Optimizing the Shear Slitting Process
Summary

Presenter: Peter Wood, Product Manager – Slitting
Tidland Corporation, Camas, WA

Shear slitting is the most versatile and commonly used method to slit flexible web materials. It is also the most demanding, requiring careful attention to control specific operating variables, for high quality slitting. These variables and their influences are identified, and guidelines for optimizing each variable to refine the slitting process are presented. These variables include:

- blade sharpness/profile
- cant angle
- overlap
- side force
- nip velocity vs. web velocity
- slitter geometry
- trim removal

Blade Sharpness / Profile

In rotary shear process, materials are slit in the nip between two overlapping, hardened metal disks which create stress in the shear mode sufficient to sever the product. This is in contrast to compressive stress when crush/score slitting, or tensile stress when razor slitting. The characteristics of the blades extreme edges determine the "sharpness," and should not be confused with the grind angle or cross-sectional "profile" of the slitting blades. All slitting blades must have sharp edges, but profiles can vary widely and still meet the criteria for "sharp" blades.

Cant Angle

The cant angle (shear angle) assures a closed nip. Like a pair of scissors, the blades must be in contact at the nip or "cut Point" in order to cleanly shear the web. Certain materials are very sensitive to cant angle settings, whereas other materials seem to slit well with almost no thought given to the question www.tappiplace.org

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Optimizing the Shear Slitting Process

Presented by:

Peter Wood

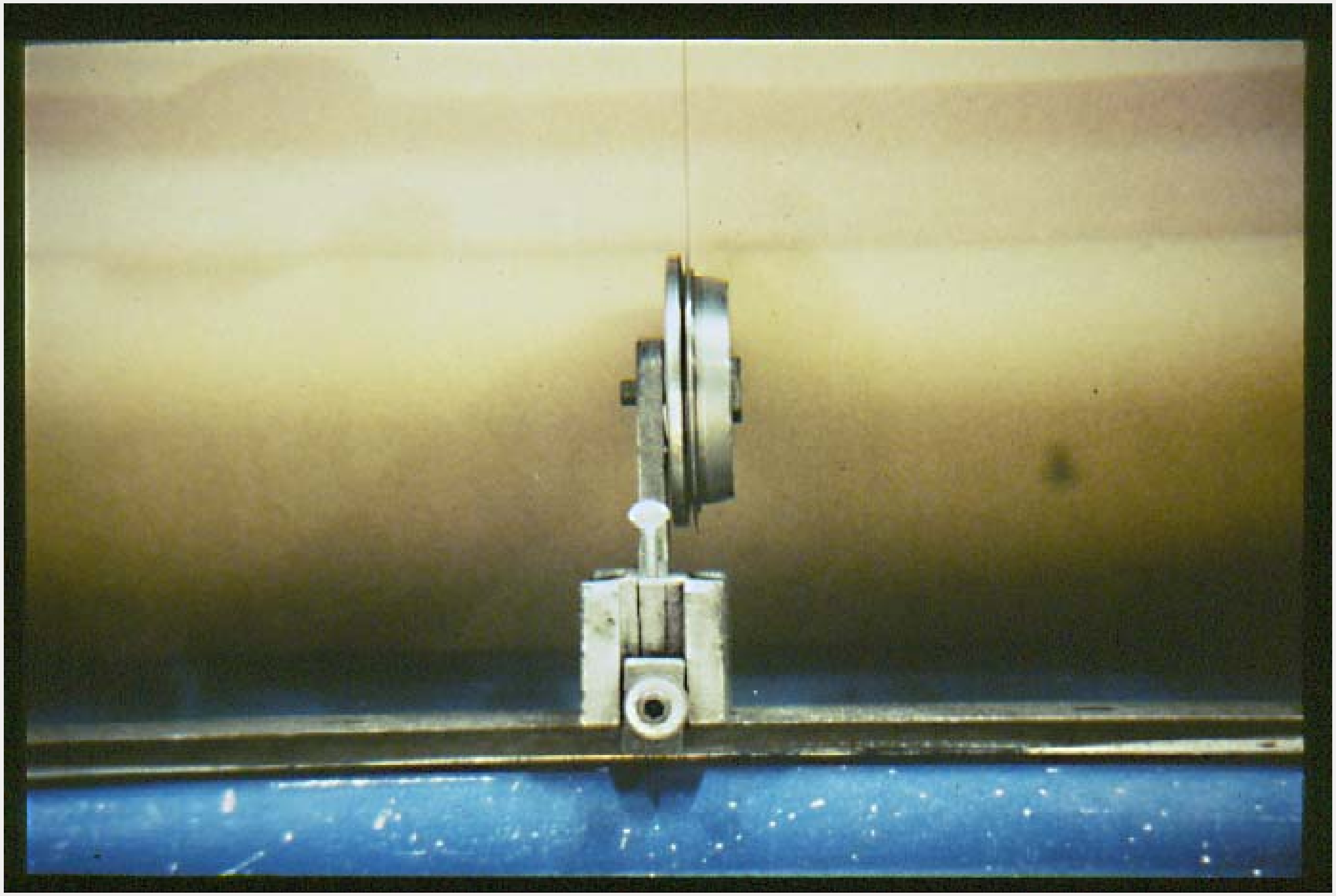
Slitting Product Manager

Tidland Corporation

Large, Complex Slitter

…Shear slitting can involve a large, complex machine, or…….

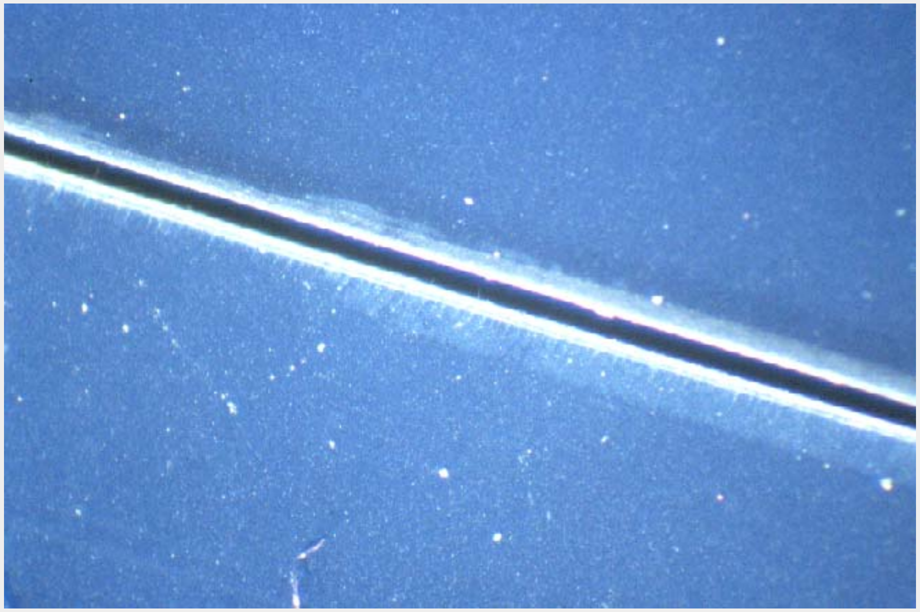
“Old Timer”

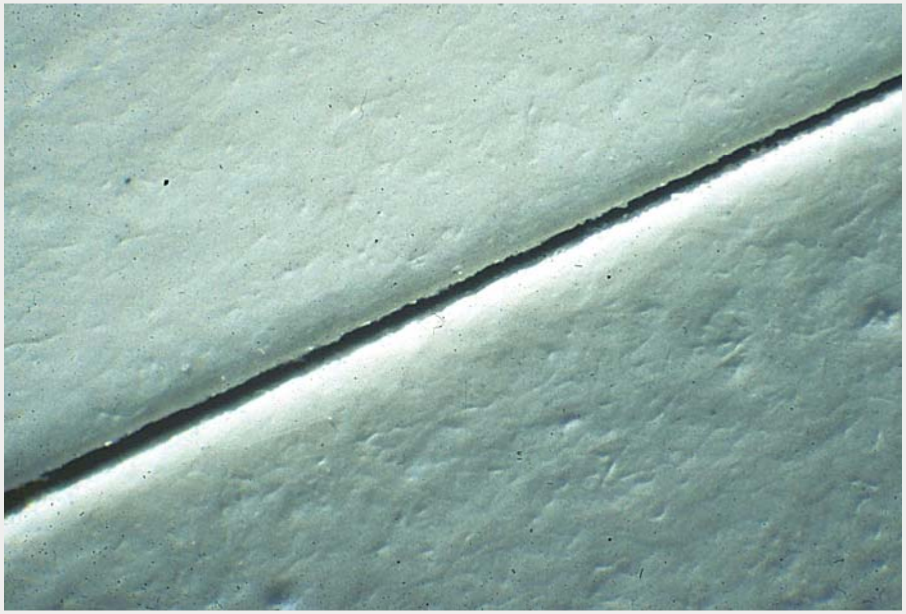


…Shear slitting can involve a simple “old timer”.

Variables to Control

- Consistency in slit quality is within reach
- Control the variables in slitting

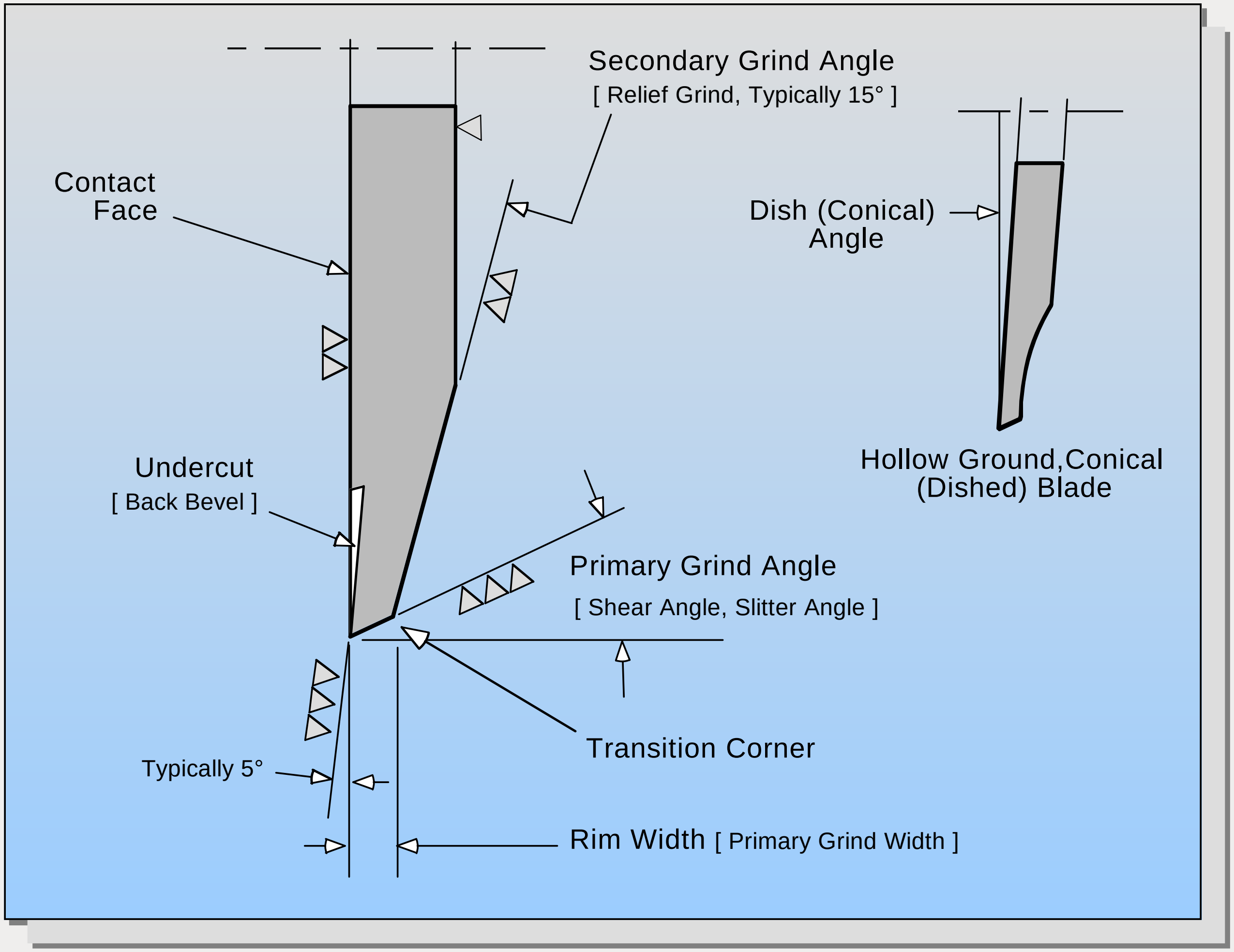




Variables to Control

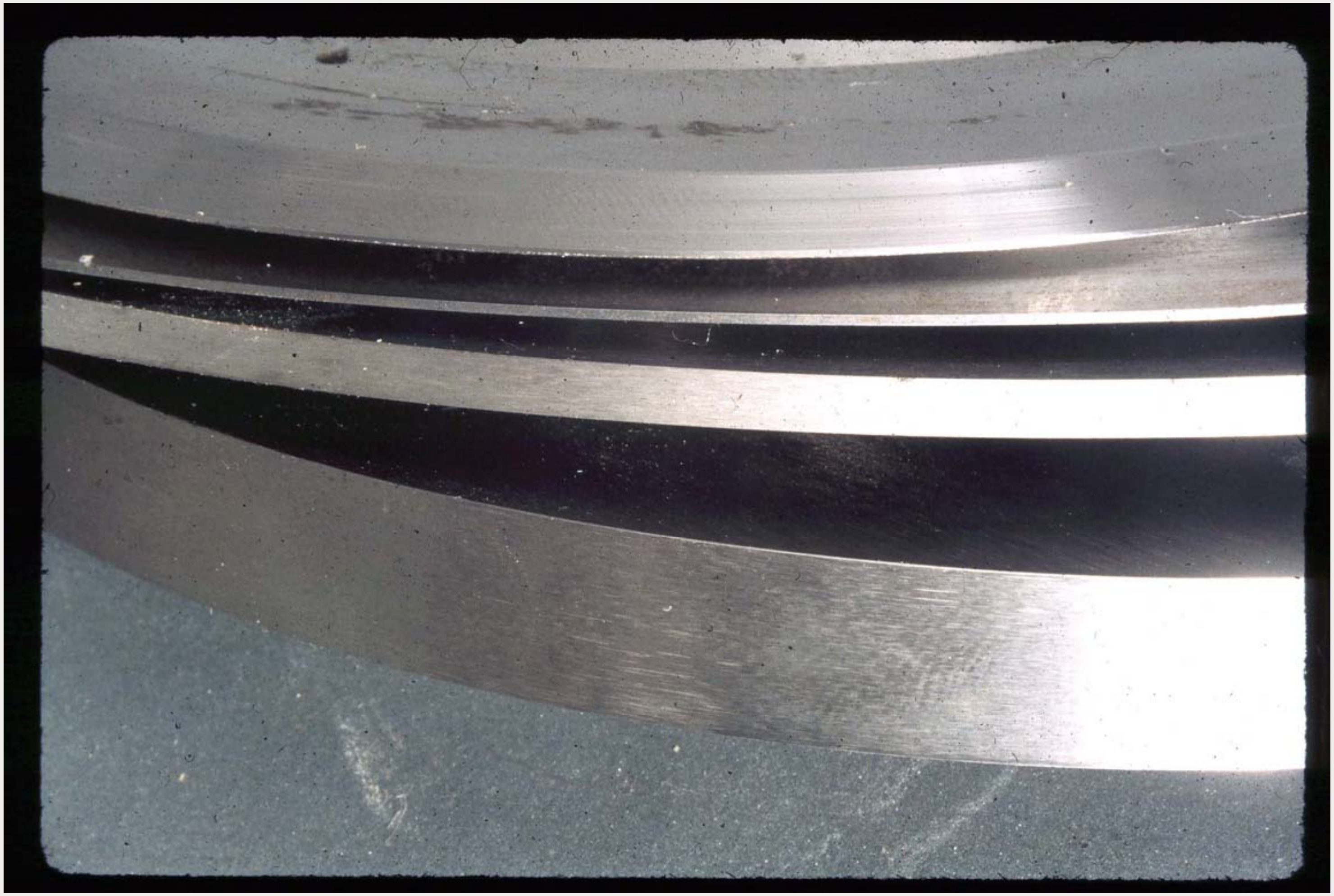
- Achieving and maintaining a quality cut is directly impacted by factors that can be controlled
  - blade sharpness/profile
  - cant angle
  - overlap
  - side force
  - nip velocity vs. web velocity
  - slitter geometry
  - trim removal

Shear Blade Profile Terminology



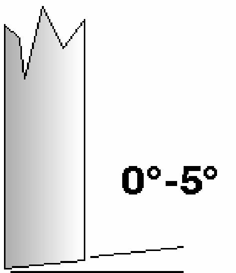
COMPOUND BEVEL, FLAT BLADE, with UNDERCUT.

4 Shear blade profiles…

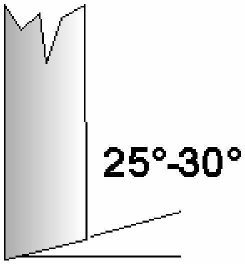


Blade Profile

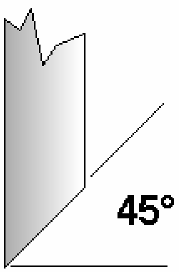
Strongest blade edge: for slitting metals, low elongation plastics, tissue, newsprint, coated products



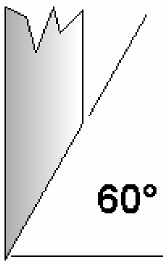
Good general purpose edge: for slitting paper, films, laminates, non-wovens, boards.



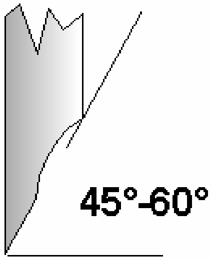
Compromise between blade edge strength and distortion of product at slit edge.



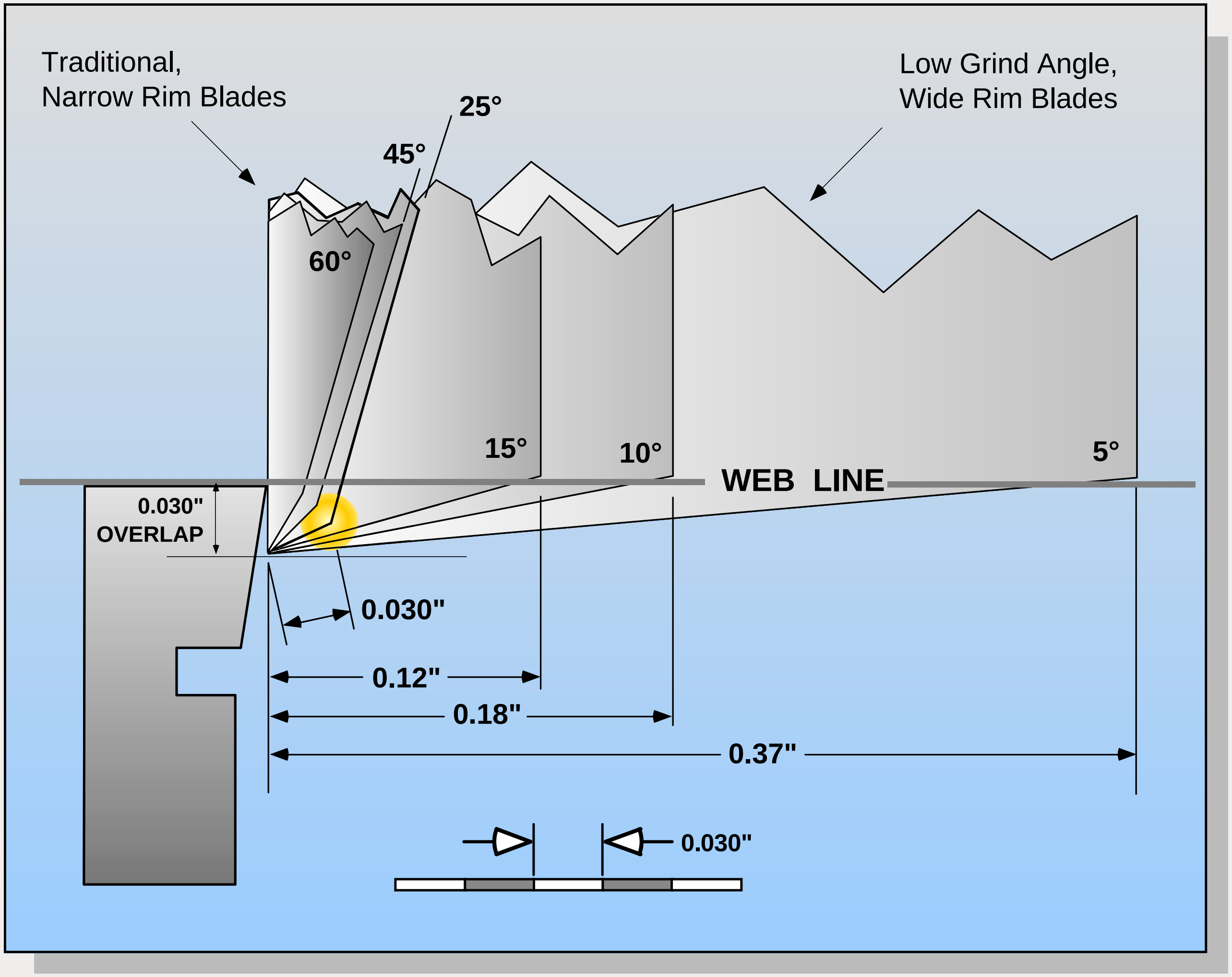
Very weak blade edge: typically used on sheeters and wrap configured slitting machines to reduce distortion of product at slit edge.



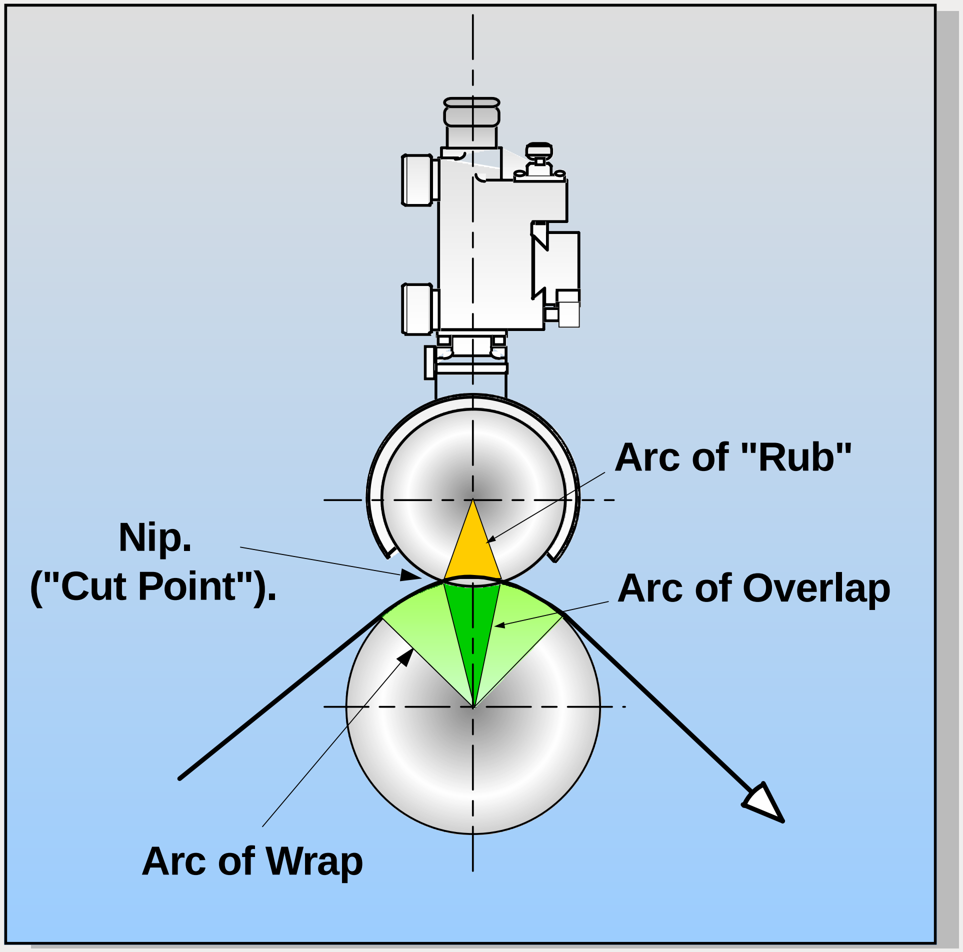
Extremely fragile edge: rarely used today, except when wrap slitting light metal foils. *Light* sideload req'd.



Blade Profile

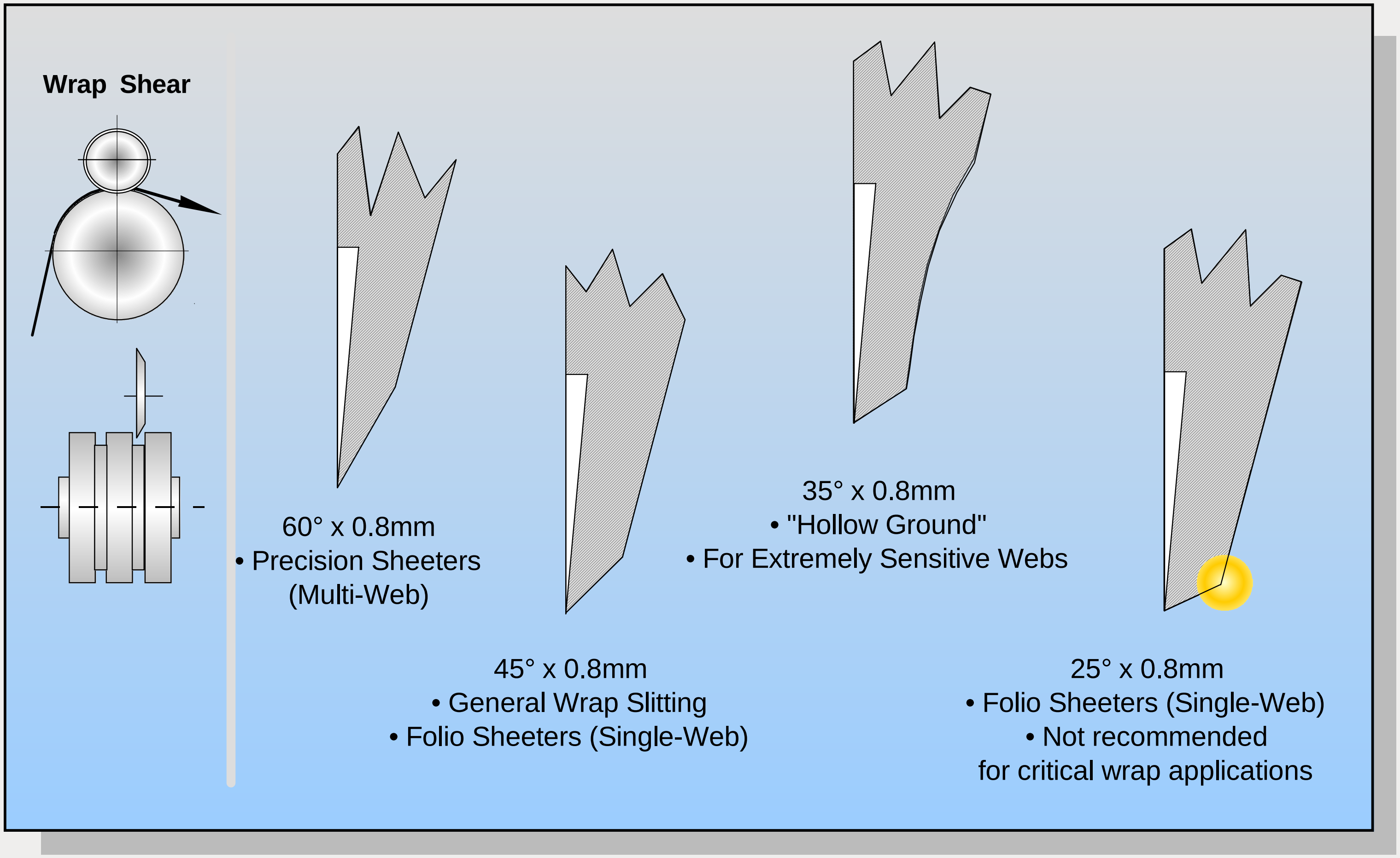


The Wrap System



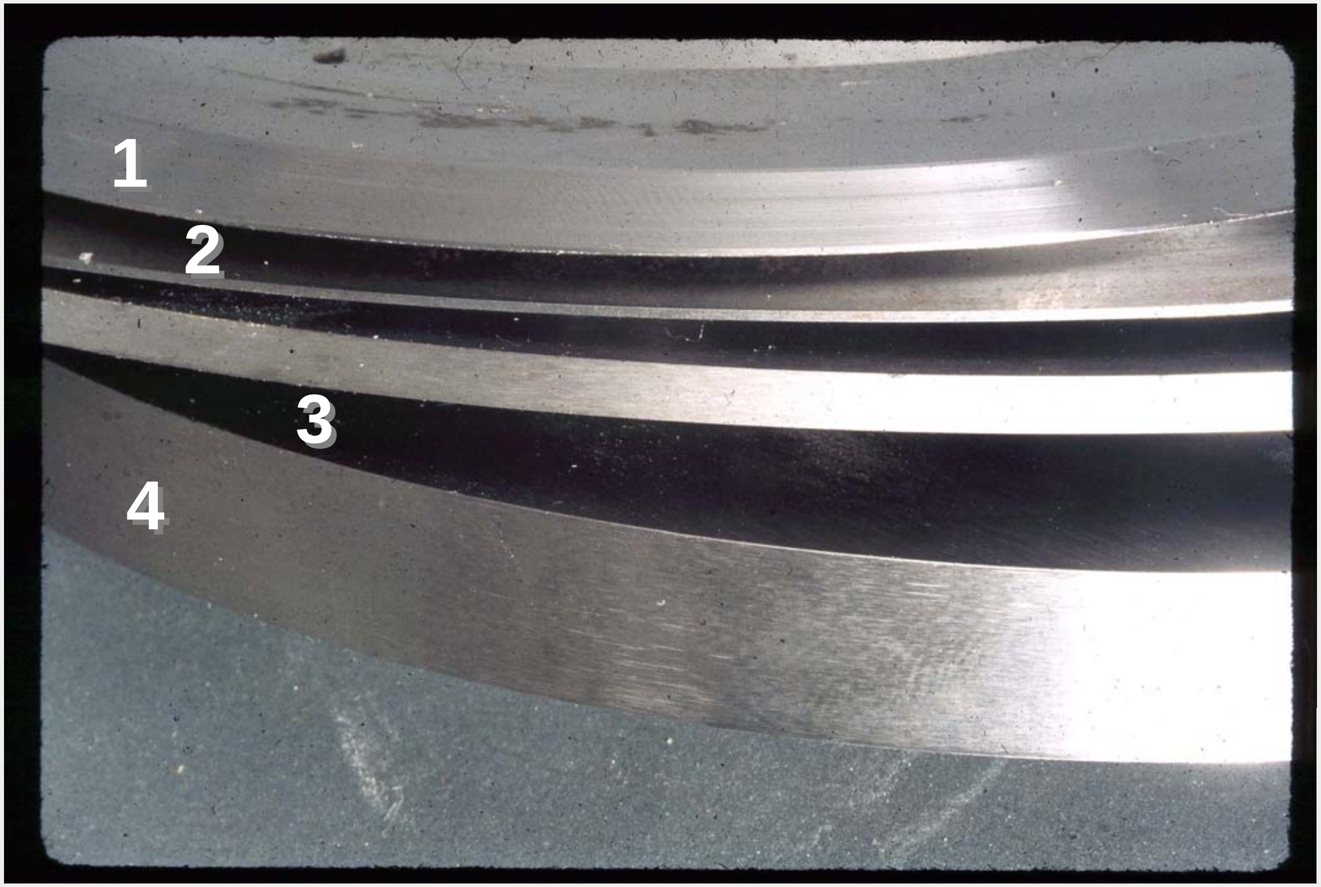
Web speed and lower slitter speed is synchronous

Profiles for Wrap Slitting



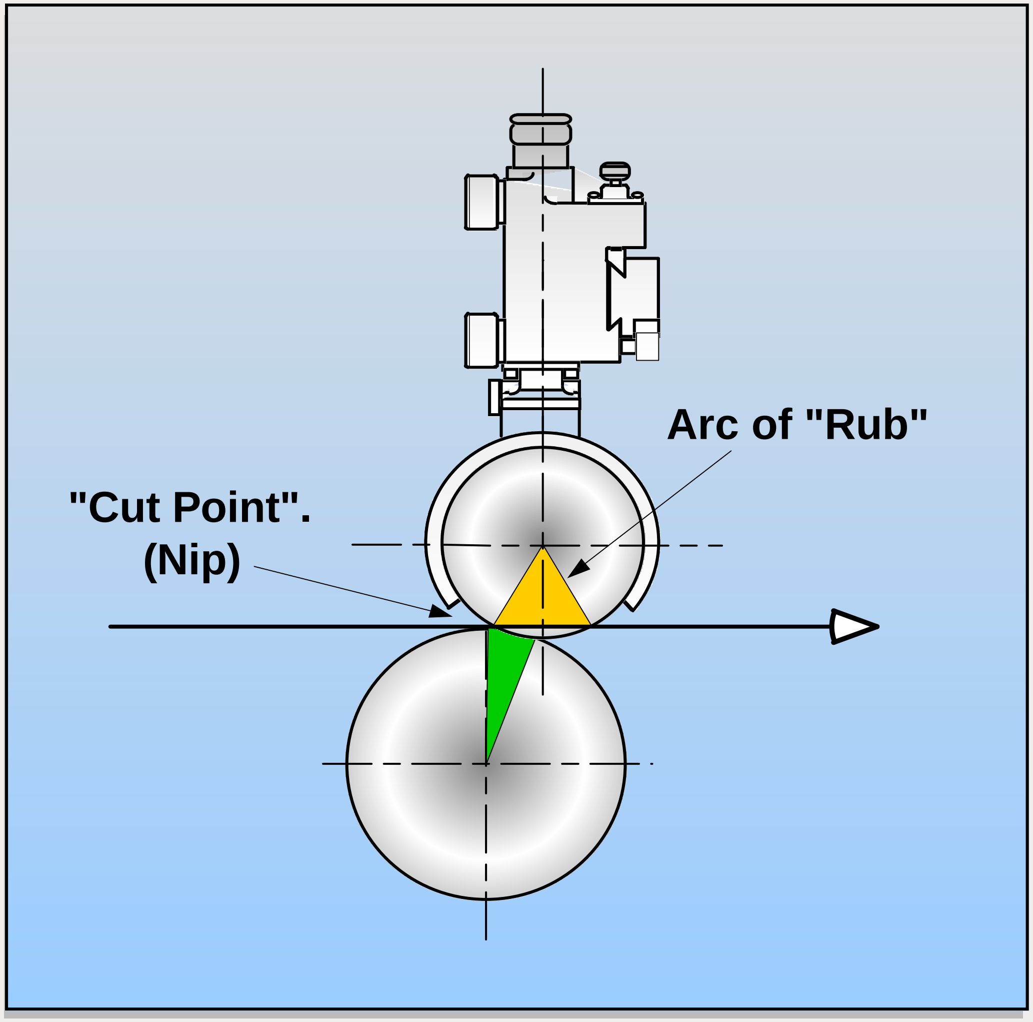
…Wrap slitters confine the shear strain into a narrow groove,
…Blades must be very thin (and fragile) to minimize edge damage.

4 Shear Blade Profiles

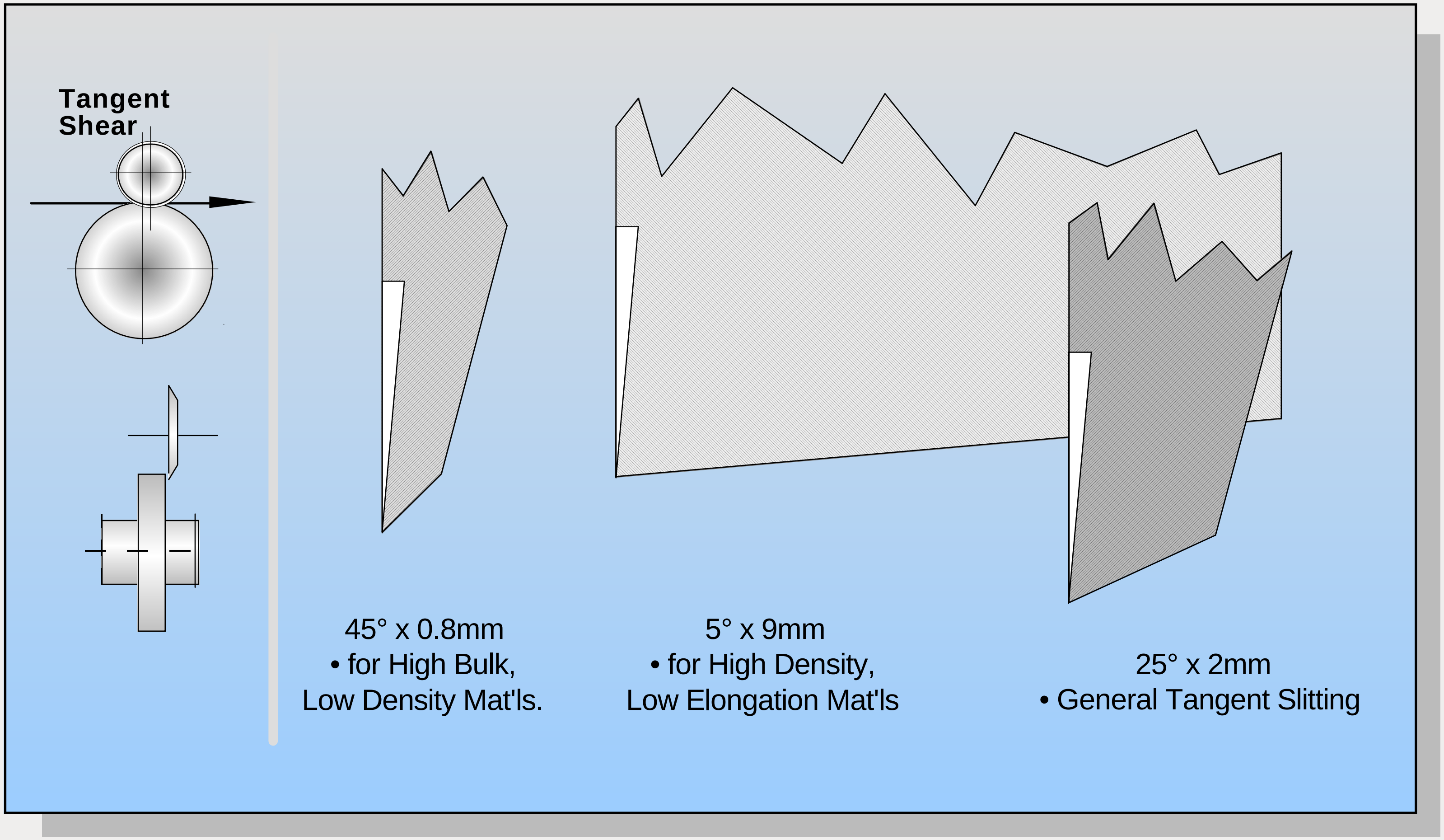


…#1 & 2: Wrap slitter blades
…#3 & 4: Tangent slitter blades

The Tangent System

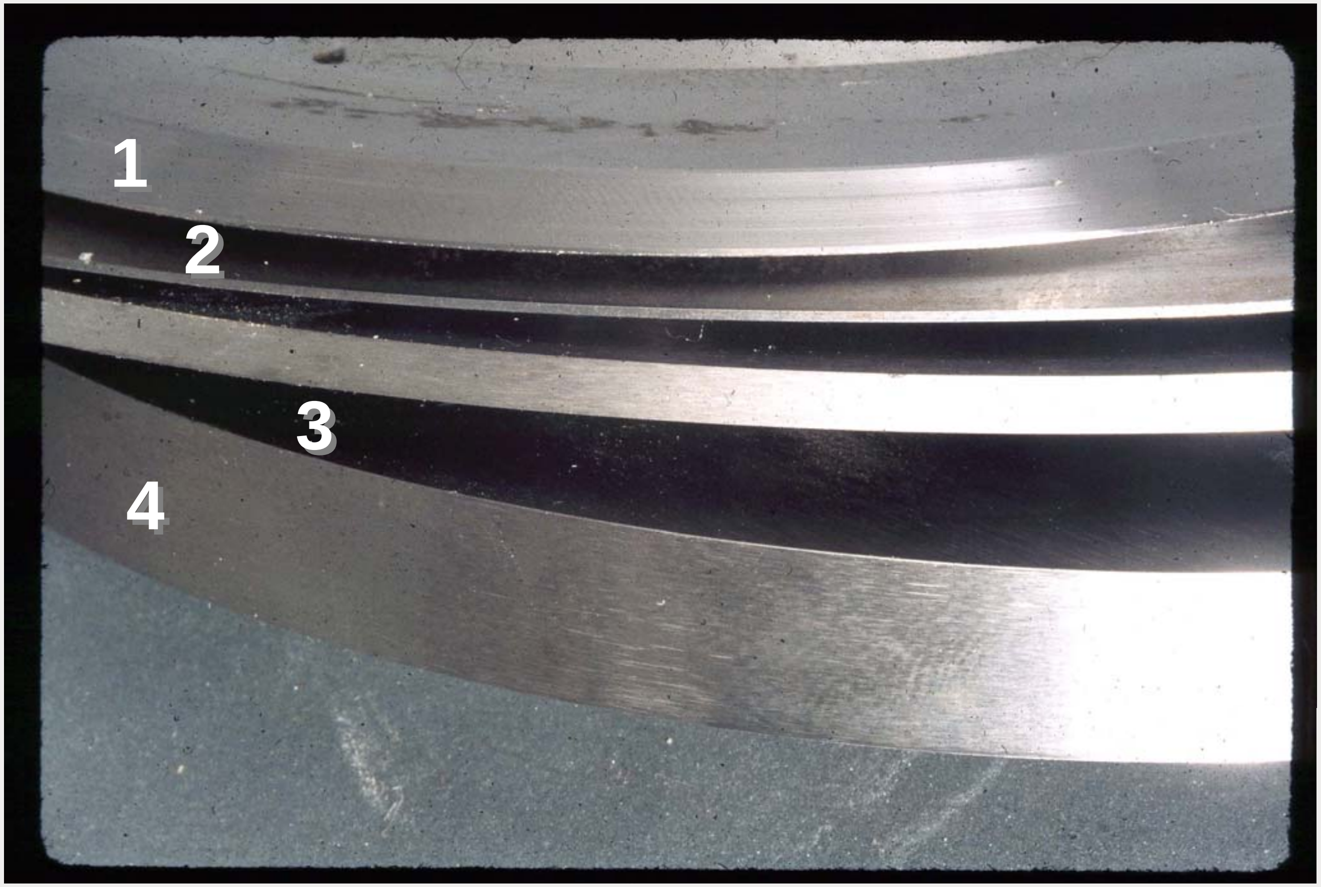


Profiles for Tangent Slitting



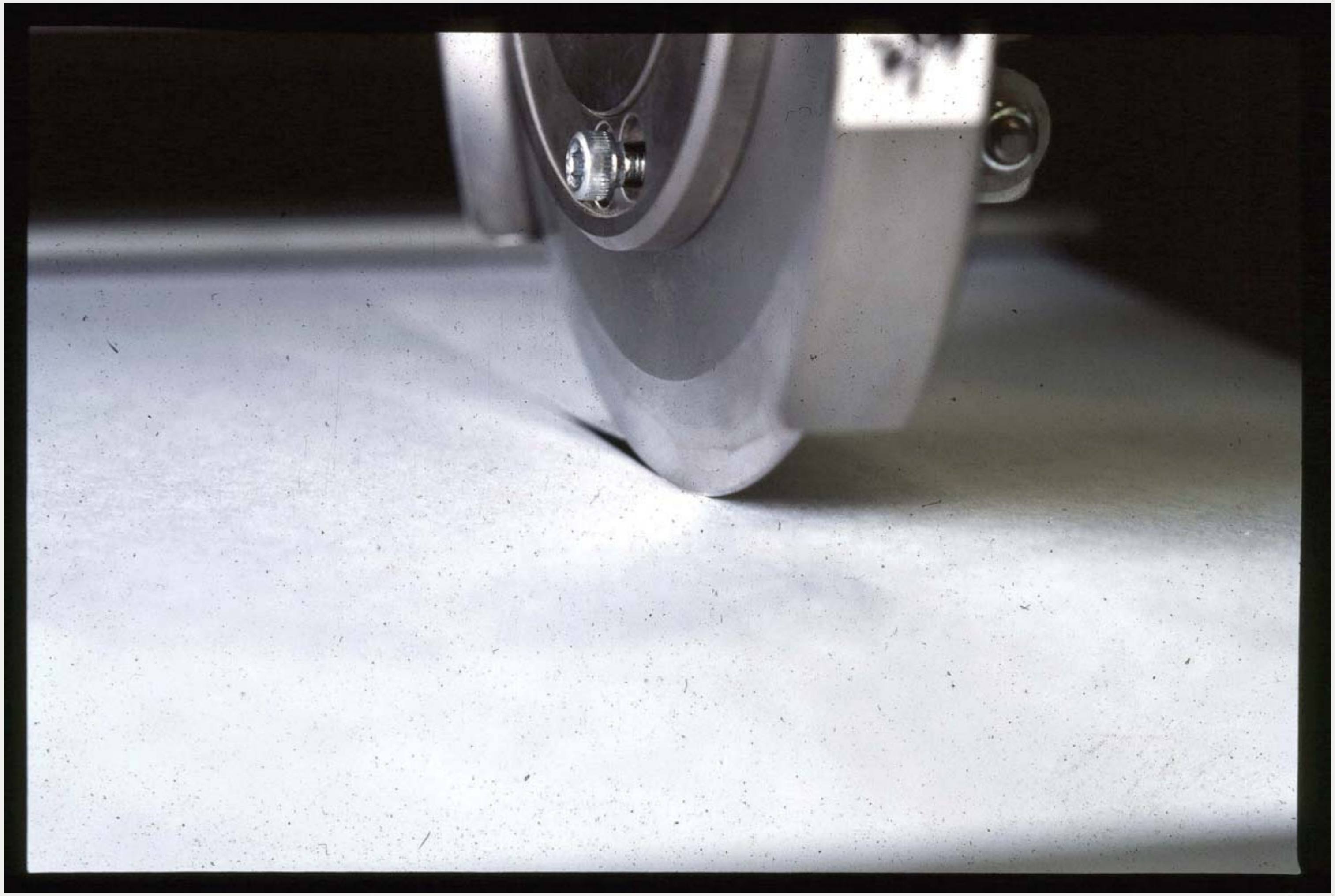
…Tangent configured slitters permit a wide variety of blade profiles.

4 Shear Blade Profiles

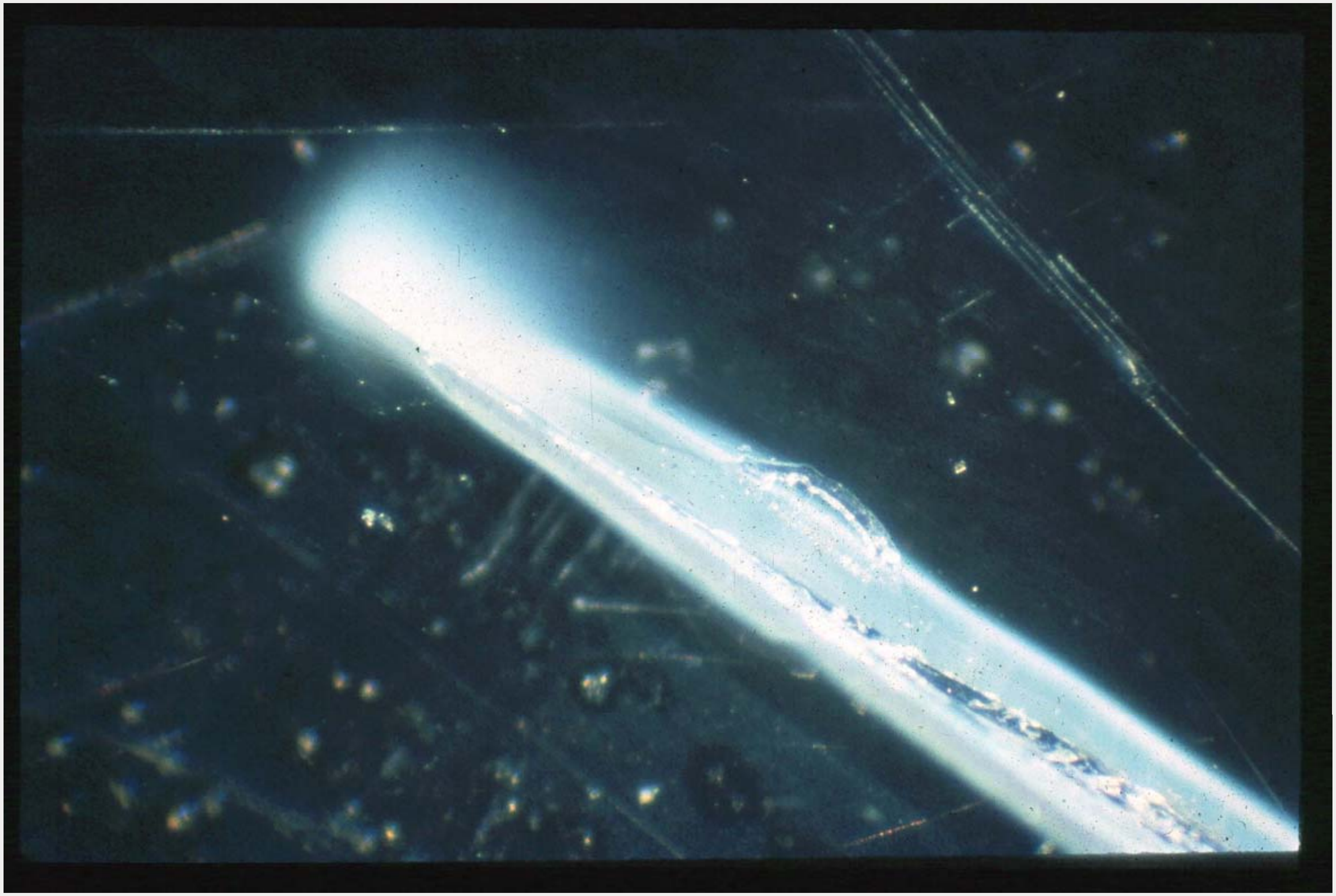


…#1 & 2: Wrap slitter blades
…#3 & 4: Tangent slitter blades

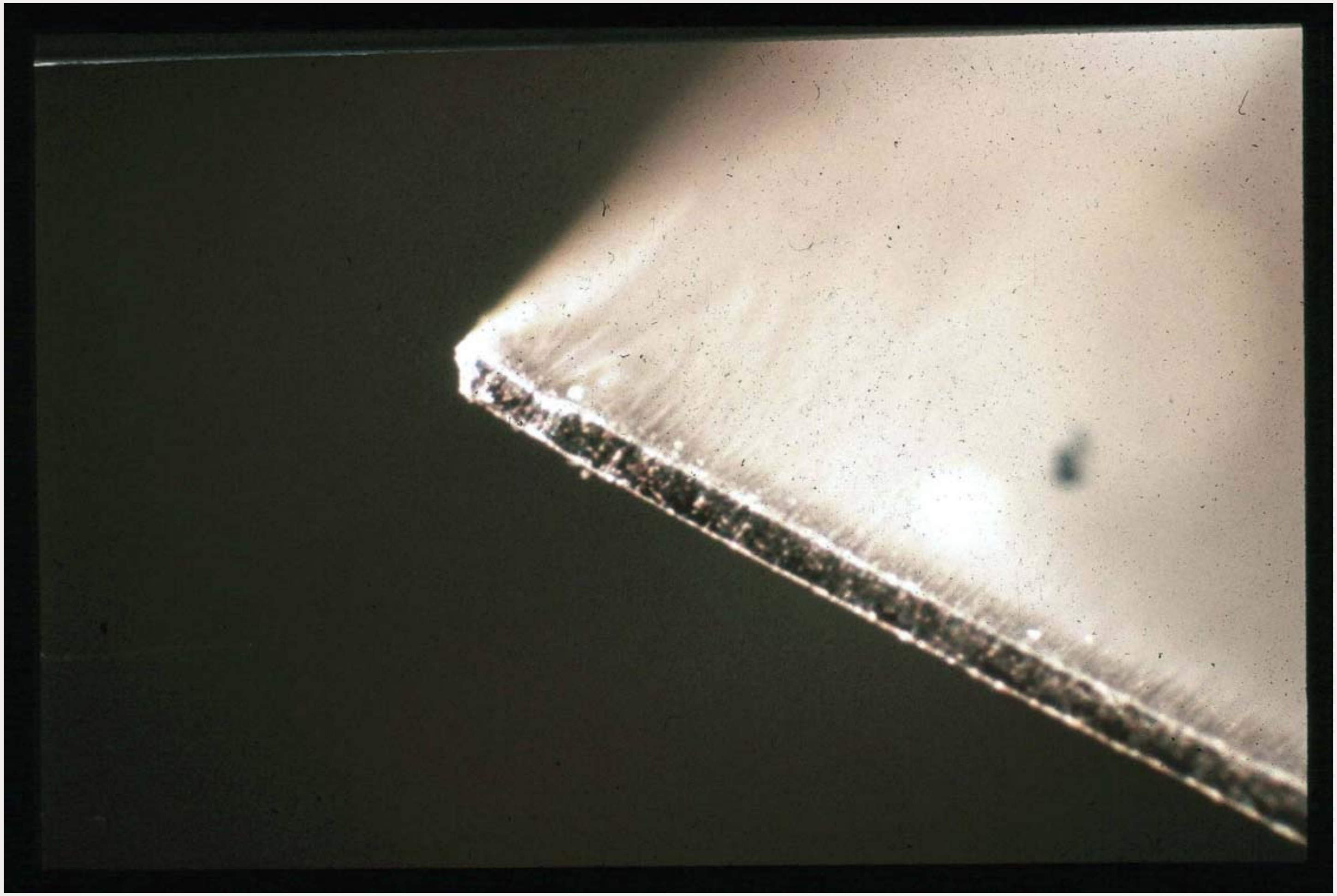
25° Blade in a Tangent Web



25° Stress in Styrene

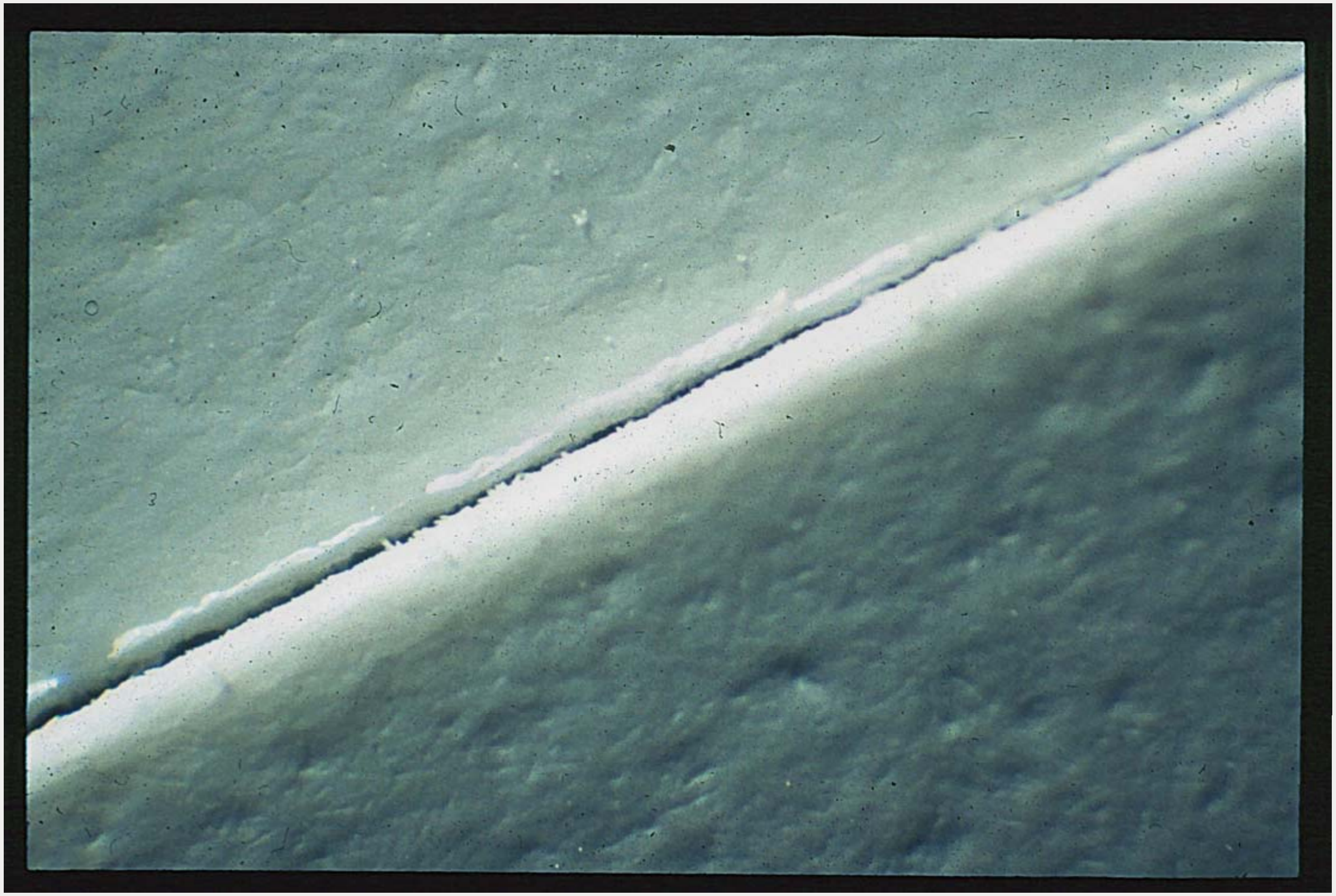


Aluminum Litho plate
25° Tangent Shear



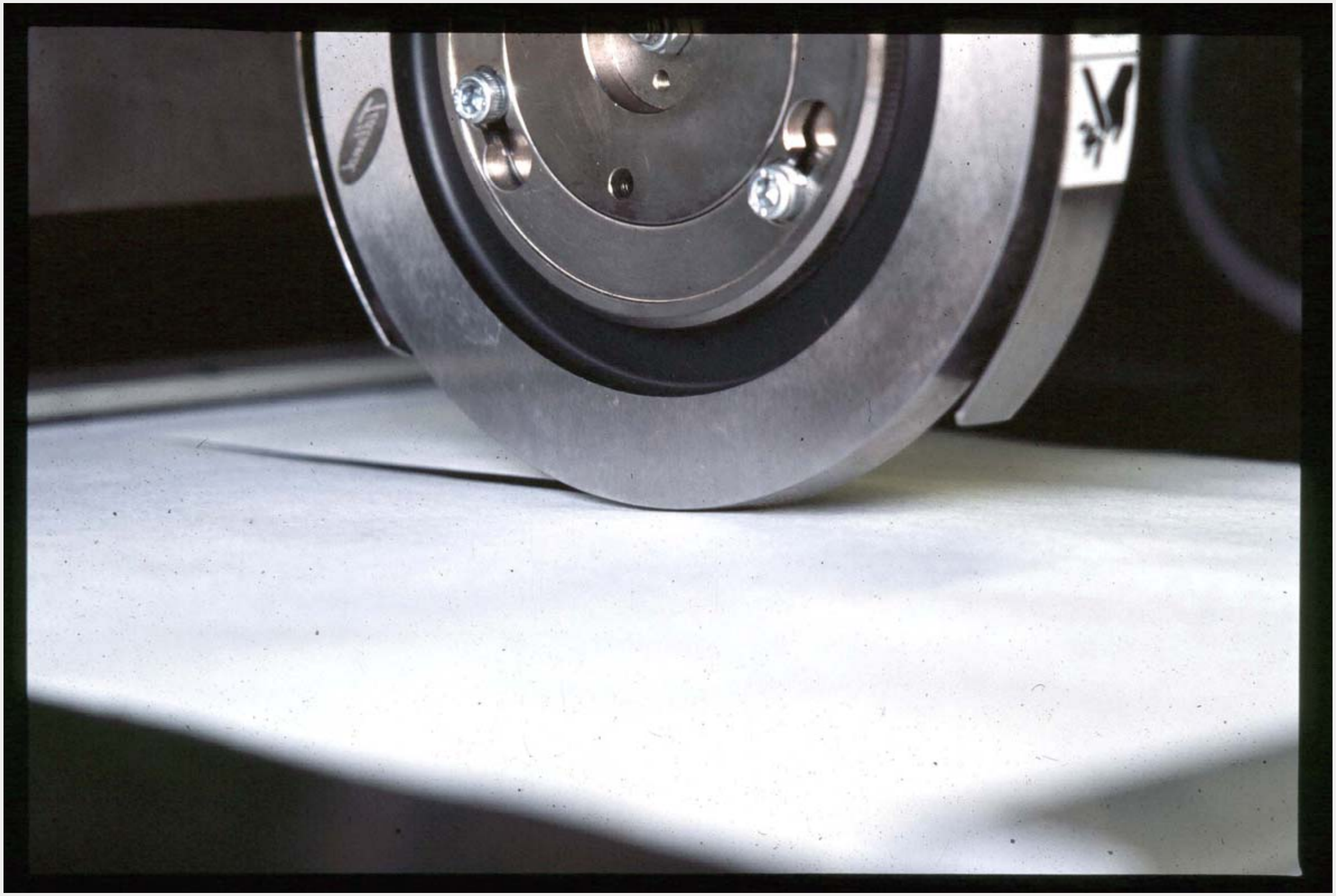
Unsupported edge

Coating ridge. 25° blade

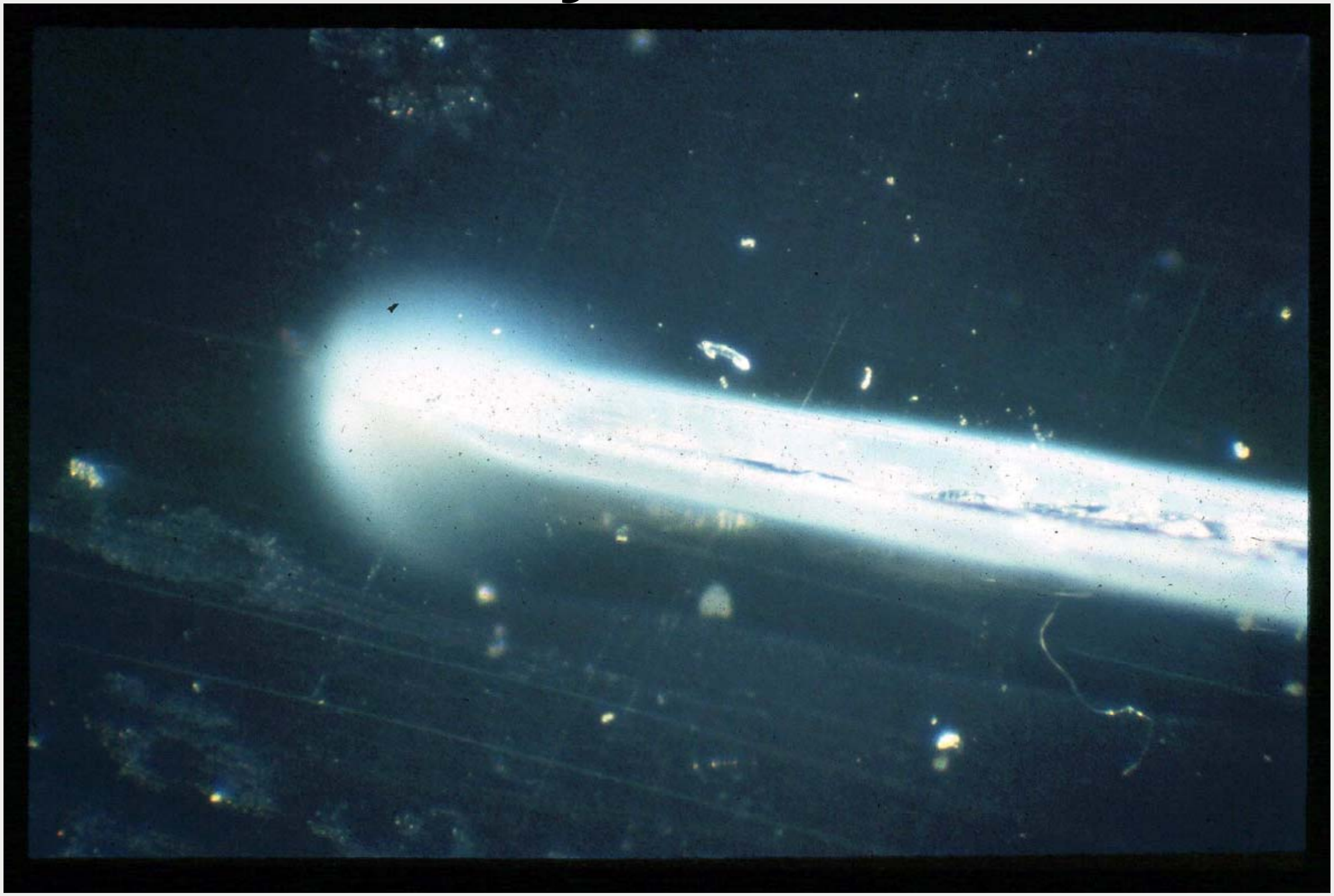


Notice ridge of coating from edge of compound bevel blade.

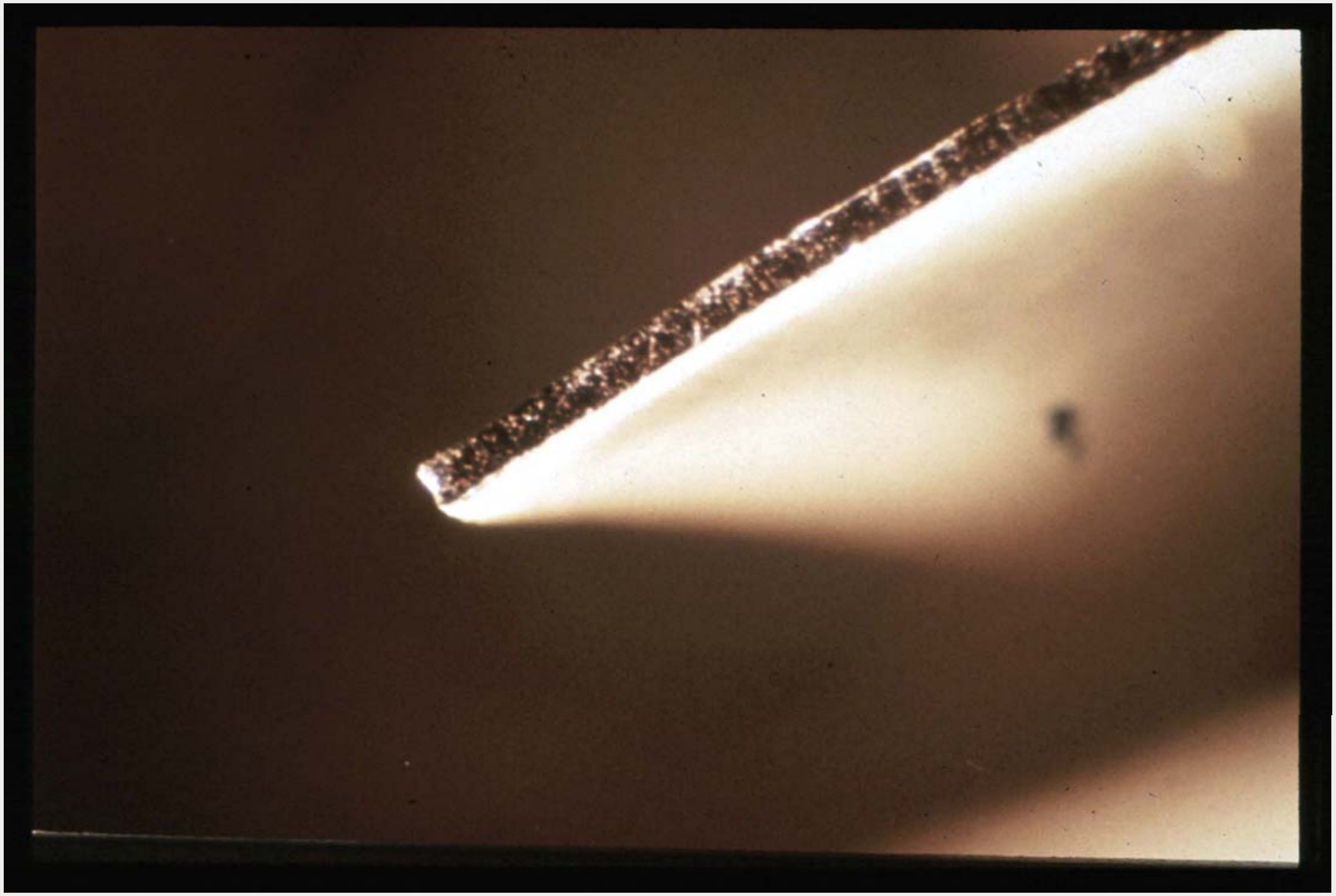
5° Wide Rim Blade in a Tangent Web



5° WR Blade Stress in Styrene

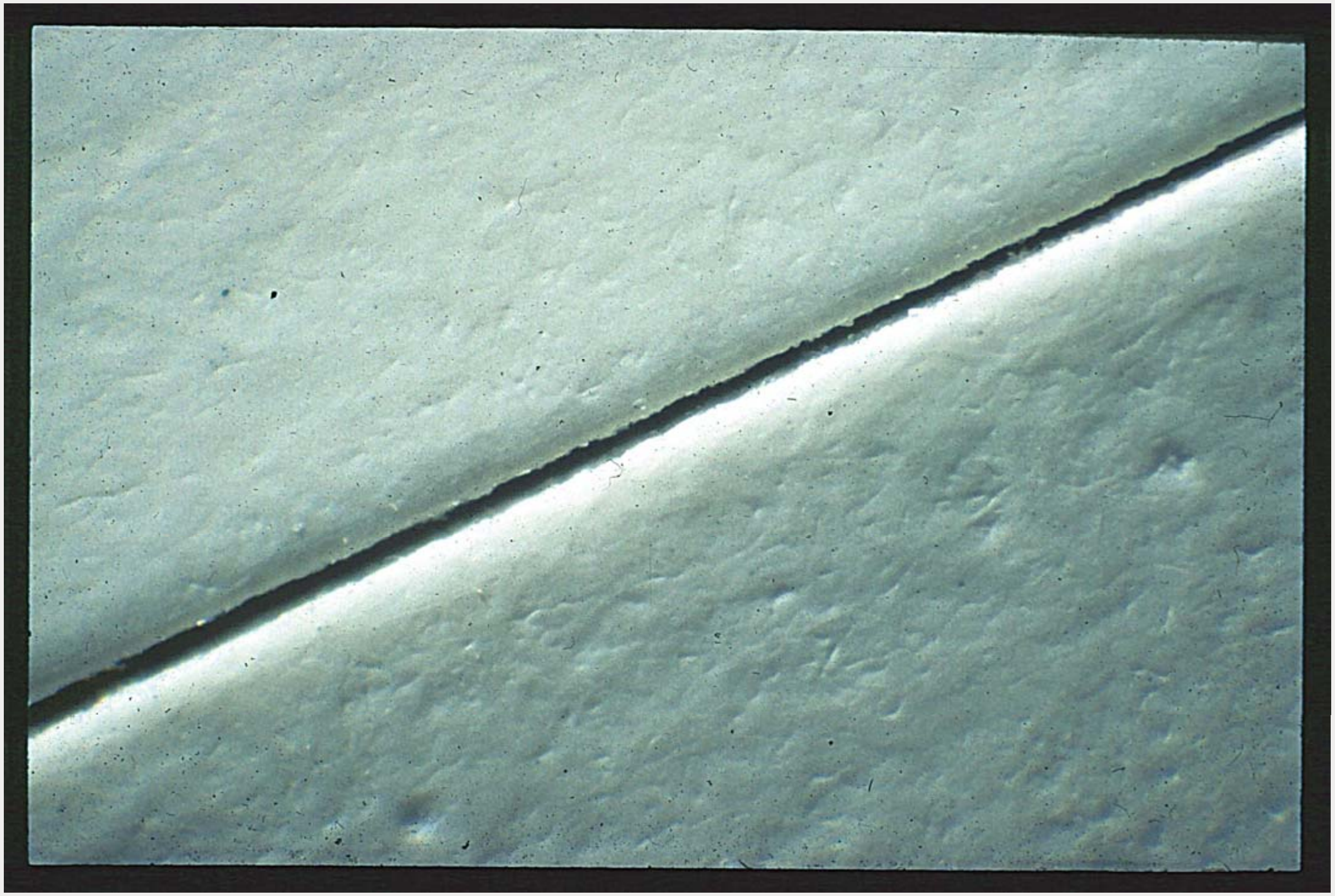


Aluminum Litho plate
5° Wide Rim, Tangent Shear



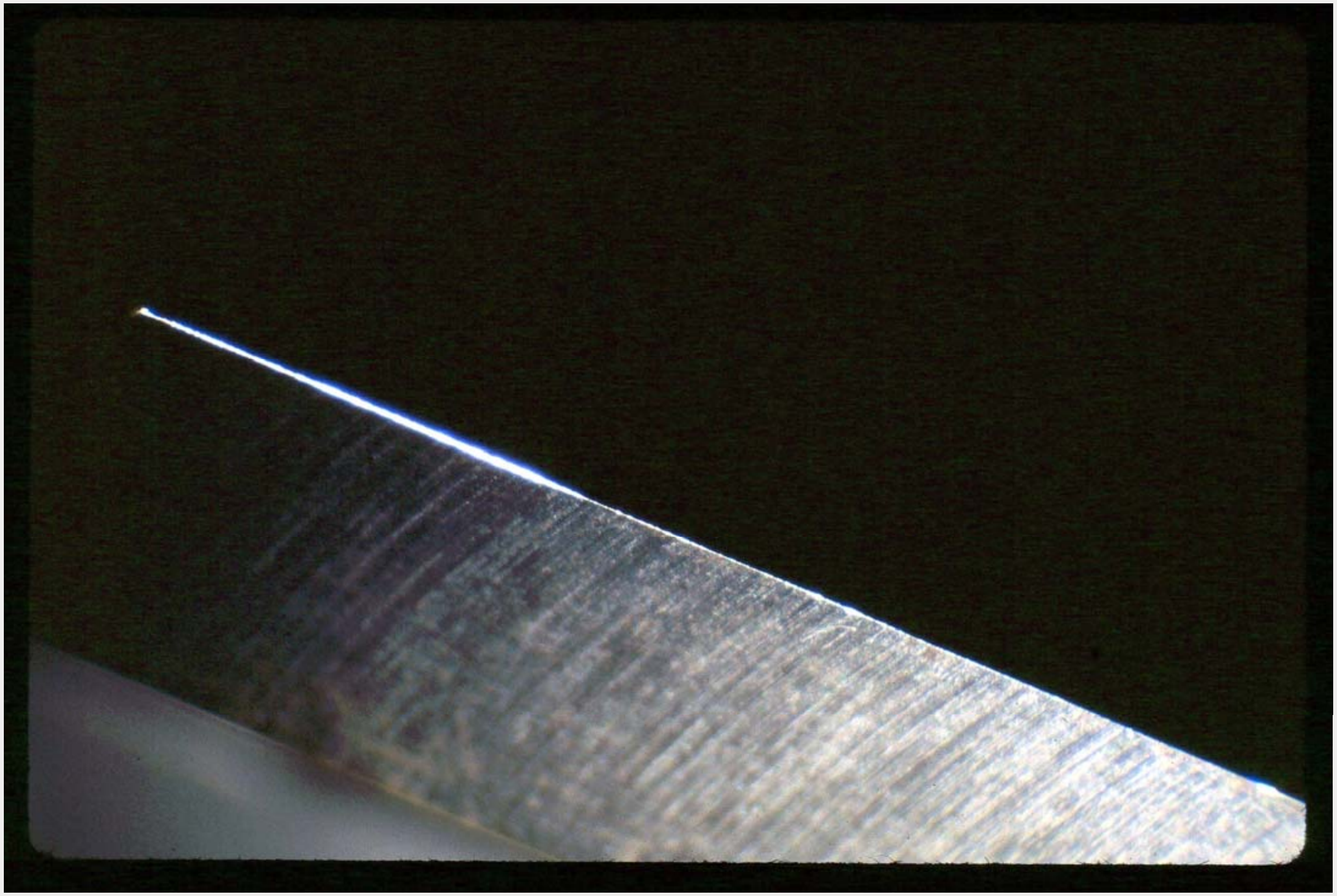
Unsupported edge

No Coating Ridge, Single Bevel Blade



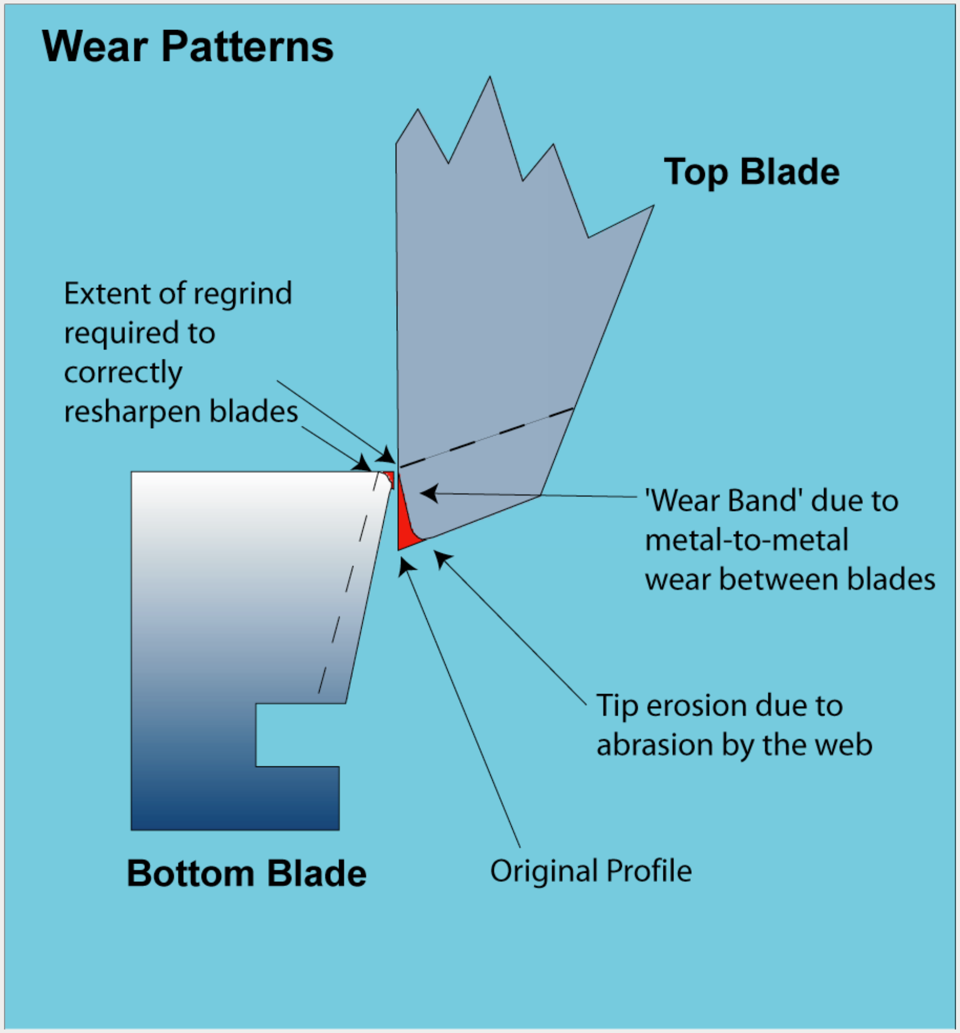
Notice elimination of coating ridge with single bevel blade.

A Sharp & Dull Edge

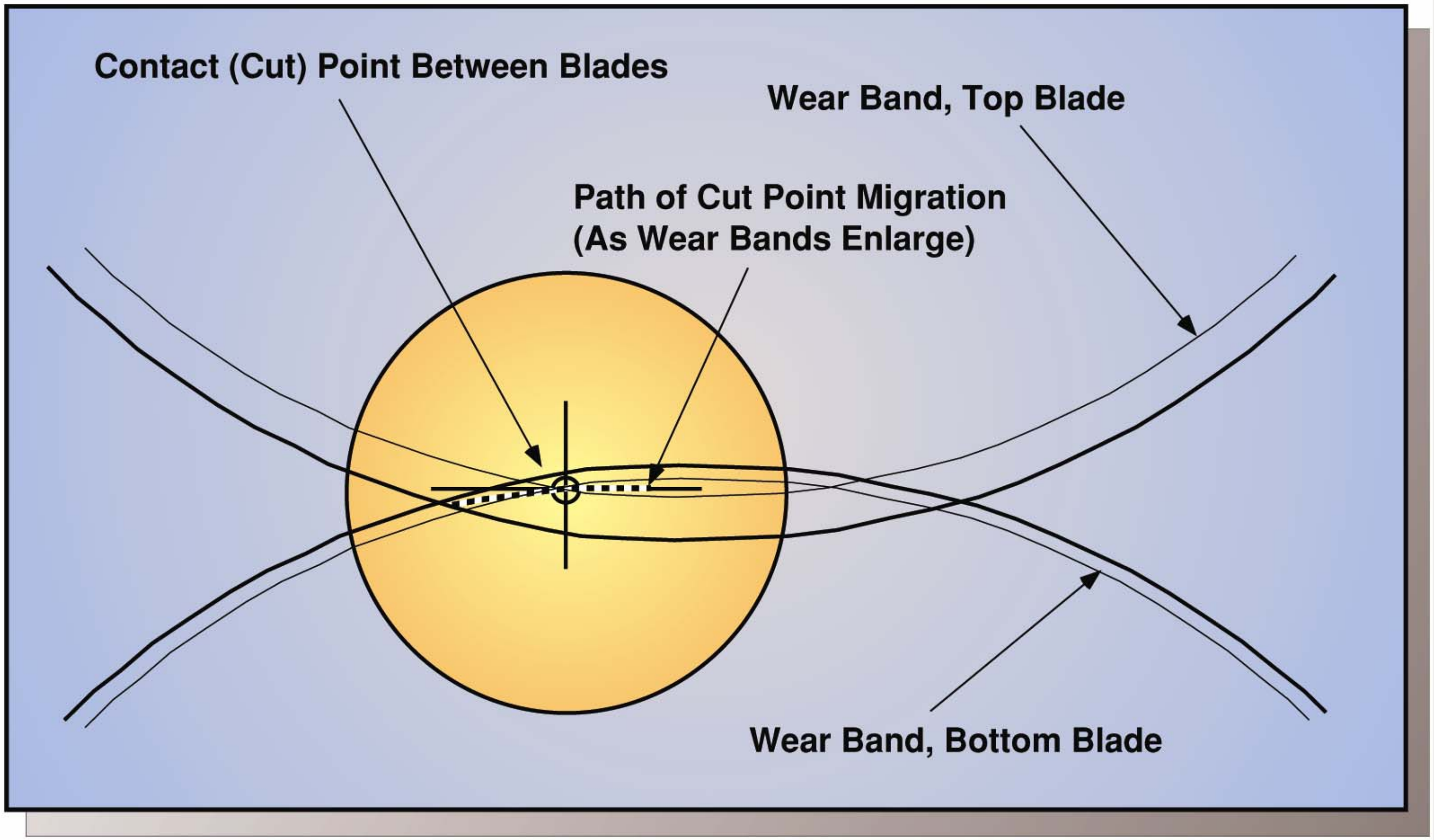


…As sharpness is lost, an "open nip" forms between the slitters.

Blade Sharpness

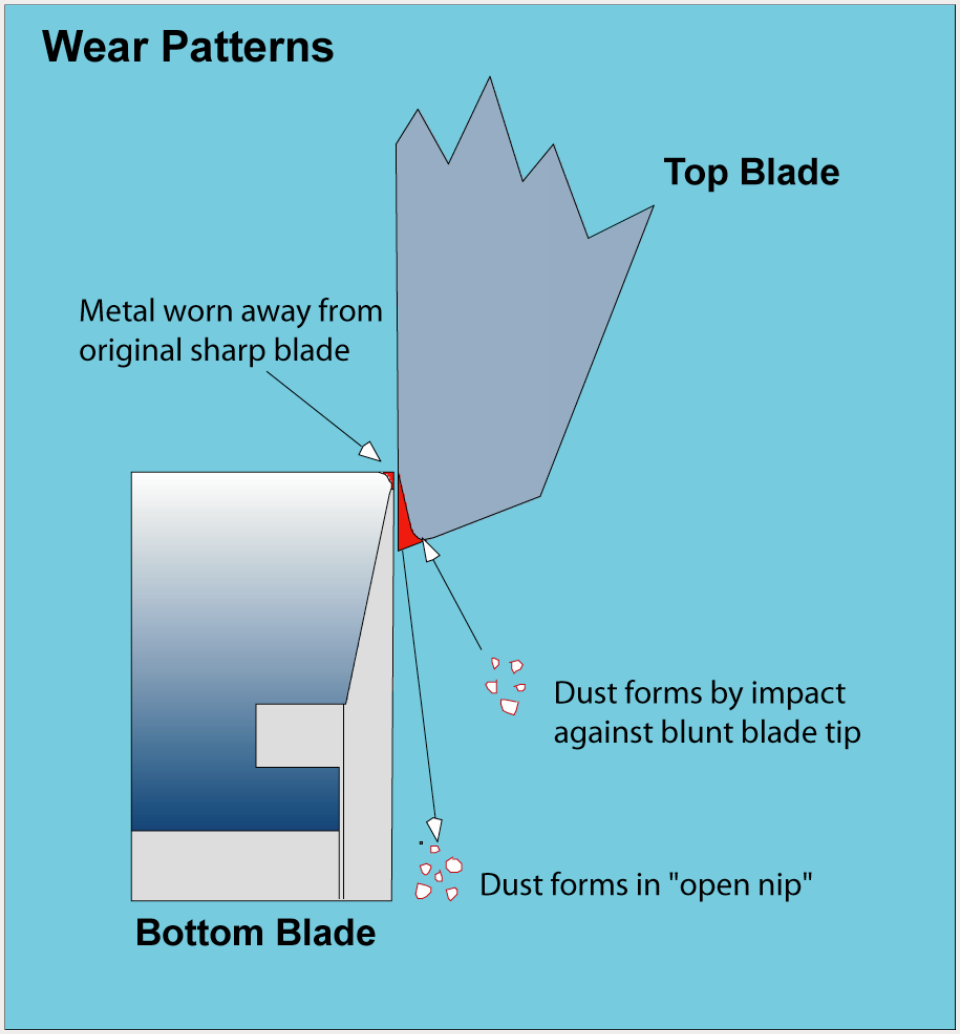


Blade Sharpness

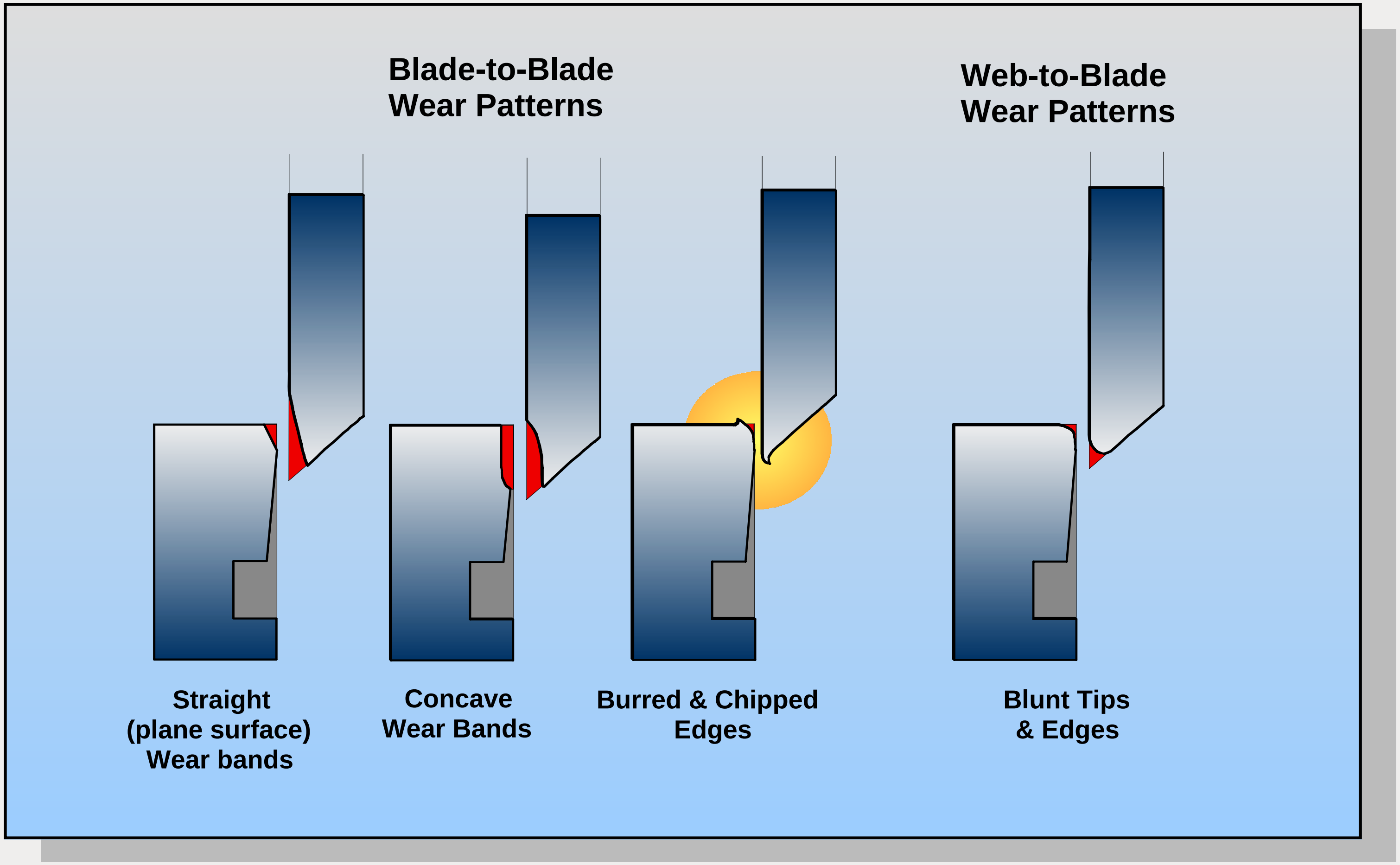


Blade Wear Affects Cut Point Position

Blade Sharpness

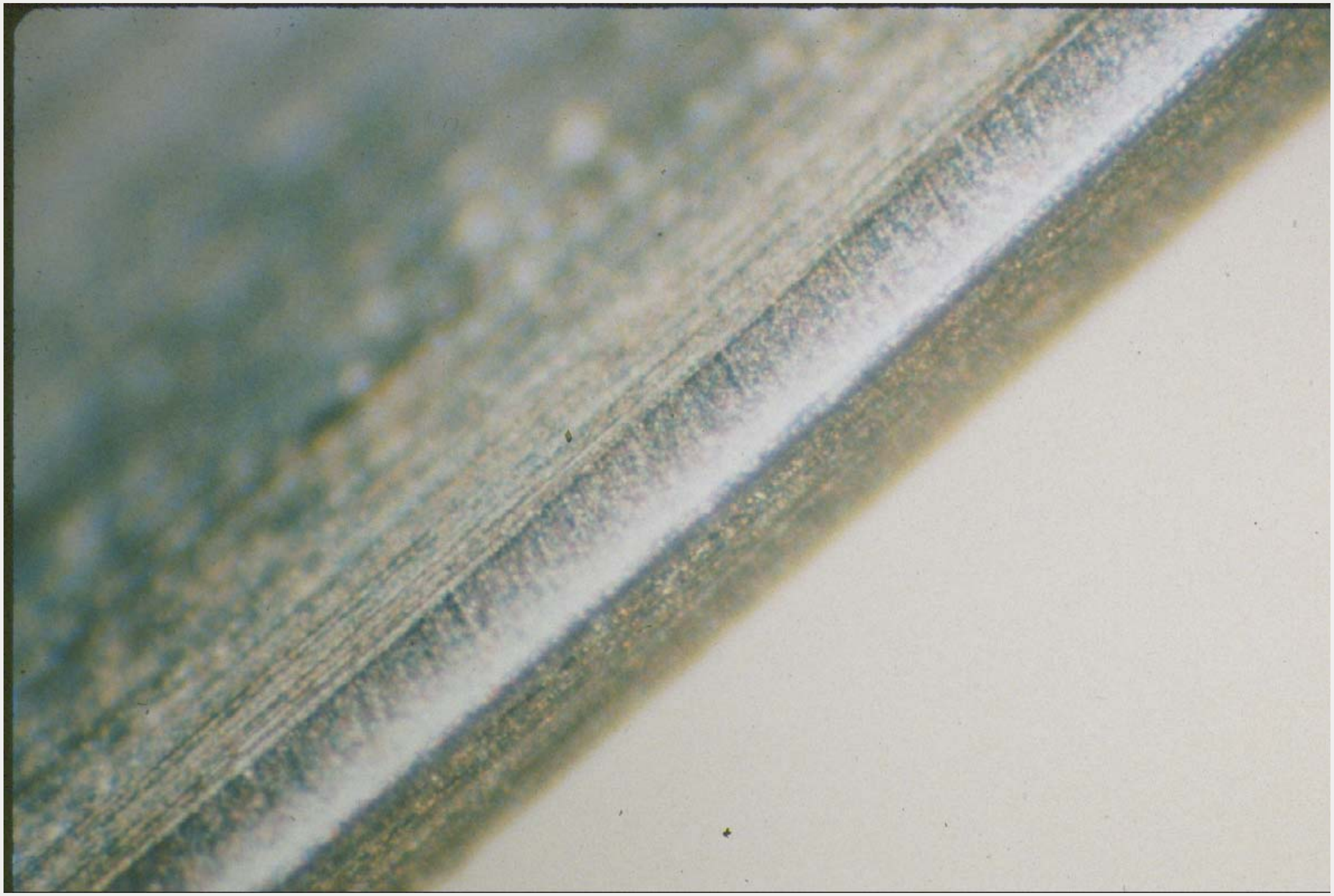


Wear Patterns

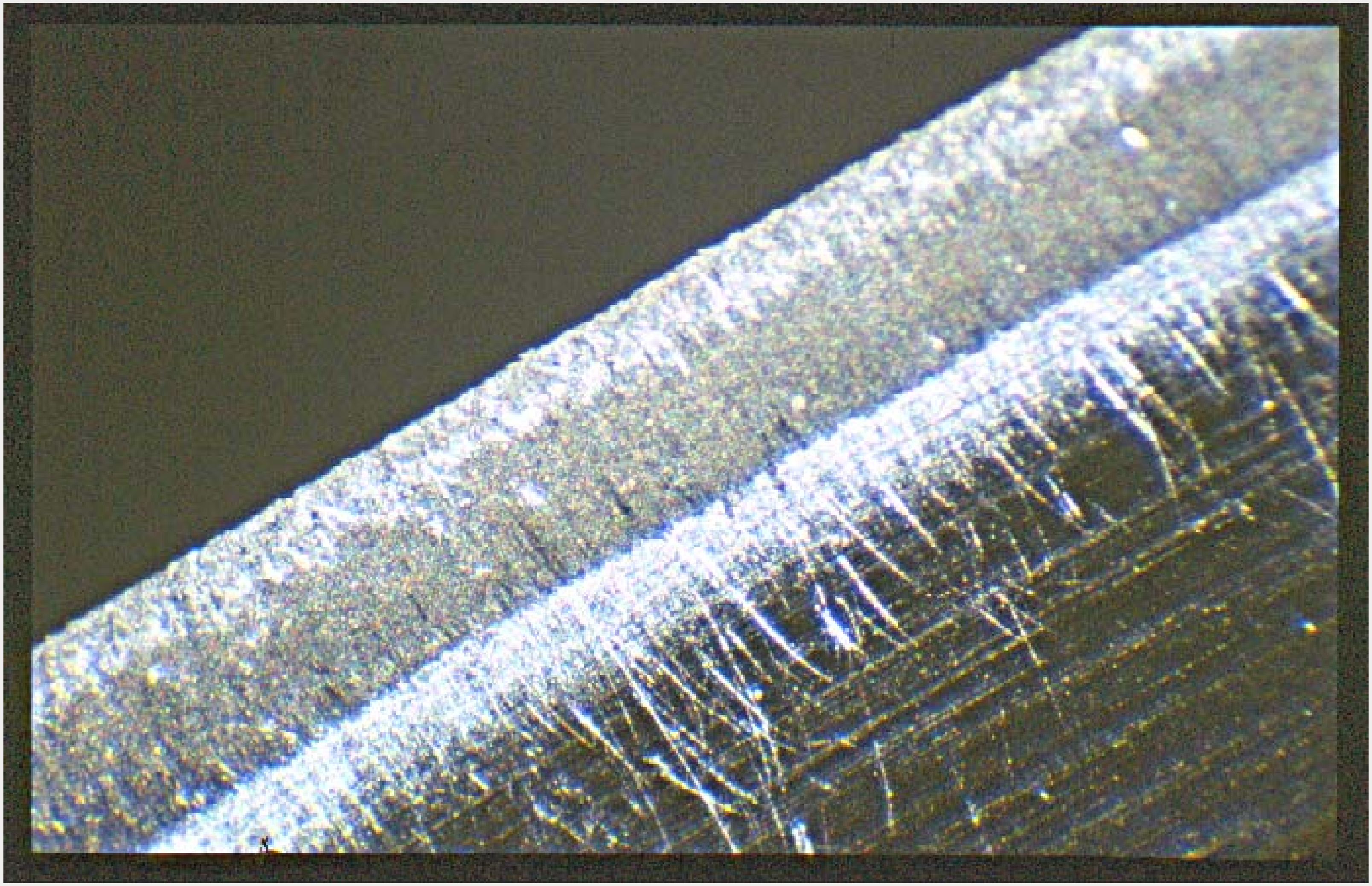


…As sharpness is lost, an "open nip" forms between the slitters.

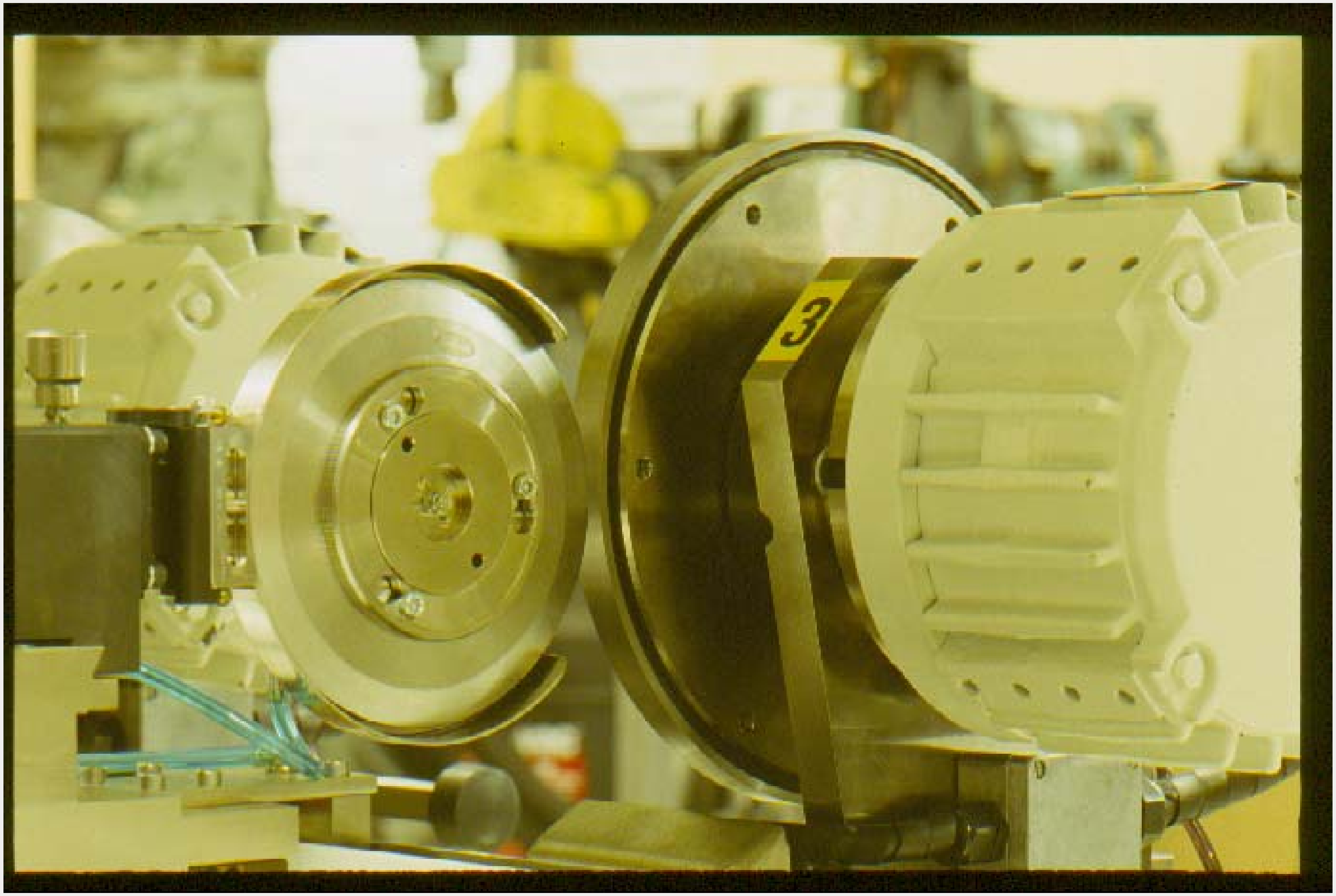
Wear Band on Blade



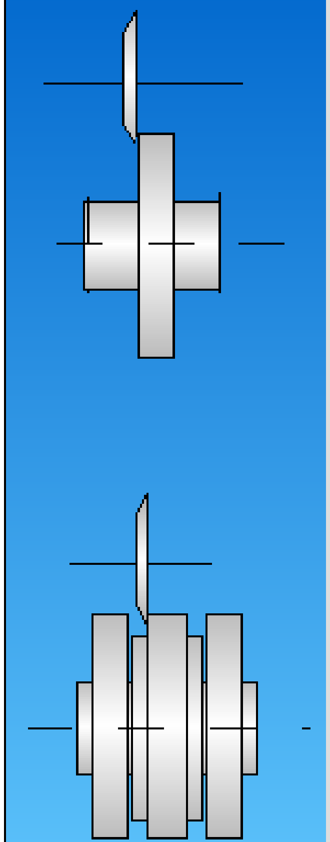
Web-to Blade & Blade-to-Blade Wear



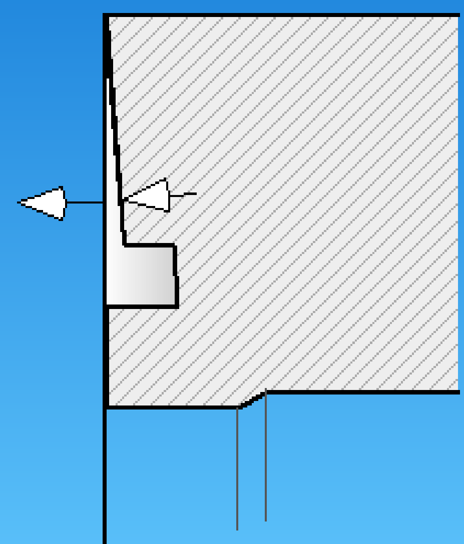
Large Lower Slitters



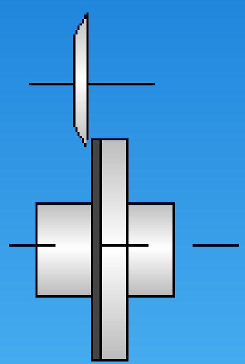
Lower Slitter Profiles - Steel



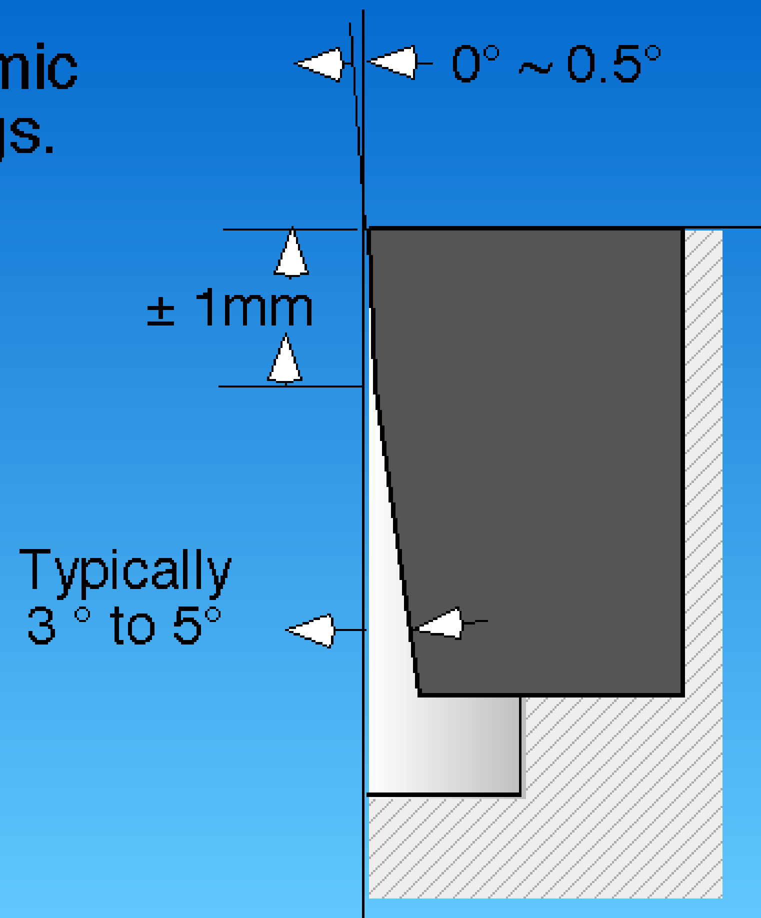
Typical Profiles:
Steel Lower Slitter Rings



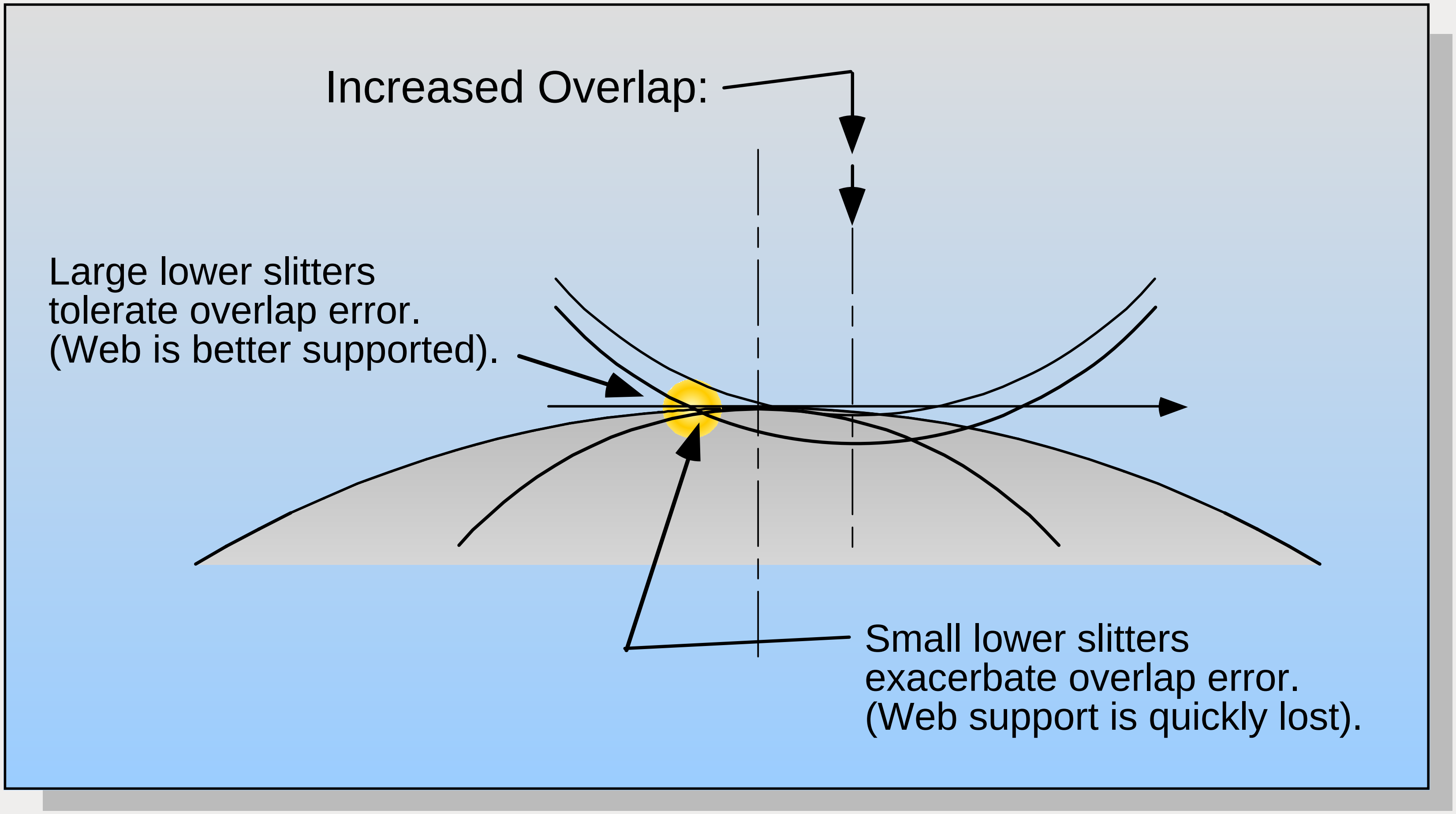
Lower Slitter Profile - Carbide



- Carbide or Ceramic edged Slitter Rings.



Benefit of Larger Lower Slitters (Tangent Systems)



…Lower slitters which are significantly larger than upper blades tolerate increased overlap with less "cut point shift”.

Minimizing Post-Slit Web Damage

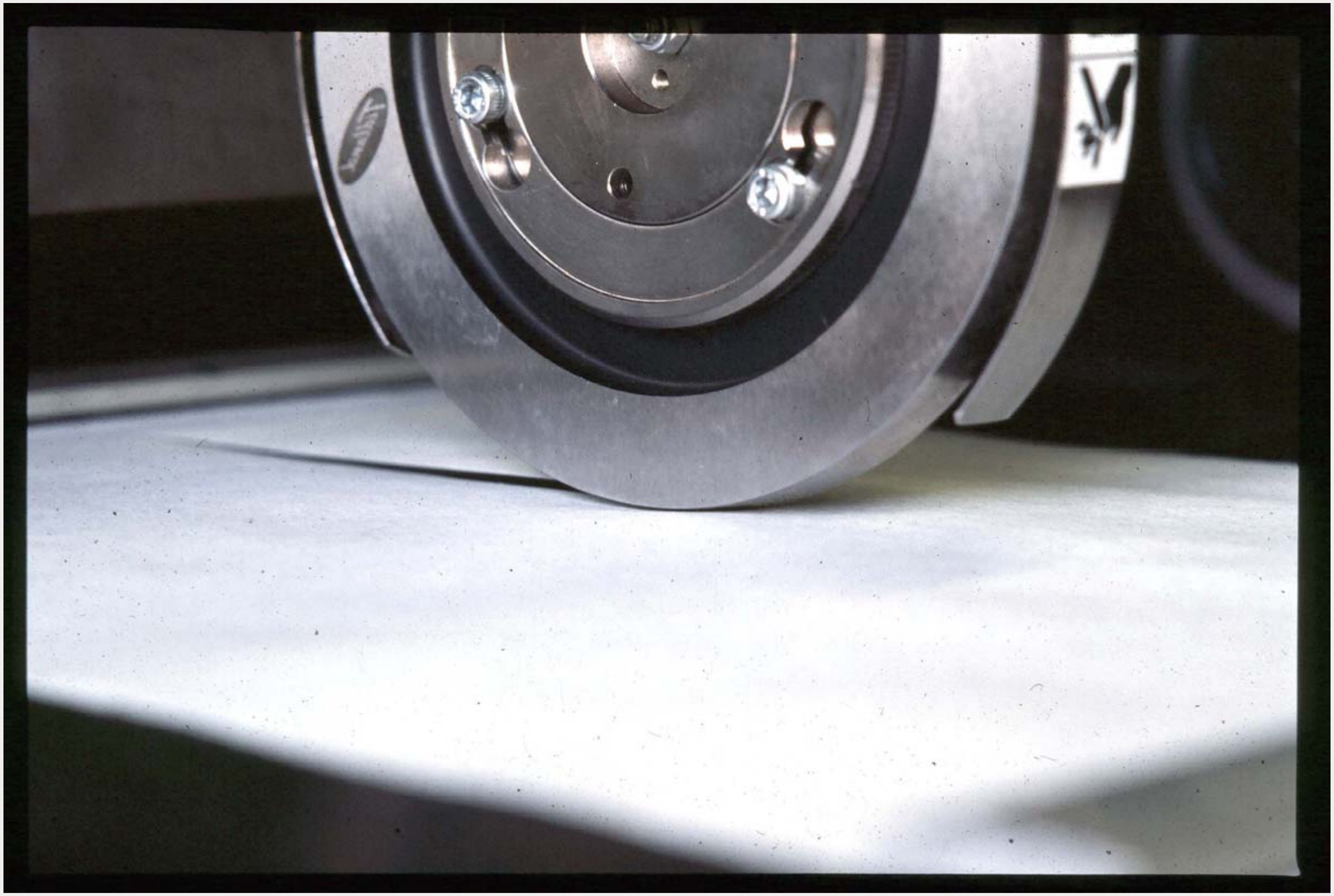
- Blade Profile Determines the Web's Path Around the Slitter Blade
- Tangent Systems Deflect the Web with Less Cross-Machine Strain, and Permit more Blade Profile Options
- Wrap Systems Create Compound Bending, Blade Profile Options are Limited

Traditional 25° Compound Bevel Blade in a Tangent Web

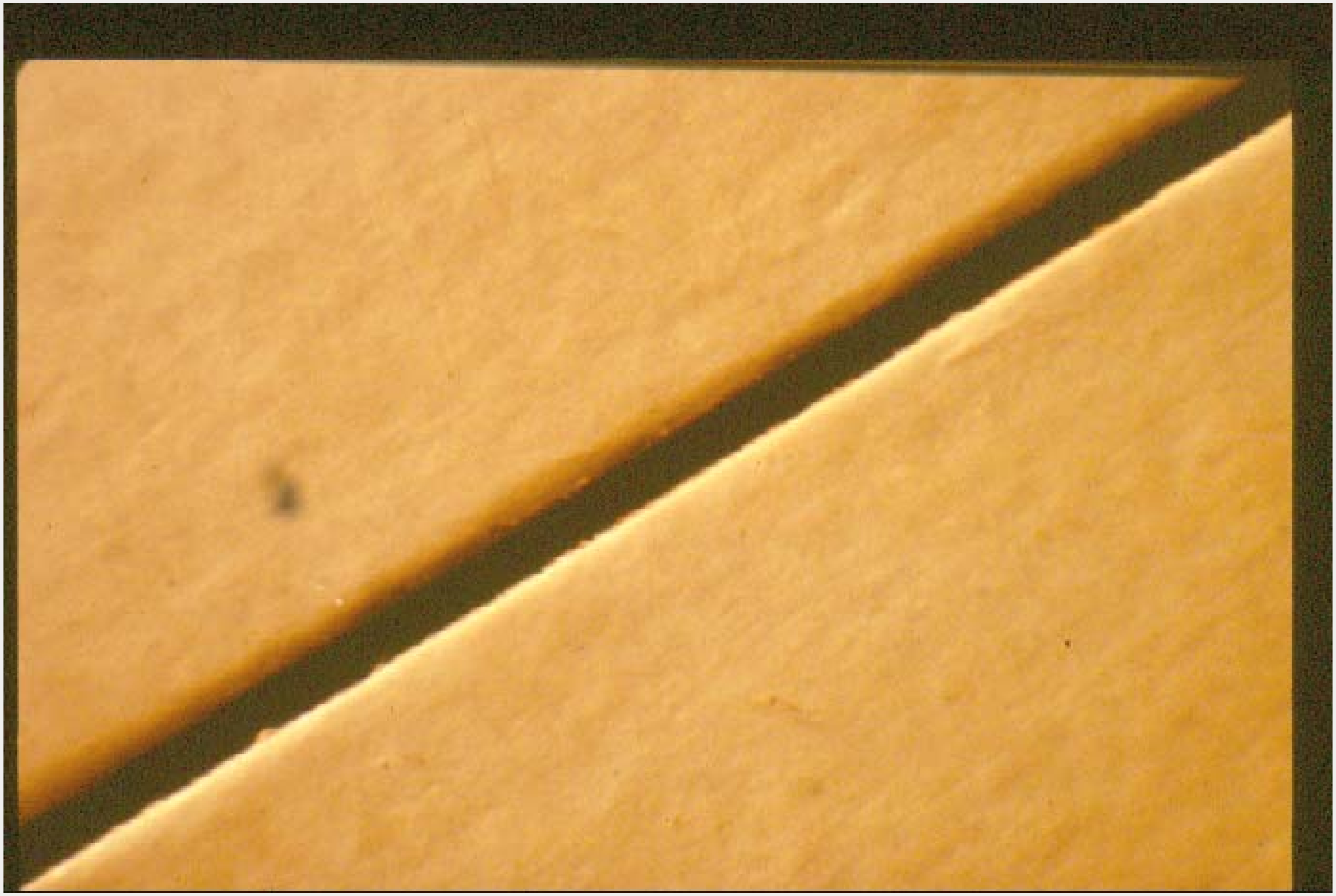
Slit Edge: PE Microfilm, Standard Blade

Slit Edge: Clay Coated Board Standard Blade

5° Wide Rim Blade in a Tangent Web



Slit Edge: Clay Coated Board, Wide Blade



Minimizing Post-Slit Web Damage

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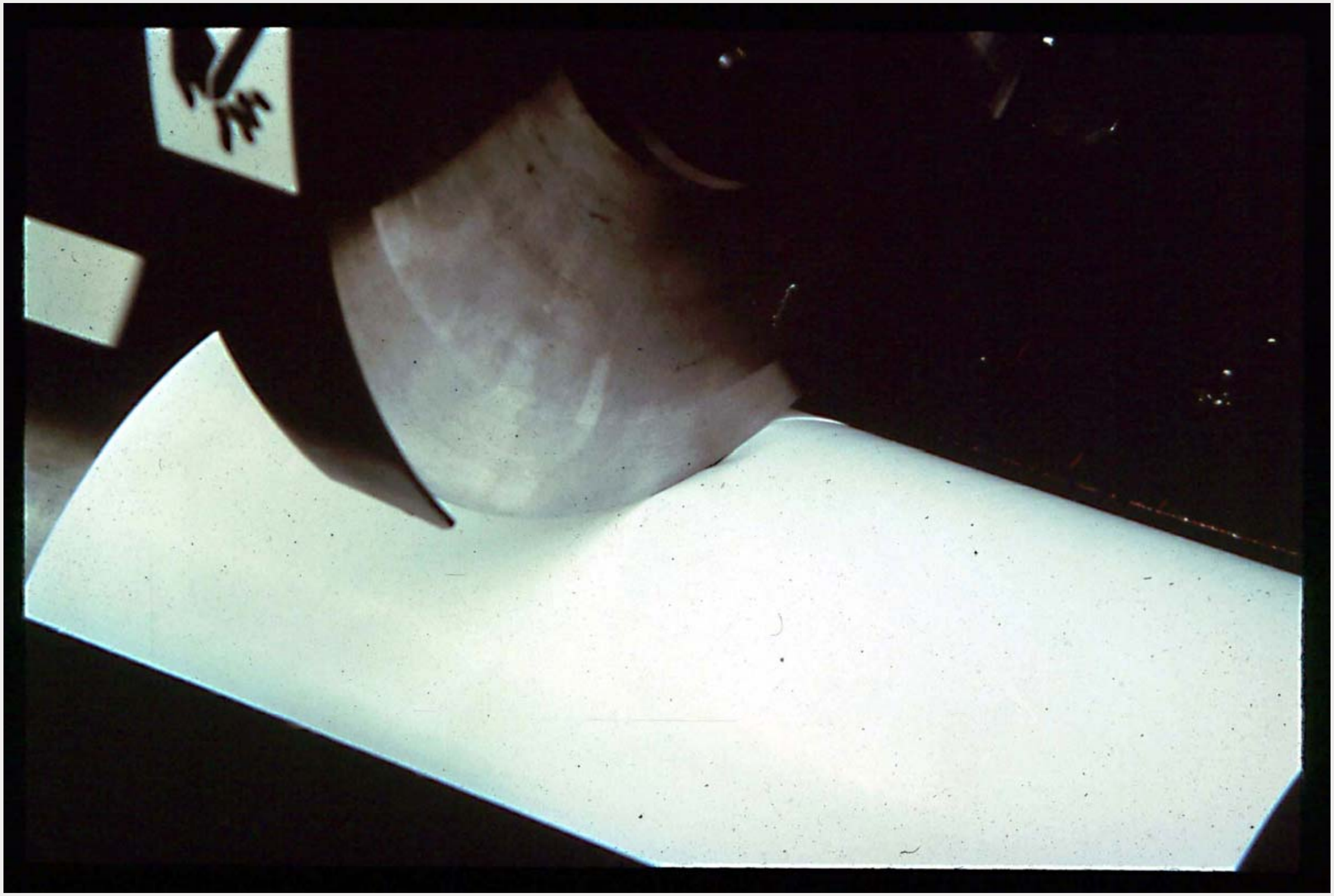
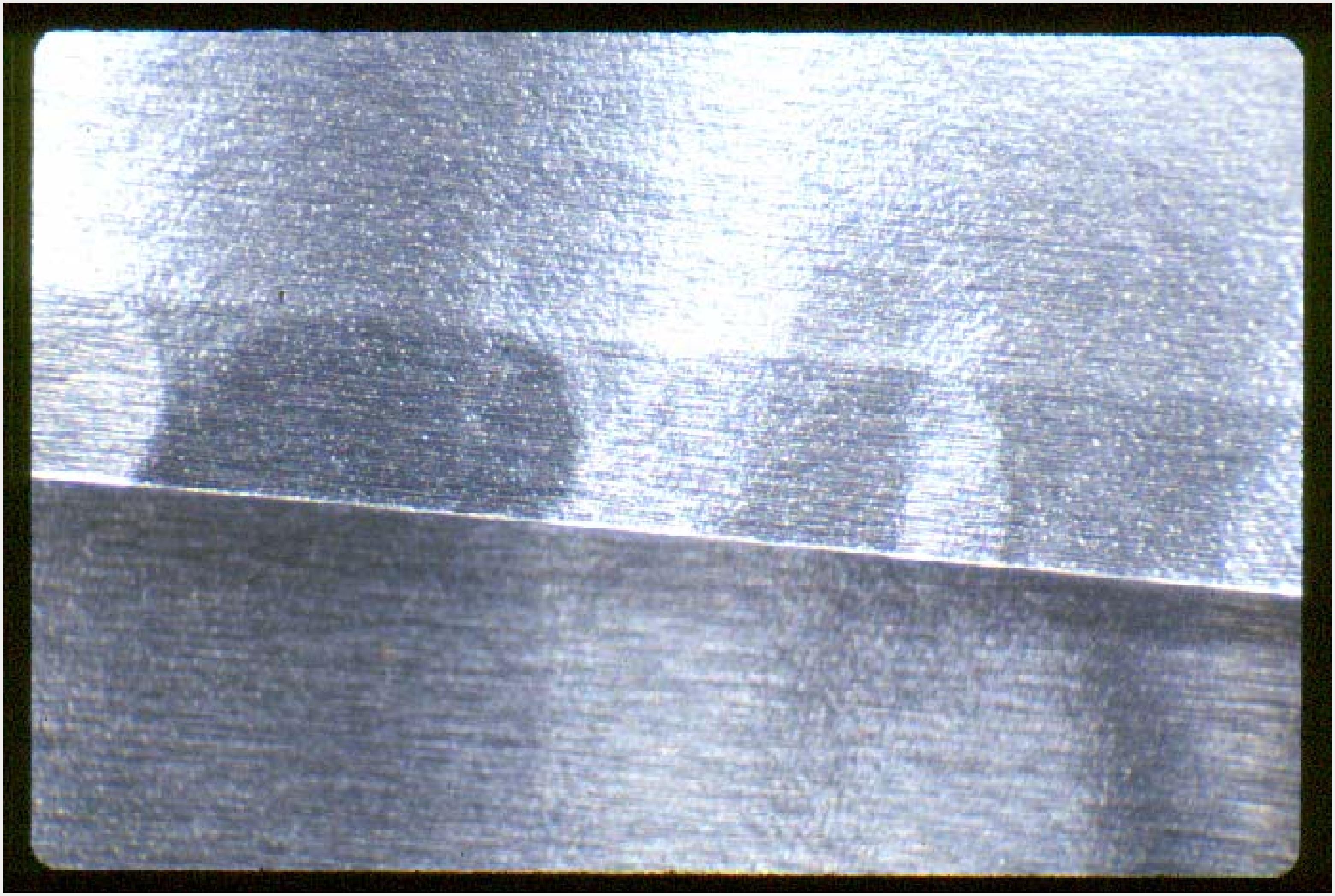
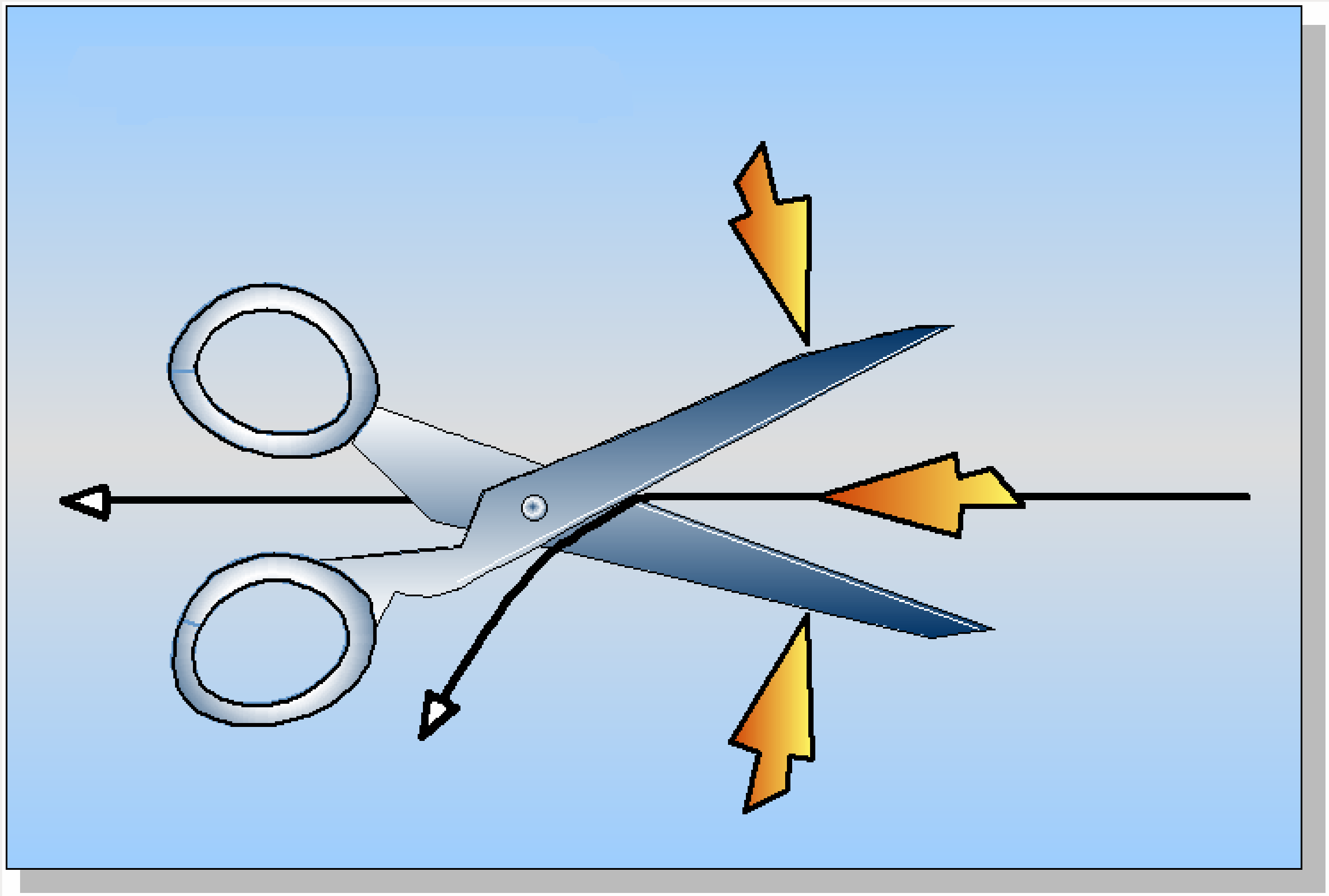
Compound Bending, Wrap Slit



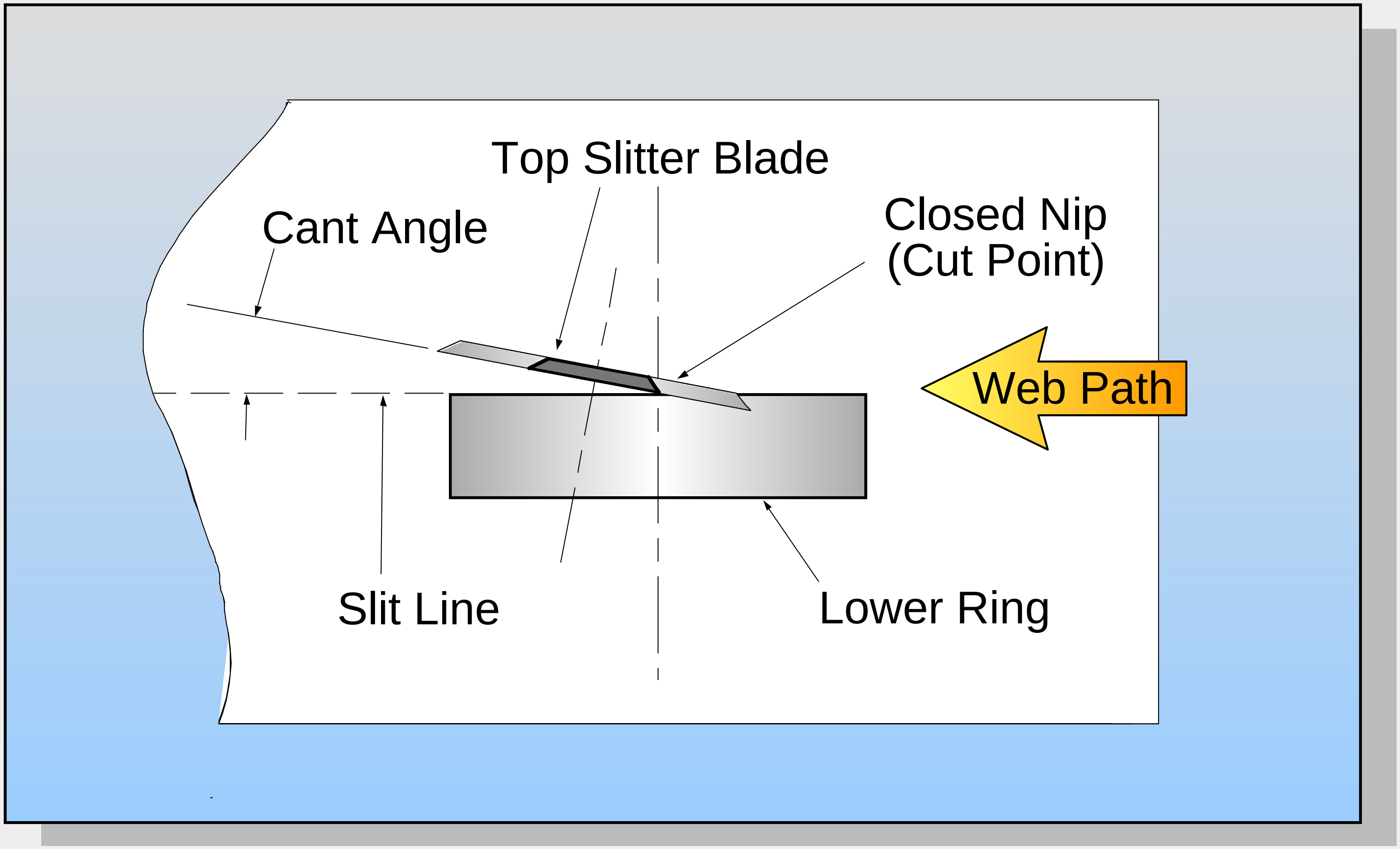
Aluminum, Wrap Slit



Cant Angle



Cant Angle



Top Slitter Blade
Cant Angle
Closed Nip
(Cut Point)
Web Path
Slit Line
Lower Ring

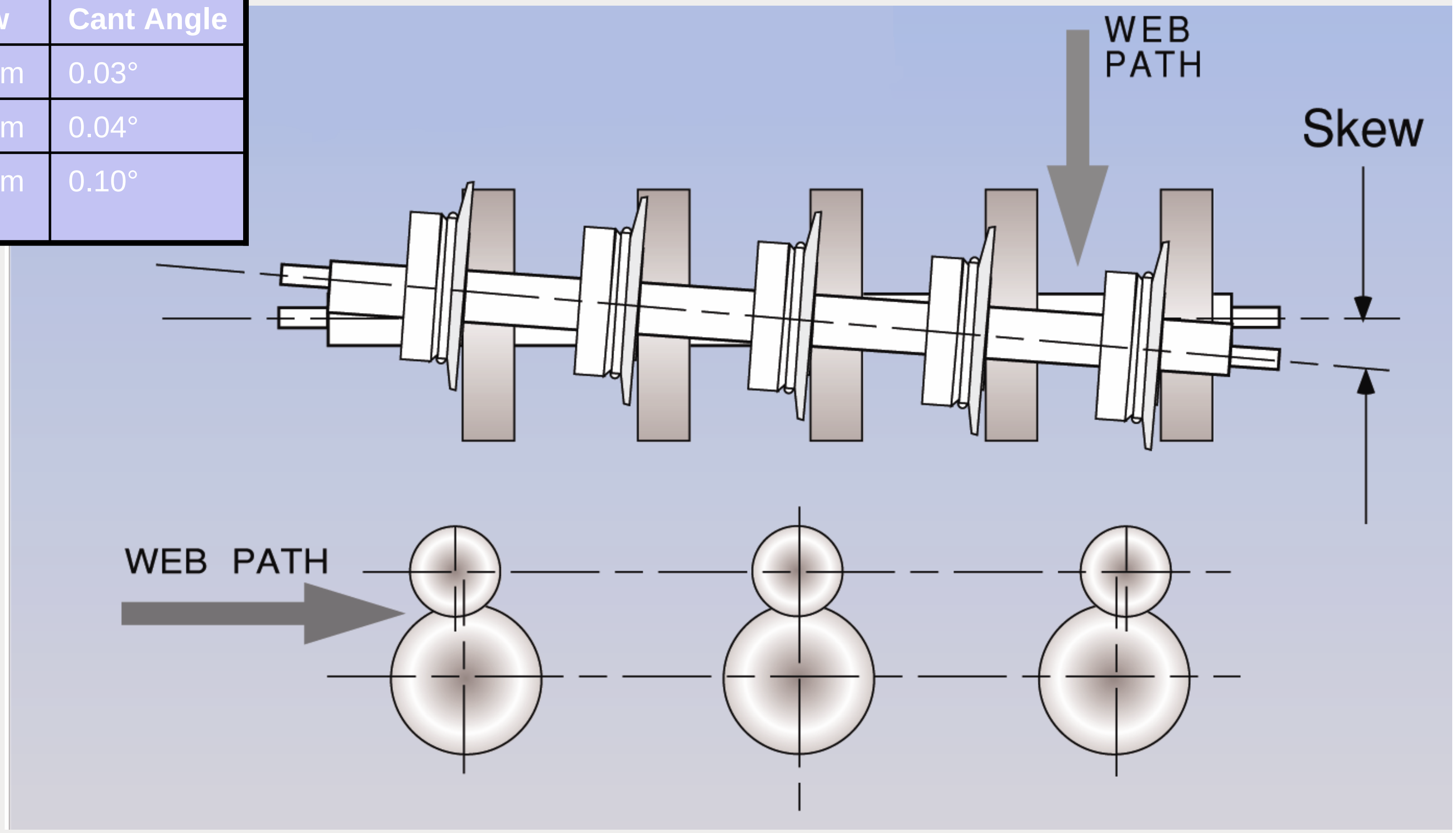
Cant Angle

Cant Angle Recommendations

Cant Angle	Material	Blade Life
0.0° to 0.25°	Metals. Plastic Sheet. Non-fiberous webs. Hard,Brittle Materials	Best
0.25° to 0.50	Optimum General Purpose Angle. Paper Products. Laminates. Plastic Films.	Good
0.50° To 0.75	Synthetic Fiber Products. Materials With Loosely Bonded Fibers. Stretchy Films.	Reduced
0.75° To 1.0°	Fabrics. Unbonded Non-wovens, Etc.	Poor

Cant Angle
Problem on 2-shafted Slitters

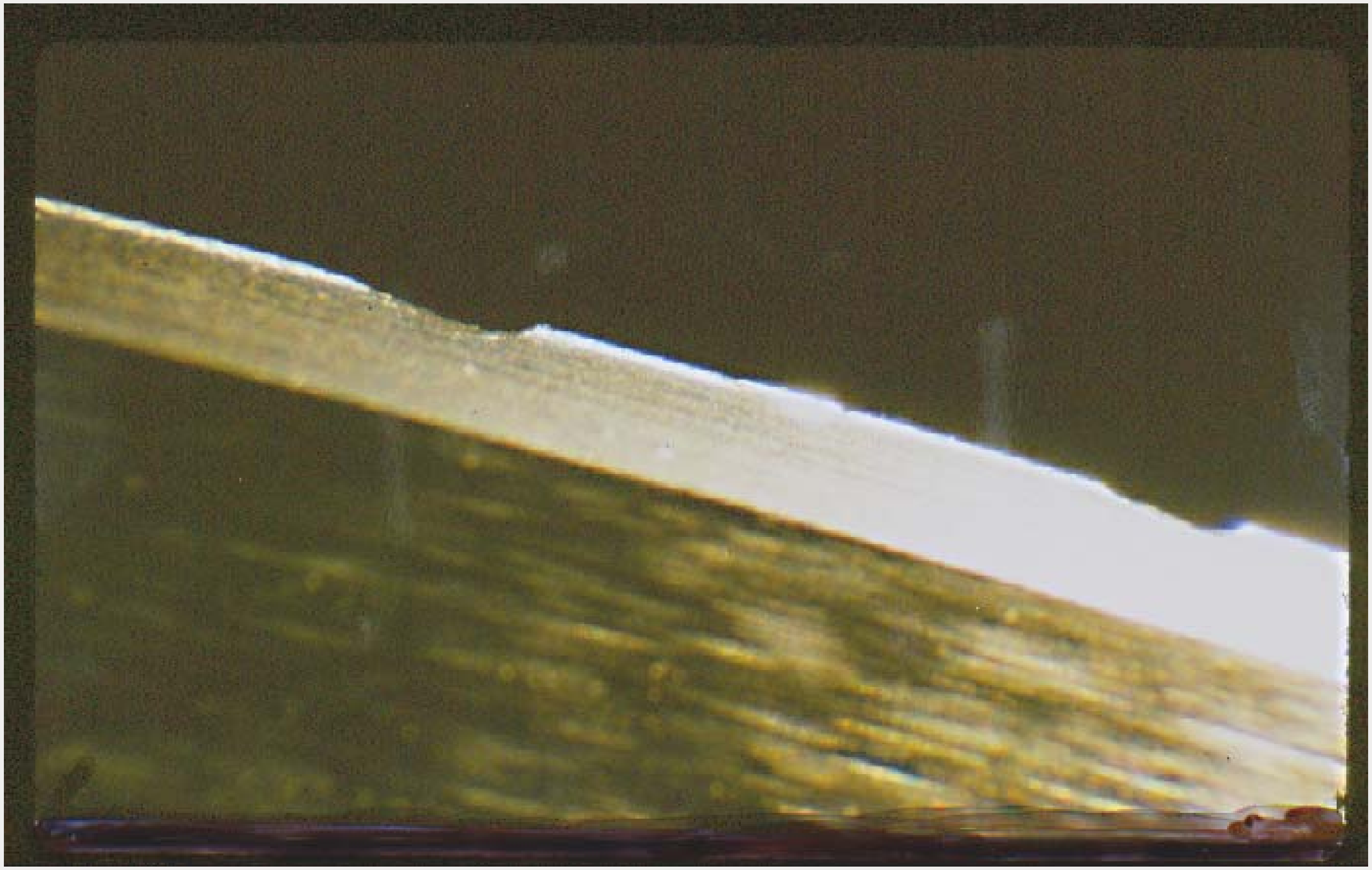
Trim Width	Skew	Cant Angle
1000mm	0.5mm	0.03°
1000mm	0.7mm	0.04°
Not Recommended	1.8mm	0.10°



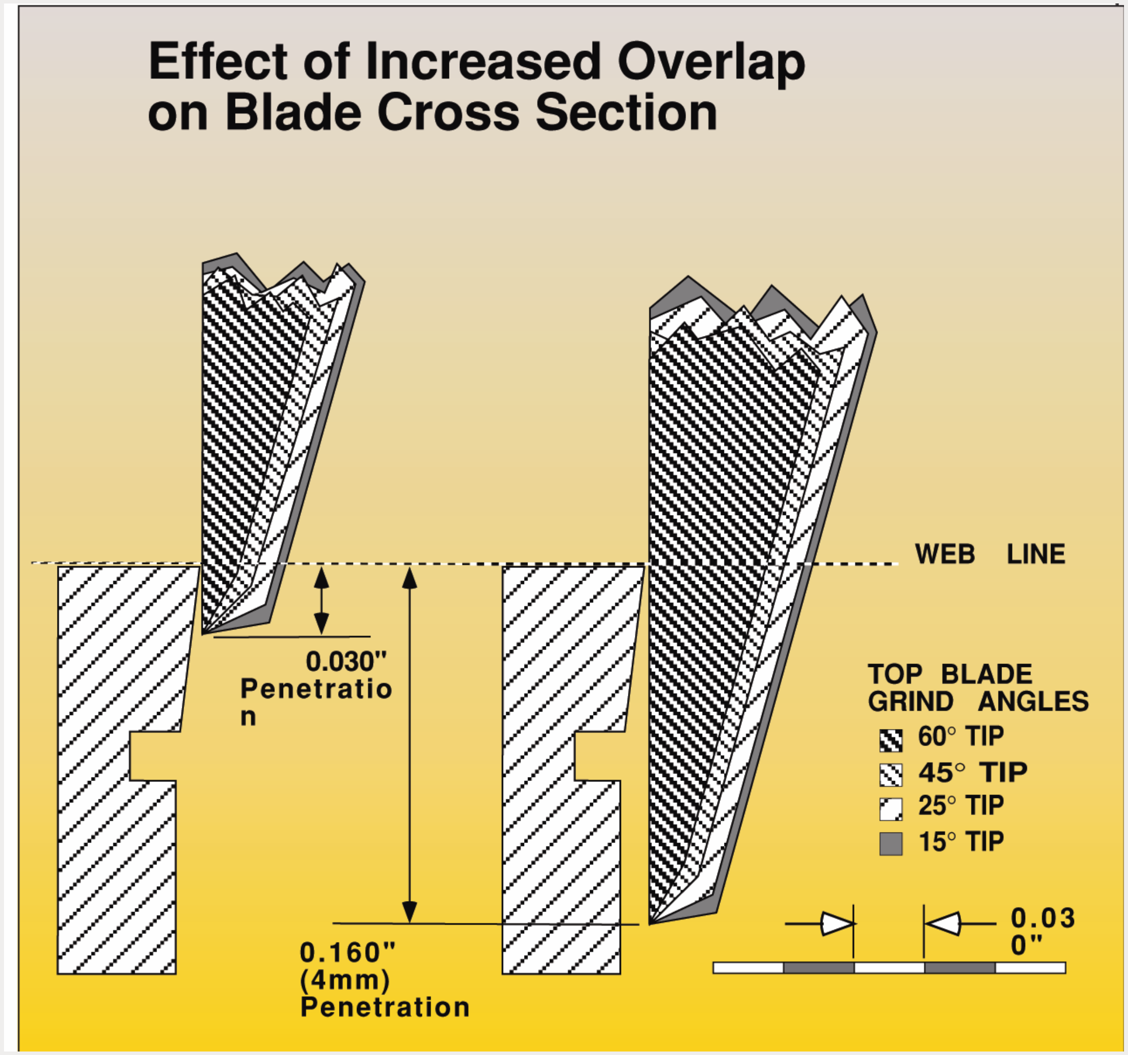
Skewing two-shafted slitters produces minimal cant angles between upper & lower blades. High elongation materials may require cant angles of 0.5° or 1.0° to slit effectively. Depending on Hub design, blade damage and increasingly poorer slitting will result as skew is increased

Cant Angle

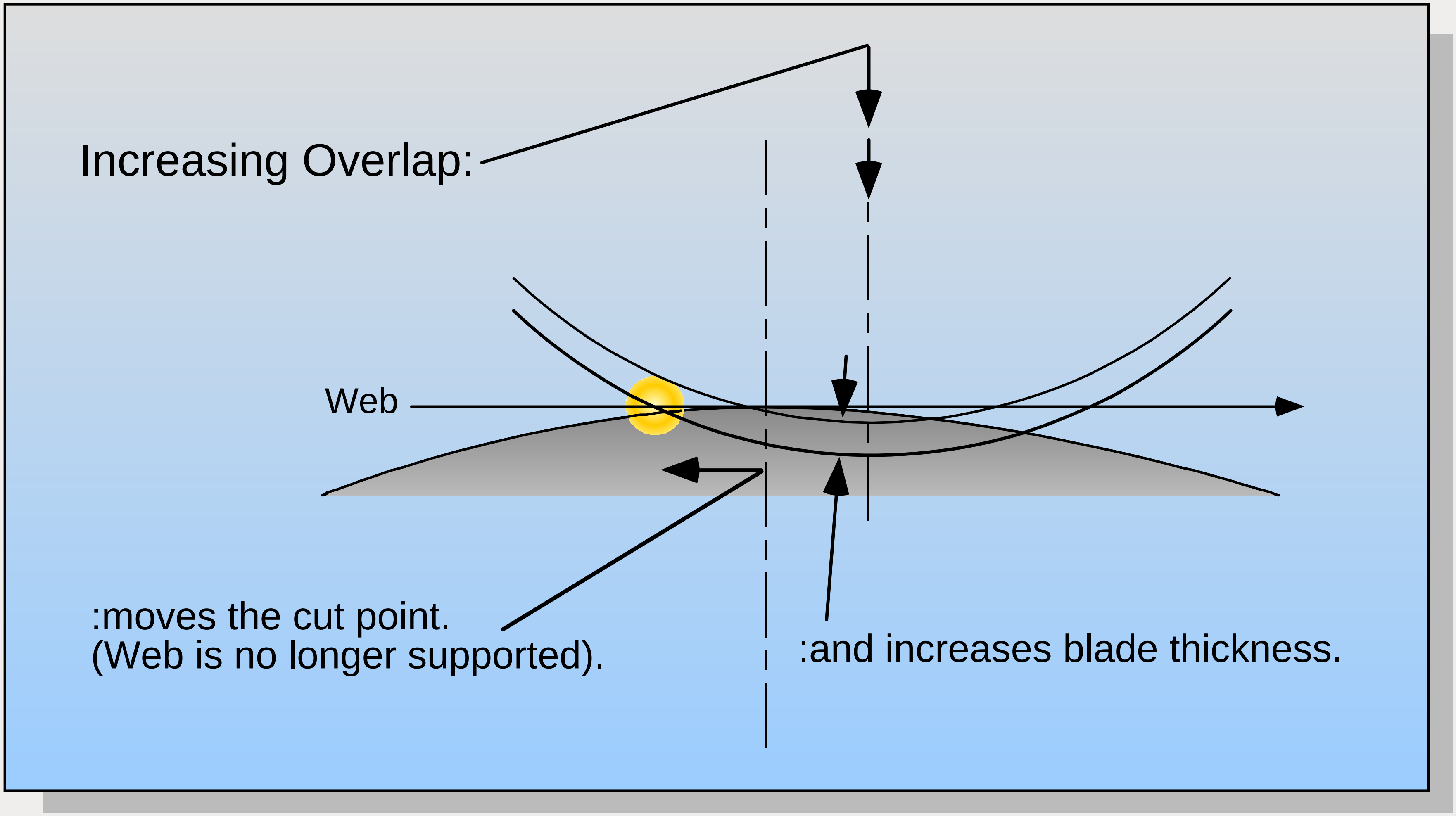
Beware of the Cant Angle



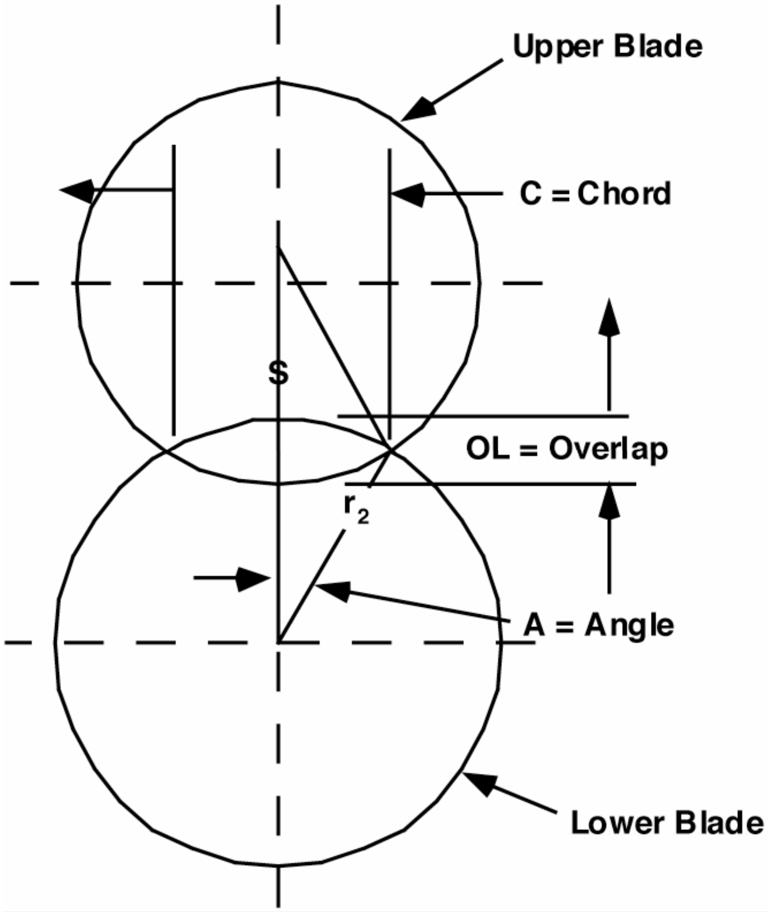
Overlap

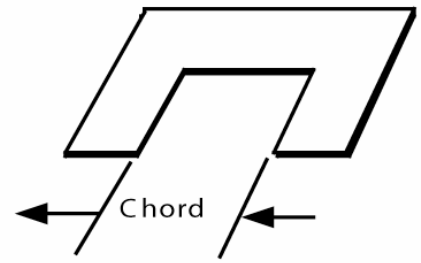

Effect of Increased Overlap
on Blade Cross Section
WEB LINE
0.030"
Penetratio
n
0.160"
(4mm)
Penetration
TOP BLADE
GRIND ANGLES
60° TIP
45° TIP
25° TIP
15° TIP
0.03
0"

Overlap


Increasing Overlap:
Web
:moves the cut point.
(Web is no longer supported).
:and increases blade thickness.

Overlap / Chord Calculations





Note; It is necessary to take thickness of material into consideration when constructing the guage.

$$S = r_1 + r_2 - OL$$

$$A = \cos^{-1}\left(\frac{r_2^2 + S^2 - r_1^2}{2r_2S}\right)$$

$$C = 2r_2 \sin A$$

Where:

OL = Overlap

C = Chord

S = Span, Blade Centers

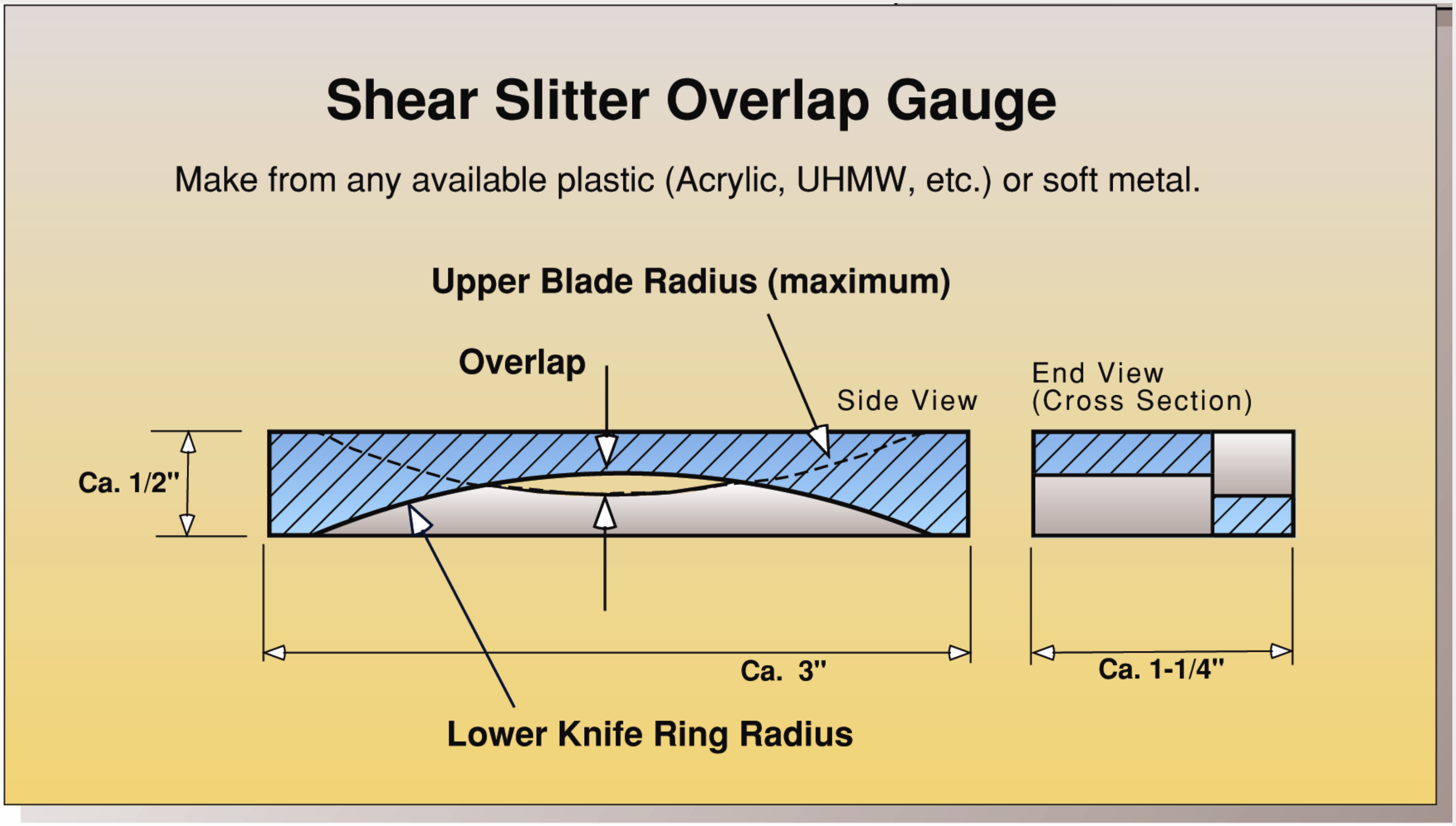
r_1 = Radius, Upper Blade

r_2 = Radius, Lower Blade

OVERLAP

Product	Inches	mm
Tissue	. 015" - .030"	.4 - .8 mm
Fine Papers	. 015" - .030"	.4 - .8 mm
Heavy Papers	. 020" - .040"	.5 -1.0 mm
Light Boards	. 020" - .040"	.5 -1.0 mm
Boards	.030" - .060"	.8 -1.5 mm

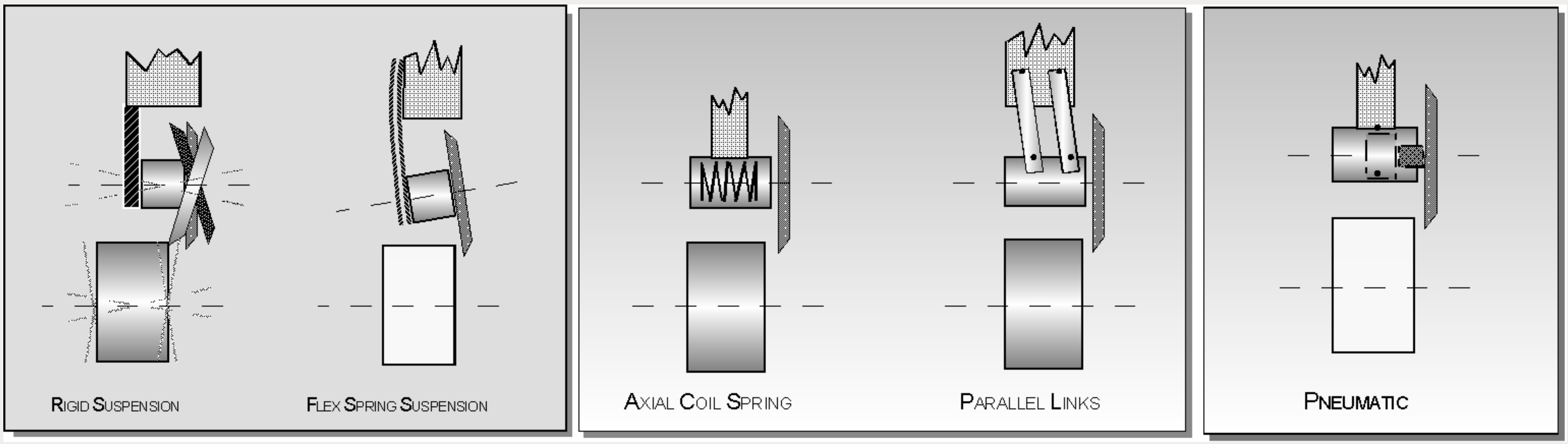
Overlap



Shear Slitter Overlap Gauge
Make from any available plastic (Acrylic, UHMW, etc.) or soft metal.
Upper Blade Radius (maximum)
Overlap
Side View
End View
(Cross Section)
Ca. 1/2"
Ca. 3"
Ca. 1-1/4"
Lower Knife Ring Radius

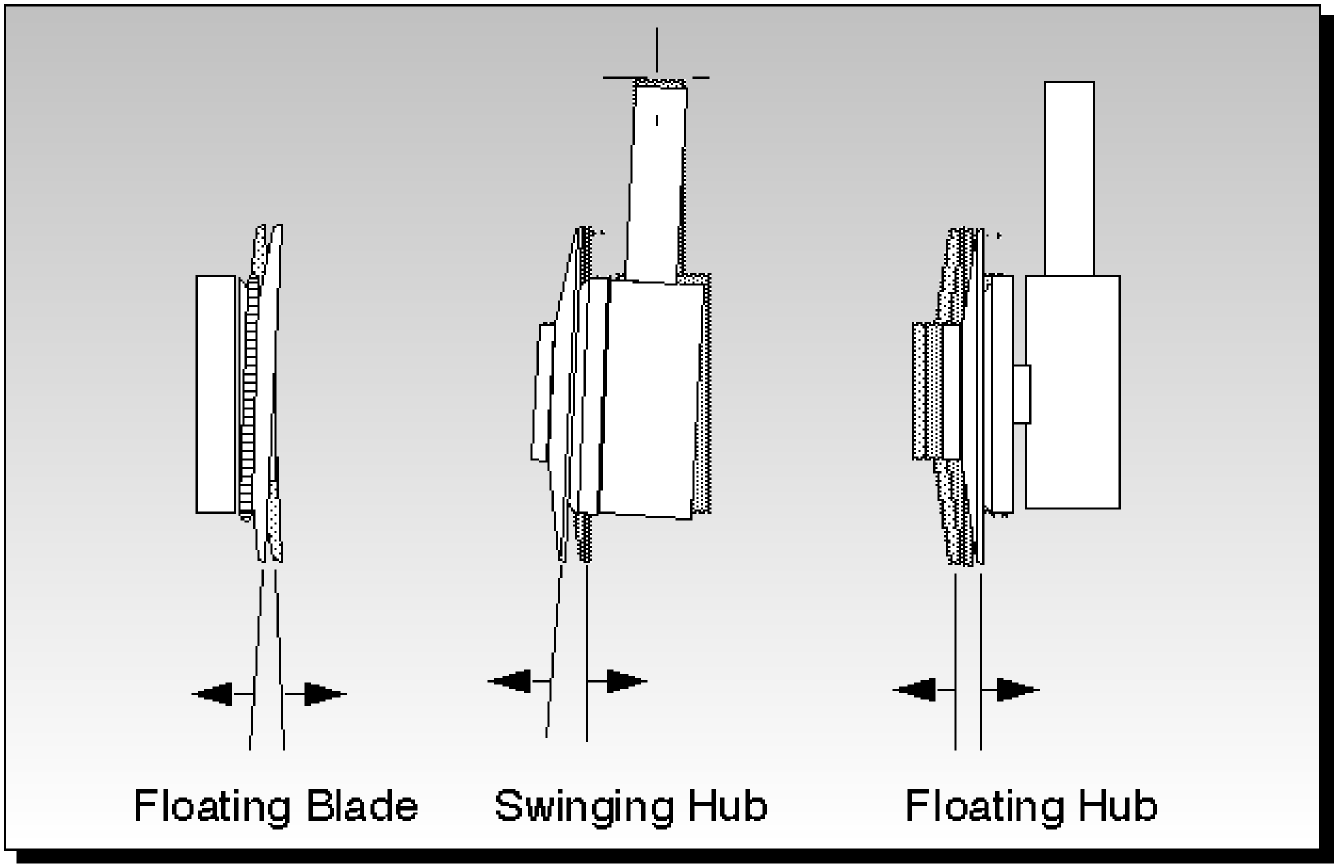
Side Force

Knifeholder Suspension Systems



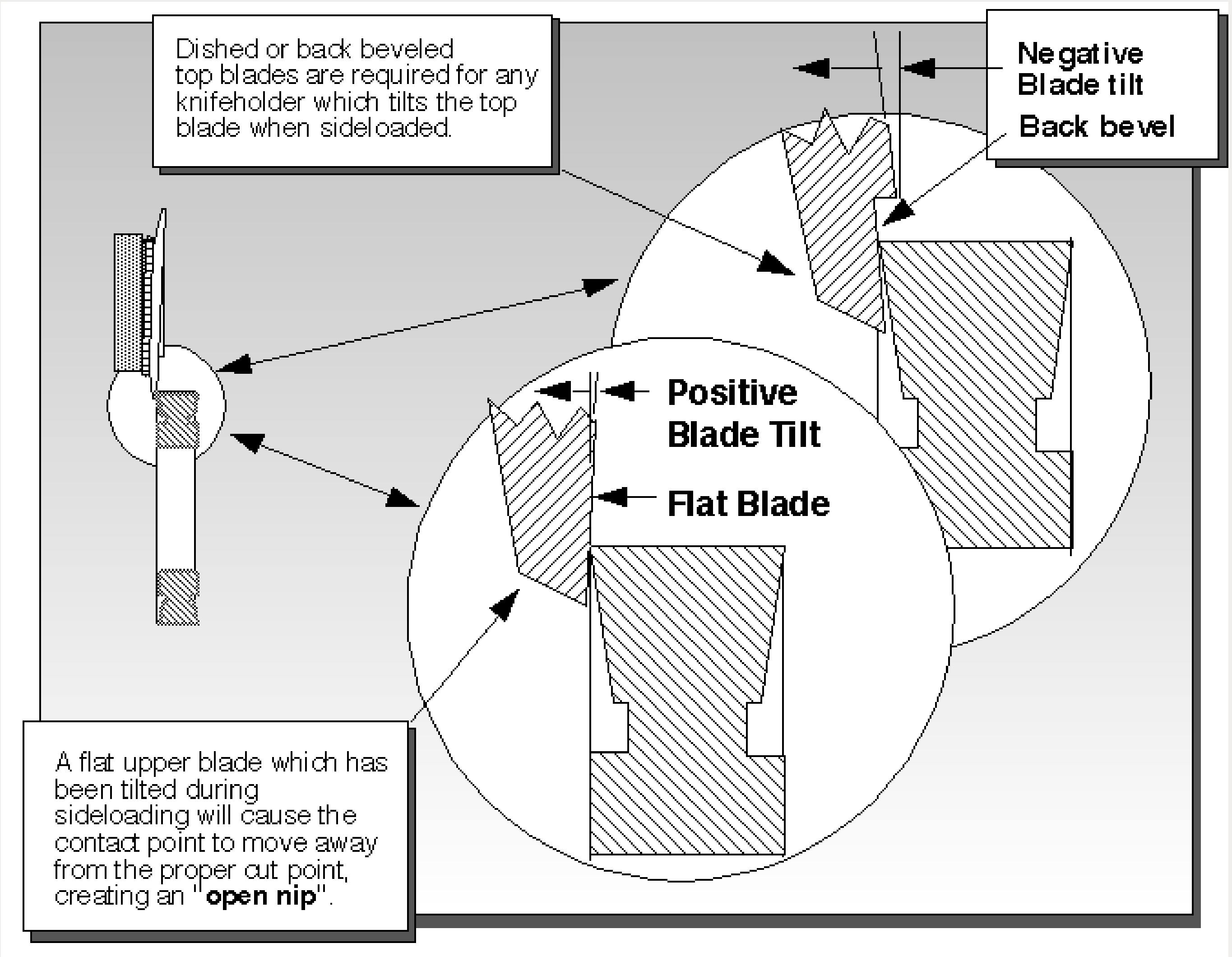
Simple Suspensions | Precision Blade Alignment | Pneumatic Systems

Side Force



Blade sideload systems which permit the blade to tilt over the rim of the lower knife edge will compromise slit quality, unless dished blades are used. Accuracy of the sideloading force is only as accurate as the active component (spring, air cylinder, etc). System mass and harmonics play a significant role in high speed slitters.

Side Force


Dished or back beveled top blades are required for any knifeholder which tilts the top blade when sideloaded.
Negative Blade tilt
Back bevel
Positive Blade Tilt
Flat Blade
A flat upper blade which has been tilted during sideloading will cause the contact point to move away from the proper cut point, creating an "**open nip**".

Side Force

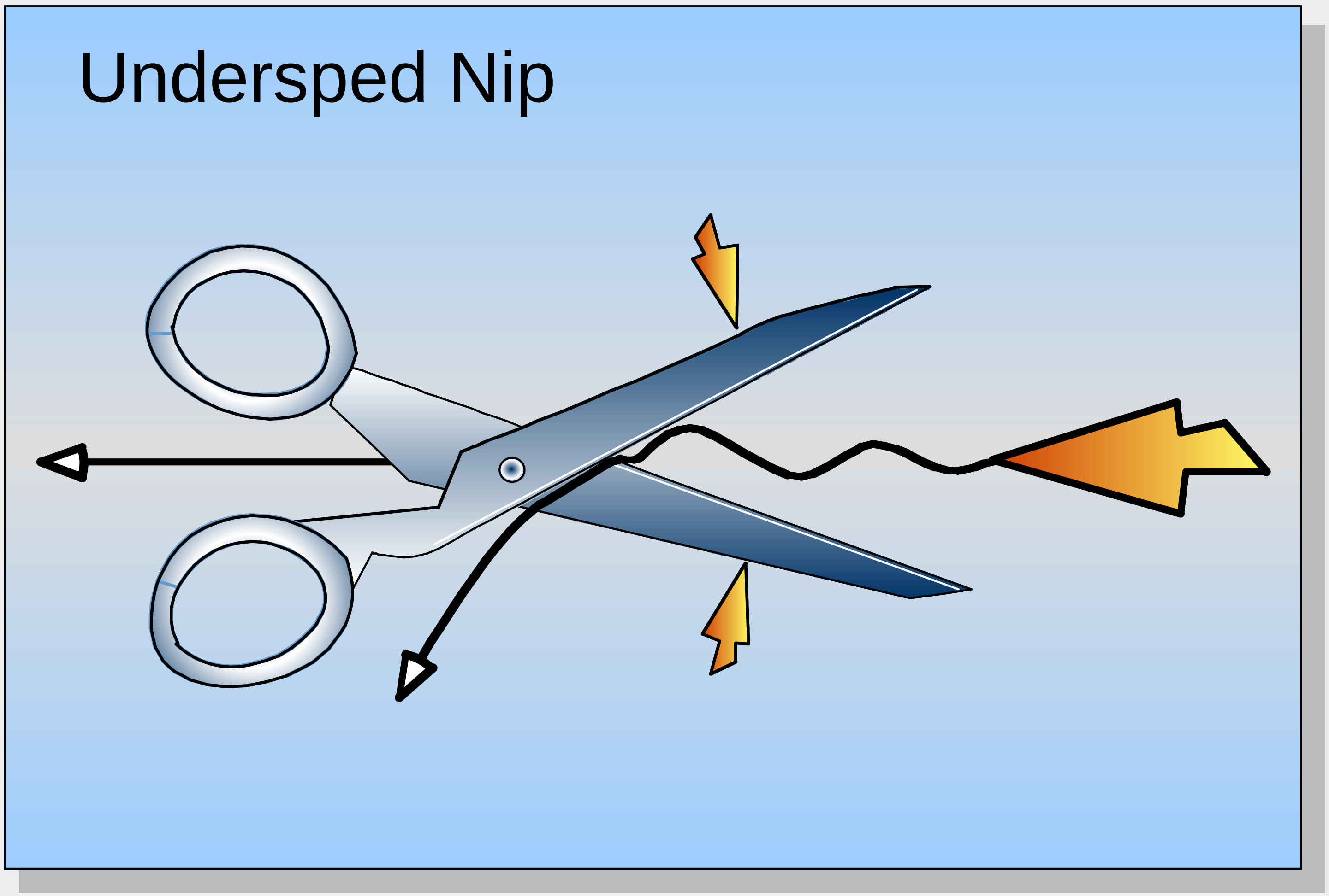
Blade Sideloading

- Sideloading is necessary to traction drive upper blade.
- Heavier materials stall blades, require more sideload
- Excessive sideloading increases wear & chipping

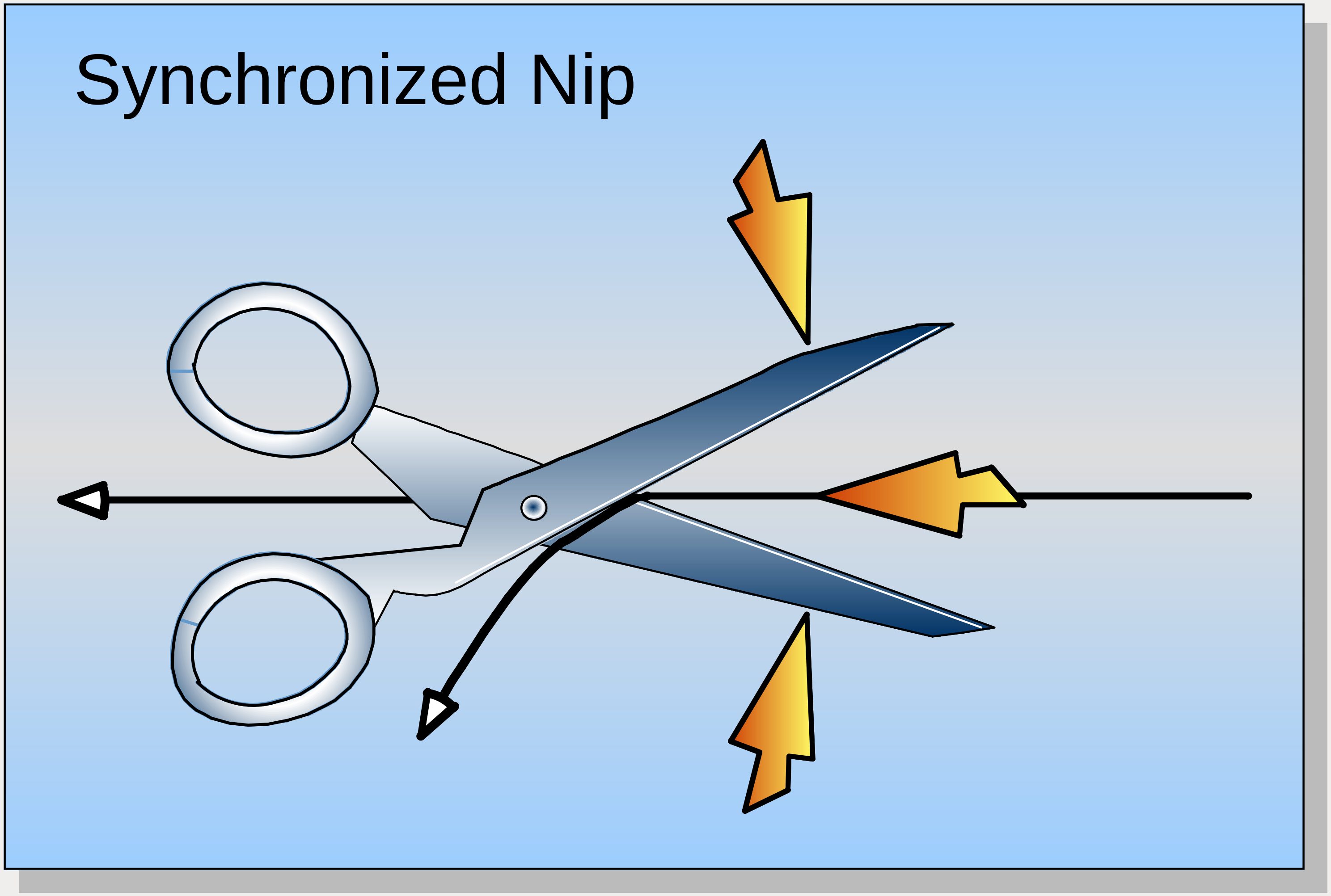
TYPICAL SIDELOAD FORCE

MATERIAL	POUNDS	KG.
Tissue	2 - 3 lbs.	.9 - 1.4 kg.
Thin Plastic Film	2 - 3 lbs.	.9 - 1.4 kg.
Communication Papers	3 - 4 lbs.	1.4 - 1.8 kg.
Packaging Laminates	3 - 5 lbs.	1.4 - 2.3 kg.
Non-wovens	2 - 5 lbs.	.9 - 2.3 kg.
Light Boards	4 - 8 lbs.	1.8 - 3.6 kg.
Heavy Boards	6 - 10 lbs.	2.7 - 4.5 kg.

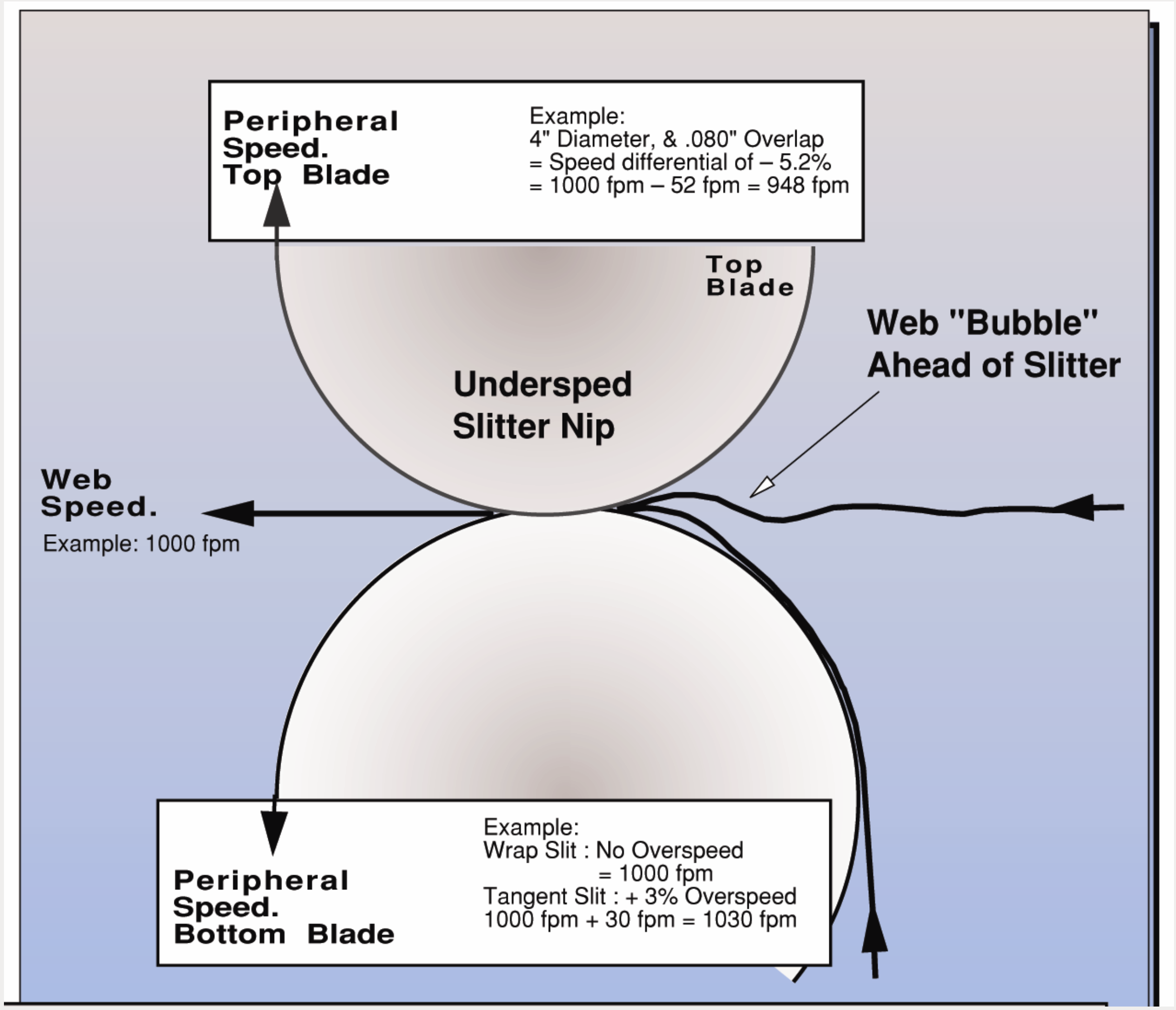
Overspeed



Overspeed

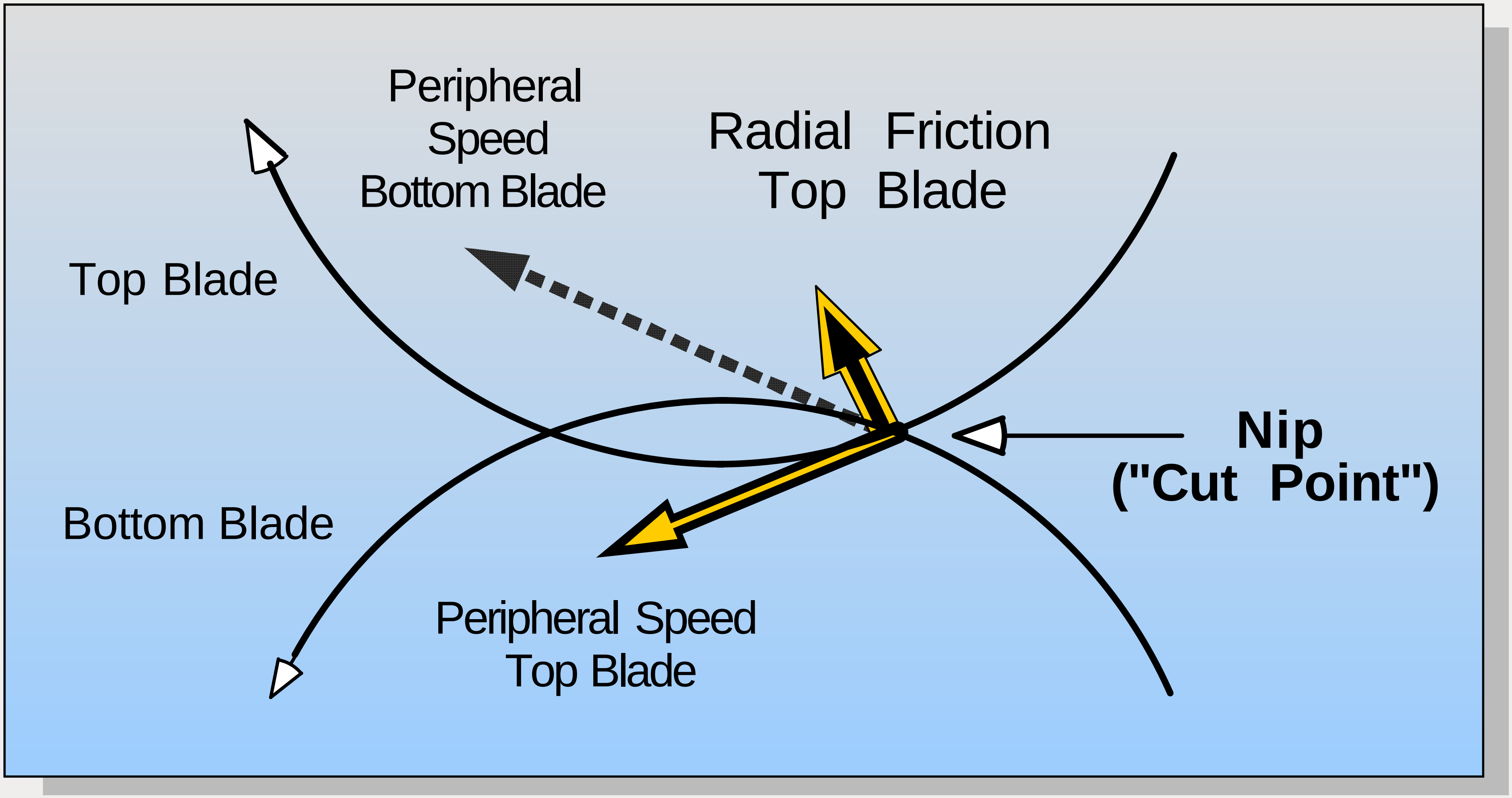


Overspeed



Peripheral Speed. Top Blade
Example:
4" Diameter, & .080" Overlap
= Speed differential of – 5.2%
= 1000 fpm – 52 fpm = 948 fpm
Top Blade
Web "Bubble" Ahead of Slitter
Undersped Slitter Nip
Web Speed.
Example: 1000 fpm
Peripheral Speed. Bottom Blade
Example:
Wrap Slit : No Overspeed
= 1000 fpm
Tangent Slit : + 3% Overspeed
1000 fpm + 30 fpm = 1030 fpm

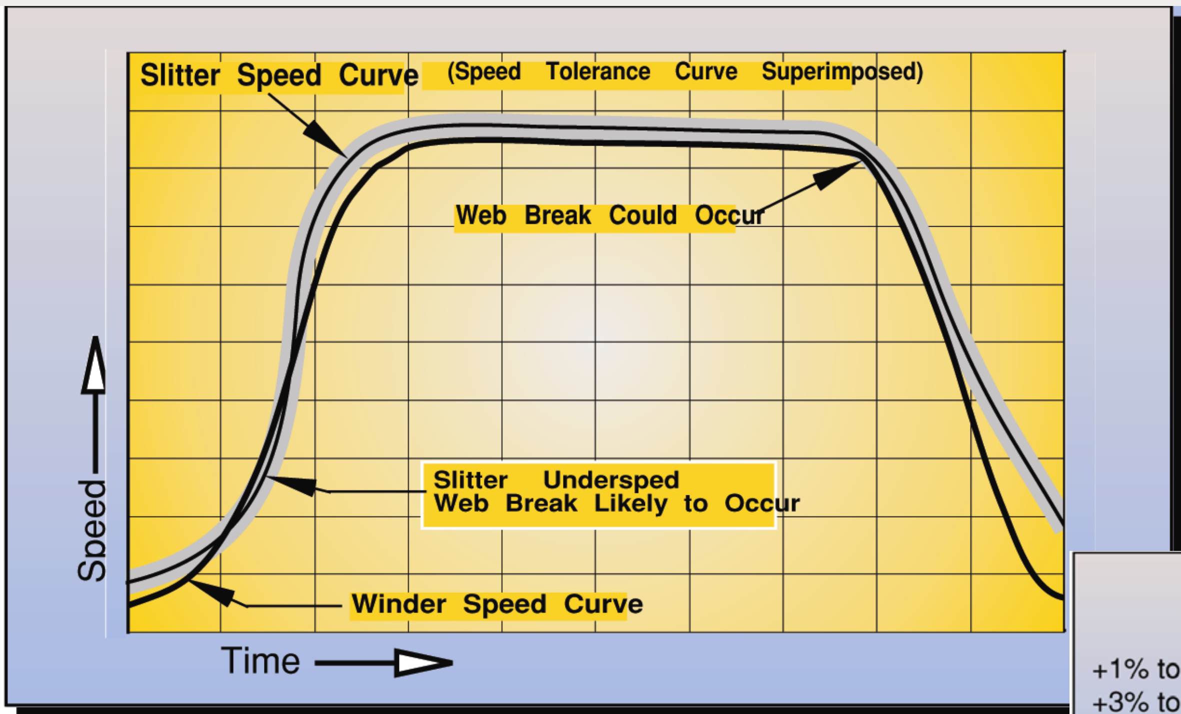
Overspeed


Peripheral
Speed
Bottom Blade
Radial Friction
Top Blade
Top Blade
Nip
("Cut Point")
Bottom Blade
Peripheral Speed
Top Blade

Overspeed

Blade Dia.	Overlap	% Speed Diff. of Top Blade	Radial Friction of Top Blade.
4"	.040"	-4.0%	29%
	.080"	-7.9%	39%
	.120"	-11.8%	47%
6"	.040"	-2.6%	23%
	.080"	-5.3%	32%
	.120"	-7.9%	39%
8"	.040"	-2.0%	20%
	.080"	-4.0%	28%
	.120"	-6.0%	34%
10"	.040"	-1.6%	18%
	.080"	-3.2%	25%
	.120"	-4.4%	30%

Overspeed

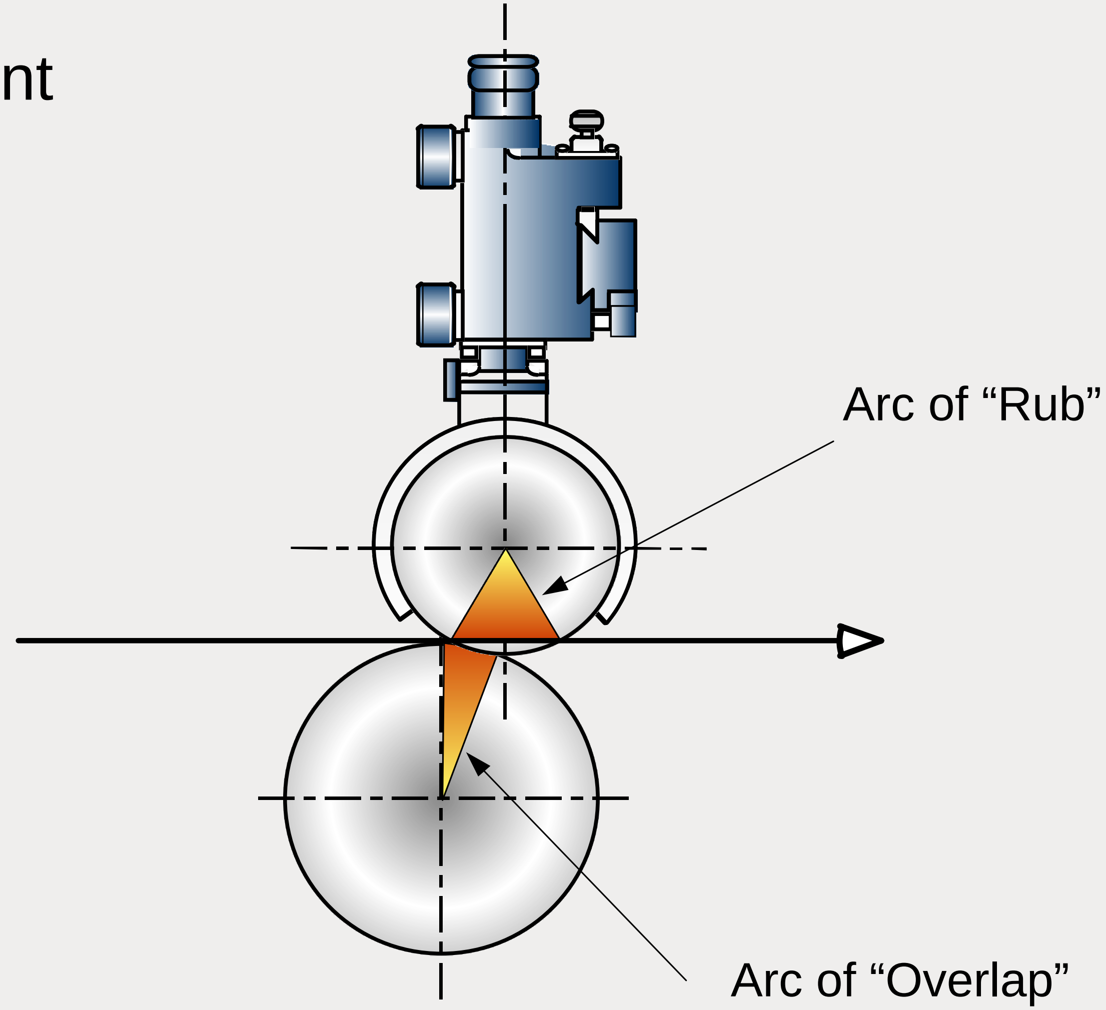


TYPICAL OVERSPEED GUIDELINES

+1% to +3%:	Foils, Low Elongation Films, Delicate Mat'ls.
+3% to +5%:	General Materials, Papers, Boards
+5% to +10%:	High Elongation Films, Loose Fibered Mat'l.
+10% to +100%:	Textiles, Unbonded Non-wovens, etc.

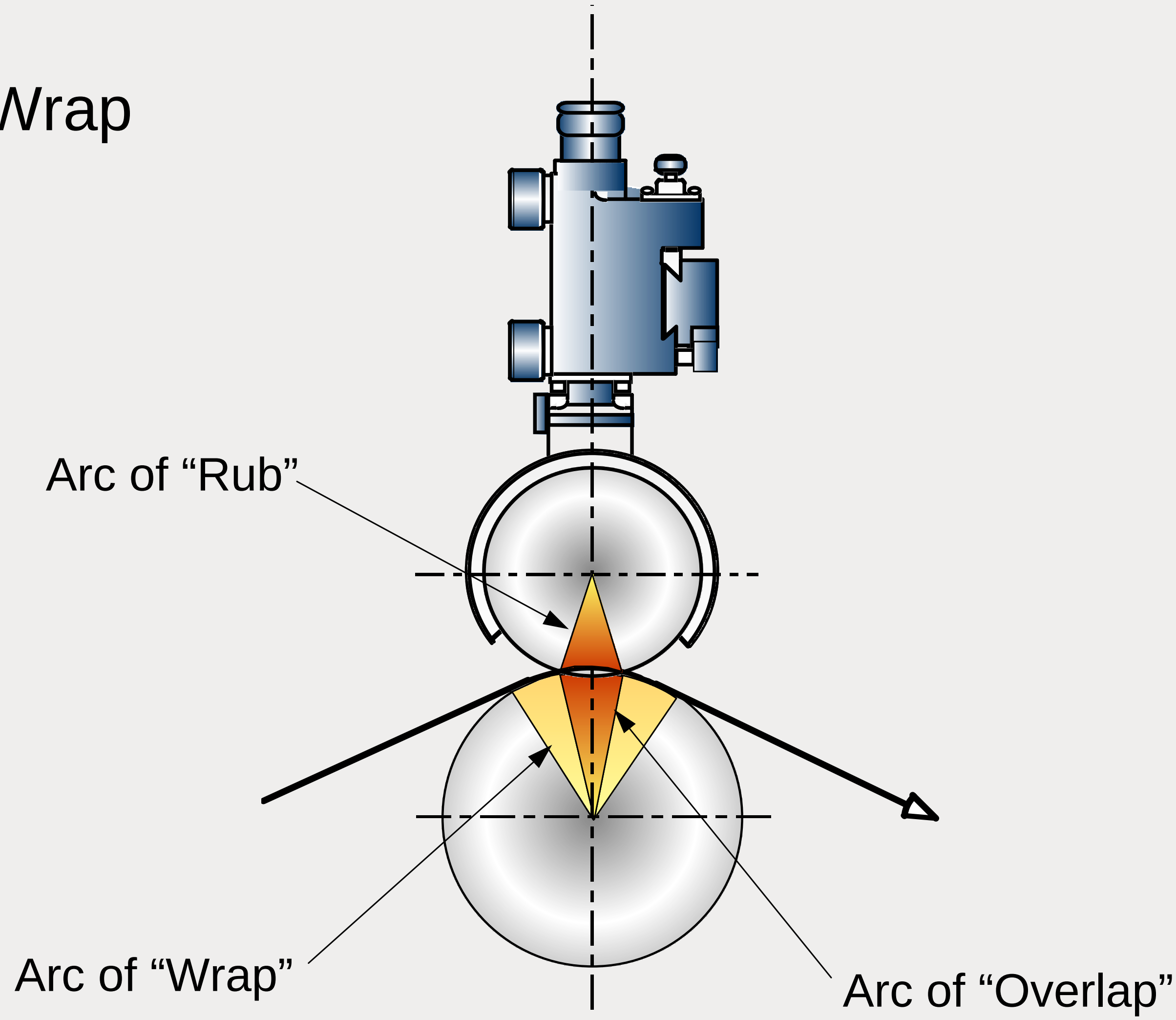
Slitter Geometry

Tangent

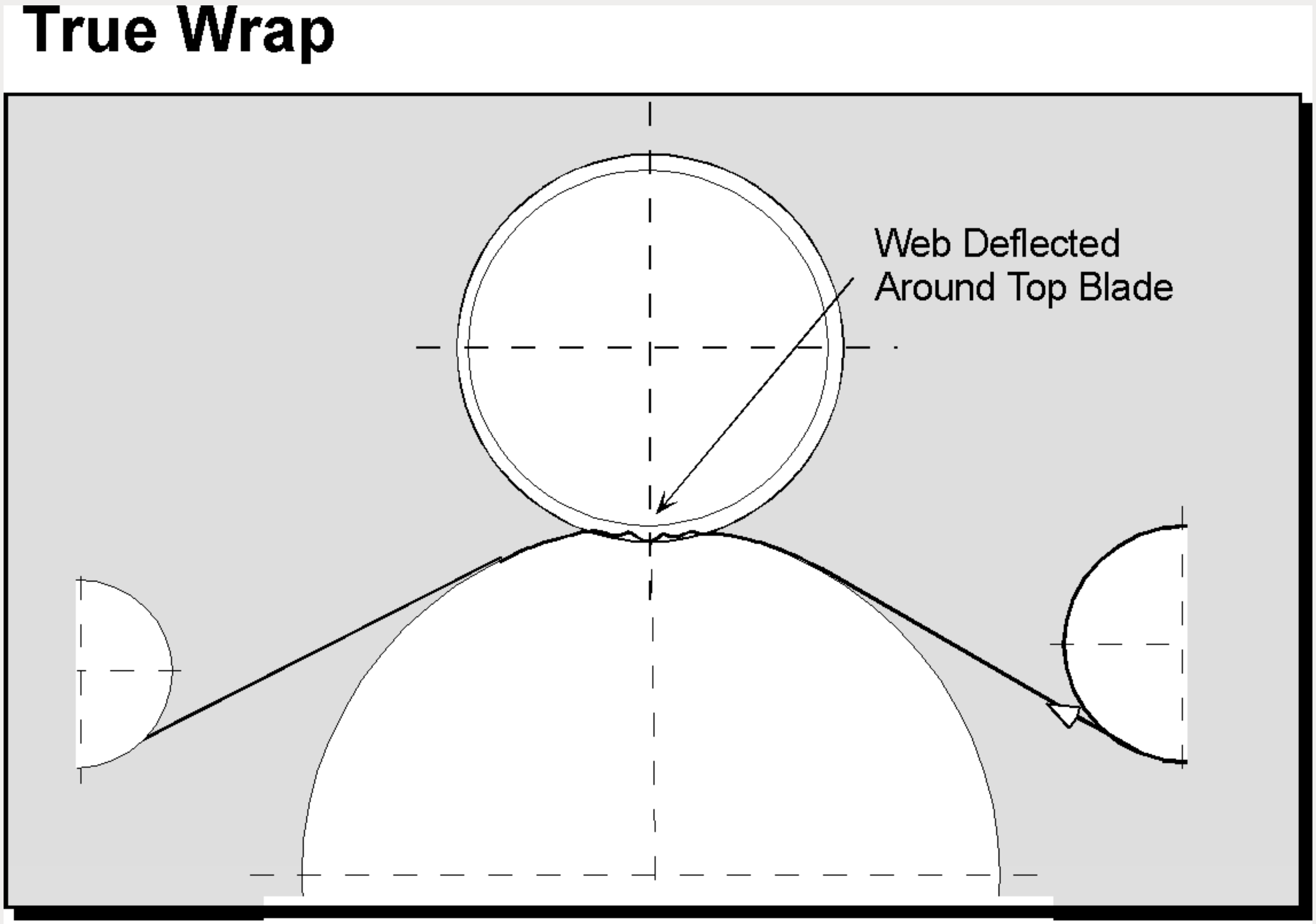


Slitter Geometry

Wrap

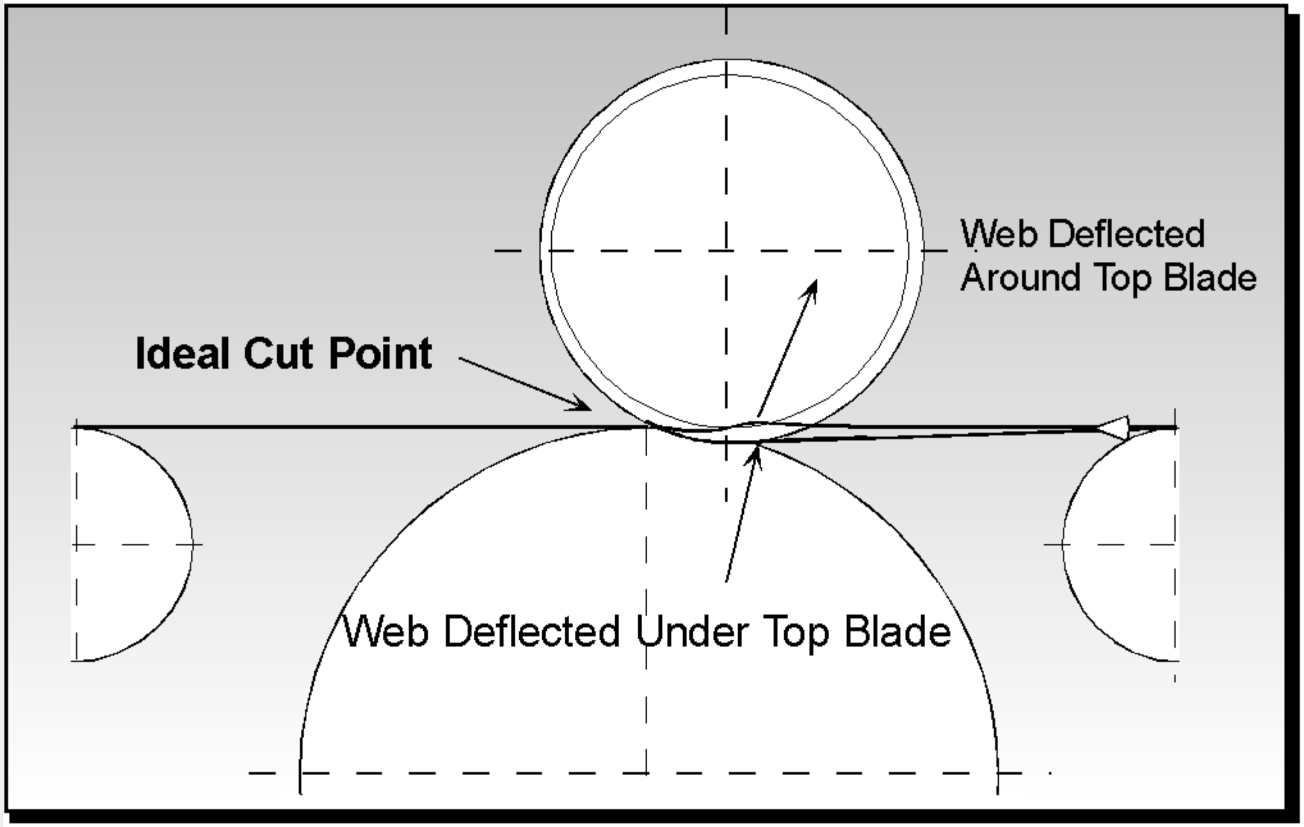


Slitter Geometry

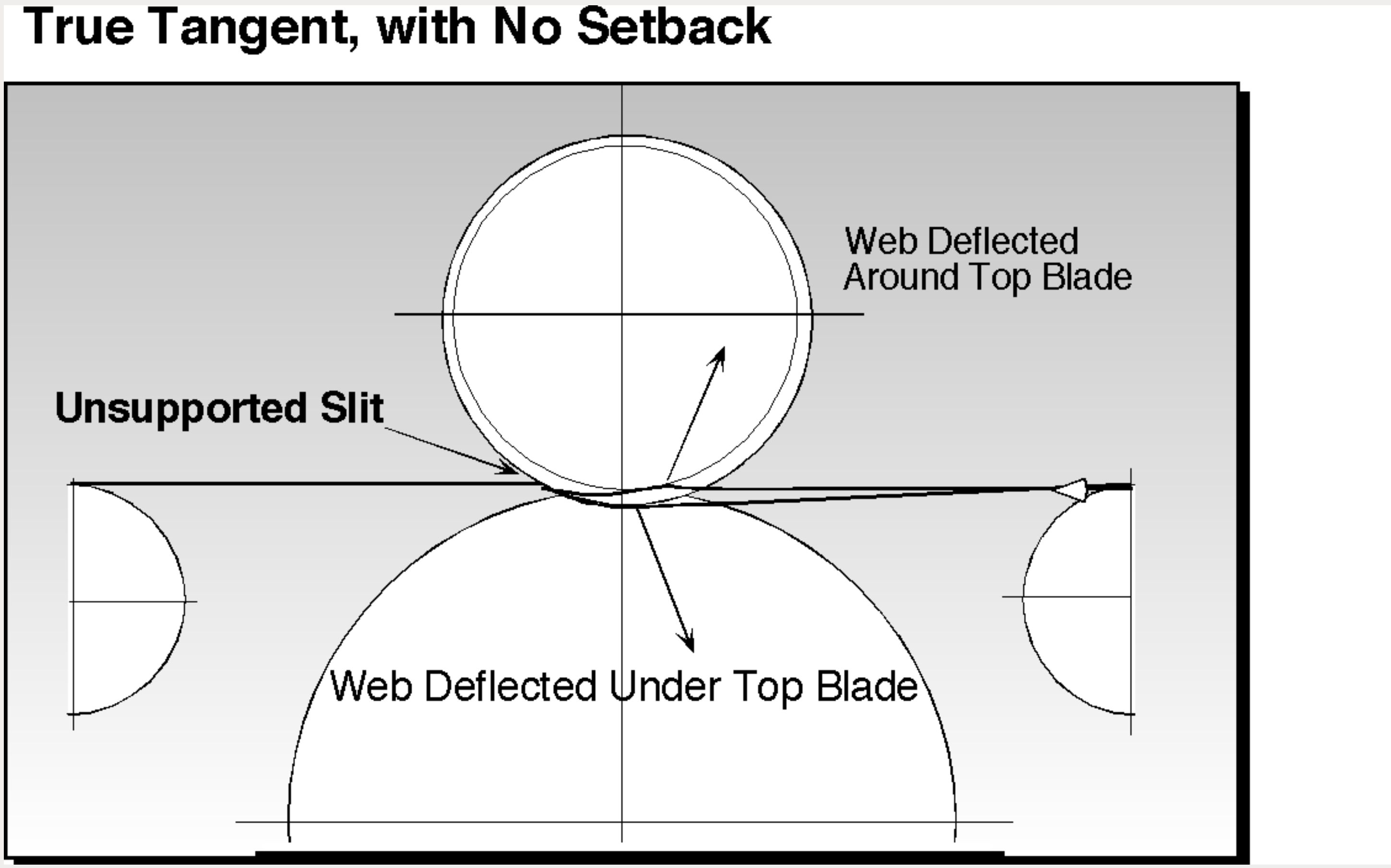


Slitter Geometry

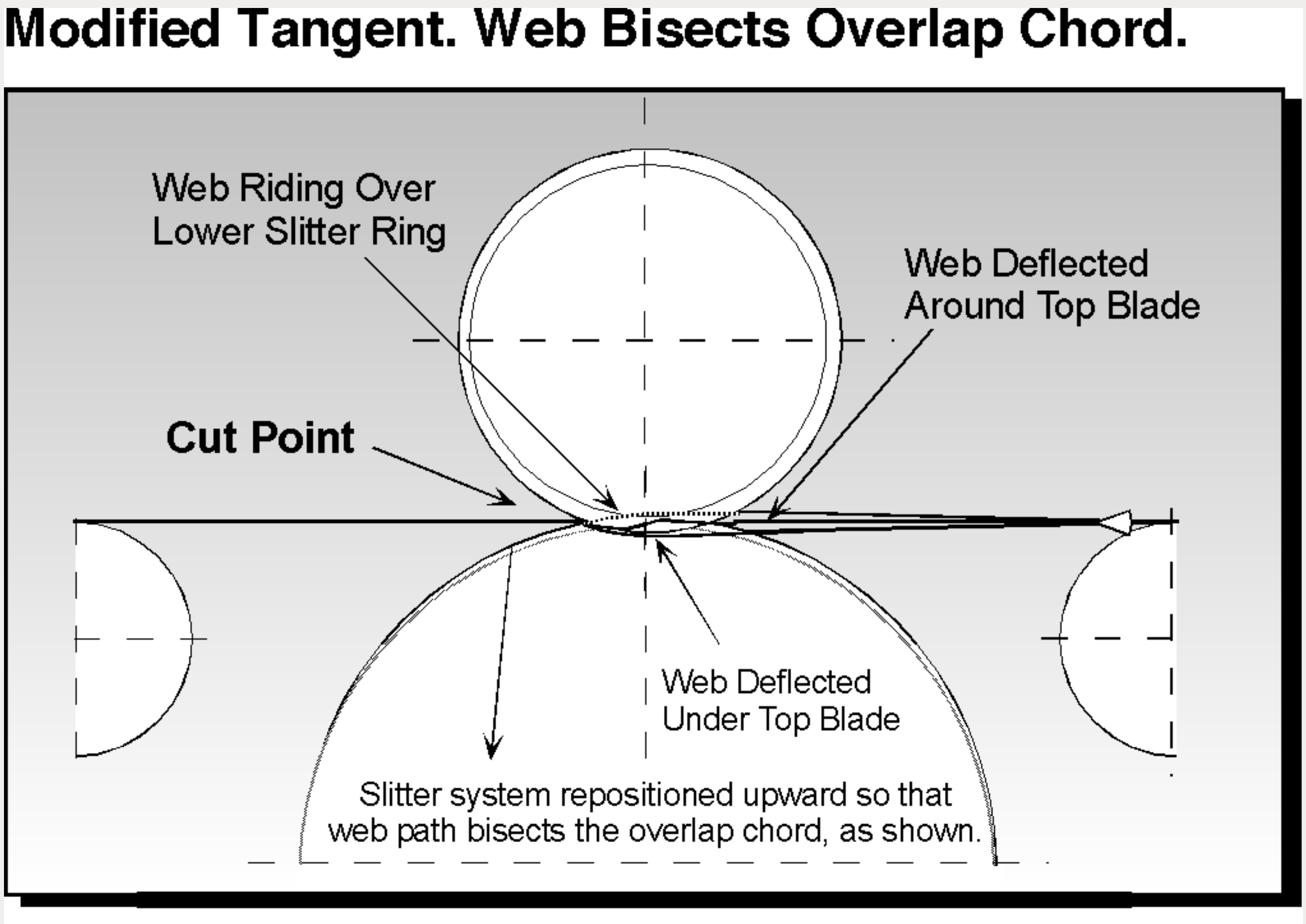
True Tangent, with Traditional Setback



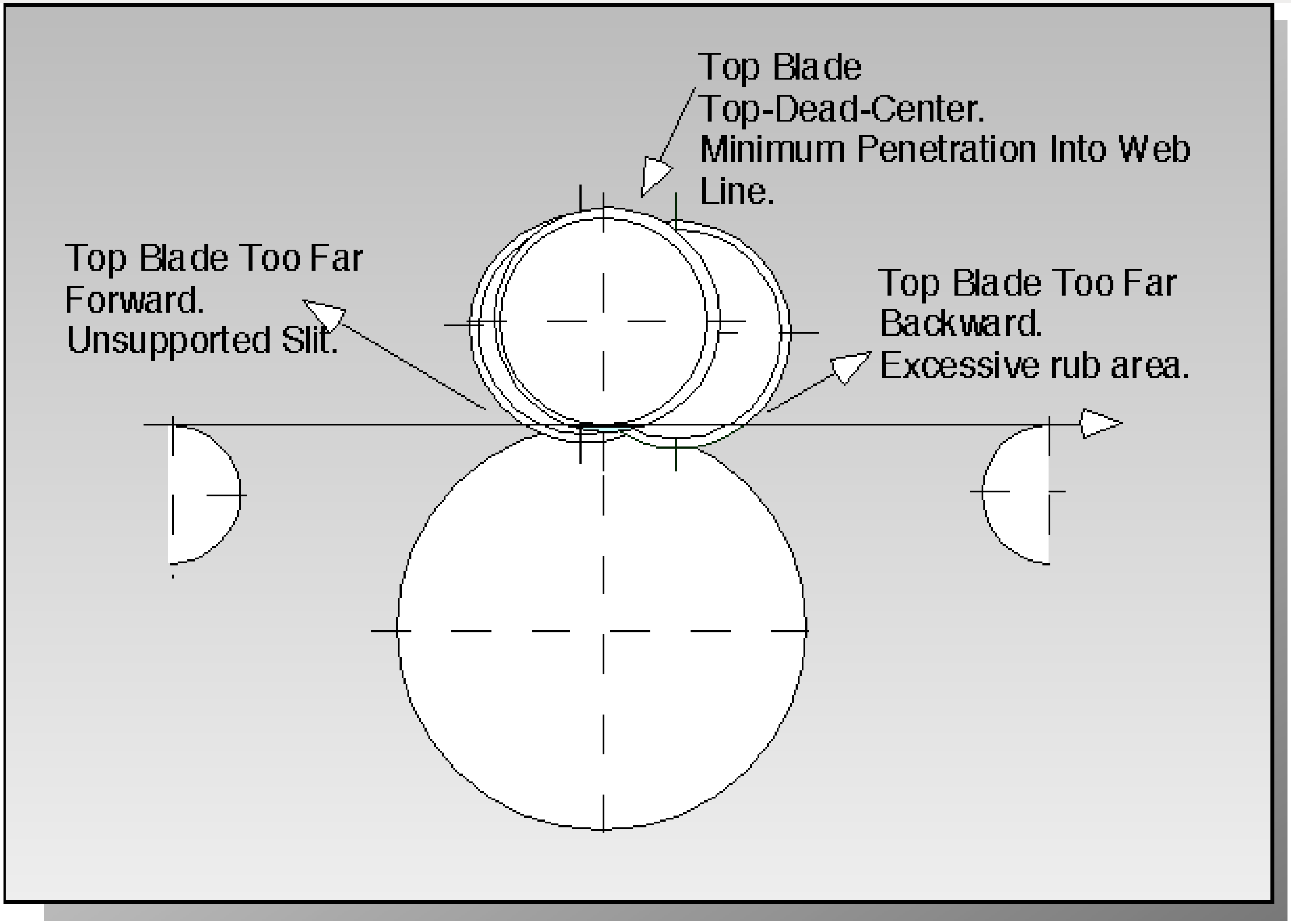
Slitter Geometry



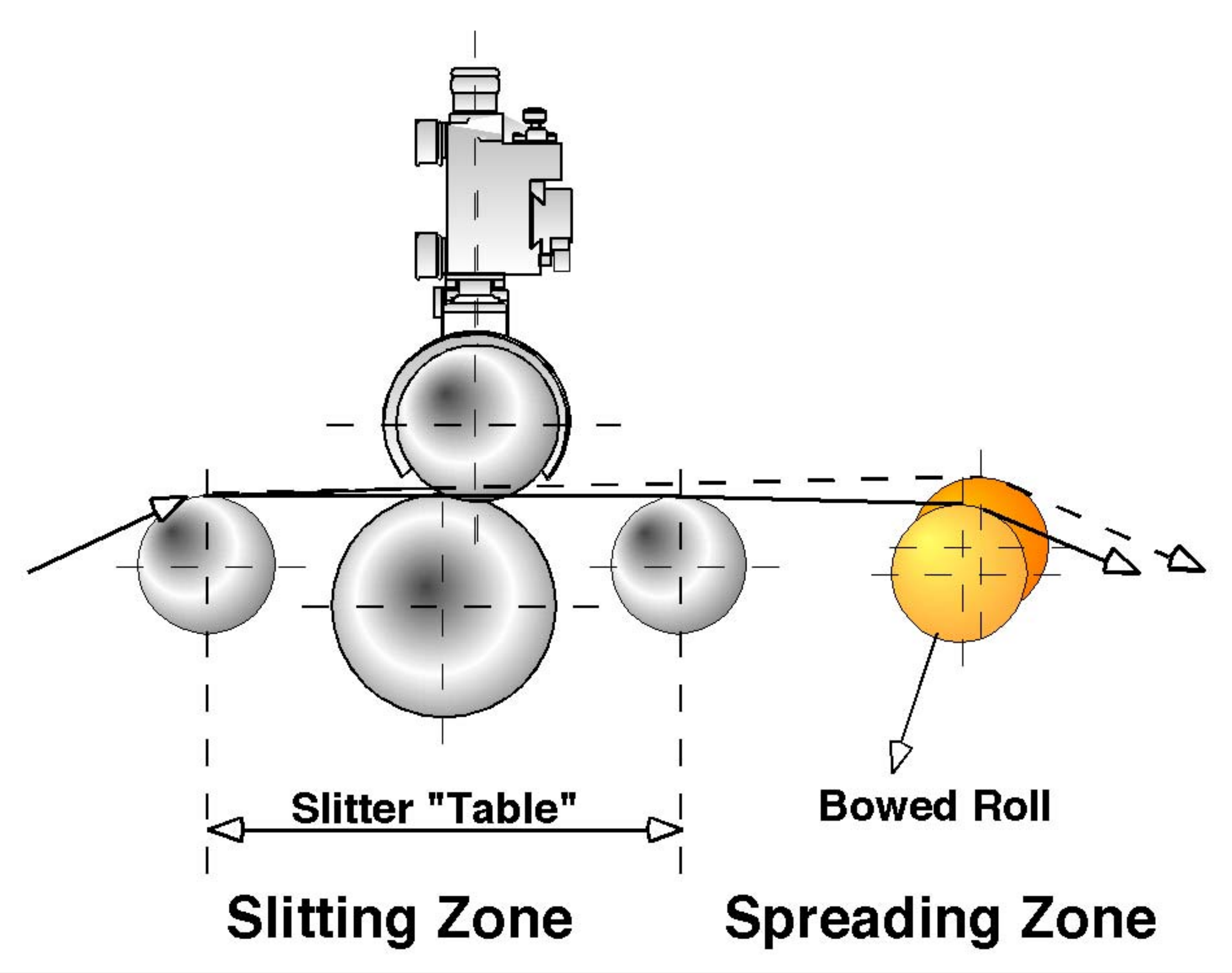
Slitter Geometry



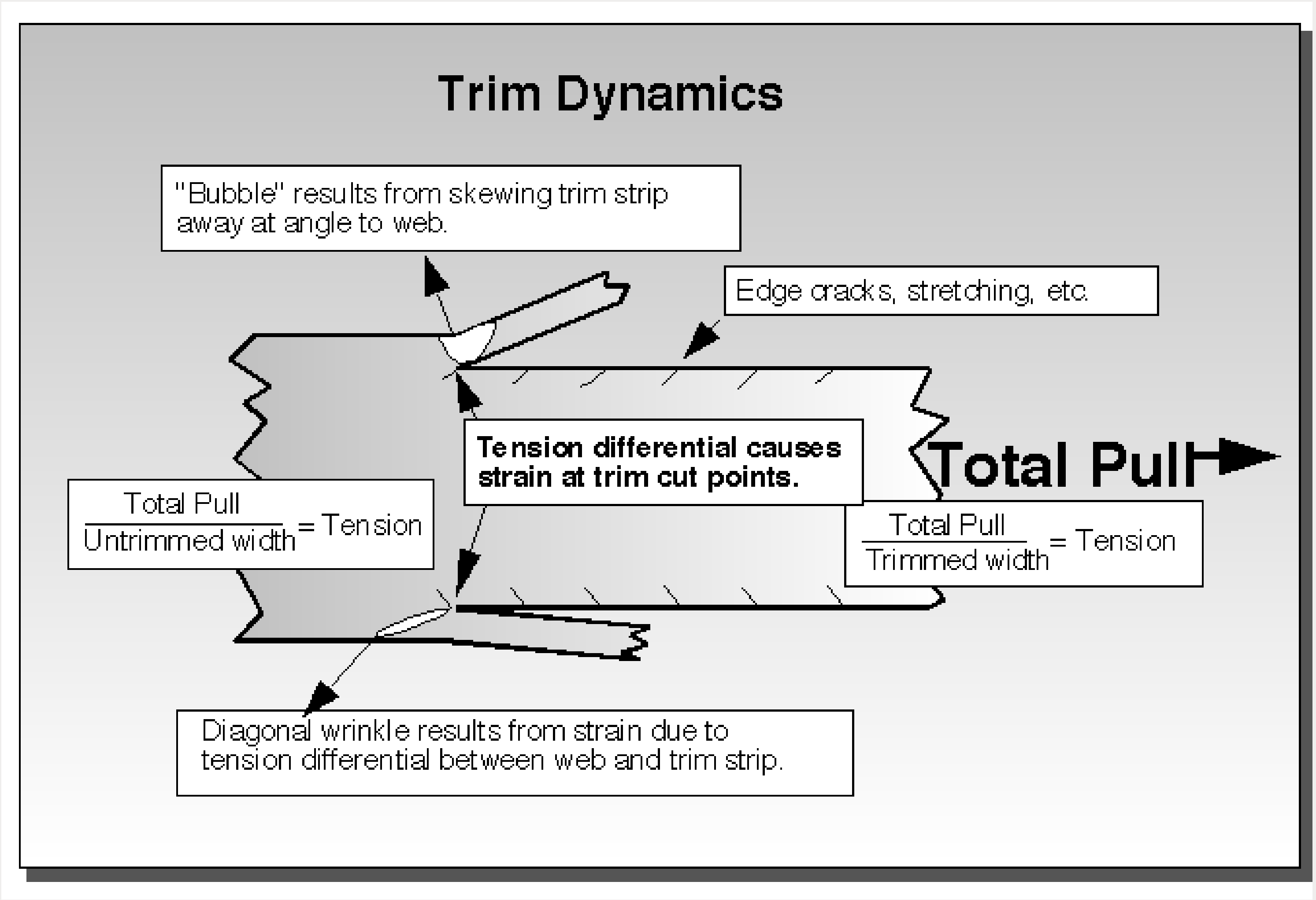
Slitter Geometry



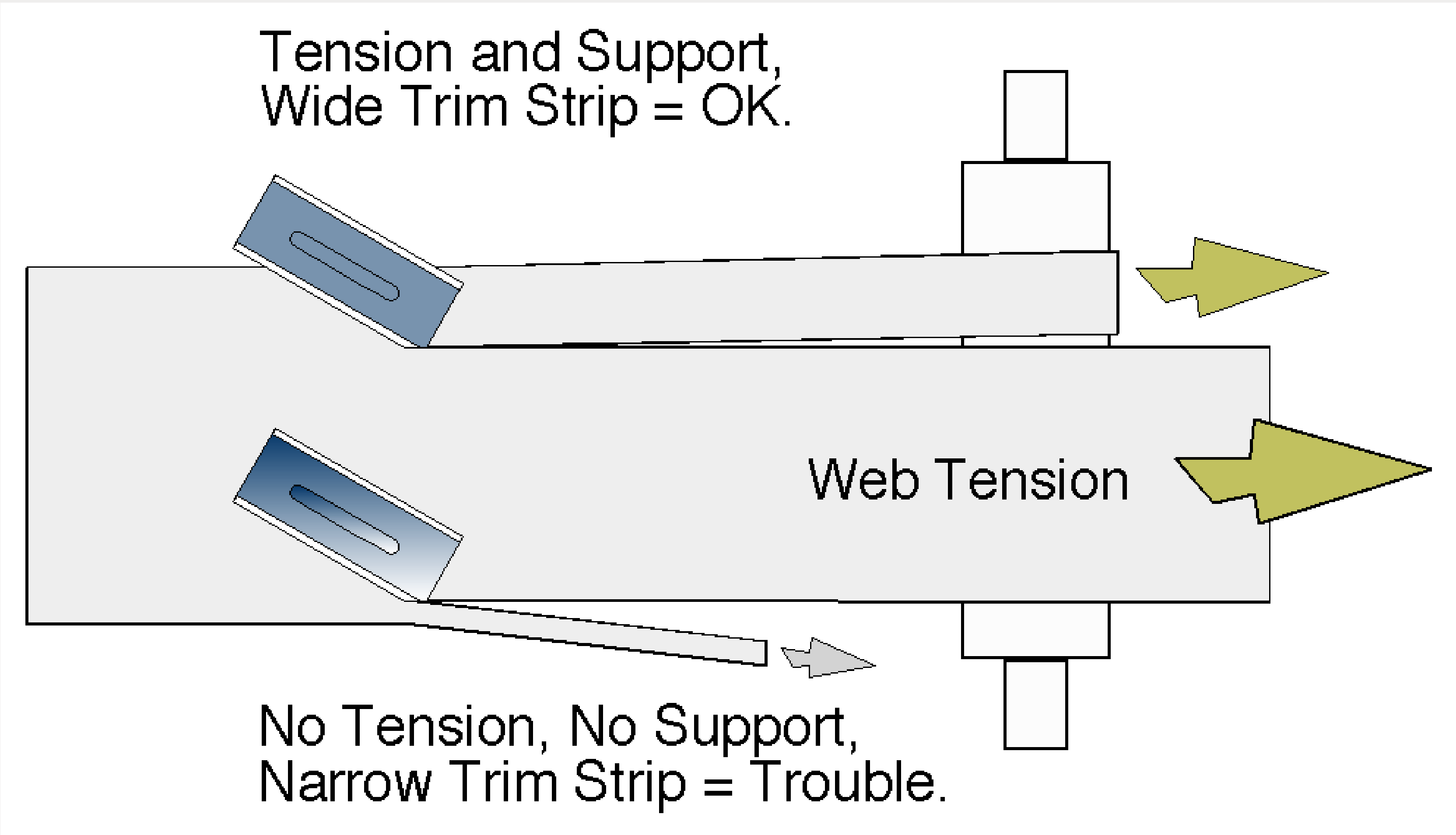
Slitter Geometry



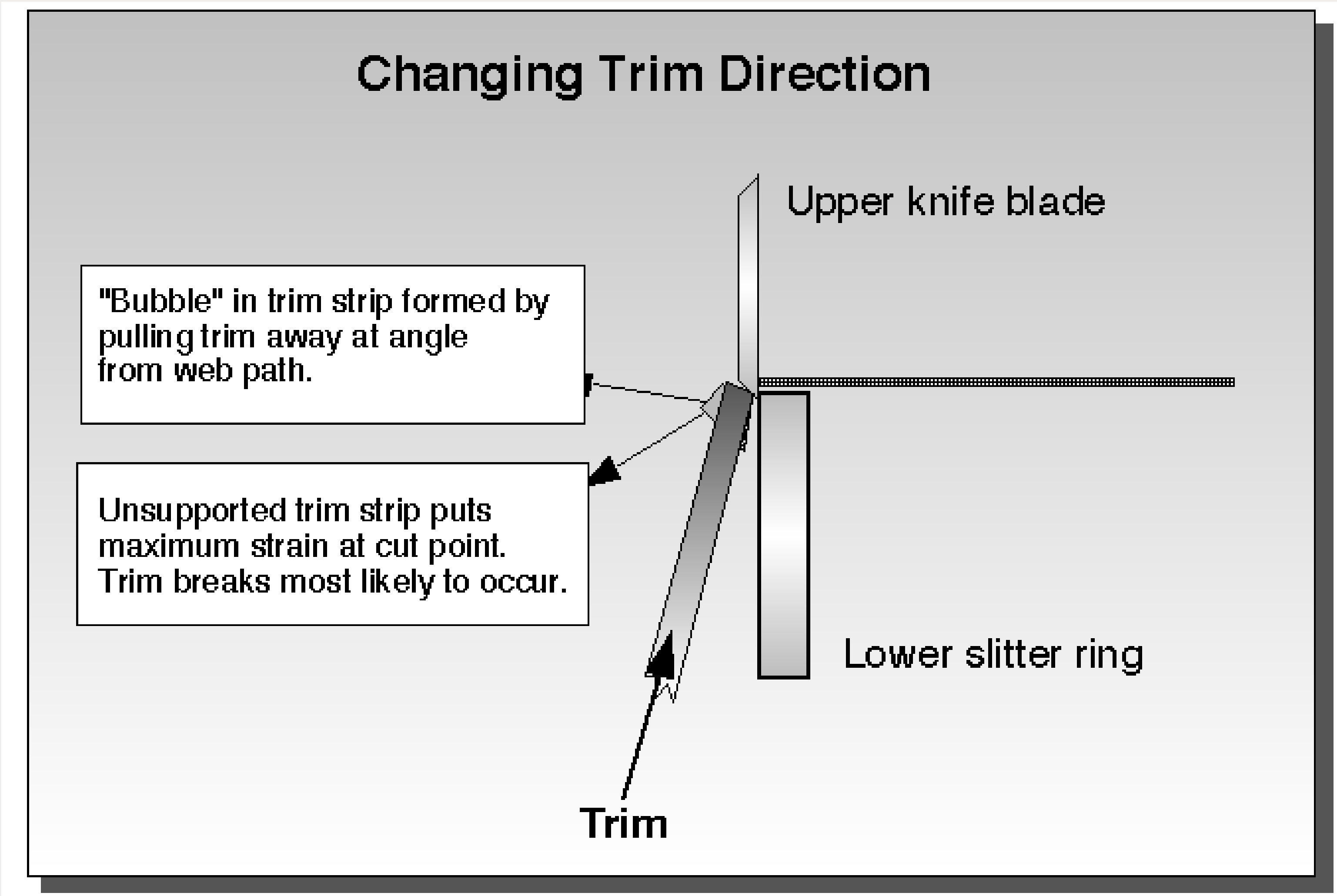
Trim Removal



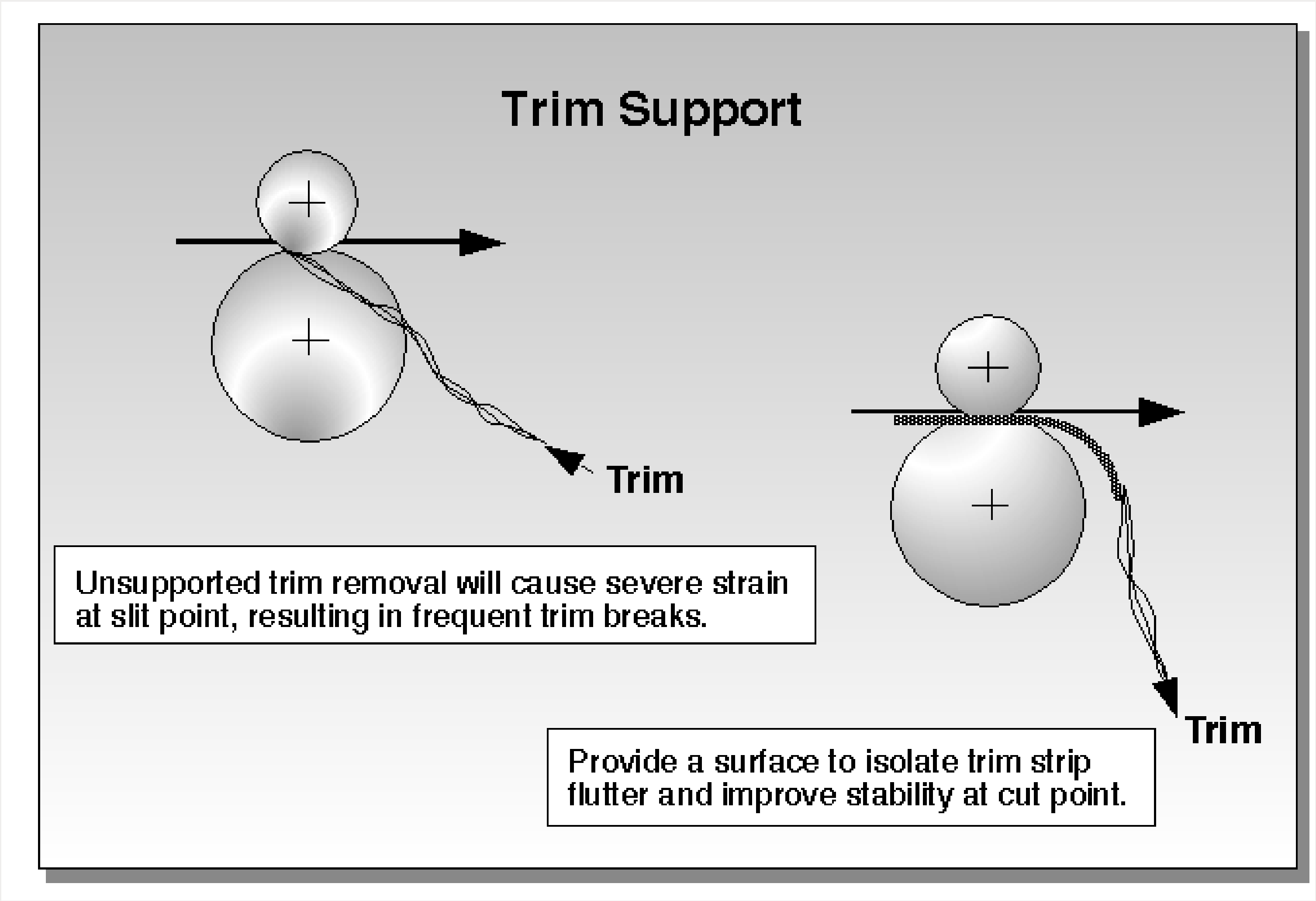
Trim Removal



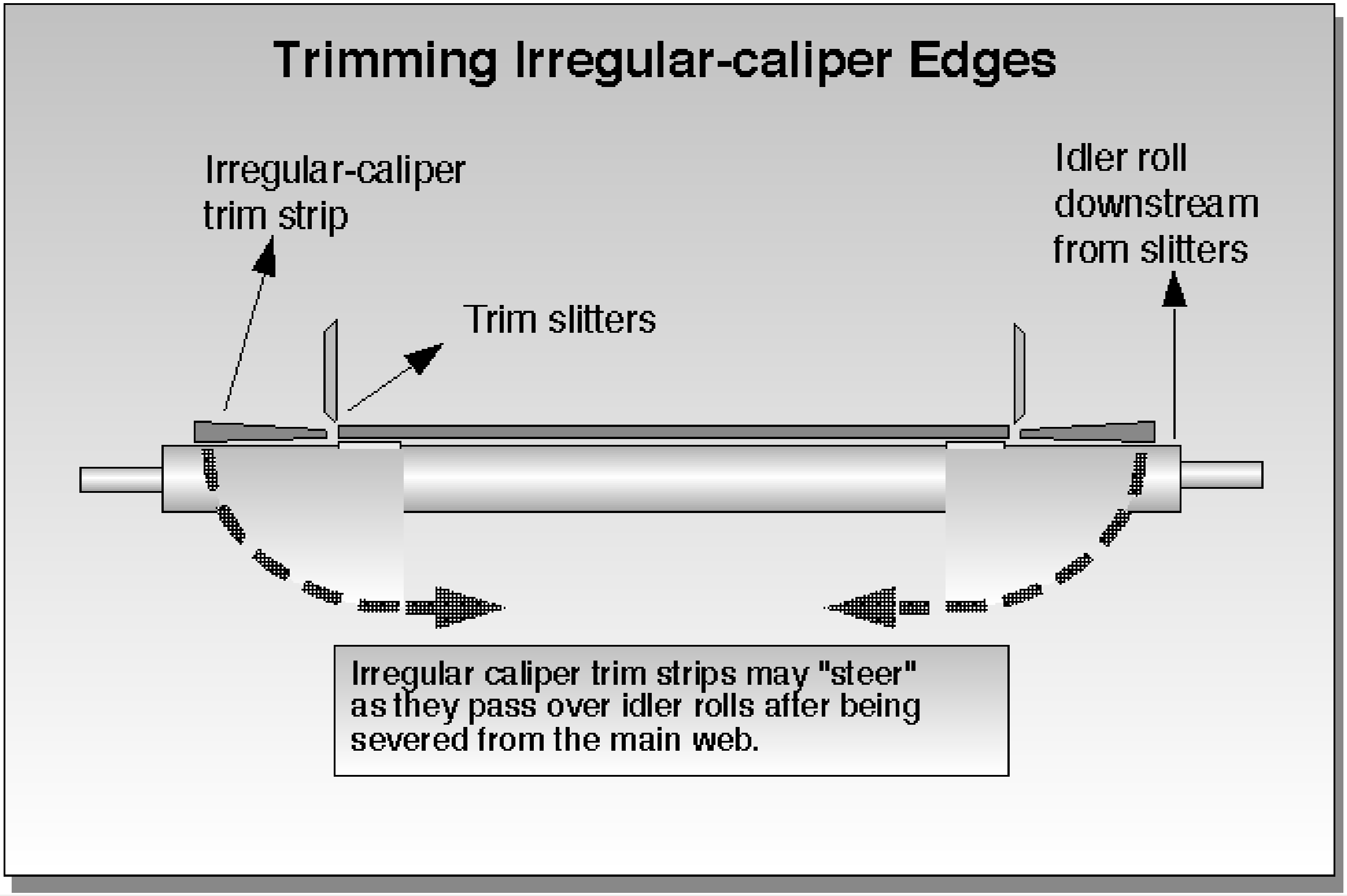
Trim Removal



Trim Removal



Trim Removal



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Thank You

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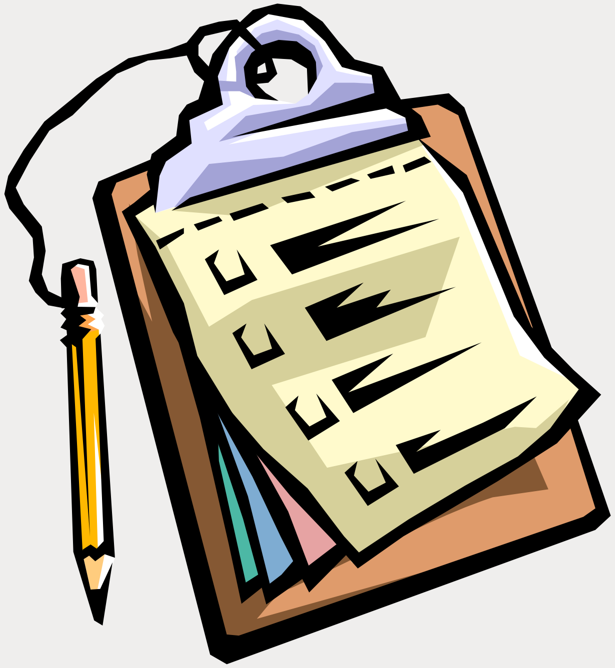

Please remember to turn in your evaluation sheet...

of toe-in. Elongation, elasticity, and fiber or filament orientation are important factors in choosing the optimum cant angle. A general rule of thumb is: "Low elongation = low cant angle, high elongation = high cant angle."

Overlap

In tangent systems, increasing the overlap between the upper and lower blades shifts the cut point ahead of the tangent point. The upper blade strikes the web too soon and the web is severed without benefit of support from the lower slitter. In wrap systems, the cut point has little effect on slit quality, assuming that the wrap angle is great enough to prevent the nip from shifting to where the unsupported web is slit before it is in contact with the lower slitter. However, increasing overlap in both systems increases the amount of deflection the web must take to go around the upper blade which can decrease slit edge quality.

Side force

Side force refers to the amount of force applied laterally from the upper blade to the lower anvil blade. This force creates friction between the upper blade and the lower anvil blade driving the rotational speed of the upper blade creating the nip speed at the cut point. Too much side force increases blade wear and can cause deflection in the upper blade which results in opening the nip point. Ideally, the side force should be as light as possible to maintain a closed nip and appropriate nip speed.

Nip velocity vs. web velocity

In shear slitting, the nip velocity must be equal or ideally faster than the web velocity. If the nip (cut point) closes at a speed slower than the web, slit quality reduces which promotes dusty, ragged, distorted edges. Any "puckering" of the web immediately in front of the top slitter is a sure sign that the slitters are running slower than the web speed. Factors that influence web nip speed are overlap and overspeed. When two circular blades are overlapped and one blade drives the other, there is an inevitable difference in the rotational speed between the blades, the amount of overlap directly influencing the speed differential. On tangent systems, the remedy is to increase the overspeed to compensate for the speed loss. On wrap systems, the situation is not as easily resolved, since they cannot be realistically oversped enough to compensate for the speed differential.

Slitter geometry

Shear slitting systems can be configured to either of two basic methods: tangent or wrap. While most paper mill primary winders are configured for tangent slitting, secondary winders and a great many general converting slitters may be wrap configured. An understanding of the specific advantages and disadvantages of each method and its influence in the slitting process will be presented.

Trim removal

As edge trim material is removed from the web the tension across the web is altered. Redirecting the trim material away from the web path and/or using a different force to pull the trim induce stress at the cut point promoting a reduced slit edge quality. To promote good edge quality the supported slit edge (lower anvil) should be on the web side of the edge trim and the trim material should follow the path of the web at the same velocity as it leaves the nip point.

Summary

By paying careful attention to the variables that affect shear slitting, namely blade sharpness/profile, cant angle, overlap, side force, nip velocity vs. web velocity, slitter geometry, and trim removal, shear slitting will produce those perfect edges our customers have come to expect.