N 50.7.2.4.7.7 Appliances installed in the cargo space of a vehicle shall be readily accessible whether the vehicle is loaded or empty. [**58:**6.26.7.7]

N 50.7.2.4.7.8 Appliances shall be constructed or otherwise protected to minimize possible damage or impaired operation due to cargo shifting or handling. [**58:**6.26.7.8]

N 50.7.2.4.7.9 Appliances shall be located so that a fire at any appliance will not block egress of persons from the vehicle. [**58:**6.26.7.9]

N 50.7.2.4.7.10 A permanent caution plate shall be affixed to either the appliance or the vehicle outside of any enclosure, shall be adjacent to the container(s), and shall include the following instructions:

(1) Be sure all appliance valves are closed before opening container valve.
(2) Connections at the appliances, regulators, and containers shall be checked periodically for leaks with soapy water or its equivalent.
(3) Never use a match or flame to check for leaks.
(4) Container valves shall be closed when equipment is not in use.

[**58:**6.26.7.10]

N 50.7.2.4.7.11 Gas-fired heating appliances and water heaters shall be equipped with automatic devices designed to shut off the flow of gas to the main burner and the pilot in the event the pilot flame is extinguished. [**58:**6.26.7.11]

N 50.7.2.4.8 General Precautions.

N 50.7.2.4.8.1 All fat fryers shall have a lid over the oil vat that can be secured to prevent the spillage of cooking oil during transit. This lid shall be secured at all times when the vehicle is in motion.

N 50.7.2.4.9 Parking, Servicing, and Repair.

N 50.7.2.4.9.1 Where vehicles with LP-Gas fuel systems used for purposes other than propulsion are parked, serviced, or repaired inside buildings, the requirements of 50.7.2.4.9.2 through 50.7.2.4.9.4 shall apply. [**58:**6.26.8.1]

N 50.7.2.4.9.2 The fuel system shall be leak-free, and the container(s) shall not be filled beyond the limits specified in Chapter 7 of NFPA 58. [**58:**6.26.8.2]

N 50.7.2.4.9.3 The container shutoff valve shall be closed, except that the container shutoff valve shall not be required to be closed when fuel is required for test or repair. [**58:**6.26.8.3]

N 50.7.2.4.9.4 The vehicle shall not be parked near sources of heat, open flames, or similar sources of ignition, or near unventilated pits. [**58:**6.26.8.4]

N 50.7.2.4.9.5 Vehicles having containers with water capacities larger than 300 gal (1.1 m3) shall comply with the requirements of Section 9.7 of NFPA 58. [**58:**6.26.8.5]

N 50.7.2.4.10* Containers shall be designed, fabricated, tested, and marked (or stamped) in accordance with the regulations of the U.S. Department of Transportation (DOT); Section VIII of the ASME code, "Rules for the Construction of Unfired Pressure Vessels"; or the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases*, except for UG-125 through UG-136. [**58:**5.2.1.1]

The DOT has approved the use of composite cylinders only when fabricated under a DOT special permit. They have a 15-year service life and must be requalified every 5 years. These cylinders can be used for all applications not prohibited by NFPA 58, such as outdoor gas grills, industrial trucks, and other applications not located in buildings.

A.50.7.2.4.10 Prior to April 1, 1967, regulations of the U.S. Department of Transportation were promulgated by the Interstate Commerce Commission. In Canada, the regulations of the Canadian Transport Commission apply and are available from the Canadian Transport Commission, Union Station, Ottawa, Canada. [**58:**A.5.2.1.1]

Construction of containers to the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases* has not been authorized after July 1, 1961. [**58:**A.5.2.1.1]

N 50.7.2.4.10.1 Used containers constructed to specifications of the Association of American Railroads shall not be installed. [**58:**5.2.1.1(A)]

N 50.7.2.4.10.2 Adherence to applicable ASME code case interpretations and addenda that have been adopted and published by ASME 180 calendar days prior to the effective date of NFPA 58 shall be considered as compliant with the ASME code. [**58:**5.2.1.1(B)]

N 50.7.2.4.10.3 Where containers fabricated to earlier editions of regulations, rules, or codes listed in 5.2.1.1 of NFPA 58, and of the Interstate Commerce Commission (ICC) *Rules for Construction of Unfired Pressure Vessels*, prior to April 1, 1967, are used, the requirements of Section 1.4 of NFPA 58 shall apply. [**58:**5.2.1.1(C)]

The intent and application of 50.7.2.4.10.3 is often misinterpreted with regard to containers that were built to the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases* (specifications U-200 and U-201) and pre-1949 editions of the ASME *Boiler and Pressure Vessel Code* (specifications U-68 and U-69). Because these ASME containers have a very long service life when properly maintained, many remain in use and are sometimes relocated and reinstalled. However, not all containers built to these older editions of the ASME Code can remain in use or relocated and reinstalled, regardless of their condition. The reinstallation of containers built to older editions of the code must be reviewed by the AHJ to determine if any current requirements meet a threshold for retroactivity.

N 50.7.2.4.10.4 DOT 4E specification (aluminum) cylinders and composite cylinders involved in a fire shall be removed from service. [**58:**5.2.1.1(D)]

N 50.7.2.4.11 After installation or modification, piping systems (including hose) shall be proven free of leaks by performing a pressure test at not less than the normal operating pressure. [**58:**6.16.1.1]

N 50.7.2.4.12 General Location of Cylinders.

N 50.7.2.4.12.1 Cylinders in storage shall be located to minimize exposure to excessive temperature rises, physical damage, or tampering. [**58:**8.2.1.1]

Because of the smaller size of the cylinders covered in Chapter 8 of NFPA 58, the temperature of their contents tends to fluctuate more directly with ambient air temperatures or solar radiation than does the temperature of larger containers. These cylinders should not relieve LP-Gas through their pressure relief devices until the temperature of their contents exceeds 130°F (54°C), at which point the cylinder may become liquid full. These high temperatures could be reached in some extremely hot climates or in poorly located, poorly constructed, or unventilated storage locations.

In addition to temperature control, physical damage protection may be needed in storage locations. Certain facilities have considerable vehicular traffic — for example, forklift trucks — and require these precautions. Finally, tampering is a valid consideration. Although small portable cylinders, such as those used with grills, will not flow gas even if the valve is opened by hand, it is still important to provide protection from tampering, which could affect the safety devices.

N **50.7.2.4.12.2** Cylinders in storage having individual water capacity greater than 2.7 lb (1.1 kg) [nominal 1 lb (0.45 kg) LP-Gas capacity] shall be positioned so that the pressure relief valve is in direct communication with the vapor space of the cylinder. [**58:**8.2.1.2]

The requirement that cylinders, other than very small cylinders, be stored so that the pressure relief valve is in the vapor space of the cylinder is an important safety concept that is repeated in several locations throughout NFPA 58. The requirement is important because the capacity of pressure relief valves is based on gas flow, not liquid flow. If the pressure in a cylinder were sufficiently high to cause the pressure relief valve to operate, and the pressure relief valve were in communication with the liquid space of the cylinder, the following might occur:

- It might take more time to reduce the pressure in the container, since liquid is more dense than gas and would therefore require a larger flow of liquid before resetting the valve.
- Liquid discharged from the cylinder will vaporize almost instantly, resulting in approximately 270 times as much vapor by volume as a gaseous release. If fire is the cause of the pressure relief valve operation, a liquid release will provide more fuel to the fire than a gaseous release.
- Liquid discharge will reduce the volume of liquid inside the container that would have contributed to the autorefrigeration reaction. Autorefrigeration occurs when the vapor pressure in the container decreases and causes the liquid to change phases. The liquid utilizes heat from the container as it changes phases, and the decrease in temperature of the container reduces the overall pressure in the container.

Cylinders less than 2.7 lb (1.1 kg) water capacity [about 1 lb (0.45 kg) of propane] are excluded from this requirement. Examples of such cylinders are those used for handheld soldering torches, portable stoves, camping equipment, refillable portable appliances such as cigarette lighters, and so forth. These small cylinders are normally stored in cardboard shipping containers, and the proper storage orientation should be indicated on the shipping container.

N **50.7.2.4.12.3** Cylinders stored in buildings in accordance with Section 8.3 of NFPA 58 shall not be located near exits, near stairways, or in areas normally used, or intended to be used, for the safe egress of occupants. [**58:**8.2.1.3]

N **50.7.2.4.12.4** If empty cylinders that have been in LP-Gas service are stored indoors, they shall be considered as full cylinders for the purposes of determining the maximum quantities of LP-Gas permitted by 8.3.1, 8.3.2.1, and 8.3.3.1 of NFPA 58. [**58:**8.2.1.4]

Once filled, an LP-Gas cylinder seldom becomes completely empty. At the very least, the cylinder will usually be full of vapor and may contain some liquid or a residue that could contain the flammable odorant. If empty cylinders were not counted as full cylinders, it would be impossible for an enforcing authority to determine whether the storage limits were being exceeded without weighing all the cylinders.

N **50.7.2.4.12.5** Cylinders shall not be stored on roofs. [**58:**8.2.1.5]

N **50.7.2.4.13 Protection of Valves on Cylinders in Storage.**

N **50.7.2.4.13.1** Cylinder valves shall be protected as required by 5.2.6.1 and 7.2.2.5 of NFPA 58. [**58:**8.2.2.1]

N **50.7.2.4.13.2** Screw-on-type caps or collars shall be in place on all cylinders stored, regardless of whether they are full, partially full, or empty, and cylinder outlet valves shall be closed. [**58:**8.2.2.2]

Protection for all cylinder valves is required by the DOT requirements for containers of hazardous materials. Smaller portable cylinders typically use a metal protective collar around the cylinder valve, while larger cylinders typically found in stationary service may have a screw-on cap or a dome cover.

N **50.7.2.4.13.3** Valve outlets on cylinders less than 108 lb (49 kg) water capacity [nominal 45 lb (20 kg) propane capacity] shall be plugged, capped, or sealed in accordance with 7.2.2.5 of NFPA 58. [**58:**8.2.2.3]

N **50.7.2.4.14 Transportation of Cylinders.**

N **50.7.2.4.14.1** Cylinders having an individual water capacity not exceeding 1000 lb (454 kg) [nominal 420 lb (191 kg) propane capacity], when filled with LP-Gas, shall be transported in accordance with the requirements of Section 9.3 of NFPA 58. [**58:**9.3.2.1]

The maximum size of an individual cylinder permitted under DOT regulations is 1000 lb (454 kg) water capacity [nominal 420 lb (191 kg) of propane]. Portable ASME containers, which generally serve the same purpose as DOT cylinders, may be encountered and are also limited to this size for transportation.

N **50.7.2.4.14.2** Cylinders shall be constructed as provided in Section 5.2 of NFPA 58 and equipped in accordance with Section 5.7 of NFPA 58 for transportation as cylinders. [**58:**9.3.2.2]

N 50.7.2.4.14.3 The quantity of LP-Gas in cylinders shall be in accordance with Chapter 7 of NFPA 58. [**58:**9.3.2.3]

N 50.7.2.4.14.4 Cylinder valves shall comply with the following:

(1) Valves of cylinders shall be protected in accordance with 5.2.6.1 of NFPA 58.
(2) Screw-on-type protecting caps or collars shall be secured in place.
(3) The provisions of 7.2.2.5 of NFPA 58 shall apply.

[**58:**9.3.2.4]

Refer to the commentary following 69.4.2.2.5 for the requirements referenced on cylinder valve plugs. The importance of providing protection for cylinder valves from damage cannot be overstated. A damaged or separated cylinder valve could result in an uncontrolled release of LP-Gas and perhaps even the propulsion of the cylinder itself.

N 50.7.2.4.14.5 The cargo space of the vehicle shall be isolated from the driver's compartment, the engine, and the engine's exhaust system. [**58:**9.3.2.5]

N 50.7.2.4.14.5.1 Open-bodied vehicles shall be considered to be in compliance with this provision. [**58:**9.3.2.5(A)]

N 50.7.2.4.14.5.2 Closed-bodied vehicles having separate cargo, driver, and engine compartments shall be considered to be in compliance with this provision. [**58:**9.3.2.5(B)]

N 50.7.2.4.14.5.3 Closed-bodied vehicles, such as passenger cars, vans, and station wagons, shall not be used for transporting more than 215 lb (98 kg) water capacity [nominal 90 lb (41 kg) propane capacity], but not more than 108 lb (49 kg) water capacity [nominal 45 lb (20 kg) propane capacity] per cylinder, unless the driver and engine compartments are separated from the cargo space by a vaportight partition that contains no means of access to the cargo space. [**58:**9.3.2.5(C)]

The transportation of privately owned cylinders in passenger automobiles is a safety concern that is addressed based on the vehicle type. The transportation of LP-Gas by private parties, where the transportation is not considered to be "in commerce" as defined by the DOT, is not regulated by the DOT, and therefore only the provisions of NFPA 58 apply. The provisions of Section 9.3 of NFPA 58 are applied in the following situations:

1. **Cylinder transported in an open-bodied vehicle (such as a pickup truck) or in a closed-bodied vehicle with a vaportight partition between the cargo space and the driver and engine compartments.** In both cases, up to 1000 lb (454 kg) of LP-Gas (total weight, including the weight of the LP-Gas and the cylinders) can be transported in the vehicle as stated in 50.7.2.4.14.1. Where the LP-Gas exceeds 1000 lb (454 kg), the requirements of 50.7.2.4.14.10 and the DOT would apply to the vehicle.
2. **Cylinder transported in a closed-body vehicle.** A maximum of 90 lb (41 kg) of propane can be transported in the passenger or cargo space of the vehicle. This requirement allows up to four typical grill cylinders [20 lb (9.1 kg) propane capacity each], up to three 30 lb (13.6 kg) cylinders, or up to two 40 lb (18 kg) cylinders to be transported.

Note that the 90 lb (41 kg) limit in closed-body vehicles effectively prohibits the transportation of a 100 lb (45 kg) LP-Gas cylinder in passenger cars, vans, sport utility vehicles, and station wagons. Also, see 50.7.2.4.14.9 for requirements on cylinder orientation during transport.

These rules apply to all transportation of cylinders, whether by propane company employees delivering cylinders to residences, by exchange cabinets, or by forklift operators or private citizens taking grill cylinders in for filling or exchange. These rules apply in much the same way as building codes apply to the modification a citizen makes to a house. In the case of building codes (and this varies with location), the citizen is responsible for obtaining a building permit, for having construction done to meet the applicable code(s), and for getting an inspection by a building code official during construction and/or after the work is complete.

NFPA 58's requirements are less well known to consumers than building codes are, which is why some jurisdictions consider it the responsibility of propane company employees to ensure that cylinders transported by customers are properly placed and secured in their vehicles before they leave the dispensing site.

N 50.7.2.4.14.6 Cylinders and their appurtenances shall be determined to be leak-free before being loaded into vehicles. [**58:**9.3.2.6]

N 50.7.2.4.14.7 Cylinders shall be loaded into vehicles with flat floors or equipped with racks for holding cylinders. [**58:**9.3.2.7]

N 50.7.2.4.14.8 Cylinders shall be fastened in position to minimize the possibility of movement, tipping, and physical damage. [**58:**9.3.2.8]

N 50.7.2.4.14.9 Cylinders being transported by vehicles shall be positioned in accordance with Table 50.7.2.4.14.9. [**58:**9.3.2.9]

TABLE 50.7.2.4.14.9 *Orientation of Cylinders on Vehicles*

Propane Capacity of Cylinder			
lb	**kg**	**Open Vehicles**	**Enclosed Spaces of Vehicles**
≤45	≤20	Any position	
>45	>20	Relief valve in communication with the vapor space	
≤4.2	≤1.9		Any position
>4.2	>1.9		Relief valve in communication with the vapor space

[**58:**Table 9.3.2.9]

Racks that hold cylinders in a horizontal position are commonly used for the delivery of industrial truck cylinders in open-body vehicles. The safety experience with this type of transportation has been good and is the reason that LP-Gas cylinders with a maximum propane capacity of 45 lb (20 kg) can be transported with the relief valve in contact with the liquid space of the container. That size is the maximum portable cylinder generally used in industrial trucks. Larger containers must be transported in a position such that the pressure relief valve is in communication with the vapor space of the container.

In closed-body vehicles, the requirements are much more stringent. Only cylinders less than or equal to 4.2 lb (1.9 kg) propane capacity can be transported in any position, thereby resulting in the relief valve being in communication with liquid. As a result of this provision, nominal 20 lb (9.1 kg) cylinders (gas grill cylinders) cannot be transported on their sides inside a vehicle.

N **50.7.2.4.14.10** Vehicles transporting cylinders where the total weight is more than 1000 lb (454 kg), including the weight of the LP-Gas and the cylinders, shall be placarded as required by DOT regulations or state law. [**58:**9.3.2.10]

Placard is a term used in the DOT regulations. Placards are used to warn others of hazardous materials present on the vehicle, placed on the outside of the vehicle or its cargo tank to identify the hazard class of the cargo. For LP-Gas, "1075" is the identification number, the "2" in the lower part is the hazard class ("gas," in this case), and the hazard class division is "flammable," as shown by the flame. A placard must convey this information to emergency responders. A typical flammable gas placard such as the one described above is shown in Exhibit 50.22. DOT rules require the placard to be identical to the one shown, with a red background color.

Exhibit 50.22

Placard for propane truck. (Courtesy of U.S. Department of Transportation)

N **50.7.3 Temporary Cooking.**

N **50.7.3.1** Temporary cooking operations and equipment shall comply with NFPA 96, Section 50.7.1 and Section 50.7.3.

N **50.7.3.2** Temporary cooking equipment and installations shall comply with NFPA 58.

N **50.7.3.3** Deep fat fryers, fry-o-lators, or other appliances having combustible liquids heated by LP Gas, solid fuels, or electricity shall be protected by an approved hood fire suppression system or other approved means of extinguishment in the event of fire.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2017 edition.
NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2015 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2016 edition.
NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2017 edition.
NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, 2017 edition.
NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2017 edition.
NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.
NFPA 54, *National Fuel Gas Code*, 2018 edition.
NFPA 58, *Liquefied Petroleum Gas Code*, 2017 edition.
NFPA 70®, National Electrical Code®, 2017 edition.
NFPA 72®, National Fire Alarm Code®, 2016 edition.
NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2016 edition.
NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*, 2017 edition.
NFPA 731, *Standard for the Installation of Electronic Premises Security Systems*, 2017 edition.
NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2015 edition.
NFPA 1192, *Standard on Recreational Vehicles*, 2018 edition.
"Firewatch," *NFPA Journal*, K. J. Tremblay, May/June 2012, p. 39.
"Firewatch," *NFPA Journal*, K. J. Tremblay, September/October 2011, p. 14.
"Firewatch", *NFPA Journal*, K. J. Tremblay, May/June 2009, pp. 43–44.
"Structure Fires in Eating and Drinking Establishments," R. Campbell, National Fire Protection Association, Quincy, MA, February 2017.

ASHRAE Research Project 1033-RP Final Report, "Effects of Air Velocity on Grease Deposition in Exhaust Ductwork," American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA, 2006.

ASTM E2336, *Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems*, ASTM International, West Conshohocken, PA, 2014.

Boston Fire Department, *Board of Inquiry report on fatal fire of August 29th, 2007,* Boston, MA, February 15, 2008.

Underwriters Laboratories Inc., Northbrook, IL

ANSI/UL 197, *Standard for Commercial Electric Cooking Appliances,* 2014.

ANSI/UL 300, *Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment*, 2005, revised 2014.

U.S. Publishing Office, Washington, DC

Title 49, Code of Federal Regulations, Part 172.504, "General Placarding Requirements."

Title 49, Code of Federal Regulations, Part 172.532, "FLAMMABLE GAS Placard."

51 Industrial Ovens and Furnaces

Explosions and fires in fuel-fired and electric heat utilization equipment constitute a potential loss to life, property, and production. Other regulations and conditions should be reviewed for the design and operation of furnaces not covered by this chapter or by NFPA 86, *Standard for Ovens and Furnaces*. Subjects covered in other regulations include, but are not limited to, toxic vapors; hazardous materials; noise levels; heat stress; and local, state, and federal regulations, such as those by the U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA).

51.1 General

Δ **51.1.1 Application.** Industrial ovens and furnaces shall comply with this chapter and the applicable provisions of NFPA 86.

The effective date for the edition of NFPA 86 referenced in this *Code* is May 19, 2014. However, the provisions of NFPA 86 might not be enforceable retroactively to its effective date if the standard has not been adopted by a separate action in the jurisdiction. The date that NFPA 1, *Fire Code*, was adopted in the jurisdiction establishes the effective date for enforcement of not only NFPA 1 but also other codes and standards incorporated into this *Code*.

Ovens and furnaces are used in many industrial processes to dry, cure, or alter the physical characteristics of materials. Common examples would be a bakery or a kiln. The fire and explosion hazards presented by ovens and furnaces are related to their operation at elevated temperatures in conjunction with their use of flammable and combustible fuels, flammable and combustible materials in process, and flammable special processing atmospheres. Examples of industrial processes that use ovens and furnaces include the following:

1. Melting metals
2. Drying cloth
3. Baking painted metal parts
4. Curing rubber conveyor belts
5. Annealing steel under a hydrogen atmosphere
6. Treating metal parts in molten salts
7. Heating materials under vacuum

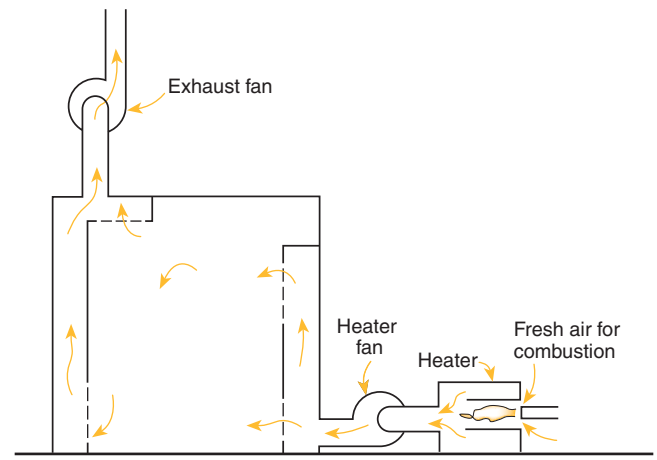
In industry, the terms *oven* and *furnace* are used interchangeably. Ovens and furnaces can be batch or continuous units. In a batch furnace, materials are loaded, the furnace is operated, the furnace is shut down, then the materials are unloaded. In a continuous furnace, materials enter one end of the furnace, are processed as they move through the furnace, then exit the furnace at the other end. In a continuous furnace, the furnace is continuously operated as new materials are constantly introduced.

Exhibit 51.1, Exhibit 51.2, and Exhibit 51.3 illustrate three examples of batch units. Exhibit 51.4 shows an example of a continuous unit.

All ovens and furnaces share similar hazards associated with their heating systems. In addition to these hazards, ovens and furnaces are classified as Class A, Class B, Class C, or Class D to address additional process hazards. Descriptions of those classifications follow.

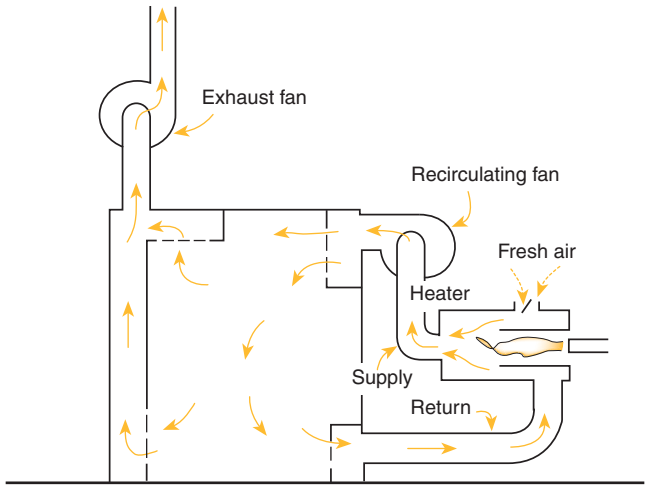
Class A. Class A ovens or furnaces have heat utilization equipment where there is a potential explosion or fire hazard that could be accompanied by the presence of flammable volatiles or combustible materials processed or heated in the furnace.

Exhibit 51.1



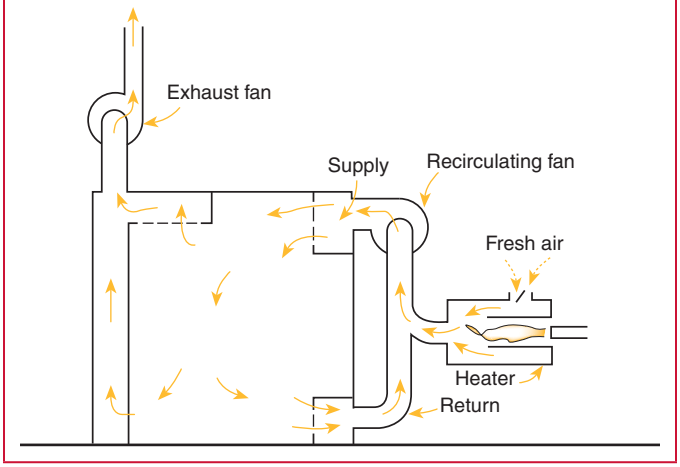
Direct-fired, external, nonrecirculating heater.

Exhibit 51.2



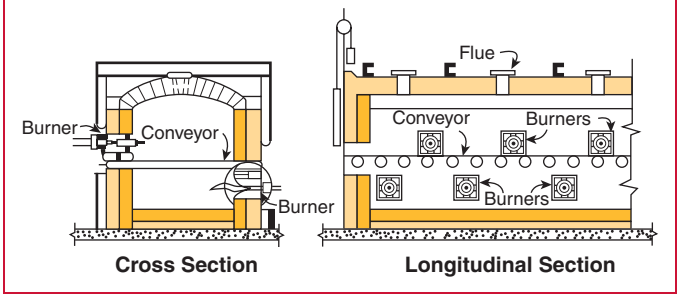
Direct-fired, external, recirculating-through heater.

Exhibit 51.3



Direct-fired, external, recirculating-not-through heater.

Exhibit 51.4



Direct-fired continuous furnace with multiple internal burners.

Flammable volatiles or combustible materials can include, but are not limited to, any of the following:

1. Paints, powders, inks, and adhesives from finishing processes, such as dipping, coating, or spraying, and impregnated materials
2. Substrate material
3. Wood, paper, and plastic pallets, spacers, or packaging materials
4. Polymerization or other molecular rearrangements

In addition, potentially flammable materials, such as quench oil, waterborne finishes, cooling oil, or cooking fats, that present a hazard should be ventilated according to Class A standards.

Class B. Class B ovens or furnaces have heat utilization equipment where there are no flammable volatiles or combustible materials being heated. It is important to note that the loads processed in Class B furnaces typically do not contain any flammable volatiles or combustible materials. However, when small amounts of flammable volatiles or combustible materials are present, it can be appropriate not to add safety ventilation, as would be required for a Class A furnace, when doing so would be detrimental to the process and would not increase the level of safety.

Class C. Class C ovens or furnaces have a potential hazard due to a flammable or other special atmosphere being used for the treatment of material in process. This type of furnace uses any type of heating system and includes a special atmosphere supply system(s). Included in this classification are integral quench furnaces and molten bath furnaces.

Class D. Class D ovens or furnaces, referred to as *vacuum furnaces,* have a pressure vessel that operates under vacuum for all or part of the process cycle. Such furnaces can process any product or material. These furnaces can use special atmospheres introduced when the furnace is above or below atmospheric pressure. During inert quenching, Class D furnaces operate at pressures from below atmospheric to over gauge pressure of 100 psi (690 kPa).

NFPA 86 provides information on the protection of Class A, Class B, Class C, and Class D ovens and furnaces against the hazards of fire and explosion. It is a compilation of guidelines, rules, and methods applicable to the safe operation of this type of equipment. Specifically, requirements on furnace location, arrangement, installation, control, and use are detailed in NFPA 86.

NFPA 86 requires that personnel who operate, maintain, or supervise the furnace be thoroughly instructed and trained in their respective job functions under the direction of a qualified person(s). When training, they must demonstrate an understanding of the equipment, its operation, and the practice of safe operating procedures in their respective job functions. A typical training program could include the following items:

1. Review of operating and maintenance information
2. Periodic formal instruction
3. Use of simulators

4. Field training
5. Other procedures
6. Comprehension testing

The following topics may be included as part of the training when it is being developed:

1. Process and equipment inspection testing
2. Combustion of fuel-air mixtures
3. Explosion hazards, including improper purge timing and purge flow and safety ventilation
4. Sources of ignition, including autoignition (e.g., by incandescent surfaces)
5. Functions of controls, safety devices, and maintenance of proper set points
6. Handling of special atmospheres
7. Handling of low-oxygen atmospheres
8. Handling and processing of hazardous materials
9. Confined space entry procedures
10. Operating instructions
11. Lockout/tagout procedures
12. Hazardous conditions resulting from interaction with surrounding processes
13. Fire protection systems
14. Molten material
15. Quench systems

In addition, personnel are required to receive regularly scheduled refresher training and must demonstrate understanding of the equipment, its operation, and the practice of safe operating procedures in their respective job functions.

Personnel must have access to written operating instructions at all times. Instructions include normal startup, normal shutdown, and emergency shutdown. Where necessary, separate instructions should be provided for cold startup and for warm startup. A warm startup might occur after a weekend when a furnace is not in use; rather than shutting down and allowing the furnace to cool off, the furnace can be brought back to an idling temperature.

Operator error has been identified as a significant cause or contributing factor in upsets and explosions involving heat utilization equipment. These unwanted events usually result from operators taking actions that deviate from written operating instructions. Operators must be thoroughly instructed and trained in the written operating instructions. When abnormal or unusual conditions are detected, written emergency shutdown procedures should be implemented. Deviation from normal or emergency written operating instructions should not be permitted at the operator level.

The cold startup of heat utilization equipment should occur under the supervision of a trained operator. When heat utilization equipment experiences an automatic safety shutdown or a manual emergency shutdown by the operator, restart of the equipment is not permitted without maintenance personnel first identifying and correcting the cause of the off-normal shutdown.

Heat utilization equipment is equipped with numerous control and safety devices intended to maintain the equipment within safe operating boundaries or cause a safety shutdown. If these controls and safety devices are to be reliable, they must be periodically inspected and tested. Maintenance must then be provided as needed.

NFPA 86 places the responsibility for establishing an inspection, testing, and maintenance program, as well as the frequency and extent of the inspection and corrective action to be taken, with the equipment user. The program should identify the features to be inspected, tested, and maintained. Frequencies for each action are based on specific installation needs.

Leak testing of fuel gas safety shutoff valves is an essential program that users often overlook. A leak test program offers a control over one of the primary causes of explosions in heat utilization equipment, that is, fuel leakage into idle equipment. NFPA 86 requires an annual leak test of each fuel gas safety shutoff valve. Written leak test procedures describing how the test is to be conducted should be provided. The typical leak test is the bubble test. In this test, one end of a flexible hose is connected to an outlet located between the safety shutoff valve to be tested and a downstream blocking valve. The other end of the flexible hose is submerged into a water bath for several minutes. The number of fuel gas bubbles per minute is measured.

The written procedure should define a pass/fail leak standard in terms of bubbles per minute. No valve is perfect; therefore, a minimum acceptable leakage rate is established. Because the head of water above the end of the hose could create sufficient pressure to hold back any leaking gas, the test operator should avoid submerging the hose too deeply into the water bath during the test.

A test procedure is to be established for verifying the performance of each safety control. Off-normal conditions should be corrected promptly. Where the control has a design set point, the following actions should be taken:

1. ***Inspect.*** Verify that the device is at the correct setting.
2. ***Test.*** Verify that the device operates at the correct set point.
3. ***Maintain.*** Recalibrate or replace the device if the displayed setting deviates from the actual setting beyond an acceptable limit.

The inspection of safety devices should include an evaluation of their physical condition. Missing cover plates should be promptly replaced. Corroded devices or devices with obvious physical damage should be repaired or replaced. Tampering with devices must not be allowed. Evidence of tampering could include wire jumpers inserted across contacts, foreign material inserted between contacts, and adjustment of devices to improper settings. Where adjustable safety devices are found adjusted to extreme high or low settings, the device is not at its proper setting.

For Class A ovens that pose a solvent hazard — for example, ovens that remove a flammable solvent from painted metal parts — a safety design form is used that describes the solvent

hazard the oven is designed to handle. The form should identify the solvent that the furnace is designed for and the solvent introduction rates. Inspections should verify that no unauthorized solvents are being used and that design solvent input rates are not being violated. Deviations should receive prompt attention.

Class A ovens and their associated ductwork might be equipped with fixed fire protection systems, such as automatic sprinklers or carbon dioxide systems. Where installed, fire protection systems must be inspected, tested, and maintained in accordance with the appropriate NFPA standard for the type of system involved. See Chapter 13 for additional guidance.

Combustible materials, such as stock and other storage, should not be allowed close to heat utilization equipment. Suitable clearance should be maintained at all times. NFPA 86 specifies a minimum required separation distance of 2½ ft (0.76 m).

51.1.2 Permits.

51.1.2.1 Permits, where required, shall comply with Section 1.12.

Subsection 1.12.8 requires a permit for the operation of an industrial oven or furnace [(see Table 1.12.8(a)]. Depending on the fuel used with the furnace, additional permits might be required for the storage and use of the particular fuel.

51.1.2.2 Applications for a permit shall be accompanied by plans for safe operation showing all essential details and calculations.

Compliance with this *Code* does not eliminate the need for an engineer or for competent engineering judgment. The intent of this *Code* is that a designer who is capable of applying more complete and rigorous analysis to special or unusual problems should be given latitude in the development of an oven or furnace design. In such cases, the designer is required to be responsible for demonstrating and documenting the safety and validity of the design.

NFPA 86 requires plans that show all essential details with respect to location, construction, ventilation, piping, and electrical safety equipment. A list of all combustion, control, and safety equipment that includes the name of the manufacturer and the type number is also required. Wiring diagrams and instructions for sequence of operations for all safety controls must also be provided. Ladder-type schematic diagrams are recommended.

As part of the approval process, the authority having jurisdiction (AHJ) should consider using the two-page application form entitled Furnace or Oven Manufacturer's Application for Acceptance, shown in Exhibit 51.5.

Exhibit 51.5

MANUFACTURER'S JOB OR CONTRACT NO. | DATE

PART A — PLANS

NAME & ADDRESS OF CUSTOMER (OWNER) | NAME & ADDRESS OF MANUFACTURER

DRAWINGS SUBMITTED, NOS. | NO OF SETS

INSTALLATION
- ERECTION & ADJUSTMENTS (SEE PART B) BY: ☐ MANUFACTURER ☐ CUSTOMER | IF OTHER, DESCRIBE
- SAFETY VENTILATION AIRFLOW TESTS (SEE PART B) TO BE MADE AFTER ERECTION BY: ☐ MANUFACTURER ☐ CUSTOMER | IF OTHER, DESCRIBE
- TYPE ☐ BATCH ☐ CONTINUOUS | TYPE NO. OR OTHER INFORMATION

CONSTRUCTION ☐ SHEET STEEL ON STEEL FRAME ☐ NONCOMBUSTIBLE INSULATION | IF OTHER, DESCRIBE

RATED HEAT INPUT ☐ GAS BTU/HR ☐ FUEL OIL NO. GAL/HR ☐ ELECTRIC KW ☐ STEAM PRESS, psig

SIZE LENGTH (External) FT | WIDTH (External) FT | HEIGHT (External) FT | VOLUME (Internal) FT³ | OPERATING TEMP. °F

LOCATION OF EQUIPMENT
- BLDG. NO OR NAME | BUILDING FLOOR CONSTRUCTION AND NO. OF FLOOR OR STORY
- AIR SPACE BETWEEN OVEN & WOOD FLOOR IN. | IF OTHER, DESCRIBE
- AIR SPACE BETWEEN STACKS, DUCTS, & WOOD BLDG. CONST. IN. | IF OTHER, DESCRIBE
- EXHAUST STACKS | DIAM OR SIZE IN. | METAL GAUGE (USS) | ☐ INSULATED | NO. OF CLEAN-OUT (ACCESS) DOORS

EXPLOSION VENTING AREA
- OPEN ENDS FT² | LOOSE ROOF PANELS FT² | ACCESS DOORS WITH EXPLOSION LATCHES FT²
- MANUFACTURER AND TYPE LATCH | TOTAL AREA FT² | VENT RATIO VENT AREA / INTERNAL VOLUME ⅓

FUEL SHUTOFF ACCESSIBLE IN EVENT OF FIRE? ☐ YES ☐ NO

FIRE PROTECTION IN OVEN
- ☐ NONE ☐ AUTOMATIC SPRINKLERS ☐ OPEN SPRINKLERS ☐ CO_2 ☐ STEAM | DRAWINGS SUBMITTED? ☐ YES ☐ NO
- ☐ OTHER (DESCRIBE) | ☐ SEPARATE EXCESS TEMPERATURE LIMIT SWITCH WITH MANUAL RESET | SET FOR °F

FIRE PROTECTION FOR DIP TANK & DRAINBOARD
- DRAWINGS SUBMITTED? ☐ YES ☐ NO | FIXED AUTO CO_2? ☐ YES ☐ NO | ☐ OTHER (DESCRIBE)
- OVERFLOW VALVES? ☐ YES ☐ NO | DUMP VALVES? ☐ YES ☐ NO | SALVAGE TANK? ☐ YES ☐ NO | IS HEAT SHUT OFF AUTOMATICALLY ON FAILURE OF CONVEYOR? ☐ YES ☐ NO

TYPE OF WORK
- IMPREGNATED-COATED ABSORBENT MATERIAL ☐ PAPER ☐ CLOTH | ☐ LITHOGRAPH COATING ☐ VARNISH ELECT. COILS ☐ GRAVURE PRESS ☐ FOOD BAKING ☐ CORES OR MOLDS
- METAL ☐ DIPPED ☐ FLOW-COATED ☐ SPRAYED | ☐ OTHER (DESCRIBE)

SOLVENTS ENTERING OVEN NAME OF SOLVENT USED | LENGTH OF BAKE MIN. | MAX. SOLVENT FOR WHICH OVEN DESIGNED ☐ CONTINUOUS GAL/HR ☐ BATCH GAL/BATCH

DESIGNED SAFETY VENTILATION
- ARRANGEMENT ☐ SEPARATE CENTRIFUGAL EXHAUSTER ☐ RECIRCULATING FAN WITH SPILL ☐ NATURAL DRAFT STACK ☐ OPENINGS INTO ROOM | FILTERS ON FRESH AIR INTAKE? ☐ YES ☐ NO
- FRESH AIR ADMITTED INTO OVEN CFM REFERRED TO 70°F | OPENING WITH DAMPER CLOSED FRESH AIR INLET ___% EXHAUST OUTLET ___% | DOES CONVEYOR STOP AUTOMATICALLY ON FAILURE OF SAFETY EXHAUST FANS? ☐ YES ☐ NO
- FAN MFR., SIZE, TYPE | WHEEL DESIGN (BLADE TIP) ☐ RADIAL TIP ☐ BACKWARD INCLINED ☐ FORWARD CURVED | DIAM. IN. | TIP SPEED FT/MIN

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HEATING ARRANGEMENT ☐ INTERNAL DIRECT-FIRED NONRECIRCULATING ☐ INTERNAL DIRECT-FIRED RECIRCULATING ☐ EXTERNAL DIRECT-FIRED RECIRCULATING ☐ EXTERNAL INDIRECT-FIRED
- ☐ OTHER (DESCRIBE)
- TYPE OF ELECTRIC HEATING ELEMENTS AND LOCATION
- NO. OF MAIN BURNERS | NO. OF PILOT BURNERS | CAN DRIPPINGS OFF WORK FALL ON HEATING ELEMENTS? ☐ YES ☐ NO

METHOD OF LIGHT-OFF ☐ PORTABLE TORCH ☐ FIXED ☐ PILOT ☐ OIL ☐ GAS ☐ SPARK IGNITER

METHOD OF FIRING ☐ HI–LOW ☐ ON–OFF ☐ MODULATING ☐ CONTINUOUS ☐ AUTOMATIC-LIGHTED ☐ MANUAL-LIGHTED ☐ SEMI-AUTOMATIC-LIGHTED
- TYPE OF PILOT ☐ CONTINUOUS ☐ INTERRUPTED ☐ INTERMITTENT ☐ OTHER (DESCRIBE)

MIXER TYPE
- ☐ GAS | NO. MAIN BURNER INSPIRATORS | ☐ ZERO-GOVERNOR TYPE ☐ ATMOSPHERIC INSPIRATOR ☐ HIGH PRESSURE ☐ LOW PRESSURE
- | NO. PILOT INSPIRATORS | ☐ ZERO-GOVERNOR TYPE ☐ ATMOSPHERIC INSPIRATOR ☐ HIGH PRESSURE ☐ LOW PRESSURE
- ☐ OIL | ☐ AIR (16–32 OZ) ATOMIZING
- ☐ OTHER | OTHER TYPE MIXERS OR OIL BURNERS INCLUDING PILOTS (MFR. & TYPE)

PROTECTION AGAINST FUEL EXPLOSION

LIGHTING OFF
- NO FUEL AND IGNITION UNTIL: ☐ TIMED PREVENTILATION BY EXHAUST AND RECIRC. FANS | TIMER SETTING MIN. | ☐ DOORS WIDE OPEN | ☐ BURNER (F.M.) COCKS CLOSED | ☐ MEANS PROVIDED FOR CHECK OF MAIN SAFETY SHUTOFF VALVE TIGHTNESS
- PILOT-FLAME-ESTABLISHING PERIOD AUTOMATICALLY LIMITED? ☐ YES ☐ NO SEC. | TRIAL-FOR-IGNITION PERIOD AUTOMATICALLY LIMITED? ☐ YES ☐ NO SEC. | OIL TEMP. INTERLOCK? ☐ YES ☐ NO SET FOR °F | PROVED LOW-FIRE INTERLOCK? ☐ YES ☐ NO
- MFR. AND TYPE NO. OF F.M. COCKS & TIMER | ☐ COMBUSTION AIR BLOWER CANNOT BE STARTED UNTIL END OF PREVENT. (IF TIMER USED) | ☐ COMBUSTION SAFEGUARD PROVES PILOT BEFORE MAIN SAFETY SHUTOFF VALVE OPENS

FIRING
- HEAT CUTOFF AUTOMATICALLY, REQUIRING MANUAL OPERATION TO RESTORE, ON FAILURE OF ☐ COMBUSTION AIR ☐ RECIRCULATING FAN ☐ SAFETY EXHAUST FAN ☐ HIGH AND LOW GAS PRESSURE ☐ LOW OIL PRESSURE ☐ FLAME (Combustion Safeguard)
- POD OR SCANNER LOCATION ENSURES ☐ PILOT IGNITES MAIN FLAME | MANDATORY PURGE AFTER FLAME FAILURE? ☐ YES ☐ NO

MANUFACTURER & TYPE NO. MAIN SAFETY SHUTOFF VALVE IPS. IN. | PILOT SAFETY SHUTOFF VALVE IPS. IN.
- COMBUSTION SAFEGUARD | PRESSURE SWITCHES | AIRFLOW SWITCHES

PART A ACCEPTED ☐ AS SUBMITTED ☐ SUBJECT TO ANY CHANGES INDICATED | DATE | BY

PART B — MANUFACTURER'S INSPECTION & TEST

SAFETY VENTILATION CFM REF. TO 70° F | MEASURED BY ☐ PITOT ☐ (SPECIFY) OTHER | MEASURED WITH FRESH AIR INLET & EXHAUST OUTLET DAMPERS IN MAXIMUM CLOSED POSITION ☐ YES ☐ NO

BURNERS ☐ LIGHTED ☐ MIXERS ADJUSTED | TEMP. CONTROL SET | ☐ ADJUSTED FOR STABLE LOW FLAME

SAFETY CONTROLS ☐ ADJUSTED | ☐ TESTED FOR PROPER RESPONSE

INSTRUCTIONS ☐ CUSTOMER'S OPERATOR INSTRUCTED | ☐ PRINTED OPERATING INSTRUCTIONS LEFT | ☐ APPLICATION FOR ACCEPTANCE POSTED ON CONTROL PANEL

SIGNATURES MFR'S FIELD REP. | TEST WITNESSED BY FOR CUSTOMER | DATE

PART B ACCEPTED ☐ AS SUBMITTED ☐ SUBJECT TO ANY CHANGES INDICATED | DATE | BY

PART C — FIELD EXAMINATION OF COMPLETED INSTALLATION

☐ PART A CHECKED ☐ PART B CHECKED ☐ SAFETY CONTROLS TESTED ☐ ROD OR SCANNER LOCATION ENSURES PILOT IGNITES MAIN FLAME

ENGINEER'S SIGNATURE | DATE

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Furnace or oven manufacturer's application for acceptance.