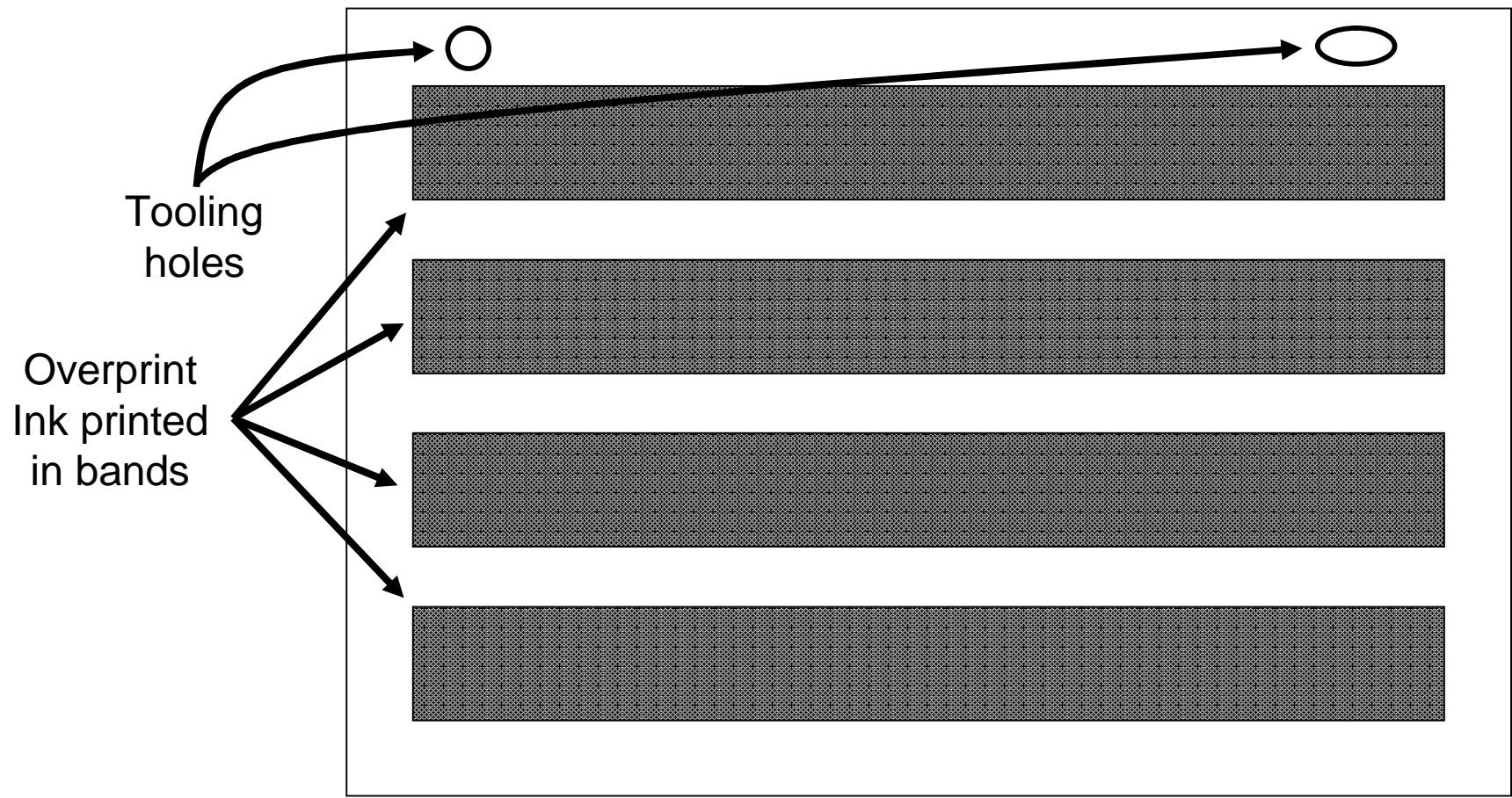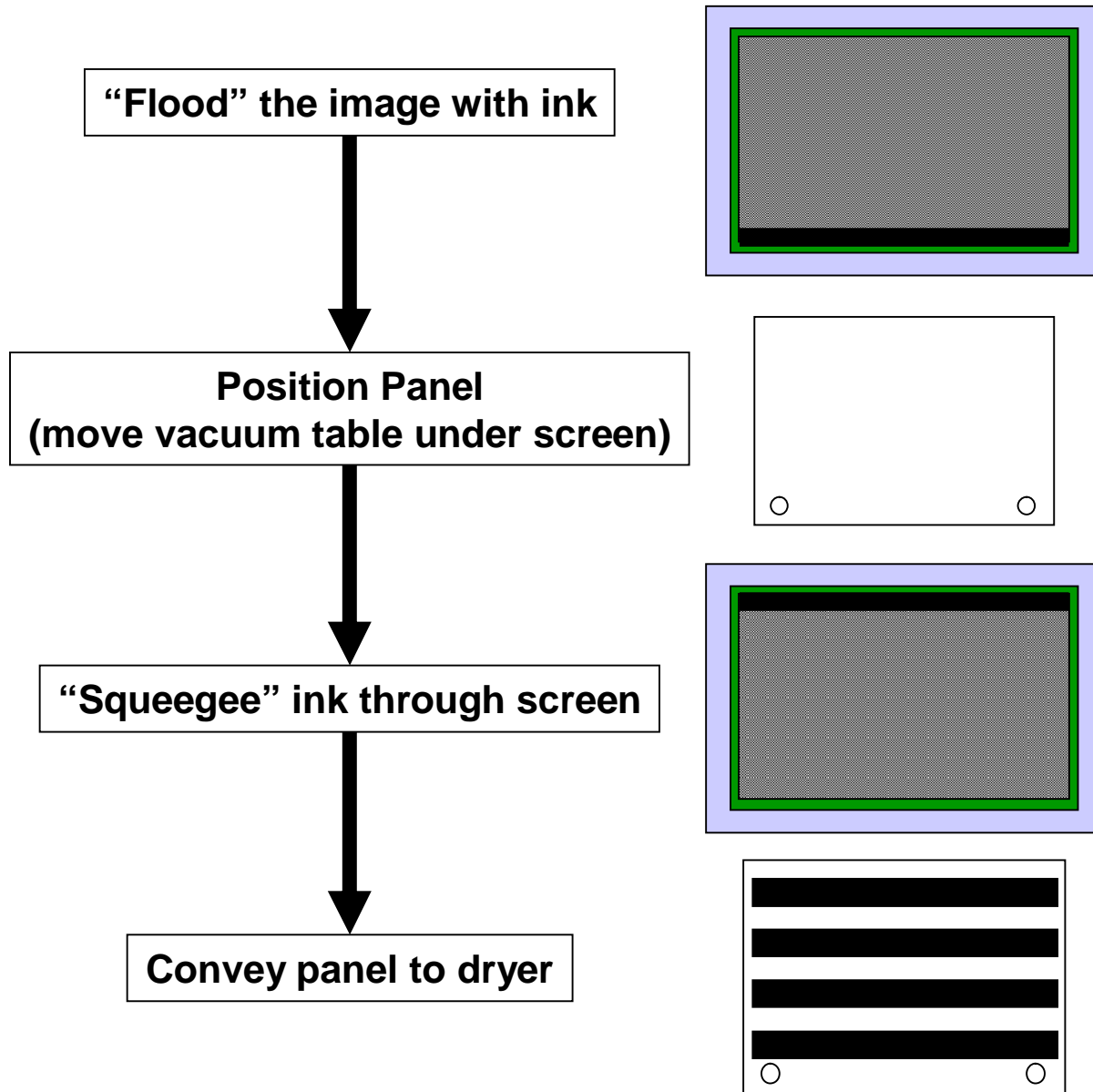# Case Study: "V" Flow Lines

- Color ink screen printed on lamp panels to change the color of the EL light ("overprint")

- Some panels get a defect in a "V" pattern that is usually not a functional defect, **but customers do not like it**

- Panels with the V defect must be reworked by removing ink with solvent – time consuming and unsafe

# "V" Defects – Part Schematic

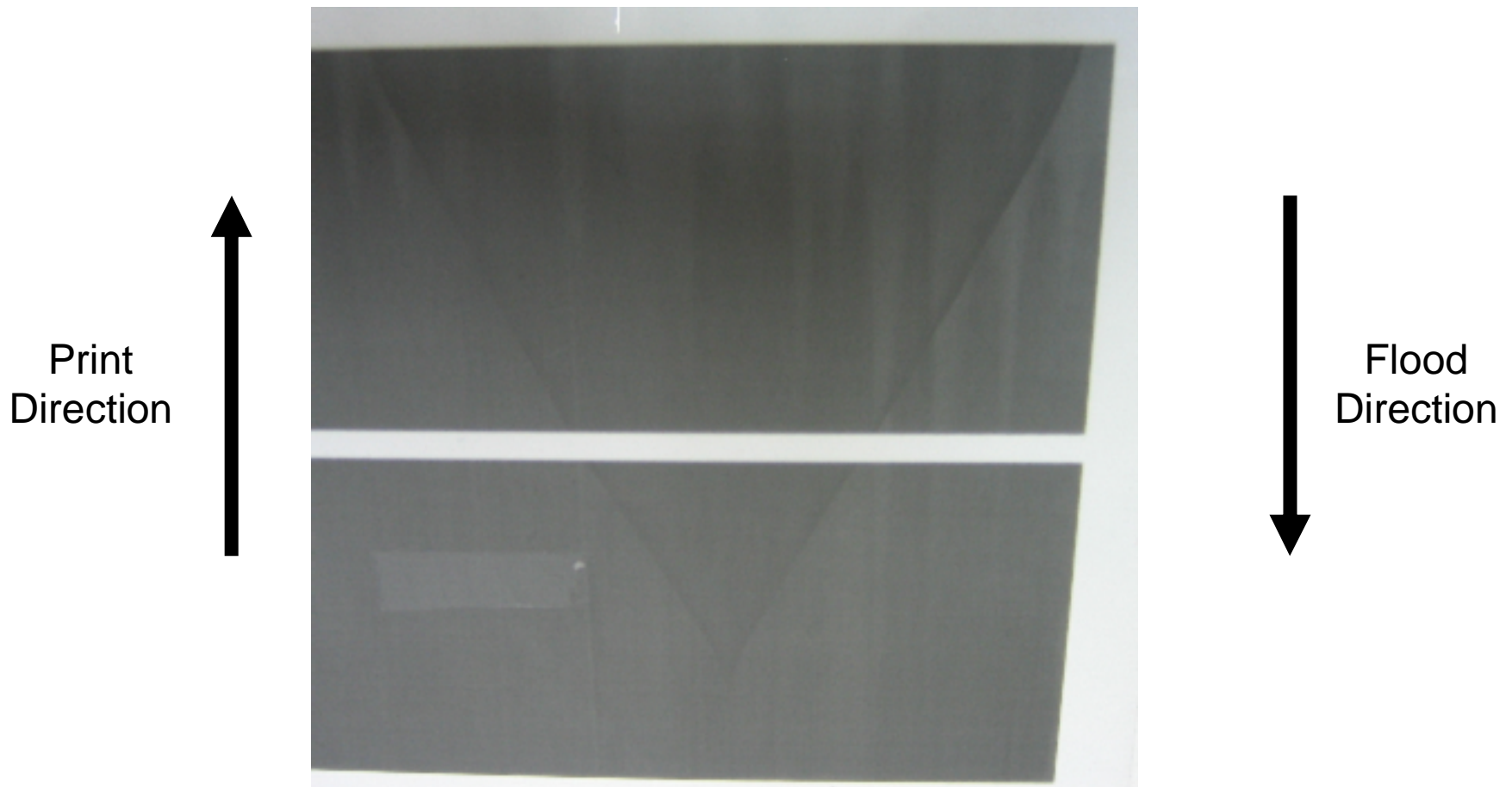- Panel screen-printed with color ink, typically in rectangular patterns:

Tooling holes

Overprint Ink printed in bands

# Process Flow Diagram

**"Flood" the image with ink**

**Position Panel
(move vacuum table under screen)**

**"Squeegee" ink through screen**
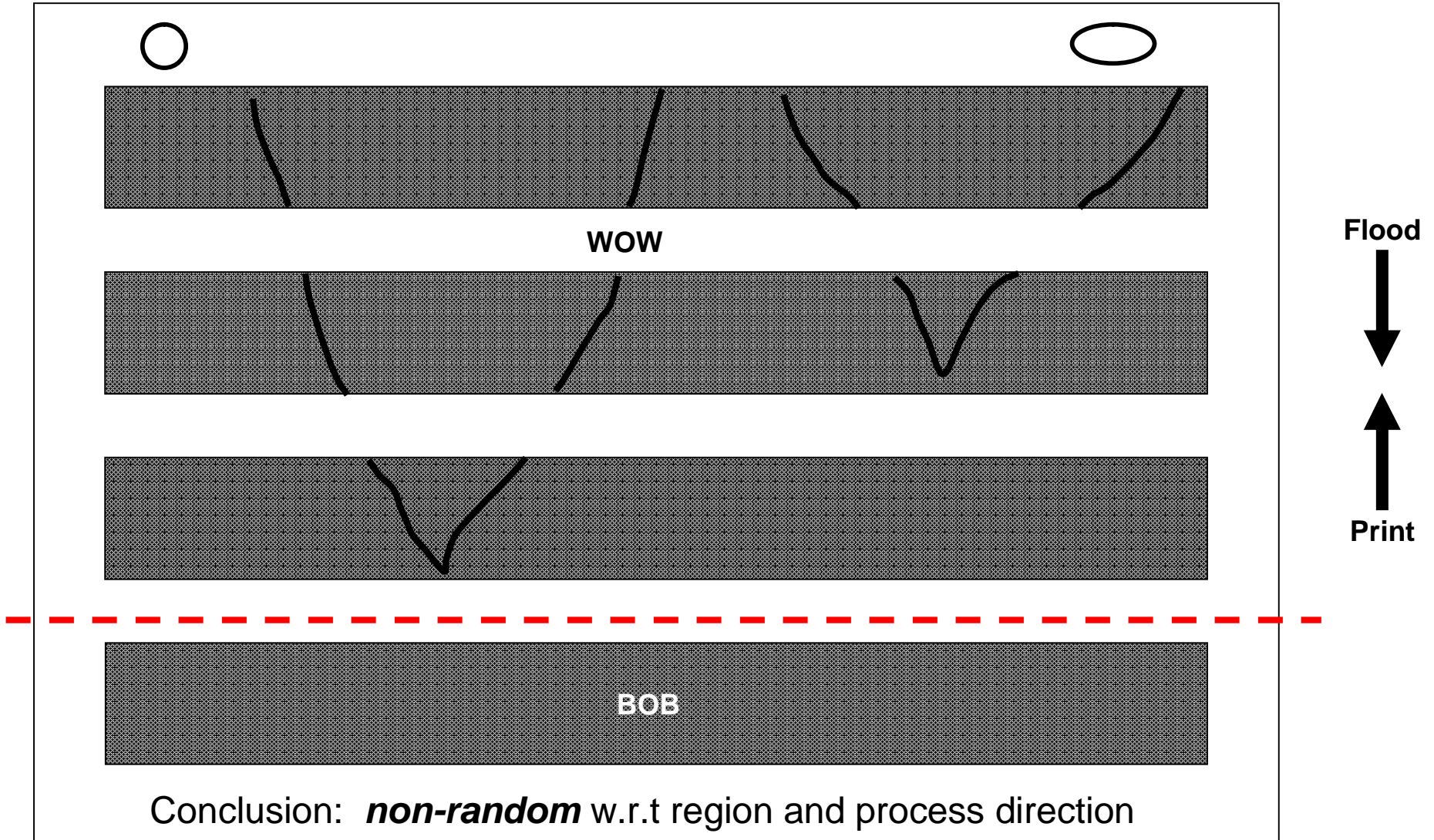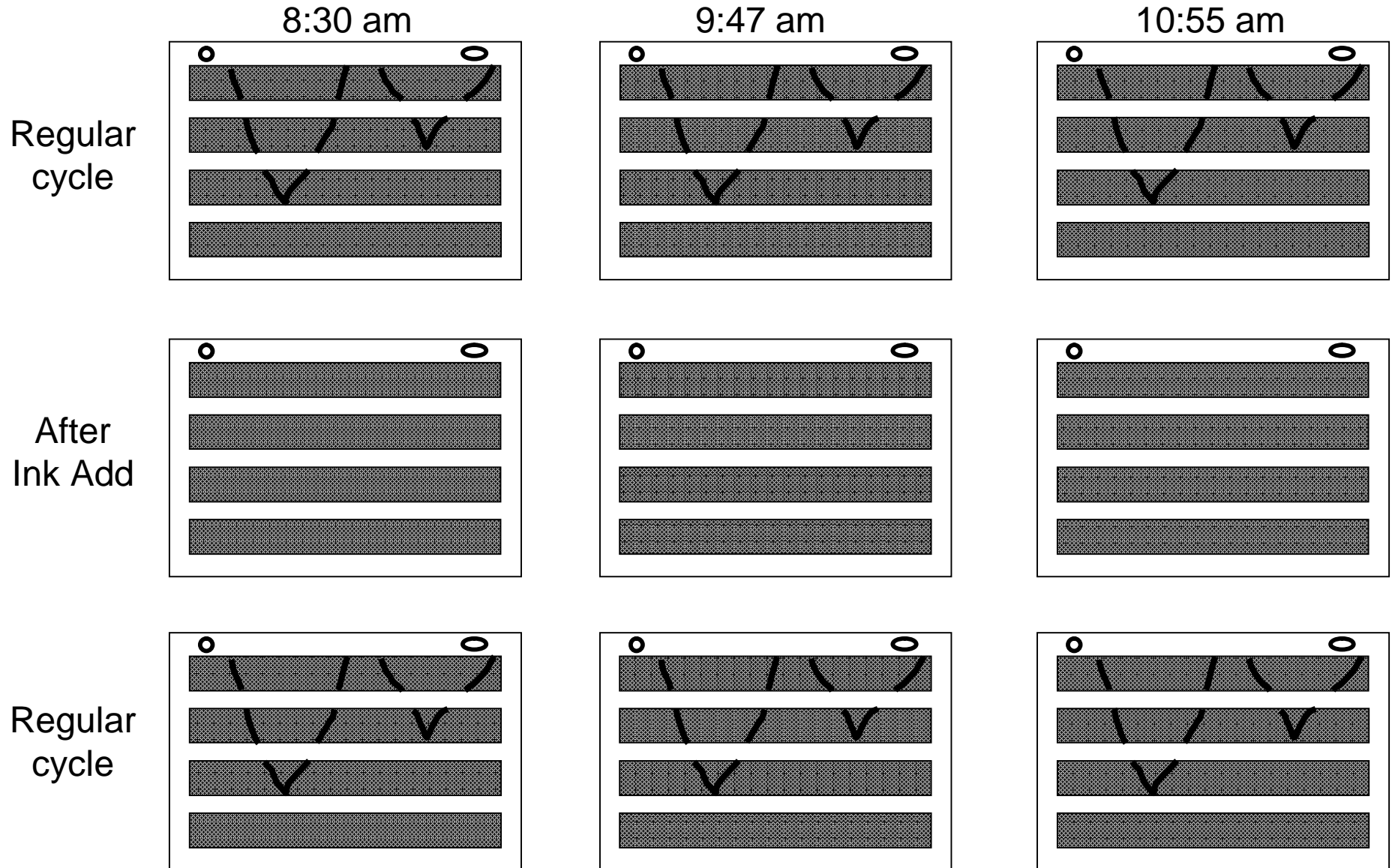
**Convey panel to dryer**

# V Flow Line Defect

- Obvious pattern seen in the printed ink – unsightly from a customer perspective
- The defect appears to align with one of the process directions

Print Direction

Flood Direction

# V Defect – Concentration Diagram



WOW

BOB

Flood

Print

Conclusion:  *non-random* w.r.t region and process direction

# V Defect – Concentration Diagram

|  | 8:30 am | 9:47 am | 10:55 am |



Conclusion: ***non-random*** with respect to a process event.

# V Flow Line – Strategy Diagram

**Flood**

**Print**

WOW

BOB

WOW
25% Rework

BOB
1% Rework

BOB | WOW | BOB

| BOB Point – WOW Point (WOW Region) |

| BOB Region – WOW Region (WOW Panel) |

| BOB Panel – WOW Panel (WOW Group) |

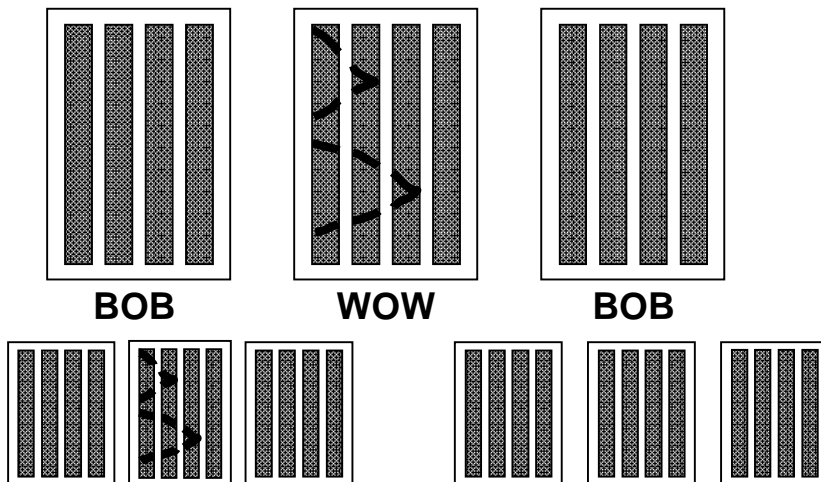| BOB Group – WOW Group (WOW Run) |

| BOB Run – WOW Run |

Notes

**Large contrast**: defect is isolated to a line. Good leverage relative to the process (pointed tip).

**Large contrast**: defects only on bottom edge. Good leverage (appears to follow flood).

**Good contrast**: WOW panels are few, but usually preceded by and followed by BOB panels. Good leverage (events).

**Some contrast**: slightly more defective groups at the start of the run. Small leverage.

**Some contrast**: some runs have up to 25% defects (can be reworked). WOW runs mostly with "large" artwork.

# Confirm Red X With "B vs. W" Test

- Green Y defect
  - Presence of "V pattern" flow lines
- Red X candidate
  - Time delay before flood coating screen
- B vs. W six-pack
  - W = 5 second delay before flooding
  - B = no delay
  - Printed in random order w.r.t. time
    - B, W, B, B, W, W
- Results
  - Rank ordered the results
    - Defect vs. no defect
  - All W's had V pattern flow line present
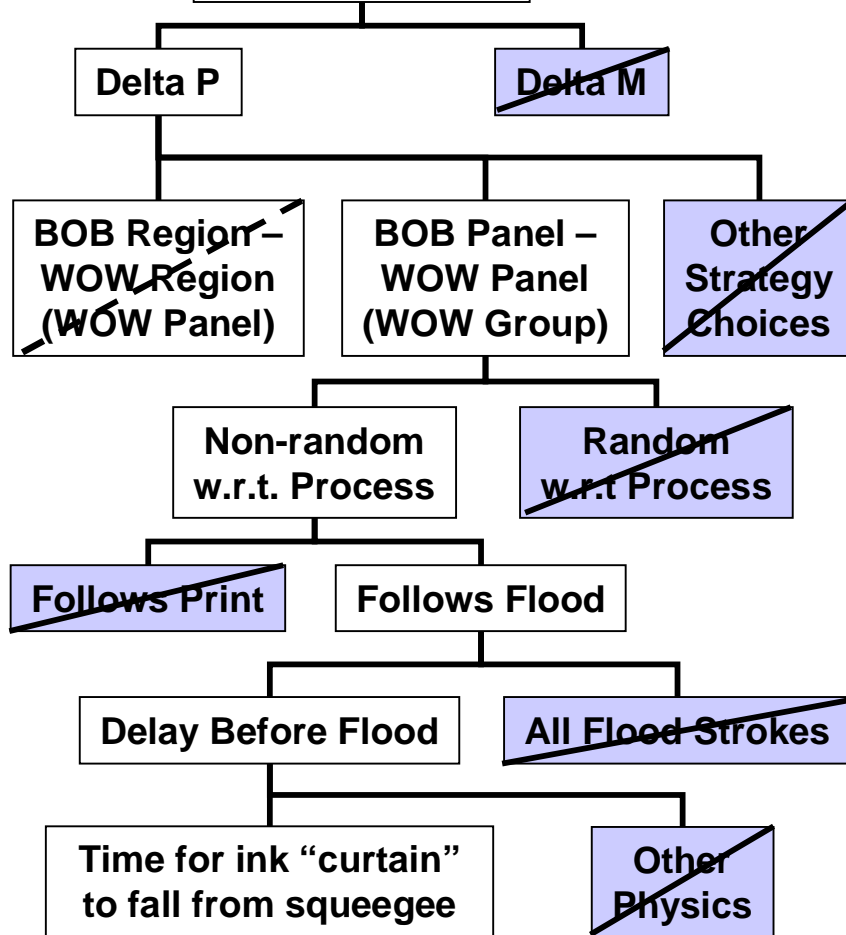  - All B's were void of the defect
- Red X confirmed at 95% confidence

B
W
B
W
B
W

Print    Flood

Panel

Printed Image

V Pattern Defect
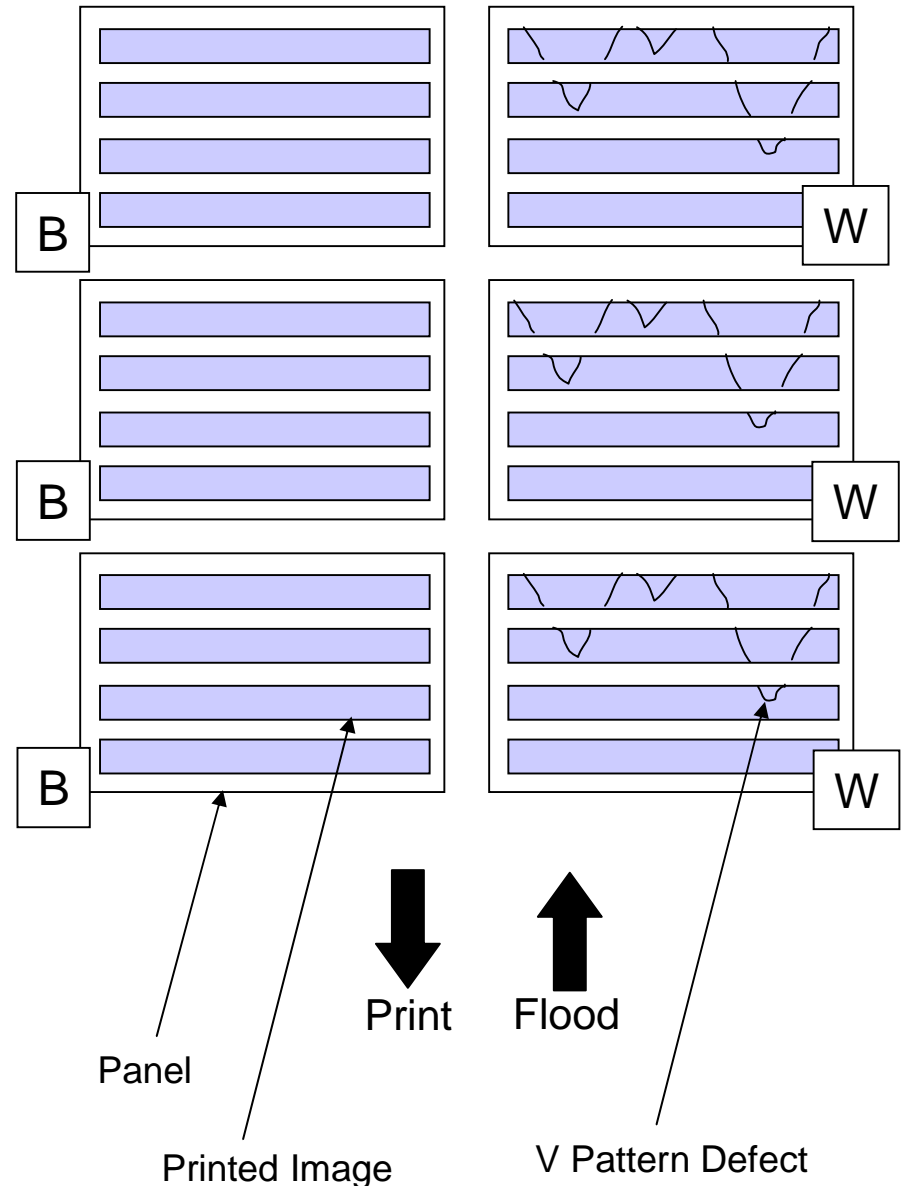
# Solution Tree for "V" Defect
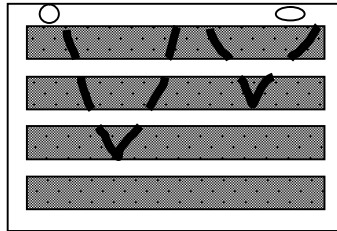
**The Green Y is the presence of V defects on lamp panels printed with overprint.**

## Solution Tree

- Delta P | ~~Delta M~~
  - BOB Region – WOW Region (WOW Panel) ~~crossed out~~ | BOB Panel – WOW Panel (WOW Group) | ~~Other Strategy Choices~~
    - Non-random w.r.t. Process | ~~Random w.r.t Process~~
      - ~~Follows Print~~ | Follows Flood
        - Delay Before Flood | ~~All Flood Strokes~~
          - **Time for ink "curtain" to fall from squeegee** — **Red X** | ~~Other Physics~~

## Reason for split

Defects visible with naked eye.

**Concentration Diagram**: BOB Panel-WOW Panel provides the best leverage by observing ink addition and scrape events. Use BOB Region-WOW Region contrast to focus observations on the flood stroke.

BOB panels occur only after ink additions or ink edge scrapes. WOW panels occur randomly throughout.

BOB and WOW panels both get the same print stroke. Only BOB panels have a different flood stroke.

Delaying the flood after printing creates BOB panels, never WOW.

Ink "curtain" from squeegee lays down in flood and causes "V" in printed image. Confirmed with B vs. W. Changed PLC program to add 5 seconds before flood.

# Irreversible Corrective Action

- The defect is completely eliminated with a 5 second delay after raising the squeegee before flooding the screen with ink
- Worked with machine maker to re-program the screen printing machine with a 5 second delay
- The increased yield and complete elimination of rework more than offsets the slightly reduced throughput
- Result:  Scrap due to "V-lines" was completely eliminated
- Translation of benefits to other printed layers can reduce other visual defects also