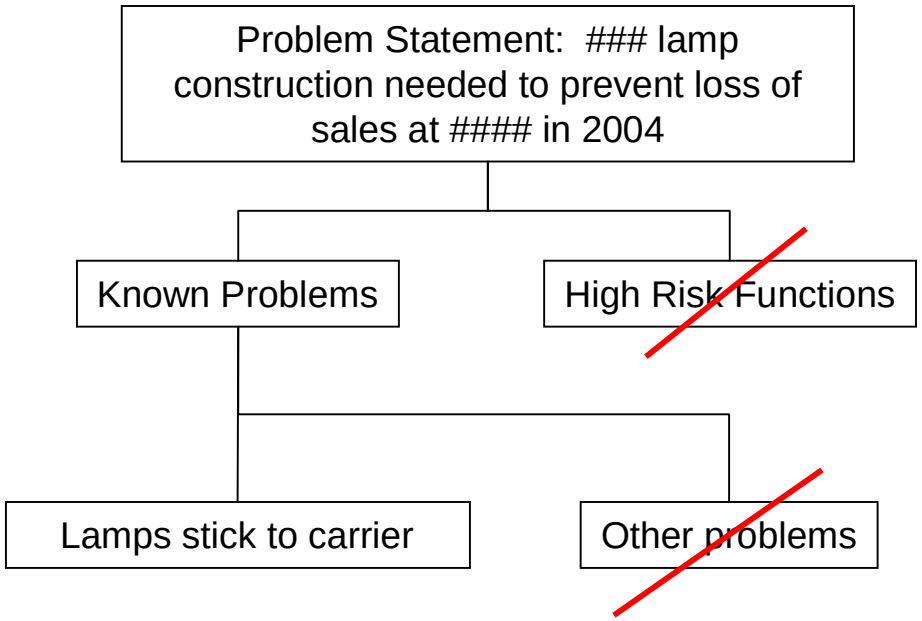
Problem Definition Tree



Rationale

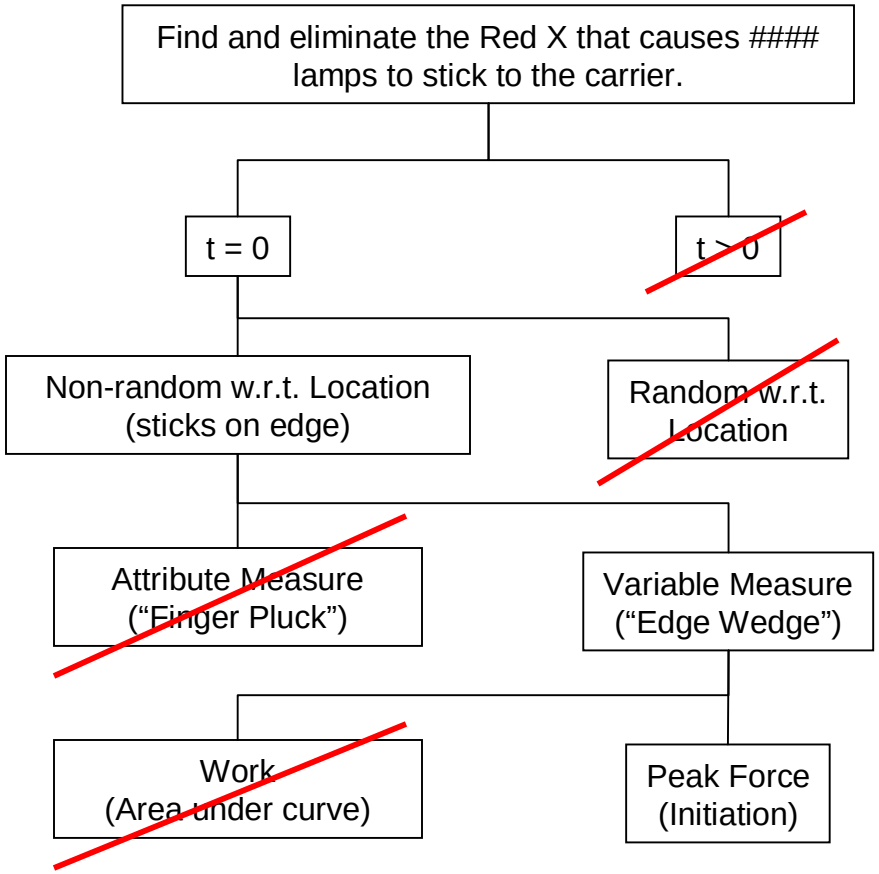
Several known problems are preventing customer prototypes from being made

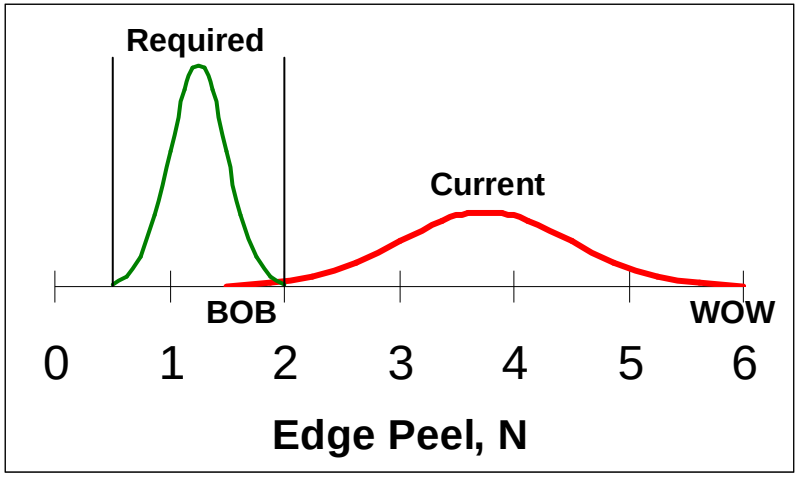
Focus split: failure to release from carrier affects customer acceptance. Other known problems affect internal metrics only.

Project statement: Find and eliminate the Red X that causes #### lamps to stick to the carrier.

Show stopper problem!

Project Definition Tree





Rationale

Lamps fail to peel at t = 0; no change after t = n (1, 7, and > 30 days)

Talk to the parts – lamps peel easily in body, but stick to substrate around perimeter edge

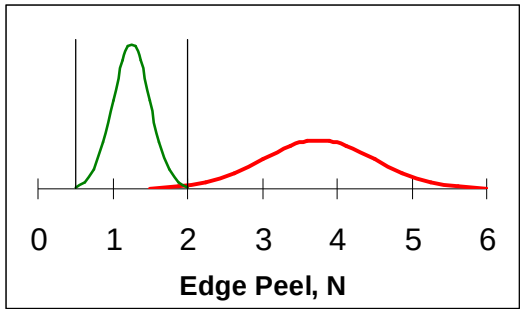
Initial BOB-WOW contrast easily seen with "finger pluck". Use variable measure to get more repeatable discrimination.

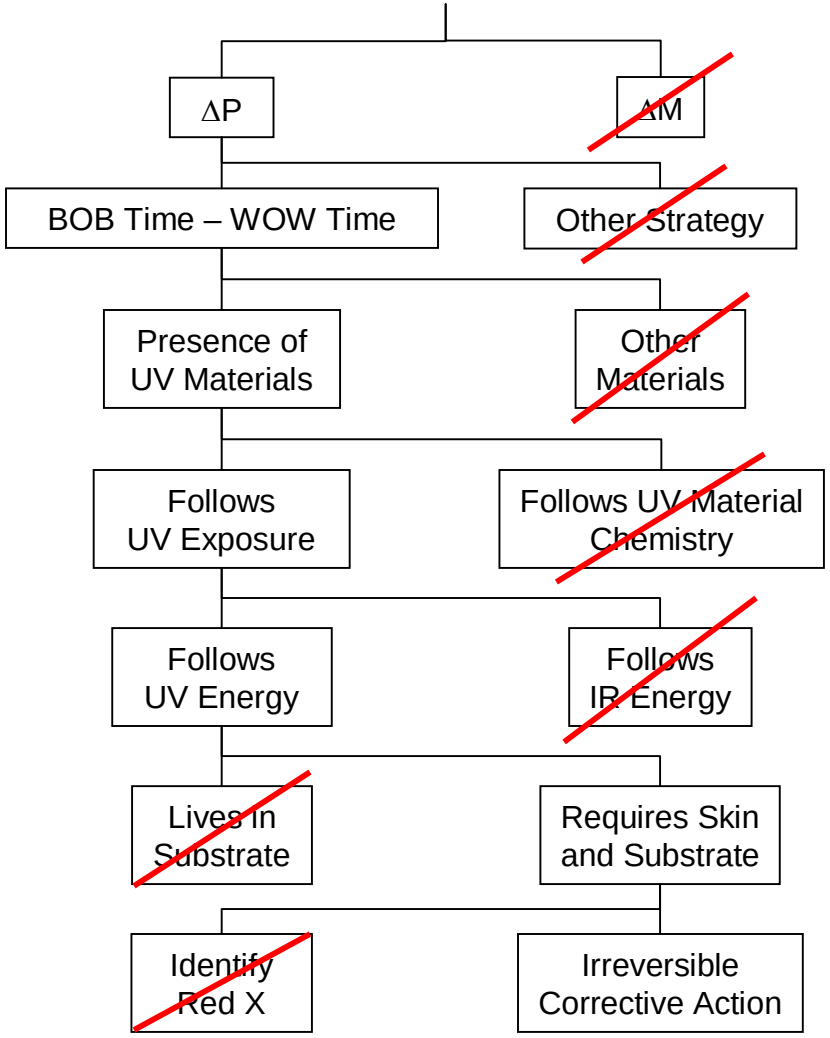
Simple digital force gauge is able to identify BOBs and WOWs using variable measure

Green Y = peak force required to initiate separation of the skin edge from the substrate using an X-acto blade at 15 degrees.

Solution Tree

Green Y = peak force required to initiate separation of the skin edge from the substrate using an X-acto blade at 15 degrees.





Rationale

Isoplot: DR = 13.9

Strategy choice: BOB time was during a previous generation (all solvent-based materials); new generation is WOW (numerous UV-based materials)

Dictionary Split #1: construction with UV materials is WOW; all solvent-based construction is BOB

Dictionary Split #2: substrate + skin only (no UV materials) is BOB and becomes WOW after 7 UV exposures that simulate building a lamp.

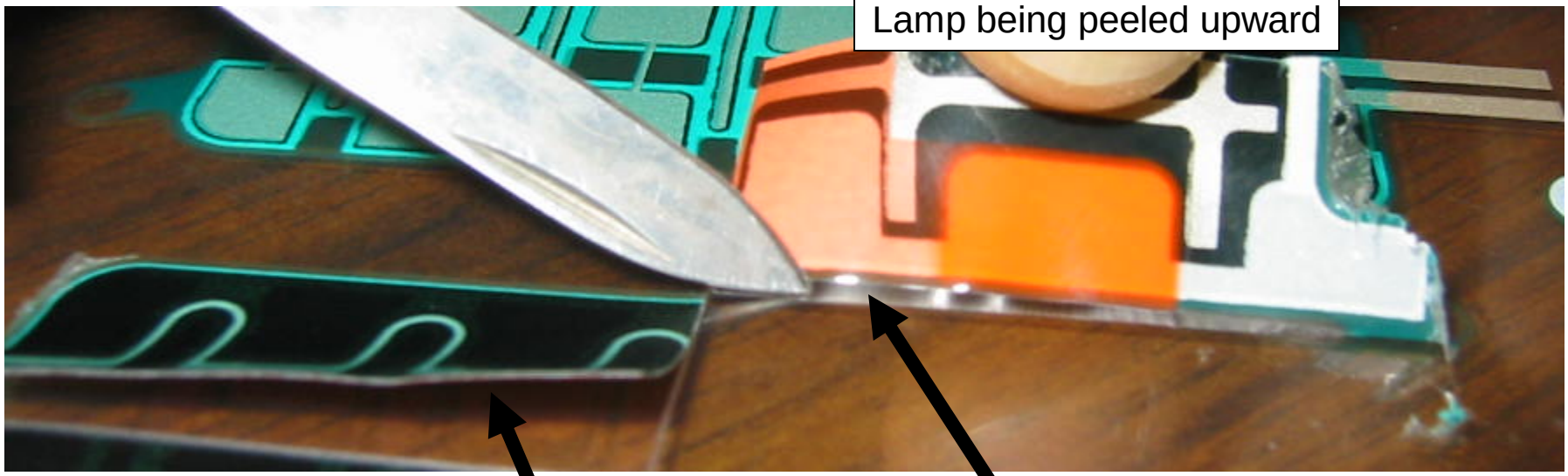
Dictionary Split #3: skin exposed only to IR energy stays BOB; skin exposed to only UV energy is WOW (can be made BOB by adding sun screen).

Dictionary Split #4: substrate exposed to UV, then printed with skin is BOB; sticking occurs only when skin is printed first, then exposed to UV

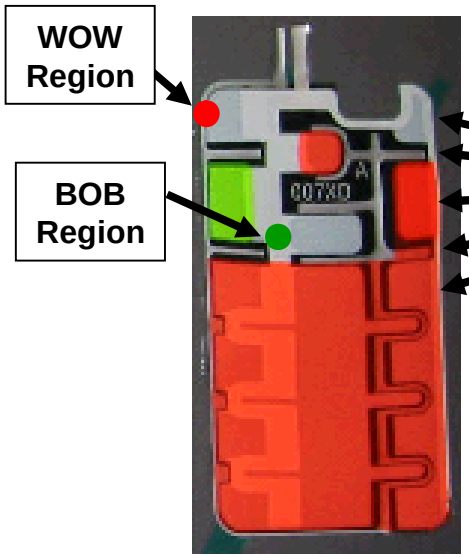
Corrective action: management review – no economic value in identifying Red X; die cutting is more economically sound and creates better edge quality. B vs. C and Green Y run chart confirm effectiveness.

BOB Region – WOW Region (WOW Lamp)

BOB = Best of the Best and WOW = Worst of the Worst



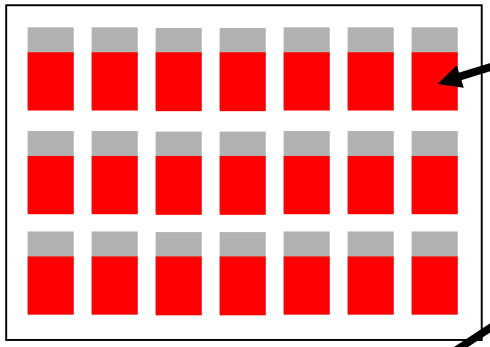
Strategy Diagram*



BOB Point-WOW Point
WOW Region

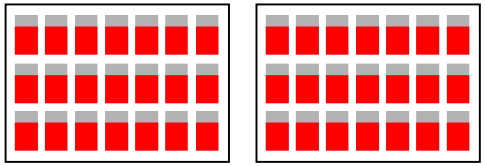
Leverage for corrective action

BOB Region-WOW Region
WOW Lamp



BOB Lamp – WOW Lamp
WOW Panel

BOB Panel – WOW Panel
WOW Run



BOB Run – WOW Run
WOW Time

BOB Time – WOW Time

Notes
Small contrast: the exposed skin perimeter is **all WOW**.

Large contrast: internal body of lamp peels easily. Perimeter of lamp (exposed skin) is WOW. Excellent leverage using a blanking tool to remove WOW perimeter. **Good leverage**.

No contrast (all lamps WOW)

See Concept Diagram

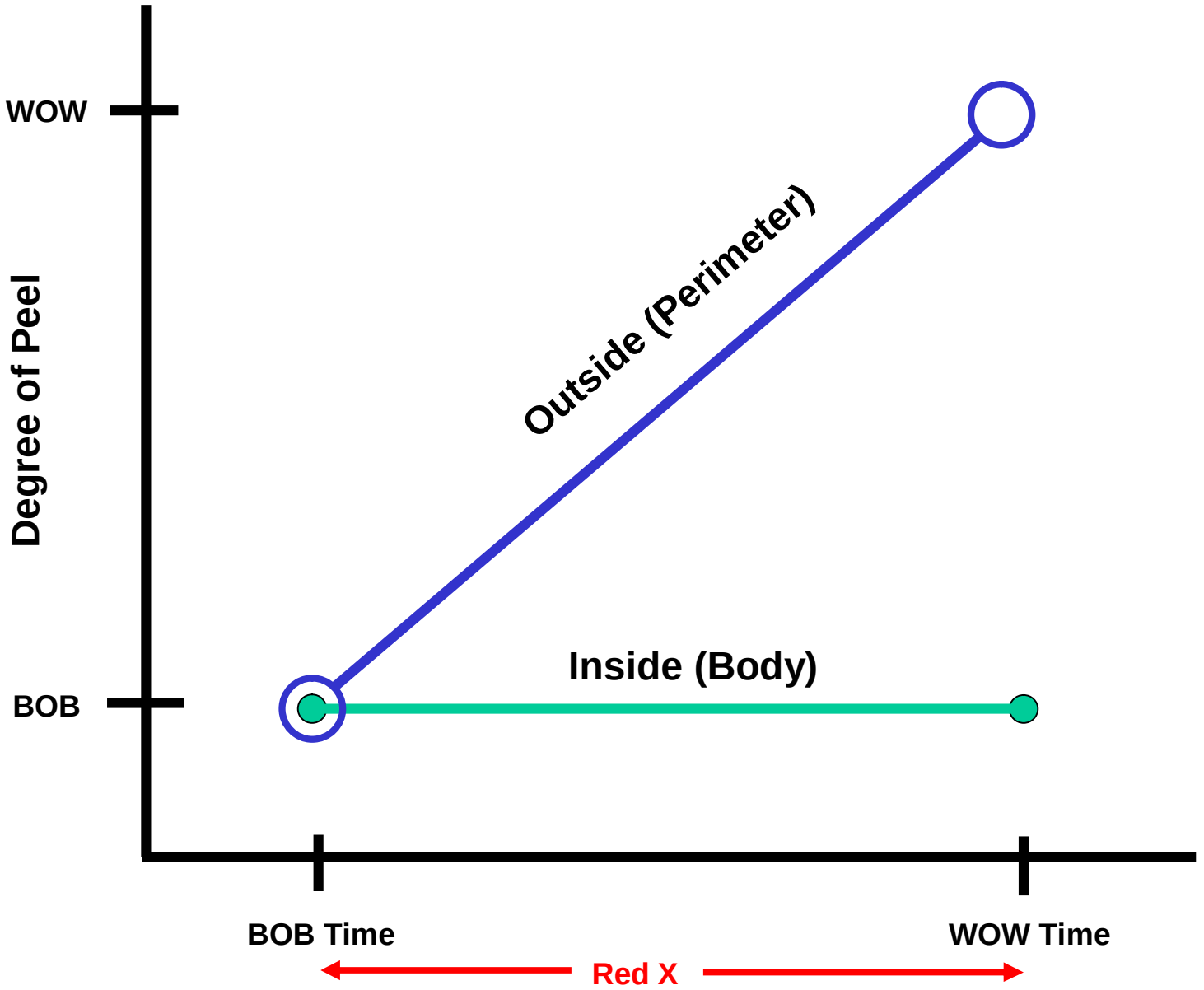
No contrast (all panels WOW)

Medium contrast: one WOW run found; run record revealed abnormally high UV cure. The only BOB runs during WOW time were designs without UV-cured color layers.

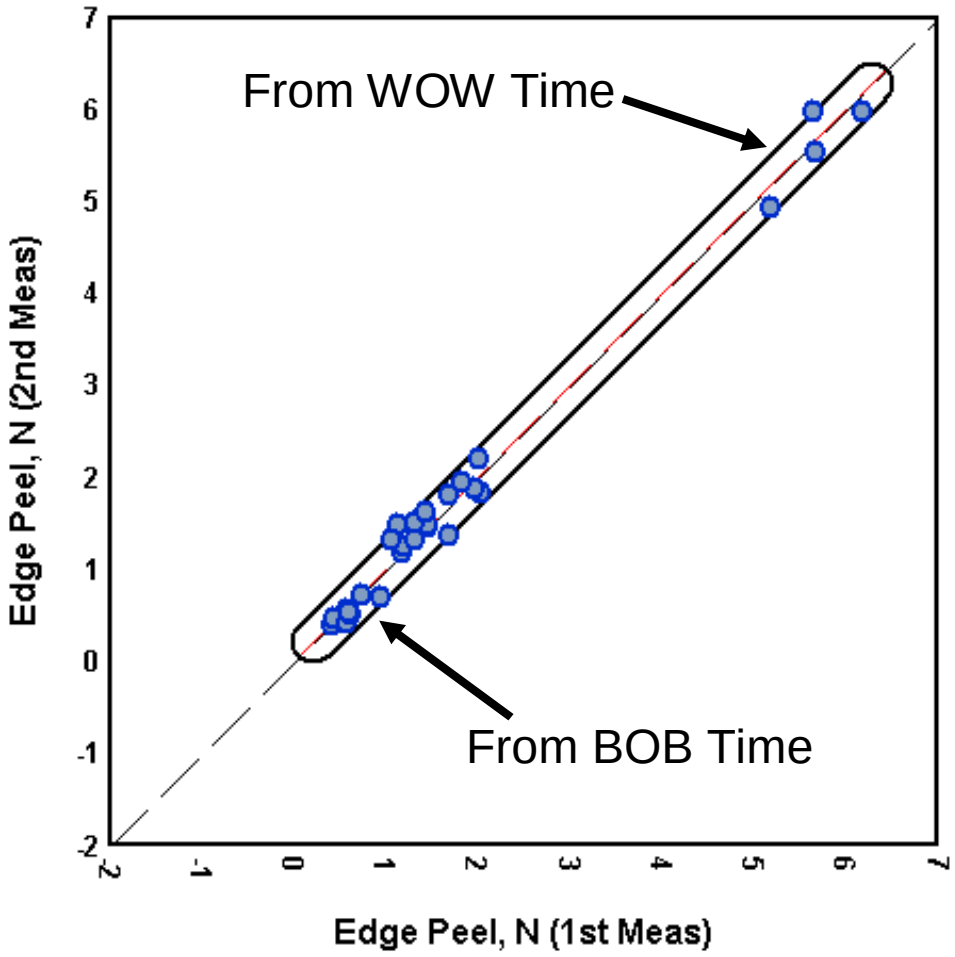
Large contrast: BOB time had a product with solvent-based materials only; WOW time is after converting to UV-based color layers and rear insulator. Refer to NOK007 prototype run & Benchmark run. **Good leverage**.

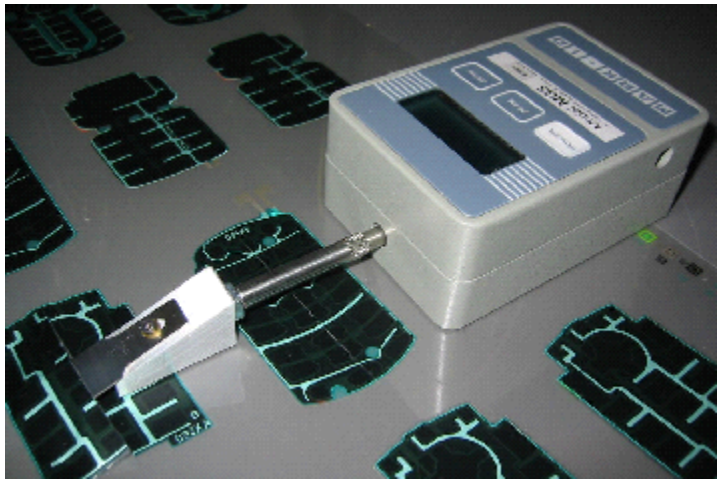
* Developed initially using Defect Strategy; later used a variable measure of the Green Y.

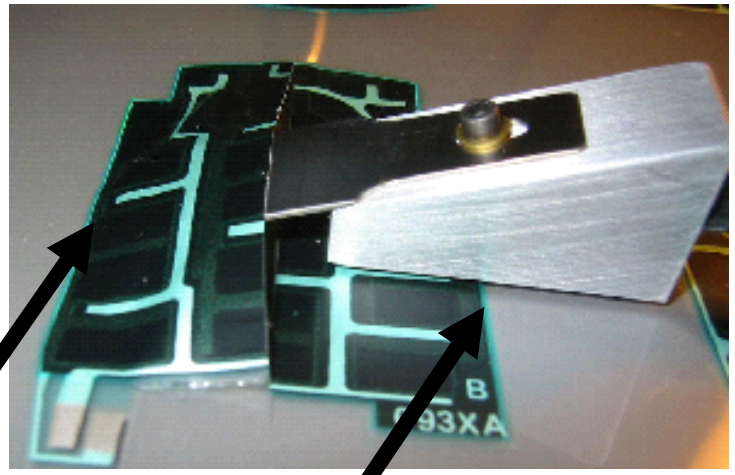
Concept Diagram



Isoplot - Edge Scraper







Delta P = 6.39
Delta M = 0.46
Discrimination Ratio = 13.9

Isoplot (1st Meas)

Isoplot (2nd Meas)

Dictionary Split #1

BOB Time – WOW Time

WOW: All UV construction

Color

RI	MI	Color	WOW	BOB
WOW	WOW	WOW	**5**	**3**
		BOB	**3**	**2**
BOB	WOW	WOW	**4**	**2**
		BOB	**3**	**1**

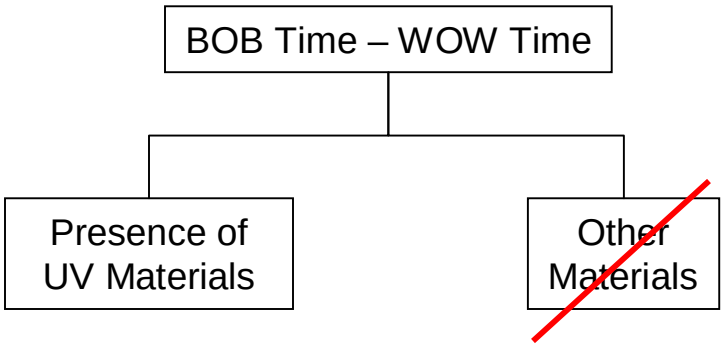
BOB: All solvent construction

Green Y = Finger pluck score for ease of peel
1 = BOB; 5 = WOW

Color Layers
- BOB: Solvent-based
- WOW: UV-cured

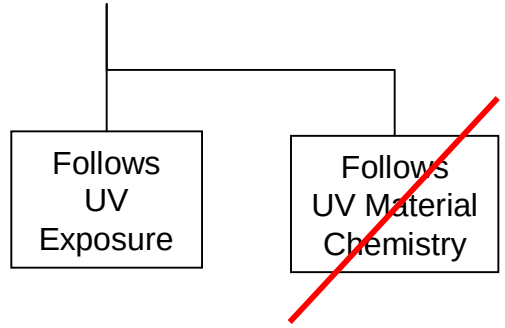
Middle Insulator (MI)
- BOB: Solvent-based
- WOW: UV-cured

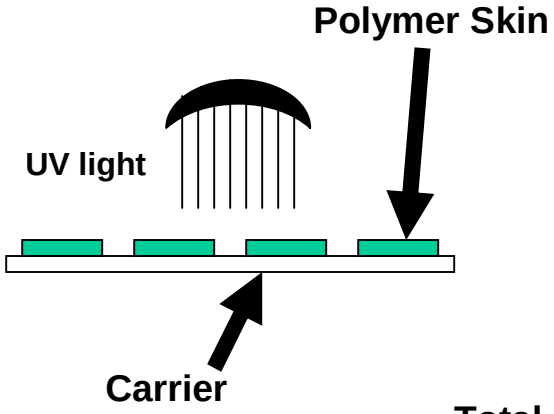
Rear Insulator (RI)
- BOB: Solvent-based
- WOW: UV-cured

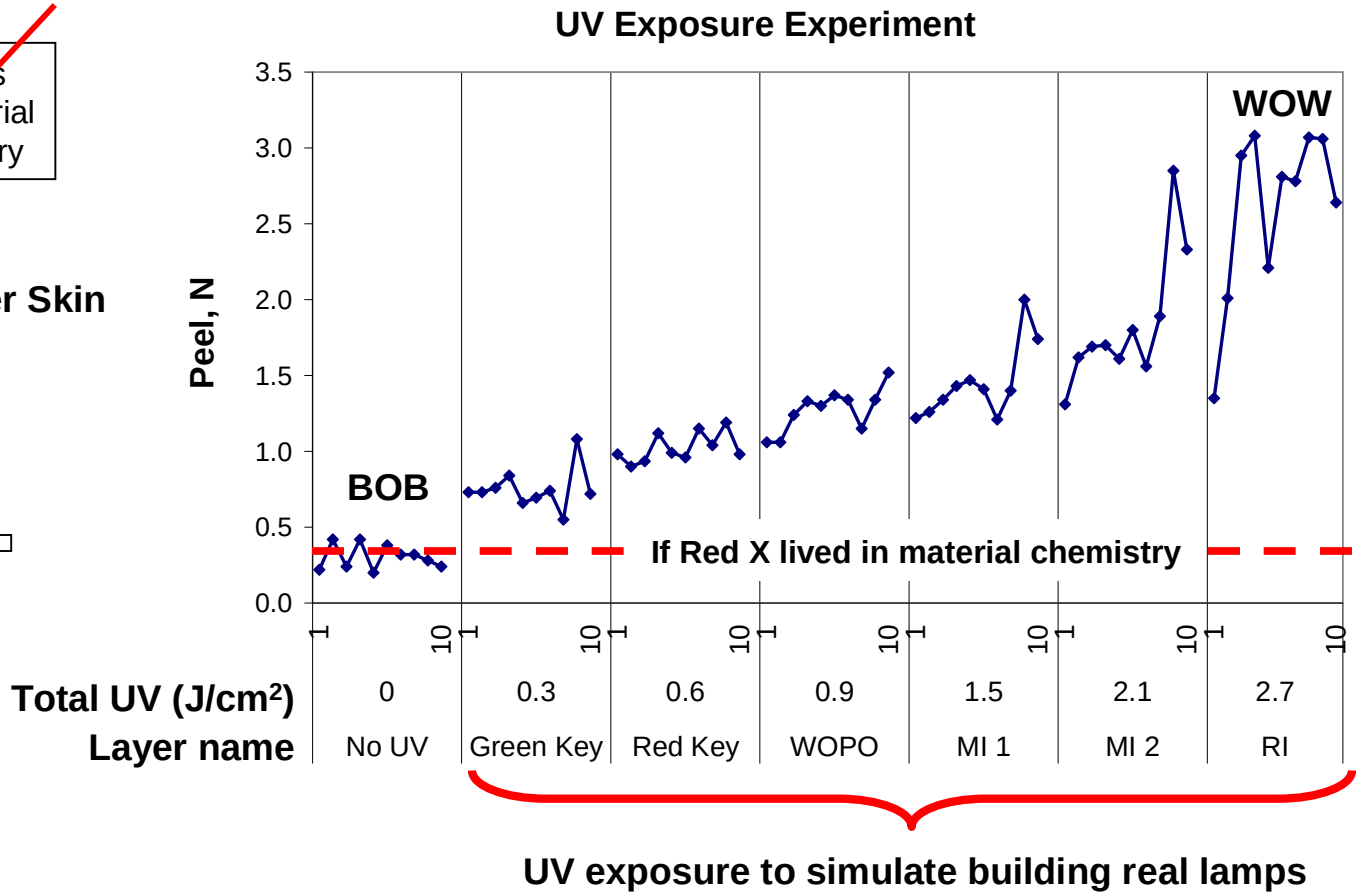


Used "finger pluck" to rate degree of stick to carrier in this experiment since it was able to discriminate between BOB and WOW. Developed variable measurement system immediately after this split.

Dictionary Split #2

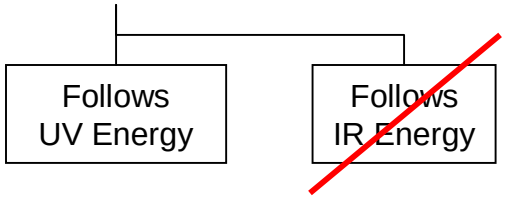


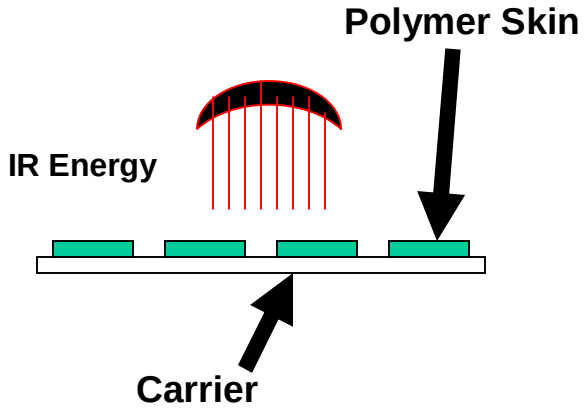


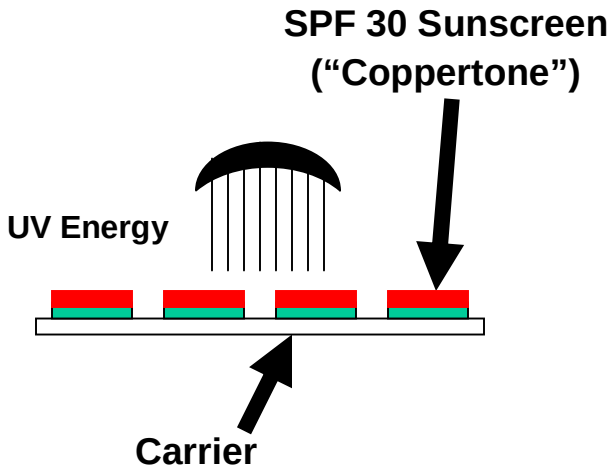


- Carrier + Skin layer only (no other lamp layers, UV-cured or otherwise)
- Multiple passes through UV cure station to simulate building lamps
- **As UV exposure increases, the release initiation force increases, therefore the Red X follows UV exposure, not the chemistry of the UV materials.**

Dictionary Split #3







Part a:

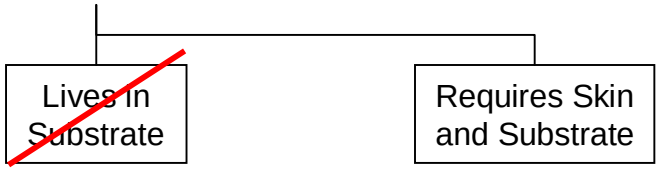
- Only IR energy (no UV light)
- Aggravated level
- BOB peel remains BOB

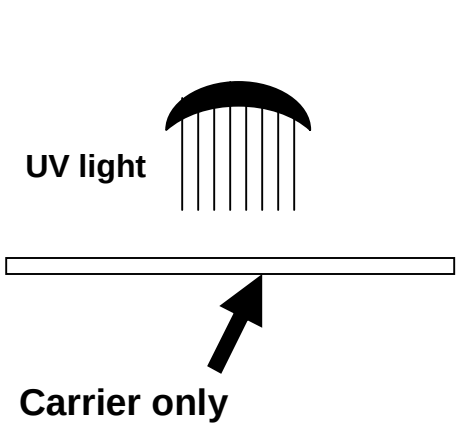
Part b:

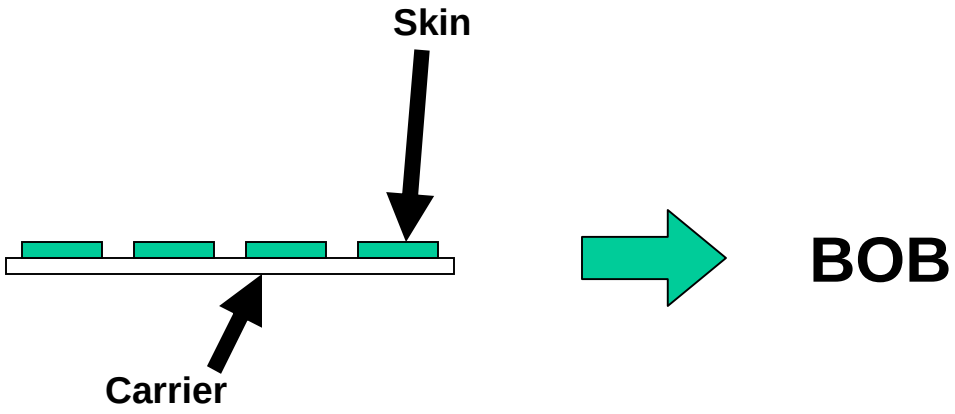
- UV energy with sunscreen applied to skin
- BOB peel remains BOB

Inability to aggravate peel with 7 passes of IR energy proves the Red X lives in the UV energy component.

Dictionary Split #4







1. **Expose carrier to UV dosage equivalent to complete lamps**

2. **Print skin layer, then measure release initiation force**

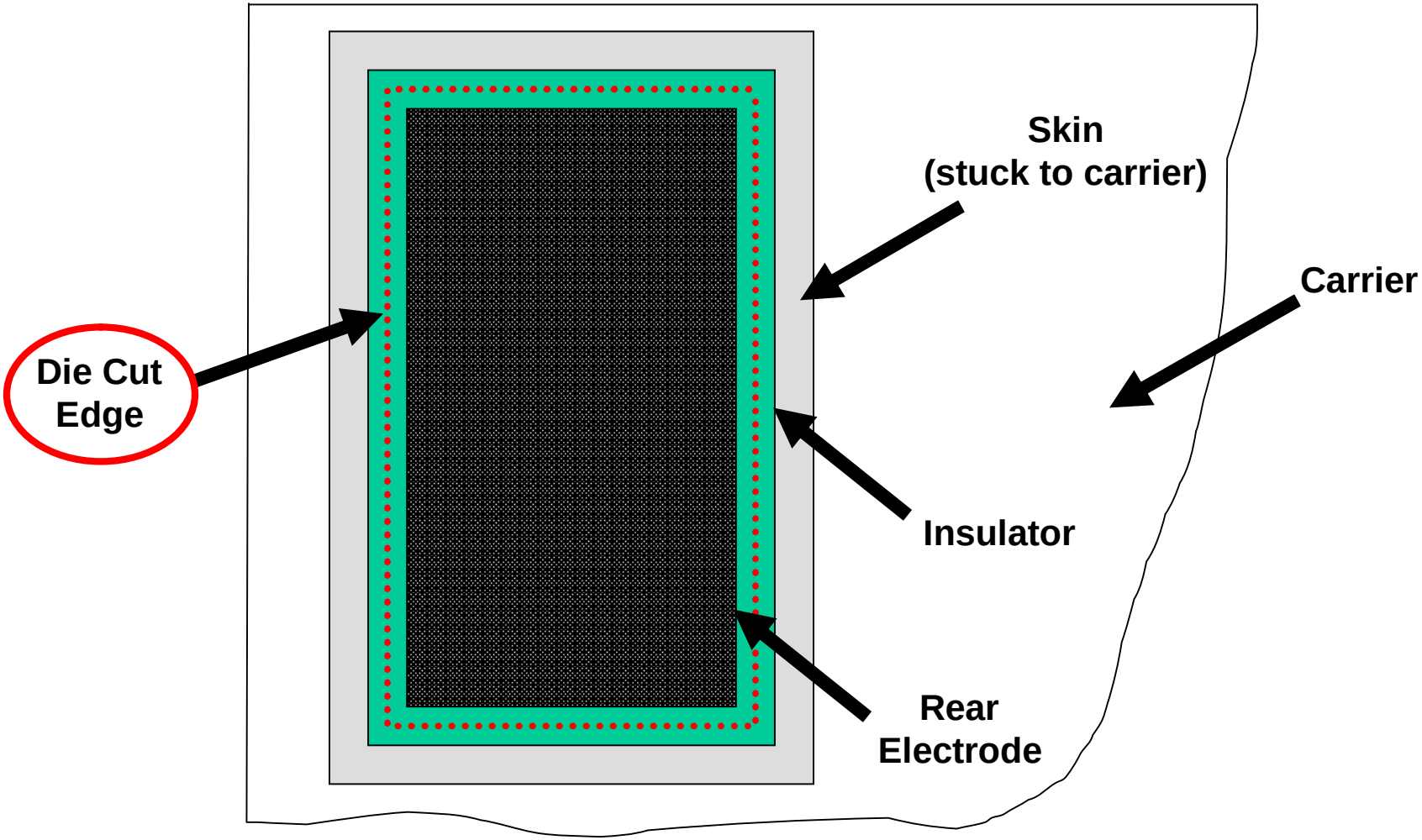
Pre-exposing carrier to UV energy does not aggravate release initiation force, therefore conclude that the Red X lives in the interaction of the skin and carrier.

Permanent Corrective Action

~~Identify Red X~~

Irreversible Corrective Action

Corrective action: die cut the edge in a BOB peel region and discard the WOW edge.



Confirmation

Green Y = Peak force at initiation of skin edge peel
Irreversible Corrective Action = Die Cut Perimeter
B = Die cut around lamp perimeter
C = Not die cut (lamp edge defined by skin)
Confidence = 95%

Run Order		
B or C	**Design**	**Peel, N**
C	Skin edge	4.75
C	Skin edge	4.28
B	Die Cut	0.57
C	Skin edge	4.28
B	Die Cut	0.24
B	Die Cut	0.78

Rank Order		
B or C	**Design**	**Peel, N**
B	Die Cut	0.24
B	Die Cut	0.57
B	Die Cut	0.78
C	Skin edge	4.28
C	Skin edge	4.28
C	Skin edge	4.75

Conclusion: with 5% risk, die cutting the perimeter of the lamp drives the peak initiation force required to remove the lamp from the carrier.

The magnitude of the effect also has practical significance.

Green Y Run Chart