.



TYPE I

TYPE II



TYPE III

Figure 7. Types of Furnaces

(g) Turn on flame curtain burners (if provided).

(h) Close outer doors.

(i) When flame appears at vestibule effluent lines, a vestibule purge is indicated. (See furnace manufacturer's instructions for further processing.)

610-2. Removal of flammable atmosphere gas from furnace Type I.

(a) Make certain furnace temperature is above 1400°F (760°C).

(b) Open all outer doors and shut off flame curtain (if provided). (See manufacturer's instructions.)

(c) Open all inner doors to allow air to enter furnace chamber and burn out the gas (see manufacturer's instructions).

(d) Shut off the flammable atmosphere gas supply to furnace.

(e) Follow the manufacturer's instructions for further shutdown procedures.

610-3. Introduction of flammable atmosphere gas into furnace Type II.

(a) Furnace temperature must be above 1400°F (760°C).

(b) Pilot burners at charge and discharge vestibules should be lighted.

(c) If flame curtain burners are provided, these should be lighted.

(d) Introduce flammable atmosphere gas into furnace and observe that ignition takes place.

(e) When flame appears at both vestibule openings, the air within the furnace and vestibules has been replaced by flammable atmosphere gas. (See furnace manufacturer's instructions for further processing.)

610-4. Removal of flammable atmosphere gas from furnace Type II.

(a) Make certain furnace temperature is above 1400°F (760°C).

(b) Shut off the flammable atmosphere gas supply to furnace.

(c) Shut off any flame curtain burners (if provided).

(d) If vestibules are equipped with any baffles or curtains which would hinder the entrance of air for burnout, special provisions should be made for allowing air to enter furnace chamber.

610-5. Introduction of flammable atmosphere gas into furnace Type III.

(a) Furnace temperature must be above 1400°F (760°C).

(b) Pilots at outer doors and effluent lines should be lighted.

(c) Open outer doors.

(d) Open all inner doors — furnace chamber and cooling chamber.

(e) Introduce flammable atmosphere gas into furnace chamber and observe that ignition takes place.

(f) Close furnace door. A reliable source of ignition is required in vestibule to ignite the flammable gas fed into the vestibule. (See furnace manufacturer's instructions.) When gas leaving furnace chamber is ignited, the air in the furnace chamber has been replaced by the flammable gas atmosphere.

(g) Provide reliable source of ignition of flammable atmosphere gas inlet in cooling section and introduce gas atmosphere into the cooling section. Observe that ignition takes place and continues.

(h) Remove ignition source from cooling section and close cooling chamber door only. (See manufacturer's instructions.) Make certain a reliable source of ignition is available to ignite flammable atmosphere gas fed to vestibule from cooling chamber.

(i) When flame appears at cooling chamber openings the air within cooling chamber has been replaced by flammable atmosphere gas.

(j) Flame curtain burners (if provided) shall be turned on and outer door closed. (See manufacturer's instructions.)

(k) When flame appears at vestibule effluent line, the air within the vestibule has been replaced by flammable atmosphere gas. (Follow furnace manufacturer's instructions for further processing.)

610-6. Removal of flammable atmosphere gas from furnace Type III.

(a) Make certain furnace temperature is above 1400°F (760°C).

(b) Open inner door to cooling chamber.

(c) Open outer door.

(d) Shut off flammable gas to cooling chamber only.

(e) Shut off flame curtain burners (if provided).

(f) Open inner door to furnace chamber.

(g) Shut off flammable atmosphere gas supply to furnace chamber.

(h) When all burning inside of furnace, cooling chamber, and furnace vestibule has ceased, the flammable atmosphere gas has been replaced by air.

(i) Follow furnace manufacturer's instructions for further shutdown procedures.

610-7. Emergency Procedures in case of interruption of flammable atmosphere gas supply.

(a) Furnace Types I, II and III.

In case an inert purge gas supply is not available, follow standard burnout procedures immediately. If purge gas is available introduce this gas into the same chamber at rate sufficient to provide positive pressure. Purge is complete when all chambers are below 4 percent total combustible.

610-8. Emergency Procedures in case of interruption of electrical power supply. Furnace Types I, II and III.

(a) An inert gas supply should be utilized for purging if available or some provisions shall be made for

1. auxiliary electrical power or

2. mechanical means for opening doors, where applicable, to immediately effect burnout procedures.

610-9. The following safety equipment shall be provided for furnace Types I, II and III in conjunction with the flammable atmosphere gas system.

(a) Safety shutoff valve in the flammable atmosphere gas supply line to the furnace. This valve shall be energized when furnace temperature is above 1400°F (760°C). Operators attention shall be required.

(b) Low pressure switch to assure that flammable atmosphere gas supply is available. Loss of pressure shall shut off the safety shutoff valve and sound an alarm.

(c) Safety interlock with furnace temperature controller — extra contact to close at 1400°F (760°C).

In case of the batch furnace, Type III, a bypass of the temperature contact after the initial gas introduction is required, such as an atmosphere flow switch.

(d) Pilots at outer doors and vent lines — one pilot at each outer door shall be supervised with an approved combustion safeguard interlocked to prevent automatic opening of the vestibule door, shut off gas to the curtain burners (if provided), and alarm operator. (See 410–4.)

(e) Manual shutoff valves and petcocks for checking tightness of safety shutoff valves.

(f) Provisions shall be made for explosion relief in vestibule.

(g) Audible and/or visual alarms to indicate normal and abnormal conditions.

CHAPTER 7

SPECIAL ATMOSPHERE FURNACES ALL ZONES ABOVE 1400°F (760°C)

ARTICLE 700. GENERAL

700-1. This chapter covers controls and procedures relating to the admittance and removal of special processing atmospheres for furnaces having no vestibules, and all zones operating in excess of 1400°F (760°C). All furnaces are considered to be either electrically heated or indirectly heated.

ARTICLE 710. ATMOSPHERE INTRODUCTION

710-1. Nonflammable processing atmospheres may be introduced into the furnace chambers at any time providing there is positive assurance regarding the analysis of the atmosphere. It is recommended that all atmospheres supplied by generating equipment, which could generate a flammable atmosphere upon malfunctioning, be introduced and removed in accordance with 710-2.

710-2. Flammable processing atmospheres should be introduced and removed under definite control, and procedures must provide proper sequencing. Because of the explosion potential when using flammable atmospheres, the following procedural guide should be used:

(a) Specific operating instructions shall be provided by the furnace manufacturer. These instructions shall be conveniently posted for ready use by operators at all times.

(b) Procedure for the introduction of flammable processing atmospheres.

1. All furnace zones shall be operating above 1400°F (760°C).

2. If flame curtain burners are provided at entrance and exit openings, the curtain burner pilots shall be ignited. Operator shall determine the pilots safely ignite the curtain burners.

3. Pilots shall be ignited at all atmosphere vent lines.

4. When provided, doors shall be opened.

5. After determining the atmosphere gas supply is adequate, the atmosphere gas may be introduced. When a positive ignition of the atmosphere gas is established, the doors (when provided) should be closed.

6. Continue the flow of atmosphere gas. When flame appears at entrance and exit openings, and at all effluent vent lines, the air has been replaced by the flammable atmosphere gas.

7. Refer to manufacturer's instructions for processing procedure.

ARTICLE 720. ATMOSPHERE REMOVAL

720-1. Procedure for the removal of flammable processing atmospheres.

(a) All furnace zones shall be operating above 1400°F (760°C).

(b) When doors are provided, these shall be opened to the extent dictated by the furnace manufacturer.

(c) The flammable atmosphere gas supply may now be shut off. The furnace manufacturer's instructions shall be followed regarding the speed of shutoff.

(d) When flame is no longer visible inside the furnace the atmosphere gas has been replaced by air. Manual valves shall be closed at all points of atmosphere introduction. This will insure against an unsafe condition developing because of malfunctioning or leaking of electric or pneumatic valves.

ARTICLE 730. EMERGENCY PROCEDURES

730-1. Procedure for emergency situations.

(a) Upon loss of the furnace heating system, the flammable atmosphere gas may be safely removed in accordance with 720-1, as long as all furnace zones are above 1400°F (760°C).

(b) If any furnace zone drops below 1400°F (760°C), the flammable atmosphere gas supply fails, or there is a power failure to the furnace, the furnace operator shall initiate one of the following:

1. A nonflammable gas should be introduced, at a rate equal to that of the flammable atmosphere, and the flammable atmosphere shut off. A complete purge of the furnace shall be determined by analyzing the furnace atmosphere less than 4 percent combustibles. The nonflammable gas supply must be adequate in volume to complete the purge.

2. A normal "burn out" of the flammable atmosphere gas (720-1) may be used if the furnace zones are all above 1400°F (760°C).

ARTICLE 740. PROTECTIVE EQUIPMENT

740-1. Protective devices shall be installed and interlocked as described in the following sections.

(a) A safety shutoff valve shall be provided on the atmosphere supply pipe to the furnace.

(b) An atmosphere gas supply monitoring device shall be provided 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 shall be provided to determine temperatures in all zones. These shall be interlocked to prevent opening of the atmosphere gas supply safety shut-off valve until all zones are at or above 1400° F.

(d) An automatic safety shutoff valve shall be provided for flame curtain burner gas supply. This shall be interlocked to prevent opening of the valves when the furnace is under 1400°F (760°C).

(e) Audible and/or visual alarms shall be provided to alert the furnace operator of abnormal furnace conditions.

(f) Manual door opening facilities to permit operator control in the event of power failure.

CHAPTER 8. FURNACES ABOVE AND BELOW 1400°F (760°C) — BURN-IN AND BURN-OUT NOT PERMITTED

ARTICLE 800. GENERAL

800-1. Scope. The two general types of furnaces covered are fuel fired or electrically heated continuous, semi-batch or batch furnaces having none, one or two vestibules attached to the furnace chamber(s) wherein:

TYPE I — All furnace zones can be heated above 1400°F (760°C) before introduction and removal of flammable atmosphere gas, but all or part of the furnace zones normally operate below 1400°F (760°C). Burn-in and burn-out procedures can normally be used; however, emergency conditions require inert gas purge.

TYPE II — All or part of the furnace zones operate below 1400°F (760°C), and cannot be heated to 1400°F (760°C), or the furnace is a batch-type and the flammable atmosphere gas must be introduced and removed below 1400°F (760°C), using the inert gas purge procedures.

ARTICLE 810. TYPE I FURNACE

810-1. Introduction of Flammable Atmosphere Gas, Type I Furnace.

A supply of flammable atmosphere gas of an acceptable analysis shall be available and the entire furnace heated to an operating temperature above 1400°F (760°C).

Make sure the emergency inert gas storage system contains sufficient purge gas. The stored purge gas must be free of oxygen and contain less than 4 percent total combustibles. Furnace doors or covers are closed and vestibule doors are open (if provided).

(a) Make certain all flammable atmosphere gas, flame curtain, etc., valves are closed.

(b) Make certain that all furnace zones are above 1400°F (760°C).

(c) Be sure the pilots at outer doors or cover and at the effluents are burning.

1. Provide reliable ignition sources to ignite flammable atmosphere gas flowing from furnace into vestibule(s).

(d) Turn on the flammable atmosphere gas:

1. Open the main and secondary flammable atmosphere gas valves to the supply headers.

2. Open the valves to all furnace chamber inlets and observe that ignition takes place.

WARNING: The operator must make sure that reliable ignition sources are at both the charge and discharge ends of the furnace and that the flammable atmosphere gas ignites when passing from the furnace into the vestibule(s).

(e) When the flammable atmosphere gas burns steadily in each vestibule at the furnace outlets:

1. Open the main and secondary hand valves to the fuel gas flame curtain burners (if provided).

2. Open fuel gas hand supply valve to the flame curtain burner (if provided) at the discharge vestibule. Make sure flame curtain burner is operating properly.

3. Close discharge vestibule door (if provided).

(f) At the charge vestibule (if provided), repeat step (e).

(g) Reset the temperature controllers to the required operating temperatures. Flammable atmosphere gas flow must be sufficient to maintain a positive pressure at all operating temperatures.

(h) Admit secondary process atmosphere or enriching gases as required.

Removal of Flammable Atmosphere Gas, Type I

810-2. Furnace.

(a) Remove all work from furnace, if required.

(b) Turn off secondary process or enriching atmosphere gases.

(c) Increase the temperature in all zones to above 1400°F (760°C).

(d) When all zones have reached 1400°F (760°C), open charge vestibule door and turn off flame curtain burner (if provided).

1. Allow flammable gas in vestibule to burn out.

(e) Repeat step (d) for discharge vestibule (if provided).

WARNING: The operator must make sure that reliable ignition sources are at both the charge and discharge ends of the furnace and that the flammable atmosphere gas ignites when passing from the furnace into the vestibule(s).

(f) Turn off the main and secondary flammable atmosphere gas valves.

(g) Close all remaining flammable atmosphere gas valves.

(h) Open furnace charge and discharge doors or cover to burn out the atmosphere.

(i) Follow manufacturer's instructions for further shutdown procedures.

810-3. Emergency Shutdown, Type I Furnace.

(a) Electric power and/or flammable atmosphere gas failure(s).

1. In case of an electrical power failure the following will stop:

1a. Heating system

1b. Flammable atmosphere gas system

1c. Secondary process atmosphere gas system

1d. Pumps, etc., (if provided).

1e. Automatic cycle (if provided).

2. The emergency inert gas standby system shall be immediately actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

2a. The operator shall immediately check and be sure purge flow is sufficient to maintain positive furnace pressure.

3. If the electric power failure occurs with all of the vestibule doors (if provided) closed, this is the way to leave the furnace. If either of the vestibule outer doors (if provided) are open — leave open.

3a. Operator must make sure that a reliable ignition source is at the open ends of the furnace and that the flammable atmosphere gas ignites when passing from the furnace to the open vestibule(s).

4. Close all flammable atmosphere gas valves to the furnace.

5. Close all the fuel gas valves to the furnace.

6. When analysis in all of the furnace chambers indicates the atmosphere in the furnace is below 4 percent total combustibles on two consecutive readings, the purge is completed. Restart furnace per Section 810-1.

(b) Heating system failure during normal operation with flammable atmosphere gas in furnace.

1. The automatic cycle where provided shall be stopped.

2. Find and correct the failure.

2a. Relight the furnace per manufacturer's instructions without shutting off any atmosphere valves, or opening any doors that are closed.

3. If heating system failure cannot be corrected:

3a. The atmosphere gas must be purged from the furnace following same procedures for power and/or flammable atmosphere failures. Reference 810-3(a).

ARTICLE 820. TYPE II FURNACE

820-1. Introduction of Flammable Atmosphere Gas, Type II Furnace.

A supply of flammable atmosphere gas and process inert purge gas of an acceptable analysis shall be available. The process inert purge gas must be free of oxygen and contain less than 4 percent total combustibles. The processing inert gas requirements shall not deplete the adequacy of the emergency purge gas supply. Make sure the emergency inert gas storage system contains sufficient purge gas. The stored purge gas must be free of oxygen and contain less than 4 percent total combustibles.

Furnace doors or cover are closed and vestibule doors are open (if provided).

(a) Make certain all flammable atmosphere gas, etc., valves are closed.

(b) Open the process inert purge gas supply to all furnace chambers making sure rate will maintain a positive furnace pressure.

(c) After the process inert purge gas has been flowing into the furnace for sufficient time and at a rate to maintain a positive pressure, take analysis of all furnace chambers, O_2 must be less than 1 percent on at least two different readings.

(d) After the furnace has been purged to less than 1 percent O_2:

1. Make sure the pilots at outer doors or cover and at the effluents are burning.

1a. Provide reliable ignition sources to ignite flammable atmosphere gas flowing from furnace into vestibule(s).

2. Open the main and secondary flammable atmosphere gas supply valves to the furnace.

3. Admit the flammable atmosphere gas.

WARNING: The operator must make sure that reliable ignition sources are at both the charge and discharge ends of the furnace and that the flammable atmosphere gas ignites when passing from the furnace into the vestibule(s).

(e) Shut off process inert purge gas supply.

(f) When the flammable atmosphere gas burns steadily in each vestibule (if provided) at the furnace outlets:

1. Open the main and secondary hand valves to the fuel gas flame curtain burners (if provided).

2. Open fuel gas hand supply valve to the flame curtain burners (if provided) at the discharge vestibule. Make sure flame curtain burners are operating properly.

3. Close discharge vestibule door (if provided).

(g) At the charge vestibule (if provided): repeat step (f).

(h) Flammable atmosphere gas flow must be sufficient to maintain a positive pressure at all operating temperatures.

(i) Admit secondary process atmosphere or enriching gases as required.

820-2. Removal of Flammable Atmosphere Gas, Type II Furnace.

(a) Remove all work from furnace, if required.

(b) Turn off secondary process or enriching atmosphere gases.

(c) Open charge vestibule door and turn off flame curtain burner (if provided).

1. Allow flammable atmosphere gas in vestibule to burn out.

(d) Repeat step (c) for discharge vestibule (if provided).

WARNING: The operator must make sure that reliable ignition sources are at both the charge and discharge ends of the furnace and that the flammable atmosphere gas ignites when passing from the furnace into the vestibule(s).

(e) Turn on the process inert purge gas supply hand valves to the furnace, making sure flow rate will maintain a positive furnace pressure.

(f) Close all the flammable atmosphere gas supply valve(s) to the furnace.

(g) After completing the above:

1. Begin sampling the furnace atmosphere until the total combustibles in all the furnace chambers are below 4 percent total combustibles.

(h) Turn off the process inert gas supply to the furnace.

(i) Open furnace charge and discharge doors or cover.

1. Make sure all atmosphere gas valves are closed.

(j) Follow manufacturer's instructions for further procedures.

820-3. Emergency Shutdown, Type II Furnace.

(a) Electric power and/or flammable atmosphere gas failure(s).

1. In case of an electrical power failure, the following will stop:

1a. Heating system

1b. Flammable atmosphere gas systems

1c. Secondary process atmosphere gas system

1d. Pumps, etc. (if provided)

1e. Automatic cycle (if provided).

2. The emergency inert gas standby system shall be immediately actuated to purge the furnace at a rate to maintain a positive pressure in all chambers.

2a. The operator shall immediately check and be sure purge flow is sufficient to maintain positive furnace pressure.

3. If the electric power failure occurs with all of the vestibule doors (if provided) closed, this is the way to leave the furnace. If either of the vestibule outer doors (if provided) is open — leave open.

3a. Operator must make sure that a reliable ignition source is at the open ends of the furnace and that the flammable atmosphere gas ignites when passing from the furnace to the open vestibule.

4. Close all flammable atmosphere gas valves to the furnace.

5. Close all the fuel gas valves to the furnace.

6. When analysis of furnace indicates the atmosphere in all furnace chambers is below 4 percent total combustibles on two consecutive readings, the purge is completed. Restart furnace per Section 820-1.

(b) Heating system failure during normal operation with flammable atmosphere gas in furnace.

1. The automatic cycle should be stopped (if provided).

2. Find and correct the failure.

2a. Restart the furnace heating system per manufacturer's instructions without shutting off any atmosphere valves, or opening any doors that are closed.

3. If heating system failure cannot be corrected:

3a. The atmosphere gas must be purged from the furnace following same procedures for power and/or flammable atmosphere failures. (See Section 820-3(a).)

ARTICLE 830. PROTECTIVE EQUIPMENT

830-1. Protective devices for Type I furnaces shall be installed as described in the following sections:

(a) Provide heating system safety controls as outlined in Chapter 4.

(b) A safety shutoff valve shall be provided in the flammable atmosphere gas supply pipe to the furnace.

(c) A flammable atmosphere gas supply monitoring device shall be provided to permit the operator to visually determine the adequacy of flammable atmosphere gas flow at all times.

(d) A sufficient number of furnace temperature monitoring devices shall be provided to determine temperatures in zones. These shall be interlocked to prevent opening of the flammable atmosphere gas supply safety shutoff valve until all zones are at, or above, 1400°F (760°C). Temperature monitoring devices shall be provided with a flammable atmosphere gas flow bypass device to permit operating furnace below 1400°F (760°C) after initial introduction of atmosphere.

(e) An automatic safety shutoff valve shall be provided for flame curtain burners (if provided). This should be interlocked in the same manner as flammable atmosphere safety shutoff valve as noted in item four (4) above.

(f) 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 alarm operator. (See 410–4.)

(g) Audible and/or visual alarms shall be provided to alert the furnace operator of abnormal flammable atmosphere flow condi-

tions detected by monitoring devices, thus giving the operator the necessary time to actuate emergency shutdown procedures.

(h) The emergency inert gas purging system shall consist of:

1. ASME coded storage tank(s) sized to hold a minimum of five furnace volumes (scf) of inert gas which is free of oxygen and contains less than 4 percent total combustibles.

2. Tank pressure monitoring devices to indicate abnormal low or high tank pressure.

3. ASME tank relief devices sized, constructed and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section 8 — Division I.

4. Operator's actuation station having necessary hand valves, regulators, relief valves, flow and pressure monitoring devices.

5. Separate furnace inlets for introduction of emergency inert gas.

6. Audible and/or visual alarms to alert operator of abnormal tank pressures, and abnormal purge flow rate.

7. Gas analyzing equipment for assuring furnace is purged.

830-2. Protective devices for Type II furnaces shall be installed and interlocked as described in the following sections:

(a) Provide heating system safety controls as outlined in Chapter 4.

(b) Process inert purge and flammable atmosphere gas supply monitoring devices shall be provided to permit the operator to visually determine the adequacy of process inert purge and flammable atmosphere gas flow at all times.

(c) An automatic flame curtain safety shutoff valve shall be provided for flame curtain gas supply. This should be interlocked so that the flammable atmosphere supply must be established prior to opening flame curtain safety shutoff valve.

(d) 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 alarm operator. (See 410–4.)

(e) Audible and/or visual alarms shall be provided to alert the furnace operator of abnormal process inert purge and flammable atmosphere flow conditions detected by monitoring devices, thus giving the operator the necessary time to actuate emergency shutdown procedures.

(f) A safety shutoff valve shall be provided in the flammable atmosphere gas supply pipe to the furnace. This valve shall be interlocked with the flammable atmosphere gas supply and shall require manual opening. Further, this valve shall be interlocked with a process purge gas timer so that it can only be opened after the process purge gas flow has been established and allowed to flow for the proper time. For other required devices see 830-2. Closure of this safety shutoff valve shall be immediately followed by introduction of inert gas purging.

NOTE: The purge timer recommended in this section shall not be considered a substitute for the atmosphere analysis recommended in other sections.

(g) Emergency inert gas purging system shall consist of:

1. ASME coded gas storage tank(s) sized to hold a minimum of five furnace volumes (scf) of inert gas which is free of oxygen and contains less than 4 percent total combustibles.

2. Tank pressure monitoring devices to indicate abnormal low or high tank pressure.

3. ASME tank relief devices sized, constructed and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section 8, Division I.

4. Operator's actuation station having necessary hand valves, regulators, relief valves, flow and pressure monitoring devices.

5. Separate furnace inlets for introduction of emergency inert gas.

6. Audible and/or visual alarms to alert operator of abnormal tank pressure, and abnormal purge flow rate.

7. Gas analyzing equipment to assure that the furnace is purged.

CHAPTER 9. CLASS C BELL TYPE FURNACES

ARTICLE 900. GENERAL INFORMATION

900-1. Scope. (a) This chapter gives procedures for introduction and removal of flammable atmosphere from directly and indirectly heated bell type furnaces operating at temperatures above and below 1400°F (760°C).

(b) Within the scope of this chapter bell type furnaces shall be only furnaces wherein the heating bell and/or retort is lifted from a stationary insulated base which supports the work to be processed.

900-2. Types of Bell Furnaces. There are two general types of bell furnaces covered within this standard. They are further classified according to their mode of operation.

TYPE A. Bell Furnaces with Retort.

TYPE A-I. Indirectly heated — operating above and below 1400°F (760°C). Where the heat source is in a space between an outer bell and inner bell (retort). The inner bell enclosed the work. (See Fig. 8.)

TYPE B. Bell Furnaces without Retort.

TYPE B-I. Directly heated operating above and below 1400°F (760°C). Where the work is exposed to the radiant heat source and an inner bell (retort) is not used.

TYPE B-II. Directly heated operating above 1400°F (760°C). Same as Type B-I except that the furnace operates above 1400°F (760°C).

The temperature of the furnace when the flammable atmosphere is introduced is most important. For Type A-I and B-I the procedures are for introduction and removal of flammable atmosphere at furnace temperatures below 1400°F (760°C) (see Article 910). For Type B-II the procedures are for introduction and removal of flammable atmosphere at temperatures at or above 1400°F (760°C), (see Article 920).

CAUTION: Flammable atmosphere gas shall not be introduced into a Bell Furnace until either an inert gas purge has been completed or until the furnace work chamber temperature is at least 1400°F (760°C).

NOTE 1: These furnaces may or may not have a circulating fan. The method of sealing the inner bell (retort) and/or outer heating bell varies. Seals may be water cooled "O" rings, water cooled packings, uncooled gaskets, or sand seals. The outer heating bell may be raised by factory crane, or may employ its own heating bell "Lift and Roll-Away" mechanism. Variations also exist in the method of atmosphere piping,

measuring the flow of atmosphere and controlling the atmosphere. For proper instruction in these areas refer to the manufacturers specific instructions for a particular unit.

NOTE 2: For details concerning heating systems for Type A-I, B-I, and B-II Bell Furnaces, see Chapters 3, 4, and 5.

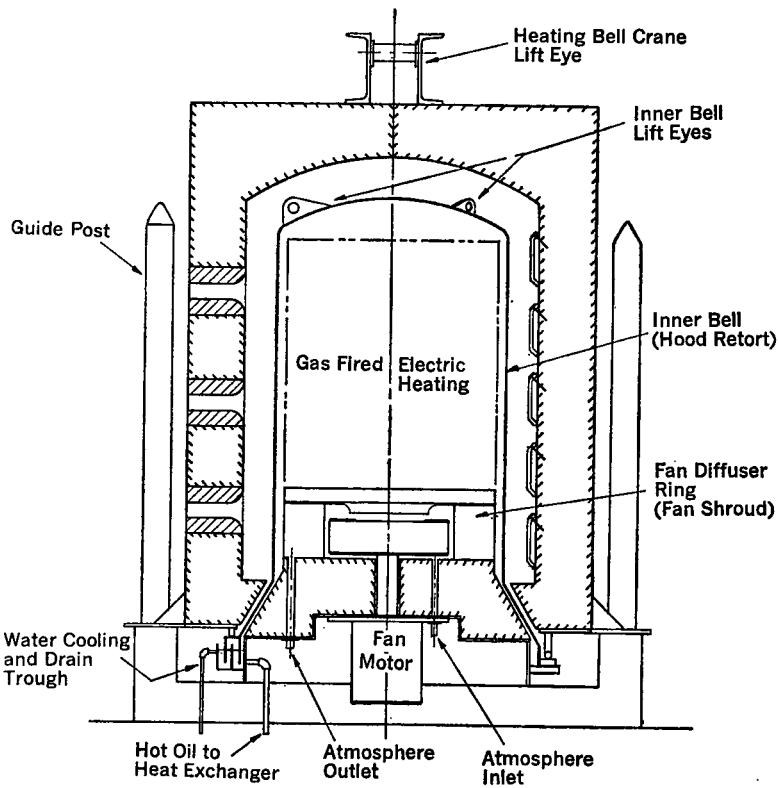


Fig. 8

ARTICLE 910. PROCEDURE FOR PURGING FURNACES BELOW 1400°F (670°C)

910-1. Procedures for Introduction of Flammable Atmosphere Into a Type A-I Bell Furnace.

(a) Purge of initial room air by means of an inert gas and/or vacuum pumps is required prior to the introduction of a flammable atmosphere. Furnace may operate above and below 1400°F (760°).

1. Starting Condition: Furnace base is loaded with work. Both the base and work load are cold. The inner bell is not in position over work load.

1a. If furnace is equipped with a fan, check the clearance between the fan blades and the combination work support and fan diffuser fixture. Make sure that the support fixture/fan diffuser has not been shifted out of its proper position during the previous unload/reload operations or that interferences were created by any other causes.

1b. Atmosphere gas valves on all bases which do not have a charge and retort in position and the atmosphere gas valve on all bases which have an unpurged retort in position are to be closed. All lines shall be marked with the type of gas in the line at the manually operated valves.

1c. Place cold inner bell (retort) over work and seal to furnace base. (Follow the manufacturer's instructions for establishing a proper seal.) If the seal is of the water-cooled oil-type, make sure liquid levels are proper, that oil seal pump is running and cooling water flowing. If the seal is of the water-cooled gasket or "O" ring-type, make sure cooling water is flowing. (Follow the manufacturer's instructions for establishing proper water flow rates, liquid levels, and/or proper seating.)

1d. Check the liquid level in manometers and/or bubbler bottles on the vent line and light the effluent gas pilot(s).

1e. Where used, follow the manufacturers instructions for establishing cooling water flow to circulating fan bearings, start fan bearing lubricators and start the circulating fan.

2. Inert Purge: Turn on control power, open manual valve in inert purge gas supply line and establish proper flow-rate whereby starting to fill the retort. When flow is established through the bubbler or seal pot the retort pressure is established and the inert gas flow should be continued until a minimum of five furnace volume changes have been completed. The effluent atmosphere leaving the retort should now be checked with an oxygen analyzer.

The inert gas flow should be continued until an oxygen analysis indicates that the oxygen within the retort is below 1 percent by volume of the inert gas. When this point is reached the inert purge can be considered completed.

(Alternate) Vacuum Purge: Turn on control power, start the vacuum pumping equipment following the manufacturers instructions. In vacuum purging, the initial room air within the retort is pumped out with a mechanical pump to a vacuum generally in the range of 100 microns (1×10^{-1}Torr.).

3. Open the flammable atmosphere supply valve to the base and adjust flow thru flowmeter to furnace retort.

NOTE: The inert purge system shall be wired in such a manner that when the control valve in the inert gas line is open then the flammable gas line is closed and vice versa.

4. Means of measuring flow rate of atmosphere and/or vacuum pressures shall be provided. If used, the manometers, or bubbler bottles should be checked for indication of proper pressure.

5. This stationary base with load and inner bell is now ready to proceed with the heat treating cycle. The outer heating bell may be placed over the inner bell (retort) and heat applied. See the manufacturers' instructions.

910-2. Removal of Flammable Atmosphere From a Type A-1 Bell Furnace. Purge by means of inert gas is required.

(a) Remove outer heating bell from over inner bell (retort). (Follow manufacturer's instructions.)

(b) After the work has cooled sufficiently, under process atmosphere and can be exposed to room air, the inner bell (retort) may be removed from the stationary furnace base after the following procedure:

1. Close the flammable gas safety shutoff valve. When this happens the automatic valve in the inert gas line will automatically open admitting inert gas into the retort. Continue to purge for a minimum of five volume changes and until the total combustible content is less than 4 percent by volume.

2. Stop pilot flame at effluent vent line (if used).

3. Stop circulating fan, (if used). Wait until fan stops.

4. Release any mechanical clamping devices which hold the inner bell (retort) to the stationary furnace base.

(c) Remove the cold inner bell (retort) from over the work.

(Follow the manufacturers' instructions). If the seal is of the water cooled oil type, stop flow, stop oil seal pump, stop running and cooling water if flowing.

(d) Shut off inert purge gas flow.

910-3. Procedure for the Introduction of a Flammable Atmosphere into a Directly Heated Type B-I Bell Furnace without inner bell (retort), operating above and below 1400°F (760°C). A purge of the initial room air within the bell by means of an inert gas or vacuum pumps is required prior to the introduction of a flammable atmosphere. An inert gas purge is required for removal of the flammable atmosphere. The furnace may operate above and below 1400°F (760°C).

(a) Starting Condition: Furnace stationary base loaded with work. Outer heating bell not over work.

1. If furnace is equipped with circulating fan, check clearance between fan blades and combination work-support fan-diffuser fixture. Operate fan for a short period of time to assure it is operating properly.

2. Check outer heating bell to base seal, making sure foreign objects have not fallen into liquid seals or across mechanical seals.

3. Check atmosphere valves. Atmosphere valves on all bases which do not have a work load under process are to be closed. All atmosphere lines at manual valves shall be properly marked or coded with the type of gas in the line.

(b) Place outer heating bell over work and seal it to the stationary base. (Follow the manufacturer's instructions for sealing and connecting the outer heating bell to the base for proper operation.)

1. Water-cooled oil seals. Establish proper cooling water flow, start oil seal pump and check liquid levels.

2. Establish proper cooling water flow to such devices if furnace is so equipped, such as: circulating fans, mechanical seals, atmosphere outlet pipes, etc. (Follow manufacturer's instructions.)

3. Check liquid level in the manometer or bubbler bottle on the vent line or light the effluent gas pilot where used.

(c) Inert Purge: Turn on control power. Open manual valve in inert purge gas supply line and establish proper flow rate, thereby starting to fill the retort. When flow is established through the bubbler or seal pot, the retort pressure is established and the inert gas flow shall be continued until five furnace volume changes have been completed. The effluent atmosphere leaving the retort should now be checked with an oxygen analyzer.

The inert gas flow should be continued until an oxygen analysis indicates that the atmosphere within the bell is below 1 percent by volume of the inert gas. When this point is reached the inert purge can be considered completed.

(Alternate) Vacuum Purge: Turn on control power. Start the vacuum pumping equipment following the manufacturer's instructions. In vacuum purging the initial room air within the heating bell is pumped out with a mechanical pump to a vacuum generally in the range of 100 microns (0.1 mm Hg).

(d) Open the flammable atmosphere supply valve to the base and adjust flow through flow meter to the furnace.

NOTE: The inert gas purge system shall be wired in such a manner that when the control valve in the inert gas line is open, the flammable gas line is closed, and vice versa.

(e) Means of measuring flow rate of atmosphere and vacuum pressure shall be provided.

(f) If used, the manometers, or bubbler bottles should be checked for indication of proper pressure.

(g) The furnace is now ready for the heat treating cycle and may be started. (See manufacturer's instructions.)

910-4. Removal of Flammable Atmosphere from a Type B-I Bell Furnace. Type B-I without inner bell (retort) operating above and below 1400°F (760°C).

(a) Close the flammable gas safety shutoff valve. When this happens the control valve in the inert gas line will automatically open admitting inert gas to the heating bell. Continue to purge for a minimum of five volume changes and until the total combustible content is less than 4 percent by volume.

(b) After work and furnace has cooled sufficiently, the heating bell may be removed from the base after the following procedures:

1. Stop circulating fan, (if used). Wait until fan stops.
2. Stop fan lubricator (if used).
3. Stop pilot flame at end of vent line (if used).
4. Release any mechanical clamping devices which hold the bell to the stationary furnace base.

(c) Remove the bell from the base. (Follow manufacturer's instructions.)

(d) Shut off inert purge gas.

910-5. Emergency shutdown for Type A-1 and B-1 Furnaces.

(a) Emergency safety purge system. An emergency safety purge system, completely independent of the normal inert purge system, shall be provided. It shall be designed to immediately purge the flammable atmosphere gas from the retort of the Type A-1 Furnace, or the heating bell of the Type B-1 Furnace, when an emergency situation occurs, such as electric power failure or failure of both the flammable and normal purge gas supply.

(b) The stored purge gas must be free of oxygen and contain less than 4 percent total combustibles.

(c) In case of electric power failure the following will stop:

1. Heating system

2. Flammable atmosphere system

(d) The normal inert purge gas system shall be immediately actuated to purge the flammable gas from the retort of the Type A-I, or the heating bell of the Type B-I Furnace.

1. If electric power failure also causes failure of the normal inert purge system the emergency safety purge system shall immediately be actuated.

(e) In case of failure of the normal inert purge system while purging a flammable gas from either the Type A-1 or B-1 Furnace, the emergency safety purge system shall be immediately actuated.

(f) The flow of emergency inert safety purge gas shall be at a rate to maintain a positive pressure in the retort of the Type A-I Furnace or the heating bell of the Type B-I Furnace.

(g) Close all flammable atmosphere gas valves to the furnace.

(h) When analysis of the effluent atmosphere indicates the atmosphere within the furnace is below 4 percent total combustibles on two consecutive readings, the purge is completed.

(i) The emergency safety purge gas can be shut off.

(j) Correct failure to heating or normal inert purge system.

ARTICLE 920. PROCEDURE FOR PURGING FURNACES OPERATING AT OR ABOVE 1400°F (760°C)

920-1. Procedure For Introduction of a flammable Atmosphere Into a Type B-II Bell Furnace. A purge by means of an inert gas or vacuum purge pumps is recommended prior to the introduction of a flammable atmosphere.

However, if the flammable atmosphere gas is not introduced until after the heating bell is at or above 1400°F (760°C), an inert or vacuum purge is not required.

If inert purging is used follow Article 910.

(a) Furnace stationary base loaded with work. Outer heating bell not over work.

1. If furnace is equipped with circulating fan, check clearance between fan blades and combination work-support fan-diffuser fixture. Operate fan for a short period of time to assure it is operating properly.

2. Check outer heating bell to base seal, making sure foreign objects have not fallen into liquid seals or across mechanical seals.

3. Check atmosphere valves. Atmosphere valves on all bases which do not have a work load under process are to be closed. All atmosphere lines at manual valves should be properly marked or coded with the type of gas in the line.

(b) Place outer heating bell over work and seal it to the stationary base. (Follow the manufacturers' instructions for sealing and connecting the outer heating bell to the base for proper operation.)

1. Water cooled oil seals. Establish proper cooling water flow, start oil seal pump and check liquid levels.

2. Establish proper cooling water flow to such devices if furnace is so equipped, such as: circulating fans, mechanical seals, atmosphere outlet pipes, etc. (Follow the manufacturers' instructions.)

3. Check liquid level in the manometer or bubbler bottle on the vent line.

(c) Turn on furnace power and bring temperature of the furnace to 1400° F or greater.

(d) Light the effluent gas pilots at all vents where gas may be discharged from the furnace.

(e) Open the flammable atmosphere supply valve to the base

and adjust flow through the flowmeter. Means of measuring flow rate of atmosphere shall be provided.

(f) (If used) manometers or bubbler bottles shall be checked for indication of proper pressure.

NOTE: A temperature of 1400°F (760°C) or greater throughout the entire furnace is required for positive ignition of the flammable gas upon being introduced into the furnace.

(g) Continue the flow of flammable atmosphere gas. When a flame appears at all effluent vents the initial room air within the bell furnace will have been replaced with the flammable atmosphere gas.

(h) The bell furnace is now ready to proceed with the balance of the heat treat cycle. (See manufacturer's instructions.)

920-2. Removal of Flammable Atmosphere From a Type B-II Bell Furnace.

Purge by means of an inert gas is recommended. However if the flammable atmosphere gas is to be removed with the furnace bell at or above 1400°F (760°C) then the following burn-out procedure of the flammable gas may be followed.

(a) Before the bell has cooled below 1400°F (760°C) the following procedures (1 through 7) shall be completed.

1. Where required, ignite pilots or torches and place in position or have ready for ignition of the flammable atmosphere gas at the heating bell to stationary base seal as soon as the seal is broken.

2. Turn off heat source.

3. Stop circulating fan, if used. Wait until fan stops.

4. Release any mechanical clamping devices which hold the heating bell to the stationary base.

5. Gradually lift the heating bell off the base and as soon as the heating bell breaks its seal with the stationary base the flammable atmosphere gas should ignite or be ignited at the base of the heating bell.

NOTE: This step is required to prevent the possible formation of an explosive mixture inside the Bell Furnace after it has been removed from the base.

6. Close the flammable atmosphere gas inlet valve.

7. Complete shutdown of cooling water flow, circulating fan lubricator, etc., following the manufacturer's instructions.

920-3. Emergency shutdown. Type B-II Furnace.

(a) Emergency safety purge: An emergency inert safety purge system shall be provided. It should be designed to immediately purge the flammable atmosphere from the heating bell when an emergency situation occurs, such as: electric power failure.

(b) In case of electric power failure the following will stop:

a. Heating system

b. Flammable atmosphere gas system

c. Heating bell hoisting equipment.

(c) The emergency inert gas standby system shall be immediately actuated to purge the flammable gas from the heating bell.

(d) The emergency inert gas flow shall be at a rate to maintain a positive pressure in the heating bell.

NOTE: Operators shall immediately check and be sure the emergency purge gas flow is sufficient to maintain a positive heating bell pressure.

(e) Close all flammable gas manual valves to the furnace.

(f) When analysis of the effluent atmosphere indicates the atmosphere within the heating bell is below 4 percent total combustibles on two consecutive readings, the purge is complete.

(g) Shut off the emergency inert gas flow.

ARTICLE 930. PROTECTIVE EQUIPMENT

930-1. Protective devices shall be installed and interlocked as described in the following sections:

(a) A safety shutoff valve shall be provided on the flammable atmosphere supply pipe to the furnace.

(b) An atmosphere gas supply monitoring device shall be provided 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 shall be provided to determine temperature in all zones. These shall be interlocked to prevent opening of the atmosphere gas supply safety shutoff valve until all zones are at, or above, 1400° F (760°C), when inert gas or vacuum purging of the initial room air within the retort or bell is not employed.

(d) Audible and/or visual alarms should be provided 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: An emergency inert safety purge system, completely independent of the normal inert purge system, shall be provided. It shall be designed to immediately purge the flammable atmosphere gas from the furnace when an emergency situation occurs, such as power failure or flammable and normal inert purge supply failure.

CHAPTER 10. INTEGRAL QUENCH FURNACES

ARTICLE 1000. GENERAL REQUIREMENTS

A. General

1000-1. (a) The heat treat furnace, having an integral quench tank, is a special furnace design which permits maintenance of the work under flammable and/or nonflammable atmosphere from the time the work enters the furnace until it has been quenched and removed from the furnace.

(b) The heat treat furnace, having an integral quench, is generally an assembly which consists of a Class C furnace, to which is added an enclosed quench tank. Work withdrawn from the heat section is immediately immersed in a quench medium and then removed from the furnace.

(c) 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.

(d) The atmosphere used will depend on the metallurgical requirements of work being processed.

(e) The integral quench tank may utilize any combination of heating and cooling depending on the metallurgical requirements of the work to be processed.

B. Hazards

1000-2. The heat treat furnace, having an integral quench tank, utilizing a combustible liquid, presents an unusually severe fire hazard.

(a) Three basic types of furnaces are covered in this chapter (see Fig. 9).

TYPE I — dunk-type elevator quench

TYPE II — dunk-type elevator quench with under oil transfer

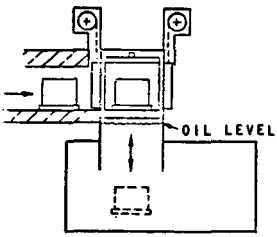
TYPE III — bottom chute-type quench

NOTE: This standard does not cover salt quench tanks or central quench medium cooling systems.

(b) 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.

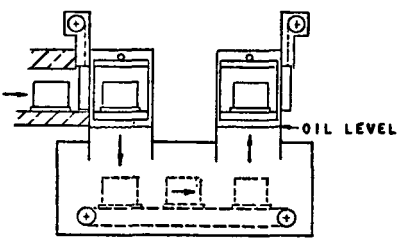
TYPE I

DUNK TYPE ELEVATOR QUENCH



TYPE II

DUNK TYPE ELEVATOR QUENCH WITH UNDER OIL TRANSFER



TYPE III

BOTTOM CHUTE TYPE QUENCH

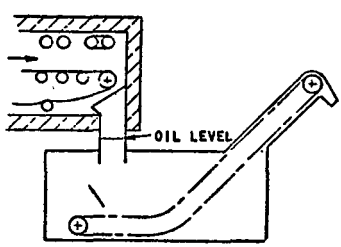


Figure 9. Integral Quench Furnaces

C. Quench Vestibule

1000-3. (a) The quench vestibule shall be gastight and shall be constructed of noncombustible materials with due regard to the fire and explosion hazards inherent to such equipment. Attention to mechanical functions and corrosive conditions is vital to ensuring reliable, safe operation.

(b) 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 1000-4.)

(c) The intermediate door between furnace and quench should close the opening to serve as an insulated baffle to block heat loss to the quench vestibule.

(d) Emergency or service openings shall be provided with gastight closures.

(e) All external load and unload doors shall be properly fitted with adequately sized and stable pilots.

(f) The quench vestibule shall be supplied with adequate atmosphere gas supply to maintain safe conditions during the entire process cycle.

(g) 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. A stable adequately sized pilot shall be provided at the effluent line to ignite the vented gases.

(h) Manual facilities should be provided to permit opening of the outer quench vestibule door. Opening of this door under emergency conditions shall be an operating personnel decision. (See 1000-7 (f).)

D. Cooling Chamber Design

1000-4. These recommendations are 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.

(a) Although hot rolled steel plate has been used for many years with water cooling, it is not to be recommended as corrosion is continuous and its physical state difficult to determine. When hot rolled steel plate is used, oil or other compatible coolant shall be used in place of water. If quench medium temperature is excessive for

desired jacket cooling, a separate heat exchanger should be employed. If a water-cooled exchanger is employed, the quench oil circulating pump should be installed on the inlet side of the heat exchanger and the quench medium pressure should always exceed that of the cooling water.

(b) 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 should be made as to compatibility of materials and welding techniques employed.

(c) Steel plate coils, attached by thermo contact cement to the external surfaces of the quench chamber, fabricated of hot rolled steel plate, have produced acceptable heat transfer, and careful attention given to the design of the junction of the upper and lower chambers minimizes the possibility of water leak into the quench reservoir.

Steel plate coils can be used with either water or oil type coolants, although the eventual plugging of the passages with rust and mineral deposits can be anticipated when water is used as a coolant. The use of stainless steel plate coils, while a more expensive construction method, will considerably reduce the possibility of plugging of the water passages.

(d) Serpentine coil formed from a noncorrosive tubing material brazed or welded to the exterior surfaces of a cooling chamber, fabricated of hot rolled steel plate, have produced acceptable heat transfer. When careful attention is given to the design of the junction of the upper and lower quench vestibule, the possibility of a water leak into the quench tank is minimized.

E. Elevator Design

1000-5. (a) 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.

(b) The elevating mechanism shall be substantially supported by structural members to handle the maximum rated loads.

(c) Elevator guides or ways shall be provided to insure uniform stabilized movement of the elevator in the confined areas of the quench tank.

(d) Tray guides and/or stops shall be provided to insure tray is properly positioned on the elevator.

F. Protective Features

1000-6. (a) Automatic temperature controls shall be installed in pressure-type water-cooling and oil-cooling systems to insure the desired jacket temperature.

(b) External door operation shall be interlocked so that it cannot be opened unless the elevator is in it's full "up" or "down" position, or on outage of the flame-supervised outer door pilot, except through action of manual override in emergencies.

(c) The admittance and maintenance of protective atmosphere within the upper quench chamber shall conform to Chapters 6 and 7.

G. Lower Quench Chamber or Tank

1000-7. (a) The quench tank shall be designed and constructed to contain the quench medium capacity at the expected operating temperature and with maximum work load volume.

(b) The quench tank shall be tested for leaks prior to use.

(c) The quench tank shall be designed and operated with a maximum quench medium level, when elevator and work load are submerged, of not less than six (6) inches (152 mm) below door or any opening into the furnace.

(d) The quench tank shall have sufficient capacity to quench a maximum gross load with a maximum temperature rise that will not exceed 50°F (10°C) below the flash point and cooling capabilities to recover quench medium temperature between minimum design quench cycles.

(e) 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 syphon effect.

1. Overflow Drains

1a. Quench tanks of over 150 gallons (0.57 m^3) in liquid capacity or 10 square feet (0.9 m^2) in liquid surface area shall be equipped with a properly trapped overflow pipe leading to a safe location outside buildings. Smaller quench tanks should also be so equipped, where practicable. The discharge of the overflow pipe should be so located and arranged that if the entire combustible contents of the quench tank is overflowed through overflow pipe by application of water during fire fighting, property will not be en-

dangered. The size of the overflow pipe should be sufficient to conduct the maximum rate of flow of water expected to be applied to the liquid surface of the quench tank from automatic sprinklers or from other sources in the event of fire.

1b. 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.

1c. If the liquid surface area of quench tank is 75–150 square feet (7–14 m^2), diameter of overflow pipe should be not less than 4 in.; if 150–225 square feet (14–21 m^2), not less than 5 in., if 225–325 square feet (21–30 m^2), not less than 6 inches.

1d. On large quench tanks, multiple overflow connections are preferable to a single large pipe, provided the aggregate cross-sectional area is equivalent.

1e. Overflow pipes should be connected to quench tanks through a flared outlet where the accumulation of caked or dried material may clog the overflow opening.

1f. Piping connections on drains and overflow lines shall be designed so as to permit ready access for inspection and cleaning of interior.

1g. The bottom of the overflow connection shall be not less than 6 in. below the top of the tank.

(f) A quench tank shall be equipped with drain piping, so located and sized to permit draining of the contents within five minutes. Drain piping shall be trapped and directed to a safe location outside the building or to a salvage tank. The drain shall be provided with an emergency valve, readily accessible to the operator. (See 1000–3(h).)

1. Bottom Drains.

1a. Quench tanks over 500 gallons (1.9 m^3) in liquid capacity shall be equipped with bottom drains to permit emergency draining of the quench liquid in the event of fire. Methods of operation for this emergency drain facility shall be determined by the operating personnel and the authority having jurisdiction. Manual operation shall be from a safely accessible location. It must be recognized that rapid removal of the quench liquid can result in a temporary negative pressure condition, which can pull air into the quench vestibule. When a flammable processing atmosphere gas is in use, this can produce an explosive gas-air mixture. Plant personnel

should develop, in consultation with the insurance carrier, necessary procedures to eliminate this possibility.

1b. Such drain shall be trapped and discharge to a closed properly ventilated salvage tank or to a safe location outside which will not endanger property.

1c. According to tank capacity the diameter of the gravity bottom drain shall be not less than the following:

500 to 750 gallons (1.9– 2.8 m^3) — 3″
750 to 1,000 gallons (2.8– 3.8 m^3) — 4″
1,000 to 2,500 gallons (3.8– 9.5 m^3) — 5″
2,500 to 4,000 gallons (9.5–15.1 m^3) — 6″
Over 4,000 gallons (15.1 m^3) — 8″

H. Quench Medium Cooling Systems

1000-8. 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.

(b) External cooler, where quench medium is withdrawn from quench tank, circulated through a water-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.

Water shall not be used as a cooling medium within a quench tank utilizing a combustible liquid quench medium.

J. Internal Tank Cooled Heat Exchanger

1000-9. The heat exchanger should be constructed of noncorrosive materials.

(a) The heat exchanger shall be subjected to a minimum pressure test of 150 percent of maximum designed working pressure after installation in quench tank. 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.

(b) 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.

(c) The cooling medium flow should be controlled by an automatic temperature control.

(d) If it is possible to completely close off the internal heat exchanger, a pressure relief shall be provided, terminating in a safe location.

K. External Water-Cooled Heat Exchanger

1000-10. Tubes of the heat exchanger which are exposed to contact with water should be constructed of noncorrosive materials.

(a) The heat exchanger, after fabrication, shall be subjected to a minimum pressure test of 150 percent of the maximum design working pressure. 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.

(b) The pressure of the quench medium through the heat exchanger shall be greater than the water pressure applied.

L. External Air-Cooled System

1000-11. 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.

(a) External air-cooled heat exchangers installed out-of-doors or which utilize supplemental water cooling shall be of materials suitably protected against corrosion.

M. Quench Tank Protective Features

1000-13. Quench Tank.

(a) Quench reservoir shall be equipped with a reliable quench medium level indicator. If of the sight glass type, the level indicator shall be of heavy duty construction and protected from mechanical damage.

(b) 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.

(c) Excess temperature limit control shall be provided, and suitably interlocked to automatically shut off the quench heating medium, and shall require operator attention in case of excessive quench medium temperature. Excess temperature limit shall be interlocked to prevent start of quenching in case of excessive quench medium temperature. Audible and/or visual alarms shall be provided.

(d) When agitation of the quench medium is required to prevent overheating, then the agitation shall be interlocked to prevent quenching until agitator has been started.

(e) 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 0.35 percent by volume.

1000-14. External Water-Cooled Heat Exchangers.

(a) The oil pressure through the heat exchanger shall be maintained greater than the water pressure.

(b) It it is possible to completely close off the external heat exchanger, a pressure relief shall be provided, terminating in a safe location.

1000-15. External Air-Cooled System.

(a) An external heat exchanger installed out-of-doors shall be provided with lightning protection if located in an exposed, rooftop location.

(b) 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.

N. Quench Tank Heating Controls

1000-16. Fuel-Fired Immersion Heaters.

(a) Fuel-fired immersion burners shall have fuel supplies and pilots and main burners installed and protected in accordance with Chapter V.

(b) Burner control systems shall be interlocked with quench medium agitation or recirculating system to prevent localized overheating of the quench medium.

(c) The immersion tubes shall be installed so that the entire tube within the quench tank is covered with quench medium at all times. The inlet and the outlet shall be through the top of the quench tank.

(d) A quench level and excess temperature supervision shall be interlocked to shut off immersion heating, during normal operations.

1000-17. Electric Immersion Heaters.

(a) Electric heaters shall be of a sheath type construction.

(b) Heaters shall be installed so that the hot sheath is fully submerged in the quench medium at all times.

(c) The quench medium shall be supervised by:

1. A temperature controller arranged to maintain quench medium at proper temperature and interlocked to shut off the immersion heating when excess temperature is detected.

2. A quench medium level control interlocked to shut off the immersion heating when low level is detected.

(d) The electrical control system shall be interlocked with the quench medium agitation or recirculation system to prevent localized overheating of the quench medium.

CHAPTER 11. MOLTEN SALT BATH FURNACES

ARTICLE 1100. GENERAL

1100-1. 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.

1100-2. 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.

ARTICLE 1110. LOCATION AND CONSTRUCTION

1110-1 Location.

(a) 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.

(b) 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 salt tight to prevent leakage should the inner wall fail, do not need curbing.

(c) 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.

(d) 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.

1110-2. Construction.

(a) All molten salt bath furnaces shall be constructed of noncombustible materials.

(b) 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.

(c) 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.

(d) All requirements outlined in Chapter 2, Location and Construction, shall also apply for the construction of salt bath furnaces except as specified in 1110-1(b).

ARTICLE 1120. SALTS

1120-1. General. For the purpose of this section, a salt shall be considered to be any chemical compound, or mixtures of compounds, that may be utilized to form a melt or fluid medium into which metal parts are immersed for processing. A list of commonly used salts and mixtures are contained in Appendix G.

1120-2. Storage and Handling.

(a) 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).

(b) 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.

(c) 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.

(d) 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.

(e) All restrictions applying to nitrate/nitrite salts in (a), (b), (c), and (d) shall apply to cyanide salts. Cyanide salts shall never be stored in the same room or area with nitrate/nitrite salts.

WARNING: Mixing of cyanide and nitrate/nitrite salts will cause an explosion.

ARTICLE 1130. HEATING SYSTEMS

1130-1. General.

(a) 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.

(b) The heat source may be externally applied or may be by direct immersion of radiant tubes or electrical heating elements.

(c) All of the requirements outlined in Chapter 3 (Heating Systems) and Chapter 4 (Safety Control Equipment) will apply.

1130-2. Gas and Oil Heating Systems.

(a) The design of a salt bath furnace shall never permit direct flame impingement upon the wall of the salt container.

(b) Whenever burner immersion tubes or radiant tubes are used, the design shall prevent any products of combustion from entering the salt bath.

(c) 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.

(d) 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.

(e) 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.

(f) For control equipment requirements, see Article 1150.

1130-3. Electrical Heating Systems.

(a) 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.

(b) 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."

(c) 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.

(d) For control equipment requirements, see Article 1150.

ARTICLE 1140. VENTILATION

1140-1. 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.

1140-2. Exhaust.

(a) Salt bath furnace hoods shall be provided with exhaust ductwork and a blower (mounted external to the hood) for the continuous evacuation of fumes.

(b) 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.

ARTICLE 1150. SAFETY CONTROL EQUIPMENT

1150-1. General.

(a) 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 malfunction.

(b) Gas and oil fired salt bath furnaces shall be provided with controls as specified in Chapter 4 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.

(c) 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.

(d) 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.

(e) 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.

(f) All electrical wiring and control cabinets and cubicles shall conform to the requirements of NFPA 70–1978, National Electrical Code.

(g) Each salt bath furnace shall be provided with audible and visual alarms. These alarms shall be interlocked with the operating and safety control instrumentation.

1150-2. Electrically Heated Salt Bath Furnaces.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

ARTICLE 1160. INTERNAL QUENCHING SALT BATHS

1160-1. General. Whenever a salt bath is utilized as an internal quenching tank in an internal quench furnace, the following additional requirements shall apply.

Exception: This chapter does not cover Type I and Type II furnaces shown in Figure 9, and these types of furnaces are not recommended for use with salt quenching.

1160-2. Low Temperature Salt Bath Quench Tanks. Salt bath quench tanks [350°F (177°C) to 750°F (399°C)], that utilize sodium and/or potassium nitrates and nitrites and operate with a combustible furnace atmosphere above all, or part, of the salt bath surface, shall be designed to:

(a) Control the interface between the atmosphere and the salt surface to prevent carbon precipitation onto the salt surface, and

(b) Provide adequate circulation of the salt to prevent localized overheating of the salt where it is exposed to furnace temperatures.

NOTE 1: Carbon concentration on the salt surface can cause localized overheating when hot material in process enters the salt quench from the furnace.

NOTE 2. A typical arrangement is shown in Appendix H.

1160-3. High Temperature Salt Bath Quench Tanks. Salt bath quench tanks that operate between 700°F (371°C) and 1300°F (704°C) shall utilize salts, or salt mixtures, that are chemically and physically stable at operating temperatures and are nonreactive to furnace atmospheres.

ARTICLE 1170. HAZARDS OF SALT BATHS

1170-1. General. The hazards that are inherent in the operation of molten salt bath furnaces can result in explosions or fires, or both. These explosions and fires can occur inside the salt bath furnace or may occur external to the furnace. Basic causes can be chemical or physical reactions and may occur in combination.

Since molten salts have high heating potential, low viscosities, and relatively little surface tension, even minor physical disturbances to the molten salt bath can result in spattering or ejection of the molten salt out of the furnace container. This ejection can become violent when liquids (water, oil, etc.) or reactive materials are allowed to penetrate the surface of the salt bath.

Nitrate salts can produce violent explosions because of chemical chain reactions when the nitrate salt is overheated. Overheating can occur because of a malfunction of the heating system controls, from a floating or "hung-up" work load, or from an operator processing error.

While this standard deals primarily with the protection and conservation of property, salt bath explosions (chemical or physi-

cal) can be expected to involve injury to personnel. As a result, it is recommended that all aspects of personnel safety be thoroughly investigated.

NOTE: Internal water cooled coils and jackets should not be used. The salt bath should be cooled by natural means; that is, direct radiation and conduction to the ambient surroundings. If insufficient to maintain operating temperatures, then forced cooling can be promoted by several proven means using air as the cooling medium.

1170-2. Operator Precautions.

(a) Each molten salt bath operator shall be thoroughly trained, as specified in Chapter 1, Section 100–5. Only trained, qualified operators shall be permitted to operate or service molten salt bath furnaces.

(b) Each molten salt bath installation shall be furnished with a prominently displayed wall chart, which shall be supplied by the manufacturer. These charts shall contain all of the instructions and information specified in Chapter 1, Section 100-5, paragraphs (d) and (e). In addition, a clearly visible, and conspicuous, sign shall be posted at each salt bath furnace. This sign shall state which salt — or salt mixtures — are to be used, and what the maximum design operating temperature is.

(c) A complete operation and service manual shall be available at each salt bath furnace, and the operator shall have access to the operation manual at all times.

(d) Since emergency procedures are not utilized on a day-to-day basis, all emergency procedures shall be reviewed with the operators on a regularly scheduled basis.

(e) Because of the potential for spattering of the molten salts, it is recommended that consideration be given to the provision of heat resistant clothing, safety glasses or goggles, full face shields, heat resistant gloves, safety shoes, and all other personnel protection recommended by the equipment manufacturer, user standards, industrial safety standards, and local, state or federal requirements.

1170-3. Miscellaneous Precautions.

(a) All fixtures, tools, baskets, parts, etc., that are to be immersed in a molten salt bath must be thoroughly dry before immersion.

(b) If a crust forms on the surface of a molten salt bath because of salt freezing, no attempt shall be made to physically break the crust while the furnace is in operation. Instead, the temperature of the bath shall be gradually raised until the crust melts. Care must be taken so that the bath temperature does not exceed the maximum design operating temperature at any time.

(c) All salt bath furnace covers shall be in the closed position whenever the furnace is not in use or is being idled over prolonged periods.

(d) All public fire department and plant emergency organizations that will respond to fires and explosions within the plant shall be made familiar with the nature of the chemical salts being used, the location and operation of each molten salt bath furnace, and the extinguishing and control methods that can be safely employed.