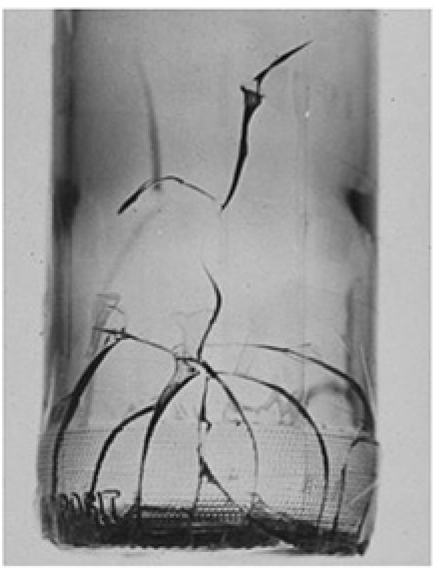
CASE STUDY #1

Bottle Breakage During Quality Assurance Testing

A glass container manufacturing company was experiencing a problem with off-lehr vertical load strengths of a 12-ounce capacity non-refillable beverage container. Their specification for this bottle was that it must survive a pass level of 1100 lbf (500 kgf).. However, their test results indicated that the container routinely failed at 880 lbf (400 kgf). The essential question that had to be answered is whether the tensile stresses were too high or whether the glass strength was too low for this specific situation?

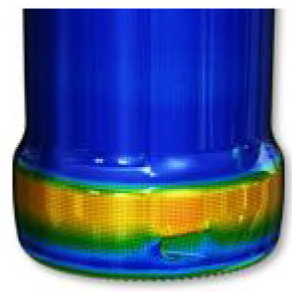


The fracture origins were consistently located at the heel contact point and exhibited a very small fracture mirrors. Based on the physical dimensions of the mirror, the breaking stress was calculated as 11,000 psi (770 kgf/cm2). Since glass strength is defined as the magnitude of the tensile stress at failure, this stress value represents the glass surface strength at the fracture origin site. Consulting a standard strength table for a non-refillable bottle, it was concluded that this value was an acceptable level of glass strength for the time duration associated with vertical load. Microscopic examination of the fracture origin site revealed that the flaw was very mild glass to glass frictive damage. Thus, neither the glass surface strength nor the severity of the flaw were problematic.

Next, it was necessary to determine the factors that had caused the tensile stress magnitude to be excessively high for this specific bottle. The glass thickness at the fracture origin was 0.060 inches (1.5 mm) which was greater than the minimum specification for this container. Likewise, the bottle was acceptable for verticality (poor

USA • 603 Evans City Road • Butler, PA 16001• Phone: +1-724-482-2163•Fax: +1-724-482-0116 • americanglassresearch.com
Europe • Kleveringweg 17• 2616 LZ DELFT, The Netherlands • Phone: +31 (0)15 890 40 20 • americanglassresearch.com/nl

verticality levels can produce highly unusual tension stresses when the bottle experiences a vertical load force). Therefore, both thin glass and the physical structure of the bottle were eliminated as possible sources for the generation of the excessively high stress levels. The stress index for vertical load was calculated (tensile stress divided by load) and determined to be 12.5 psi/lbf (11,000 psi/880 lbf). This value is abnormally high for vertical load where more common values, in our experience, are usually far less than 5 psi/lbf. Thus, it was determined that the source of the excessively high tensile stress magnitude was the design of the heel region of the container.



The solution to the vertical load test failure is to decrease the magnitude of the tensile stress. This could be accomplished by either increasing the glass thickness at the heel contact region or by re-designing the entire container. If glass thicknesses are increased, that will normally require an overall increase in the weight of the container. Otherwise, simply moving glass from one area to the heel contact point may result in thin glass at another critical region that could then become problematic. Thus, the most effective solution will be to re-design the container to reduce the magnitude of the vertical load stress index at the heel contact point.