Guidelines for Glass Scoring and Breakout Quality

The cut quality of glass edges is the single most important factor affecting the edge strength of glass. Poor cut edge quality can reduce the glass edge strength by 50% or even more, depending on the severity of the edge damage resulting from poor cutting techniques.

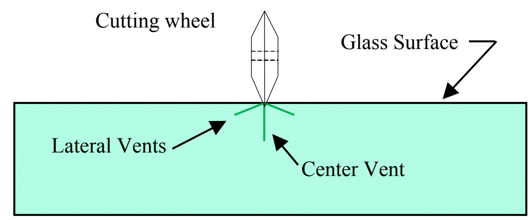
Glass edge quality, and the resulting glass edge strength, is critical to downstream fabrication process such as heat treatment in a roller hearth furnace. Glass with poor edge quality is more likely to break during handling and shipping functions. Edge quality can also affect breakage during installation or years later when the glass experiences wind and/or thermal loading, and in applications where one or more edges are not supported such as butt-glazed applications.

Vitro (formerly PPG Industries) is pleased to offer these Guidelines and Best Practices of the fundamentals of glass scoring and breakout to achieve the desired glass edge quality. The representative pictures to follow can be used for comparative purposes to provide a relative judgement of cut edge quality. The information presented here is intended as a starting point only, and may not give you the desired result for your specific glass cutting situation. For a detailed analysis of your particular glass cutting equipment and wheel needs, we recommend that you contact the equipment manufacturer and the various manufacturers of glass cutting wheels.

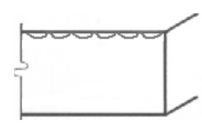
TERMINOLOGY

Although the term glass "cutting" is often used, the process actually involves the use of a small wheel commonly made of tungsten carbide to "score" the near surface of the glass so that the glass will break out in a controlled fashion. Here are some additional terms to describe this process and the resultant glass edge quality.

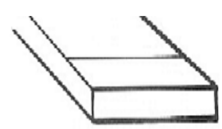
Score: Fractures made in the glass surface by the glass cutting tool, most often a beveled carbide wheel, creating center and lateral vents. The depth of the center vent into the body of the glass is called the fissure depth.

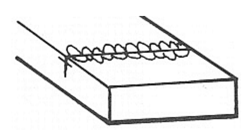


Wheel Serrations: Indentations left in the glass from the cutting wheel; heavy serration marks likely indicate too much pressure or wheel alignment issues.

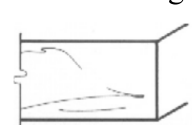


Wing Vents/Chips: Glass flakes originating on each side of the score from the lateral vents that turn and reach the surface. These flakes may pop out under excessive cutting wheel pressure or subsequent handling.

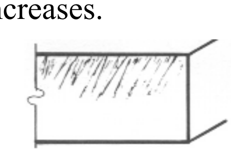

Clean score


Too heavy score w/ wing vents

Convolutions: Smooth rolling surfaces on the glass edge - not a weakening factor.



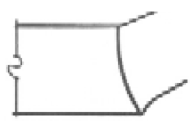
Shark Teeth: Dagger-like imperfections adjacent to the score surface. The edge strength and resulting potential for glass breakage increases as the depth, roughness, and number of shark teeth increases.



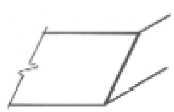
Guidelines for Glass Scoring and Breakout Quality

Hackle & Spall: Edge imperfections, usually perpendicular to the glass surface, which occur at the surface opposite the score and sometimes break out in chunks. The edge strength and resulting potential for glass breakage increases as the density and depth increases.

Flare: Sharp protrusion at the junction of the edge and glass surface which can be due to shallow score depth and / or less than ideal break out. Susceptible to further damage.

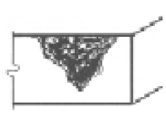


Bevel: An edge that is not perpendicular to the glass surfaces.



Flake (shell) Chips: Smooth shallow chips.

V-chips: Rough, penetrating chips in the shape of a "V"; Never allowed anywhere on the edge.



Acceptable Clean-Cut Edges may have:

- ✓ Normal wheel serrations; minimal wing vents
- ✓ Convolutions
- ✓ Hackle & some Shark Teeth, only within 6" of the corners
- ✓ Flare or Bevel, if not more than 1/32" on 1/8" (3.2mm) or thinner glass and 1/16" on 5/32" (4mm) and thicker glass. Flare is not allowed where setting blocks contact the glass (typically > 6" from corners).
- ✓ Flake Chips, only within 8-inches of corners and if not longer than ¼-inch across and not deeper than ½ the glass thickness.
- ✓ Wave lines, if smooth and continuous
- ✓ Frost/Rubble, fine grain effect on the cut edge

Borderline Edges may have additional:

- ✓ Shark Teeth, if penetration does not exceed ½ the glass thickness
- ✓ Serration & Hackle, if not deep or dense and if spalling is not present
- ✓ Flake Chips, if not larger than ¼" across and not deeper than ½ the glass thickness

GLASS CUTTING BEST PRACTICES

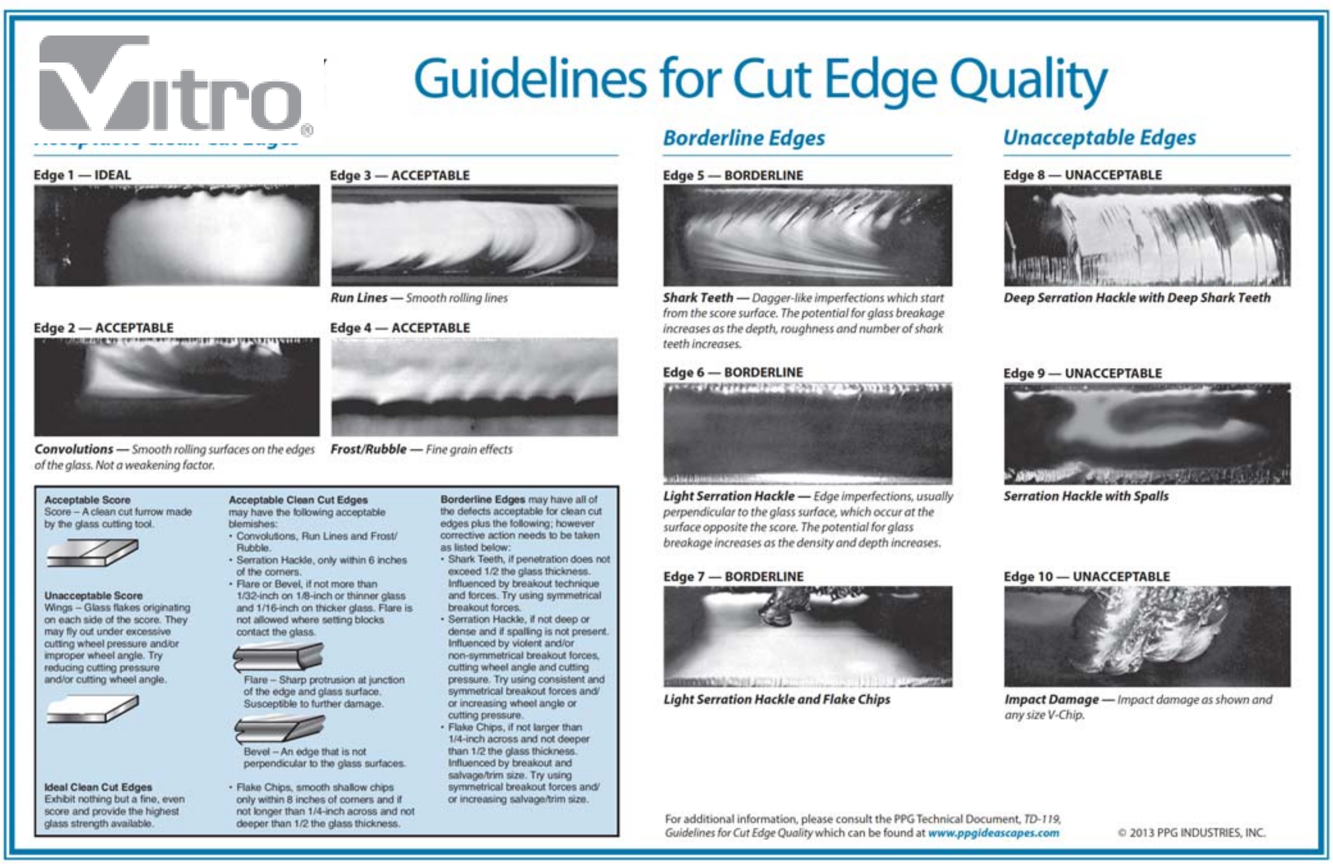
- ✓ Good housekeeping – keep area, tabletop, and equipment clean and clear of glass chips or other debris; dust & glass fines can clog the wheel resulting in dragging or skips.
- ✓ Use the proper wheel for the glass thickness being cut to achieve the proper score / fissure depth and good break out.
- ✓ Ensure that a good quality, unworn wheel is being used to achieve consistent scores and break out. Recommend changing wheel and axle frequently based on usage which could be every shift (8hrs). Using a finger, check that wheel spins freely in cutting head assembly but without excessive slop.
- ✓ Cutting fluid should be used to keep the wheel lubricated and assist with the break out process. Use quality fluids in the proper quantity (fluid should not run down the glass when positioned vertically).

Guidelines for Glass Scoring and Breakout Quality

- ✓ Use proper score pressure (wheel load) for the type of wheel and glass thickness being processed. Too much pressure results in chips, shark teeth, and bad edge quality although glass break out may actually improve.
- ✓ Keep cutting bridge properly aligned and table properly leveled. Check cutting wheel assembly for any loose components and replace as needed.
- ✓ Use proper breakout procedures. Using popup break out bars is the preferred method since they apply a uniform force under the score to evenly split the glass.
- ✓ Use the appropriate amount of trim around the lehr end stock sheet. The ideal amount of trim is 8 times the thickness of the glass for the best quality edges. However, this could be impractical for achieving acceptable layout yields. It is widely accepted to obtain a balance between trim size and layout yield by using 4 times the glass thickness for trim size. This means that for ¼" glass, a 1" trim around the perimeter should be acceptable. Using less trim than 4 times the glass thickness will usually result in poor edge characteristics such as flares, hackle & spalls, and sharks teeth.

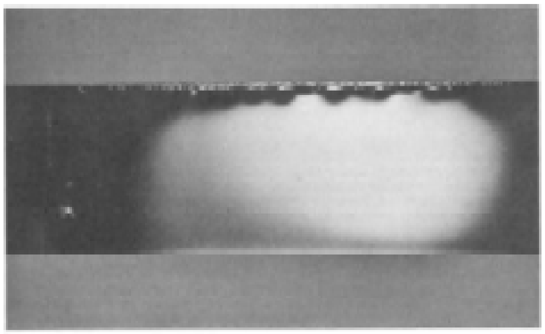
Guidelines Poster

Vitro Customers are encouraged to request a *Guidelines for Cut Edge Quality* poster (size is 24" x 38" and available in English and Spanish) from their Sales Account Manager. The poster is intended for display in the cutting work area as a visual reference.

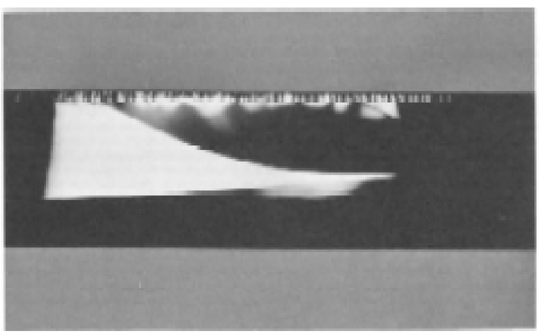


Guidelines for Glass Scoring and Breakout Quality

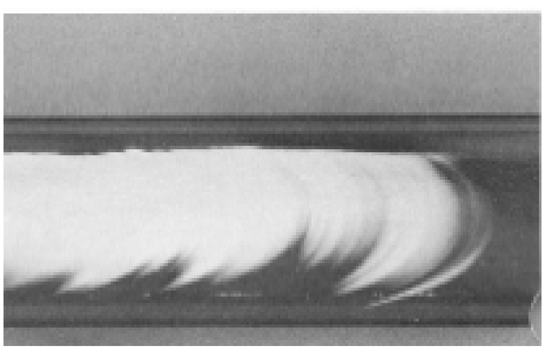
ACCEPTABLE CLEAN CUT EDGES



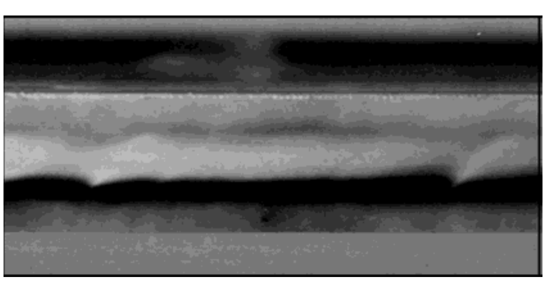
IDEAL



ACCEPTABLE - Convolutions

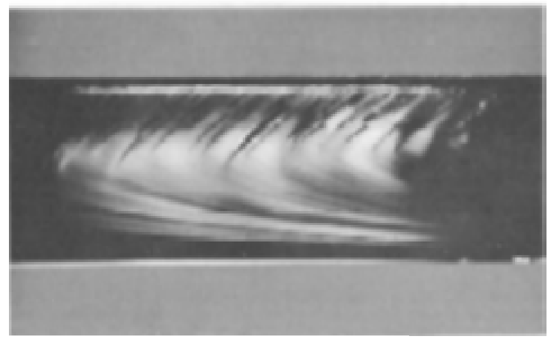


ACCEPTABLE – Wave Lines

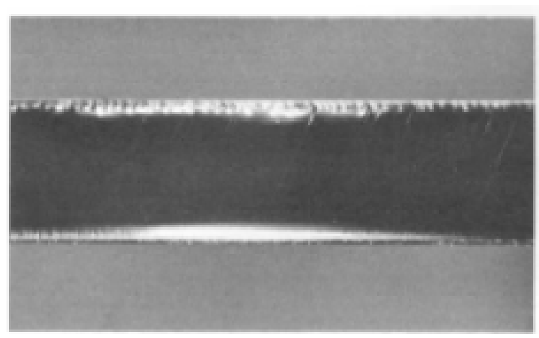


ACCEPTABLE – Frost/Rubble

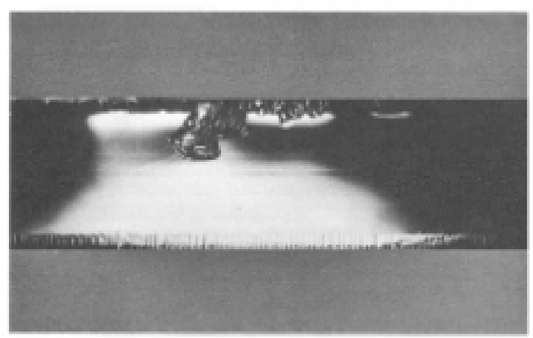
BORDERLINE EDGES



BORDERLINE – Shark Teeth



BORDERLINE – Light Serration, Hackle

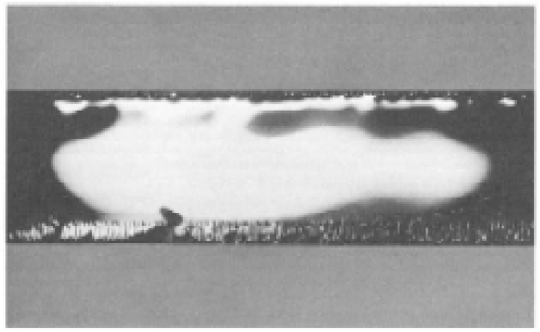


BORDERLINE – Light Serration, Hackle, Chips

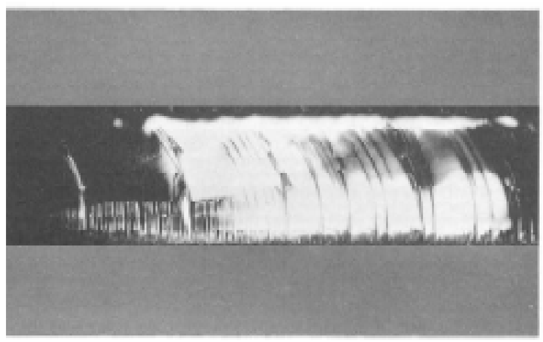
✓ Always work to improve borderline edges by adjusting the cutting process or replacing the wheel or performing maintenance as required to achieve the "ideal" clean cut edge.

Guidelines for Glass Scoring and Breakout Quality

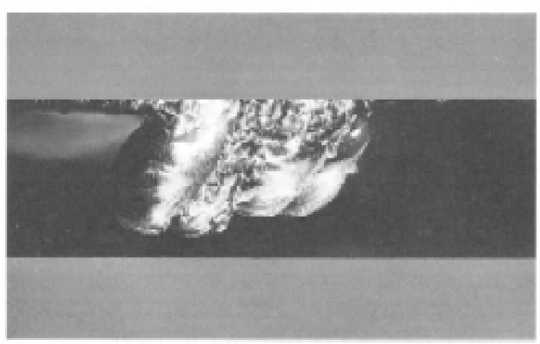
UNACCEPTABLE EDGES



UNACCEPTABLE – Serration Hackle with Spalls (see lower



UNACCEPTABLE – Deep Serration Hackle, Deep Shark Teeth



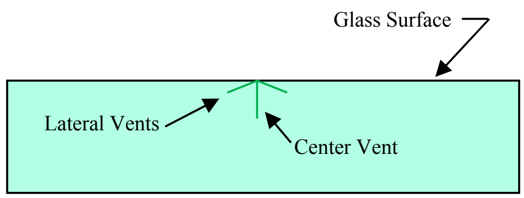
UNACCEPTABLE – Impact Damage

- ✓ These unacceptable glass edges should not be allowed to proceed to downstream fabrication processes. The cutting process must be adjusted or the wheel replaced or maintenance performed as required to get the edge quality back to an acceptable condition.

Guidelines for Glass Scoring and Breakout Quality

GLASS CUTTING WHEELS

A score is a fracture that is put into the glass by the action of the cutting wheel. When a cutting wheel scores the glass, actually three fractures are made in the glass.



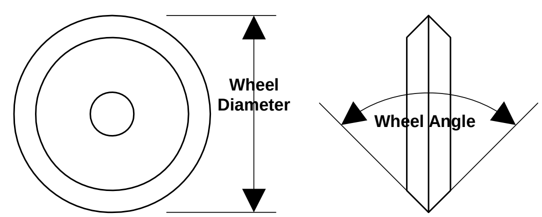
The center vent penetrates into the glass body to a certain depth, depending on wheel angle and pressure. A lateral vent is always created on each side of the center vent. The lateral vents go into the glass at roughly right angles to the angle faces of the wheel edge. The greater the wheel angle and pressure, the deeper these vents can be driven into the glass. This means that the vents can be made to go much deeper into the glass body with a 148° wheel than with a 120° wheel for the same glass thickness. Therefore in general, the thicker the glass is the greater the wheel angle should be. Increasing the wheel diameter will also drive vents deeper into the glass. But as is the case with greater wheel angles, more pressure is also needed with larger wheel diameter to drive the score deeper.

Lateral vents usually cannot be seen. If they are visible, then the pressure was too high on that particular wheel. With excessive wheel pressure, these lateral vents will actually propagate some depth into the glass, then curve back out to the glass surface, resulting in flake chips called wing vents along the score line. A good score is a straight or curved line across the top surface of the glass, with no skips, and should appear as a continuous line in reflection off the bottom surface of the glass. There should be no plowing, digging, or crushing of the glass, and contain minimal wing vents. Skips in the score line reflection are a good visual indicator that the scoring parameters need adjustment or wheel should be replaced.

The use of cutting fluid often masks an over pressure condition, by hiding small chips that may pop out along the score line when too much wheel pressure (load) is applied. Dry cutting makes it much easier to quickly recognize an over pressure condition, reducing the chance of a large quantity of glass being cut before realizing that it has poor edge quality due to excessive wing vents and chips. However, dry cutting can lead to shorter wheel life so this is only done as a process setup test. Also, cutting fluid has been shown to improve the ease of breaking out the scored glass.

Wheel Selection

Glass cutting wheels are available in a variety of combinations of wheel diameter and edge angle (see below).



Larger wheel angle means the wheel has a blunter edge

Different wheel diameters and different edge angles produce different results relative to cut edge quality. Also, wheel load (wheel force against the glass) will affect cut edge quality. Table-1 below indicates, there is some logic to how these parameters are selected. Although not an exact recipe due to other possible influences, these values provide a good starting point, and should help you produce center vent or fissure depths in the target range of 6% to 10% of the glass thickness (closer to 6% with ≥ 12mm).

Guidelines for Glass Scoring and Breakout Quality

Table-1: Wheel Selection Guide*

	Glass Thickness						
Wheel Diameter (inches)	2mm	3mm	4mm	5mm	6-8mm	10-12mm	15-25mm
.140	134°	145°	145°	148°	154°		
.156, .175	128°	140°	140°	145°	152°		
.196, .215, .219	124°	134°	134°	138°	145°	155° - 160°	
.228, .230, .245	120°	128°	128°	128°	140°	150° - 155°	155° - 160°
Wheel Load (lbf) Note: 1bar=14.5psi; 1lbf=4.45newtons	3 to 4	4 to 5	5 to 6	6 to 7	10 to 12	12 to 24	30 to 60

* Values shown are based on achieving proper score fissure depth of up to 10% of the glass thickness for straight cuts on non-coated glass. For curved cuts, the score fissure depth should be 15 – 20% of the glass thickness. For coated glass, a 5° – 10° sharper (lower angle) wheel should be used to achieve the proper score fissure depth. For glass with temporary protective film (TPF), 5° – 10° sharper wheel with additional pressure (5 – 10 lbf) should be used. Consult TD-152 for specific information related to cutting through TPF.

Selecting the correct wheel for a given cutting job is of critical importance. Here are some general guidelines to follow. However, you will need to experiment with your equipment and environment to optimize the right cutting wheel and other cutting process settings.

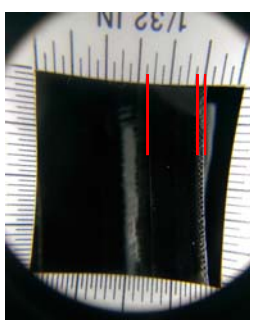
- ✓ For ¼” (6mm) non-coated glass, start with a 0.215” diameter wheel with 145° angle. If your cutting wheel mounting system requires 7/32” (0.228”) diameter, then use a 140° angle wheel.
- ✓ With a new wheel, start with a pressure of 10 – 12 lbf (~45N) or less. As the wheel wears, it actually flattens out effectively reducing the angle. After a period of time, the wheel becomes dull and likely requires more and more pressure to achieve break out. Then a point is reached where the desired quality of the score and resultant edge quality can no longer be achieved. It is recommended to replace the cutting wheel before this happens. It is not recommended to use these “dull” used wheels to cut other thicker glass since the wheel wear and therefore angle

Guidelines for Glass Scoring and Breakout Quality

may not be consistent resulting in inconsistent cutting and edge quality.

- ✓ Use the proper amount of cutting fluid to keep the wheel lubricated and assist with the break out process. A guideline is to use just enough to keep the score wet until the break out is done. The cutting fluid should not run down the glass when the glass is positioned vertically after cutting or pool excessively when the glass is sitting on the cutting table or subsequent conveyors. When cutting Sungate® or Solarban® Low-e Glass, use only approved cutting fluids (see TD-149).

- ✓ Examine the cut edges in both directions. Pay particular attention to the trim edges and to edges where the cutting head starts and stops (i.e. towards corners). Use a tool such as a magnifying flashlight (Donegan Optical V-980-10-65693) to view the glass cross-section. Compare the actual cut edge quality to the typical cross sections shown on pages 4-5 or to the poster illustrated on page 3. Use this same tool to measure the actual score fissure depth. Remember the fissure depth should be about 10% of the glass thickness for straight cuts.



- ✓ Note the ease (or difficulty) to break out the glass at the score lines. Keep in mind that good (easy) break out does not always mean good edge quality. Don't react and adjust the cutting process too quickly. Glass flatness and anneal condition can have an affect with individual glass sheets. Continue to monitor the edge quality, score and fissure depth.

- ✓ Allow cold glass to equalize to room temperature. Generally speaking, cold glass reacts differently than glass at room temperature (~70° F) with the results being less predictable break out.

- ✓ The speed of the cutting wheel across the glass surface is generally not a variable that is adjusted. However, it's important to realize what affect speed has on the glass cutting process. Basically speed acts along with wheel pressure or force. If only the cutting wheel speed is increased, all other factors remaining constant, the fissure depth will also increase. An unwanted side effect could be increased flake chips or wing vents on either side of the score. This is particularly true with curved or patterned cuts where the speed may vary into and out of the radius. If a good quality cut edge cannot be achieved by adjusting other process parameters, then adjusting the speed of the cutting wheel may be considered.

- ✓ Consult with the cutting equipment manufacturers and the suppliers of cutting wheels for further information and their recommended procedures. Shown here are some of the cutting wheel suppliers.

  The Fletcher-Terry Co.
  http://www.fletcher-terry.com/

  MacInnes Tool
  http://www.macto.com/

  Bohle America, Inc.
  http://www.bohle-america.com/

Guidelines for Glass Scoring and Breakout Quality

HISTORY TABLE		
ITEM	DATE	DESCRIPTION
Original Publication	10/1982	TSR-130
Revision #1	1/4/2002	Excerpts from TSR-130 to TD-119
Revision #2	10/4/2016	Updated to Vitro Logo and format
Revision #3	10/12/2018	Combine TD 117 & 119 and revised to be current and consistent with best practices.