

# UV Ink Performance as a Function of UV or UV LED Cure

Presented by:

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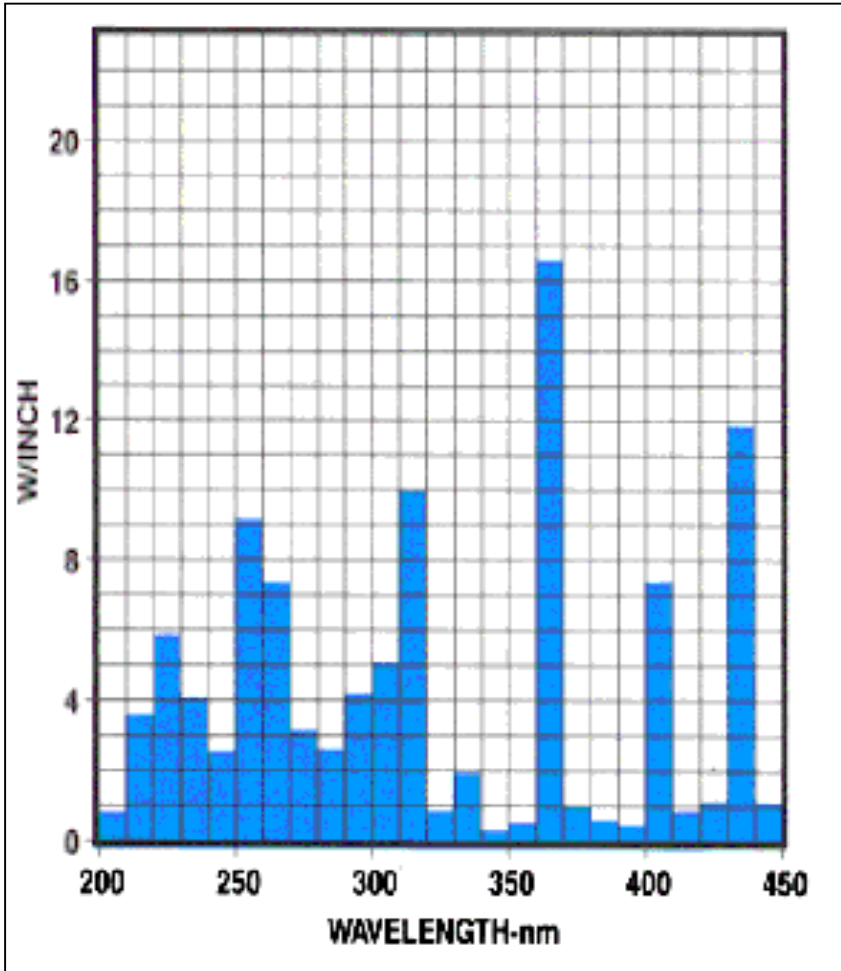


# AGENDA

- Available Lamp Technologies
- Project Strategy
- Determine Cure Scenarios
- Lab Testing
- Results
- Open Discussion



# LAMP TECHNOLOGIES



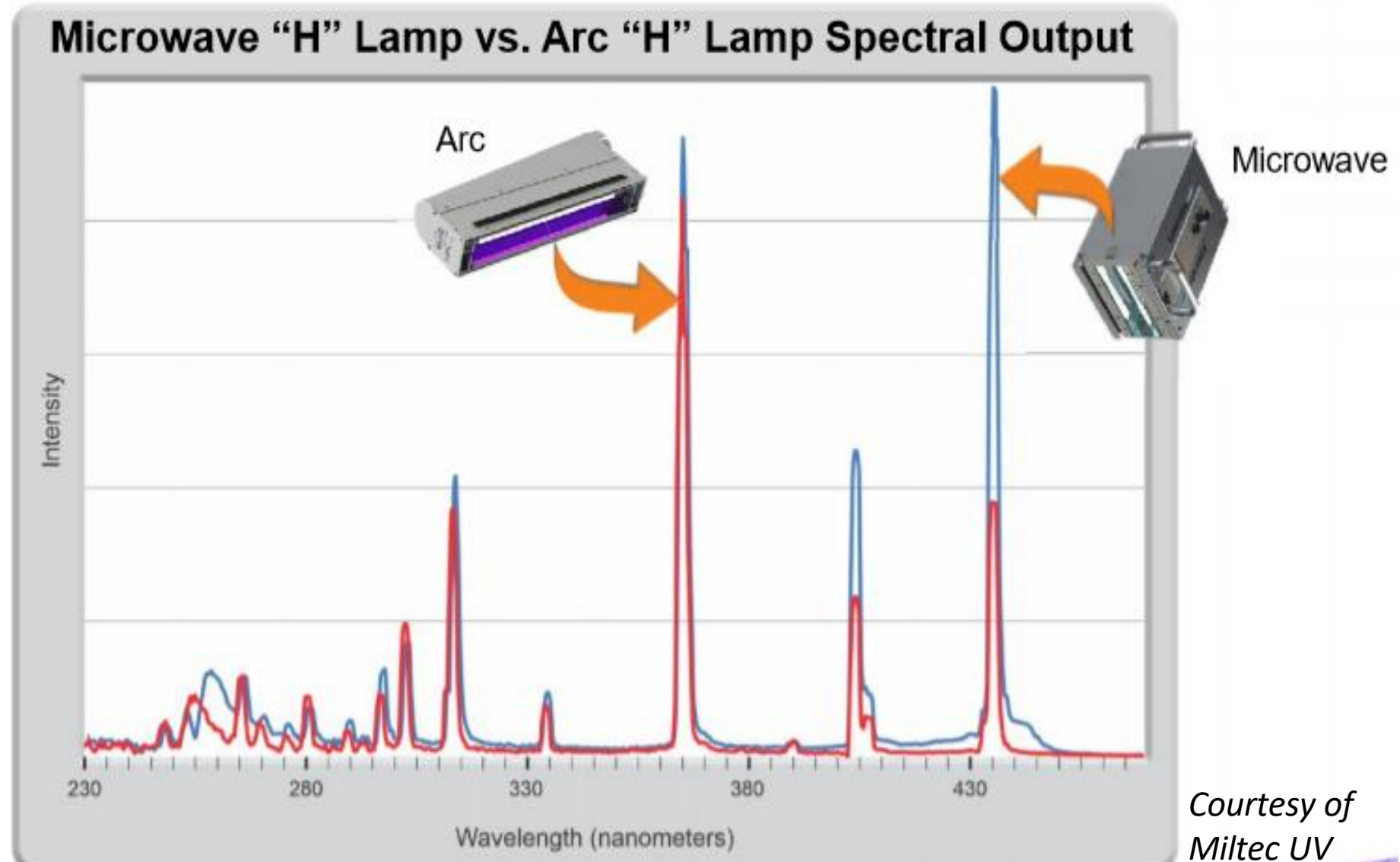
## UV “Hg” Lamp

- Standard type is medium pressure Mercury (Hg) vapor.
- Simplified UV-H Lamp Output
- Highest Energy Peak is UV-A 365nm
- H is most common type of UV bulb



# LAMP TECHNOLOGIES

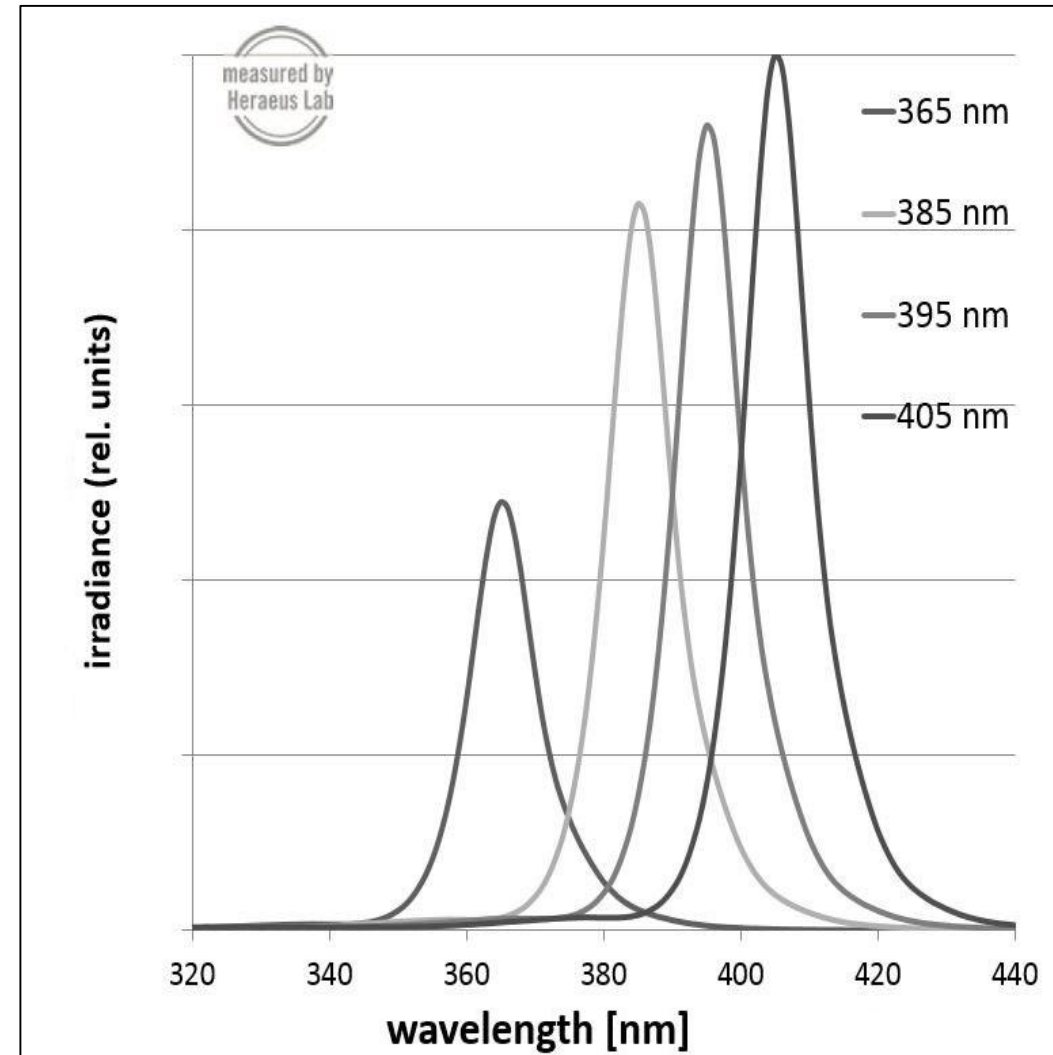
Microwave powered lamps have higher intensity and therefore can provide better cure



# LAMP TECHNOLOGIES

## UV LED Lamp

- 365nm, 385nm, 395nm & 405nm
- Low temperature
- Instant ON/OFF
- Higher energy efficiency
- No ozone created
- Mercury risk avoidance

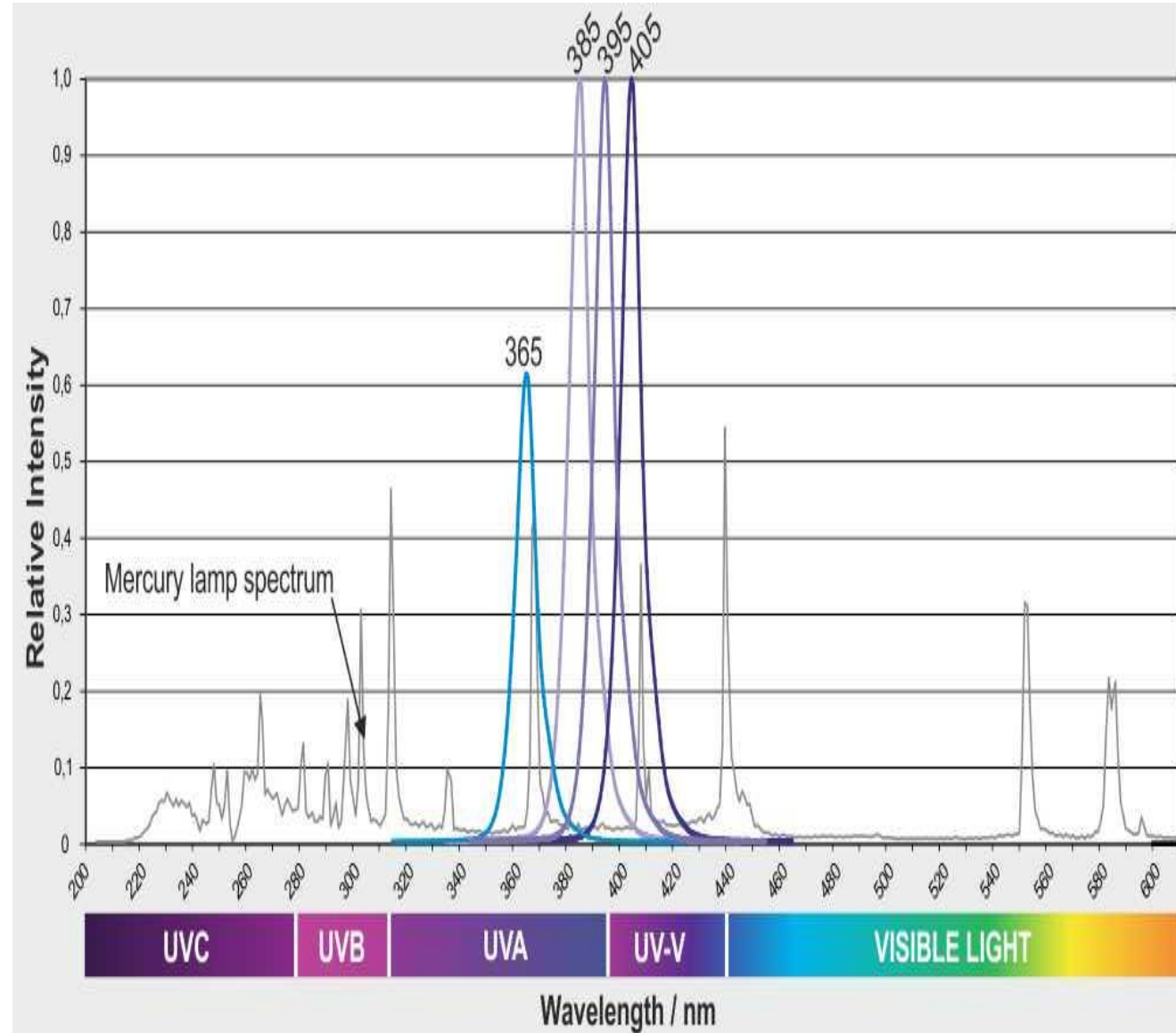


Courtesy of Heraeus

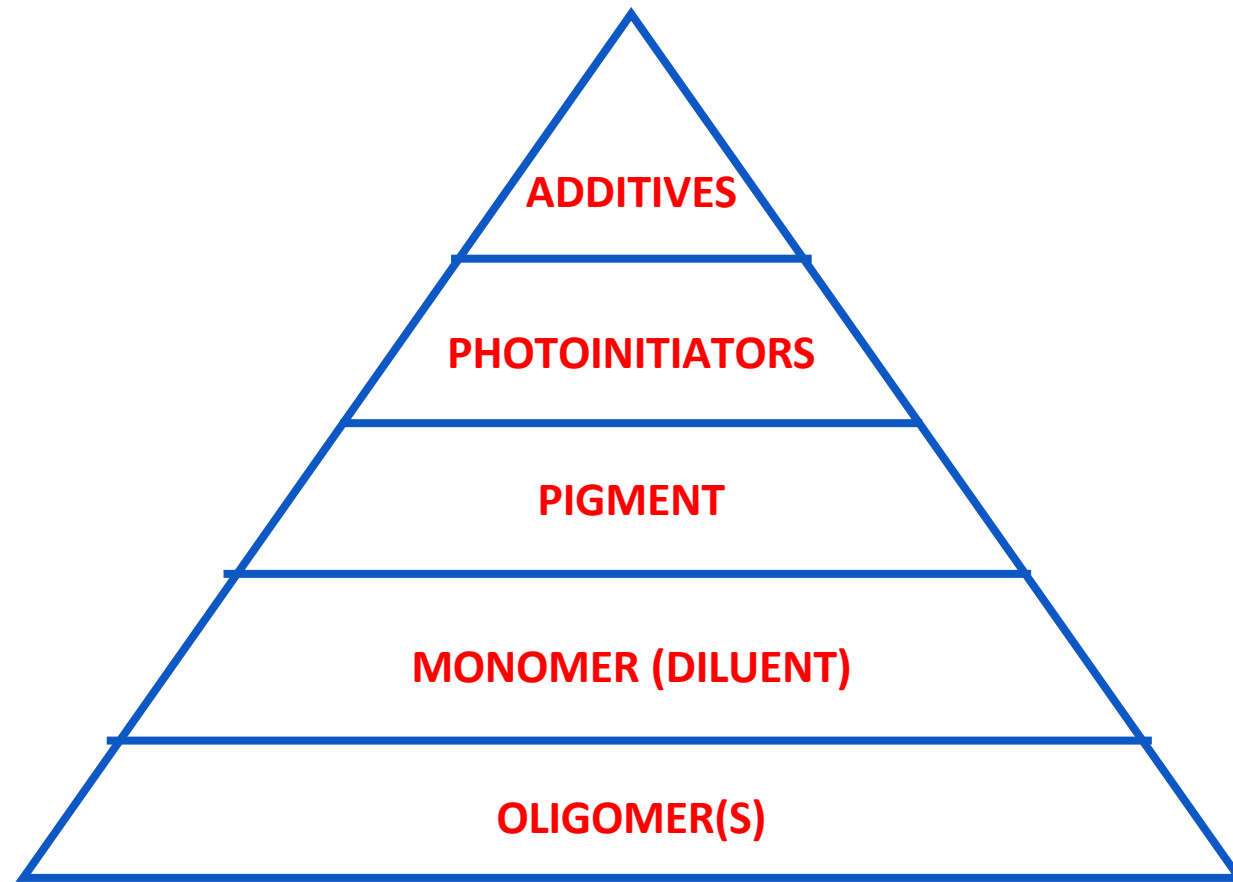
# LAMP TECHNOLOGIES

## Mercury Lamp Versus LED Lamp

UV curable ink needs to be formulated according to lamp type used



# TYPICAL UV CURABLE INK FORMULATION



## Choose model UV inks and cure by varying:

- Inks:
  - INX 1594489 Black
  - INX 1597278 Opaque White
- Light source (UV Mercury Arc Lamp vs. LED array)
- Speed
- Power of light source
- Height of light source



# Determine Cure Scenarios



# DETERMINE CURE SCENARIOS

- AMS UV/LED Unit
- UV Mercury Arc Lamp
- Bulb wattages:
  - LED: 17 Watts
  - UV: 400 Watts
- Speed: 0 - 800 fpm
- Height: 25 – 165mm
- LED Bulb Wavelength: 395nm



# DETERMINE CURE SCENARIOS

9 runs each for both UV and LED Cures



Run #	1	2	3	4	5	6	7	8	9
Light Source:	LED	LED	LED	LED	LED	LED	LED	LED	LED
Power:	100	60	20	100	60	20	100	60	20
Height:	25	25	25	95	95	95	165	165	165

Run #	1	2	3	4	5	6	7	8	9
Light Source:	UV	UV	UV	UV	UV	UV	UV	UV	UV
Power:	100	60	20	100	60	20	100	60	20
Height:	25	25	25	95	95	95	165	165	165



# DETERMINE CURE SCENARIOS

## Radiometer

Power Puck II used to obtain standardization values



# DETERMINE CURE SCENARIOS

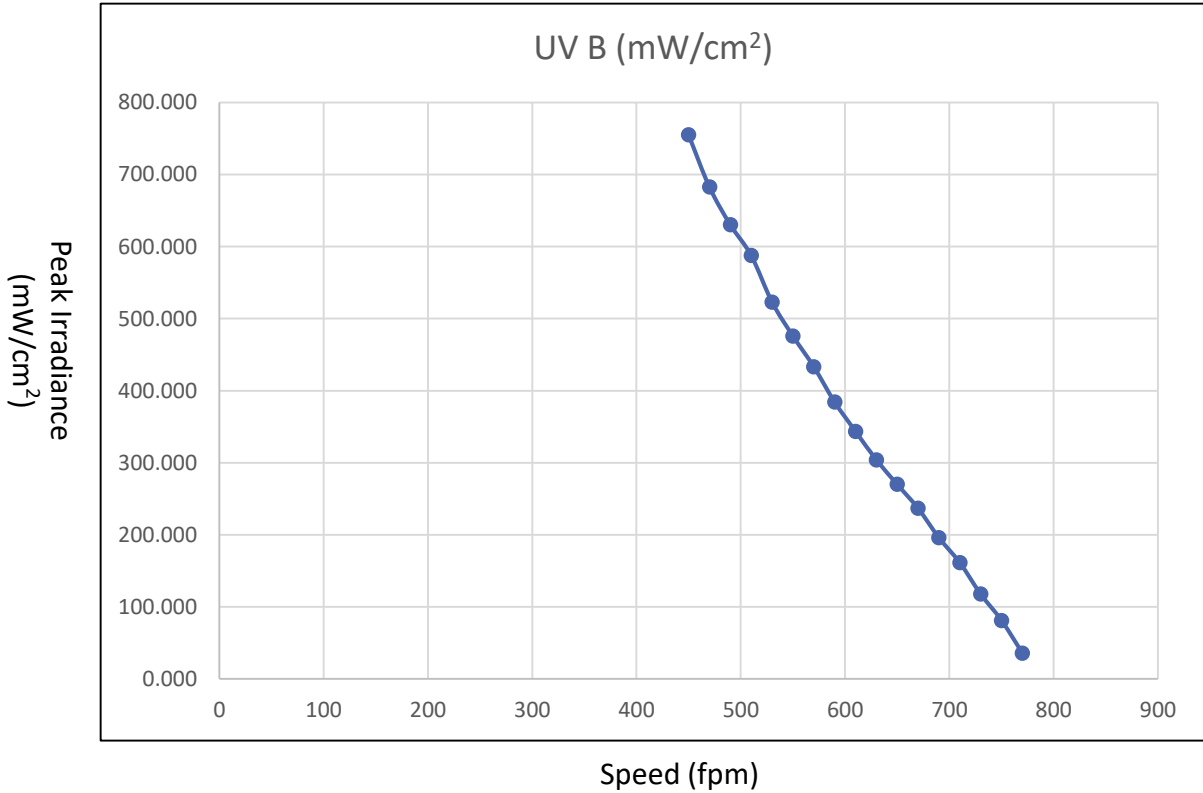
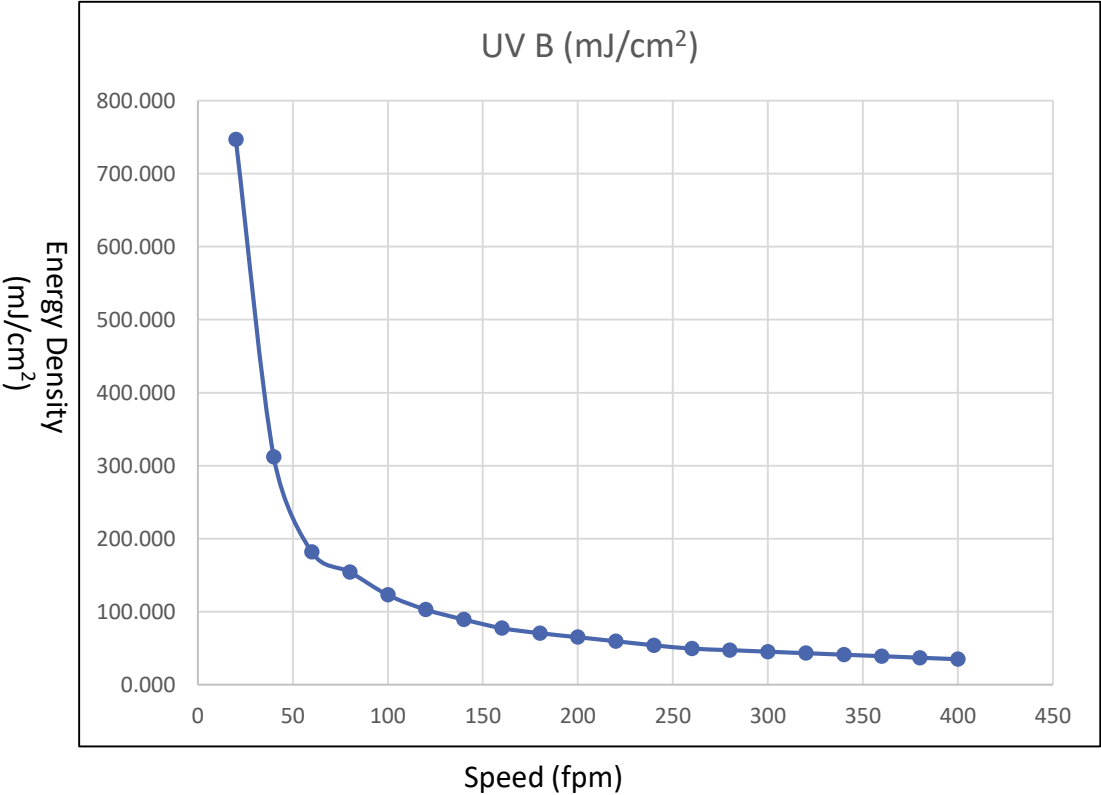
Example of UV Energy Density & UV Irradiance from 25 fpm to 100 fpm

	UV A	UV A	UV B	UV B	UV A <sup>2</sup>	UV A <sup>2</sup>	UV V	UV V
feet/min	mJ/cm <sup>2</sup>	mW/cm <sup>2</sup>	mJ/cm <sup>2</sup>	mW/cm <sup>2</sup>	mJ/cm <sup>2</sup>	mW/cm <sup>2</sup>	mJ/cm <sup>2</sup>	mW/cm <sup>2</sup>
25	290.348	2091.083	6.124	46.82	440.059	3273.569	721.757	1624.523
50	141.22	1964.6	3.066	47.246	219.327	3044.108	110.311	151.005
75	92.825	1780.43	2.084	42.138	148.539	2788.868	72.608	1379.665
100	70.851	1631.374	1.537	40.01	109.914	2517.536	55.357	1266.14



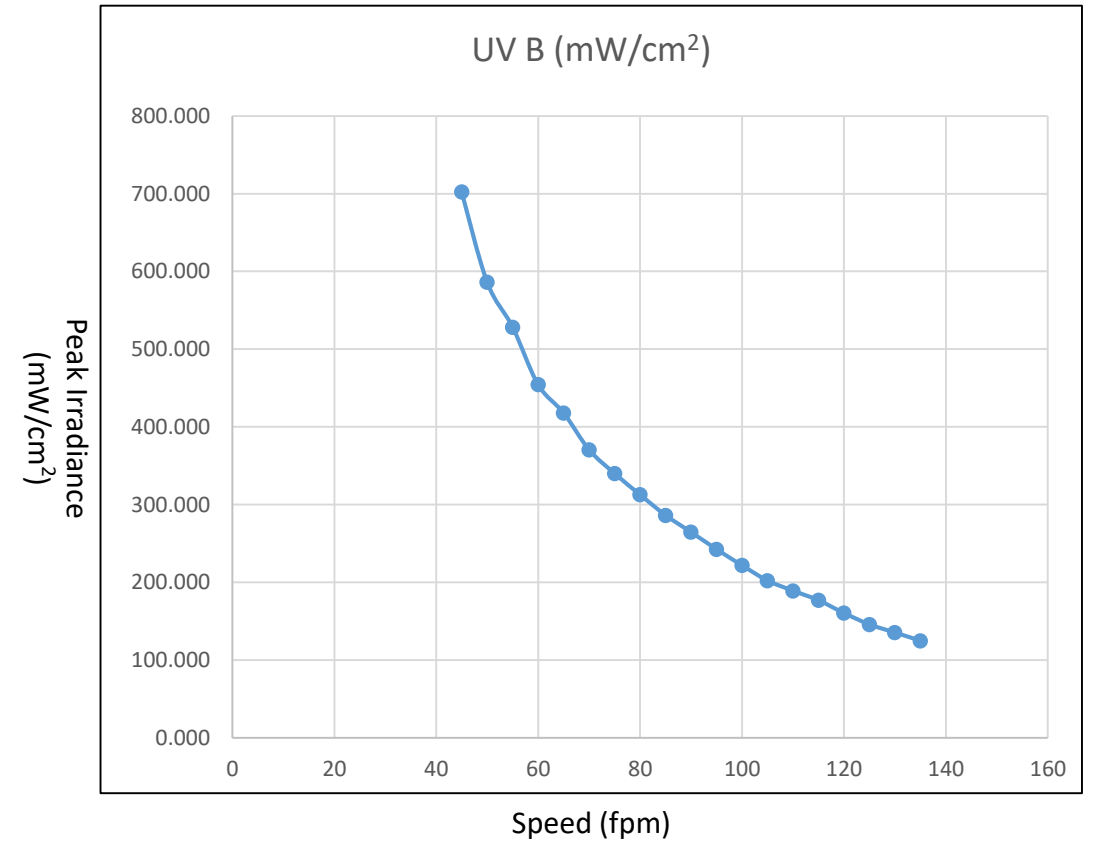
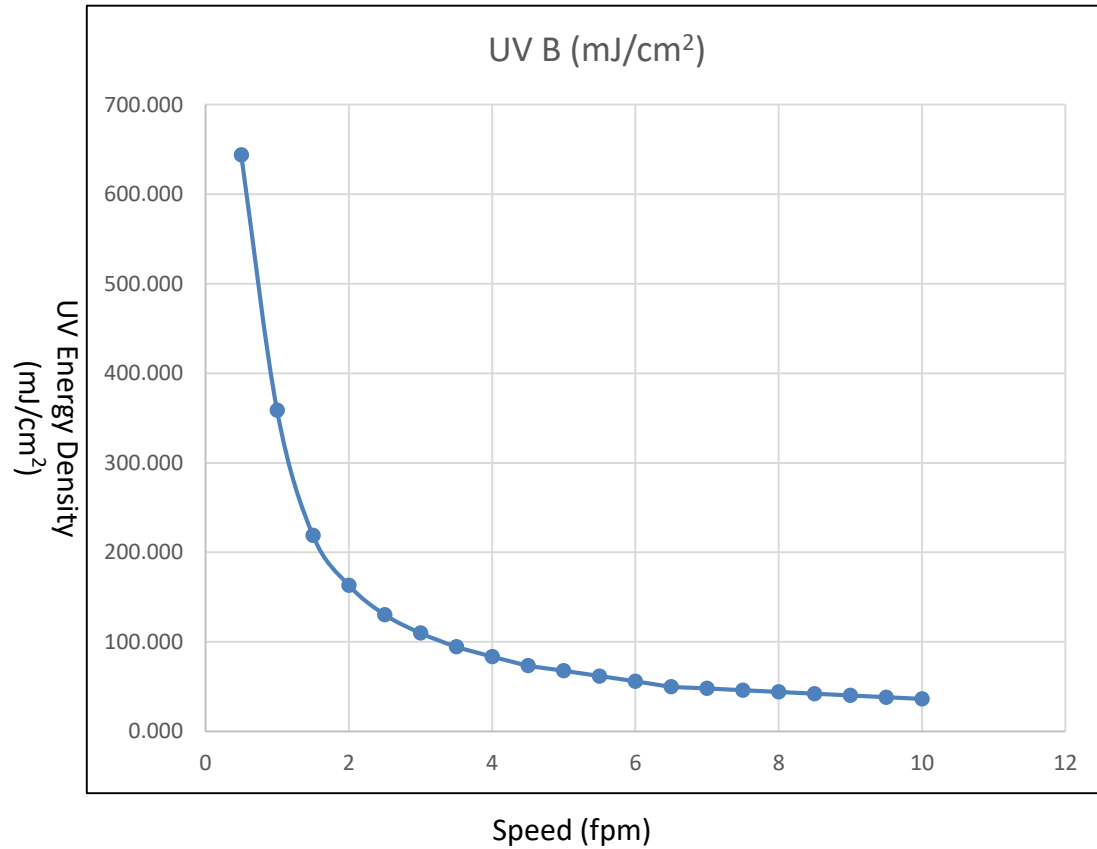
# DETERMINE CURE SCENARIOS

## UV Example Charts



# DETERMINE CURE SCENARIOS

## LED Example Charts



# DETERMINE CURE SCENARIOS

## Best Case-Scenario for Cure

Cure	Power	Speed (fpm)	Height (mm)		
<b>LED</b>	100%	25	25		
UV A	UV A	UV B	UV B	UV A2	UV A2
mJ/cm2	mW/cm2	mJ/cm2	mW/cm2	mJ/cm2	mW/cm2
923	6,764	25	187	1,842	10,000
Cure	Power	Speed (fpm)	Height (mm)		
<b>UV</b>	100%	25	25		
UV A	UV A	UV B	UV B	UV A2	UV A2
mJ/cm2	mW/cm2	mJ/cm2	mW/cm2	mJ/cm2	mW/cm2
577	840	496	772	201	293

# DETERMINE CURE SCENARIOS

## Worst Case-Scenario

Worst case considered the slowest cure which did not fail thumb twist test  
(Note: For UV bulb is out of focus at 95mm)

Cure	Power	Speed (fpm)	Height (mm)		
LED	50%	100	95		
UV A	UV A	UV B	UV B	UV A2	UV A2
mJ/cm2	mW/cm2	mJ/cm2	mW/cm2	mJ/cm2	mW/cm2
131	1,589	3	42	225	2,737
Cure	Power	Speed (fpm)	Height (mm)		
UV	50%	100	95		
UV A	UV A	UV B	UV B	UV A2	UV A2
mJ/cm2	mW/cm2	mJ/cm2	mW/cm2	mJ/cm2	mW/cm2
53	221	34	141	17	69

# LAB TESTING



## TEST PROTOCOL

### 1. Film Properties: Ink Only

- UV Thumb twist Cure, 80mj/cm<sup>2</sup>
- IPA Resistance
- Crosshatch 610 tape

### 2. Film Properties: Ink + Retortable Coating

- Crosshatch 610 Tape
- Impact 20inch-lbs / 610 tape
- Impact 40inch-lbs / 610 tape
- MEK Resistance
- Sheen Scratch
- 38mm Cap Fabrication

### 3. Migration Testing

- Black Ink
- Zero pressure
- Stack simulated pressure (3.5 ton/cm, 16 hours, 50°C)

# LAB TESTING



## Sample Preparation – Film Property Testing

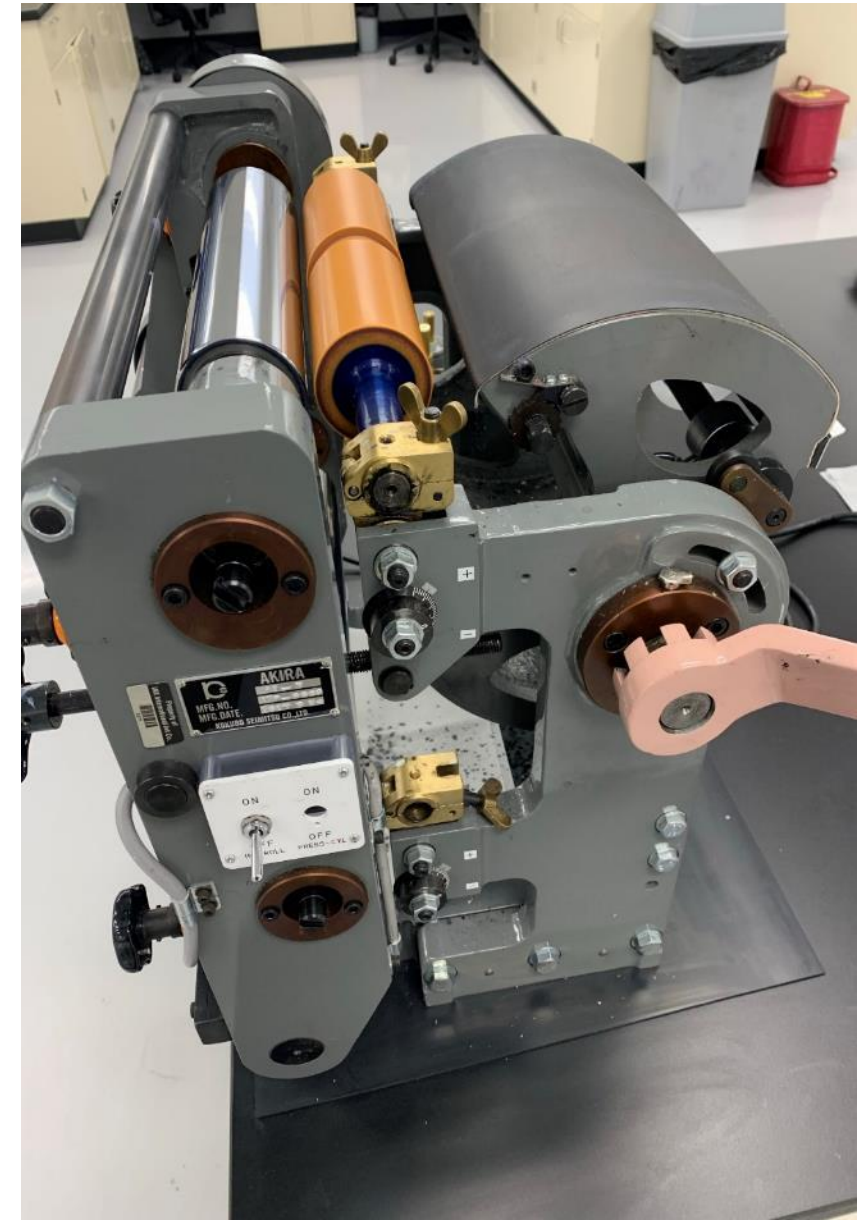
- Little Joe Proofer
- 2.2 grams white ink for 0.28 - .30 visual density
- 0.75 grams black ink for 1.90 visual density



# LAB TESTING

## Migration Testing – Print Method

- RI Proofer
- Prints large enough for migration testing plates

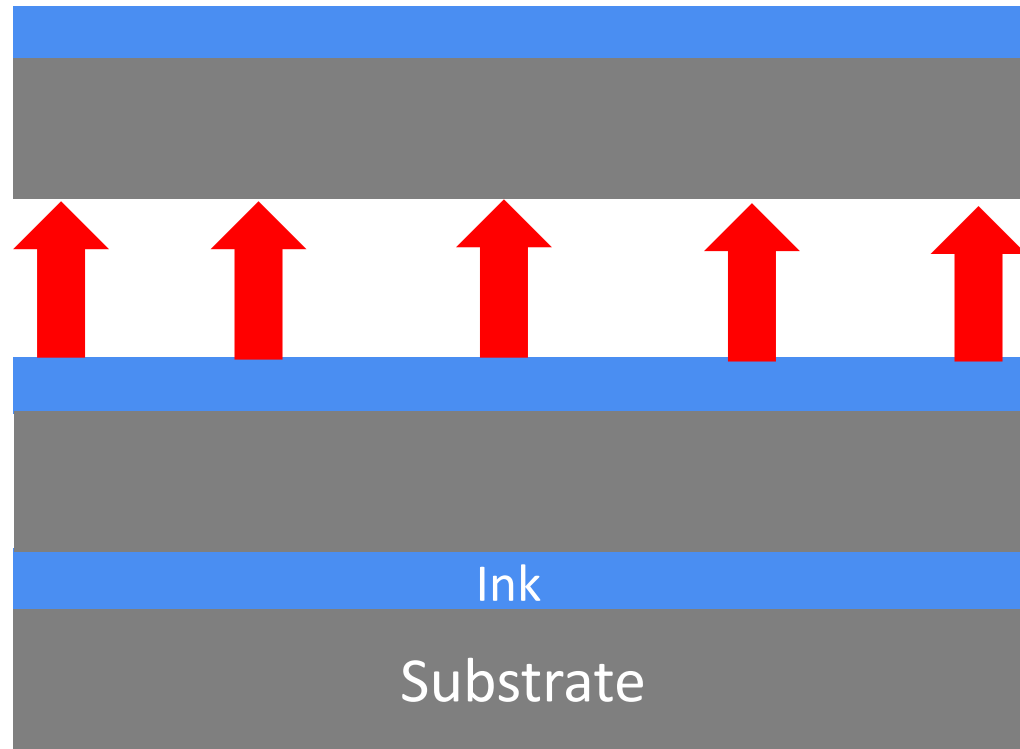


# LAB TESTING

## Variable Key

	<b>Color</b>	<b>Light Source</b>	<b>Power</b>	<b>Speed (fpm)</b>	<b>Lamp Height (mm)</b>
<b>1</b>	Black	UV	50%	100	95
<b>2</b>	Black	LED	50%	100	95
<b>3</b>	White	UV	50%	100	95
<b>4</b>	White	LED	50%	100	95
<b>5</b>	Black	UV	100%	25	25
<b>6</b>	Black	LED	100%	25	25

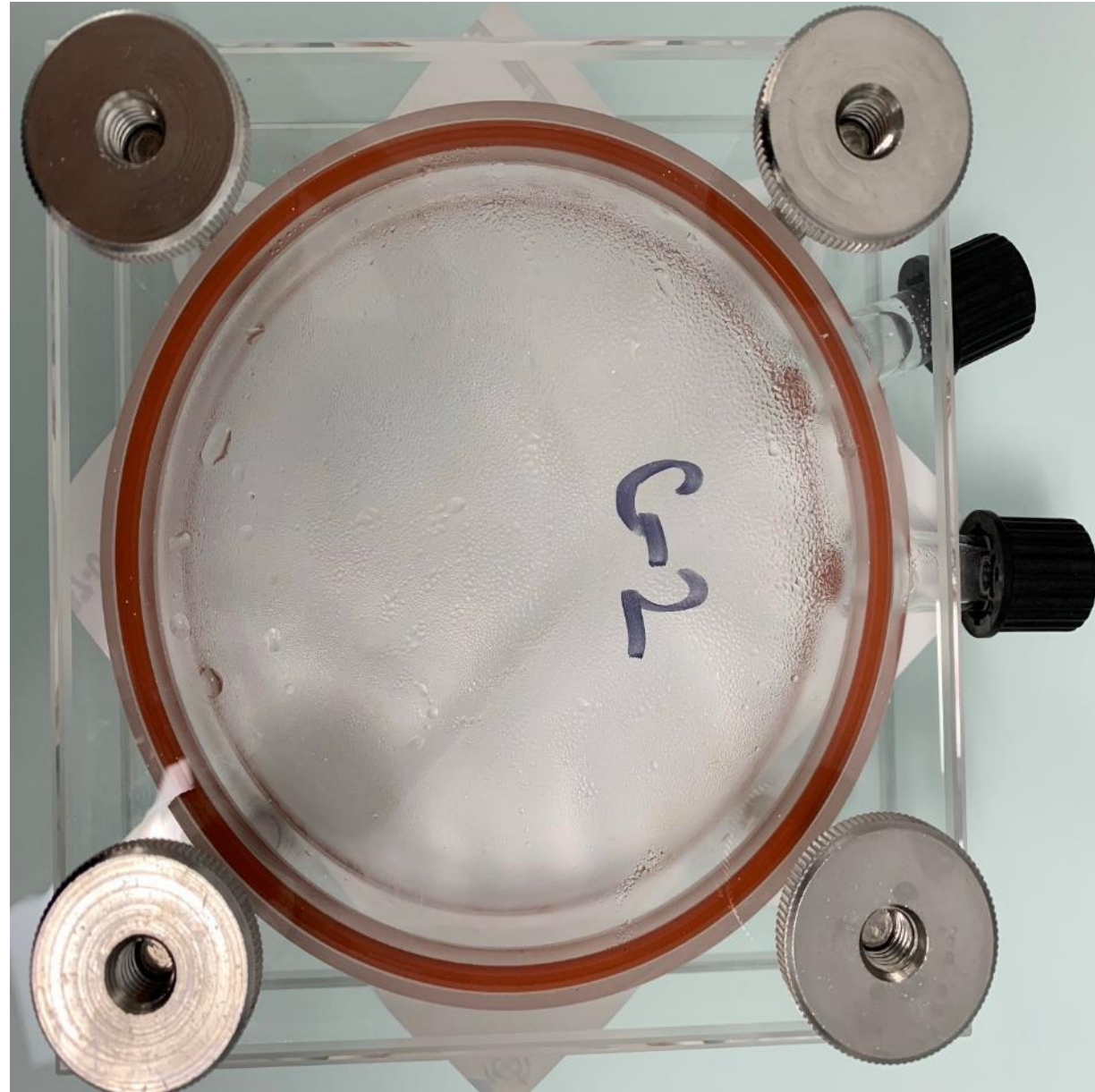
# MIGRATION VIA BACKSIDE TRANSFER



# LAB TESTING

## Migration Testing

- Migration cells with seal to eliminate leaking of simulant
- Simulant: 95% ethanol
- Temperature: 40°C
- Duration: 1 day
- Contact: backside, 1dm<sup>2</sup>
- Analyzed by GC/MS



# RESULTS



# RESULTS (Film Properties)









<b>Film Properties</b>						
<b>No Varnish</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
UV Thumbtivist Cure	Pass	Pass	Pass	Pass	Pass	Pass
IPA Resistance	6	12	40	38	42	40
Crosshatch 610 Tape Adhesion	Pass	Pass	Pass	Pass	Pass	Pass
<b>Retortable Coating</b>						
Crosshatch 610 Tape Adhesion	Pass	Pass	Pass	Pass	Pass	Pass
Impact 20inch-lbs	Pass	Pass	Pass	Pass	Pass	Pass
Impact 40inch-lbs	Pass	Pass	Pass	Pass	Pass	Pass
MEK Resistance	Pass	Pass	Pass	Pass	Pass	Pass
Sheen Scratch (grams)	3600+	3600+	3600+	3600+	3600+	3600+
38mm Cap Fabrication	Pass	Pass	Pass	Pass	Pass	Pass

**Key:**

- 1: UV, 50% Power, 100 fpm, 95mm black
- 2: LED, 50% Power, 100 fpm, 95mm black
- 3: UV, 50% Power, 100 fpm, 95mm White
- 4: LED, 50% Power, 100 fpm, 95mm White
- 5: UV 100% Power, 25 fpm, 25 mm Black
- 6: LED 100% Power, 25 fpm, 25 mm Black





# RESULTS



Variable	Sidewall (Mag: 27.5x)	Curl (Mag: 29.5x)
1 – Black UV		
2 – Black LED		
5 - Black UV		
6 – Black LED		

# RESULTS



Variable	Sidewall (Mag: 27.5x)	Curl (Mag: 29.5x)
3 – White UV		
4 - White LED		



# RESULTS

## Migration

- Ink cure: Best case scenario
- Pressure: zero



Print Side

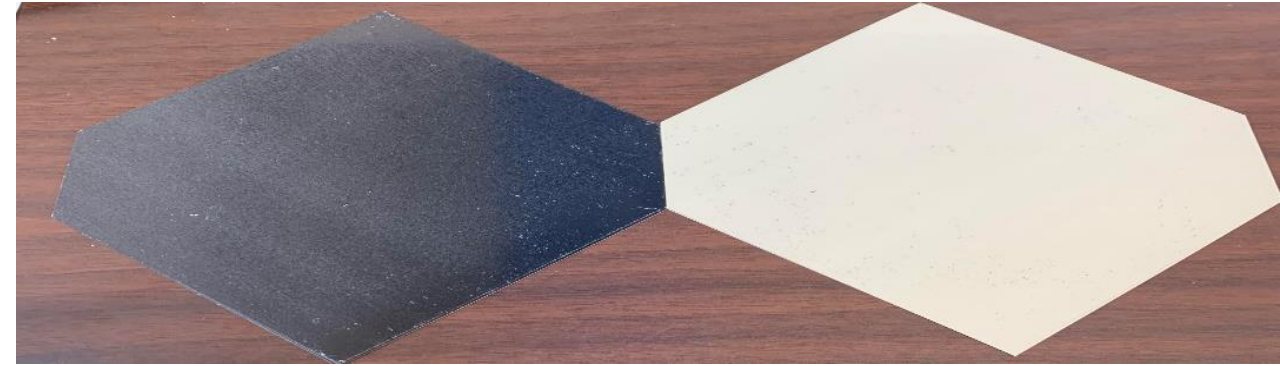
Back Side

Substance	Variable 1 (UV Mercury)	Variable 2 (LED)
Monomer 1	Not Detectable	Not Detectable
Monomer 2	Not Detectable	Not Detectable
Photo-initiator 1	Not Detectable	Not Detectable
Photo-initiator 2	Not Detectable	Not Detectable
Photo-initiator 3	Not Detectable	Not Detectable

# RESULTS

## Migration

- Ink cure: Worst case scenario
- Pressure: Zero



Print Side

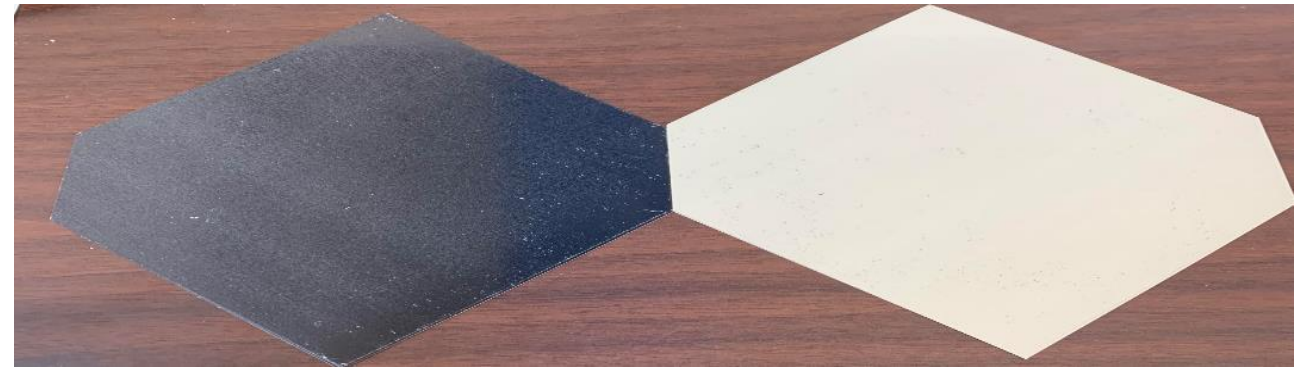
Back Side

Substance	Variable 1 (UV Mercury)	Variable 2 (LED)
Monomer 1	Not Detectable	Not Detectable
Monomer 2	Not Detectable	Not Detectable
Photo-initiator 1	25 ppb	13 ppb
Photo-initiator 2	Not Detectable	Not Detectable
Photo-initiator 3	Not Detectable	Not Detectable

# RESULTS

## Migration

- Ink cure: Best case scenario
- Pressure : Stack simulated



Print Side

Back Side

Substance	Variable 1 (UV Mercury)	Variable 2 (LED)
Monomer 1	Not Detectable	Not Detectable
Monomer 2	Not Detectable	Not Detectable
Photo-initiator 1	16 ppb	17 ppb
Photo-initiator 2	6 ppb	8 ppb
Photo-initiator 3	2 ppb	2 ppb

# RESULTS

## Migration

- Ink cure: Worst case scenario
- Pressure : Stack simulated
- Backside transfer observed for both samples
- Migration testing not performed due to backside transfer



# CONCLUSIONS

## For inks tested:

- No differences in film properties
- No differences in fabrication of 38mm caps
- No differences in migration testing for inks tested when thoroughly cured
- Backside transfer was observed when inks were cured under the worst case scenario regardless whether UV mercury or LED cured



# CONCLUSIONS (continued)

- Even after passing thumb twist cure test black ink still exhibits backside transfer (e.g. low peak irradiance)
- This is a lab study only. Results on a commercial press may vary.

Cure	Power	Speed (fpm)	Height (mm)		
LED	50%	100	95		
UV A	UV A	UV B	UV B	UV A2	UV A2
mJ/cm2	mW/cm2	mJ/cm2	mW/cm2	mJ/cm2	mW/cm2
131	1,589	3	42	225	2,737
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53	221	34	141	17	69



# QUESTIONS??

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