Thermal shock resistance of glassware

Glass is a versatile material used around the home, but it can be significantly affected by sudden changes in temperature.

Glass is manufactured by fusing together a mixture of sand, soda and lime at high temperature. The resultant liquid glass is then blown, pressed or moulded into the desired shape. Liquid glass can easily be manipulated and solidifies into the required shape as it cools.

Here we will look at assessing the thermal shock resistance of glass and the types of flaws that can reduce resistance.

What can cause glass to fail?

Although glass is a robust material, it is sensitive to impact damage, external and internal pressures, and thermal shock. Any flaws in the glass will significantly lower its strength and may initiate failure. Flaws may include defects, visible marking or inclusion of foreign material within the glass.

Thermal shock resistance

Thermal shock resistance is the ability to withstand a rapid and significant temperature change. This is assessed in the laboratory by heating an item in an oven and then plunging it into cold water. SATRA uses BS EN 1183:1997 method B and, if the test sample survives, the procedure is repeated until failure occurs.
(the glass cracks or shatters). Each time the test is repeated, the oven temperature is increased 10°C to produce a higher temperature differential. The item’s thermal shock resistance is recorded as the highest test temperature that the item survived without showing damage.

Alternatively, method A of the standard involves heating the item in a water bath before plunging it into the cold water. This method is used for items which are more sensitive to thermal change. However, the test is limited to a maximum of 90°C difference.

This test simulates a ‘worst case scenario’ in use. For example a glass cooking dish is removed from a hot oven, food served from it and then it is plunged into a sink of cold water for soaking while it is still hot.

This test is also useful for assessing the overall manufacturing quality of glass items that are not usually heated during use. This highlights any flaws present that would lead to failure. It is ideally used in conjunction with the annealing assessment test to gain a complete picture of the item’s likely performance.

Flaws

Very few glass failures are caused by impact or thermal shock alone. Failures usually occur due to a combination of these, together with the presence of a significant flaw in the structure of the glass. Flaws commonly seen in glassware include ‘seeds’, ‘stones’, ‘cords’ and surface discontinuities.

‘Seeds’ are gas bubbles within the structure of the glass. They may be spherical or stretched into an elliptical shape. The seeds may be wholly contained within the glass structure or open at one surface creating a pit, which is often called a blister.

‘Stones’ are solid defects which could be undissolved batch material or a contaminant. Contaminants may drop into the glass from the oven ceiling, sinking into its molten structure during manufacture. These
particles may have different thermal expansion properties to the main body of the glass and therefore create stresses when the temperature of the test item is altered. In extreme circumstances this internal stress may cause the item to break spontaneously.

‘Cords’ are visible streaks of glass with a different composition to the main body. These appear within the glass or on its surface. Insufficient stirring of the molten material or a chemical reaction in the furnace may cause cords. Again, these faults may have different expansion properties to the main glass item. Often cords are hard to see – in fact, SATRA uses a polarimeter to detect their presence. A polarimeter consists of two perpendicularly aligned, polarised lenses viewed against a light source. Using a white light source, any stress will appear as coloured fringes, making it easier to identify them.

Surface discontinuities include chips, scratches and bruises. Scratches are fine line damage caused by a sharp object. Bruises, sometimes called ‘fish eyes’, are circular marks on the glass surface caused by impact damage.

The shape of surface irregularities will often determine the overall effect on the finished item. A smooth shaped flaw such as a bruise may have little effect whilst a very sharp shaped flaw, like a deep scratch, may cause considerable weakening as the stress is concentrated at the point of the surface discontinuity.

SATRA tests

SATRA prefers to carry out thermal shock resistance tests in conjunction with an annealing assessment to provide a detailed picture of the test item and its likely performance. During inspection of the test sample through our polarimeter, any flaws are noted. After the thermal shock resistance test we identify whether failure has occurred at, or close to, these flaws.

SATRA usually carries out thermal shock resistance tests in accordance with BS EN 1183:1997 – ‘Materials and articles in contact with foodstuffs’, as we believe it is applicable to all types of glassware.

How can we help?

15 PER CENT DISCOUNT ON FIRST SATRA TEST - please click here.

SATRA's comprehensive testing facilities allow it to offer a suite of tests to ensure items are fit for purpose. Please email homeware@satra.com for further information on glassware testing.