



An Overview of:
NFPA 86
Standard for Ovens and Furnaces

Introduction

The most widely referenced standard in the United States for industrial heat processing equipment is the National Fire Protection Agency (NFPA) 86 Standard for Ovens and Furnaces. This standard is updated on a regular basis with the latest revisions happening in 2015. It is intended to minimize fire and explosion hazards of ovens and furnaces used for commercial and industrial processing of materials.

Oven Classes

There are four classes of ovens as defined by NFPA 86 - Class A, B, C, and D. The Classes of ovens we will discuss in this document will be limited to **Class A** and **Class B**, as these are the only classes that pertain to **LEWCO** Ovens.

Class A ovens are defined as: *“Heat utilization equipment operating at approximately atmospheric pressure wherein there is potential explosion or fire hazard that could be occasioned by the presence of flammable volatiles or combustible materials processed or heated in the furnace.”*

While **Class B** ovens are defined as: *“Heat utilization equipment operating at approximately atmospheric pressure wherein there are no flammable volatiles or combustible materials being heated.”*

Design Requirements

In addition to NFPA 86, it should be noted that there are many other publications by various organizations affecting the design of process heating equipment. These include American Society of Mechanical Engineers (ASME), American Society for Testing & Materials (ASTM), Compressed Gas Association (CGA), and others.

NFPA 86 list some general guidelines. These guidelines include approval drawings, design plans and specifications. The guidelines are applicable to any major technical project and are not specific to process heating.

Oven location and construction specifications start in chapter 5 of NFPA 86. Aside from general oven placement and surrounding building design, the actual oven design is discussed, specifically explosion relief. **LEWCO** follows the guideline of:

“The amount of explosion relief area shall be at least 1 ft² of relief area for each 15 ft³ of furnace volume.”

To estimate the total workspace volume **LEWCO** multiplies the workspace area by a factor of 1.6 to include the plenum and heater box. This number is then divided by 15 to determine the amount of relief area required. Once a new oven design has been modeled, the exact volume and thus explosion relief area can easily be determined.

LEWCO commonly uses explosion relief latches on workspace doors. This area is then calculated to determine if additional explosion relief is required. If it is not possible to incorporate enough explosion relief in the oven design, the oven shell shall be made of 3/16” plate construction or larger to comply with NFPA’s standards.

Heating Systems

NFPA 86 also discusses heating systems. LEWCO commonly employs one of three different heating methods. These include fuel-fired burners, electric resistance heaters and thermal fluid. Some of the major points discussed in regards to these methods are described below.

Fuel-fired burners include the following requirements:

1. An emergency shutoff valve located away from the oven that is readily accessible and provides visual indication.
2. Regulators, relief valves and switches shall be vented to an approved location.
3. Vent lines may not tie into a common manifold from different ovens.
4. Prior to the furnace heating system startup, provision shall be made for the removal of all flammable vapors and gases that have entered the heating chambers during the shutdown period.
5. Where combustion air is provided, combustion airflow or pressure shall be proven and interlocked with the safety shutoff valves so that fuel gas cannot be admitted prior to establishment of combustion air and so that the gas is shut off in the event of combustion air failure.
6. Where air from the exhaust or recirculation fans is required for combustion of the fuel, airflow shall be proved prior to an ignition attempt.

Combustion air minimum pressure or flow shall be interlocked into combustion safety circuitry by any of the following methods:

- a. A low pressure switch that senses and monitors the combustion air source pressure
- b. A differential pressure switch that senses the differential pressure across a fixed orifice in the combustion air system
- c. An airflow switch
7. A timed pre-ignition purge shall be proved.
 - a. This purge must consist of 4scf of fresh air or inert gas per cubic foot of system volume.
 - b. The system volume shall include the heating chambers and all other passages that handle the recirculation and exhaust of products of combustion.
 - c. Before the timed pre-ignition purge, the following must be satisfied:
 - i. Minimum required pre-ignition airflow is proved.
 - ii. The safety shutoff valve is proven to be closed.
 - d. The minimum airflow must remain proven throughout the entire pre-ignition purge.
 - e. In the event the airflow drops below the minimum required, the purge timer shall stop.
8. A pre-ignition purge must be completed before any re-ignition of the burner unless the system is a multi-burner system and at least one burner remains operating.
9. A trial for ignition of a gas burner shall not exceed 15 seconds.
10. Current to a spark igniter must be discontinued at the end of the 15 second trial for ignition period unless the flame is contained in an explosion proof radiant tube.

Electrically heated units include the following requirements:

1. The heater housing must provide access to the heating elements and wiring.
2. Heating elements must be securely fastened.
3. Externally energized components must be guarded.

Thermal fluid heating systems include the following requirements:

1. Oven isolation valves shall be installed on the supply and return lines.
2. Enclosures must be constructed of noncombustible material with access opening for maintenance and cleaning.

SAFETY - Equipment Installation, Training & Operation

For every new equipment installation, the oven may not be released for use until the installation, verification, and operation of all safety devices has been completed. Furthermore, all set points of safety interlock devices must be recorded.

All personnel who operate, maintain or supervise the oven shall be thoroughly instructed and trained in their respective job functions. The personnel must go on to demonstrate an understanding of the equipment, its operation and practice of safe operating procedures.

With each piece of equipment the oven manufacturer **MUST** supply the following:

1. Schematic piping and wiring diagrams
2. Startup procedures
3. Shutdown procedures
4. Emergency procedures
5. Maintenance procedures

All personnel must have access to the documentation listed above at all times.

All safety devices must be listed for the service intended, and be approved if listed devices are not available. All safety devices must be maintained per the original manufacturer's instructions. It is up to the user to establish the schedule and enforce the frequency and extent of all inspection, testing and maintenance programs. All safety devices must be tested and the test documented at least annually. Isolation valves must be replaced before the end of their stated lifetime open-close cycles. Further, any isolation valves must be cycled at least annually. Temperature indication and excess temperature limit interlock must be verified to be accurate. Testing records must be kept for a minimum of one year or until the subsequent inspection has taken place.

SAFETY - Controls

Safety devices include, but are not limited to:

1. Air flow switches
2. High and low gas pressure switches and indicators
3. Excess temperature limiting device
4. Purge timer
5. Proof of closure device

Safety interlocks are provided on all **LEWCO** ovens and depend on the type and construction of the oven in accordance with the NFPA standards. These interlocks shall meet one or more of the following criteria:

1. Be hardwired without relays in series ahead of the temperature control device
2. Be connected to a relay that represents a single safety interlock configured to initiate safety shutdown in the event of power loss

3. Be connected to a listed safety relay that represents one or more safety interlocks and initiates safety shutdown upon power loss

An excess temperature limit interlock is provided and interlocked into the safety circuitry and must meet the following requirements:

1. Must be separate from the operating temperature controlling device.
2. Shall cut off the heating system before the oven's maximum temperature is exceeded.
3. Shall require manual reset before restart of the furnace.
4. Open-circuit failure of the temperature-sensing components shall cause the same response as an excess temperature condition.
5. Shall be equipped with temperature indication.
6. The temperature-sensing element shall be selected for the temperature and atmosphere to which they are exposed, and shall be located where recommended by the oven manufacturer or designer.
7. Must indicate its set point in temperature units that are consistent with the primary temperature controller.

Where a fan is essential to the operation of the oven, fan operation shall be proved and interlocked into the safety circuitry. Electrical interlocks and flow switches shall be arranged in the safety control circuit so that loss of ventilation or airflow shuts down the heating system.

Electrical power for safety control circuits shall be DC or single-phase AC, 250 volt maximum with one-side grounded, with all breaking contacts in the ungrounded, fuse-protected, or circuit breaker-protected line.

Ventilation & Exhaust Systems

One of the major considerations with either **Class A** ovens and or **fuel-fired burners** is fresh air supply and exhaust. **Class A** and **fuel-fired burners** must be exhausted due to the products of combustion and or flammable vapors. Any oven requiring an exhaust fan must have an airflow switch interlocked to prevent heat being applied if the exhaust fans are not operating. These interlocks must be designed so that when at the minimum setting they exceed the minimum volume required for safety ventilation.

There are a series of calculations used to determine the required safety ventilation. The first equations used are volume correction factors for temperature and altitude.

The altitude correction factors for volume have been pre-calculated and are provided in a table available in NFPA86 guidelines. Correction factors are not required for any ovens being installed less than 1,000 feet above sea level.

If the oven is direct fuel-fired a ventilation rate must be calculated for the products of combustion. This is determined simply by dividing the heat input in BTU/hr by 1,000,000 then multiplying by 183scfm. The resulting number must be adjusted using the temperature and altitude correction factors.

For determining exhaust requirements for volatiles there are different equations for continuous ovens versus batch ovens. After this is determined, the ovens are categorized by powder curing and solvent vapor.

Continuous powder curing ovens ventilation requirement shall be based on the percentage of volatile content of the powder released during the oven cure cycle. If the percentage is not known, the ventilation is calculated assuming that 9

percent of the mass of the power is volatile and the remaining mass is inert. Calculations may be conducted assuming the volatile components are xylene.

There are two methods for designing safety ventilation systems for continuous ovens. The first is to prevent the vapor concentration in the oven exhaust from exceeding 25% of the LFL (Lower Flammable Limit). The second method is to continuously monitor the solvent vapor and control the vapor concentration in the oven exhaust from exceeding 50% of the LFL. If the monitoring method is used, the controller must take one of the three following actions to prevent the vapor concentration in the exhaust from reaching 50% LFL.

1. Alarm and shut down the oven
2. Alarm and operate additional exhaust fans
3. Alarm and shut down the solvent input to the oven

Just like the volume correction factors for products of combustion, LFL levels must also be corrected for temperature.

There are three methods for determining the solvent safety ventilation rate for continuous process ovens. The standard method used by **LEWCO** requires the specific gravity of the solvent and the vapor density of the solvent vapor.

The ventilation rate of a batch oven is much easier to estimate due to the static load size of a batch oven. There are also multiple methods for calculating ventilation rates for batch ovens.

The resulting ventilation rate for either continuous or batch ovens must be corrected using both the temperature and altitude correction factors discussed earlier. If a direct fired burner is implemented in the oven, the required ventilation rate for the burner must also be added to the required ventilation rate. When designing the oven, use a standard size blower that is slightly larger than the corrected value. Using a blower that is larger than necessary is not efficient and will increase the operating costs of the oven.

Other ventilation control methods include the implementation of a LEL (Lower Explosive Limit) monitor or continuous vapor concentration controller.

It should be noted that this is just a simple overview of NFPA 86. Please consult NFPA 86 for additional details and a list of application examples.

Source: *NFPA 86: Standard for Ovens and Furnaces*. Quincy, MA: National Fire Protection Association, 2011. Print.

NOTE: This document provides a brief overview of NFPA 86 and is not endorsed by the NFPA. Please consult NFPA 86 before engineering or modifying any oven or furnace.