Technical Guide for Glass Cutting
Section 1 - Two Basic Types of Cutting

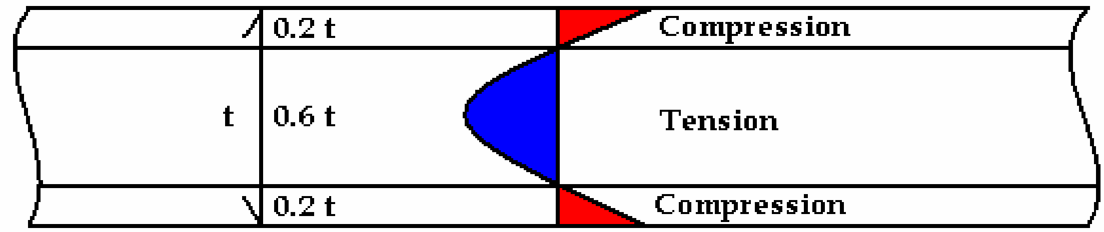
Part 2 – Pressure Cutting

Basic Principles of Pressure Cutting

This portion of Part 2 deals with those aspects of the basic principles of glass cutting that are common to all types of pressure cutting.

Pressure cutting is essentially an extension of conventional glass cutting and is characterized by much deeper fissures. It can be used on all glass thickness but is primarily used on pattern cutting of difficult shapes and on very thick glass for the purpose of ease of score opening. Pressure cutting differs from conventional cutting in several aspects: fissure depth, influence of cutting speed, wheel angles, and the influence of concentrated support.

Pressure cutting takes advantage of the stress distribution through the glass thickness – compressive stress in the top layer, tensile stress in the mid-plane, and compressive stress in the bottom layer.



Conventional scoring uses the guidelines of 8-10% fissure depth or nearly **0.1t** whereas in pressure scoring the guideline is 17-20% fissure depth or nearly **0.2t**.

The purpose of driving in the deeper (17-20%) fissure is so that it can be drawn deeper by the mid place tensile stress region. When the tip of the fissure reacts with the tensile stress it will fracture deeper into the glass. This reaction can be slight or up to as much as 80% or **0.8t** of the thickness of the glass (to the border of the bottom surface compressive stress layer). The fracture extension of

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the fissure deeper into the glass has been termed “score fracturing”, “score deepening”, “vent scoring”, etc. in the trade.

Pressure scoring requires wheel angles of at least 144 degrees and can be as high as 162 degrees. Wheel diameters have been used successfully in the full range from 1/8”diameter to 1 1/2” diameter. This covers the full range of commercial float glass thickness up through 1”. The larger diameter wheels require special mounts, special cutting heads and special wheel manufacture.

Unlike conventional glass cutting, velocity is a dominant variable in pressure cutting. Wheel velocity adds a component to the applied cutter head pressure to drive the fissure deeper than if just the applied load alone were applied. This occurs only if the fissure depth is at or near the 20% depth or **0.2t**. This action is what occurs in most automotive pattern cutting operations. The problem is that, when the cutter slows for the pattern corners, the velocity component disappears. This has been helped somewhat by programming cutter pressure increases when the cutter head slows. Pattern corner break out remains a problem.

In order for the velocity component to be very helpful the support under the glass should be very firm. Likewise, on straight-line conveyor cutting of heavy glass a back up roller directly under the cutting head will help. This creates an effect similar to the velocity component in that it pulls the fissure deeper.

For straight-line pressure cutting, larger diameter wheels have much larger operating ranges. The higher angle wheels along with the larger diameter allow higher pressures to produce deeper fissures. Wheels over 1/2” diameter require special manufacture, mounts and cutting heads. In lieu of the larger diameter wheels, pinch scoring will enhance the capabilities of smaller diameter wheels and, high heat (hot air or hot gas) applied after the score can deepen the fissure through the tensile stress region. Pinch scoring causes the stress field in the glass caused by scoring to enlarge and pull the fissure deeper.

Like everything else, there is a price to be paid for deeper fissures and easier opening. And, that is opened edge quality – deep fissure scores are inherently weaker.

Product Quality Expectations

This portion of Part 2 deals with what is expected in the cut glass product.

- Score Line Quality
- Opened Edge Quality

Score Line Quality

The expected quality of an unopened pressure score should be similar to that of a conventional score expect that all characteristics are of a larger magnitude. The score line itself will have more crushed glass debris. For this reason it is highly recommended that all pressure scores have a cutting fluid applied. This will help keep the wheel and wheel mount assembly clear of chips that might clog the clearances. The fluid will also retard the growth of the lateral wing structure.

Once a proper cutting pressure has been established, lateral wing fissures are minimized. If too much pressure is applied, lateral wing fissures can extend out away from the score by an amount equal to or greater than the scoring fissure depth.

Open Edge Quality

The expected opened edge quality resulting form pressure cutting should be similar to that of a conventional cut except that all the characteristics are of a larger magnitude. The opened edge should be square with surface. The wheel fissures should be of uniform depth but would also be twice as deep. With the deeper fissures the pitch of the fissures increase and the line of fissures tends to approach an appearance similar to a zipper.

On edge faces where the fissure was deepened directly after scoring there may be some convolutions resulting from the propagation of the score deepening vent. Convolutions are not a defect.

The strength of a pressure cut edge is less than that of a conventional cut opened edge. Heat deepening does not further reduce edge strength but it does drastically reduce applied stress required to open the score.

Influences on the Quality of Cutting

This portion of Part 2 deals with seven aspects of the cutting equipment that affect pressure cutting product quality.

1. Cutting Support System
2. Pinch Scoring
3. Cutting Wheel Assembly
4. Cutting Wheel Angle, Fissure Depth, and Wheel Finish
5. Cutting Wheel Speed
6. Glass Cutting Fluids
7. Cutting Wheel Life

Every cutting installation has to be treated as a system and each component contributes to the performance of the system. It is therefore important to pay attention to each component.

1. Cutting Support System

With pressure cutting the same concerns come into play as with conventional cutting in terms of cutting support, mainly: firm support under the glass, a rigid cutting head support, the handling of warped plates, and cutting over or across voids. However, the influence of each of these is more critical because of increased cutting pressure for a given pressure cutting application. This is a result of the use of higher angle (144 degrees – 162 degrees) wheels and the possible use of larger diameter wheels.

Pressure cutting is used primarily in three different areas of cutting: machine pattern cutting of difficult to break out shapes (primarily automotive), on-ribbon bulb edge removal on heavy glass, and specialized pressure cutters for manual use.

In machine pattern cutting, thinner belts or thinner felt coverings provide the best support because their thickness is very uniform and allow minimum deflection under cutter loading. Thicker belts or thicker felt table tops tend to be less uniform and can allow the glass to deflect downward under cutter loading resulting in non-uniform fissure depths in the score line.

For on-ribbon bulb edge removal, pressure cutters are normally positioned in a location downstream of the crosscut snap. The support under the cutter is either a solid roll across the conveyor or a pedestal mounted roller.

For any pressure cutting application, the key to consistent, uniform fissure depth scoring is rigid glass support and rigid cutter head support. When these two key variables are satisfied, the cutting wheel will function properly.

2. Pinch Scoring

When pressure cutting over a flat support or a solid roll support, the stress field generated by cutter pressure is volumetrically large. Thus, high applied wheel loads are required to generate fracture propagation stress levels.

The purpose of pinch scoring is to concentrate the stress field into a volumetrically smaller volume. This results in score propagation at greatly reduced cutter loads. The benefit is a higher quality score.

Pinch scoring is accomplished by using a narrow, flat surface directly under the cutting wheel. Alignment of cutting wheel to support wheel is super critical.

3. Cutting Wheel Assembly

With pressure cutting, the same concerns come into play as with conventional cutting, mainly: providing wheel swivel, providing wheel tracking, and maintaining the wheel plumb with the glass. However, using higher cutting pressures and larger diameter wheels require larger and stronger assembly components.

For cutting wheels 3/8" – 1" in diameter, the changes required are an increase in wheel axle diameter and an increase in the pillar post and insert dimensions. Wheels larger than 1" diameter are not commercially available.

The strength of the cutting wheel mount and the ability of the cutting head to apply and maintain higher cutting pressures are critical. Maintaining the cutting assembly plumb with the glass and maintaining uniform cutting pressures are critical to score line quality.

4. Cutting Wheel Angle, Fissure Depth, and Wheel Finish

All of the elements that contribute to the performance of cutting wheels for conventional cutting are also critical for pressure cutting. Of significant difference are the narrow range of wheel angles used in pressure cutting (144 degrees – 162 degrees) and the targeted fissure depths.

In the wheel angle range of 144 degrees – 162 degrees small changes in wheel angle (2 degrees – 3 degrees) can produce significant differences in performance and quality. In conventional cutting the wheel angle range of 128 degrees – 154 degrees require larger changes in wheel angle (6 degrees – 8 degrees) to produce significant differences in performance and quality. For any given pressure cutting application, it is best to try 2 or 3 wheel angles (152 degrees, 154 degrees, 157 degrees for example) before settling on the angle that produces the best quality.

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Keeping in mind fissure depth targets are the key to ease of break-out or snapping, it is good practice to periodically monitor fissure depth on the product to insure the best edge quality.

The contact area between a high angle, larger diameter pressure cutting wheel and the glass is much larger than for a conventional cutting wheel. This is the reason higher cutter pressures are required. More of the indented contact area is exposed to the wheel finish so it is important that the finish be maintained free of nicks or other damage. It is also important that no accumulation of glass dust or debris be present on the tip line.

5. Cutting Wheel Speed

In pressure cutting, the velocity of the cutting head can greatly influence the performance of a cutting wheel in terms of fissure depth. Keeping in mind that scoring is done with a wheel having an angle in the range of 144 degrees – 162 degrees and at a cutter load to achieve fissure depths at or near 20% of glass thickness.

Unlike conventional glass cutting, scoring velocity is a dominant variable. Wheel velocity adds a component to the applied cutter head pressure to drive the fissure deeper than if just the applied load alone were at work. The higher the wheel velocity, the larger effect it has on fissure depth. This type of cutting is used most often on automotive pattern cutting. When patterns have large radius corners, cutter head velocity remains constant except at start/stop. This results in uniform fissure depths all around and consequently easy, high quality breakouts. But, with today's myriad of pattern shapes and small radius corners, the cutter must slow for the corners and consequently lose the velocity component resulting in shallow fissures around the corners. Programming cutter pressure increase when the cutter head slows has helped this situation. Still, breakout is not what is desired and quality of the score line and opened edge suffers. This is not a scoring problem but rather a process problem.

Generally speaking, with straight-line pressure cutting or large radius pattern pressure cutting, deeper fissures resulting from elevated scoring speeds do not degrade the score line quality or opened edge quality. Keeping in mind that any pressure cut edge is inherently weaker than a conventional cut edge.

6. Glass Cutting Fluids

Unlike the case of conventional cutting where there is a choice whether or not to use a cutting fluid, pressure cutting does require a cutting fluid. It is important to keep the score line intact until breakout by using the cutting fluid to retard healing. The fluid is also useful to contain the glass dust and debris generated by scoring. In automotive pattern cutting and multiple layout off-line machines, extended delays are often encountered between scoring and breakout.

If the cutting fluid is a lubricant, it can be run through the wheel assembly and serve a dual purpose of lubricating and flushing the wheel assembly and lubricating the score line. If the cutting fluid is not a lubricant it should not be applied to the glass through the wheel assembly.

The use of, and type of, cutting fluids are left to the discretion of the user.

7. Cutting Wheel Life

Pressure cutting wheels have the same wear characteristics as those used for conventional cutting. The primary difference is that the applied cutter load is higher. In the case of larger diameter wheels (3/8", 1/2", etc.) the applied loads are very much higher.

Also, the same factors shorten wheel life by abusive practices – hard set downs, climbing an edge, running off of an edge, nicks in the tip line from handling. Most off-line machine cutters have an over travel limit device to instantly retract a cutter in the event of glass puncture, broken glass, or running off of an edge. This minimizes damage to the cutting wheel and will prevent damage to the cutting head.

How does wheel wear effect edge quality? Normal wear does not effect edge quality, but wheels with tip line damage will transfer this defect to the score line.

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