



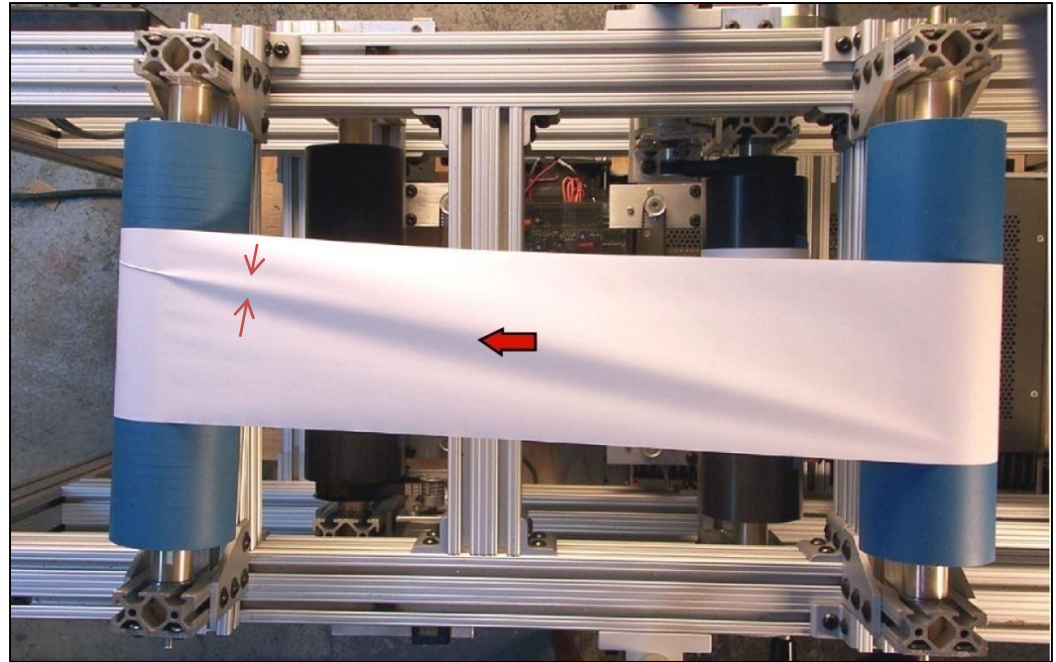
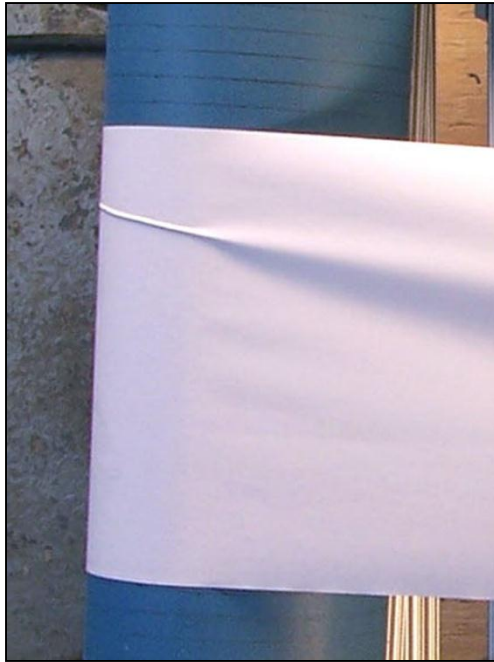
Anatomy of a Wrinkle

Jerry Brown

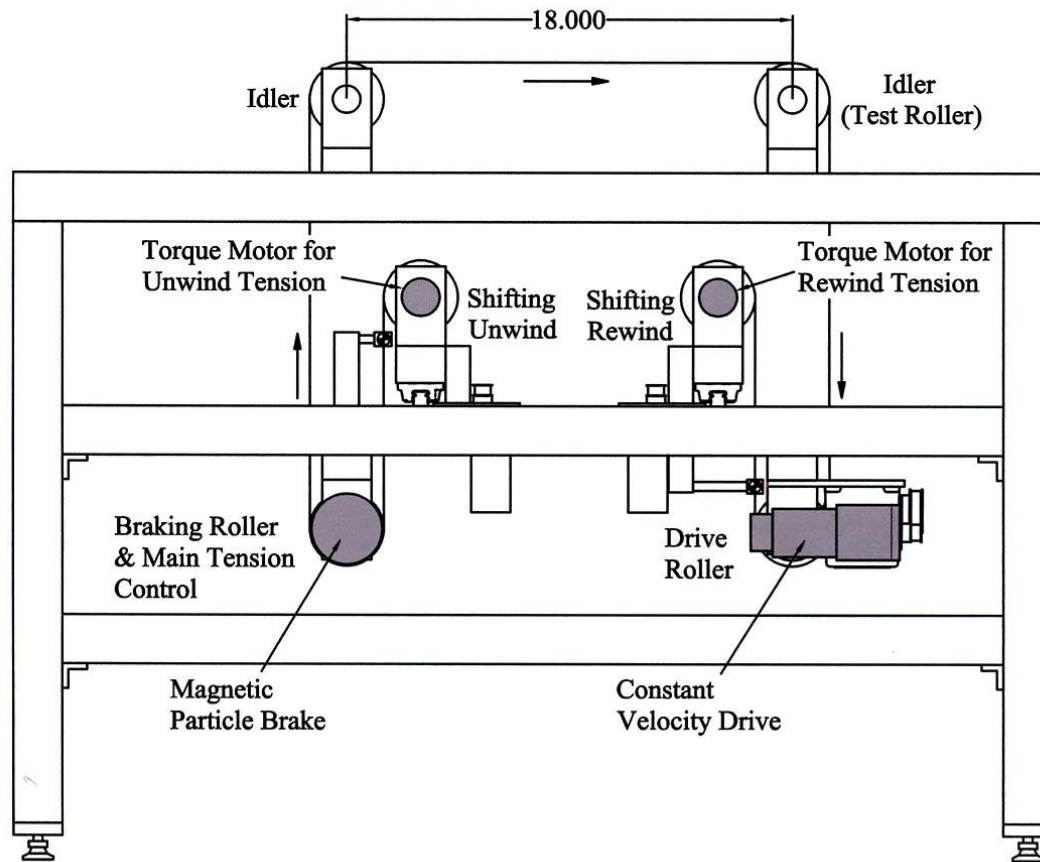
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Shear wrinkle at a misaligned roller



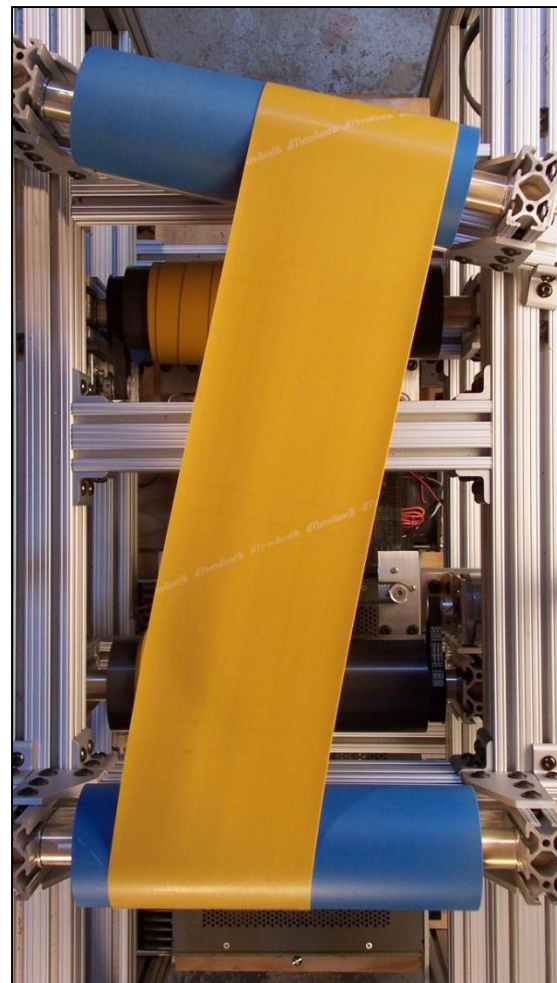
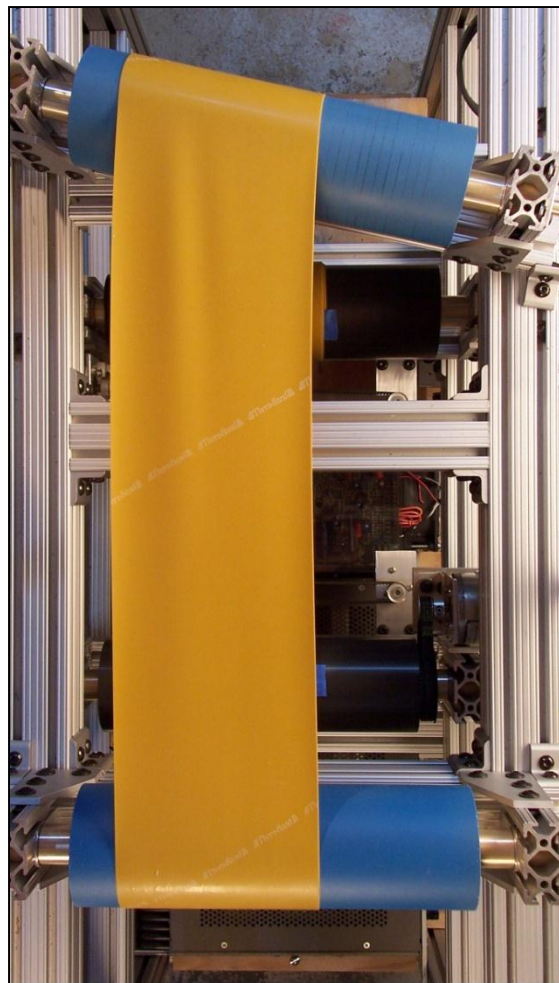
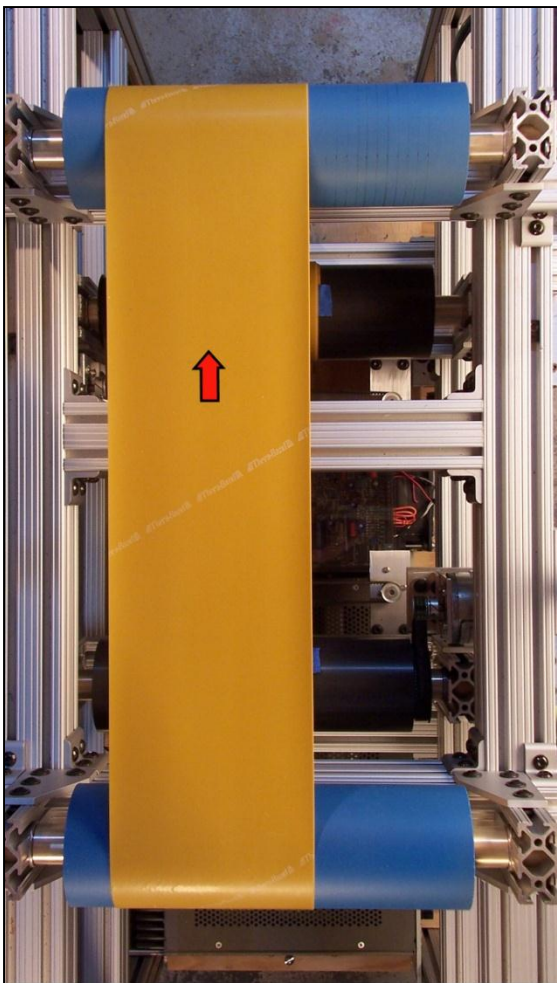
Lab machine



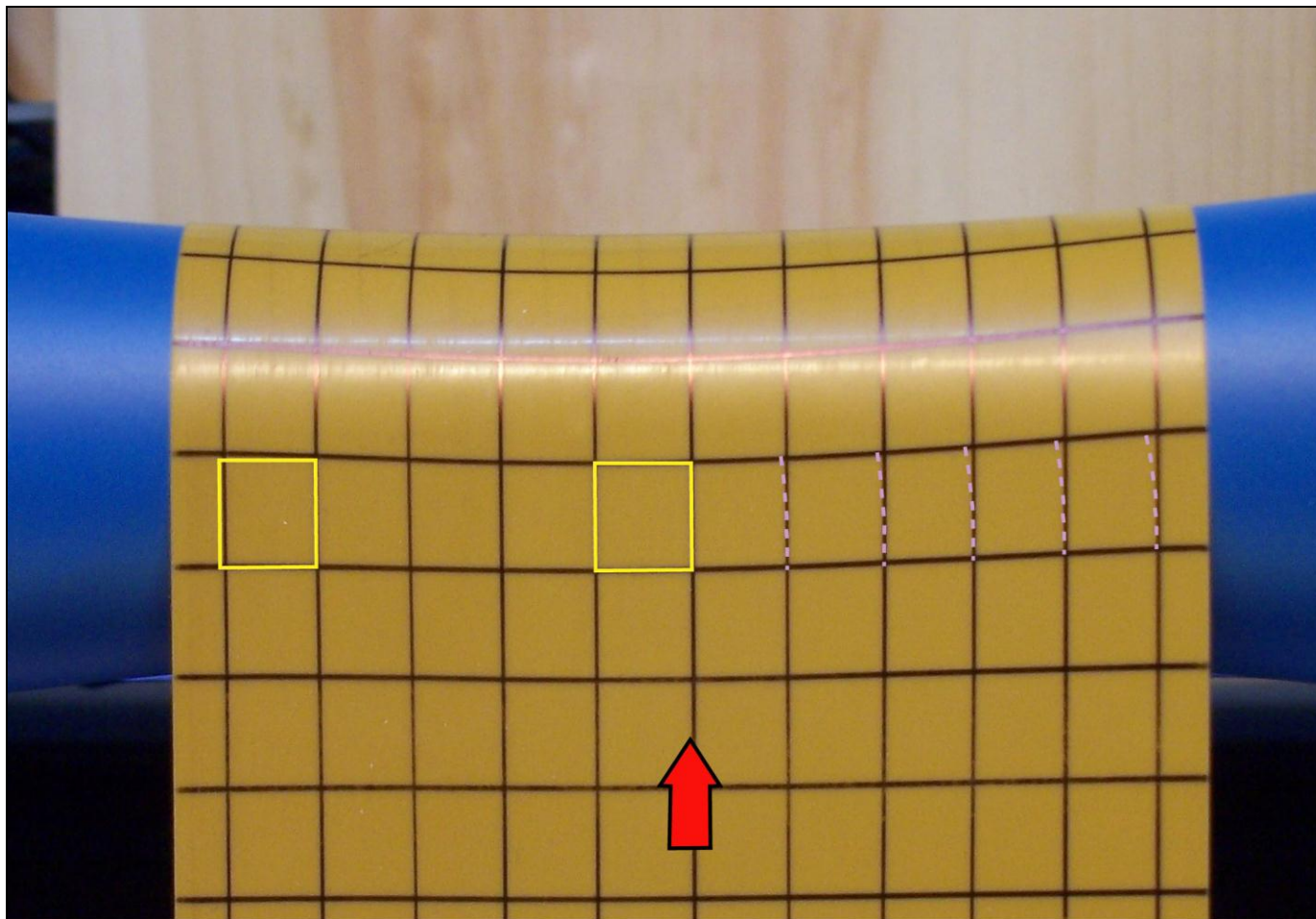
Two fundamental principles

- Normal entry rule
- Normal strain rule

Normal entry rule



Normal strain rule



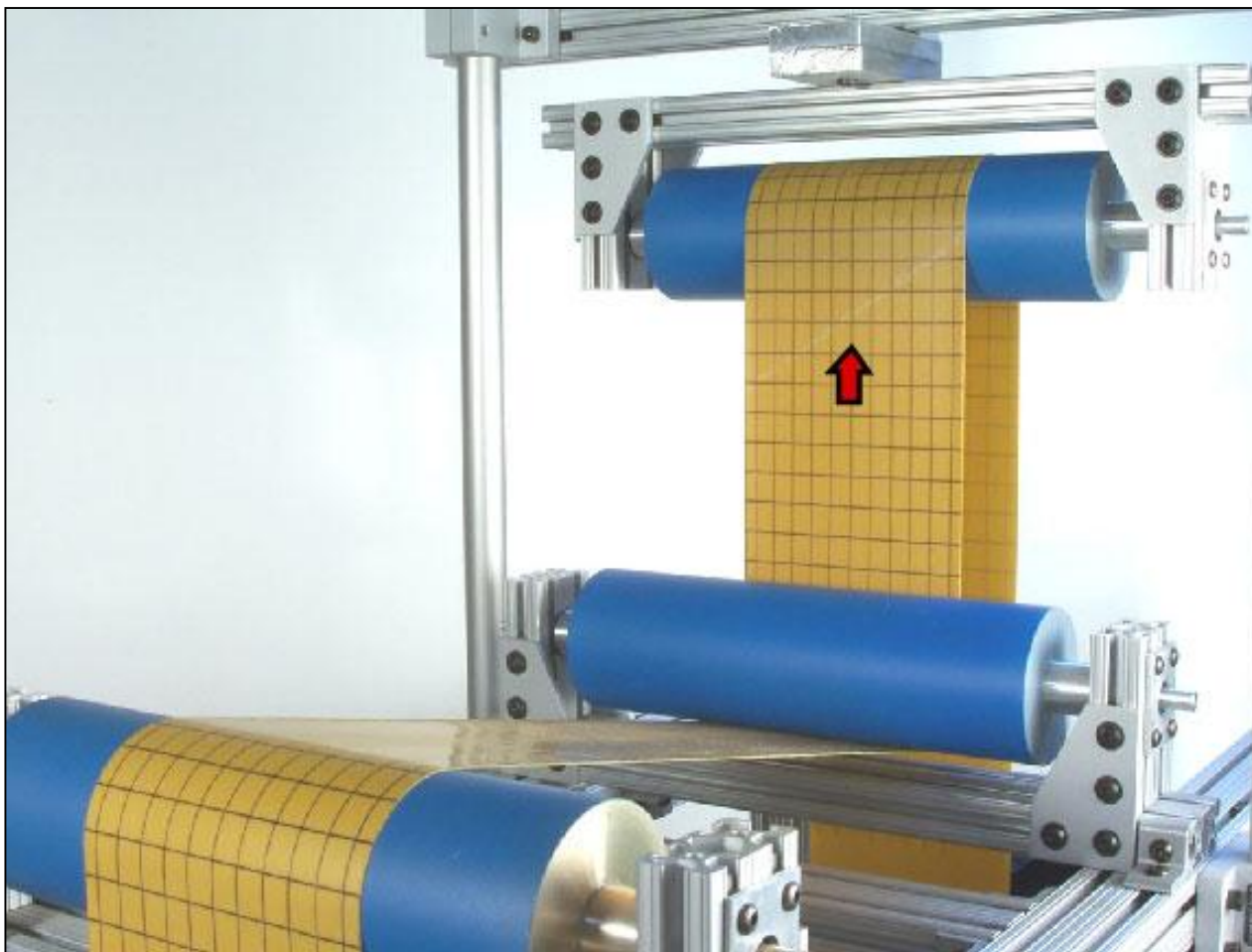
All wrinkles have the same cause

- Compressive CD stress at entry to a roller
 - Roller misalignment
 - Roller deflection (reverse bow)
 - Tension drop across a driven roller
 - Expansion to temperature increase
 - Twist

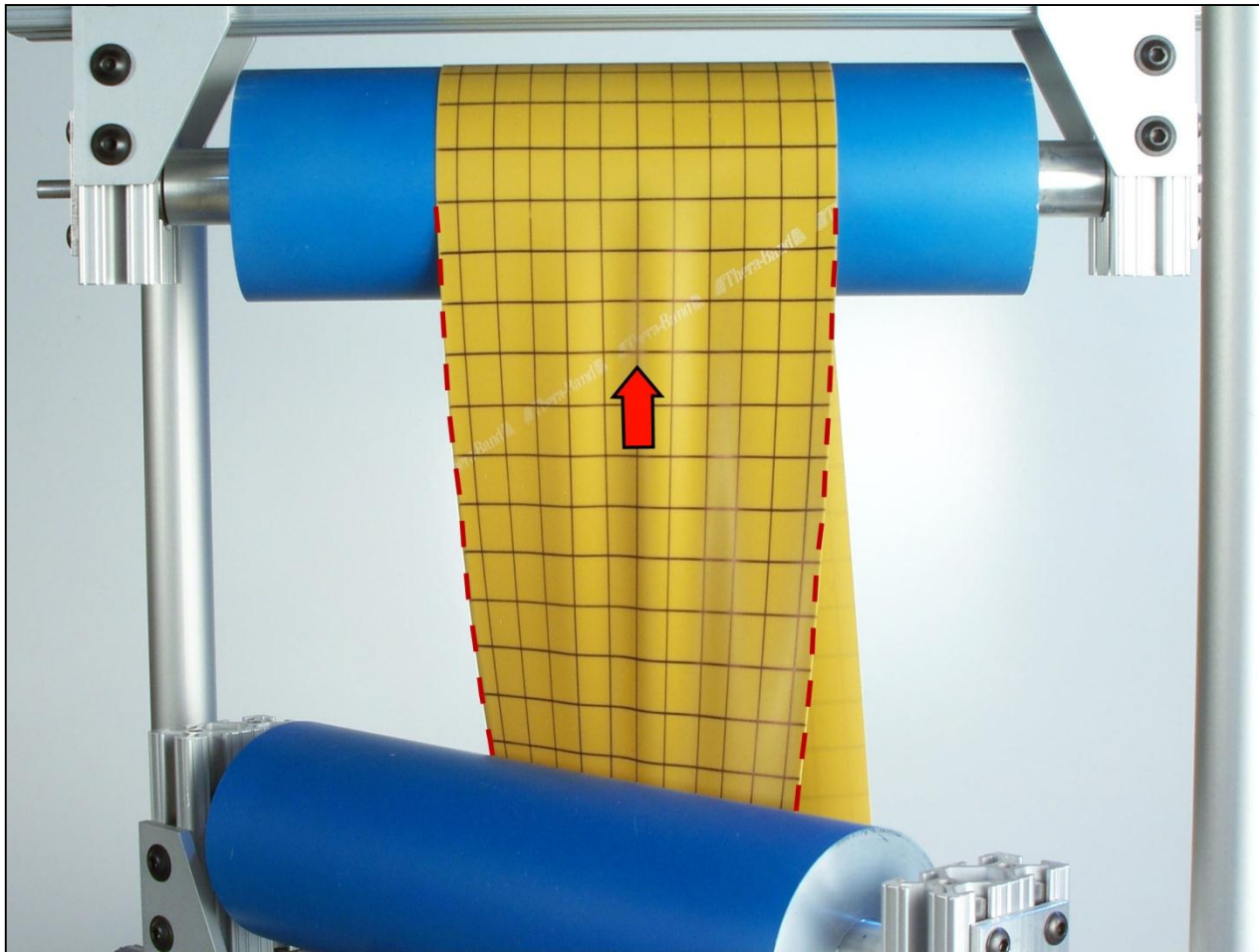
Twist is an ideal case to study

- Wrinkle forms in center of web
- It's aligned with machine direction and doesn't move laterally
- Formation is easily controlled by adjusting angle of twist

Experimental setup



Deep troughs form at 45 degrees



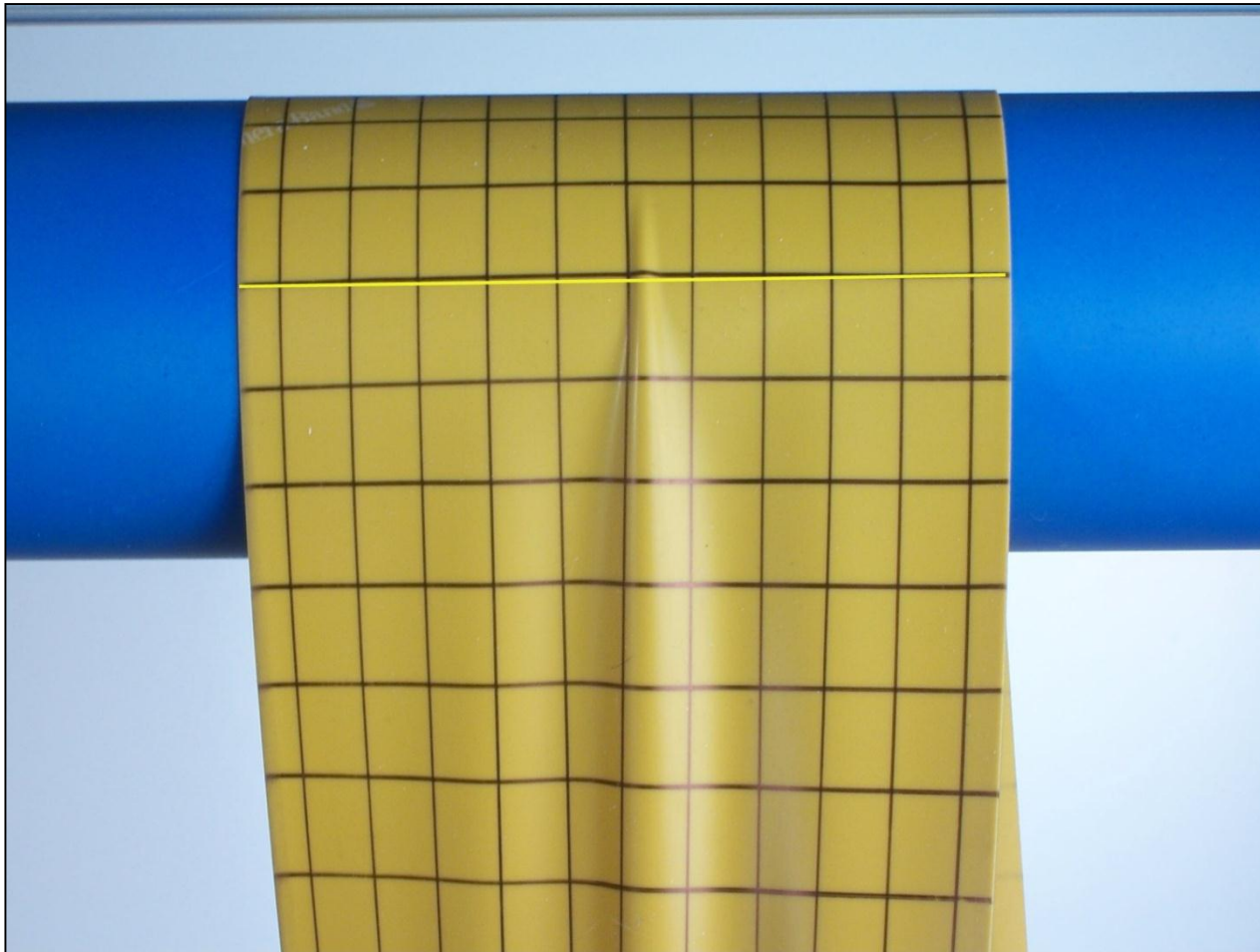
Wrinkle formation



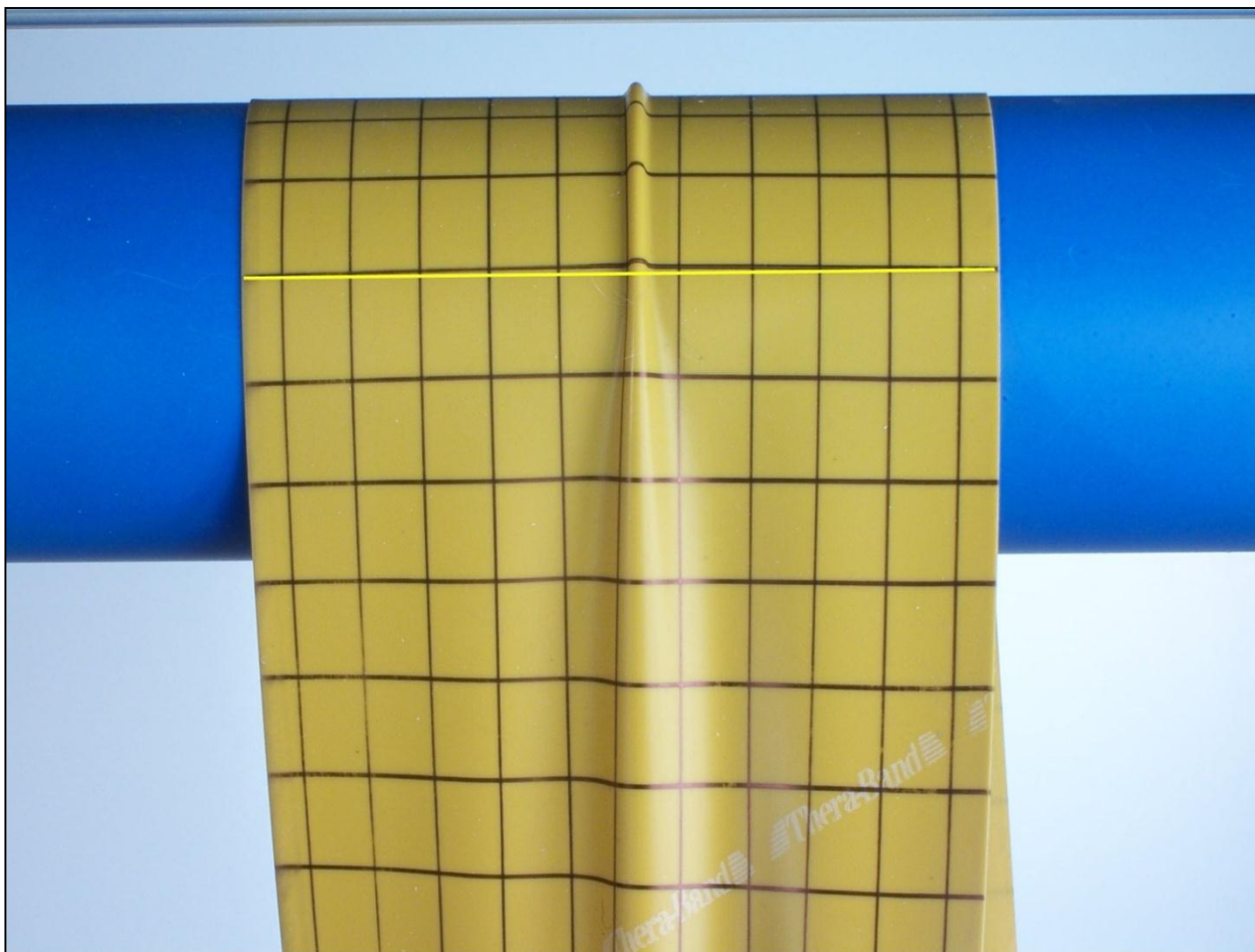
Web has advanced a few inches



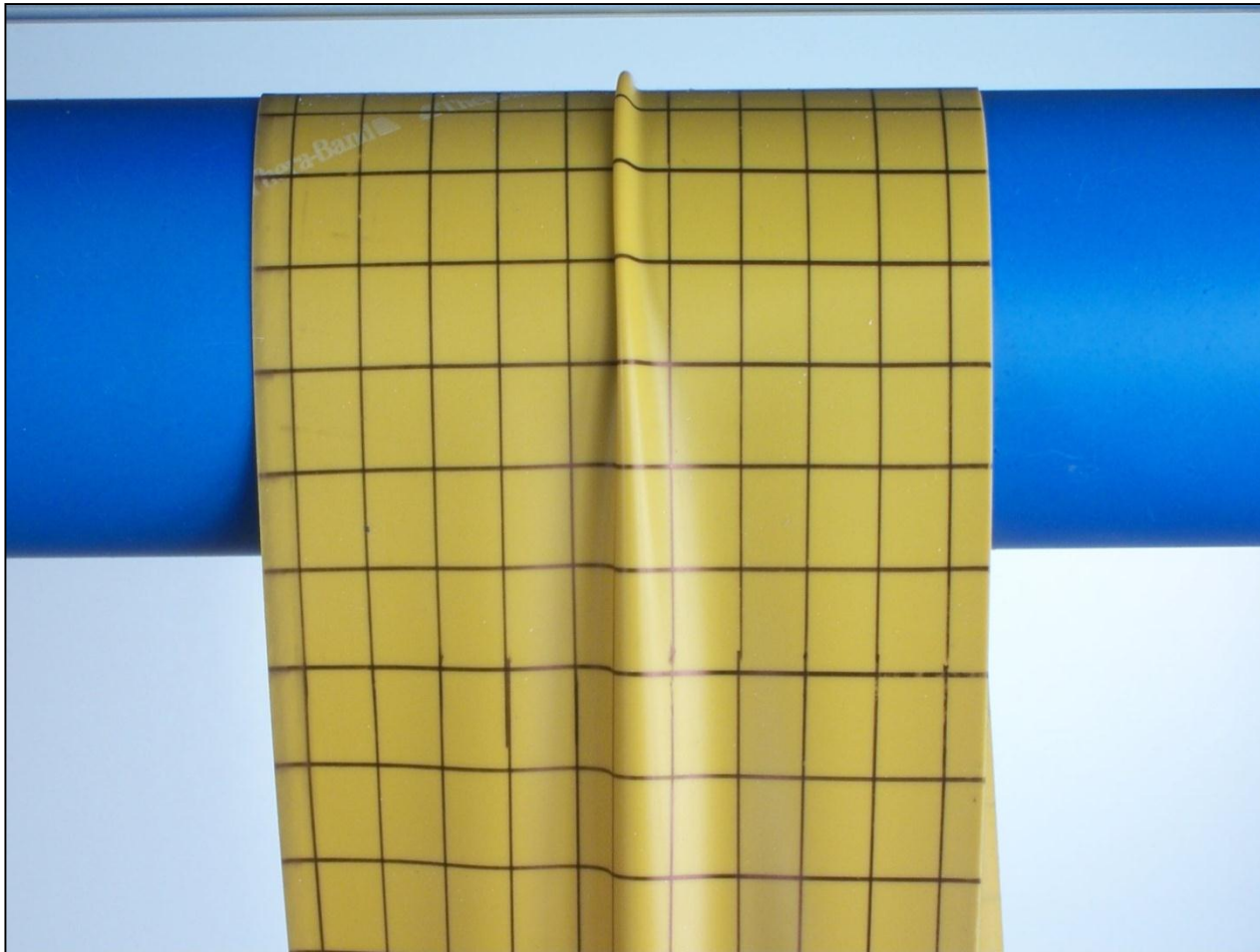
Wrinkle begins to form



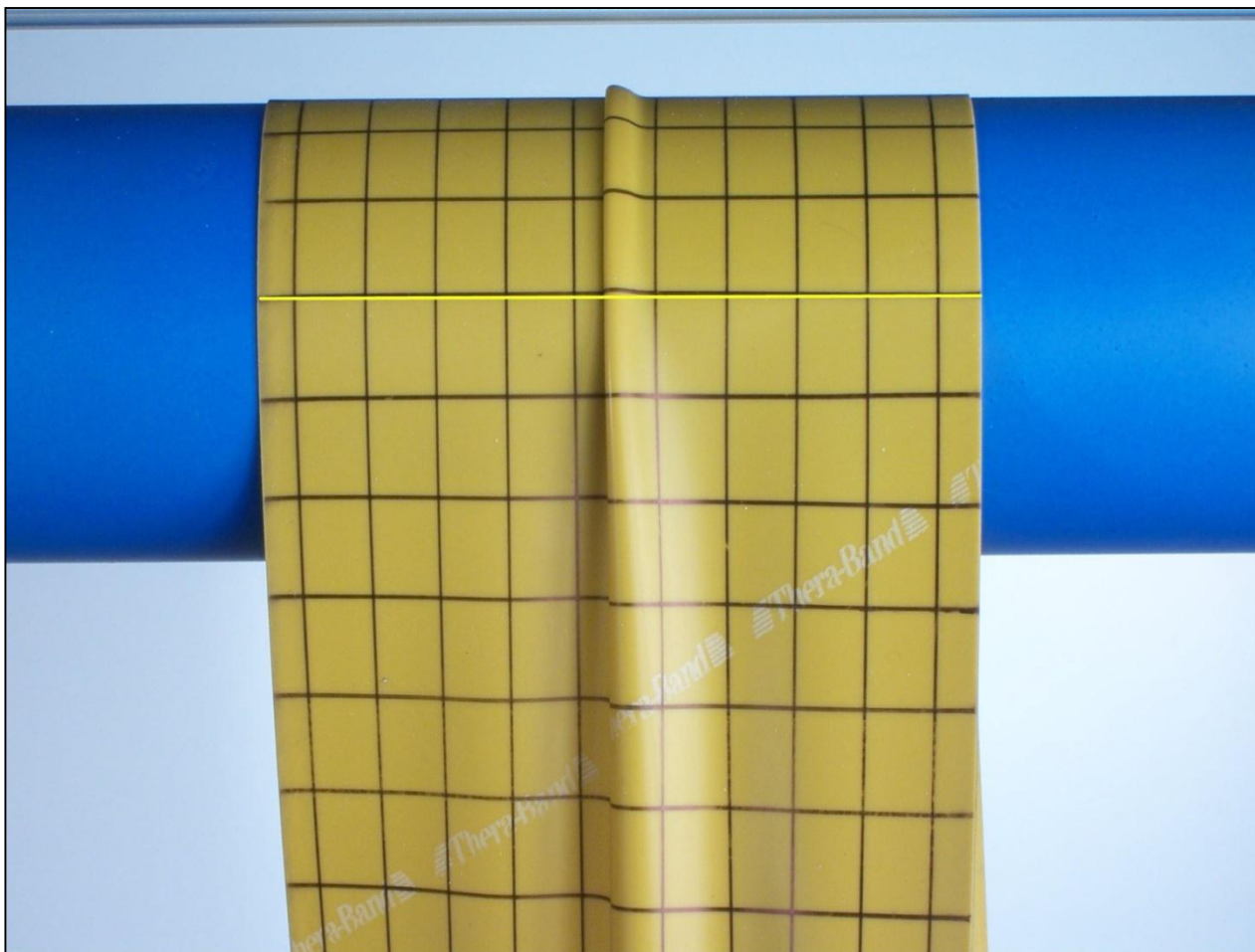
Wrinkle continues to grow



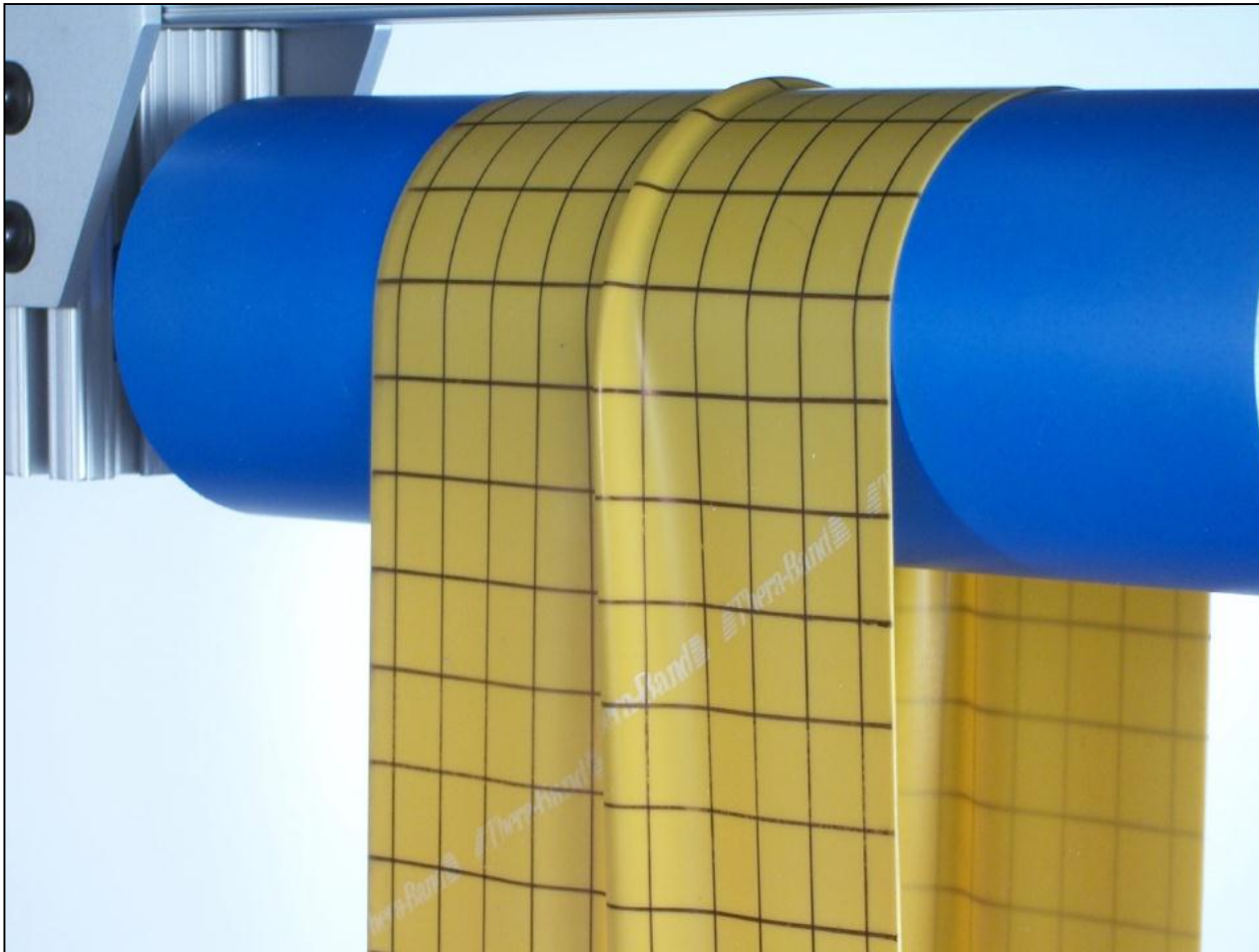
Wrinkle begins to fold



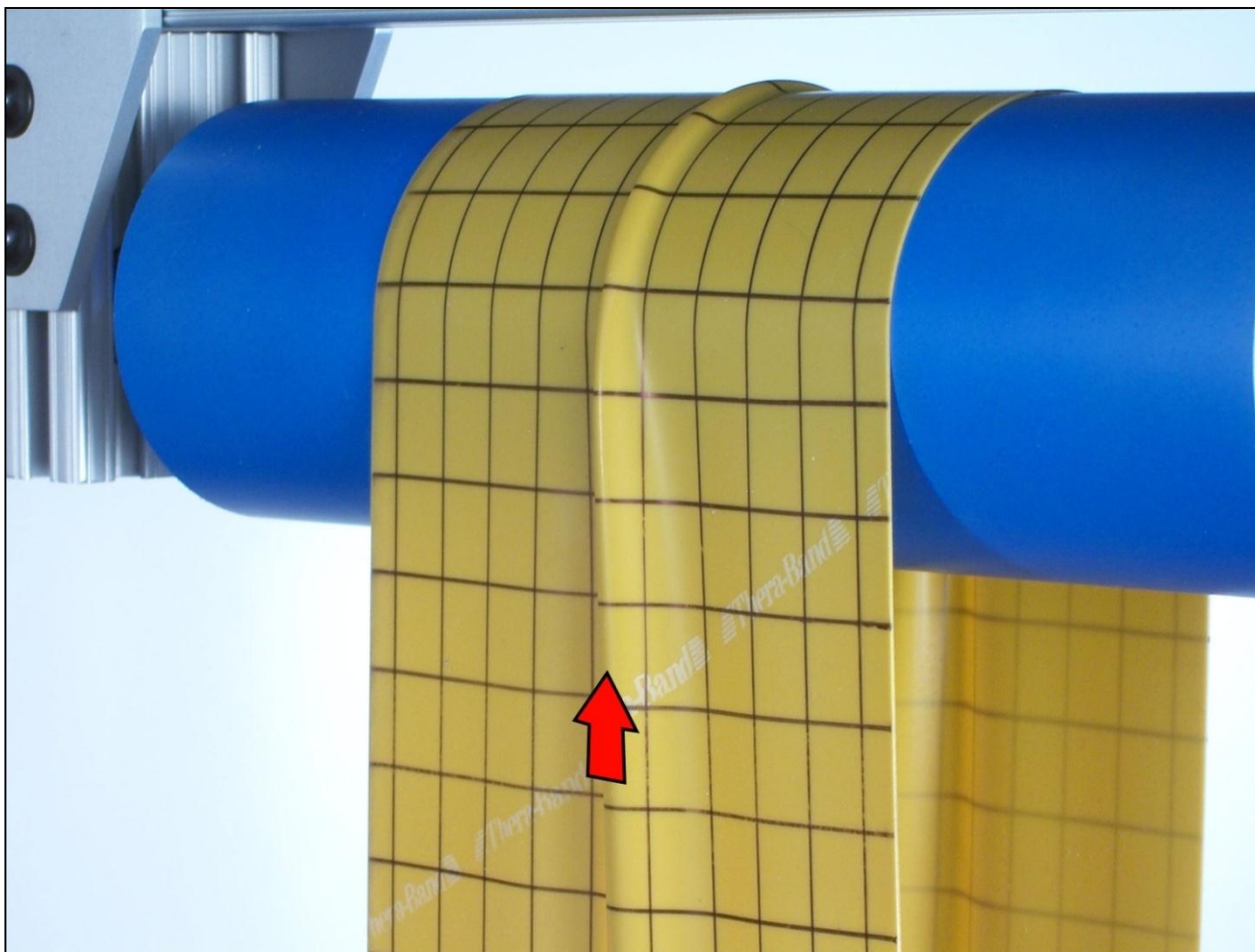
Fold continues to grow



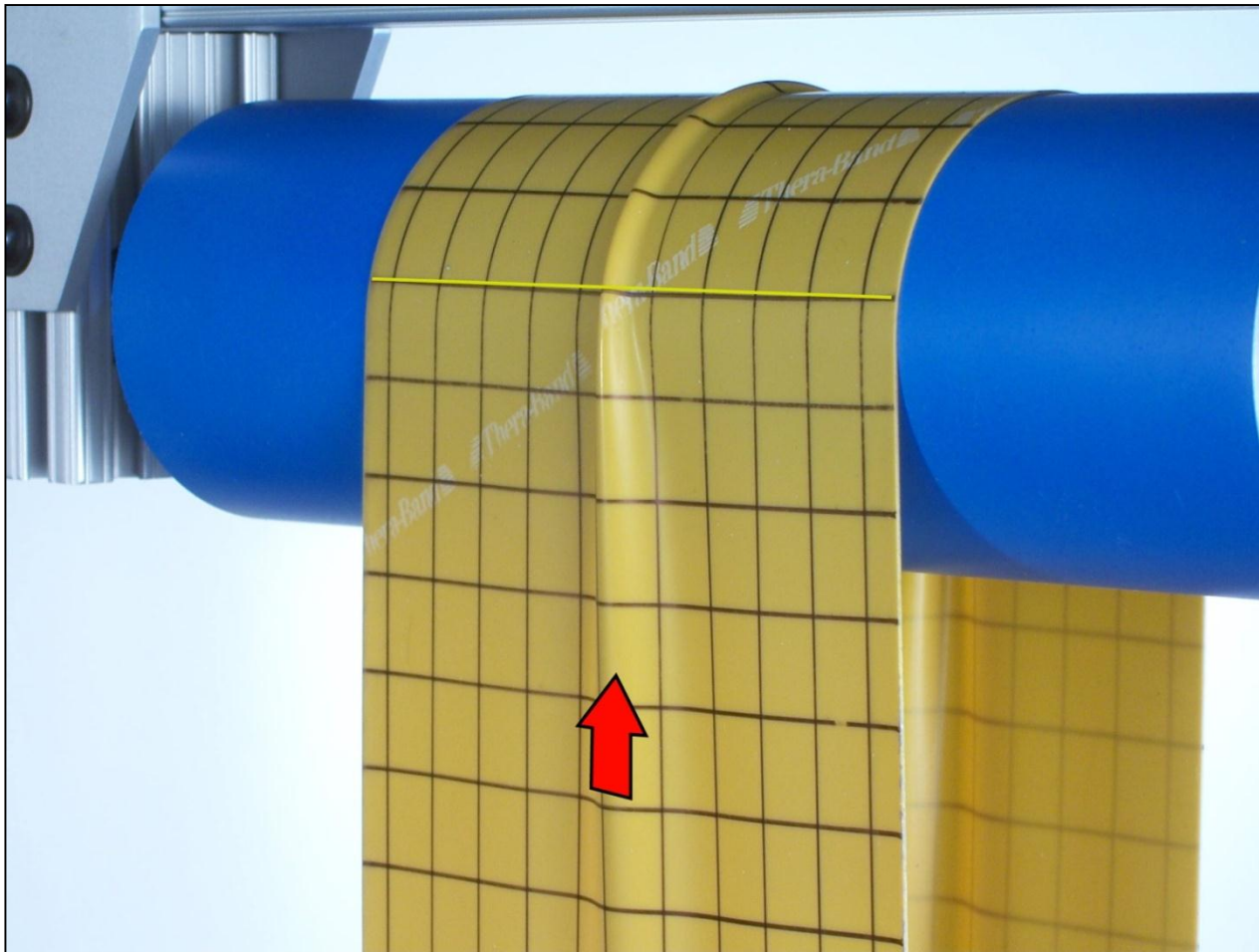
Effect of realignment



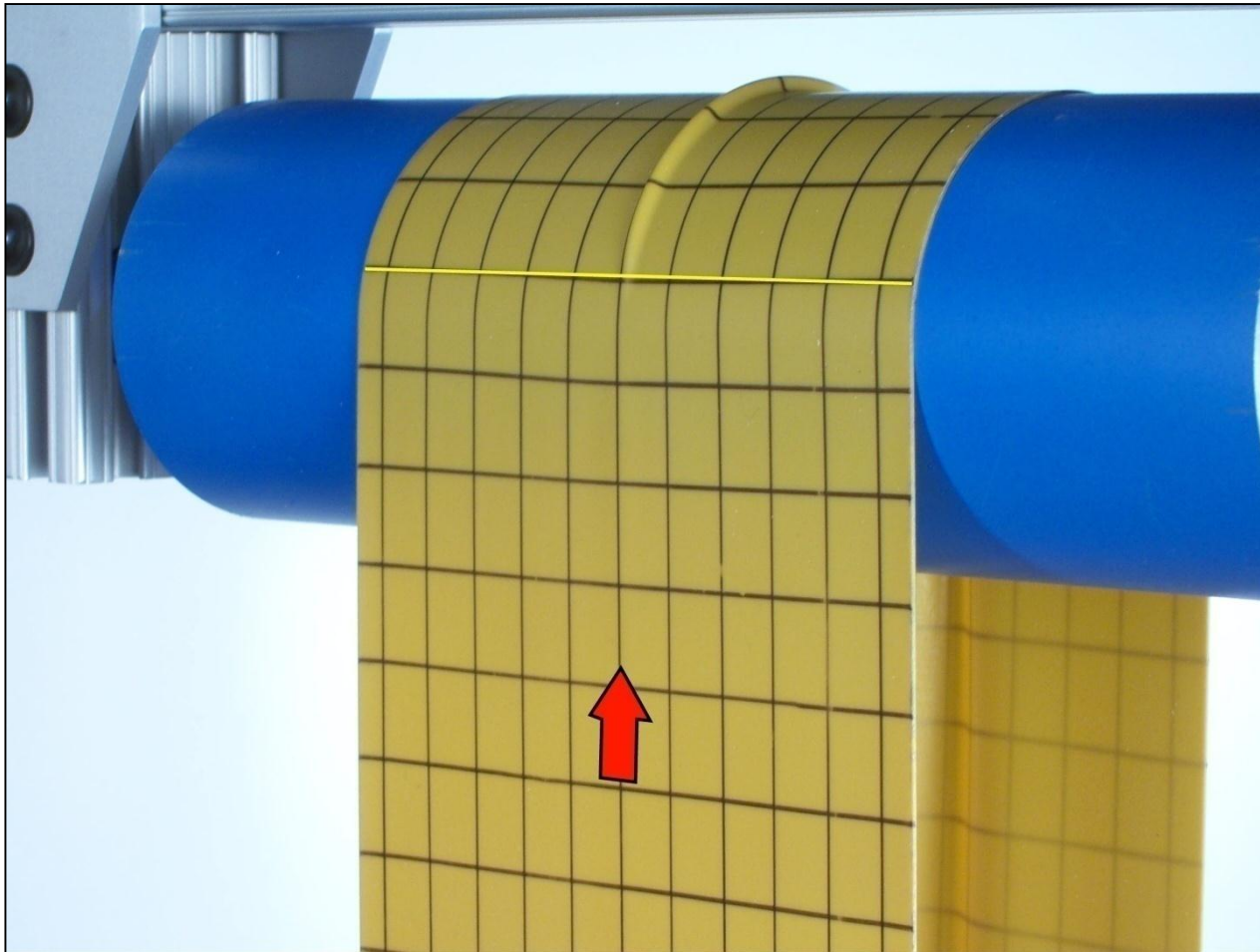
Initial realignment



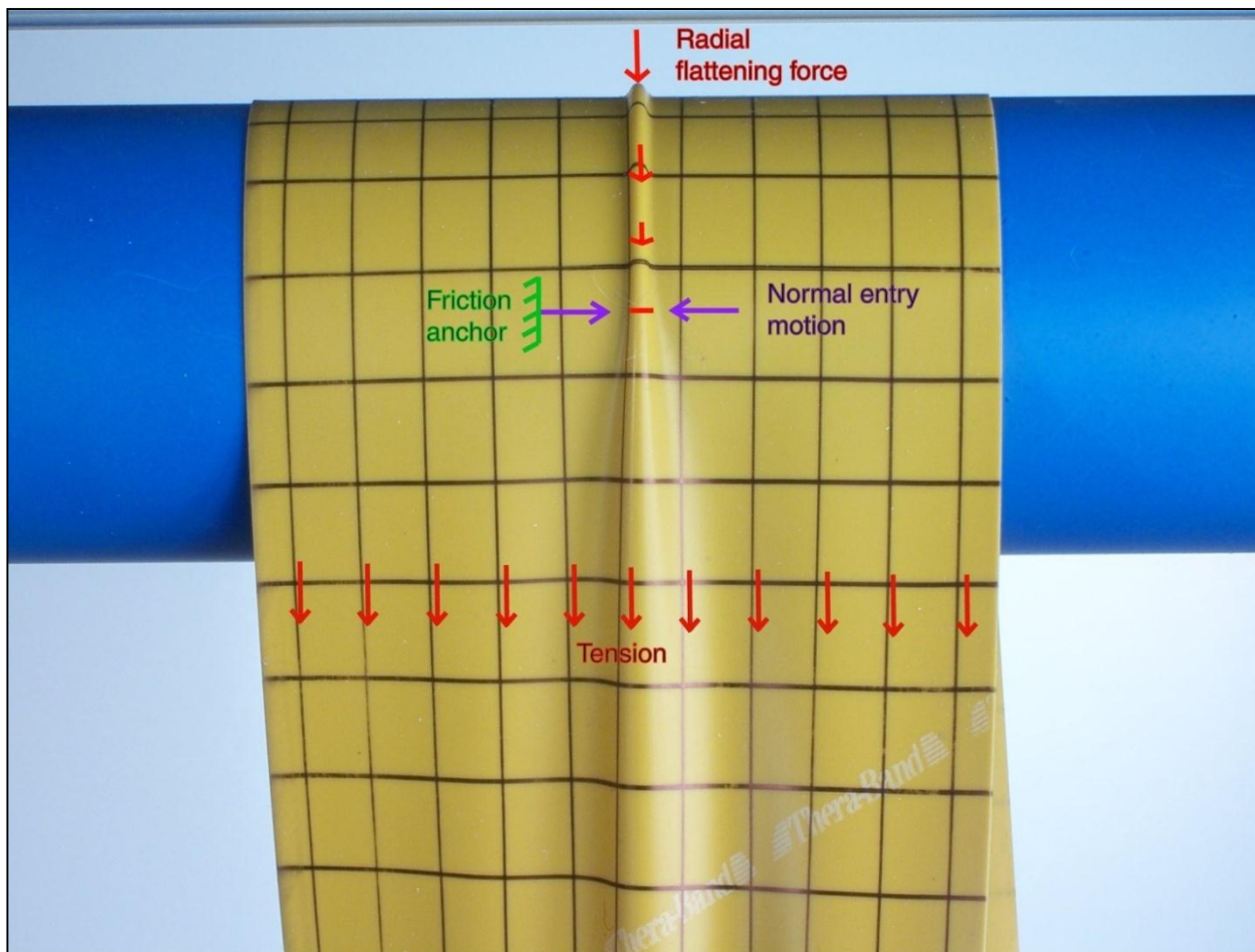
Wrinkle begins to unfold



Wrinkle almost gone



Forces acting on a wrinkle



An important conclusion

- Trough formation in the span causes the effect of the normal entry rule to amplify the compressive stress on the roller above the level that would exist in the span without the trough.

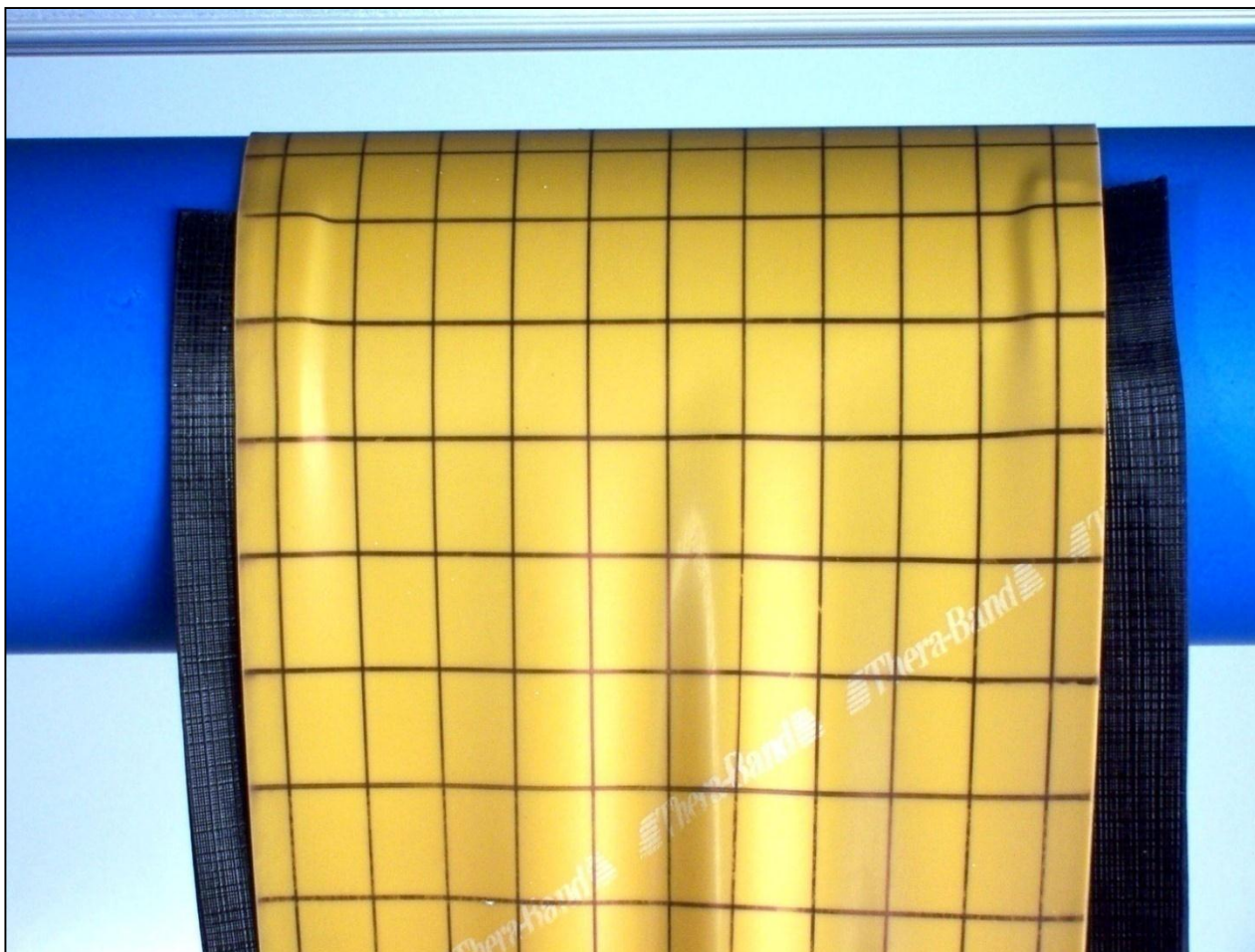
It goes this way

- Formation of a wrinkle on a roller is preceded by formation of troughs in the span.
- Movement of trough material into the space above and below the plane of the span causes the web to gather laterally upstream of the line of entry onto the roller.
- As the web gets closer to the roller, it flattens out. The normal entry rule requires the paths of web particles to be normal to the roller axis. The only way this can happen is for the web on the roller to be compressed enough to match the “effective” width of the troughed web in the span.

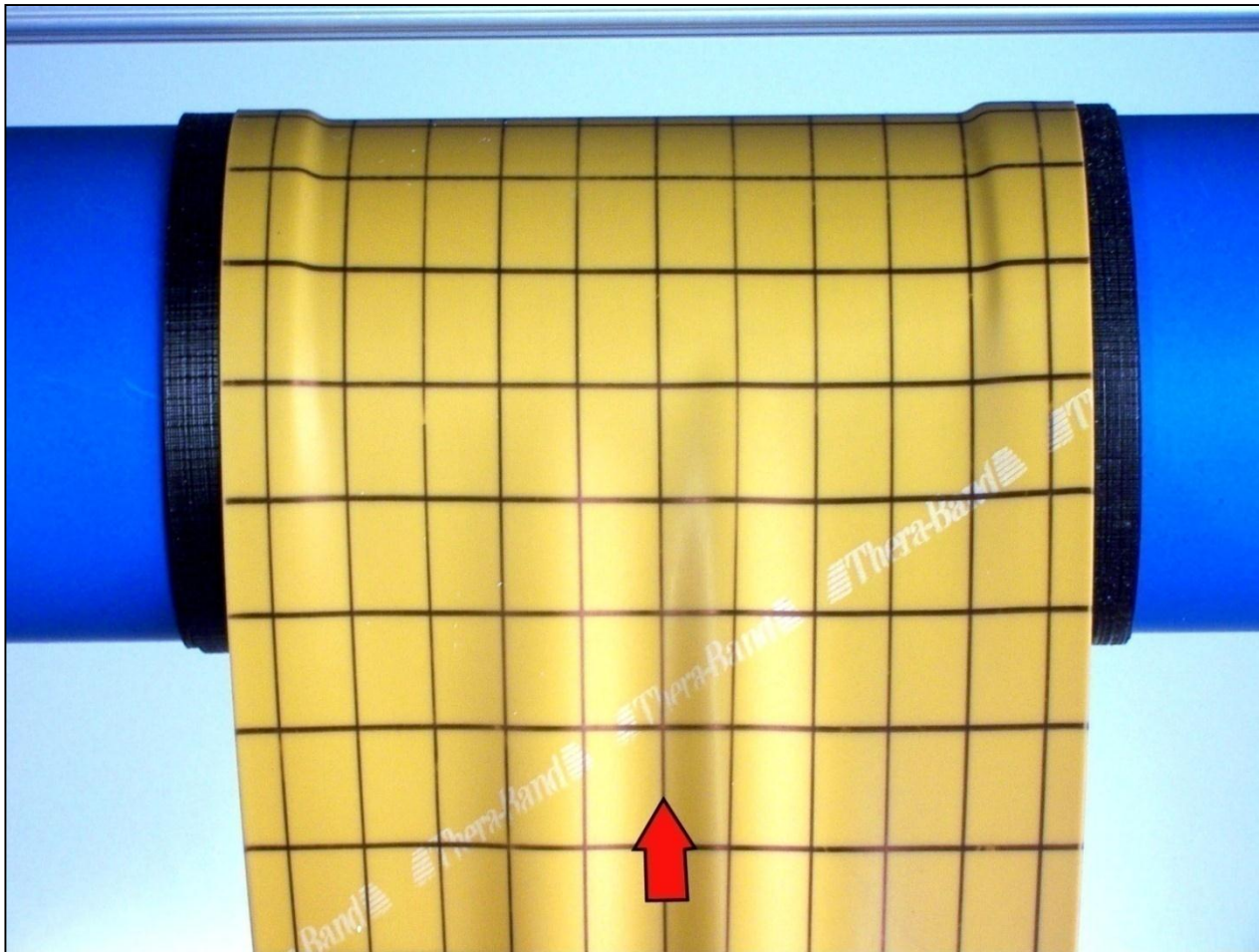
Eliminating wrinkles

- Counteract the effect of normal entry motion on the roller itself – concave or tape bumpers.
- Put a spreading device such as a concave or bowed roller upstream to eliminate or reduce troughs.
- Defeat wrinkle formation by reducing traction on the roller so that radial forces can keep the web flat.

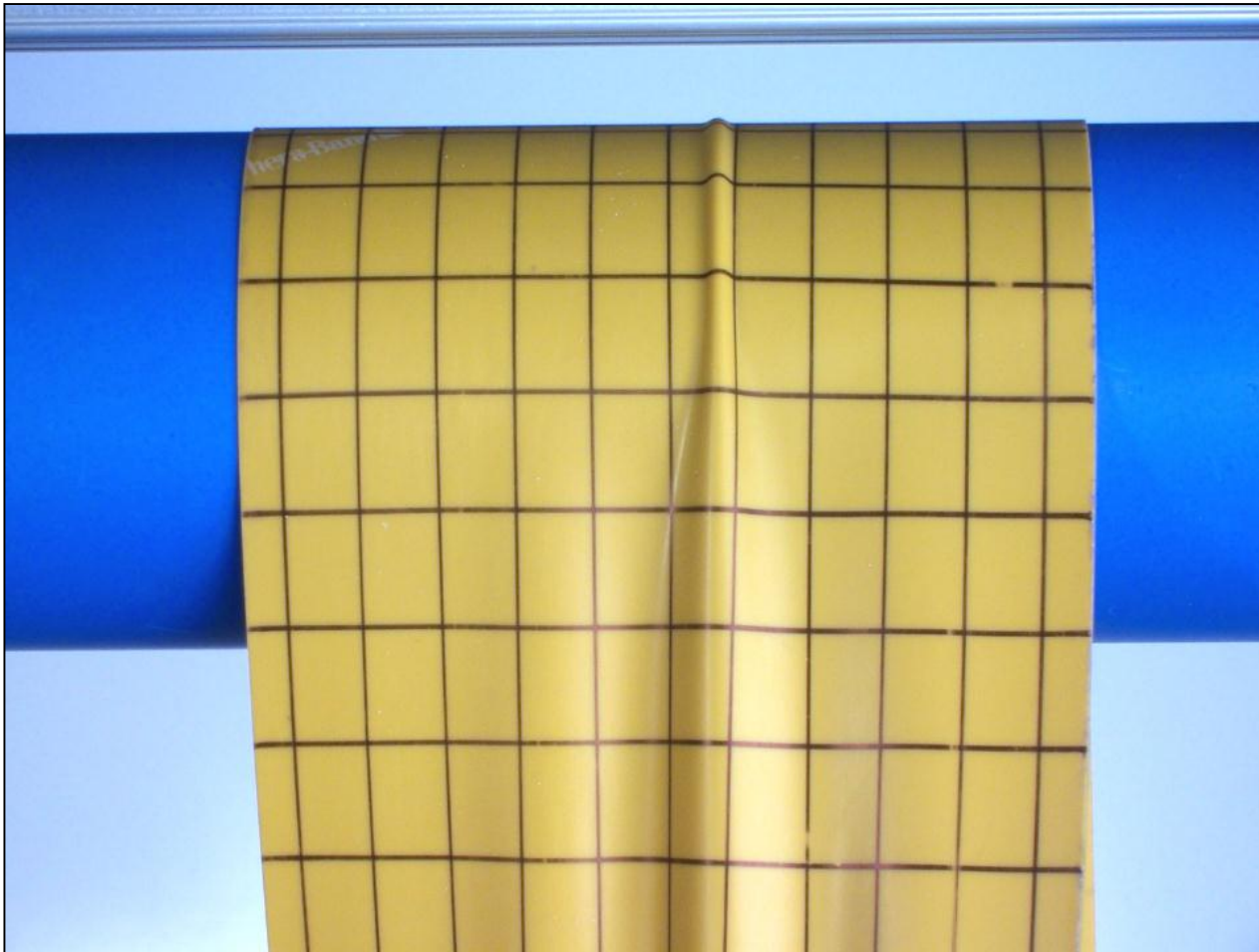
Application of tape bumpers



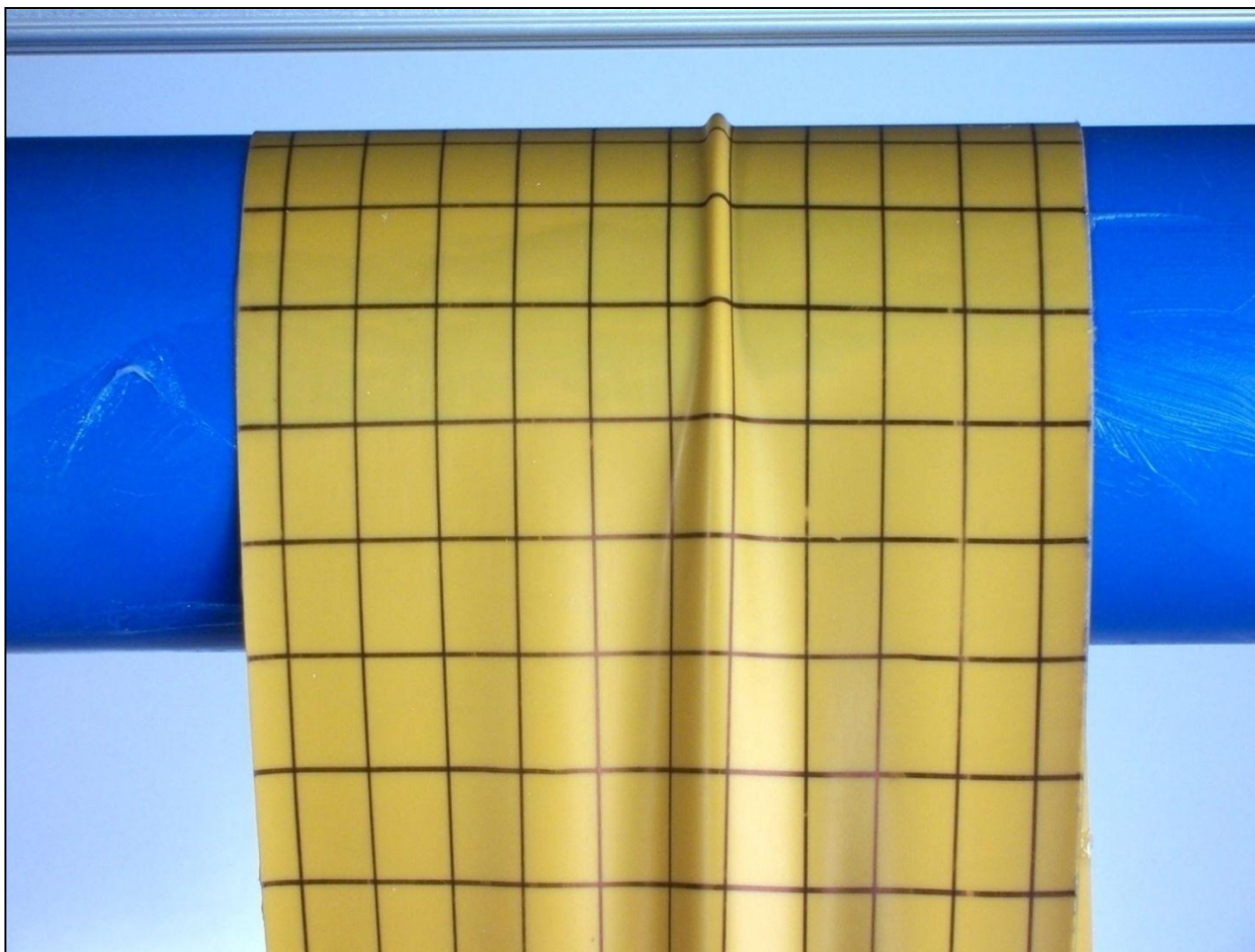
Concave roller – tape bumpers



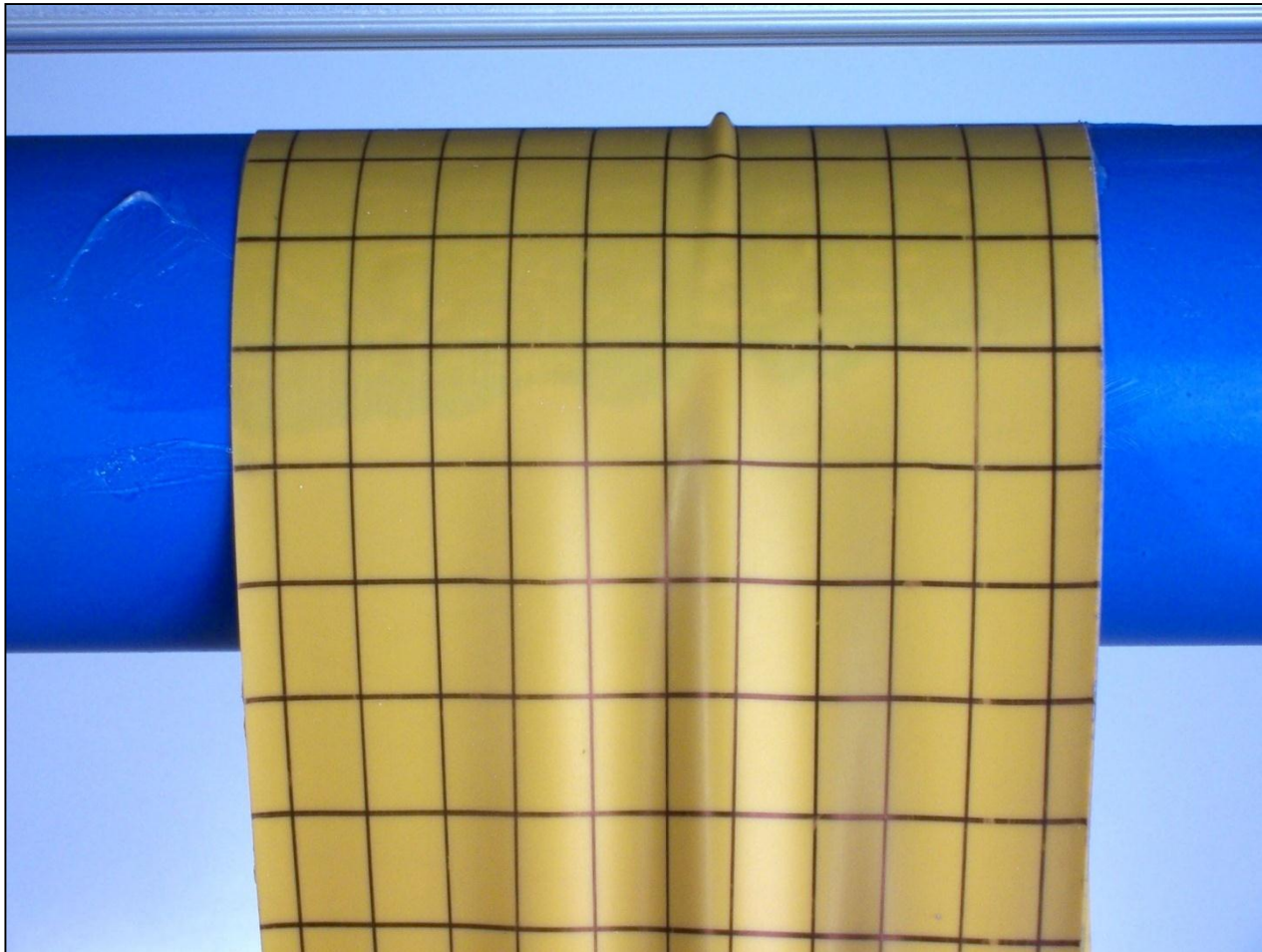
Elimination of traction



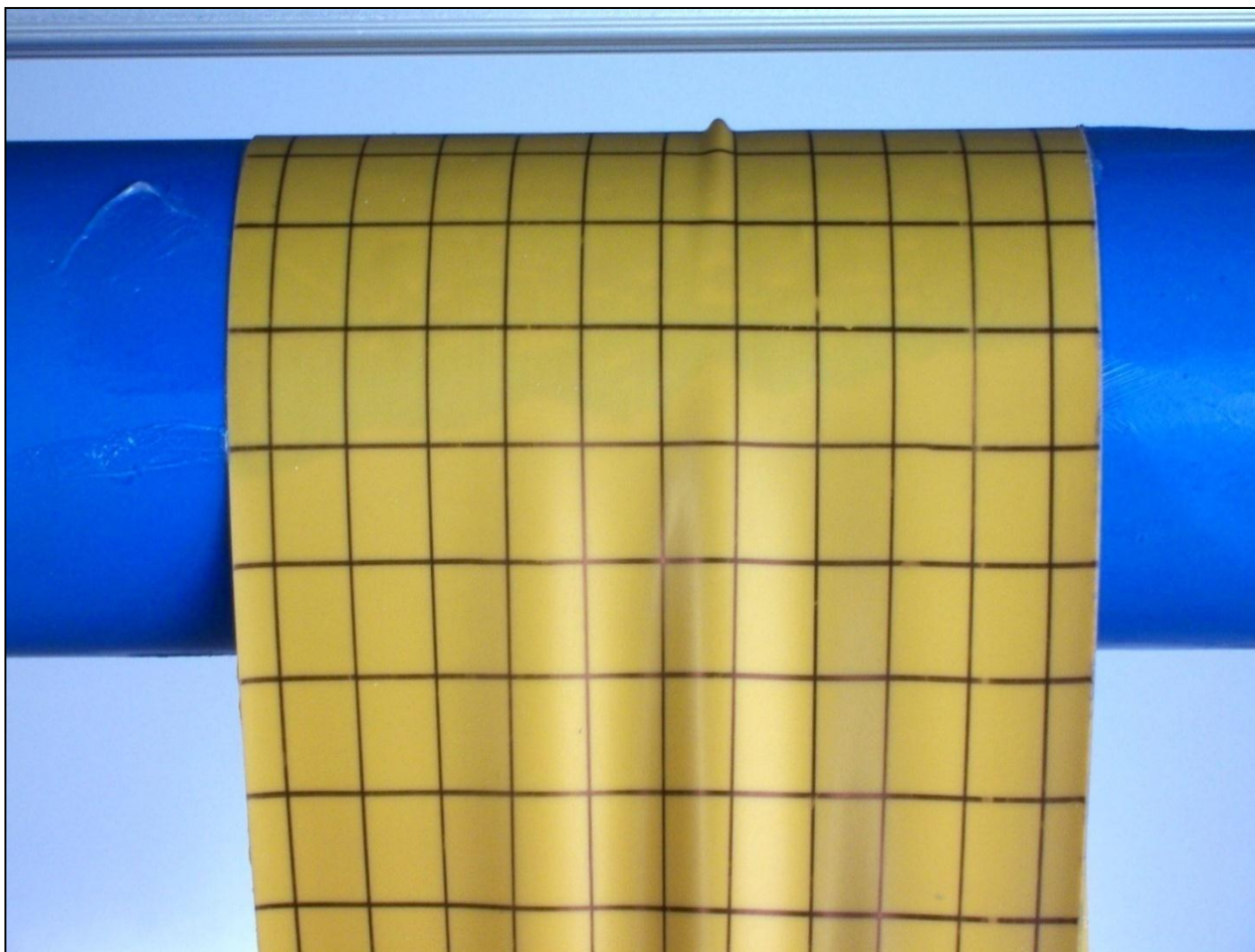
Initial wrinkle



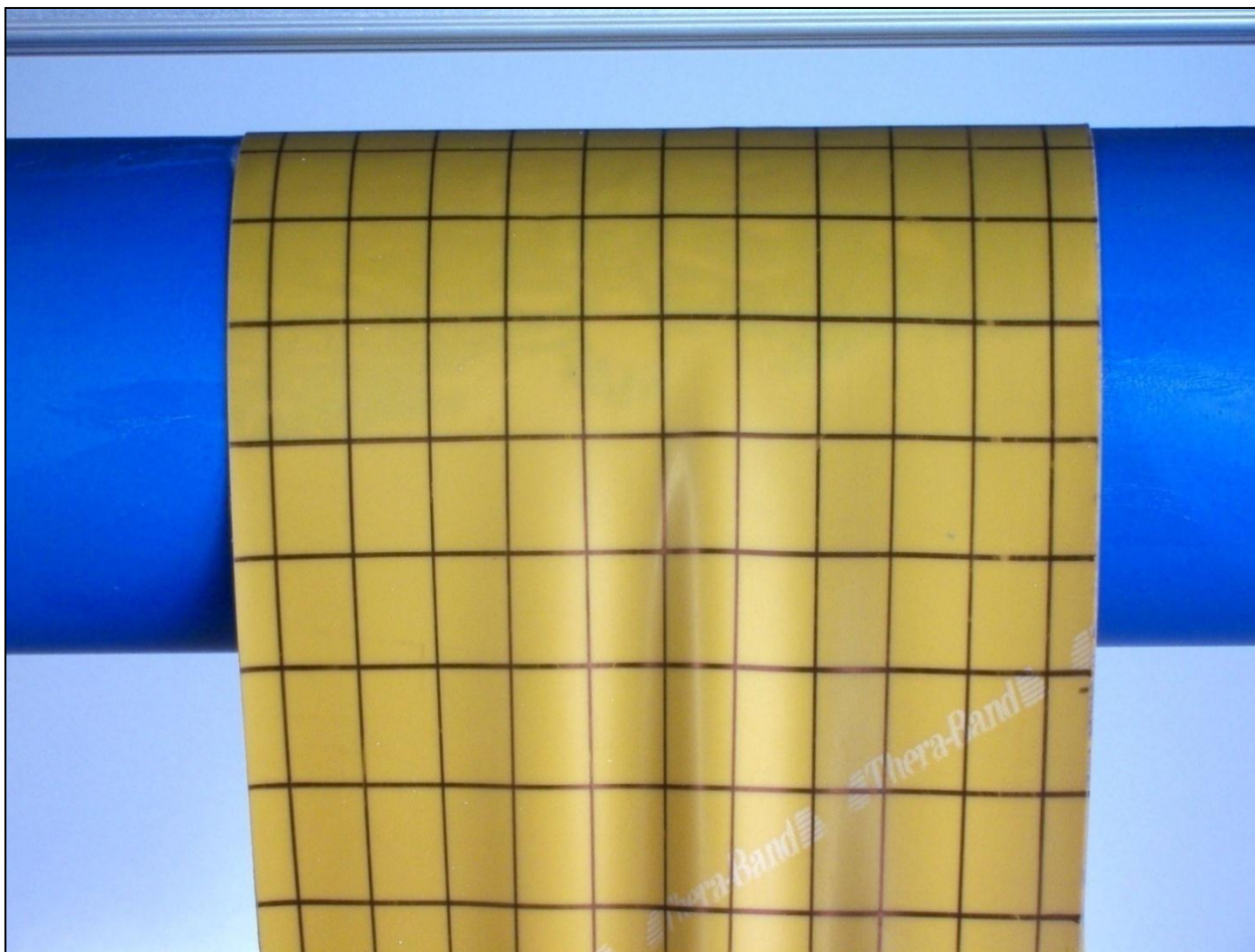
Wrinkle beginning to flatten



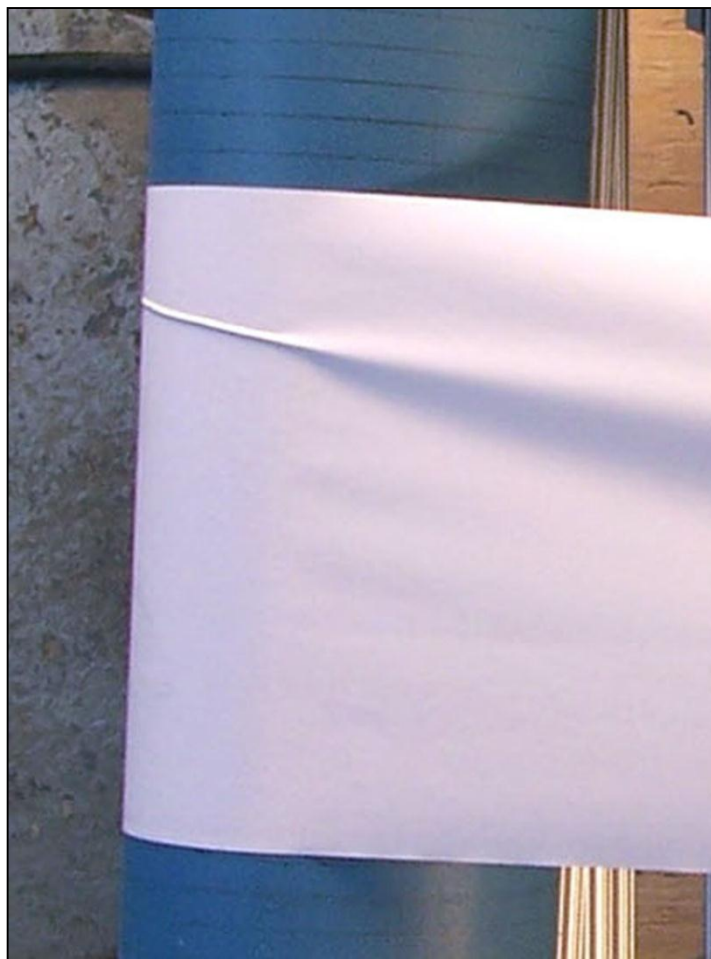
Wrinkle almost gone



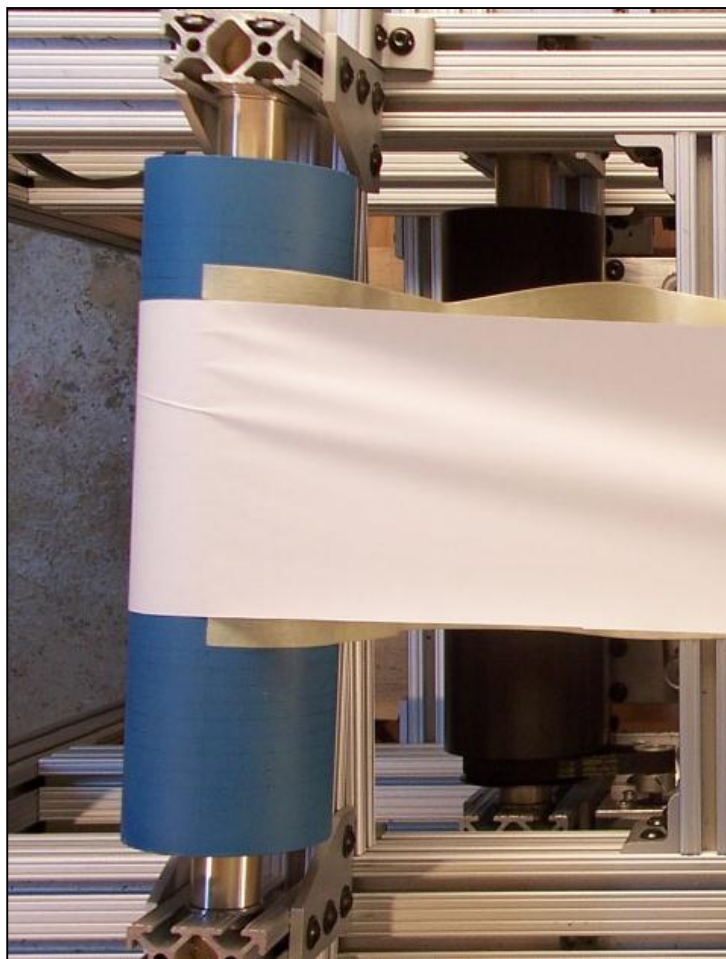
Wrinkle gone



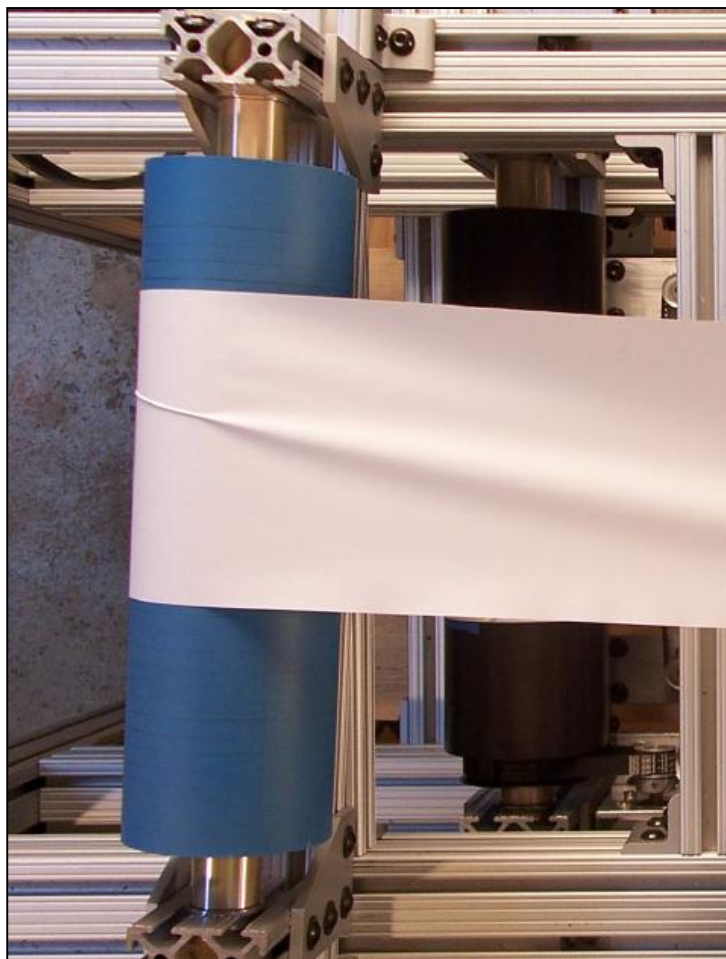
Wrinkle in paper web



Masking tape - 5 mils



Scotch tape – 2 mils





QUESTIONS?

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