Property Risk Consulting Guidelines

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PRC.17.22.1

GLASS MELTING FURNACES

INTRODUCTION

Glass manufacturing facilities use specially designed furnaces to form molten glass and keep it at the correct temperature for further processing. Glass melting furnaces vary in design, capacity, type of fuel fired and other features, but they are subject to the same types of losses.

The weakest point of every glass melting furnace is the refractory, which is the primary component of the furnace. Normal glass processing erodes the refractory, which can break through if not repaired or replaced frequently enough.

Refractory is even more quickly damaged by maintaining its temperature too high or too low, by sudden overheating or by excessively fast cooling. These situations can be caused by improperly set controls, failure of controls, electrical power outage, loss of furnace cooling medium, or flame failure. Refractory can also be damaged by tramp metal from raw materials.

Molten glass breakout from a melting furnace can result in extensive cleanup and long downtime. This PRC Guideline describes the measures necessary to protect glass melting furnaces against refractory damage and against damage from molten glass breakout and fire.

POSITION

Management Programs

Implement effective management programs for loss prevention and control in all the areas discussed in *OVERVIEW*. Incorporate all practices and procedures necessary for safe operation of glass melting furnaces into these programs. Place special emphasis on the following areas:

Process Hazard Evaluation

Determine where molten glass could go in the event of a furnace break, and identify what could be damaged. Remove from the potential area of damage as many furnace components as possible, and protect components that must stay in this area with refractory. Route all piping, power cables and control cables outside this area. Always use heat-resistant cables.

Base the type and thickness of refractory on conditions in the furnace, including expected temperatures, chemical composition of the glass being made, and amount of time anticipated between relines.

TABLE 1
Preventive Maintenance For Glass Melting Equipment

Equipment	Guidelines
All	PRC.1.3.1
Emergency generators	PRC.6.2.1.1
Motors	PRC.5.10
Refractory in furnace and regenerators	Perform daily visual inspections and regular thermographic inspections.
Regenerator selector valves	Perform regular inspections and servicing.
Transformers	PRC.5.4.5 and PRC.5.9.1
Water cooling systems	Control water quality and measure piping thickness at relines.

Back up all utilities needed to prevent molten glass breakout from the furnace in an emergency. These include, but may not be limited to, electrical power supplies, electrical distribution grids, cooling water supplies, cooling water distribution piping, cooling water pumps and pump motors, cooling air fans and fan motors, combustion air fans and fan motors, supplies of oxygen and other gases, and furnace fuel supplies. Arrange onsite fuel gas storage in accordance with NFPA 58 and PRC.8.2.0.1.

Maintenance

When estimating furnace reline schedules, take into account furnace operating temperatures, the expected performance of the refractory, chemical composition of the glass, amount of glass made and length of time since the last reline. Factor in the condition of the furnace refractory at previous relines. However, always base actual furnace reline schedules on the overall condition of the furnace.

Design the preventive maintenance program as described in PRC.1.3.0. Inspect, test and maintain equipment associated with glass melting furnaces according to the guidelines listed in Table 1.

Spare all critical furnace components, including combustion air fans and fan motors, cooling air fans and fan motors, and cooling water pumps and pump motors. Make arrangements in advance for obtaining all the types of refractory used in each glass melting furnace.

Employee Training

Review with employees the history of the furnaces they are operating. Teach furnace operators to identify hot spots. Have them check the furnace for hot spots at least daily. Have independent teams monitor the color of hot spots. Base the decision to reline a furnace early on the seriousness of the hot spots and the expected remaining life of the furnace.

Train furnace operators to take the appropriate actions upon receiving alarms from the furnace control system. Also train them in using all the furnace backup systems and in how to safely shut down the furnace. Training should include draining molten glass from small process lines before it solidifies, where this is possible.

Pre-Emergency Planning

Develop plans for handling furnace upsets and molten glass breakouts. Include procedures for safe, orderly shutdown and draining of the furnace. Also include procedures for cleanup of spilled molten glass.

Prohibit applying hose streams to cool an overheated furnace. Use the cooling system, backup cooling system or specially designed and installed cooling nozzles. If water is used to solidify glass that has broken out of a furnace, apply it carefully to avoid damaging the furnace. Invite the responding fire department for a tour, and show them where hose streams should not be applied.

Housekeeping

Do not store combustible materials near the furnace or any associated equipment or controls. Keep the furnace equipment and building structural members free of combustible residue buildup.

Furnace Controls

Install tramp metal separators on all lines for incoming raw materials.

Monitor the temperature of the furnace refractory with thermocouples. Locate the thermocouples where furnace breakouts are most common, such as the tank sides, bottom and throat. Also locate thermocouples at the crown, where high temperatures can cause collapse.

Monitor the furnace water and air cooling systems. Monitor the coolant inlet pressure, outlet flow and outlet temperature. Also compare the cooling input to the refractory temperature. Provide vibration monitoring for rotating equipment.

Install safety shut-off valves and pressure supervision on all fuel and combustion air trains. Arrange pressure switches to shut off the fuel supply upon sensing any unacceptable pressure.

Use only specially trained personnel to start glass furnaces. Such personnel should provide portable flame supervision equipment and additional fuel train valving, and they should be experienced in handling the thermal stresses of starting a glass furnace.

Containment

Surround the area under the glass melting furnace with a masonry dike designed to contain glass that may spill from the furnace. Do not locate process control equipment in this area. Protect all furnace structural elements in this area against a molten glass spill.

DISCUSSION

Most glass furnaces are large, regenerative tank furnaces that can hold up to 1500 tons (1360 tonnes) of molten glass. These furnaces recover heat by passing combustion air through a set of brickwork, called checkerwork or regenerators, that has been heated by furnace exhaust gases. At the same time combustion air is being heated in one set of checkerwork, exhaust gases heat a second set of checkerwork. Selector valves alternate flow of combustion air and exhaust gases between the two sets of checkerwork.

Small pot furnaces, which are clay- or platinum-lined crucibles, are used to process special glasses, including those that cannot be exposed to furnace exhaust gases. Pot furnaces have capacities of 2 tons (1.8 tonnes) or less.

Some specialty glass melting furnaces are electrically heated. In addition, some fuel-fired glass melting furnaces have electric booster coils.

Today, glass melting furnaces produce hundreds of types of glass. Flat glass has the most varieties. Depending on the desired strength, resistance to extreme temperatures, resistance to fast temperature changes, optical properties and many other features, the chemical composition of flat glass varies widely. Bottle glass tends to have a more uniform composition.

Glass furnaces usually run continuously for six to ten years. Using the results of a process hazard evaluation in the design of a furnace and its refractory helps assure that the furnace will run its entire projected campaign without incident.

Many types of refractory are used in glass melting furnaces. The type chosen depends on many factors, including the corrosiveness of the glass being made and how often the glass recipe will be changed. The process hazard evaluation helps determine the refractories suitable for each furnace.

Since glass melting furnaces operate at approximately 2800°F (1500°C) for years at a time, flame supervision is rarely provided. This is acceptable if the furnace is started only by those experienced in starting glass melting furnaces who provide the necessary combustion safeguards. Some facilities may have their own equipment and trained personnel; many use contractors.

Under normal operating conditions, molten glass erodes the furnace refractory, which is a highly heat resistant type of glass. When the refractory wears enough, hot spots can be seen on the furnace when the lights are turned off. Further wearing can break through the refractory and furnace wall. This is why monitoring hot spots and adequate preventive maintenance is so important for glass melting furnaces.

The refractory in a glass furnace requires a well designed cooling system. Cooling water is usually applied to the furnace throat, around the charger (raw materials feeder), and around the booster electrodes. Furnace walls are usually air cooled. If the cooling system fails while the furnace contains molten glass, the refractory will be seriously damaged. This is why the cooling system must be monitored and must have backup water supplies, fans, pumps, drivers and electrical power supplies.

Keeping the refractory too cool also decreases its service life. When the temperature difference between the inside and outside of the refractory is too high, the refractory wears more quickly. This makes it undesirable to shut down glass melting furnaces, even in an emergency.

Attempting to cool a furnace with hose streams subjects the refractory to very high thermal stresses. In at least one case where a furnace was cooled this way during an electrical power outage, the refractory broke through, resulting in a serious loss. If water fog is used to cool furnace structural elements, the water should be kept away from the furnace.

Molten glass escaping from a glass melting furnace damages everything it contacts that is not protected against such high heat. Control system components are particularly vulnerable. Many furnaces have incurred additional damage after spills due to loss of furnace controls. Diking the furnace, protecting its structural elements with refractory, and moving controls out of the diked area reduces the amount of damage that molten glass breakout can cause.