Determining Curved Glass Quality

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Curved marine glass is often considered a separate animal from its flat glass counterpart. The reason is simple, to fully specify curved glass, one needs to be familiar with its unique language. This language encompasses height and width dimensions characteristically associated with flat glass, but curved glass is three-dimensional and getting to the desired shape of the glass is a more complicated endeavor. Besides the terminology used to describe the bend, manufacturing issues associated with bending must be considered in assessing the quality of the final product.

Starting with Flat Glass

As with the other fabricated products, curved marine glass is made from flat glass. The quality requirements for flat glass are contained in ASTM C1036-01, Standard Specification for Flat Glass. The ASTM C1036 standard contains a terminology section that includes a variety of linear and point blemishes, such as scratches, rubs, digs, knots, dirt, stones, and gaseous inclusions. Tolerances on these blemishes and test methods for viewing glass are also presented in the standard. Table 1 of ASTM C1036 is probably the most referenced table in any glass standard. The traditional thickness designations of flat glass are given, along with a thickness range, cut size length and width tolerances, cut size squareness tolerances, and stock sheet tolerances for length and width. Because distortion can occur in flat glass due to non-homogeneous layers of flat glass, the standard includes inspection guidelines to identify the vision interference angle, or the angle at which distortion in transmission first occurs.

The vocabulary of curved marine glass

Once the flat glass intended for bending has been inspected, a whole new vocabulary comes into play. The customer must be able to describe the shape and size of the curved marine glass so that it is manufactured in accordance to the specification. With a variety of shapes available, this is not always an easy task. There are single bends, consisting of a single radius curved on a single axis, possibly with one or two flat areas adjacent to the curvature. There are compound bends, consisting of curvature of one or more radii, curved on two or more axes. There are multiple bends, consisting of curvatures of two or more radii, all curved on a single axis, with at least two of the curvatures possibly separated by a flat area, and with or without one or more additional flat areas next to the curvatures. And there are serpentine bends, composed of concave and convex curvatures of one or more radii on a single axis with or without flat areas adjacent to the curvatures. The customer should provide a template or production piece to be used in detailing the exact shape required.

Besides height, curved glass measurements include several other descriptors. Radius is a geometric term that is based on a circle. If you measure from the center of the circle to the outside of the glass, you will arrive at the outside radius. The chord dimension is determined by drawing a straight line between two points of an arc. The girth is the distance around the concave or convex surface including flat sections, measured perpendicular to the height.

All of this information and more is contained in ASTM C1464-00, Standard Specification for Curved Glass. The standard includes tolerances on two process surface blemishes that can occur during bending, pock marks and ring marks. In addition, the standard presents test methods for determining shape accuracy, twist, and crossbend. One way to measure shape accuracy is determined by placing a template on the concave surface of the bend, then measuring the deviation between the template and the glass. When one or more of the corners of the glass are out of plane, twist is present. Crossbend is determined by placing a straightedge along the vertical edge on the concave surface of the glass, and then measuring the distance between the glass and straightedge.

Other standards

Because curved marine often incorporates low-e coatings or is laminated for safety, the overall quality of the glass must consider other fabricated glass standards, such as ASTM C1376, Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Glass and ASTM C1503 and ASTM C1172, Standard Specification for Laminated Marine Flat Glass. Coating blemishes are addressed in ASTM C1376 and laminating blemishes, such as bubbles, delamination, discoloration, hair, lint, interlayer scuff, and streaks are covered in ASTM C1172. Considering the fact that one piece of curved marine glass can face a myriad of quality issues, the only way to handle the matter is through a vigilant inspection process. That is to say, incoming glass must be inspected before it is cut, glass must be inspected after cutting and before bending, and after bending before laminating. In this way, problems will be detected before further value-added fabrication occurs.

Bringing Quality into the Day-to-Day Operation

Inspecting glass for quality involves training and teamwork. As employees incorporate a regular inspection routine into their work areas, they are likely to complain that the effort is time-consuming and problematic. No one wants to bring attention to a problem or find another person's mistake. However, it is important for employees to understand that detecting nonconformance is really helping to improve overall quality in the workplace.

Training is vital to teach employees how to detect nonconformance. A supervisor or quality manager is responsible for giving specific instructions to each department in the factory on the inspection process. A team approach is also an effective way of assessing nonconformance issues and proactively generating innovative solutions to management.

Satisfying the customer

To many customers, specifying and detailing curved marine glass prior to ordering is an intricate and lengthy process. At ProCurve Glass Design, Inc. we have learned that it is worth it to fully understand the customer's expectations before attempting to produce the order. We provide technical support to determine the proper dimensions and shape of the glass and work with templates, tracings, and computer-generated drawings to be sure we are on the same page as the customer. Quality standards are useful to transmit key ideas and terms to the customer. It is important to be speaking the same language so that the end result is satisfying, both from a production and design perspective.