Explosion Relief Requirements in Industrial Ovens

Proper design of an Industrial Oven requires provisions for Explosion Relief

The design of industrial ovens is dictated by two primary standards:

1. National Fire Prevention Association Standard NFPA-86 ***Ovens and Furnaces***
2. Factory Mutual Property Loss Prevention Data Sheet 6-9 ***Industrial Ovens and Furnaces***

The redundant safety systems and construction methods required by these standards have three primary safety goals:

1. **Safeguards Against Fire**.
   Fire prevention in ovens requires good design, maintenance and care not to exceed safe operating temperatures. Fire protection or control is largely a matter of providing automatic sprinklers or other types of fixed fire extinguishing systems. Any oven that has sufficient combustible material in its contents to sustain a fire needs automatic sprinkler protection. Exhaust ducts that will contain combustible deposits also need sprinklers. Sprinkler heads should be rated at 50°F to 100°F above the *maximum* operating temperature of the oven.

2. **Preventing Fuel Explosions**.
   Basic safeguards for oven burner systems include (a) a reliable ignition source before fuel can reach the main burner, (b) a limited trial-for-ignition of the main burner flame, and (c) shutoff of fuel on flame failure. Burner flame outage is the ultimate result of undesirable conditions in the ventilation, circulation, fuel-air supply or ignition equipment. The proper combination of interlocks and flame-supervisory combustion safeguards are essential. Supervision of fuel pressure, airflows, and purging is important for anticipating the development of unsafe conditions and initiating a safety shutdown. This supervision gives further protection by preventing improper sequences of operation that could result in a hazardous condition.

3. **Preventing Vapor Explosions**.
   An explosion hazard exists in any oven where the internal oven temperature exceeds the flash point of *any* flammable constituent of the material or coating being processed. It is impractical to eliminate all ignition sources in an oven used for processing materials which emit flammable vapors during the heating cycle. Primary dependence for prevention of a vapor explosion must be placed on
   (a) not exceeding the design limits for the volume of solvents entering the oven
   (b) diluting the vapors with fresh air to well below the lower explosive limit (LEL) and discharging them outdoors by a positive and dependable system.

   This is referred to as ‘‘safety ventilation.’’ Safety ventilation rate is designed to maintain the oven below 25% of the LEL.

The design criteria of the "explosion vents" are cited in NFPA-86 and FM 6-9. These guidelines have been observed in the design of all Infratrol ovens.

FM 6-9 Elaborates on the Practicality of "Explosion Vents"

The design of explosion vents for ovens, dryers, and furnaces is based upon empirical values and formulae.

Precise calculations cannot be made because of insufficient knowledge of the flame acceleration rates during vented explosions, variations in flammable mixtures and the resistance of enclosures to internal forces.

Extensive release of flammable vapors has occurred where internal air currents mixed and distributed the vapors throughout most of the oven. Ignition of the vapors under near-optimum combustion conditions has resulted in serious damage to the oven and the surrounding building.

Fortunately, most incidents have not involved a flammable mixture throughout the total volume of the enclosure. Ignition frequently occurred when the mixture was near the limits of the flammable range. Thus, the deflagration forces were weak, and venting was effective.

It is not practical to provide sufficient vent area and structural strength to the enclosure to prevent serious damage from deflagration of a near optimum mixture occupying a large portion of the total volume of an oven.

The FM standard also recognizes and accepts minor inconsistencies between NFPA-86 ***Ovens and Furnaces*** and NFPA-68 ***Venting of Deflagrations***:

NFPA-86 Ovens and Furnaces, provides recommended venting ratios and other guidance with reference to NFPA-68 Venting of Deflagrations.

NFPA-68 discusses explosion venting for a broad range of building occupancies and equipment.

There are no basic conflicts [in FM 6-9] with NFPA-86 Ovens and Furnaces.

There are conflicts with the referenced NFPA-68 Venting of Deflagrations, in the method of determining the vent size, the recommended maximum mass of the vent, and allowing the relief of the vented gases into a structure.

The design criteria of NFPA-68 address equipment which appears to be considerably stronger than a typical oven.

Built-In Redundancy

Redundant safety devices are incorporated into the oven design to recognize any unsafe condition and shut down the oven burner. The chance that all these devices would fail simultaneously is **extremely** unlikely.

- The following devices would have to fail in order for the atmosphere in a gas-fired oven to reach the Lower Explosive Limit (LEL) and result in a fuel explosion:

  1. Both of the motorized gas valves would have to fail, allowing gas to seep into the oven.
  2. The proof-of-closure switch on the gas valve would have to fail in an energized state.
  3. The exhaust fan or exhaust fan motor would have to fail. (The oven could not purge).
  4. The exhaust airflow switch would have to fail in an energized state.
  5. INFRATROL safety circuit exceeds NFPA and FM requirements. We look for a change-of-state on all airflow switches during initial start-up. That check circuit would have to fail.
  6. The recirculation fan or fan motor would have to fail. (With no exhaust fan running, air would pour out each end opening, resulting in dilution of the oven atmosphere).
  7. The recirculation airflow switch would have to fail in an energized state. (See #5)
  8. The gas/air mixture would have to ignite during the 10-second trial for ignition period; otherwise the entire safety check/purge cycle is repeated.

- The following devices would have to fail during operation in order for the atmosphere in an oven to reach the Lower Explosive Limit and result in a vapor explosion:

  1. The exhaust fan or exhaust fan motor would have to fail.
  2. The exhaust airflow switch would have to fail in an energized state.
  3. INFRATROL safety circuits exceed NFPA and FM requirements. We look for a change-of-state on all airflow switches during initial start-up. That check circuit would have to fail.
  4. The recirculation fan or fan motor would have to fail. (With no exhaust fan running, air would pour out each end opening, resulting in dilution of the oven atmosphere).
  5. The recirculation airflow switch would have to fail in an energized state. (See Item #3).
  6. With no fans running, the temperature in the upper section of the oven would rise quickly, so the over-temperature controller would have to fail before the concentration of vapors reached the LEL.

All of the above scenarios assume that none of the safety devices have been over-ridden or jumpered-out. It also assumes that you are processing water-based coatings in the volumes as originally specified.

At Infratrol, we have been building ovens for over 50 years. Infratrol has never failed to receive insurance approval.

We are happy to work with you and your underwriter to answer any questions, complete any forms and assuage any concerns about this equipment.

Steve Onsager
INFRATROL Manufacturing Corp.
sonsager@infratrol.com

Steve Onsager is the President at INFRATROL Manufacturing Corp, New Berlin, Wis., a manufacturer of industrial ovens, powder coating and paint systems, and parts washers. For more information from INFRATROL, call (262) 797-8140; e-mail sonsager@infratrol.com; or visit www.infratrol.com.