Technical Guide for Glass Cutting
Section 2 - Three Basic Categories of Cutting

Three basic categories of glass cutting represent the majority of cutting applications – straight-line machine cutting, machine pattern cutting and hand cutting. In this section each category has a brief description of the various cutting functions. There are also listings of process considerations when setting up the cutters, cutting wheel selection guides for the various glass thickness and, some typical in-plant problems associated with the cutting process.

Part 1 – Straight Line Machine Cutting

Description of On-Ribbon Machine Cutting

Float tanks run at essentially constant tonnage, i.e., a 600 ton tank is charged with 600 tons of batch daily, melted and refined. The net tonnage (after the gaseous by products are exhausted) represents a near constant mass throughput into the wareroom. Ribbon speed increases inversely as ribbon thickness decreases. Right/left terminology is determined as one is facing the change end of the float tank. Most 2 tank plants have one tank dedicated to one range of products and the 2nd tank dedicated to a different range of products. (Example: automotive thin glass on one and glazing on the second.)

There are two distinct cutting applications – slit cutting and crosscutting. Slit cutters (X-axis) on fixed bridges score the ribbon longitudinally. Crosscutters (Y-axis) score across the ribbon on an angled, fixed bridge. The crosscuts cut the ribbon to various lengths and the slit cutters cut the ribbon to various widths.

Slit cutters are mounted on fixed bridges and positioned with reference to the ribbon either manually and/or servo-positioned. A main line cutting section can have one or as many as four fixed slit cutter bridges. Each bridge can have anywhere from 2 to 12 cutting heads. Terminology for slit cutters varies across the industry: longitudinal cutters, long-beam cutters, X-axis cutters, slit cutters, etc.

Order cutting has gradually been moved from re-entry cutting machines or offline cutting machines to an on-line operation. This has required a laundry list of developments: accurate ribbon tracking, computerized control of order mix

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assignments (which bridge will slit and moving cutters to position), accurate slit cutter set down and pick up on imaginary crosscut scores, and responsive cutters. Thin glass small size order cutting requires processing the cascade of ribbon tracking data to assign which crosscut will be ready to make the next crosscut score. With thin glass there can be as many as 5 active crosscuts.

On-ribbon order cutting dictates frequent and rapid thickness changes from thin (3/32″) to heavy (3/8″ or 1/2″) and back to thin. One problem which is not obvious is that the anneal stabilization lags in time behind gage and optics coming into spec. This can and often does create snapped edge quality problems.

On-ribbon bulb edge removal can be and often is an ugly problem, particularly when the anneal has not yet stabilized or when the bulb edge mill strain is too high. This is accomplished by double scoring inside the bulb edge – two parallel scores ranging from 2″ to 6″ apart. The score near the bulb edge (called the relief cut) is snapped or peeled off first. This effectively reduces the effect of bulb edge stress on the interior of the plate. The second score (called the money cut) can then be snapped or peeled off resulting in good edge quality.

Description of Off-Line Machine Cutting

Most off-line cutting machines have multiple operations: plate loading, plate squaring, plate scoring, plate score opening, plate unloading and/or packing. Of all these processes our concentration is on the cutting berth. Many designs and configurations are available and, the choice of which, depends on the product. The glass supplied to off-line machines can be supplied in nominal stock sizes or in exact sizes (also depending on the product).

Some of the cutting machines in common use are:

- Single head CNC cutter with X, Y, and Z axis positioning (Z being the axis of rotation of the pillar post). These machines have a single bridge and single cutting head scoring stationary glass. (used for mixed orders)
- Double bridge machine (one fixed bridge, the second at 90 degrees and is movable) with multiple, manually positioned cutting heads. The fixed bridge scores the Y-axis scores during the run into the berth and the movable bridge sweeps the plate with the X-axis scores. (used for large volume, small cut size orders)
- Double bridge machine (both bridges fixed, 90 degrees apart with plate squaring and edge referencing upon entry into each cutting station), multiple cutters manually or servo-positioned. (used for high volume, larger sized plates).

This list is incomplete but it points out some of the basic differences.

The products cut on off-line machines are primarily those that are low volume (by float line standards) or are too small to be cut on-line. Another type of product is glass such as that used for insulation glass units where the cutting machine is a dedicated part of the insulated glass assembly line.

In the operation of these machines there are two cardinal rules of glass cutting that are often ignored or overlooked: trim cuts that are too narrow, and running a cutter up onto an edge or running off of an edge.

- Trim width should be no less than 8 times glass thickness to achieve a quality edge. (Recommended by the glass suppliers) This mean 1" trim on 1/8" glass, 2" trim on 1/4" glass, etc. This amount of trim is necessary to provide a proper moment when opening a score to produce good edge quality. As this ratio is reduced, opening defects are introduced and become more numerous and severe. These defects can reduce edge strength of products both in handling and shipping and are in no way connected to scoring but rather to score opening principles. Some operations permit the trim ratio to be reduced to save money.
- On straight line scores running edge to edge, the score should start 1/16" in from an edge and stop within 1/16" of an edge. These scores should snap without a "corners on – corners off" situation. Many operations permit running up onto an edge and running off of an edge.

Process Considerations for Cutting Set Up of On-Ribbon Machine Scoring

Check List:

- *Cutting Support* – maximum support directly under cutter location or under path of crosscutter.
- *Cutting Assembly* – all cutting heads properly aligned so that wheel is presented perpendicular to glass. Check wheel mount, inserts, and axles for wear – also, check linkage on cutting heads.
- *Cutting Wheel* – select cutting wheel diameter and wheel angle from either a predetermined specification or from the "Recommended Wheel Angle" table for the glass thickness scheduled. Assemble wheel into a clean insert and lubricate. Select cutting head load from either a predetermined specification or from the "Recommended Wheel Load Chart" for the glass thickness scheduled.
- *Cutting Wheel Finish* – the wheel finish will more than likely be predetermined as "regular grind" (220x). Special products may require a higher finish (800x) or a coarser grind (180x).

- *Cutting Wheel Speed* – glass ribbon speed can run up to 1000 in/min. This should be no problem for the slit cutters. At 1000 in/min ribbon speed, the crosscutters will score (depending on crosscut angle) at up to 8 times ribbon speed. At these speeds it is very important to keep the cutting wheel assembly clean and clear of debris, such as interleaving build-up.
- *Glass Cutting Fluid* – if a cutting fluid is used for scoring and to retard healing, the fluid flow should be checked. If a lubricant is used for the wheel assembly only (dry cutting), the wheel assembly has to be pulled periodically to clean and lubricate the wheel/axle/insert assembly. If compressed air (with entrained oil) is used to purge and lubricate the wheel assembly, the amount of oil in the air stream should be checked.
- *Cutting Wheel Life* – check for extra hard cutter set-down onto the glass surface for both slit cutter heads and crosscutter heads. Abusive set-downs result in reduced wheel life. Also, check that crosscutter heads set down inside the ribbon edge and pick up short of the opposite ribbon edge. Also, running across knurled or nipped edges may at times be necessary but expect some effect on wheel life and/or score quality.

Process Considerations for Cutting Set Up for off-line Machine Cutting

Check List

- *Cutting Support* – for single bridge CNC/XYZ cutting machines the glass is normally transported into and out of the cutting berth on a belt running on a good, solid metal surface. Machines with cut out openings for glass transport rolls can expect quality problems when thin glass is scored over these voids. Cutter bridges, fixed or movable, should be rigid enough to resist the upward reaction force form the cutter head/heads.
- *Cutting Assembly* – the cutter head or heads should be properly aligned so that the cutting wheel is presented perpendicular to the glass. Check wheel mount insert and axle for wear.
- *Cutting Wheel* - select cutting wheel diameter and wheel angle from either a predetermined specification or from the "Recommended Wheel Angle" table for the glass thickness scheduled. Assemble cutting wheel in a clean insert and lubricate. Select wheel load from either a predetermined specification or from the "Recommended Cutting Wheel Load" table for the glass thickness scheduled.
- *Cutting Wheel Finish* – the cutting wheel finish will more than likely be predetermined as "regular grind" (220x). Special products may require a higher finish (800x) or a coarser finish (180x).

- *Cutting Wheel Speed* – There should be no problem with cutting wheels because of cutting speed, even for the newer extremely fast cutters (several thousand in/min). However, with the higher product throughputs, more glass interleaving particles can collect in the insert/axle/wheel assembly and cause the wheel to drag and not score. The insert should be pulled and cleaned periodically. Also, the snapped edge fissure depths should be checked periodically to make sure the cutter was at full load at start and end of cut.
- *Glass Cutting Fluid* – if a cutting fluid is used for scoring and to retard healing, the fluid flow should be checked. If a lubricant is used for the wheel assembly only (dry cutting), the wheel assembly has to be pulled out periodically to clean and lubricate the wheel/axle/insert assembly.
- *Cutting Wheel Life* – cutting wheel life will depend on whether the wheel is abused. Hard set downs will shorten life. Also, extremely hard set downs can cause the axle to break. Cutters should be set down inside an edge 1/16" and picked up 1/16" short of the opposite edge. Continuous running onto and running off of an edge can cause severe wheel tip damage and shorten wheel life and cause poor scoring. When a cutter runs over a contained glass defect (such as a stone) the stress razor caused by the stone will interact with the wheel score and cause the glass to break at that point. It is important that the retract switch be operational for the glass thickness being processed. If it is not operational or if there is no switch, severe damage can be done to the cutting wheel, mount or even the entire cutting head. Severe damage can also occur when a machine is started up with glass on the belt – make sure the cutter head is in the up position so that it does not collide with the glass when the bridge begins it's start up routine.

The following guidelines are divided into two basic groupings as a function of glass thickness. The cutting wheel angles shown in the tables are intended as starting points to achieve the "target fissure depth" for each glass thickness. Also shown are rough figures for applied cutter head force. (in pounds, not psi)

Wheel Selection Guide for 3/32" Glass and Thinner

Glasses in this group are a mixture of float, sheet and specialty glass. Hard surface and specialty glass often require sharper wheel angles than those recommended in the wheel angle recommendations. The cutting wheel diameters, cutting wheel angles, and wheel loads in the thickness range of 3/32" and thinner are recommended in the table below. The wheel angles and wheel loads are only intended to be starting points to develop quality cutting.

		Glass Thickness			
	in.	< .0400	.0400	.0625	.0938
Wheel Code	mm.	< 1.016	1.016	1.588	2.381
732		*	105°	128°	128°
		--	--	2-3 lbs.	3-4 lbs.
532		*	115°	128°	134°
		--	--	2-3 lbs.	3-4 lbs.

Notes: * Wheels can be made to suit specific needs.

Common Processing Problems	**Possible Causes**
• Sliver chips	Score too heavy
• Breakage during scoring	Warp Poor anneal
• Wheel slips during scoring	Wheel finish too smooth
• Wheel punctures plate	Glass Defect (stone)
• Wheel punctures plate (repetitive)	Anneal Score too heavy

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Wheel Selection Guide for 3/32" Glass through 1/2" Glass

Most warerooms and off-line operations follow the guideline of producing the best quality glass edges. In order to achieve this, most machine operators set up their lines or machines score no deeper than necessary to achieve successful score opening.

All glass in this group is assumed to be float glass with conventional cutting. Target fissure depth is 7-10% of glass thickness. Target fissure depth for 3/8" and 1/2" thick glass will require considerable cutting wheel loading to achieve this. The recommended cutting wheel diameters, cutting wheel angles and wheel loads through the range of 3/32" to 1/2" glass thickness are shown in the table below. The wheel angles and wheel loads are only intended to be starting points to develop quality cutting.

	Glass Thickness						
in.	.0938	.1250	.1875	.2500	.3125	.3750	.5000
Wheel Code mm.	2.381	3.175	4.762	6.350	7.938	9.525	12.700
732	128°	134°	138°	145°	148°	152°	152°
	3-4 lbs.	4-5 lbs.	6-7 lbs.	10-12 lbs.	14 lbs.	18 lbs.	26 lbs.
532	134°	140°	145°	152°	152°	154°	154°
	3-4 lbs.	4-5 lbs.	6-7 lbs.	10-12 lbs.	14 lbs.	18 lbs.	26 lbs.

Notes: Pyrolytic coated glass may have a hard surface and require sharper wheel angles.

Common Processing Problems	Possible Causes
• Wavy cuts	Insert slot wear Wheel mount alignment
• Light/heavy scores	Concentricity of cutting wheel Concentricity of cutter cart wheel
• Chips coming from score line	Cutting wheel load too high
• Cutting wheel dragging	Interleaving plugging wheel slot