Risk Control Guide

PROCESS HAZARD – INDUSTRIAL OVENS

Introduction and Scope

The purpose of this document is to give property risk management guidance to end-users of industrial ovens and dryers and address the inherent fire hazards associated with them.

There is a history of fires within ovens of practically every type, including:

- Paint ovens
- Textile, fibreboard, paper dryers and similar
- Dryers for evaporating low flash point solvents
- Baking ovens

Causes include spontaneous heating or auto-ignition of waste deposits in ovens/dryers or associated ducts and over-heating due to failure of temperature controls. Static sparks can also be a cause where ovens/dryers evaporate large quantities of low flash point solvents.

Some ovens and dryers use an organic heat transfer media (e.g. thermal oil). The fluids are generally high-flash-point ignitable liquids, but the systems are often operated above or close to the liquid flash point. If the fluid escapes from the system and is ignited, a severe fire can result. The heaters for the organic-fluid filled system usually operate at temperatures that can result in spontaneous heating and ignition of leaks.

Fuel explosions can occur from the ignition of unburned fuel or flammable products of incomplete combustion during lighting-off, firing, or re-lighting. Explosions can also occur after shutdown if fuel leaks into the combustion chamber.

Burner management, temperature control, safety ventilation, control of solvent feed, explosion venting, and cleaning of internal deposits are all very important safeguards. Installation and testing of safety devices, control of ignition sources, good housekeeping, and the installation of automatic fire protection systems are equally important loss prevention practices.

Loss Control Recommendations

Construction and Location

Locate ovens and dryers on the ground floor in buildings/areas of non-combustible construction. Do not locate equipment in below-ground locations. If below-ground installations are unavoidable, communicate with the local Fire Service to ensure adequate access for manual fire-fighting is achieved.

Avoid storage of combustible materials close to or under ovens and dryers. A minimum clearance of 3 metres should be achieved from the oven/dryer and its burners/heaters.

Construct ovens and dryers as follows:

- Use non-combustible construction and insulation throughout.
- Ensure interiors have smooth surfaces to allow for easy cleaning.
- Provide easy access to all internal areas for inspection and cleaning.
- Use non-combustible racks, trays, spacers, and containers. Location inside ovens should allow for easy cleaning of these items.
- Ensure joints between sections of insulated metal panels are tight to minimize the leakage of condensable vapour into the interiors of the panels.

Construct ducts entirely of sheet steel or other non-combustible material.

Ducts should be vertical wherever possible. Avoid major changes of direction or horizontal runs where flammable/combustible deposits could generate.

Wherever ducts pass through combustible walls, floors or roofs, provide non-combustible insulation or clearance (or both) to prevent combustible surface temperatures exceeding 71°C. This would normally be achieved by ensuring combustible materials are cut away for at least 150mm and back filled with non-combustible mineral wool, or alternative non-combustible, low heat-conducting material. A steel collar/sleeve should then be fitted around the duct through the full thickness of the wall, floor or roof which it passes.

Provide inspection hatches throughout the whole duct length to allow for inspection and cleaning of the interior surfaces of ducts handling flammable vapours or combustible solids.

Where ducts pass through non-combustible walls, floors or partitions, the space around the duct should be sealed with non-combustible material to maintain the fire resistance rating of the barrier. The duct should have the same fire rating as the wall, floor or partition through which it passes or could also be fitted with an automatic fire damper of the same fire rating where it passes through the wall, floor or partition.

Equipment and Processes

An emergency fuel supply shut off valve or power isolation switch should be provided in a safe remote location away from the ovens/dryers. It should be readily accessible so that a fire or explosion does not prevent access to the valve or switch. A good level of signage should be provided to highlight the valve or switch location and position.

Individual equipment isolation valves or switches should also be provided for each piece of equipment in accessible locations. A good level of signage should again be provided to highlight the valves/switches and their position and training provided for operators in their use.

Provide explosion vents for ovens/dryers where there are fuel or process vapour explosion hazards. For installations with multiple zones, treat each zone separately when calculating the extent of explosion venting required. For ovens where flammable mixtures could accumulate below the conveyor, vents are likely to be needed on the oven/dryer wall both above and below the conveyor.

Safeguards for gas or oil fired oven/dryer burner systems include:

- Prior to each fryer heating system start-up, provision should be made for the removal of all flammable vapours and gases that have entered the heating chambers during the shutdown period. At least four system volumes of fresh air or inert gas should be introduced during this purging cycle.

- Prior to the re-ignition of a burner after a burner shutdown or flame failure, a pre-ignition purge should be completed.

- Where a fan is essential for purge or safety ventilation of a fryer, fan operation should be proved and interlocked into the burner management system.

- Ensure adequate combustion air for proper operation of the burners and mixers and for subsequent combustion. Interlock each fan/blower to ensure that they are placed in operation before the fuel safety shutoff valves and electric ignition can be energized. This should also ensure that failure of any fan will automatically close the safety shutoff valves and de-activate the ignition system.

- Proof of a reliable ignition source before fuel can reach the main burner.

- A limited trial-for-ignition of the main burner flame.

- Shutoff of fuel on flame failure.

- Provide fuel pressure interlocks, low and high gas pressure switches for gas burners, low oil pressure switches for oil burners, and low atomizing medium pressure switches (air or steam) for oil burners.

- Provide oil temperature interlocks for heavy oil burners that require pre-heated oil. The interlocks should prevent lighting-off if the oil temperature is below that recommended by the burner manufacturer, and shut off all oil safety shutoff valves if oil is not at the recommended temperature during firing.

- Safety interlock trips - when an oven or dryer operates automatically without constant operator attendance, all trip interlocks would normally require a manual reset unless the interlock system includes a high-high (or low-low) redundant interlock. In those cases, operation of the high (or low) interlock may not require a manual reset provided:
  - The control system is designed to automatically re-start the oven/dryer when the trip condition clears.
  - Operation of the high-high or low-low interlock would require a manual reset.
  - All trips should require operator intervention and manual reset for ovens and dryers not designed for unattended automatic operation.

- Provide observation ports for each of the burners so pilots, electric igniters and flame-sensing elements of combustion safeguards can be easily observed.

The proper combination of interlocks and flame-supervisory combustion safeguards is essential. Supervision of fuel pressures, air-flow, essential air-damper positions, fans, purging, oil temperatures (if relevant), and oil-atomizing medium (if relevant) is important for anticipating the development of unsafe conditions and for initiating an automatic safe shutdown of the fryer.

Alarms/Interlocks

Provide and arrange a high-temperature limit switch to alarm and shut down the fryer heat source if the oil temperature in the fryer (or any associated heat exchanger feedline to the cooker) exceeds 30°C above the normal maximum operating temperature. Ensure these high temperature limit switches are independent of the normal heating system controls.

Adjust the set point of the over-temperature limit control as specified by the oven/dryer manufacturer, but no higher than 30°C above the normal oven/dryer temperature. If combustible materials are processed in the oven/dryer, set the limit at least 50°C below the auto-ignition temperature of the material being processed. Adjust the temperature limit when the product is changed and has a lower auto-ignition temperature.

Locate the sensor for the over-temperature limit control where it will most rapidly detect an over-temperature condition. In some cases, more than one limit control may be needed.

For gas-fired or oil-fired ovens and dryers, interlock the over-temperature limit control with the fuel safety shutoff valves.

For steam-heated ovens and dryers, interlock the over-temperature limit control with a self-closing valve in the steam supply line.

For electrically heated ovens and dryers, interlock the over-temperature limit control with a contactor in the main supply circuit to the heating units. Do not use the contactor that is used for standard temperature control.

Only use components for the over-temperature control that will fail safe (i.e., cause the same response as an over-temperature condition).

For zoned ovens, provide separate over-temperature limit controls in each zone.

Safety Ventilation

Ensure there are adequate safety ventilation systems to keep flammable vapour concentrations below 25% of the lower explosion limit (LEL). Interlock detection systems to shut down the source of heat and solvent or product feed (and by-pass the exhaust to atmosphere where an oxidizer is used) at no more than 50% of the LEL.

Provide interlocks for fans, conveyors, and heating systems to ensure the following:

- All fans whose failure would adversely affect the safety ventilation rate or flow pattern are placed in operation before the conveyor can be started.

- Failure of any fan should automatically stop the conveyor, close the safety shutoff valves, and deactivate the ignition (of gas-fired or oil-fired ovens) or de-energize electrically heated ovens. If stopping the conveyor is likely to result in the work igniting, additional interlocks could be provided to ensure the following:

  1) The conveyor is in operation before the safety shutoff valves can be energized and opened and the electric ignition system activated (for gas-fired and oil-fired ovens), or the heating system energized (for electric-heated ovens).

  2) Failure of the conveyor will automatically close the safety shutoff valves, deactivate the ignition system, or (for electric-heated ovens) open the contactor in the main power supply.

It is acceptable to move the conveyor semi-automatically to remove work from the oven in the event of a conveyor stoppage due to fan failure. This may be controlled by a push button switch located in a safe, accessible area.

Operation and Maintenance

Oven/Dryer Maintenance

Inspect and test safety controls at least annually and in accordance with the manufacturer's instructions.

Clean ovens/dryers and ducts at regular intervals if they are subject to a build-up of flammable deposits of condensed solvent or oil vapour, accumulations of combustible lint, dust, or other combustible material. The rate at which deposits build varies considerably with different ovens/dryers and processes. No specific inspection and cleaning schedule can cover all ovens. Frequency of inspection and cleaning should be based on a thorough risk assessment and original equipment manufacturers/providers may be able to provide guidance. Inspection and cleaning programmes should be continually monitored for adequacy and the frequency increased if abnormal deposits are observed. It is best practice to record volume/weight of debris removed, along with production volumes for the period; this allows comparisons and to identify any abnormal conditions which may be causing excessive debris build up.

Clean deposits from racks, trays and conveyors regularly. Use metal (or other non-combustible material) trays to collect deposits from ovens/dryers. Use trays that can be easily removed for cleaning.

Pay particular attention to cleanliness at heaters, steam coils, housings, and ductwork since these are the hottest spots where charring and eventual ignition are most likely. Remove fuel oil leakage or condensed oil vapour in the vicinity of oven heaters frequently, and tighten piping to prevent further leakage. Also pay particular attention to the end of ducts supplying fume incinerators since these incinerators are a likely ignition source.

Explosion Vent Maintenance and Tests

Check door vents and associated latches regularly (at least every 6 months) and record the results as part of the oven/dryer inspection and maintenance programme. Conduct actual pull/push tests with pressure release measurements at least annually.

Inspect roof and wall panels annually to verify they move freely and are not stuck in place.

Safety Ventilation Maintenance and Tests

Before any oven or dryer is placed in operation, measure the minimum ventilation rate provided by the safety ventilation system. At the same time, check the evaporation rate to ensure the safety ventilation system capacity is proven adequate. Tests have often shown wide variance between design capacity and actual measurements taken once installed in the field.

Measure the ventilation rate before making any process changes that would affect the rate of ventilation required. These include changing the character of the work or solvent (or the percentage by weight of solvent), increasing batch loads or conveyor speeds, shortening pre-drying periods, and increasing oven/dryer temperatures or ramp rates. Moreover, before making such changes, determine the evaporation rate and re-calculate safety ventilation needed. Never operate an oven with its safety ventilation system impaired or over-burdened.

Test safety ventilation systems at least annually to prove sufficient ventilation is achieved.

Additional hazards are introduced when ovens/dryers are connected to solvent recovery or fume incineration systems, so more frequent checks of the safety ventilation's adequacy should be made. Include determination of the evaporation rate and air-flow checks.

Inspection of Safety Controls

Inspect and test safety controls using personnel who are familiar with the equipment and functions of the controls.

The following inspection schedule is proposed as a guide. Details and intervals may vary according to the operation and equipment. The recommended frequencies are considered best practice. Keep documented records of inspections, tests and maintenance work.

Quarterly:

- Fuel safety shutoff valves for leakage
- Fan and airflow interlocks
- Purge interlocks
- Flame failure system components
- High-temperature limit switch
- Door and damper limit switches
- For oil:
  1) Fuel pressure and temperature interlocks
  2) Atomizing media interlocks
- For gas:
  1) High and low fuel pressure interlocks

Six Monthly or Annually:

- Igniter and burner components
- Combustion air supply system
- Piping, wiring, and connections of all interlocks and shutoff valves
- Combustion control system
- Calibration of indication and recording instruments
- Automatic firing checks
- Operating sequence tests, all components
- Combustible gas analysis automatic interlocks (calibrate as needed)
- Gas cleaner and drip leg
- Explosion venting latches
- Conveyor interlocks

Protection

Consider the installation of fixed automatic fire protection systems in oven or dryers under any of the following conditions:

- Oven/Dryer construction or insulation is combustible.
- Material being processed is combustible.
- Racks, trays, spacers, conveyors, or containers are combustible.
- Appreciable accumulations of combustible deposits are likely on the interior oven surfaces or on racks, trays, etc.

Ensure protection is also provided in ducts or plenum chambers that accumulate combustible deposits. If ovens or dryers use an organic heat transfer media comprising ignitable liquid, then protection should also be provided for the room containing the heater for the organic heat transfer system.

Conduct a risk assessment to identify the appropriate response of critical equipment (e.g., fuel supply/heating system, conveyors, fans, dampers, etc.) on activation of any fire protection system. Factors for determining the proper response include:

- The design of the oven or dryer
- The source of combustible materials
- The ability to isolate combustible sources

- The impact of fresh air
- The consequences of shutting the equipment down or keeping it in operation.

Provide interlocks to automatically perform these actions, as determined by the risk assessment.

Various protection options can be considered, with the most common being automatic sprinklers, water mist systems and gaseous systems.

Systems should be fully compliant with any international approval standards that may be applicable. Examples include:

- EN 12845 or NFPA 13 for Sprinklers
- EN 15004 or NFPA 2001 for Gaseous Systems
- BS8489 or NFPA750 for Water Mist Systems

Whichever protection system is considered, a full risk assessment should be completed to confirm appropriateness and adequacy. Refer to RSA, or your normal risk management advisor, for review and approval before any decision is made on the installation of fixed fire protection systems to ovens or dryers.

Reference / Further Reading:

RC26 - Recommendations for thermal fluid heating systems

RC36 - Recommendations for fire prevention on bakery ovens

RC31 - Recommendations in automotive refinishing and paint spraying (heating, drying and curing sections)

RC32 - Recommendations for paint spraying (heating, drying, stoving and curing sections)

RC53 - Recommendations for fire safety in the use of thermal oxidation plant