NFPA No. 86

STANDARDS FOR

CLASS A OVENS AND FURNACES

1950

75 Cents

NATIONAL FIRE PROTECTION ASSOCIATION
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National Fire Protection Association

INTERNATIONAL

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes over a hundred and seventy-five national and regional societies and associations and thirteen thousand individuals, corporations, and organizations.

Membership in the National Fire Protection Association is open to any society, corporation, firm or individual interested in the protection of life or property against loss by fire. The Association is a clearing house for authoritative information on fire protection and prevention. The Association is always glad to send samples of its publications to prospective members upon request.

This standard, prepared by the NFPA Committee on Ovens and Furnaces, was tentatively adopted by the Association at the 1948 annual meeting and finally adopted in 1950, incorporating extensive revisions resulting from research and cooperative effort on the part of the oven industry and various organizations concerned. It supersedes the NFPA Standards for Ovens for Japan, Enamel, and Other Flammable Finishes, edition of 1931.

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STANDARDS FOR CLASS A OVENS AND FURNACE DESIGN, LOCATION AND EQUIPMENT.

(No. 86)

Foreword.

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

Class A ovens or furnaces are those operating at approximately atmospheric pressures and temperatures not exceeding approximately 700°F. where there is an explosion hazard from either, or a combination of, the fuel in use or flammable volatiles from material in the oven; 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 approximately atmospheric pressure and temperatures exceeding approximately 700°F.

Class C ovens or furnaces are those in which there is an explosion hazard due to a flammable special atmosphere being used for treatment of material in process.

Class D ovens (dryers, coating machines, etc.) are those where there is an explosion hazard due to flammable vapor and provided with solvent recovery equipment, with or without air recirculation.

The following standards cover Class A ovens and furnaces only.

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CHAPTER 1. GENERAL.

ARTICLE 100. GENERAL INFORMATION.

1001. Scope. (a) These standards refer to *Class A ovens or furnaces only* and shall apply to new installations or alterations or extensions to existing equipment. These standards are not retroactive unless deemed so by the authority having jurisdiction.

(b) Within the scope of these standards, an oven shall be any heated enclosure operating at approximately atmospheric pressure used by industry for the processing of materials, including metals, finishes (coating materials), textiles, grains, foodstuffs, or any other commercial product at temperatures up to approximately 700°F. (Food processing ovens up to 900°F.)

(c) Small cabinet or stove type ovens for domestic use are not covered.

(d) Although baking ovens for food products are usually classed as a group apart from the other types of industrial ovens which are used for the finishing and treating by heat of manufactured, agricultural, or chemical products, they are nevertheless, ovens in the same sense and subject to the same problems of construction, location, heating, safety, protection and maintenance. These standards, therefore, shall also apply to bakery ovens in all respects and reference is made to those Sections of the American Standard Safety Code for Bakery Equipment, A.S.A. Z50.1-1947, or the latest revisions thereof, which cover bakery oven construction and safety.

(e) The drying or baking of material containing flammable volatiles such as sprayed or dipped paint work, impregnated material and coated fabrics may involve a serious fire and explosion hazard endangering the oven and the building in which the process is located, and possibly the lives of employees. For this reason adequate safeguards should be provided as specified herein for the location, equipment and operation of such ovens.

1002. Definitions. (a) For the purpose of these standards "Batch Process Ovens" include all ovens into which the work charge is introduced all at one time so that the evaporation of flammable volatiles within the oven is not at a constant rate.

(b) "Continuous Process Ovens" are ovens into which the work charge is more or less continuously introduced, as by a conveyor, so that the evaporation of flammable volatiles within the oven approaches a constant rate.

1003. Approvals, Plans and Specifications. (a) Before new equipment is installed or existing equipment remodeled, complete working plans and specifications should be submitted for approval to the authority having jurisdiction. Plans shall be drawn to an indicated scale, and shall show all essential details as to location, construction, ventilation ductwork, volume of fresh air at 70°F. introduced for safety ventilation, heater equipment, fuel piping, heat input, and safety control wiring diagrams. The plans should include a list of all equipment giving manufacturer and type number.

(b) Any material deviation from these standards will require special permission from the authority having jurisdiction.

MANUFACTURERS SERIAL NUMBER .....

OVEN SAFETY DESIGN FORM.

THIS OVEN IS DESIGNED FOR THE CONDITIONS AS INDICATED BELOW, AND IS APPROVED FOR SUCH USE ONLY

WARNING—Do not deviate from these conditions without approval.

NAME OF OWNER.....

LOCATION.....
City State Plant Building Floor

PURPOSE.....
For Example: Baking: Paint Enamel Japan Food. Dehydrating - Heat Treating - Curing.

KIND OF MATERIAL HANDLED..... LBS. PER HOUR OR PER BATCH.....
For Example: Wood Paper Textiles Foods Metal Minerals

TYPE OF HEATING SYSTEM..... HEAT MEDIUM.....
For Example: Convection, Radiant, Induction. For Example: Gas, Oil, Electricity, Steam, Dowtherm.

SOLVENTS USED.....
For Example: Alcohol Naphtha Benzol Turpentine

SOLVENTS AND VOLATILES ENTERING OVEN.....
Gallons Per Batch or Per Hour

PURGING INTERVAL.....

DO PRODUCTS OF COMBUSTION ENTER OVEN? ....
Yes No

BAKING TIME (BATCH OVEN).....

OVEN TEMPERATURE, DEG. F.....

OVEN DIMENSIONS..... VOLUME.....
Inside Length, Width, Height In Cubic Feet

FRESH AIR ADMITTED INTO OVEN IN CU. FT./MIN. (70°F.).....

INDEX NO..... DATE.....

BASED UPON INFORMATION SHOWN AND SUBJECT TO INSPECTION AND TEST

APPROVED BY.....
Approving Engineer

FOR .....
Inspection or Underwriting Organization

(THIS SPACE RESERVED FOR MANUFACTURER'S NAME)

Above information is for checking sole performance and is not a guarantee of this equipment in any form, implied or otherwise, between buyer and seller relative to its performance.

Fig. 1.

1004. All wiring in and around ovens shall be in accordance with the National Electrical Code and as described hereafter.

ARTICLE 110. OVEN SAFETY DESIGN DATA FORM.

1101. (a) A suitable, clearly worded, and prominently displayed oven safety design data form shall be provided by the builder of each oven stating the safe operating conditions for which the oven was designed and built, and disregard of which may put the apparatus in jeopardy of failure to function safely, and cause it to become liable to destruction by fire or explosion.

(b) For the purpose of information as to the original purpose of the oven and for specifying the operating limitations, both for the benefit of the user and the field inspector, a uniform data form has been adopted which lists the pertinent information. This listed information will also serve as a check as to whether the equipment is being used as originally intended, and whether any changes have occurred in its use since installation.

(c) It is, therefore, required that: each oven and/or heating or ventilating system for ovens shall be provided with prominently displayed identifying and limiting specifications; i.e., data giving the limiting conditions of design and operation for safety.

(d) Data shall be furnished on approved forms similar to Figure 1. (These forms are available at cost from the NFPA.) They shall be prepared in quintuplicate, the original to be on a good quality lightweight card which is to be inserted in a metal frame fastened to the equipment and protected either with a glass or clear plastic cover. It shall be placed at a point where it will be fully visible. The other four sheets, which are to be exact duplicates and serve as file copies of the original, may be a lightweight paper of sufficiently good quality to preserve as a record.

(e) Upon completion of an oven design, the builder shall provide the inspection department or authority having jurisdiction with this form properly filled out in quintuplicate, to be used by the examining engineer for approval. This form shall bear the name of the oven manufacturer and/or installing contractor. The affixing to this form by the insurance inspection department's or authority's examining engineer of the impressed seal of the inspection department or authority together with his signature and the date of approval shall constitute formal acceptance, subject to inspection and test, by the inspection department or authority. Two copies will be retained by the inspection department or authority and the original and two copies returned to the oven builder who will affix the original to the equipment, retain one copy for his file, and transmit the remaining copy to the purchaser.

Figure 1 is a facsimile of the approved form.

CHAPTER 2. LOCATION AND CONSTRUCTION.

ARTICLE 200. LOCATION OF OVENS AND OVEN HEATERS.

2001. General. Ovens, oven heaters and related equipment should be located with due regard to the possibility of fire resulting from overheating or from the escape of fuel gas or fuel oil, and the possibility of damage to the building and injury to persons resulting from explosion.

While the possiblity of fire or explosion will be very much reduced by compliance with these standards, the possibility of mechanical failure of the protective devices or of failure of the operators should be considered in oven location.

2010. Grade Location.

2011. (a) Class A ovens shall be located at or above grade, or if in basements, at least fifty per cent of the wall area of the room in which the oven is located shall be above grade.

Basements do not lend themselves to natural ventilation and offer severe obstacles to providing proper explosion release. Damage to upper stories of a building resulting from an oven explosion in a basement may be severe.

(b) In general, ovens should not be located in closely confining or restricting spaces.

2020. Structural Members of the Building.

2021. (a) Structural members of a building shall not pass through an oven having an operating temperature in excess of 500°F.

(b) Inclusion of the building columns, girders, beams, or trusses within oven structures shall be a matter of serious concern in all cases. Appropriate insulation and ventilation shall be provided to safely avoid all deterioration in strength or ignition caused by heat, including linear expansion of the building structure in either a vertical or horizontal direction.

2022. Where structural members of a building pass through an oven having an operating temperature in excess of 160°F. they shall be noncombustible and fireproofed.

For suitable methods of fireproofing, see the National Building Code of the National Board of Fire Underwriters or the building code of the locality in which the building is located.

2023. The above requirements do not apply to supporting steel structural members which are not subjected to temperatures above 160°F.

It is frequently advantageous to locate a large oven outdoors with only the end or ends entering a building for loading or unloading. In many cases, the oven may be above the roof with work taken into the oven by an inclined conveyor from the floor below. Such designs lend themselves readily to effective explosion venting.

2030. Location in Regard to Stock and Other Processes.

2031. Valuable Stock. Ovens, so far as possible, should be well separated from valuable stock, important power equipment, machinery and sprinkler risers, thereby securing a minimum interruption to production and protection in case of accidents to the ovens.

2032. Personnel. (a) Ovens shall be located so that possible fire or explosion will not expose groups of persons to possible injury.

(b) In general, ovens should not adjoin recreational areas, lockers, lunch rooms or main passageways and should not obstruct passage to exits.

2033. Finishing operations. (a) Industrial ovens and heaters (except those heated by steam) should be safely located and protected from exposure to dip tanks, spray booths, storage and mixing rooms for flammable liquids, or storage areas used for readily flammable materials, or exposure to the diffusion of flammable air vapor mixtures. The hazard is particularly severe when vapors from dipping operations may flow by gravity to heating units at or near the floor level.

(b) The use of combined dipping and baking, and spraying and baking, units is permissible when adequately ventilated.

Suitable, well-designed units for dipping and baking, or spraying and baking, provided with adequate, interlocked ventilation systems are available.

(c) The room in which flammable vapors are produced should be ventilated in such a manner that the atmosphere in the vicinity of painting operations will be kept well below the lower explosive limit. Flow of ventilating air from paint room or area should be away from the ovens or heaters.

2040. Floors and Clearances.

2041. Ovens should be so located as to be readily accessible with adequate space above oven to permit installation of automatic sprinklers, the proper use of hose streams, the proper functioning of explosion vents, inspection and maintenance. Roofs and floors of ovens shall be sufficiently insulated and the space above and below sufficiently ventilated to keep temperatures at combustible ceilings and floors below 160°F.

2042. (a) Ovens located at floor level should be placed on noncombustible floors. If such locations are not available, then sufficient insulation and ventilation shall be provided to protect the combustible floor from damage by fire, and wood deterioration due to long time heat exposure.

(b) The following procedure should be observed if the oven is located in contact with a wood or other combustible floor and the operating temperature is above 160°F.:

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

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

(3) Whether the supporting floor is of concrete, steel channels, or hollow tile, for operating temperatures above 300°F., the oven floor shall be further insulated with suitable material equivalent in insulating value to that used for oven walls and roof, and suitably enclosed or covered for protection against mechanical damage or abrasion. Insulation may consist of an adequate layer of insulating

cement and Portland cement mixed in equal parts by weight, and should be poured and troweled to a smooth, evenly applied floor surface after the side walls are erected.

Insulating cement may be diatomaceous earth or its equivalent mixed 50:50 by weight with Portland cement, and the thicknesses used should be:

2 in. for 300°F. oven heat
3 in. for 400°F. oven heat
4 in. for 500°F. oven heat
5 in. for 600°F. oven heat
6 in. for 700°F. oven heat

(4) For special cases where electrical wiring will be present in the channel spaces of certain types of steel floors, the surface temperature of the steel should not exceed 140°F.

(5) Combustible floors in immediate area of oil burners shall be covered with noncombustible material. See the building code having jurisdiction. Adequate protection from heat and from fuel spillage shall be provided for combustible floors under heaters.

2043. Where oven ducts or stacks pass through combustible walls, floors or roofs, adequate insulation and clearances shall be provided to prevent surface temperatures of combustible materials exceeding 160°F.

2044. Combustible work benches and other combustible equipment shall not be located within two feet of an oven, oven heater or ductwork.

ARTICLE 210. CONSTRUCTION OF OVENS.

2100. General.

2101. Ovens 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 insuring reliable, safe operation over the expected maximum life of the equipment.

2110. Materials.

2111. (a) Ovens should be constructed of noncombustible materials throughout. If operating temperatures are 160°F. or lower, combustible materials may be used providing that the installation is approved by the authority having jurisdiction. If combustible materials are used, they should be faced (covered) on both sides with noncombustible material, such as sheet metal or asbestos board.

(b) Oven interiors should have smooth surfaces arranged to permit easy cleaning. Where oven walls are formed of insulating material covered with (encased in) sheet metal, care should be used in construction to prevent absorption of solvent vapors. Expansion joints should be provided at suitable intervals in oven framing and paneling to prevent damage from expansion and contraction.

(c) The amount of insulation used in oven panel construction shall be enough to prevent the outside surface temperature exceeding 160°F. or adequate guards shall be provided to protect personnel.

(d) Oven 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.

(e) Access doors or openings in adequate number and size shall be provided to facilitate inspection and maintenance, also the effective use of extinguishers or hose streams in all parts of the oven. All access doors should be provided with hardware which will permit manual opening from either side.

(f) The metal frames of ovens shall in all cases be electrically grounded throughout for the safe removal of static electric charges. See NFPA pamphlet, "Static Electricity" (No. 77).

2120. Explosion Vents for Ovens.

2121. Ovens which may contain flammable air gas mixtures shall be equipped with unobstructed relief vents for freely relieving internal explosion pressures. These vents shall be provided in the form of gravity retained panels designed to afford adequate insulation and possess the necessary structural strength. These explosion relief panels shall be proportioned in the ratio of their area in square feet to the explosion containing volume of the oven, due allowance being made for openings or access doors equipped with approved explosion relieving hardware. The preferred ratio is 1:15; i.e., one square foot of relief panel area to every fifteen cubic feet of oven volume. Since it may not in all cases be either practical or even possible to secure these proportions, the effort of the designer should be in the direction of a rational approach to this ratio (i.e., 1:15).

2122. Arrangement of Explosion Vents. (a) Explosion venting panels or doors shall be arranged so that when open, the full vent opening will be an effective relief area.

In installation, care should be taken to make sure that the operation of relief vents to their full capacity is not obstructed by low ceilings, piping, building columns or walls, instrument panels or other fixed equipment.

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

(b) Explosion relief vents, where possible, should be placed in the top of the oven or inside walls and located so that employees will not be exposed to injury.

(c) Explosion relief vents for long ovens should be reasonably distributed throughout the entire oven length.

The Standards for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying (Standard No. 91, published by NFPA in the National Fire Codes, Vol. III, and by the National Board of Fire Underwriters in Pamphlet 91) should be followed.

ARTICLE 220. DUCT WORK.

2201. (a) Proper consideration should be given to the design and construction of air circulating duct systems. All duct work shall be constructed of noncombustible materials.

(b) Whenever possible, the oven location should permit the shortest and most direct path for ducts (exhaust or relief) to discharge to atmosphere.

(c) Whenever oven ducts or stacks pass through combustible walls, floors, or roofs, adequate insulation and clearance shall be provided to prevent surface temperatures exceeding 160°F.

(d) Ducts shall be constructed entirely of sheet steel or other noncombustible material, and of adequate strength and rigidity to meet the conditions of service and installation requirements, and shall be properly protected where subject to mechanical injury.

(e) The entire duct system should be self-contained. No rooms or portions of the building shall be used as an integral part of the system.

(f) All ducts shall be made tight throughout and shall have no openings other than those required for the proper operation and maintenance of the system.

(g) All ducts shall be thoroughly braced where required and substantially supported by metal hangers or brackets. All laps in the duct joints should be made in the direction of the air flow.

(h) The passing of ducts through fire walls should be avoided.

(i) Where ducts pass through noncombustible walls, floors, or partitions, the space around the duct shall be sealed with asbestos rope, mineral wool, or other noncombustible material to prevent the passage of flame and smoke.

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

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

(l) Dampers in the ducts which affect the volume of fresh air admitted to and vapors or gases exhausted from the oven shall be so designed that when in closed position they will pass the volume required for safe ventilation.

(m) Ovens shall be designed to prevent excessive spillage of objectionable fumes into the building.

(n) All exposed hot fan casings and hot ducts within 7 feet of the building floor shall be protected to prevent injury to personnel. (Temperature not to exceed 140°F.)

(o) Exhaust ducts shall not discharge near doors, windows, or other air intakes in a manner that will permit re-entry of vapors into the building.

(p) All air inlets outside the oven should be protected by coarse screens and so guarded that they cannot be obstructed.

ARTICLE 230. ACCESS, MOUNTINGS AND AUXILIARY EQUIPMENT.

2301. Access openings shall be provided to facilitate inspection and maintenance and to permit effective use of first-aid fire extinguishers and hose streams.

2302. When such openings are intended to permit persons to climb inside ductwork for cleaning, ladders, steps and grabrails should be provided to permit safe and easy access and egress and safe working conditions within the duct work.

2310. Mountings.

2311. Mountings for auxiliary equipment shall provide for rigid mounting of control instruments and safety devices protected against injury by heat, vibration and mechanical equipment.

2320. Ladders or Steps.

2321. Where ladders or steps are needed to reach valves or other controls, they shall be noncombustible and provided as an integral part of the equipment.

2330. Auxiliary Equipment.

2331. Auxiliary equipment such as conveyors, racks, shelves, baskets and hangers shall be noncombustible and designed to facilitate cleaning.

Exception: When ovens operate at temperatures which cannot exceed 160°F. and the oven is equipped with automatic sprinklers, combustible material may be employed.

CHAPTER 3. HEATING SYSTEMS.

ARTICLE 300. GENERAL.

3001. Scope. (a) For the purpose of these standards the term "oven heating system" shall include the heating source such as gas burners, oil burners, electric heaters, infrared lamps, induction heating, steam radiation systems, and associated ductwork and circulating fans used to convey heat to the oven or work therein.

(b) From a fire safety viewpoint, ovens processing combustible materials should preferably be heated by convection, using external heating units and an air circulating system, thus avoiding the introduction of naked flame or other high temperature elements, which may ignite such combustible material within the baking chamber.

(c) Other heating systems such as coal or other solid fuel firebox and firing equipment, and hot oil or other liquid circulating systems and electrical high frequency heating systems, which are not generally used in Class A ovens, are not included in these standards and should be referred for approval to the authority having jurisdiction.

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

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

(f) The means of heat transfer may be air, passed into, through, and out of the oven by ducts, or steam, or other transfer agents such as Dowtherm, circulated through pipes, or it may be electric energy. (See Section 3001 (c).)

3002. Control Equipment. For control equipment requirements, including combustion safeguards, air flow switches, time relays and temperature controls, see Chapter 5.

3003. Fuel Supplies. For the handling of fuel supplies up to the point of connection with the oven, see Sections 3130 and 3220 of these standards and the following NFPA standards: Oil Burning Equipments (No. 31), and

Liquefied Petroleum Gases (No. 58), published by the National Fire Protection Association in the National Fire Codes, Vol. I, and by the National Board of Fire Underwriters in separate pamphlets with the numbers indicated.

3004. Electrical Equipment. Electrical installation shall be in accordance with the National Electrical Code and as described hereafter.

3005. Exhaust Ducts and Ventilation. For exhaust ducts, fans, clearances and ventilation requirements, see Chapter 4.

ARTICLE 310. GAS HEATING SYSTEMS.

3101. Scope. This section includes oven heating systems fired with commercial manufactured gas, natural gas, mixed gases, liquefied petroleum gases or producer gas and other fuel gases.

3102. Selection of Burners. Gas burners and associated mixing equipment shall be a proper type and suitable for service intended, as follows:

(a) For the Btu. content of the gas used.

(b) For the operating pressures available.

(c) Capable of maintaining a reasonably constant air-gas ratio at sufficient mixture pressure throughout turndown range so that safe combustion is independent of pressure conditions and secondary air within the combustion area.

(d) Shall permit the use of safety interlocks. See Chapter 5, Safety Control Equipment.

(e) Gas pilots should be provided for ignition of gas burners. In cases where other means of ignition are deemed necessary, approval shall be obtained from the authority having jurisdiction.

3110. Types of Fuel Gases.

3111. Commercial Manufactured Gas shall mean in these standards a mixture of gases usually composed of various proportions of some of the following gases:

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

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

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

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

3112. Natural Gas shall mean in these standards, a mixture of gases, principally methane and ethane obtained from gas wells and from which less volatile liquids such as propane and butane have been removed, leaving a mixture of gases which will remain in the gaseous state at all pressures and temperatures encountered in the distribution system.

The relatively low rate of flame propagation as indicated in Par. 3122 requires additional care in the design of natural gas burning equipment.

3113. Liquefied Petroleum Gases. (a) The term "liquefied petroleum gases" as used in these standards shall mean and include any material which is composed predominantly of any of the following hydrocarbons, or mixtures of them; propane, propylene, butanes (normal butane or iso-butane), and butylenes.

The composition of liquefied petroleum gases varies, but in all the established grades the predominant compounds are propane and butane (iso-butane and normal butane). Under moderate pressure, the gases liquefy, but upon relief of the pressure are readily converted into the gaseous phase. Advantage of this characteristic is taken by the industry, and for convenience, the gases are shipped and stored under pressure as liquids. When in the gaseous state, these gases present a hazard comparable to any flammable natural or manufactured gas, except that being heavier than air, ventilation requires added attention. The range of combustibility is slightly narrower and lower than that of natural gas. When below 30°F., butane is a liquid and the hazard is similar to that of a flammable liquid. Propane is a liquid at atmospheric pressure at temperatures below minus 44°F. Rapid vaporization takes place at temperatures above the boiling points (butane above 30°F.; propane above minus 44°F.).

(b) Installation of liquefied petroleum gas storage and handling systems used to supply oven heating systems shall be made in accordance with the NFPA Standards for Liquefied Petroleum Gases (No. 58), published by the NFPA in the National Fire Codes, Vol. I, and by the National Board of Fire Underwriters in Pamphlet 58.

(c) Mixtures of liquefied petroleum gases and air are distributed by public utilities through gas systems for use in place of commercial manufactured gas or natural gas and may satisfactorily be used in equipment designed for use with those gases. Such mixtures shall be considered equivalent of commercial manufactured gas or natural gas except that provision should be made for ventilation based on these mixed gases being heavier than air.

3114. Producer Gas. (a) Producer gas shall mean in these standards any gas formed by blowing air through incandescent coal, coke or charcoal. Such gases often contain solid particles and carry liquids which cause difficulty in burner operation. Special design is needed and automatic control is often difficult.

(b) The use of producer gas for heating systems should be restricted to equipment under constant supervision of a qualified operator. Installation of gas producers should be made in accordance with the NFPA Recommended Good Practice Requirements for the Installation and Use of Coal Gas Producers, No. 37A (published by NFPA in the National Fire Codes, Vol. I; by the National Board of Fire Underwriters in Pamphlet 37). Plans for producer gas equipment, distribution systems and oven heating systems should be submitted to the authority having jurisdiction for approval. The use of other types of gases is recommended.

3120. Properties of Fuel Gases.

Table I is included for information only and indicates the properties of typical commercial gases (next page).

3121. Ignition temperature means the lowest temperature at which a gas-air mixture may ignite and continue to burn. This is also referred to as the

TABLE I.

	Properties of Typical Commercial Gases				
Gas	B.t.u. per cu. ft.	Limits of Explosive Range in Air by Volume Percent Lower	Upper	Specific Gravity Compared to Air—1.0	Cu. ft. of air required to burn 1.0 cu. ft. of gas
Natural (High B.t.u. type)	1115	4.6	14.5	.64	10.6
Natural (High methane type)	960	4.0	15.0	.56	9.0
Natural (High inert type)	1000	3.9	14.0	.70	9.4
Coke Oven	575	5.0	28.4	.44	5.1
Carbureted Water (Heavy oil with blow run)	530	6.5	37.5	.70	4.1
Carbureted Water (Gas oil)	530	6.4	37.7	.67	4.5
Oil Gas (Pacific Coast)	496	4.5	29.6	.47	4.0
Coal Gas	536	5.6	30.8	.47	4.9
Water Gas (Blue gas)	287	6.9	69.5	.57	2.1
Producer Gas (Anthracite)	136	20.7	73.7	.86	1.1
Producer Gas (Bituminous)	153	16.8	64.0	.86	1.2
Propane	2500	2.4	9.5	1.52	24.0
Butane	3200	1.9	8.5	1.95	31.0

auto-ignition temperature. When burners supplied with a gas-air mixture in the flammable range are heated above the auto-ignition temperature, flashbacks may occur. In general, such temperatures range from 870°F. to 1300°F. A much higher temperature is needed to ignite gas dependably. The temperature necessary is slightly higher for natural gas than for manufactured gases, but for safety with manufactured gas, a temperature of about 1200°F. is needed and for natural gas, a temperature of about 1400°F. is needed.

3122. Flame propagation and explosive range. The term "rate of flame propagation" means the speed at which a flame progresses through a combustible gas-air mixture under the pressure, temperature and mixture conditions existing in the combustion space, burner or piping under consideration.

For any combustible gas, the range of its concentration in air within which flame is propagated is known as the explosive range or as the limits of flammability. The lowest flammable concentration is the lower explosive limit. Within the range, the maximum rate of flame propagation occurs when the combustible gas and air are mixed in proportions for complete combustion or often with the gas at a slightly higher concentration.

The rate of flame propagation has practical significance in the design and operation of gas burners. If the velocity of the mixture at the burner diminishes, the tendency of the flame to flash back into the burner body is increased. Conversely, if the gas velocity leaving the burner is much greater than the rate of flame propagation, the flame may be blown away from the burner. For this reason, a burner which has been used on a manufactured gas, with a relatively high rate of flame propagation,

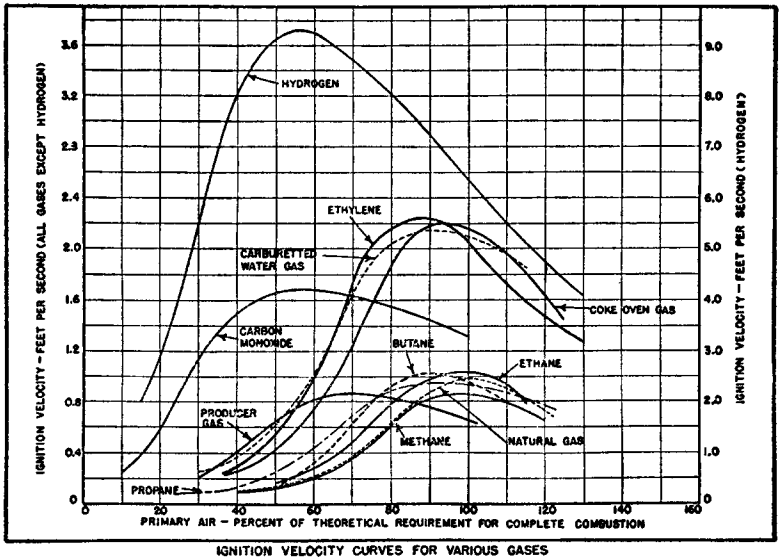


Fig. 2. The rate of flame propagation is defined in Par. 3122. Values are given in the above graph.

may not be suitable for natural gas or butane which has a low rate. Fortunately, the relation between burner discharge velocity and flame propagation rate is not critical, so that neither variation in the rate of flow nor changes in mixture adjustment over a fairly wide range will cause the flame to blow away from the burner or to flash back.

3130. Gas Piping and Valves.

3131. Other Standards Applicable. Gas piping and valves for natural and manufactured gases should be installed in accordance with the following paragraphs. Where high pressure services are utilized, the installation requirements shall comply specifically to the following paragraphs and to the applicable provisions of the A.S.A. Code for Pressure Piping B31.1 and revisions thereof. For requirements on Liquefied Petroleum Gas Installations see Section 3113 (b).

3132. Pipe Material. (a) Gas piping shall be so constructed and installed as to be durable, substantial, and gas tight. Either screwed, flanged or welded joints may be used. Unions where needed shall have metal to metal seats.

(b) The pipe and fittings used shall be of good material, clear and free from burrs and defects in structure or threading. Cast iron pipe and fittings shall not be used.

(c) Wrought-iron or wrought-steel pipe shall comply with the American Standard for Wrought-Iron and Wrought-Steel Pipe, ASA B36.10-1939 and revisions thereof.

(d) Pipe and fitting threads shall comply with the American Standard for Pipe Threads, ASA B2.1-1945.

(e) Semi-rigid tubing and fittings where used, with approval of the authority having jurisdiction, for small main and pilot burner assemblies, shall comply with the American Standard Listing Requirements for Semi-Rigid Gas Appliance Tubing and Fittings, Z21.24-1941 and revisions thereof.

(f) Brazed or soldered joints using solder having melting point over 1000° F. may be used for small tubing with the approval of the authority having jurisdiction.

3133. 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 without undue loss of pressure between the points of delivery and use.

3134. Installation of Piping. (a) Gas Piping shall be well supported and guarded against mechanical injury and properly pitched to permit draining of any condensate.

(b) Piping should be supported by round wrought-iron or steel U-type or approved adjustable hangers at proper intervals.

(c) Flat Iron may be used for hangers or parts of hangers provided that the thickness of the metal is not less than 3/16 inch and that the hanger or part is of sufficient width to assure metal at the screw holes of approximately equal area to that required for round wrought-iron or steel U-type hangers.

(d) C-type hangers are acceptable for use on steel beams when provided with a strap. Where the steel beam is tilted so that the clamp cannot fall off, the strap may be omitted.

(e) Where piping is supported from masonry walls, through anchor bolts shall preferably be used, except in certain cases for small pipe sizes, metal expansion shields may be acceptable. Approved pipe hangers shall be securely fastened to the anchor bolts or expansion shields.

(f) All branch outlet pipes shall be taken from the top or side of running lines and not from the bottom.

(g) A tee fitting with the bottom outlet provided with nipple and cap instead of an ell fitting should be used at the bottom of all risers and drops.

(h) A drip in which condensate may collect and be removed, shall be provided at any point in the line of pipe where condensate would collect. Drip drain valves shall be closed with a valve provided with nipple and cap to prevent accidental opening. Drips shall not be located where the condensate is likely to freeze unless adequate provisions are made to prevent freezing. Suitable provisions should be made to protect persons or property from hazard while draining the drips or when disposing of condensate from the drips.

(i) Underground pipes should not pass through or below foundation walls into unfrequented spaces below buildings. Pipes for buildings having such spaces should rise above grade before passing through building wall to indoors.

(j) Pipe should not run in inaccessible or concealed spaces in or under buildings, where its condition cannot be inspected and undetected leakage might cause dangerous accumulations of gas.

(k) Pipe which is outdoors, buried or otherwise exposed to moisture or corrosive conditions, should have an outside protective coating.

(l) Pipe joint compounds, suitable for the fluid handled, should be used sparingly and applied to male pipe threads only.

3135. Test of Piping for Tightness. (a) Before any system of gas piping is put in service, it shall be cleaned and carefully tested to insure that it is gas tight. Air, inert gas, or fuel gas should be used and a test pressure of at least 1.5 times the normal working pressure, but in no case less than 3 psig., should be bottled up in the system for a 10-minute period without any drop in pressure.

(b) Defects in pipe shall not be repaired other than by welding or by replacing defective pipe. Defective fittings shall be replaced.

(c) No flame or fire in any form shall be used in attempting to locate a gas leak.

(d) In no case shall gas piping be filled with water or other liquids to locate or eliminate leaks. Under no circumstances shall oxygen be used for this purpose, since it may form an explosive mixture with any oil or fuel gas within the pipe. A soap and water solution may be applied to the pipe exterior to locate leaks.

(e) Before gas is turned on into a system of new gas piping, or after being shut off, the entire system shall be checked to make certain that there are no open fittings or ends and that all valves at outlets are closed.

3136. Emergency Manual Shut Off Valves. Manually operated shut off 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 ovens and furnaces will not prevent access to these valves.

3137. Manually Operated Valves. For pressures below 5 pounds per square inch, plug cocks or globe valves may be used. Where pressures are in excess of 5 pounds per square inch, plug cocks, lubricated plug cocks or packless globe valves should be used. Packed globe valves may be used in well ventilated areas. Gate valves should not be used. Valves should be suitable for type of fluid handled.

On high-pressure systems, it is often desirable to provide a vent pipe to outdoors between the burner valves and the main shut-off. After burners are extinguished, the main valve should be closed and the vent opened. This is best accomplished by using a combination of a 3-way cock with 2-way key and a straight way cock arranged as shown in Figure 3.

3138. Power Operated Valves shall be packless construction and arranged to close in event of failure of the power supply except vent valves which may be arranged to open in event of failure of the power supply. For further information in regard to power operated valves, see Chapter 5.

3139. Pressure Regulator. Where a pressure regulator or governor is used as part of an oven 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 constant burning pilot 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. 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.

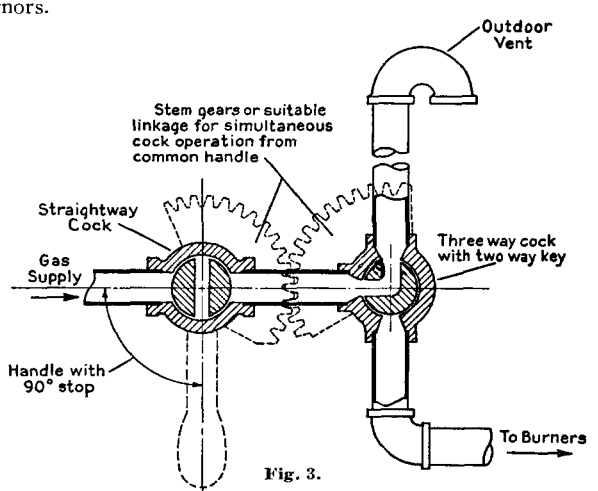
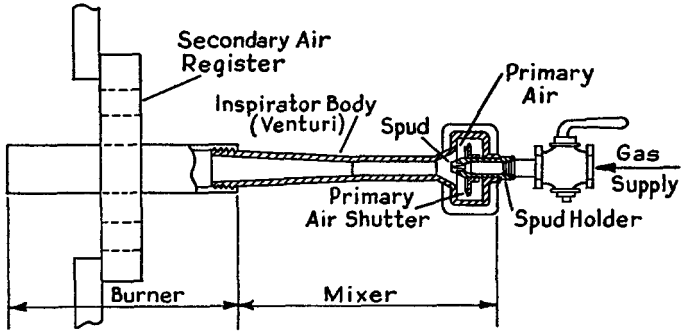


Fig. 3.

3140. Atmospheric Inspirating Burners.

3141. Definitions. (a) The term "Atmospheric Inspirator (venturi) Mixer" shall mean any mixer in which part or all of the combustion air (primary air) is drawn in by the inspirating effect of a gas jet entering the inspirator, the remaining combustion air (secondary air), if needed, being supplied from the atmosphere in which the burner is located. See Fig. 4.



Atmospheric Inspirating Burner Mixer.

Fig. 4.

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

3142. Yellow flame burners in which no primary air is used shall be in accordance with pertinent paragraphs in this section.

3143. Air Adjustment or shutter shall be fixed or provided with a locking screw or nut which will effectively prevent accidental change of setting and shall be so located that adjustments may readily be made when the oven is in operation at normal working temperature.

3144. Multiple Port Burners. (a) Burners of the perforated pipe, ribbon or slot type or other shapes 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 oven. They shall light easily, flash across the entire burner surface and not blow off or flash back when the burner is hot and shall operate without forming yellow tips on the flames.

Such burners must be carefully maintained and should not be used where foreign material can fall into ports.

Various special burner designs have been developed to improve stability of operations and continuity of ignition. Careful selection of burner design is essential where multiple port burners are employed.

(b) Multiple port burners shall be so designed that ignition of gas from every port shall rapidly result 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.

3145. Nozzle 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 draft conditions which may be encountered in oven operations.

Due to the fact that a single such burner or small number of such burners may be used to meet the entire heat requirement of an oven, the installation of combustion safeguards for each burner is usually simple and practical. For this reason, the use of a small number of such burners is often preferred to the use of multiple port burners or to other arrangements having a number of separate burners.

The use of a special burner so designed that a number of separate units light reliably from each other and are under single control can be considered as the equivalent of a single nozzle or torch burner.

Where a number of nozzle burners are supplied from a single inspirator, the provisions of section 3147, Grouped Burners, shall apply.

3146. 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 tendency to flash back or blow off shall be maintained over the entire range of turndown.

3147. Grouped Burners. When a number of separate burners are supplied having a single mixing inspirator, such inspirators shall be capable of inspirating all the air needed for combustion and shall be installed in accordance with section 3150 governing proportioning burners.

3148. 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.

3149. 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 by-passes where manual control is used, is recommended.

3150. Automatic Proportioning Burners.

3151. Definitions. (a) The term "proportioning burner" (automatic proportioning burner) shall mean a combination of one or more burner tips, nozzles or other firing heads and a proportioning device intended to supply a gas-air mixture to the firing point in proper proportions for combustion. Similar devices with additional controls to permit operation with control devices between burner and proportioning device are governed by paragraphs 3154 and 3155.

(b) The term "proportioning inspirator" shall mean an inspirating tube which, when supplied with gas, will draw into the gas stream all the air necessary for combustion.

(c) The term "proportioning mixer" (Fig. 5) shall mean a mixing device comprised of an inspirator which, when supplied with air, will draw into the air stream all the gas necessary for combustion and a gas governor or zero regulator which reduces incoming gas pressure to approximately atmospheric.

(d) The term "mixing blower" shall mean a motor driven air blower equipped with a gas control valve at the air entrance to the blower so arranged that gas is admitted to the air stream entering the blower in proper

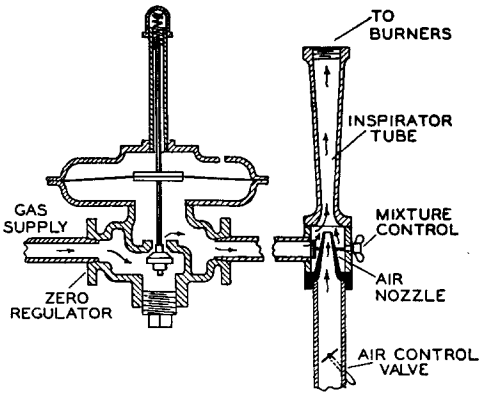


Fig. 5. Typical Proportioning Mixer.

proportions for correct combustion. The gas control device may be a "zero governor" or a "ratio valve" controlling the gas and air adjustments simultaneously.

3152. All the above types of burners shall be equipped with a proportioning device (3151 b, c or d) or other device which will insure a correct gas-air ratio over the entire range of turndown.

3153. Burner Limitations. (a) In any single gas mixing burner assembly, no valve, obstruction, or control device 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 the entire length or surface of the burner 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.

(d) Tunnel and impact burners should be regulated to light reliably when cold without tending to blow-off.

3154. Proportioning Inspirators. (a) No valve or other obstruction shall be installed between a proportioning inspirator and burners.

(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 by a gas tight plug or cap.

(c) The air adjustment shall be provided with locking means.

(d) The inspirator shall be located so that combustible materials are not exposed to overheating in event of backfire.

3155. Proportioning Mixers. (a) No valve or other obstruction shall be installed between a proportioning mixer and burners.

Exception: When the diaphragm space of a zero governor is so connected to the mixer discharge that uniform mixtures can be obtained when individual burners are provided with control devices, paragraph 3156 applies.

(b) Each proportioning mixer shall be equipped with an adjustment means for setting the air-gas ratio which shall be equipped with locknut or other means of effectively securing the setting.

3156. Mixing Blowers. (a) No valve or other obstruction shall be installed between a mixing blower and burners.

Exception: Control valves at individual burners may be used on installations of gas-air mixers of the proportioning type when the mixer is supplied by an individual blower having a discharge outlet not larger than 2-in. (iron pipe size) and when the proportioning valve is equipped with a pilot tube in the mixed gas piping arranged to control the governor diaphragm by velocity changes in the mixed gas piping. Such installations are permitted only when proper gas-air proportions are secured over the range of turndown with any single burner or any combination of burners operating.

(b) An approved safety shut-off valve of the manually 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 event of gas pressure failure. (See Article 520.)

(c) Each mixing blower shall be equipped with a proportioning control device or with a ratio control by which changes in total flow of mixed gas are made by a single adjustment—air shutter and gas valve being linked together.

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

3160. Gas Mixing Machines.

3161. Definitions. 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 following provisions, Pars. Nos. 3162, 3163 and 3164 shall apply.

NOTE: The mixer described in the Exception under Section 3155 is not subject to this section.

The essential difference between the mixing devices used with automatic proportioning burners, Section 3150, 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. Such machines are useful in many types of installations and in fact may add to safety of the equipment since it becomes possible to operate burners in gas tight enclosures (except for vent connections) and to assure stable operations under difficult draft conditions. The advantages outweigh the inherent possibility of backfire and explosion within the machine or piping and when properly installed this possibility can be practically eliminated.

A gas mixing machine usually comprises a pressure regulator or

"zero governor" which reduces the gas supply pressure to atmospheric and a proportioning valve and compressor. The proportioning valve is usually a sliding plate or a cylinder valve having admission ports for gas and air. The valve is moved by a connection to a diaphragm, bellows or a gasometer bell in response to changes in demand to control the total amount of gas and air admitted.

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

3162. Non-explosive Mixtures (outside the flammability limits). Gas mixing machines supplying gas-air mixtures which are above the upper explosive limit shall be installed as follows:

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

(b) The machine should be located in a large, well-ventilated area, but if in a small detached building or room cut off, explosion vents shall be provided in the ratio of 1 sq. ft. of vent area to each 20 cubic foot of room volume.

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 an oven heating system.

In 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) Electrical equipment and wiring in a gas mixing machine room shall be installed in accordance with National Electrical Code for hazardous locations. When such machines are installed in well ventilated manufacturing areas, the type of electric equipment should be governed by other conditions in the area. Ordinarily, in the vicinity of gas fired ovens, explosion proof or enclosed equipment would not be used.

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

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

3163. Explosive Mixtures (within flammability limits). Gas mixing machines supplying gas-air mixtures within the explosive range shall be installed in accordance with Sect. 3162 b, c, d and e, and the following paragraphs shall also apply.

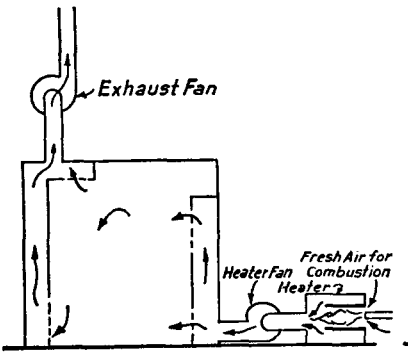
(a) Flame arresters—Flame arresters approved for use with gas mixtures shall be installed close to the burner or burners and/or in the discharge pipe between the machine and the nearest burner and as close to the machine as practicable.

Exception: The mixing device described under 3155 Exception, may be installed without flame arresters at burners when this mixing device is used in connection with blast tip burners particularly designed for it, and when the installation meets the requirements of 3155.

(b) The flame arrester shall effectively prevent propagation of flame in the piping and should be so constructed that gas flow will be shut off if the mixture continues to burn at the arrester. This may be accomplished by a fusible link or thermostatic bimetal element at the outlet of the arrester controlling a valve at the inlet which closes when the link fuses or by arranging a bursting disc at the arrester outlet which is arranged so that an inlet valve closes when the disc is ruptured. When bursting disc type is used, it shall be placed outdoors or blowout vent piped outdoors except in a very large manufacturing area.

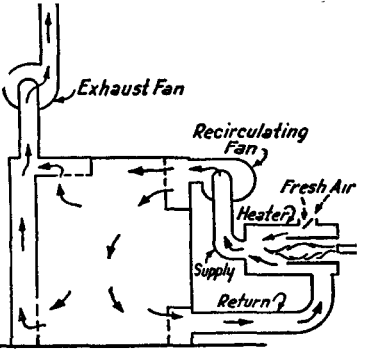
(c) Burners used with explosive mixtures shall be designed with port areas and length of gas passage through each port such that the possibility of backfire is largely eliminated. When necessary to secure stability of operation, water cooled burners may be used, the water discharging through an open cup located where it will be plainly visible.

3164. Controls for gas mixing machines shall include interlocks and safety shutoff valve of the manually opening automatic closing type in the gas



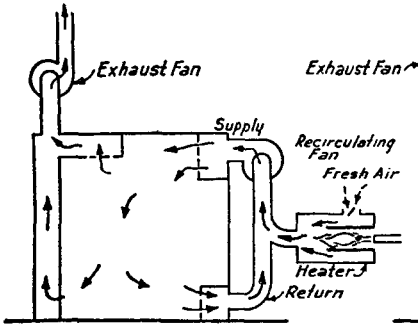
Direct Fired External Non-Recirculating.

Fig. 6



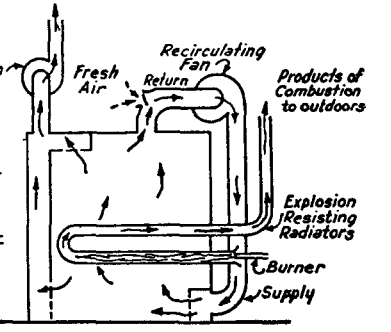
Direct Fired External Recirculating.

Fig. 7



Direct Fired External Non-Recirculating Through Heater.

Fig. 8



Indirect Fired Internal Explosion Resisting.

Fig. 9

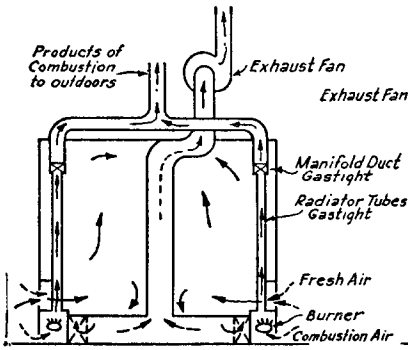
supply connection to each machine arranged to automatically shut-off the gas supply in event of air and/or gas supply failures. Where compressor or blower is used, it should be interlocked where practical so that the blower will stop operating following a gas supply failure. (See Article 520.)

3170. Oven Heaters.

3171. General. Oven heaters are of two general types, direct fired and indirect fired. With direct fired heaters, the products of combustion enter the oven chamber and come in contact with work in process.

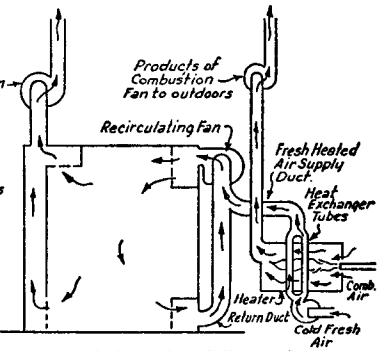
Indirect fired oven heaters are so arranged that the products of combustion do not enter the oven chamber, heating being accomplished by radiation from tubes or by passing air over heating tubes and then into the oven.

There are certain advantages and disadvantages with each type. However, from the safety standpoint, dangerous accumulations of fuel-air mixture



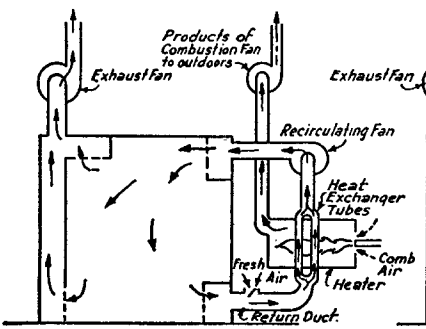
Indirect Fired Internal Non-Explosion-Resisting.

Fig. 10



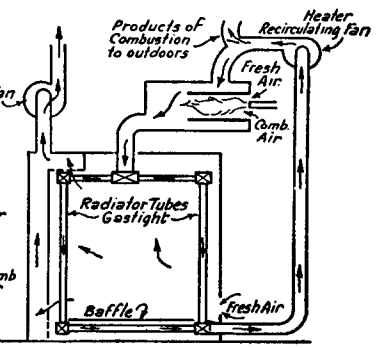
Indirect Fired External Non-Recirculating Through Heater.

Fig. 11



Indirect Fired External Recirculating.

Fig. 12



Indirect Fired External Internal Radiator.

Fig. 13

cannot readily fill the oven work space where indirect type heaters are used. On the other hand, it will usually be found that the direct type is reasonably safe when constructed in accordance with these regulations.

3172. Direct Fired Internal Heater shall mean any oven heating system in which the burners are within the oven chamber and in contact with the oven atmosphere. Such a system may have multiple burners.

3173. Direct Fired External Heater shall mean any oven heating system in which the burners are in a combustion chamber effectively separated from the oven chamber and so arranged that products of combustion from the burners are discharged into the oven chamber by a circulating fan or blower. There are two classes of these heaters as follows:

(a) Direct fired external non-recirculating heater shall mean any direct fired external heater so arranged that products of combustion without any return or recirculation from the oven chamber are discharged into the oven chamber. Fig. 6.

(b) Direct fired external recirculating heater shall mean a direct fired external heater so arranged that oven atmosphere is recirculated to the oven heater and in contact with the burner flame. Fig. 7.

NOTE 1: A heating system so constructed that the oven atmosphere circulates through a blower with products of combustion admitted to the recirculating duct work but without the oven atmosphere actually passing through the combustion chamber shall be designated as "direct fired external, non-circulating through heater," Fig. 8.

NOTE 2: A combustion chamber of a recirculating oven heater may be built within an oven chamber but substantially separated from the oven atmosphere by gas tight construction. This type of heater shall be classed as direct fired external and may be either non-recirculating or recirculating.

Attention is called to some advantages of direct fired external heaters either recirculated or non-recirculated for ovens which are to be direct fired because of the use of a single burner for each heater.

This type of operation permits the installation of a single combustion safeguard for each heater, usually a less complicated and less expensive installation than can be secured in any design using multiple burners particularly those designs making use of multiple line burners where it is not ordinarily possible to secure ignition over the entire length of each burner by reliable automatic controls.

In general, any design which makes use of the smallest possible number of burners is preferred to multiple burner installations.

3174. Indirect Fired Internal Heater shall mean a heating system of gastight radiators containing gas burners not in contact with the oven atmosphere. These systems may be of two types as follows:

(a) Explosion resisting shall mean an indirect fired internal heater so constructed as to withstand explosion pressure from ignition of a gas-air mixture in the radiators, Fig. 9.

(b) Non-explosion resisting shall mean an indirect fired internal heater with gastight radiators, which however, are not designed to withstand an internal explosion, Fig. 10.

(c) Radiation surfaces shall be guarded to prevent their coming dangerously close to or in contact with combustible material in the oven.

(d) Prime radiation surface shall be ample in area to be at all times

at temperatures below color visible heat (in sheet steel the temperatures indicated are of the order of 875°F.).

3175. Indirect Fired, External Heater shall mean an oven heater in which burners and combustion chamber are outside of the oven chamber and the oven atmosphere is kept separate from combustion gases. These heaters may be of three types as follows:

(a) Indirect fired, external heater, non-recirculating, in which air is drawn or blown through the radiator of a heater without any recirculation of the oven atmosphere through the heater, Fig. 11.

(b) Indirect fired, external heater, recirculating, in which oven atmosphere is recirculated through radiators outside the oven chamber, Fig. 12.

(c) Indirect fired, external heater, internal radiator, in which products of combustion from a heater located outside the oven chamber are circulated through radiator tubes located within the oven, Fig. 13.

Heaters of these types are well adapted to low temperature drying operations and practically eliminate the possibility of explosion in the oven or dryer from fuel gases, but do not in any way reduce the possibility of explosion from vapors given off by the work being dried.

3176. Construction. (a) Gas fired heaters 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.

(b) Where refractory materials are used, they shall be supported so that there is little likelihood of refractories falling out of place. The construction should provide for quick and simple replacement of refractories.

(c) Where "gastight" construction is indicated, tests of the completed assembly shall be made with air at a pressure of at least one pound per square inch, and examined for leaks with soap solution at least annually. The heater design shall facilitate testing.

(d) Where "explosion resisting" construction is indicated, a sample heater or radiator tube and/or other parts of the assembly intended to withstand internal explosion shall be subjected to test by igniting a gas-air mixture of manufactured gas and air in the optimum proportions for maximum explosion pressure, within the sample assembly which shall show no distortion or leakage after the test except for the bursting of relief discs or explosion panels.

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

(f) 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.

Exception: If it is not possible to locate manual valves operated for starting and shutdown at convenient height, steps shall be provided.

(g) Gas fired heaters shall not be located directly under the product being heated where combustible materials may drop and accumulate. Neither shall they be located directly over readily ignited materials such as cotton unless for controlled exposure time, as in continuous processes where further automatic provisions and/or arrangement of guard baffles preclude the possibility of ignition. Parts of oven heaters which operate at temperatures in excess of 140°F. shall be so guarded by location, guard rails, shields or insulation as to prevent accidental contact with personnel. All parts of equipment operating at elevated temperatures shall be installed in accordance with Section 2040 Clearances.

(h) Bursting discs or panels, mixer openings or other parts of the heater from which flame or hot gases may be discharged shall be so located or guarded as to prevent injury to personnel.

(i) Indirect heaters which require draft for satisfactory burner operation shall be reliably vented so that products of combustion are discharged to a safe location, preferably outdoors.

ARTICLE 320. OIL FIRED HEATING SYSTEMS.

3201. Scope. This section includes oven heating systems fired with fuel oil and the oil burning portions of combination systems of oil and other fuels. When convertible heaters are used, this section shall apply to such heaters when oil fuel is being used.

3210. Fuel Oil.

3211. The definition of fuel oil shall be that contained in NFPA Standards for Oil Burning Equipments (No. 31) and which is here quoted:

"Fuel Oil" shall mean any hydrocarbon oil as specified by U. S. Department of Commerce Commercial Standard CS12 or A.S.T.M. D396.

3220. Fuel Supply.

3221. The installation of fuel storage tanks, piping and valves shall be in accordance with the NFPA Standards for the Installation of Oil Burning Equipments (No. 31) (published by NFPA in the National Fire Codes, Vol. I; by the National Board of Fire Underwriters in Pamphlet 31).

3230. Oil Burners.

3231. (a) Oil burners for use with oven heating systems shall be arranged for "full automatic" operation. Oven burners cannot ordinarily be operated under constant attention of a qualified operator, thus more than usual dependence must be placed on automatic safety controls. Only the most reliable burner types and control devices should be selected for oven work and shall be acceptable to the authority having jurisdiction. See Section 5032 (c).

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

3232. Oil burners shall be of a proper type and 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 ignition in their order of preference for safety are gas pilots, electric ignition and manual ignition. See Section 5605.

(c) Oil Burner Types:

1. Air or steam 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 is forced through small orifices.
4. Vapor; oil vaporized by heat.
5. Combination—gas and oil burners.

This unit should 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.

3233. Oil Burner Controls. See Chapter 5.

3240. Oven Heaters.

3241. Oven heaters are of two general types, direct fired and indirect fired. With direct fired heaters, the products of combustion enter the oven chamber and come in contact with the work in process. Indirect fired oven heaters are so arranged that the products of combustion do not enter the oven chamber, heating being accomplished by radiation from tubes or by passing air over heating tubes and then into the oven.

Direct firing has certain disadvantages with oil fuel, as carbon and other undesirable products of incomplete combustion may be carried into the oven. Where this is not objectionable, direct fired ovens may be used.

3242. Definitions. For the purpose of these standards, the general types of oven heating systems are defined as outlined in Sections 3172, 3173, 3174 and 3175.

3243. Construction. The construction of oil fired heaters should be in accordance with Sections 3171 and 3176.

ARTICLE 330. ELECTRIC HEATING SYSTEMS.

3301. Scope. This section includes all types of heating systems where electrical energy is used as the source of heat.

3302. Definitions. The following definitions apply to the several types of electrical heating systems included under Article 330.

(a) Resistance heater—Any electric heater consisting of an electrical resistance through which current flows. Resistance heaters may be of "open" type with bare heater wires or elements or "insulated sheath" type with element covered by a protecting sheath which may be filled with electrical insulating material.

(b) Infrared lamp heater—A form of resistance heater in which the resistance elements are enclosed in glass bulbs similar to ordinary electric light bulbs and operate at incandescent heat.

(c) Induction heater—A heating system in which a coil surrounds the work passing through the oven. Alternating current applied to the coil causes electric current to flow in the work itself resulting in an increase in temperature of the work going through the oven.

3303. Control Equipment. For control equipment requirements, including air flow interlocks, time relays and temperature switches see Chapter 5.

3304. Electrical Installation. All parts of the electrical installation shall be in accordance with the National Electrical Code and as described here-

after. All electrical installations in areas or locations hereafter defined as "hazardous" shall be in accordance with Article 500 of the National Electrical Code, Class I, Group D, except where other specific classification is made.

NOTE: The use of an electric heating system in a Class A oven does not indicate that the interior of the oven is to be considered as a "hazardous" area in relation to the National Electrical Code unless materials within the oven are hazardous or special conditions outside of the oven itself may make the area "hazardous."

3310. Resistance Heating Systems.

3311. General. The following paragraphs apply to resistance heating systems including those of the infrared lamp type. Resistance heaters of either the insulated sheath or open ribbon type are to be preferred over the infrared lamp heater type from the standpoint of their ability to withstand water discharge from automatic sprinklers without damage. Resistance heating systems are suitable for Class A ovens but as the surfaces of all types of resistance heaters operate above ignition temperatures of most finishing materials, the fire and flammable vapor hazards are comparable to that of direct fuel fired heating systems.

3312. Enclosure. (a) When used with flammable vapors, electric heating systems should be employed in conjunction with an enclosed oven.

The use of so called "oven-less" or unenclosed systems employing glass bulbs or infrared heaters without an oven structure is not advised as the flammable and toxic vapors may escape into the room, and should be used only with adequate ventilation or in very large rooms. Ventilation safeguards can be more readily applied when an oven enclosure is used.

(b) All parts of heaters operating within an oven at elevated temperatures and all energized parts shall be protected to prevent contact by persons and also to prevent accidental contact by work in process or metal objects as by drippage from work going through the oven.

(c) External electric heating systems shall have the electric elements encased in a sufficiently insulated chamber to prevent injury to personnel and property.

(d) The heater housing shall be so constructed as to provide easy accessibility to heating elements and wiring.

(e) Heating elements shall be fastened securely to a substantial supporting frame.

3313. Heater Locations. (a) Heaters shall not be located directly under the product being heated where combustible materials may drop and accumulate. Neither shall they be located directly over readily ignited materials, such as cotton, unless for controlled exposure time, as in continuous processes, where further automatic provisions and/or arrangement of guard baffles preclude the possibility of ignition. Heaters shall not be located over dip tanks.

(b) When infrared lamp heaters are used as above, they should be located behind a suitable protective barrier (such as heat resisting plate glass) but only if the barrier does not interfere with safety ventilation and is located where it will not become contaminated with accumulations of lint, residue, or combustible materials.

(c) Parts of oven heaters, which operate at temperatures in excess of 140°F., or which are energized at potentials in excess of 20 volts, shall be so guarded by location or enclosure as to prevent accidental contact with personnel.

3314. Construction. (a) Resistance heaters of all types shall be substantially constructed to resist damage from falling work, trucking or other mechanical hazards inherent in industrial use.

(b) Where refractory materials or insulators are used, they shall be supported so that there is little likelihood of their falling out of place. The construction shall provide for quick and simple replacement of refractories.

(c) Corrosion resistance—Where subject to corrosion, metal parts shall be adequately 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 Section 2040 Floors and Clearances.

3315. Controls for Resistance Heaters. Refer to Chapter 5.

3320. Induction Heating System.

3321. General. High Frequency Heating Systems should be referred for approval to the authority having jurisdiction.

3322. Controls for Induction Heating Systems should be as called for in Chapter 5, Article 570, as they may apply.

ARTICLE 340. STEAM HEATING SYSTEMS.

3401. Scope. This section includes all types of heating systems where steam is used as the source of heat and refers specifically to the steam heat exchangers, which are usually supplied from a central steam generating source.

NOTE: The construction and controls for steam boilers are covered by ASME Rules for the Installation of Heating Furnaces, Boilers and Fire Boxes of Power Boilers, and by any applicable local or state regulations. Burners and controls for boilers using gas, oil or pulverized coal are covered by NFPA Standards for Oil Burning Equipments (No. 31), and Pulverized Coal (No. 60A), published by the NFPA in the National Fire Codes, Vols. I and II and by the National Board of Fire Underwriters in Pamphlets 31 and 60; also by any applicable requirements of the authority having jurisdiction.

3402. Construction. (a) Piping and fittings associated with steam heat exchangers shall be in accordance with the American Standard Code for Pressure Piping, ASA B-31.1 or the latest revision thereof. Suitable relief valves should be provided where needed in the system.

(b) Enclosures or duct work for steam heat head exchanger coils shall be of noncombustible construction with suitable access openings provided for maintenance and cleaning.

(c) Steam heat exchangers or steam coils shall not be located on the floor of an oven or in any position where paint drippage or combustible material can accumulate on the coils.

3403. Controls. Refer to Chapter 5 for control equipment and application to steam heating systems.

3404. General. (a) To avoid abnormally high temperature at coil surfaces, steam pressure in heat exchanger coils should be maintained at the minimum pressure necessary to provide the required drying temperature. This is usually accomplished by an automatic pressure regulating device.

(b) Recirculation directly over the heat exchanger coils shall not be used if lint or other light combustibles may be carried back to and deposited on the steam radiator surfaces unless properly filtered.

CHAPTER 4. VENTILATION.

ARTICLE 400. GENERAL.

4001. The proper ventilation of ovens is of prime importance. Proper ventilation within the scope of this chapter means a sufficient supply of fresh air and proper exhaust to outdoors with a sufficiently vigorous and properly distributed air circulation to insure that the flammable vapor concentration in all parts of the oven or dryer enclosure shall be safely below the lower explosive limit at all times. This chapter does not apply to ovens operating in conjunction with solvent recovery systems.

4002. The basis for the determination of the fresh air for safe ventilation shall be the amount of vapor produced by the flammable solvent used on the work in process. The design of any given oven ventilation system requires due consideration of:

(a) Type of oven
(b) Materials to be processed
(c) Work to be performed on these materials
(d) Method of heating and fuel to be used

4003. (a) Careful consideration shall be given to the safe removal, dilution, or other disposal of flammable vapors or vapor air mixtures. To do this, all necessary consideration shall be given to temperatures of operation, periods of dripping and predrying, speed of conveyor travel, safe disposal of flammable drippings, safe escape of flammable vapors or gases, safe control of combustion and the safety of chains, carrier belts, hoods, racks and carts.

(b) The consideration of all of these factors and their evaluation, the selection of the equipment and its design including arrangement to safely meet all requirements of safe operation, and adequate ventilation, should be done by a qualified person familiar with oven design and basic rules of safety.

4004. In general, the need for and type of ventilation required for safety in ovens covered by these standards is as follows:

(a) Ovens in which flammable or toxic vapors are liberated must be mechanically ventilated to outdoor atmosphere regardless of the type of heating equipment employed.

(b) Ovens heated by direct fired gas or oil heaters shall be mechanically ventilated to outdoor atmosphere to safely dispose of the products of combustion even though the process does not produce flammable or toxic vapors.

Exception: Ovens with 64 cu. ft. volume or less need not be equipped with mechanical exhaust except where it is known that the products or materials processed in the oven give off flammable vapors or toxic fumes.

(c) Ovens using steam or electrical energy for heat, or gas or oil fired indirect heating equipment, and which do not at any time liberate combustible or injurious (toxic) fumes, do not require fresh air ventilation for safety. Also, such ovens may be arranged to recirculate any portion of the air supplied. (See Section 3170.)

4005. General Basic Requirements for Oven Ventilating Systems Handling Flammable or Toxic Vapors are as follows:

(a) Exhaust duct openings shall be located in the area of greatest concentration of vapors.

(b) Exhaust duct openings should be so placed and sized that they will gather and discharge vapors to outdoor atmosphere as directly as practical.

(c) All exhaust shall be by mechanical means, using power driven fans.

(d) Each oven should be equipped with individual exhaust systems not connected to exhausts serving other equipments. Ovens which are divided into several small compartments, or groups of small individual ovens, may be exhausted by a common exhaust fan provided the fumes exhausted from the several compartments do not, when mixed, cause a more hazardous condition than if exhausted individually and subject to the approval of the authority having jurisdiction.

(e) Ovens in which the temperature is controlled by dampers (manual or automatic) which affect the volume of hot air admitted to the oven, must be so designed that a reduction in the volume of hot air supplied does not result in a reduction of the volume of fresh air supplied to meet the requirements for safe ventilation.

(f) It is recommended that a separate draft fan, not connected with the oven ventilation, be used for exhausting the products of combustion from indirect gas or oil fired air heaters.

(g) On small installations subject to the approval of the authority having jurisdiction, it may be permissible to connect the draft flue to the oven exhaust system, provided that:

The temperature of the products of combustion shall be reduced (if necessary) by the addition of fresh air to a point where it will prevent ignition of any combustible fumes in the oven exhaust system.

(h) Air supplied into the oven shall be circulated to produce a thorough distribution and movement in all parts of the oven and through the work in process.

(i) The temperature of the air contacting the work in the oven shall not be higher than that to which the material in process can be safely subjected.

4006. The ventilation of the oven and heating equipment shall be assured as follows:

(a) INTERLOCKS. (See Art. 510, also 560.)

1. Mechanical interlocking actuated by devices such as air flow or pressure switches, centrifugal switches actuated by the fan shaft.
2. Electrical interlocks obtained through interconnection in a motor starter by use of a relay or transformer.

(b) FRESH AIR SUPPLY.

1. All ovens in which flammable vapors are being liberated shall be assured of receiving the full required amount of fresh air for safe dilution of vapors. (See Articles 410 and 420.)
2. All ovens heated by electric resistance heaters or by combustion of any fuel shall have the air supply fans electrically or mechanically

interlocked in such a manner as to prevent operation of the heating units unless the air supply fans are running.

3. Dampers affecting the quantity of fresh air intake to the oven shall be reduced in size to pass the required amount of fresh air when in a closed position.

(c) EXHAUST.

1. Ovens in which flammable vapors are being produced or into which the products of combustion of fuels are permitted to enter, shall be assured of having the required amount of exhaust for safe ventilation. (See Articles 410 and 420.)
2. Ovens heated by electric heaters or infrared lamps or by combustion of any fuel shall have the exhaust fans electrically and mechanically interlocked in such a manner as to prevent operation of the heating units unless the exhaust fans are running.
3. Dampers affecting the quantity of exhaust air shall be reduced in size to pass the required amount of exhaust air when in a closed position.

(d) PURGING INTERVAL. Purging cycle or preventilation shall be in accordance with Article 560.

4010. Forced Ventilation.

4011. The following ventilation requirements are entirely independent of and in addition to (a) recirculation within the oven enclosure, (b) exhaust for removal of products of combustion in an indirect heating system.

4012. Mechanical means for reliable and adequate ventilation of ovens shall be provided except as specified in Section 4013.

On completion of an oven installation it is recommended that air-flow tests be conducted on the ventilation systems under operating conditions of oven in balanced condition and adjustable dampers at minimum opening, and that tests of safety devices be made to assure proper ventilation and operation of the system. These tests should be repeated periodically. It is further recommended that the user make arrangements to have these tests conducted by qualified personnel if not equipped to do so himself.

4013. Natural Ventilation shall not be used on Class A ovens where flammable volatiles or toxic fumes are given off from the work in process. However, subject to the approval of the authority having jurisdiction, natural ventilation may be used in ovens having only the fuel hazard; provided the burner-mixer design is such that all air necessary for complete combustion of the fuel is reliably obtained by means independent from and not adversely affected by the natural draft.

4014. Temperature Corrections. Temperature conversion factors shall be taken into consideration in the application of the following rules since the volume of a gas varies in direct proportion to its absolute temperature (0°F. equivalent to 460° absolute).

For example, in order to draw 9,200 c.f.m. of fresh air referred to 70°F. (530° absolute) into an oven operating at 300°F. (760° absolute), it is necessary to exhaust 760/530 x 9,200 or 13,150 c.f.m. of 300°F. air.

For convenience, temperature conversion factors are listed in the following table:

TABLE II.

TEMPERATURE-VOLUME CONVERSION TABLE.

Temp.	Factor	Temp.	Factor	Temp.	Factor
100°	1.06	175°	1.20	350°	1.53
110	1.075	200	1.24	400	1.62
120	1.09	225	1.29	450	1.72
130	1.11	250	1.34	500	1.81
140	1.13	275	1.38	550	1.90
150	1.15	300	1.43	600	2.00

4015 Dilution of Vapors. Ventilation shall be arranged in an oven enclosure in such a way that there are no zones in which circulation does not take place. In compliance with this rule, due consideration shall be given to the proportioning of fresh air and recirculated air inlets and exhaust outlets in such a way that maximum dilution is obtained at points of maximum solvent evaporation, and also to the specific gravity of the solvent vapor and fuel gas.

The vapors of all volatile solvents and thinners commonly used in finishing materials are heavier than air, consequently bottom ventilation is of prime importance. Fuel gases are generally lighter than air and liquefied petroleum gases are heavier than air.

4016. Air Drying or Dripping. In areas where volatiles are given off by material prior to entering oven, adequate provisions should be made to exhaust vapors to the atmosphere.

ARTICLE 410. CONTINUOUS PROCESS OVEN.

4101. Calculated Rate of Ventilation. When an oven is designed to operate with a particular solvent and where ventilating air may be accurately controlled, the following formula may be used:

$$\text{Required ventilation} = \frac{444 \times \text{Sp.Gr.} \times (100 - \text{L.E.L.})}{\text{V.D.} \times \text{L.E.L.}} \text{ cu. ft. of air referred}$$

to 70°F. per gallon of solvent evaporated, where:

Sp.Gr. = Specific gravity of solvent (water = 1).
V.D. = Vapor density of solvent vapor (air = 1).
L.E.L. = Lower explosive limit expressed in per cent by volume. (For example, L.E.L. of gasoline written 1.3, not .013.)

The derivation of the above formula is as follows:

$$\text{One gallon of solvent produces } \frac{8.33 \times \text{Sp.Gr.}}{.075 \times \text{V.D.}} \text{ cu. ft. of flammable vapor}$$

where:
8.33 = Weight of one gallon of water in lbs.
.075 = Weight of 1 cu. ft. of air in lbs.

The volume of air required to render this amount of vapor barely explosive is $\frac{(100 - \text{L.E.L.})}{\text{L.E.L.}}$ x this figure, or 1 gallon of solvent will form $\frac{8.33 \times \text{Sp.Gr.} \times (100 - \text{L.E.L.})}{0.075 \times \text{V.D.} \times \text{L.E.L.}}$ cu. ft. of the barely explosive mixture.

Providing a factor of safety of 4 (maintaining an average concentration of 25% of the lower limit) then the equation becomes

$$4 \times \frac{8.33 \times \text{Sp.Gr.} \times (100 - \text{L.E.L.})}{.075 \times \text{V.D.} \times \text{L.E.L.}} \quad \text{or} \quad \frac{444 \times \text{Sp.Gr.} \times (100 - \text{L.E.L.})}{\text{V.D.} \times \text{L.E.L.}}$$

A convenient listing of the properties and approximate volumes of air required to render one gallon of common solvents barely explosive appear in data tables found in Appendix C.

4102. Estimated Rate of Ventilation (Alternate Method). In continuous process ovens the rate of safety ventilation shall not be less than 10,000 cu. ft. of fresh air referred to 70°F. per gallon of solvent evaporated in the oven except as permitted in Section 4101.

The basis for the above general rule is that one gallon of common solvent produces a quantity of flammable vapor which will diffuse in air to form roughly 2,500 cu. ft. of the leanest explosive mixture. (See calculation Section 4101.)

Since a considerable portion of the ventilating air may pass through the oven without completely traversing the zone in which vapors are given off and on account of a possible lack of uniform distribution of the ventilation air, and also to provide a margin of safety, four times this amount of air, or 10,000 cu. ft. (referred to 70°F.), for each gallon of solvent evaporated should be allowed.

Warning: It should be noted that with certain solvents, where the volume of air rendered barely explosive exceeds 2,500 cu. ft. (Column J, Appendix C) the factor of safety decreases in proportion.

4103. Extensive tests have been conducted by the Underwriters' Laboratories to obtain data as to the effect of elevated temperatures on the L.E.L. of many of the solvents commonly used in connection with ovens. These tests show that the L.E.L. of all solvents tested decreases as the temperature increases, the conclusion being that more air (referred to 70°F.) is required for safety per gallon of solvent as the oven temperature increases. The actual figures vary considerably with different solvents, but for the sake of simplicity the following rule shall apply:

(a) Volumes of air specified or calculated as per section 4101, corrected for operating temperature, shall apply for oven temperatures up to 250°F. For temperatures from 250°F. to 500°F., increase the volume by a multiplier of 1.4. See Appendix A.

ARTICLE 420. BATCH PROCESS OVEN.

4201. Rate of Ventilation.

(a) COATED METAL.

Industrial experience indicates that the nature of the work being baked is the main factor in determining the ventilation rate. Different types of work produce different evaporation rates while baking and field tests show that sheet metal or metal parts coated by dipping produces the highest evaporation rates ordinarily encountered. Tests and years of experience have shown that 380 cu. ft. per minute referred to 70°F. of ventilation, per gallon of flammable volatiles in the batch, is reasonably safe for dipped metal.

NOTE: Tests of dipped sheet metal in batch process ovens show that in typical one hour bakes practically all the solvent is evaporated in the first twenty minutes. Further, the peak evaporation rate occurring from four to eight minutes after loading is about three times the twenty minute average. With one gallon of solvent in the batch, the twenty-minute average evaporation rate is 1/20 gpm. and the peak rate three times this or 3/20 gpm. Using one gallon of solvent whose vapor requires approximately 2,500 cubic feet of air referred to 70°F. to barely keep the mixture below the lower explosive limit, the rate of ventilation required in order to be safe under the worst conditions would be 3/20 x 2,500 or approximately 380 cfm. referred to 70°F.

(b) OTHER TYPES OF WORK.

For other types of work, the figure of 380 cfm. referred to 70°F. should be used unless the required ventilation rates can be calculated on the basis of reliable previous experience or the maximum evaporation rate determined in tests run under actual oven operating conditions. It is recommended that on the basis of the maximum evaporation rate determined by test, sufficient ventilation be furnished to prevent the vapor concentration in the oven exceeding ¼ of that required to produce a lower explosive limit mixture.

(c) ALTERNATE ESTIMATION OF VENTILATION—ALL TYPES OF WORK.

If the maximum number of gallons evaporated during any one hour of the total heating period is known, this figure may be used to estimate the required amount of ventilation as follows: The required amount in cubic feet per minute referred to 70°F. is equal to the gallons of solvent evaporated during the maximum hour multiplied by the volume of air (referred to 70°F.) computed as rendered flammable at the lower explosive limit (per formula section 4101) then multiply by an empirical factor of 10 and divide by 60.

Warning: Use caution in applying this estimating method to work of low mass which will heat up quickly (such as paper, textiles), or work coated with materials containing highly volatile solvents. Either condition may give too high a peak evaporation rate for the estimating method.

(d) Where data mentioned above in (b) and (c) is not obtainable, consult with the authority having jurisdiction.

4202. See Section 4103, which shall apply to all batch ovens.

ARTICLE 430. FIXTURES AND EQUIPMENT.

4301. Damper Control. If electrically or mechanically controlled dampers are used, limit switches should be utilized to assure proper position of the dampers, including those used as gas barriers on Carbon Dioxide extinguishing systems. See Section 2201 (l).

4302. Fans. To assure uninterrupted dependable ventilation, all fans in an oven ventilating system should be directly connected to the motor. Any fan not directly connected to the motor shall be multiple V-belt driven, suitably interlocked as described in Chapter 5.

4303. Location of Motors. Motors shall not be located inside ovens or exhaust ducts.

4304. Cleaning of Ducts. Vent ducts should have ample hand-holes for clean-out purposes and should preferably be installed in flanged sections to facilitate removal for cleaning.

4305. Guards. All moving parts shall be guarded from mechanical accidents or possibility of causing personal injury.

CHAPTER 5. SAFETY CONTROL EQUIPMENT.

ARTICLE 500. GENERAL.

5001. General Discussion of Hazards. (a) For safety of personnel and for protection against fire or explosion, careful consideration shall be given to the hazards peculiar to each individual project. This consideration of safety shall include exposures offered by the oven, its means of heat transfer and sources of heat, supplementary apparatus, such as spray booths, also dip tanks; the mixing, transferring, or storage of flammable materials; or auxiliary operations such as impregnating, surfacing, coating, rustproofing, washing, or combining by the use of adhesives. It is essential that all ovens or dryers processing flammable materials, or those involving flammable vapors or heated with combustible fuels, be provided with adequate safety devices. These devices must assure protection against the possibility of hazards developing into fires or explosions.

(b) Suitable equipment must be used which will insure sufficient preventilation and adequate ventilation during operation. Also, there *must* be constant supervision over all operating conditions that might otherwise become unsafe.

It has been said that the best safety apparatus is a safety minded man. However true this statement is, no man can substitute manual performance for the necessary constant unremitting attention which carefully chosen automatic safety apparatus will provide. Proper maintenance of instrumentation is also an important requisite in this regard.

The supreme test of safety apparatus, when used in a properly coordinated assembly, is that it fails safe in the event of the interruption of the safety sequence or the development of unsafe conditions of operation.

Partial protection might be, and in many cases is, much more dangerous than no protective equipment at all. Insufficient, ill chosen, or improperly installed or maintained safety control equipment may cause operators to lapse into carelessness by supposed safety not actually present.

The type of apparatus selected to attain the degree of safety required by the authority having jurisdiction is based upon choice from those available.

5002. Definition of Safety Control. Safety controls should be understood to mean automatic supervising devices sufficient in number, substantially constructed, and so arranged that they will maintain the required conditions

of safety for the purpose of preventing the development of any fire and explosion hazard.

5010. Flammable Vapor Hazard—General Case.

5011. If flammable vapors are permitted to accumulate within an oven enclosure, their concentration may come within the explosive range; experience has shown that such an accumulation in the presence of an ignition source may be ignited and exploded or result in a serious fire.

5012. A careful study of industrial heating equipment shows that it is unwise to depend for safety upon elimination of ignition sources. Therefore, the only reasonable solution is to introduce a sufficient quantity of fresh air ventilation into the oven so as to dilute any possible flammable vapor-air mixture to a safe concentration below the lower explosion limit. The recommended amounts of ventilation for conveyor and batch type ovens are given in Chapter 4. In general, it is essential for safety, that the proper amount of ventilation be applied in ovens evaporating flammable volatiles as follows:

(a) Reliable ventilation shall be continuously provided while the oven is in operation and flammable vapors given off.

(b) Failure of any ventilation fan shall automatically shut down the heating system and stop the conveyor.

(c) Means for oven preventilation shall be provided before the heating system (which may originate ignition), can be started in order to dissipate any accumulated vapors due to a work charge left in an unventilated oven, either accidentally following safety ventilation failure or intentionally following normal shut down, or due to leakage of fuel during shut down.

5013. Control devices and application for accomplishing the foregoing are described in Article 510, Ventilation Controls, and in Article 560, Application of Safety Controls.

5020. Fuel Hazard—General Case.

5021. To minimize the fire and explosion hazard from fuel gas or fuel oil, it is essential to avoid dangerous accumulation of unburned or incompletely burned fuel in a heater or oven; such vapors or gases may mix with air and become diluted to within the explosive range.

5030. Discussion of Fuel Hazards.

In order to cope with the fuel hazard, it is necessary to recognize three different conditions when operating a fuel gas or fuel oil burner:

5031. 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.

5032. Firing. (a) Safety requires continuous ignition and complete burning of the fuel before it passes beyond its normal combustion zone at the burner. To maintain this safe condition of a stable flame with complete combustion, 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 blow-off 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. For each different fuel used, there is only one fuel-air ratio for perfect combustion and maximum efficiency. Deviation from this "perfect" or "complete" fuel air ratio, through 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, this results in an overrich mixture and incomplete combustion. The resultant *flammable* incomplete products of combustion after 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 oven or recirculating duct work 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, and to require manual reset.

(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.

5033. Shutting Down. A dangerous accumulation of unburned fuel may occur in an oven and heating system following a shut down if any manual fuel valves are left open or leaking and/or safety shut-off valves are not tight closing. Subsequent ignition by hot refractory or ignition source when starting up may produce an explosion.

5040. Protection Relating to Fuel Hazards.

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

5041. Lighting Off. (a) First check all fuel valves for closure before any main valve is opened; and second, to remove any possible accumulation of fuel leakage during shut-down, preventilate oven and heater before introducing an ignition source. (See Sections 5250, 5613, 5623 exception e.)

(b) Provide reliable ignition source before main burner fuel can be turned on and keep ignition source in place until stable flame is obtained over the entire burner.

(c) Before fuel can be turned on, make certain proper fuel supply pressure and air necessary for reliable and efficient combustion is present.

5042. Firing. (a) In event of flame failure, fuel must be shut off immediately. Where applicable, flame-failure combustion safeguards should be used to provide automatic fuel shut off on flame failure.

(b) Relighting after flame failure, provided fans continue in operation, should be as outlined under Sections 5041 and 5614 (b).

(c) In event of excess oven or heater temperature, the main burner fuel shall be shut off with manual restart required.

5043. Shutting Down. (a) All fuel valves, including individual burner cocks, shall be closed.

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

ARTICLE 510. VENTILATION CONTROLS.

5101. Ventilation Controls are devices such as air flow switches, pressure switches, and time delay relays which are placed in the safety control arrangement in order to insure required ventilation of the system prior to ignition of burners and during their operation. Only devices of recognized manufacturers, with proven field experience, and acceptable to the authority having jurisdiction should be used.

5102. Air Flow Switches are devices actuated by the flow of air in a duct system. Air flow switches installed in ducts handling vapor-laden air shall be located on the suction side of fans to minimize condensed deposit on moving parts.

(a) Vane type air flow switches consist of a vane or paddle mounted on a movable arm. The vane is so located that a differential pressure or air flow against the vane will cause the vane arm assembly to move and actuate a switch contact.

(b) Diaphragm type air flow switches consist generally of a diaphragm with one side open to room pressure and the other connected to the exhaust or ventilation duct. Movement of the diaphragm by a pressure differential will actuate a switch contact.

5103. Rotational Switches for ventilation interlocking are devices which are usually driven directly by the fan wheel or fan motor shafts. When the speed of the fan shaft or drive motor reaches a certain predetermined rate—which will give a safe minimum air flow—a switch contact will close.

5104. Limit Switches for use on oven doors or ventilation system dampers, consist basically of a lever and suitable connecting mechanism to a switch contact. By swinging the door or damper to a predetermined position, usually wide open, where it moves the lever, the switch contact is made. Limit switches are used mostly for safe lighting-off sequence to insure the doors or dampers will be wide open or positioned for preventilation before electric-ignition or fuel will be made available for lighting up burners, or power is available for energizing electric heaters.

5105. Electrical Ventilation Interlocking means a fan that is motor driven by direct shaft or at least two Vee belts, is interlocked with the safety control circuit, by energizing the circuit from the load side of an overcurrent-protected starter for the fan motor, through an extra contact of the starter, a suitable relay or transformer.

5110. Preventilation Time Delay Relay.

5111. A time delay relay for preventilation consists of a switch which is closed automatically after a preset time interval usually measured by a timing device. Such a relay should be arranged to reset instantly to the starting position when the current supply is interrupted.

ARTICLE 520. FUEL SAFETY CONTROLS.

5201. These are devices such as safety shut off valves, combustion (flame failure) safeguards and pressure switches. These are suitably interlocked and arranged in control circuits to minimize the possibility of dangerous accumulation of explosive air fuel mixture in a heating system. Only devices of recognized manufacturers, with proven field experience, and acceptable to the authority having jurisdiction, should be used.

5210. Safey Shut-off Valves.

5211. Safety Shut-off 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 shut-down periods. The safety shut-off valve can usually be considered as 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 shut-off valve should be of material suitable for the fuel handled and the design of the valve such as to assure positive shut off under the maximum operating pressure of the fuel handled. Safety shut-off valves should be of such design that they cannot be readily by-passed or blocked in the open position. In general, a safety shut-off valve should be reserved for safety shut-off service only, and not subjected to the additional wear and tear of temperature control operation.

5212. Electric, Manual-Opening, Automatic Closing Safety Shut-Off Valves can be opened only after the valve solenoid coil is energized and must be opened manually by means of a suitable "free-handle." De-energizing the valve solenoid coil automatically closes the valve.

5213. Electric Opening, Automatic Closing Safety Shut-Off Valves open automatically on energizing the valve actuating device, and close automatically on de-energizing the actuating device.

5214. Mechanical, Pressure-Operated Safety Shut-Off Valves must be opened manually but automatically shut off the fuel supply if the fuel and/or air pressure necessary for proper atomization or combustion falls below predetermined values. These pressure settings are usually the minimum values for stable combustion and safe operation. These valves must be reopened manually but will reclose when the hand is removed unless the fuel and/or air pressure has been restored to above the set point.

5220. Combustion (Flame Failure) Safeguards.

5221. Combustion (Flame Failure) Safeguards are devices which detect the presence or absence of flame, and which in event of flame failure, will automatically shut off the fuel supply for the burner being supervised and actuate an alarm (if provided). Proper application, taking into consideration the peculiarities of each main and pilot burner arrangement, and periodic testing and maintenance, is a primary requirement for satisfactory and reliable operation.

5222. Flame Conductivity Combustion Safeguards have an electrode or rod of temperature resistant material which extends into the flame being supervised. These devices depend on the conductive property of the ionized

gases in the flame to permit a current flow which, through a suitable electronic or electric circuit, will actuate suitable relays. The relays will make or interrupt the power to a safety shut-off valve in event of presence or absence of flame respectively and actuate an alarm (if provided) on flame failure. This type of combustion safeguard is practically instantaneous in operation and is suitable for use on main burner and/or pilot burner fuel gas flames. The electrode should always be located so that the pilot cannot reach it without providing prompt reliable ignition for main burner.

5223. Photoelectric Combustion Safeguards are mounted outside the firebox and sighted on the flame being supervised. They depend on the radiation (light) from the flame striking a light-sensitive cell. When enough light intensity is present, sufficient current will flow in the cell (phototube). This minute current is amplified electronically and will then actuate suitably arranged relays to make or interrupt the power to a fuel safety shut-off valve in event of presence or absence of flame, respectively, and actuate an alarm (if provided) on flame failure. The photoelectric combustion safeguard is suitable for use on the usual highly radiant oil flames; it is not generally used on gas flames, owing to the scant radiation intensity of properly proportioned gas flames which are "non-luminous." This type of combustion safeguard is practically instantaneous in operation.

5224. Radiant-Heat-Actuated Type Combustion Safeguards are mounted outside the fire box and sighted on the flame being supervised. They depend on the radiant heat from a luminous flame being absorbed on a "black" body, such as a diaphragm or a bi-metal coil, thus causing expansion and contraction to make or break an electrical contact, in the presence or absence of flame, respectively. This opens or closes the safety shut-off valve and actuates an alarm if one is provided. These radiant-heat-actuated devices are designed principally for use on oil flames only. Due to the time required for heat transfer, and for interrupting the safeguarding circuit (five to thirty or more seconds), they are not considered sufficiently responsive for use on industrial ovens or heaters. Further, the diaphragm type has a slip clutch for quick response which makes it unsuitable for modulating or "high-low" flames, as a slight reduction in flame intensity would cause the contacts to open, resulting in false shutdowns.

5225. Heat Actuated Combustion Safeguards operate by the heating of a thermal element such as a liquid-filled bulb, or bimetal helix by the burner or pilot flame; and the resultant movement or expansion closes a switch contact. Loss of flame causes contraction of the bimetal or reduction in confined fluid pressure, thus opening the switch contact. Electric safety shut-off valves and alarms are powered through these contacts.

(a) These devices are not usually well suited to supervising industrial size burner flames owing to their relatively slow response or inability to furnish direct main flame supervision.

(b) One type of metallic-element, heat-actuated, combustion safeguard, which has a small built-in pilot, compares favorably in speed of response to the radiant-heat-actuated combustion safeguard, however its small pilot is easily deflected by drafts giving false operations. The liquid-filled-bulb type usually has an excessively slow response when subjected to the relatively high temperatures near industrial size main burners (40 sec. to 5 min.). Neither the metallic element nor the liquid-filled-bulb-types will withstand for a reasonable time the high temperatures usually adjacent to industrial main burners, hence they ordinarily supervise only gas pilot flames and frequently an auxiliary gas pilot flame. They should not be used in oil flames or in industrial size main gas burners.

(c) The bimetallic helix (stack switch) type is used with oil burners and mounted in the flue between boiler and chimney. Its response is considered too slow for good protection against explosion hazard for industrial size oil burners.

5226. Thermocouple Operated Combustion Safeguards consist of a thermocouple with its hot junction in a gas pilot flame. The heat from the flame generates a minute electric current in the thermocouple which may open a magnetic gas valve or actuate a relay. Since high ambient temperatures will provide an excessively long response time and short thermocouple life, this type of combustion safeguard is not suitable for supervising industrial size gas burners. In general, they are suitable only for supervision of gas pilot flames in small burner installations.

5230. Pressure Switches.

5231. Pressure Switches maintain an electric circuit when the pressure in a fuel gas, fuel oil, or combustion air supply line is above its proper minimum value for safe stable combustion. The circuit is interrupted if the pressure drops below the minimum. Pressure switches on fuel or combustion air piping with contacts in series with an electric safety shut-off valve may be used to provide automatic fuel shut-off.

The fuel safety valve controlled by pressure switches should not automatically reopen upon restoration of normal pressure, but should require a manual reset.

5232. Diaphragm-Operated Pressure Switches are used for low pressures, generally not exceeding several pounds per square inch. The diaphragm, suitable for the fluid being handled, bears against a lever controlling a switch contact. A spring, with tension adjustment for pressure setting, provides counter thrust to the diaphragm.

5233. Bellows-Operated Pressure Switches are used for higher pressures and are generally similar in operating principle to the diaphragm type, except that a flexible metal bellows replaces the diaphragm.

5240. Program Relays.

5241. Program Relays are used with oil burners and occasionally with gas burners, under full automatic control or semi-automatic control, to govern the sequence of events in the lighting off and shutting down of the burner in response to the controller. Such burners may operate "On-Off" at a single firing rate, "high-low" or "multi-point" firing rates, or full modulating, depending upon the accuracy desired in matching heat input to heating load.

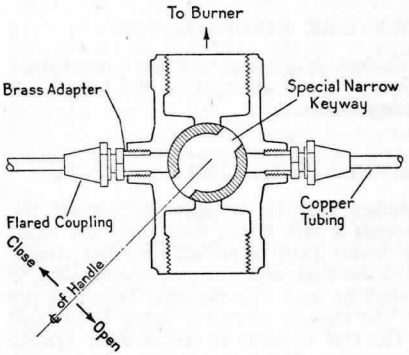
5242. Where program relays are used to automatically light off and shut down industrial size burners and are of the type which do not incorporate a combustion safeguard to prove the presence of the gas pilot flame before the main burner fuel valve can be opened, they should be of the type which will give immediate shut-off and not give a relight cycle, following accidental flame failure; in addition, the time allowed by the relay for main flame establishment on automatic lighting-up should not exceed 15 seconds after main burner fuel flow is established.

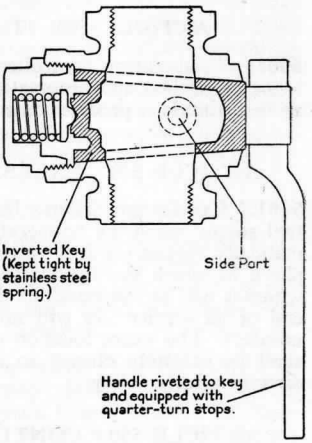
5243. Certain types of program relay arrangements with instantaneous-acting combustion safeguards are arranged to sense a strong pilot flame before the main valve can be opened. With relays of this type, it is considered

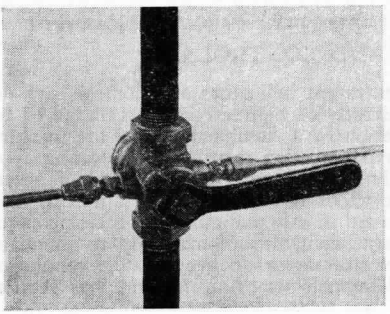
reasonably safe to permit one retrial for ignition after an accidental flame failure.

5244. The usual program relay assembly consists of various relays and thermal-operated warp switches which govern the time of various periods during the burner operation. The burner combustion safeguard operates in conjunction with the program relay. When the temperature control calls for heat, the relays start the electric spark and gas pilot ignition system, burner motor combustion air blower, and permit them to operate for a predetermined period before opening the main fuel valve. If the combustion safeguard does not sense lighting of the main fuel within a predetermined time after the main fuel valve has opened, a thermal time switch trips and locks out the current supply and shuts off the fuel. The relay requires manual resetting to start the burner again.

5245. If the main fuel lights properly, the combustion safeguard responds, shunting out the thermal time switch, and allowing the burner to run. A post-ignition switch allows the ignition system to operate for a predetermined period after the main fuel is ignited in order to stabilize the flame. In case of flame failure, the combustion safeguard responds and immediately shuts down the burner. Power failure, or thermostat operation, shuts off the burner in readiness for a new start, which is not made until the relay and combustion safeguard return to the starting position.







Supervising Cock. (F.M. Cock). Fig. 14

5250. Supervising Cock.

5251. The Supervising Cock shall be a special approved cock similar to the usual burner gas cock, but incorporating two side outlets which furnish a small independent passageway that is open only after the main gas passage is completely closed. The key-way width is narrow enough, with respect to the size and proportions of the main gas ports, to insure positive closure of the main gasway before opening the side outlets. See Fig. 14.

(a) In applying Supervising Cocks on multi-gas burner systems, the side ports are connected in series with copper tubing to adjacent cocks, so that when the gas passages of all cocks are closed a new continuous passageway is provided through all the closed Supervising Cocks. One end of the line of tubing is connected to the main gas line on the upstream side of the main burner safety shutoff valve; or where combustion air is used, it can be connected to the combustion air line downstream from the main blast gate. The other end of the line of tubing beyond all Supervising Cocks, is connected to a checking pressure switch and terminates in a bleed orifice which must be unobstructed at all times. By properly interlocking the checking pressure switch with the main burner safety shutoff valve, the arrangement requires complete closure of the individual burner Supervising Cocks before the main burner safety shutoff valve can be opened. (For application see Section 5623, exception (e)).

ARTICLE 530. TEMPERATURE CONTROLLERS.

5301. Temperature controllers are devices which measure the temperature to be controlled and automatically control the heat input of the burner, so as to maintain a predetermined set temperature.

ARTICLE 540. EXCESS TEMPERATURE LIMIT SWITCH.

5401. 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. 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 550. CONTINUOUS VAPOR CONCENTRATION INDICATORS AND CONTROLS.

5501. (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) Where 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 should be set to not exceed 50 per cent of the lower explosive limit. Higher settings must be approved by the authority having jurisdiction.

5502. 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 (Class D) are frequently equipped with these instruments.

5503. 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.

5504. Flammable vapor concentration indicators should be used to test only flammable vapors having a flash point below 70°F. unless it is possible to maintain the sampling line and measuring assembly at the temperature of the vapors, so that condensation will not occur.

5505. Maintenance of continuous flammable vapor indicators and controls should 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 should 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 560. APPLICATION OF SAFETY CONTROLS.

5601. Application of safety controls and safeguards to protect against vapor and fuel hazards in ovens 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.

5602. Preferred Automatic Operating Sequence. The following outlined order of starting procedure is recommended: Require personal initial supervision in regard to ignition of pilot and main flame; provide for automatic supervision of power supply, ventilation, purge interval, also, proper pressures of fuel and/or atomizing supply; i.e., air or steam.

5603. Operation.

(a) The lighting of pilots and burners are to be accomplished only by the operator in attendance on the system and not by automatic means.

Exception: See Section 5240 Program Relays.

(b) All safety devices and safeguarding sequences must be automatic in operation following lighting.

(c) It shall be required that the operator visually observe the lighting of each main burner from a point close to the burner. A manually operated valve shall be provided at each main burner and the operator should be satisfied that conditions are suitable and safe before turning on the burners.

This condition can be insured only if the operator is in close proximity to the burners while turning on the fuel.

5604. Power. Safety devices should be operated from the power line, through a transformer if necessary, rather than the lighting circuit in order to provide a single source of current supply for all electrical devices in the system, and to avoid unnecessary outages.

5605. Pilots.

(a) Raw gas pilots shall not be used.

(b) Electrically ignited gas pilots are recommended on gas and oil fired burners.

(c) Pilots used for ignition of fuel burners may or may not be continuous in operation.

(d) Electric ignition without gas pilots may be employed on burners using light fuel oil.

5606. If several flame failure combustion safeguards are used on one heating unit having a common safety shutoff valve, they shall be so interconnected that the failure of one combustion safeguard will result in the cutting off of all fuel to that heating unit.

5610. Ventilation Controls—General Application.

5611. Controls shall be provided for the oven and heating system to insure the amount of ventilation required by Chapter 4, and as may be hereafter noted under the following sections on Safety Control Application, while the oven is in operation, and also to provide for preventilation before starting the heating system and, if practical, the conveyor, by the following means:

(a) Where mechanical ventilation is used to dilute solvent vapors or for heat transfer and introduction of fresh air necessary for complete combustion, the entire safety control circuit for the oven including conveyor (if practical) and heating system shall be interlocked electrically with fan motor circuits, or shall be interlocked by means of rotational switches on fan shafts (fan must have positive drive, see Section 5105).

(b) Vane or diaphragm type air flow switches installed at proper location should also be used to indicate air movement. (See Section 5102.)

5612. Direct electrical interlocks and/or air flow switches shall be arranged in the safety control circuit so that loss of ventilation or air flow will immediately shut down the heating system of the particular oven section affected; or if necessary loss of ventilation should shut down the entire oven heating system as well as the conveyor.

5613. Purging Cycle or Preventilation. (a) Timed Preventilation is required for all ovens and heaters in which flammable vapors or fuel can accumulate during a shut down period.

(b) Timed Preventilation may be omitted in ovens of less than 350 cu. ft. volume, if doors must be opened to light burners or turn on heat, provided that the area of doors gives an explosion venting area of 1 sq. ft. to 15 cu. ft. of oven volume and all fans are operating.

(c) Ovens with natural ventilation shall be arranged so that oven doors must be opened fully before burners can be lighted or heat can be turned on. See Section 4013.

(d) Where preventilation is required an approved time delay relay (see Sect. 5111) shall be arranged in the safety control circuit and set so as to require operation of exhaust and recirculating fans for sufficient time to pro-

vide a minimum of four complete oven volume air changes with fresh air before the burner ignition system may be operated, fuel turned on, or the conveyor operated. Where conditions are such that safe preventilation may be secured with less than four air changes, the approval of the authority having jurisdiction should be secured.

(e) Oven doors and/or dampers in fresh air inlets or safety exhaust outlets may require limit switch interlocks (see Section 5104), 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.

(f) It may be impractical to provide timed preventilation on some steam heated ovens. Omitting preventilation on such ovens is subject to the approval of the authority having jurisdiction.

5614. Preventilation Recycling. (a) Serious explosions have frequently demonstrated that if safety ventilation should fail while solvents are being evaporated, a dangerous accumulation of vapor air mixture is likely to occur, which is likely to be ignited if heaters are restarted immediately upon restoring the safety ventilation. Recycling of the time delay relay to repeat preventilation, before restarting heaters, shall be required following failure or shut down of safety exhaust or recirculating fans.

(b) Following an unscheduled shutdown after an accidental flame failure in an oven not having mechanical ventilation to exhaust flammable volatiles, and using a Direct Fired External—one or two burner—heater (see Section 3170) : the time delay relay, combustion safeguard, and where practical, doors and/or dampers, should be interlocked so as to provide a repeat of the preventilation purge by means of all heater and oven fans (except combustion air blower) before it is possible to re-introduce an ignition source and attempt relighting (see Section 5032 (b)).

NOTE: This protection is not applicable where more than one combustion safeguard system and safety shutoff valve is used.

5615. 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. Exceptions shall be subject to approval of the authority having jurisdiction.

5620. Safety Control Application—Direct Fired Internal Gas Heating Systems.

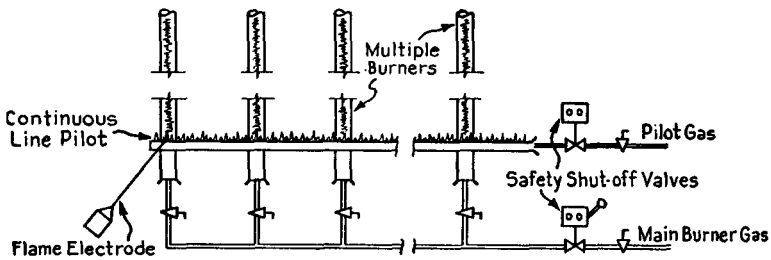
5621. These heating systems are defined in Section 3172. Each oven equipped with a gas-fired (Direct Fired Internal) heating system shall be provided with the control devices and safety control circuit with proper operating sequence as covered in Sections 5622-5626 inclusive.

5622. Ventilation Controls shall be as outlined in Section 5610.

5623. Combustion Safeguards. In general, each burner shall be equipped with an approved practically instantaneous (flame conductivity) combustion safeguard (see Section 5222), arranged through suitable approved safety shut-off valves to shut off fuel to the burner and its pilot in the event of flame failure. The flame rod of the combustion safeguard should be located at the junction of the main and pilot burner flame paths, so that prompt reliable ignition by the pilot is assured before the main fuel valve can open. (See Section 5606.)

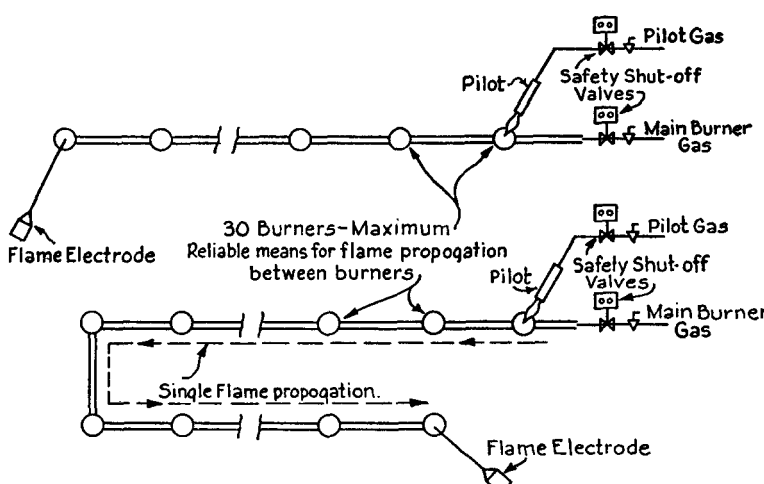
The following exceptions to Section 5623 are noted below:

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 (see Sections 3142, 3144) can be used: An approved practically instantaneous (flame conductivity) combustion safeguard shall be provided at the far end of each line-burner type pilot, away from the pilot fuel source, with flame rod located at the junction of the flame paths of both pilot and last main burner. The pilot safety shut off valve must be initially opened by a manual momentary push button.



Exception A

Exception (b): Multiple burners of the individual cup type, not located directly adjacent to one another, having reliable means for flame propagation between burners (where combustion safeguards for each burner and continuous line burner type pilots for groups of burners are impractical) shall preferably have the burner manifold arranged in groups containing no more than thirty (30) burners—having, by means



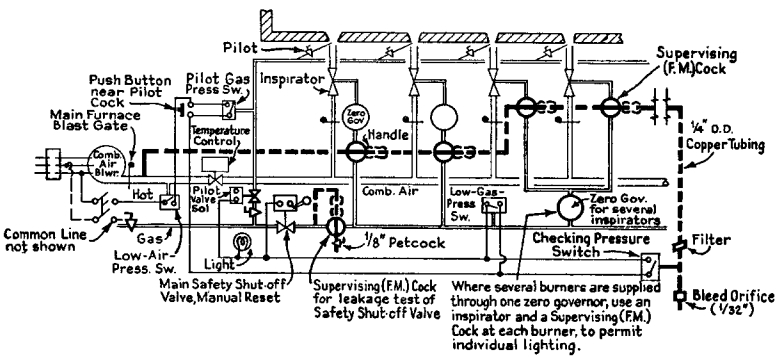
Exception B

of propagation devices, a single flame path between all burners, starting from the burner which is first ignited. The number of burners on a single manifold may exceed thirty (30) in special cases, subject to the approval of the authority having jurisdiction. A lighting pilot shall be provided at the burner which starts the flame propagation path and an approved instantaneous acting flame failure combustion safeguard shall be provided at the burner which terminates the flame propagation path. On lighting the main burner and pilot, safety shutoff valves shall be initially opened by means of a manual momentary push button. The length of time the valves can be kept open by the push button without the flame being sensed by the combustion safeguard shall not exceed 30 seconds after which the purge must be repeated. A timer may be required.

Exception (c): Where two burners, which will reliably ignite one from the other, are used, it shall be permissible to use a single approved practically instantaneous (flame conductivity) 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 (d): Burners for Direct Fired Internal gas heating systems which supply an oven—at a fuel rate per burner not exceeding 150,000 btu/hr may be equipped with heat actuated combustion safeguards or safety pilots. (See Sections 5224, 5225, 5226.) For small equipment under constant attendance, approaching in size the household gas range or very small laboratory test ovens, combustion safeguards may be omitted, subject to approval of the authority having jurisdiction.

Exception (e). In general, for greatest security, all burners should be protected with combustion safeguards as outlined in the foregoing sections. Where 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 shut off valves) (see Sections 5210, 5230, 5250) to assure, where practical, closure of all individual burner



Exception E.

Supervising Cock and Gas Safety Control System.

cocks before the main burner safety shutoff valve can be opened, and to shut off all gas in case of 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 is illustrated below. (See Section 5250 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 and remain open until all Supervising Cocks are closed, combustion air pressure 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.

5624. Safety Shut-off Valves. (See Section 5210.) (a) Each Direct Fired Internal gas heating system shall be provided with an approved electric safety shut-off valve arranged for manual reset. An approved electric safety shut-off valve shall also be provided on the gas pilot line. These valves shall be arranged to close in event of failure of ventilation air flow, flame failure (where combustion safeguards are used), failure of gas pressure, failure of air pressure if this is necessary for proper operation of burners and controls, and failure of electric current.

(b) For small ovens not equipped with forced mechanical ventilation (see Chapter 4), the safety shut-off valve shall, in addition to the foregoing, be connected so that it will close when the oven is shut down and require opening of the oven doors before it can be reopened.

5625. Excess Temperature Limit Switches (see Article 540) shall 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 oven or heating system. They shall not automatically reopen the fuel valve. These controls shall be in addition to any normal temperature control devices used.

5626. Conveyor Interlocks shall be provided in conveyor ovens having a flammable volatile hazard so that the conveyor cannot move unless ventilating fans are operating and discharging the proper amount of air, as required in Chapter 4, and purge cycle completed.

Exception (a): It is permissible to install provision for operating the conveyor manually or by means of a constant pressure push button for the purpose of removing material from the oven in event of conveyor stoppage from ventilation failure.

Exception (b): Where an automatic material feeding system supplies a conveyor at a point adjoining the oven entrance, such as a lithograph oven coater, the material feeding system may be interlocked with the ventilation system and the conveyor interlocks omitted.

Exception (c): Certain one line conveyor systems supplying several processes may prevent a practical ventilation interlocking arrangement. Omitting the interlocks in such cases is subject to the approval of the authority having jurisdiction.

5630. Safety Control Application—Direct Fired External Gas Heating Systems.

5631. These heating systems are defined in Section 3173. Each oven equipped with a gas fired Direct Fired External heating system shall be equipped with the following control devices and safety control circuit with proper operating sequence.

5632. Ventilation Controls shall be as outlined in Section 5610.

5633. Combustion Safeguards shall be provided on the burners as outlined in Section 5623.

5634. Safety Shut-Off Valves shall be provided for Direct Fired External heating systems as outlined in Section 5624.

5635. An excess temperature limit switch should be provided as outlined in section 5625.

5636. Conveyor Interlocks shall be provided in conveyor or ovens as outlined in Section 5626.

5640. Safety Control Application—Indirect Fired Internal Gas Heating System—Explosion Resisting.

5641. These heaters are defined in Section 3174. Each oven equipped with a gas fired Indirect Fired Internal Gas Heating System-Explosion Resisting heater shall be provided with the following control devices and safety control circuit with proper operating sequence.

5642. Ventilation Controls shall be as outlined in Section 5610 with the exception that preventilation of the heating system is not required.

5643. Combustion Safeguards may be omitted at the burners, subject to the approval of the authority having jurisdiction. Electric ignition is desirable to facilitate lighting and for the protection of the operator. Fuel and combustion air interlocks shall be provided as outlined in Section 5623, exception (e).

5644. Safety Shut-Off Valves shall be provided for Indirect Fired Internal-Explosion Resisting heating systems as outlined in Section 5624.

5645. An Excess Temperature Limit Switch or Switches should be provided as outlined in Section 5625.

5646. Conveyor Interlocks shall be provided as outlined in Section 5626.

5650. Safety Control Application—Indirect Fired Internal Gas Heating Systems—Non-Explosion Resisting.

5651. These heating systems are defined in Section 3174. Each oven equipped with a gas fired Indirect Fired Internal Non-Explosion Resisting heater shall be equipped with the following control devices and safety control circuit with proper operating sequence.

5652. Ventilation Controls shall be as outlined in Section 5610.

5653. Combustion Safeguards shall be provided on the burners as outlined in Section 5623.