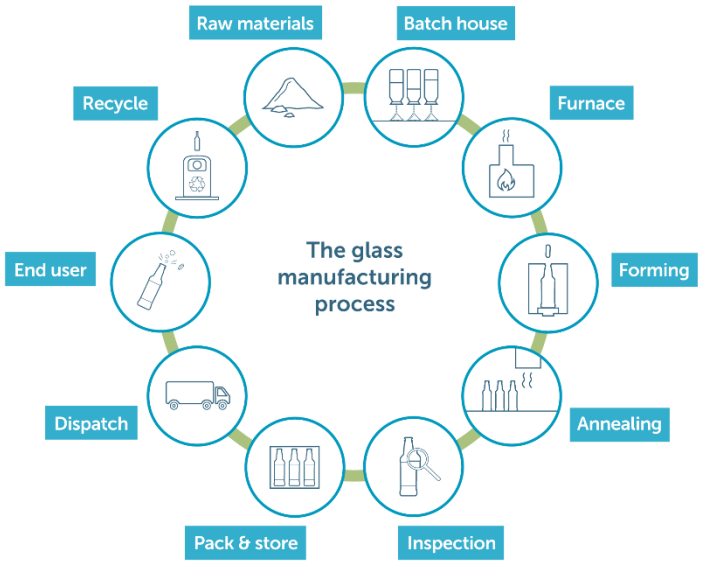
Appendix 1

The glass manufacturing process

Glass containers are produced from soda-lime silica glass through a continuous manufacturing process that operates 24 hours a day, 365 days a year. The various stages of this process are shown in the diagram below.



Batch preparation

The main raw materials used to produce container glass are silica sand, soda ash (sodium carbonate), and limestone. Small quantities of other materials may be added to impart colour, enhance chemical or physical properties, or assist in removing gas bubbles during the melting process.

Only raw materials that meet the required chemical purity specifications are used. The raw materials are stored in the batch plant, typically in large silos. Before melting, they are combined in a batch mixer equipped with load cells to ensure precise weighing of each component. Cullet (recycled glass) is also added to the mix. Manufacturers aim to maximise cullet usage for its environmental benefits; however, this may be limited by glass colour requirements or the availability of cullet of suitable quality.

Both internal cullet (rejected glass from within the factory) and external cullet (processed containers from recycling streams) are used, provided they meet set specifications. In some cases, flat glass cullet from windows may also be incorporated.

Glass melting

The raw materials and cullet are transported via conveyor from the batch house to the furnace, where they are fed at a constant rate by the batch feeder. The furnace is a large refractory, box-like structure operating at temperatures of up to 1,600 °C. Heat is supplied by gas burners firing over the surface of the glass melt, and in some cases, supplemented by electrodes submerged in the melt.

The high furnace temperature is essential to drive a complex series of reactions between the raw materials, forming glass. From entry into the furnace to exit at the far end, the melting process can take up to 24 hours. This time allows the melt to homogenize and enables gas bubbles to rise to the surface.

Glass forming

The molten glass from the furnace flows along a forehearth, which maintains a uniform temperature. At the end of the forehearth is the spout, where a mechanical plunger feeds the glass through an orifice to form a continuous stream. This stream is cut into sausage-shaped pieces of molten glass called gobs, which are delivered via a chute into moulds on the glass-forming machine (IS machine).

The forming process consists of two stages. First, the gob enters the blank mould, where it is either blown using compressed air or pressed with a plunger to create the container's top (glass finish) and a preliminary shape. The blank container is then transferred to a second mould, where it is blown to form the finished container.

The IS machine operator periodically swabs the moulds with a lubricant (mould dope) to prevent sticking.

The hot containers (above 500 °C) leave the IS machine via a conveyor and pass through a hot-end coating hood. This process applies a very thin layer of tin oxide to the container's outer surface, acting as a primer for the cold-end coating and improving mechanical strength.

Annealing

The forming process involves rapid temperature changes, which induce internal stresses within the glass. These stresses must be removed before the item is safe to handle. This is achieved through annealing, a process that reheats the glass to around 550 °C to relieve stresses, followed by a controlled cooling cycle to prevent new stresses from developing.

Annealing is performed continuously by passing the containers through a long annealing oven on a conveyor. As the containers exit the oven, their outer surface is sprayed with a cold-end coating, which helps prevent damage during subsequent handling.

Inspection, packing and dispatch

Each container undergoes multiple online checks using automatic inspection equipment. In addition, containers are periodically removed from the line, both at the hot end and cold end for manual quality checks conducted in the factory and laboratory.