TEMPERED GLASS
SPONTANEOUS BREAKAGE

S-031

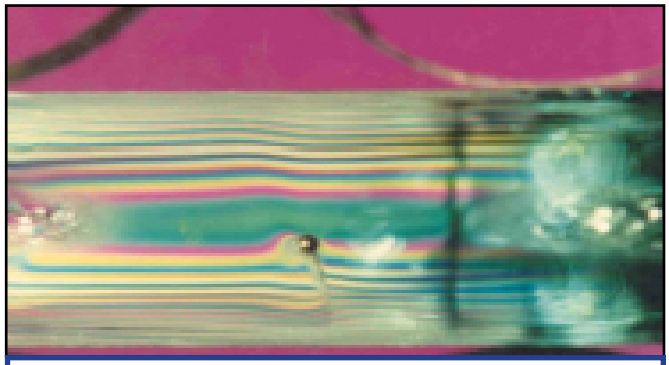
GLASS

What is Spontaneous Breakage and What Causes It?

There are instances, post production and even after installation, of tempered glass breaking due to no apparent cause. In these cases of "spontaneous breakage", it is most often determined that glass breakage in the field (post installation) is due to existing surface or edge damage that severely compromised the ability of the glass to withstand wind loads, thermal loads, or normal structural movements; In some cases, the glass to metal contact combined with movement under wind load initiated the break. In other instances, the breakage has been traced to the presence of nickel sulfide stones in the center tension zone of the tempered glass. This is especially true in the cases where glass stacked neatly on a rack randomly bursts for no apparent reason.

Although unintended, nickel sulfide stones can form in the production of float glass. All North American glassmakers (Float Suppliers) have implemented procedures and controls to greatly reduce the likelihood of nickel sulfide stones. Float Suppliers no longer include nickel in any of its primary glass batch formulations, and use magnetic separators that remove any nickel bearing components.

There is, however, no known technology to totally eliminate the possibility of nickel sulfide stone inclusions in float glass. Such inclusions can occur at random, are often benign, and are almost always very small. Nickel sulfide stones typically range in size between 0.003" and 0.015" (0.076 mm and 0.380 mm) in diameter. This size precludes the use of practical inspection methods common to the production of float glass. ASTM C1036 "Standard Specification for Flat Glass", the basic specification to which float glass is manufactured in the U.S., permits blemishes (including stones) between 0.020" and 0.100" (0.5 mm and 2.5 mm) in float glass, depending on glass size and quality level.



Microscopic electron scan of glass edge showing NiS stone. (photo courtesy of PPG)

Since nickel sulfide stones can occur in the production of float glass, they may be present in annealed and heat strengthened glass, as well as in tempered glass. However, annealed and heat strengthened glass are almost never subject to spontaneous breakage due to nickel sulfide stone inclusions. NiS stone breakage is due to a phase transformation that results in an increase in the stone size. The volumetric growth of the stone is small, ranging from approximately 2 to 4%. This volume growth, if the stone is in the center tension zone, can cause stresses potentially resulting in glass breakage.

During the manufacturing process the glass is intentionally cooled at a slow, controlled rate in order to produce glass with as little residual surface and edge compression as possible. During this annealing phase, any stones have time to undergo the phase change and become stable, without causing glass breakage.

When glass is re-heated for heat strengthening or tempering, any NiS stones that are present will shrink back to the smaller high-temperature-stable form. The slower cooling cycle of the heat strengthening process allows the stones to undergo the phase change. However, the rapid cooling cycle required to produce tempered glass arrests the phase change and may trap the stone before it completes its volumetric growth. Then later, due to in-service temperature exposure, the phase change and accompanying volume growth continues and may lead to breakage.

Therefore there is general agreement that spontaneous breakage due to stone inclusions is not an issue with annealed or heat strengthened glass. The phenomenon is limited to tempered glass.

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