**Glossary**

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| Alumino-Silicate Glasses | These glasses have high deformation temperatures and are suitable for the envelopes of high pressure discharge lamps. Typical composition 55.3 $SiO_2$, 7.2 $B_2O_3$, 0.6 $Na_2O$, 0.4 $K_2O$, 22.9 $Al_2O_3$, 8.5 MgO, 4.7 CaO |
| Annealing | The removal of undesirable stress by suitable heat treatment. The glass is held at a constant temperature in the annealing range until the stresses have almost completely disappeared, then cooled very slowly until considerably below the lowest possible annealing temperature and then finally cooled rather more rapidly to room temperature. Annealing allows finishing operations such as cutting, grinding and polishing to be carried out safely. The temperature, and speed of cooling depends upon the type of glass, thickness, thermal properties of the glass i.e. dark coloured glass has different heat transmission properties to clear glass. |
| Annealing Point | The temperature at which a fibre of glass of length 230mm and diameter 0.65mm extends at a rate of 0.14mm/min under a load of 1kg. It is the temperature at which internal stress is relieved. |
| Batch | The mixture of raw materials used to make glasss. |
| Batch Charger | A machine that charges batch into a tank furnace, at a rate adjusted to balance the rate at which glass is removed from the other end of the furnace and keep the glass level constant. It is usually linked to the glass level controller. |
| Batch House | The buildings in which the raw materials for making glass are stored, weighed out, and mixed together before being melted are collectively known as the batch house. |
| Batch-free Time | The time needed to complete the melting reactions in a glass melt is known as batch-free time. It includes the times required 1) to heat the batch until it begins to react; 2) to complete the vigorous initial melting reactions; and 3) to dissolve the residual sand grains. |
| Borates Glasses | Due to their resistance properties it is used in sodium vapour lamp glass. Also in optical applications due to their high indices with modest dispersion |
| Borosilicate Glasses | Ovenware and sealing glasses in the electrical valve and lamp industries. Typical composition of ovenware 80.6 $SiO_2$, 11.9 $B_2O_3$, 4.5 $Na_2O$, 0.5 MgO, 0.5 CaO, 2.0 $Al_2O_3$ |
| Bridgewall | A transverse wall built across a tank furnace to divide the tank into two separate chambers, the melting end and working end. |
| Container Glasses | Bottles, jars, or any container which may be subsequently capped or closed. Clear glass is known as “Flint” and typical composition 73 $SiO_2$, 2.0 $Al_2O_3$, 13.0 $Na_2O+K_2O$, 11.0 MgO+CaO, 0.5 BaO |
| Cross-Fired | Refers to regenerative furnaces in which the flames pass across the width of the furnace. The width must be such as to allow proper development of the flames. The number of ports along each side of a cross-fired furnace is relatively small. |
| Crown | The roof of a glass tank furnace is referred to as the crown. It is |

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| | usually a free-standing arch (part of a cylinder or sphere) built of high quality silica bricks. Since it is supported only along the edges (or around the circumstances) it must be heated to operating temperatures very carefully. |
| Crown Optical Glasses | Optical glass of relatively low refractive index and high Abbe number v. |
| Cullet | Previously melted glass, often waste from the manufacturing process, added to the furnace with the batch. Until recently cullet formed perhaps 20-30% of total batch but this proportion can now be very significantly higher. Problems can arise if the cullet is not close to the composition of the glass being melted. |
| Danner Process | A mechanized method of making rod and tubing. A steady stream of glass falls on to the upper end of a rotating refractory mandrel inclined at about 30 degrees to the horizontal. As it spreads towards the tip it forms a layer of glass which is drawn off and turned horizontally by a drawing machine. To make tubing air is blown down the hollow central core of the mandrel. |
| Day Tank | A small tank furnace which is used like a pot furnace: batch is charged in the late afternoon, melted overnight, and worked the next morning / day. Most often used when the glass is corrosive or the melting temperature is so high that pots would have a very short life. |
| Devitrification | The growth of crystals which can occur when the melt is held too long at a temperature just below the liquidus temperature. This can happen unintentionally in glass manufacture – see tips. |
| End-Fired | A furnace in which the flames travel lengthwise through ports in the end wall. Not as common as cross-fired types. |
| Feeder | A mechanism fitted to the end (nose) of a forehearth for measuring out gobs of glass of accurately controlled weight and delivering them to the forming machines at the proper rate. |
| Flint Optical Glasses | Optical glass of relatively high refractive index and low v value. |
| Float Glasses | The modern method of making high quality flat glass which has now largely replaced both sheet and plate glass in many applications. A horizontal stream of glass “floats” on to a bath of molten tin in such a way that both surfaces become flat under the influence of surface tension and gravity. The atmosphere above the tin must be kept strongly reducing to prevent oxidation of the tin which would then react with the glass. When almost rigid the fire-finished ribbon is lifted off and passes into the lehr. The thickness of the ribbon can be changed from it’s natural value of approx. 6mm by special techniques. There is no need for expensive grinding and polishing stages in the process. |
| Forehearth | A channel along which molten glass flows from the furnace to the forming machines. There is now full automotive control of the temperature distribution, both transverse and longitudinal, so that the glass is brought to the correct temperature for feeding to the machine. There may be cooling vent and burners in various postions to control the temperature. Forehearths vary in size but typically might be 6m in length and 0.5m in width. The depth of |

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| | the glass would be perhaps 0.2m. |
| Glass | A glass, or a substance in the glassy or vitreous state, is a material formed by cooling from the normal liquid state, which has shown no discontinuous change (such as crystallization or separation into more than one phase) at any temperature, but has become more or less rigid through a progressive increase in its viscosity. As a material, glass behaves like a typical solid in certain respects such as mechanical properties but has a non-crystalline structure |
| IS Machine | Unlike earlier machines for mass production of container glass these machines have independent sections which are placed side by side in sections. The moulds on each section can be adjusted independently of the other sections and the parison and blow moulds remain stationary except for the lateral movements involved in opening and closing. Typically each section will have 1, 2, 3 or 4 moulds working simultaneously and the machine would have 8, 10, 12, 16 or more sections. Typical is a 10 section double gob machine (2 moulds in each section) but for small ware such as baby food jars or stubby beer bottles 12 or 16 section triples or quads are not uncommon. |
| Lead Glasses | Flint Optical Glasses contain significant proportions of lead oxide but the term usually refers to “Lead Crystal” glasses of 24% approx. or “Full Lead Crystal” of 30/32% approx. content. |
| Lehr | A furnace in which a suitable temperature profile has been established in order to provide adequate annealing for the ware in question. The ware moves on a continuous belt and experiences a period of stress release, slow cooling to minimize the re-introduction of stress, and a faster rate of cooling to allow the ware to be handled at the exit to the lehr. |
| Liquidus Temperature | The highest temperature at which a liquid can exist in equilibrium with crystals of its primary crystalline phase is its liquidus temperature. Above this all crystal dissolve, below crystallization may not occur and the glassy “solid” can be created without crystals. |
| Melting End | The main chamber of a tank furnace into which the batch is charged and melted. Much of the refining and homogenising also occurs in this area. |
| Orifice | The circular opening in the bottom of the forehearth through which the feeder forms gobs and delivers them to the forming machine. The orifice can be changed so that the gob size is suitable for the ware being made. |
| Parison | The shaped and partly blown object formed as the first stage in making a container (or other article) by a two stage process. The paraison is also called the blank. |
| Paste Mould | An iron mould having a lining of solid porous material. It is dipped into water before use so that a cushion of steam forms between mould and glass. The porous layer may be carbon made by carefully heating a coating of cork granules mixed with a suitable adhesive already applied to the mould. |
| Plate Glasses (cast) | Cast between water cooled rollers which smooth the glass |

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| | surface as the glass passes through. Both faces are then ground and polished subsequent to annealing. |
| Pot | A container used for melting glass in amounts from only a few grams to several hundred kilograms. The largest pots are made from special clays which are carefully dried and fired before use. Small pots may be either refractory or metal and will be chosen according to the nature of the melt. |
| Pot Furnace | A furnace designed and built to hold one or more pots for melting glass. Many pot furnaces are roughly circular in plan and hold several pots of glass of the same type. |
| Recuperator | A structure for transferring heat from furnace waste |
| Residual Stress | The internal stress present in glass after annealing. Complete removal of residual stress would take extremely long times and annealing schedules are therefore designed to reduce the stresses below the acceptable maximum value. The permissible residual stress is much lower for optical glass than for containers – their annealing control is a major part of their quality process. |
| Regenerator | A chamber for transferring heat from furnace waste gases to incoming air and which has one set of passages constructed from bricks. The latter are heated by waste gasses and then used to heat the air as it passes in the opposite direction around the same bricks. There must always be two regenerators so that one is heated while the other is being cooled, and the direction of firing of the furnace must be reversed at regular intervals. |
| Ribbon Machine | A machine with two continuous tracks, one above the other; glass is fed between the tracks, the upper one carries blow moulds. The gobs of glass hang down from the continuous ribbon are blown into thin-walled articles such as electric lamp bulbs. The speed of operation will depend on the size of the article. |
| Shadow Wall | An open lattice structure built with refractory bricks on top of the bridge wall of a tank furnace. By reducing the radiation received from the flames in the melting end the shadow wall keeps the temperature in the working end considerably lower than it would otherwise be. |
| Tank Furnace | A furnace in which the bottom part (the tank) is filled with molten glass. The tank is constructed from very resistant and close fitting refractory blocks. Capacity vary from a few hundred tonnes to several thousand tonnes, and the hottest parts operate at temperatures up to 1600oC |
| Throat | The single passage at the bottom of the bridge wall through which the melt flows from the melting end to the working end in a tank furnace |
| Unit Melter | A type of narrow tank furnace with burners along both sides and no heat recovery equipment or, sometimes, a recuperator. |
| Vello Process | A continuous method of making rod or tubing in which the stream of glass flows vertically downwards out of an orifice in the bottom of a forehearth and is then drawn off horizontally. |
| Working End | The smaller chamber of a tank furnace in which the melt cools down from the melting temperature (say 1500oC) to near |

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| | working temperature (perhaps 1200oC). In a container glass tank the working end is separated from the melting end by the bridge wall and the shadow wall. In a flat glass tank the two ends of the furnace are not divided by a bridge wall. Some refining and homogenising occurs in the working end. |
| Blisters | Bubbles which are present in the finished glassware. They are generally quite large. |
| Cord | Threadlike tails of glass produced by the complex chemical reactions involved in melting. They are obvious because they have a different refractive index to the surrounding glass. Poorly mixed batch, cullet can be the source of the problem. |
| Foam | A high concentration of gas bubbles near the surface of a glass melt. Such a layer is a good insulating material and can lead to serious problems in the melting process. |
| Ream | Similar to cord but occurs in layers rather than threads. More common in flat glass where the layers are be drawn out. |
| Reboil | The formation of gas bubbles at refining temperatures which can lead to blister. |
| Scum | Material floating on the surface of a glass melt. Usually solid and often siliceous in nature |
| Seed | Relatively small bubbles either in the body of the melt or present in the finished article are known as seed. |
| Stone | Any crystalline inclusion in the glass such as incompletely dissolved batch, devitrified material, or refractory inclusion. The presence of stones is a serious cause of defects since they can often initiate fracture. |
| Striae | A form of very fine cord which would be troublesome in optical glass. |
| Optical Fibre | Essentially any optical media in which the cross-section is very small relative to the length of the medium. If the cross-section is also small relative to the wavelength of the radiation being carried then the fibre can act as a waveguide. In nearly all cases, whether the fibre acts as a waveguide or simply transmits the beam, the fibre is immersed in another medium of slightly lower refractive index. Fibres can be used in bundle form either to transmit images or give high illumination, or as single fibres to carry information as in optical communication systems. |
| Viscosity | Materials in which there is no resistance to a permanent change in shape and in which deformation continues as long as the force is applied are said to be viscous. The level of resistance is its viscosity. Water is viscous : treacle is far less viscous. |
| Thermal Expansion Coefficient | All materials either expand or contract upon heating at constant pressure. This coefficient is not constant with temperature and at absolute zero of temperature it vanishes. The coefficient is usually quoted along with the temperature range that it relates to. There is a marked dependence on the constitution of the material. For isotropic materials, like glass, the volume coefficient is three times the linear coefficient. Thermal expansion is extremely important in glass science since it is involved in annealing, thermal toughening, sealing etc. It may |

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| | be noted that very large mechanical stresses can be generated by modest temperature changes. |
| Thermal Toughening | Once formed, thermally toughened glass cannot be cut or processed because it would break into small, relatively harmless fragments. Heated to a temperature near the top of the annealing range and cooled extremely quickly. |