



Property Risk Consulting Guidelines

XL Risk Consulting

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PRC.17.22.0

GLASS MANUFACTURING

INTRODUCTION

Glass is a supercooled liquid that is viscous enough to stay rigid. Like less viscous liquids, glass has an amorphous, noncrystalline physical structure. Its properties depend on how different atoms and molecules interact within that structure.

The primary components of glass are silica, lime, soda ash and alumina. However, most glass contains small amounts of many other components. Though minor in amount, these components are important for achieving desired properties in the glass, like strength, abrasion resistance, heat resistance and color. Control of the glass manufacturing process, including the temperature of the glass melting furnace, is also important for achieving the desired properties.

The most common glasses are the soda-lime glasses, which are used to make most windows and bottles. Other common glasses are borosilicate, aluminosilicate, borate, lead, phosphate, halide and metallic glasses. Other glass products include ceramics and fiberglass.

Hundreds of kinds of glass are now available. As manufacturers learned to control glass properties and make glass more economically, they have developed glass suitable for more and more applications. In addition to windows, bottles, laboratory glassware and light bulbs, glass is now used to make solar heating panels, acid distillation columns, semiconductors, face plates for space suits, and ports for underwater exploration vessels and space ships.

Glass is broadly categorized as either flat glass or container glass. Flat glass is drawn, rolled or floated. Half of all flat glass produced today is automotive glass. Container glass is pressed, blown or pulled into molds to make jars, bottles, drinking glasses and other vessels, such as video display tubes.

The primary hazards of making glass are from the furnaces used for melting, conditioning, annealing and tempering, and from the bottle forming machines. Most of the furnaces are fuel fired, though some may be electric. Melting and conditioning furnaces also present molten glass hazards. Forming machines involve the hazards associated with combustible liquids since the molds must be lubricated to get the bottles out.

PROCESSES AND HAZARDS

Figure 1 shows a process flow chart for manufacturing glass. Raw materials are mixed, melted, formed and heat treated to make the finished product. Scrap glass from throughout the process, called cullet, is returned to the glass melting furnace. Returning the cullet reduces waste and saves energy in the glassmaking process.

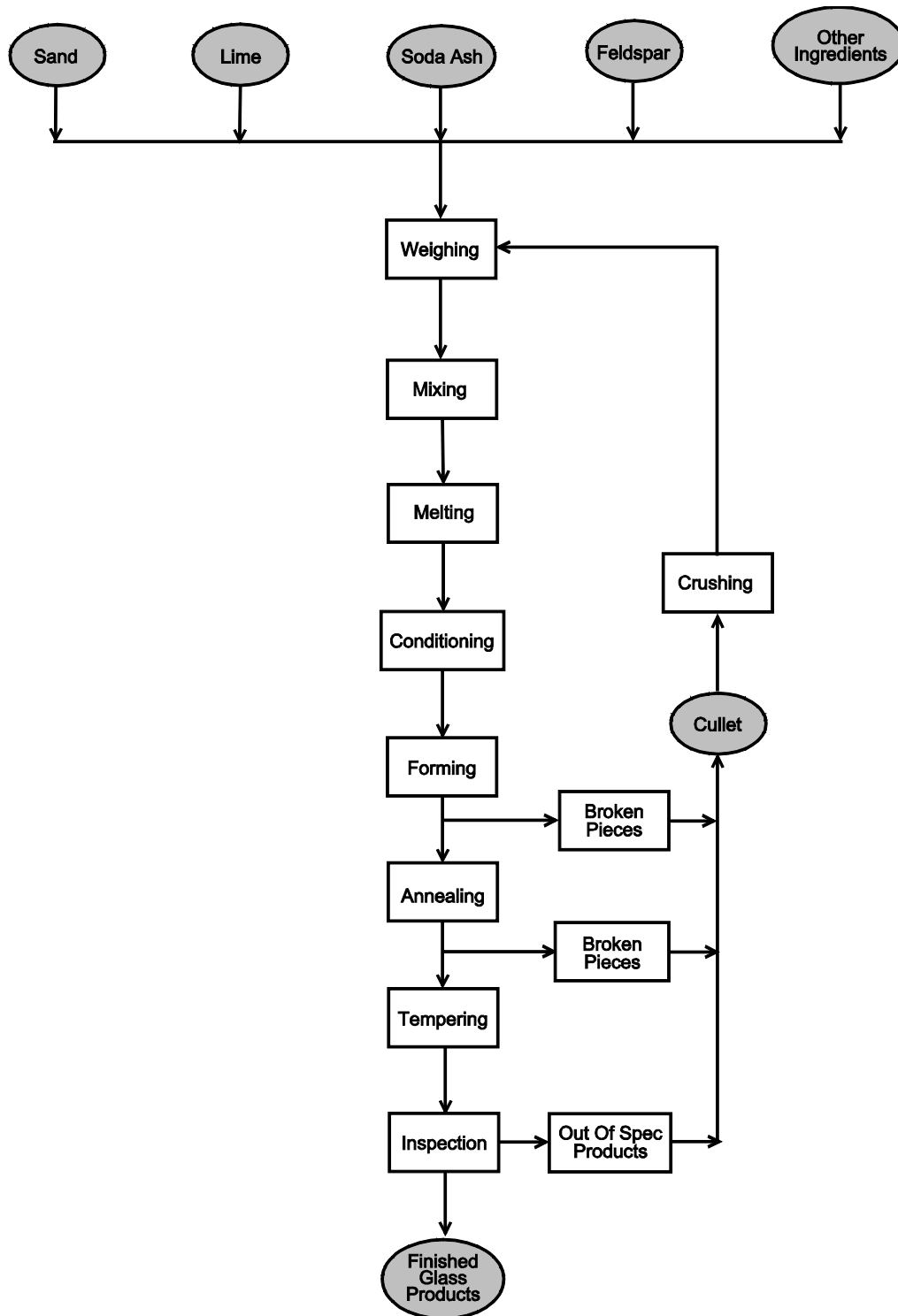


Figure 1. Process Flow Chart For Manufacturing Glass.

Conveyors, including screw, bucket and belt conveyors, are widely used in the glassmaking process. They carry raw materials, cullet and glass products throughout the facility. The primary hazards associated with the conveyors are mechanical breakdown, electrical breakdown and fire in combustible belts.

Glass manufacturing can be highly automated, particularly when the same type of glass is being made for long periods of time. Computers control the equipment that weighs raw materials, adds needed materials to a mix, and runs glass drawing and forming machines. Computers help optimize the process by balancing end use demands with materials preparation, mixing and processing demands. Computers are also used to design container molds.

Automation is required for producing large amounts of consistent quality glass. Loss of computers can totally shut down glassmaking operations.

Raw Materials

To make glass with consistent properties, the particle sizes of all the raw materials must be well controlled. Particles must be kept within specific size ranges, and ratios of different particle sizes must be kept constant. This is accomplished either by purchasing particles of the correct sizes or by screening and sorting raw materials.

Glass usually contains between 70% and 90% silica (from sand) with most of the remainder consisting of a mixture of lime, soda ash and feldspar. Glass also contains small amounts of many other ingredients.

Sand

Good glass sand is over 99.5% silica (quartz). Silica, or silicon dioxide, is the most common glass-forming oxide and the base for most glasses. The next most common glass-forming oxides are the oxides of boron and phosphorus.

Lime

Lime can be magnesium oxide, calcium oxide or a mixture of the two, depending on the type of glass being made. Most lime for glassmaking is obtained from mined dolomite or calcite. Lime is the most common glass modifier, used to make the glass easier to heat and melt.

Soda Ash

Soda ash is sodium oxide, a common flux added to glass. Fluxes act on glass at relatively low temperatures and improve its forming characteristics. Soda ash can actually make glass soluble in water if enough stabilizers are not added.

Feldspar

Feldspar is a source of alumina, which is one of the most important stabilizers added to glass. Glass stabilizers improve the resistance of the glass to chemicals, including water. Many other stabilizers are also used in glass.

Other Ingredients

Almost every stable element in the periodic table and many, many compounds are added to glass for one reason or another. Elements commonly added to glass include arsenic, antimony, barium, fluorine, iron and lead. Compounds commonly added to glass include various oxides and sulfates. Even coke and blast furnace slag are added to glass.

Some of these ingredients make glass easier to prepare and process. Some improve its consistency, strength, flexibility, optical characteristics, opacity, heat resistance, insulating ability, chemical resistance, resistance to thermal shock and many other properties. Metal oxides give glass color, e.g., selenium for red, chromium for green and cobalt for blue.

Mixing

Raw materials for making glass are mixed in batches, usually under computer control. Mixed materials are then usually stored in silos for distribution at the proper speed into the automated glassmaking processes. The primary hazards associated with the mixing process are loss of computer control and breakdown of mixing equipment.

Melting

Glass melting furnaces melt the mixed raw materials to enable working the molten glass into a finished product. The hazards associated with glass melting furnaces are fuel firing, refractory damage and molten glass breakout. PRC.17.22.1 discusses molten glass furnaces and their protection in more detail.

Conditioning

Once the glass is melted, it must be conditioned before it can be processed further. Glass conditioning furnaces (forehearths) are usually separate compartments attached to the melting furnace. These furnaces have their own temperature control system. Conditioning makes the smaller amount of glass a uniform temperature throughout and helps avoid imperfections called blisters, seeds and stones.

The hazards of conditioning furnaces are those associated with fuel firing and molten glass breakout.

Forming

The methods of forming, or shaping, depend on the type of glass being made. There are three common methods for forming flat glass and two for forming glass containers. Each method has its own hazards.

Flat Glass

Flat glass is drawn, rolled or floated. Two glass drawing processes are the Fourcault process and the Colburn process. In the Fourcault process, drawing rolls pull a vertical ribbon of glass through a kiln, called a débiteuse. Still traveling vertically, the glass passes through an annealing lehr and is cut to appropriate lengths. The Colburn process is similar to the Fourcault process except that the glass is bent to the horizontal right after drawing.

Rolled glass is also called plate glass. Forming rolls continuously roll molten glass into a horizontal ribbon. The ribbon is cooled, annealed, ground, polished and inspected. After all other processing is complete, it is cut to the desired size.

Float glass is the newest type of flat glass. In this process, molten glass floats over a bath of liquid tin in a nitrogen atmosphere with some hydrogen. Electrodes in the float enclosure heat and fire polish the glass before it leaves the chamber. Floating molten glass this way produces a very high quality surface that needs only limited grinding or polishing.

The hazards of producing flat glass are from the fuel firing in melting and conditioning furnaces and in débiteuse kilns, and from the molten glass in the holding tanks. An additional hazard of producing float glass is from the molten tin in the float enclosure.

Glass Containers

Glass containers are made by pressing, blowing or pulling molten clumps of glass, called gobs, into molds. A combination of these methods can also be used.

Two common machines for making glass containers are the Owens machine and the Individual Section (I.S.) machine. The Owens machine is a large, nonmoving central cylinder with 10 to 15 processing units on a rotating perimeter. Each unit performs a different step. The Owens machine is cam driven and rotates the bottles through the appropriate work stations.

The I.S. machine is the most modern and most common machine for making glass containers. Each unit on an I.S. machine performs all the steps needed to make a bottle. Instead of having the machine travel to the gob, the gob is delivered to the machine. Each unit on the machine can be individually timed, and when units are inactivated, the remaining units on that machine can keep running.

The hazards of making glass containers are similar to those for making flat glass. In addition, releasing containers from molds requires that the molds be well lubricated. The lubrication can be in the form of lubricating fluids or carbon deposits. The lubrication oil, usually called mold release oil or forming oil, vaporize and collect on building and machine surfaces. This oil residue presents the most

serious fire hazard at any facility manufacturing glass containers. The carbon deposits are a result of either acetylene gas or MAPP gas being injected into the hot mold and the gas cracking to form carbon. Making containers also requires other oils, including lube oil for air compressors and gob distributors.

Large clamshell ventilators at the roof remove vaporized forming oil from the machines that make glass containers. The ventilators usually run over the entire container forming line from the glass furnace to the Lehr. Oil constantly collects on the surfaces of these ventilators, and they can easily become involved in a fire.

The gob distributors for the machines that make glass containers are in constant motion and must be kept lubricated. The lubricating fluid used, usually an oil, is another fire hazard associated with making glass containers.

Annealing

Glass is annealed in furnaces called Lehrs. Annealing removes the strain glass undergoes when solidifying. If this strain is not removed, the glass products will break very easily. Flat glass is annealed after it is drawn, rolled or floated and before it is cut. Glass containers are annealed after they are formed.

Most annealing Lehrs are fuel fired. The hazards of these Lehrs are those associated with any fuel fired equipment.

Tempering

Glass is greatly strengthened by being heated in a tempering furnace, then cooled in a specified manner. The tempering process introduces compressive forces at the glass surface that counterbalance the tension in the central layers of the glass. This balancing of forces within the glass makes it very strong.

Like annealing Lehrs, most tempering furnaces are fuel fired. The hazards of tempering furnaces are those associated with any fuel fired equipment.

Scrap Processing

Scrap from the glassmaking process is crushed into small pieces called cullet. The oil coating on the cullet pieces drains into an oil reclaim area holding about 300 gal–500 gal (1100 L–1900 L) of oil.

LOSS PREVENTION AND CONTROL

Management Programs

Implement effective management programs for loss prevention and control in all the areas discussed in *OVERVIEW*. Incorporate all practices and procedures relevant to glassmaking operations into these programs. Place special emphasis on the areas described in PRC.17.22.1 and on the following areas:

Housekeeping

To the extent possible, keep oil residue from accumulating in bottle forming areas. Inspect and clean oil from forming equipment at each changeover. Steam clean or wipe down all process and peripheral equipment, including motors and conveyors, at least twice a year.

Inspect building surfaces near the forming equipment, including pits, walls, roofs and ventilators. Clean these surfaces whenever enough oil accumulates for lint to stick to it or at least once a year. Include the forehearth mezzanine and surrounding areas in the cleaning program.

Maintenance

Implement preventive maintenance for the following equipment:

- Motors and electrical equipment, in accordance with PRC.1.3.1 and PRC.5.10.

- Compressors in accordance with PRC.3.1.1.
- Lubricating systems
- Hydraulic systems, in accordance with PRC.9.2.4.
- Fuel fired equipment, in accordance with NFPA 86 and PRC.4.0.1.
- Conveyors, in accordance with PRC.9.3.1.

Also follow the recommendations for preventive maintenance in PRC.17.22.1.

Process Hazard Evaluation

Evaluate the hazards involved in all parts of the glassmaking process. Estimate and take safeguards against the consequences of all process upsets. Re-evaluate hazards when planning any process changes. Such changes should include making a different type of glass or using a different type of oil anywhere in the process.

Back up the electrical power supply, compressed air supply and other utilities critical to keeping the process running safely. Install backup critical cooling wind fans and water pumps, or keep spares available.

Refer to PRC.17.22.1 for information on process hazard evaluation for glass furnaces.

Employee Training

Teach employees about the hazards of the equipment they operate, and train them to take appropriate action upon observing unsafe conditions. These conditions should include off-normal process temperatures, problems with utilities, and excessive accumulation of oil residue anywhere in the facility.

Building Interior

Provide sprinkler protection for all areas of combustible construction or occupancy. Unless otherwise specified, design sprinkler systems for production areas in accordance with NFPA 13 and PRC.12.1.1.0 to provide 0.12 gpm/ft² (4.9 L/min/m²) over the most hydraulically remote 3000 ft² (279 m²).

Provide automatic or manual deluge systems to protect clamshell ventilators. Design these systems to meet a density of 0.30 gpm/ft² (12.2 L/min/m²) over the protected area.

Provide sprinkler protection for storage areas in accordance with NFPA 13 and PRC.12.1.1.0. Install inside hose connections throughout processing and storage areas and supply them from the sprinkler systems.

Conveyors

Install vibration monitoring equipment on the moving parts subject to vibration on large conveyors necessary for glassmaking. Protect conveyor motors in accordance with PRC.5.10.

Arrange and protect belt conveyors in accordance with PRC.9.3.1. Monitor all incoming raw materials for tramp metal.

Computers

Arrange and protect computers controlling glassmaking processes in accordance with PRC.17.10.1.

Melting And Conditioning Furnaces

Protect glass melting and conditioning furnaces in accordance with PRC.17.22.1.

Float Glass Enclosures

Monitor the temperature of the tin bath and annunciate high or low temperature in the control room. Provide a hydrogen safety shut-off valve arranged to close automatically upon sensing high or low hydrogen pressure, high or low nitrogen pressure, or low tin bath temperature.

Dike the area around the molten tin bath so spills of liquid tin will not damage any process equipment. Maintain refractory in accordance with the process hazard evaluation for the tin bath.

Bottle Forming Lines

Protect forming machines with a water spray system. Design the water spray in accordance with NFPA 13 and PRC.12.1.1.0. Use a design of 0.35 gpm/ft² (14.2 L/min/m²) over entire area including all surfaces exposed to the accumulation of oily residues. This could include all forming machine surfaces, elements of the building structure adjacent to the forming machine, mezzanines above the forming machines, and oil collection pans below the forming machines. Arrange the water spray system for automatic and manual release. Automatic operation can be initiated by a dry-pilot system or heat detectors. Design the manual operation to use a mechanical release placed at a location that will be accessible during an emergency. Train the Forming machine operators and other personnel working in the area on the location and operation of the manual releases. Equip the water spray nozzles with caps to avoid the accumulation of oily residue inside the nozzles and system piping. Periodically, remove the caps to verify that their operation has not been compromise by accumulated residues.

Have operators use the least amount of oil necessary for manually swabbing molds.

Arrange automated mold lubricating systems to spray as little excess oil as possible. Monitor these systems for high oil pressure. Interlock these systems to shut down upon detection of excess flow.

Annealing Lehrs And Tempering Furnaces

Provide combustion safeguards and process interlocks for annealing lehrs and tempering furnaces in accordance with NFPA 86 and PRC.4.0.1.

Cullet Oil Reclaim

Locate cullet oil reclaim in a separate area of the facility remote from glass processing operations. Design sprinkler protection for this area for Extra Hazard, Group 1 in accordance with NFPA 13 and PRC.12.1.1.0.