IEEE Round Robin QUV Testing

PPG / Sherwin Williams

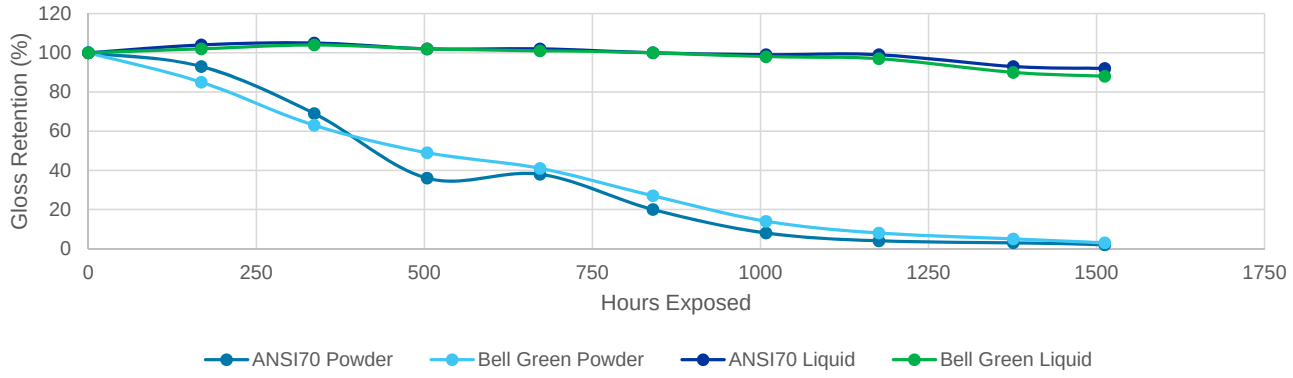
October 31, 2017

Round Robin Test Matrix Background

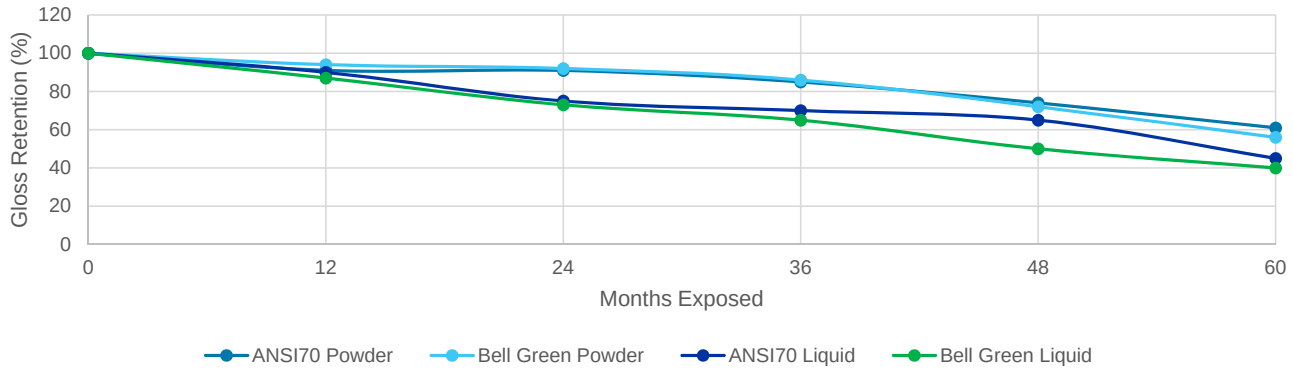
- Developed from discussion during IEEE meeting in Vancouver in October 2016
- Designed to evaluate gloss retention of current coatings used by several manufacturers using different QUV bulbs
- Test results would be used to determine whether a test method specification using UVA-340 bulbs could be developed as a replacement for the current test method specification based on FS-40 bulbs
- Five manufacturers prepared and submitted panels to PPG and Sherwin Williams for testing using UVA-340 and UVB-313EL bulbs
- Each manufacturer tested panels using FS-40 bulbs
- Additional panels were prepared by PPG and Sherwin Williams and included as negative controls for testing using UVA-340 and UVB-313EL bulbs

Review of UVB-313EL vs Florida durability for Powder & Liquid IEEE Approved Systems

UVB-313EL I=0.48 @ 313 nm (simulates FS-40)

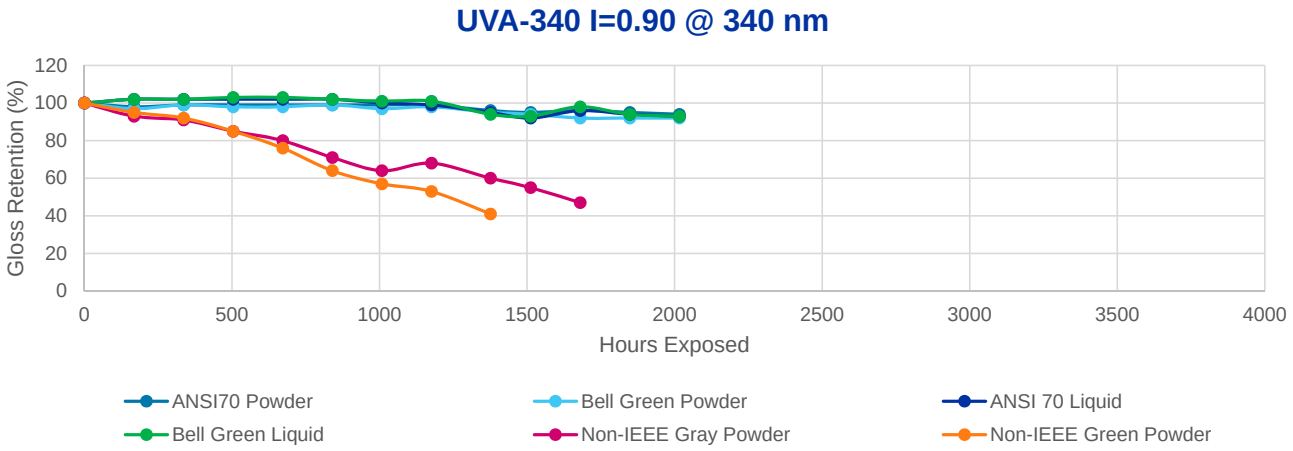


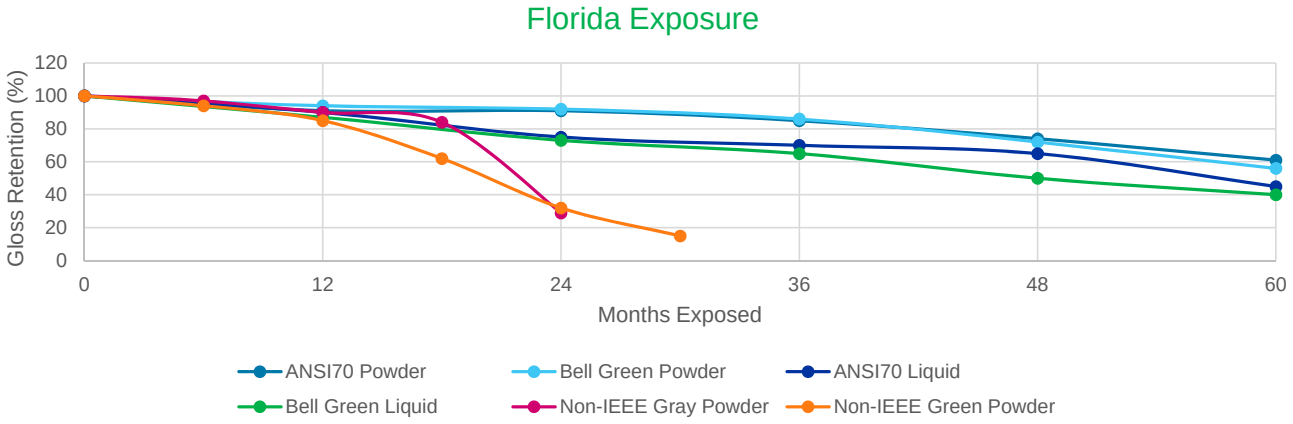
Florida Exposure



Information previously presented at IEEE 2016 Fall Conference – Vancouver, Canada

Review of UVA-340 vs Florida durability for Powder & Liquid IEEE Approved Systems





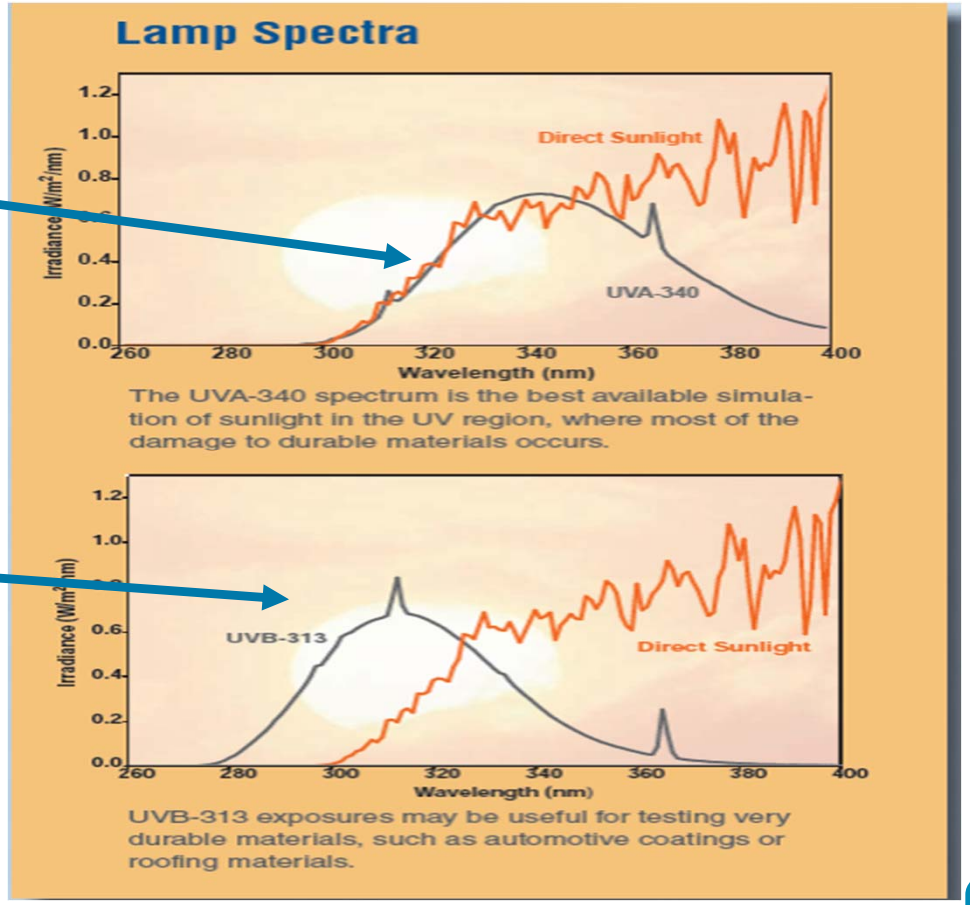
Information previously presented at IEEE 2016 Fall Conference – Vancouver, Canada

Comparison of spectral curves of UVA and UVB bulbs versus sunlight

UVA-340 bulbs mimic sunlight better

than UVB-313 bulbs do

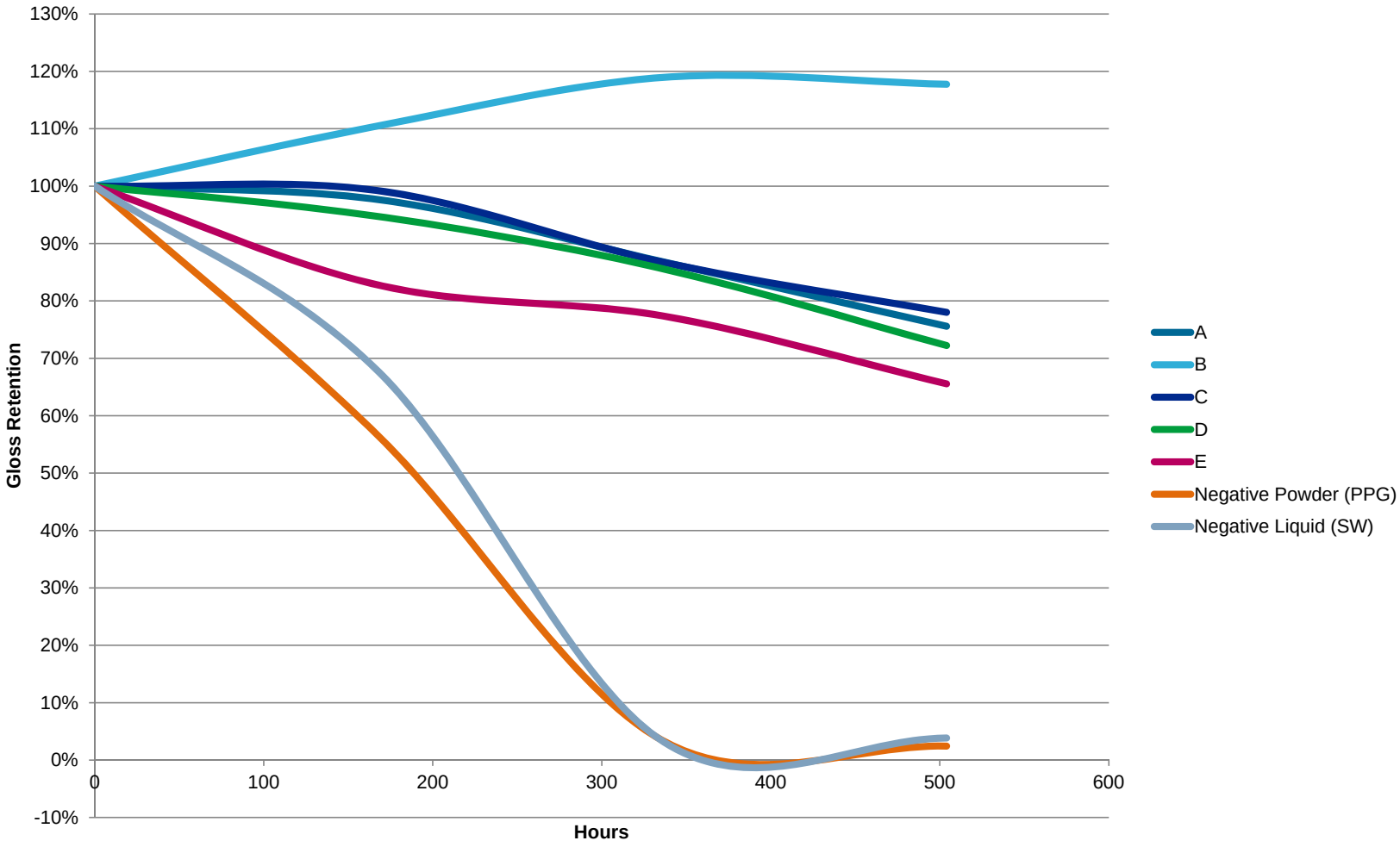
- Some wavelengths (<300nm) don't exist on terrestrial earth so can be too aggressive on some paint systems



Green Topcoat UVB-313EL vs. FS-40

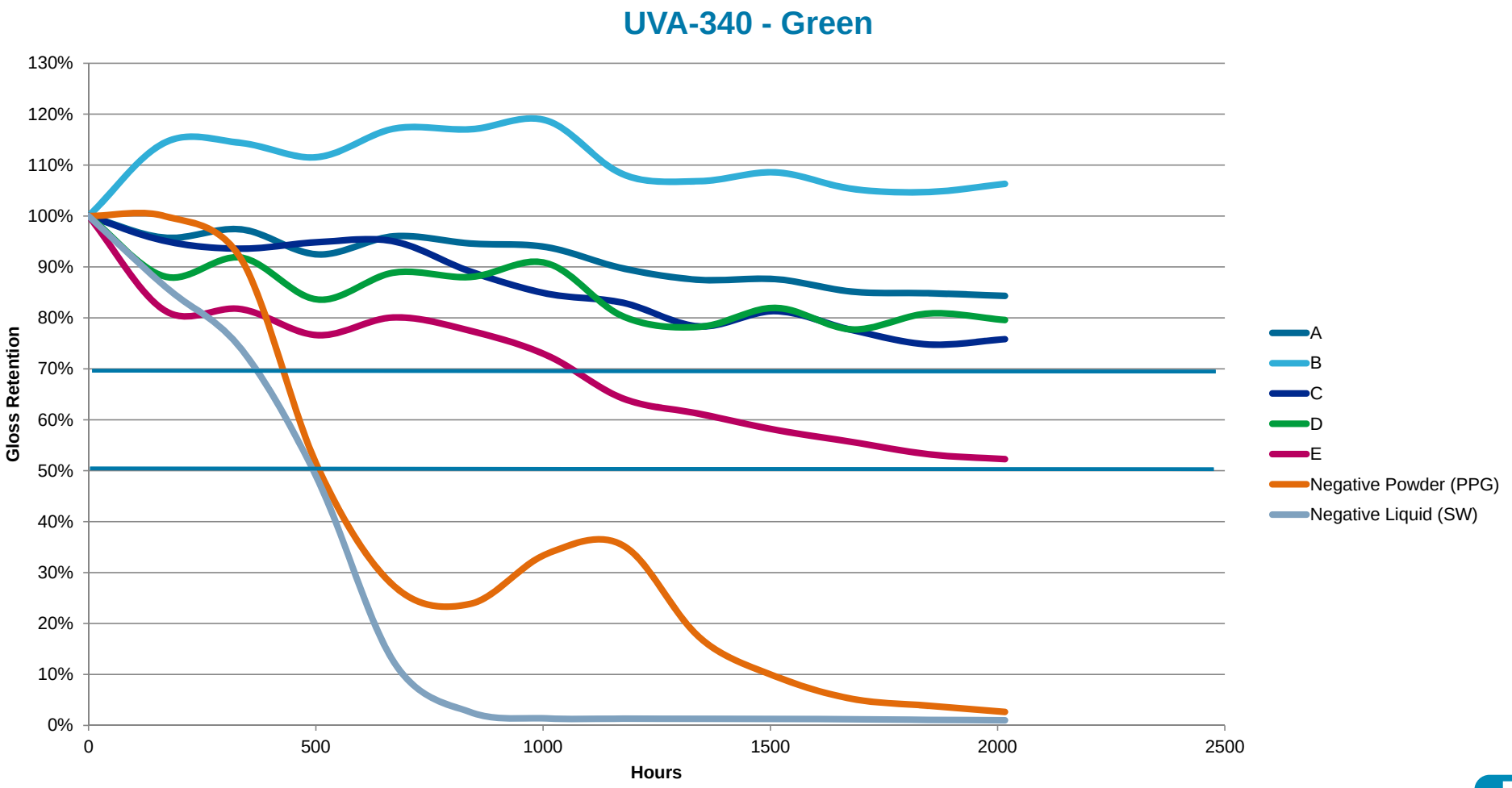
Panel ID	Test Lab	QUV Bulb	Irradiance	Initial Gloss	504 Hours Gloss	504 Hours % Ret.
	PPG	UVB-313EL	0.48	66.5	44.4	66.8%
GN1	SW	UVB-313EL	0.48	60.5	47.2	77.9%
		FS-40	0.48	64.6	32.3	50.8%
	PPG	UVB-313EL	0.48	47.0	31.7	67.3%
GN2	SW	UVB-313EL	0.48	45.4	29.0	63.8%
		FS-40	0.48	48.5	28.4	58.6%
	PPG	UVB-313EL	0.48	52.5	43.9	83.6%
GN3	SW	UVB-313EL	0.48	43.4	31.4	72.3%
		FS-40	0.48	53.0	47.4	89.5%
	PPG	UVB-313EL	0.48	58.5	42.1	72.0%
GN4	SW	UVB-313EL	0.48	56.4	44.6	79.1%
		FS-40	0.48	63.1	53.9	85.4%
	PPG	UVB-313EL	0.48	44.5	54.0	121.2%
GN5	SW	UVB-313EL	0.48	39.8	45.4	114.2%
		FS-40	0.48	40.9	50.6	123.7%
	PPG	UVB-313EL	0.48	60.0	1.8	2.9%
GN6	SW	UVB-313EL	0.48	58.8	1.2	2.0%
	PPG	UVB-313EL	0.48	95.0	6.3	6.6%
GN7	SW	UVB-313EL	0.48	95.0	1.1	1.1%

UVB-313EL - Green



Green Topcoat UVA-340 vs. FS-40

Panel ID	Test Lab	QUV Bulb	Irradiance	Initial Gloss	504 Hours Gloss	504 Hours % Ret.	1008 Hours Gloss	1008 Hours % Ret.	1512 Hours Gloss	1512 Hours % Ret.	2016 Hours Gloss	2016 Hours % Ret.
	PPG	UVA-340	0.9	65.0	52.6	80.9%	56.2	86.5%	49.3	75.8%	45.4	69.8%
GN1	SW	UVA-340	0.9	57.7	49.7	86.2%	54.8	95.0%	50.8	88.0%	51.5	89.2%
		FS-40	0.48	64.6	32.3	50.8%						
	PPG	UVA-340	0.9	48.5	36.2	74.6%	36.7	75.7%	27.9	57.5%	25.4	52.3%
GN2	SW	UVA-340	0.9	45.1	35.4	78.6%	31.4	69.7%	26.4	58.5%	23.6	52.3%
		FS-40	0.48	48.5	28.4	58.6%						
	PPG	UVA-340	0.9	53.5	54.8	102.3%	53.7	100.4%	54.8	102.4%	53.9	100.7%
GN3	SW	UVA-340	0.9	45.7	40.0	87.4%	31.7	69.3%	27.5	60.2%	23.3	51.0%
		FS-40	0.48	53.0	47.4	89.5%						
	PPG	UVA-340	0.9	58.5	53.9	92.1%	54.3	92.8%	48.9	83.5%	46.4	79.3%
GN4	SW	UVA-340	0.9	56.6	52.5	92.7%	53.8	95.0%	51.9	91.6%	50.5	89.2%
		FS-40	0.48	63.1	53.9	85.4%						
	PPG	UVA-340	0.9	43.5	47.8	109.8%	54.2	124.5%	45.2	103.8%	44.2	101.6%
GN5	SW	UVA-340	0.9	40.5	45.9	113.3%	45.8	113.0%	45.9	113.3%	45.0	111.0%
		FS-40	0.48	40.9	50.6	123.7%						
	PPG	UVA-340	0.9	62.5	32.7	52.3%	19.9	31.8%	9.1	14.5%	2.0	3.1%
GN6	SW	UVA-340	0.9	59.6	29.3	49.2%	21.2	35.5%	2.8	4.7%	1.3	2.2%
	PPG	UVA-340	0.9	96.0	35.9	37.3%	1.3	1.4%	1.2	1.3%	1.0	1.0%
GN7	SW	UVA-340	0.9	93.9	55.6	59.2%	1.3	1.4%	1.2	1.3%	1.0	1.0%

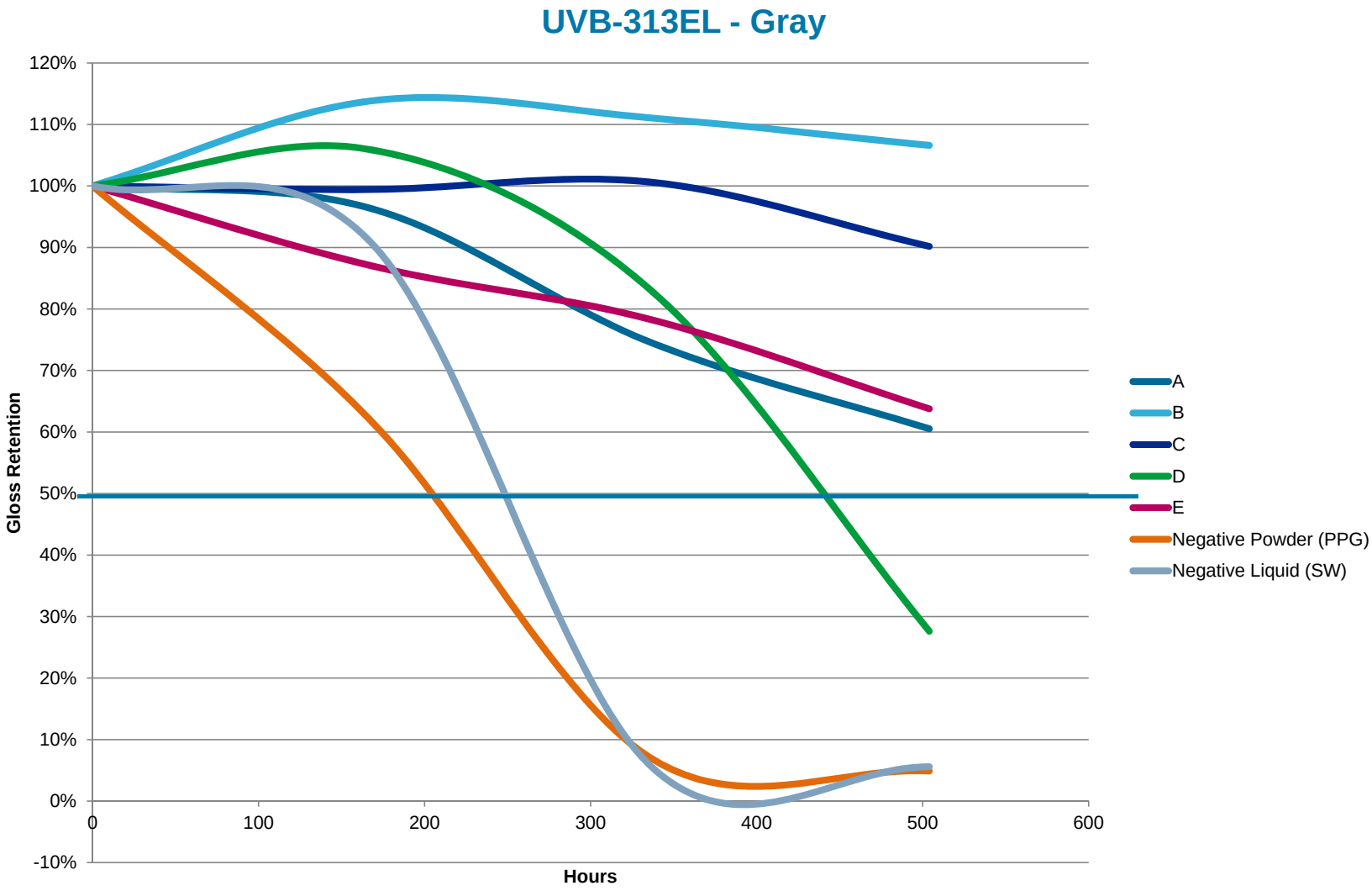

UVA-340 - Green
Gloss Retention
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
500
1000
1500
2000
2500
Hours
A
B
C
D
E
Negative Powder (PPG)
Negative Liquid (SW)

Conclusions – Green Topcoats

- The gloss retention of the manufacturers panels was >50% after 504 hours exposure to UVB-313EL and FS-40 bulbs
- The gloss retention of the negative controls (GN6, GN7) was <10% after 504 hours exposure to UVB-313EL bulbs
- The gloss retention of most of the manufacturers panels was >70% after 1008 hours exposure to UVA-340 bulbs
- The gloss retention of the negative controls (GN6, GN7) was <40% after 1008 hours exposure to UVA-340 bulbs
- The gloss retention of the manufacturers panels was >50% after 1512 hours exposure to UVA-340 bulbs
- The gloss retention of the negative controls (GN6, GN7) was <20% after 1512 hours exposure to UVA-340 bulbs

Gray Topcoat UVB-313EL vs. FS-40

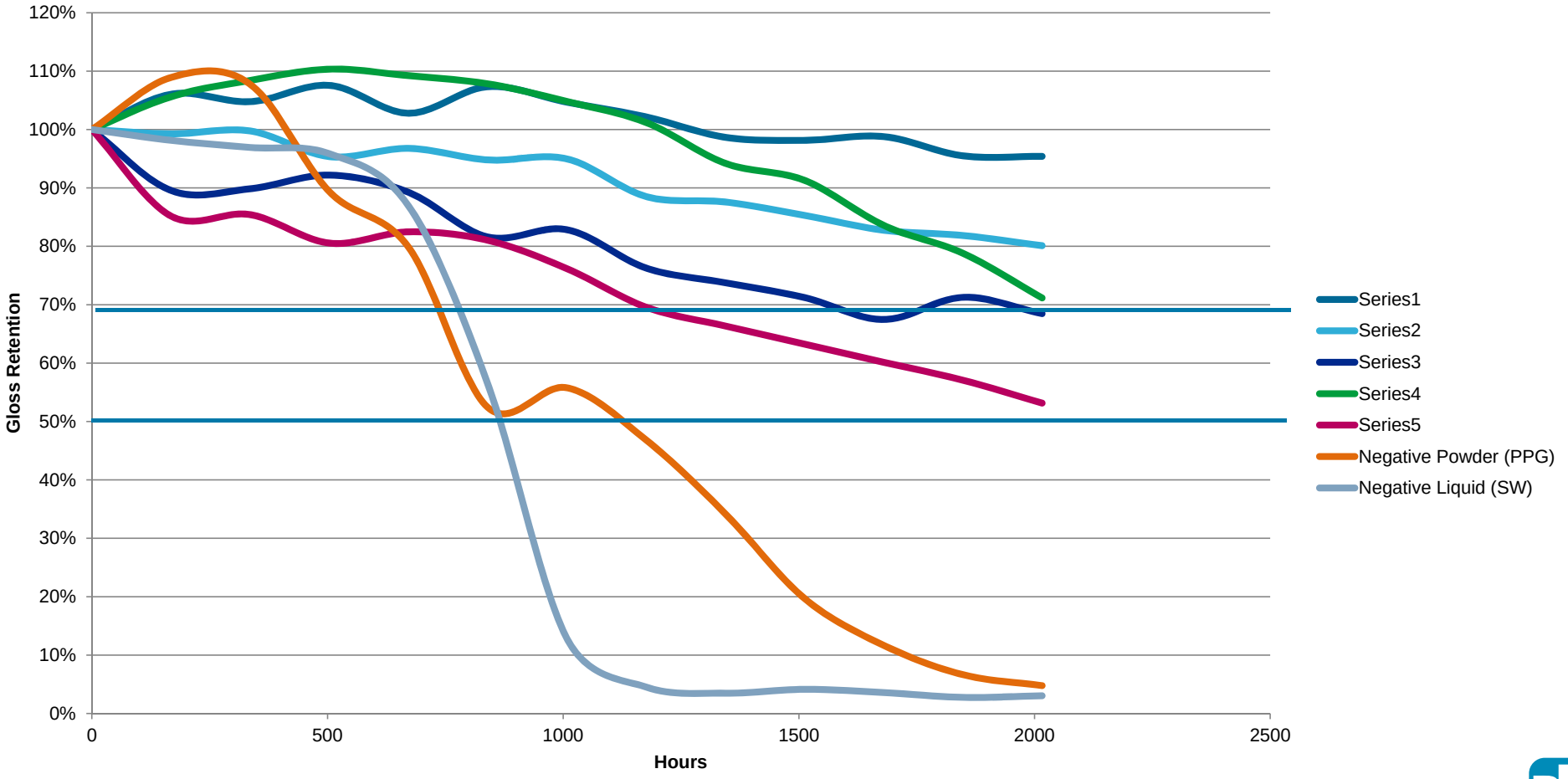
Panel ID	Test Lab	QUV Bulb	Irradiance	Initial Gloss	504 Hours Gloss	504 Hours % Ret.
	PPG	UVB-313EL	0.48	59.5	34.5	57.9%
GY1	SW	UVB-313EL	0.48	56.7	35.8	63.1%
		FS-40	0.48	64.4	66.3	102.8%
	PPG	UVB-313EL	0.48	52.5	43.2	82.2%
GY2	SW	UVB-313EL	0.48	35.6	35.0	98.2%
		FS-40	0.48	52.0	48.3	92.9%
	PPG	UVB-313EL	0.48	52.0	14.2	27.2%
GY3	SW	UVB-313EL	0.48	28.2	8.1	28.7%
		FS-40	0.48	54.6	12.5	22.8%
	PPG	UVB-313EL	0.48	75.0	72.2	96.2%
GY4	SW	UVB-313EL	0.48	54.9	64.2	116.9%
		FS-40	0.48	77.4	63.1	81.5%
	PPG	UVB-313EL	0.48	63.0	41.9	66.4%
GY5	SW	UVB-313EL	0.48	60.4	36.9	61.1%
		FS-40	0.48	61.6	42.0	68.2%
	PPG	UVB-313EL	0.48	50.0	2.3	4.6%
GY6	SW	UVB-313EL	0.48	50.2	2.6	5.2%
	PPG	UVB-313EL	0.48	97.5	9.3	9.5%
GY7	SW	UVB-313EL	0.48	94.5	1.6	1.7%


UVB-313EL - Gray
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
-10%
Gloss Retention
0
100
200
300
400
500
600
Hours
A
B
C
D
E
Negative Powder (PPG)
Negative Liquid (SW)

Gray Topcoat UVA-340 vs. FS-40

Panel ID	Test Lab	QUV Bulb	Irradiance	Initial	504 Hours		1008 Hours		1512 Hours		2016 Hours	
				Gloss	Gloss	% Ret.	Gloss	% Ret.	Gloss	% Ret.	Gloss	% Ret.
	PPG	UVA-340	0.9	64.0	71.0	110.9%	69.4	108%	66.4	104%	62.8	98%
GY1	SW	UVA-340	0.9	58.1	60.6	104.2%	58.7	101.0%	53.7	92.4%	53.8	92.6%
		FS-40	0.48	64.4	66.3	102.8%						
	PPG	UVA-340	0.9	53.5	52.8	98.7%	49.5	92.5%	43.9	82.0%	44.8	83.6%
GY2	SW	UVA-340	0.9	46.3	39.6	85.5%	33.9	73.1%	27.9	60.3%	24.7	53.2%
		FS-40	0.48	52.0	48.3	92.9%						
	PPG	UVA-340	0.9	53.0	60.0	113.2%	56.4	106.4%	48.7	91.9%	40.6	76.6%
GY3	SW	UVA-340	0.9	41.2	44.2	107.2%	42.6	103.4%	37.2	90.3%	27.1	65.8%
		FS-40	0.48	54.6	12.5	22.8%						
	PPG	UVA-340	0.9	74.0	71.1	96.1%	72.4	97.8%	63.7	86.1%	58.4	78.9%
GY4	SW	UVA-340	0.9	69.5	65.8	94.7%	64.1	92.2%	58.8	84.5%	56.6	81.4%
		FS-40	0.48	77.4	63.1	81.5%						
	PPG	UVA-340	0.9	65.0	50.8	78.2%	49.4	75.9%	39.0	60.0%	31.5	48.5%
GY5	SW	UVA-340	0.9	64.1	53.2	82.9%	49.0	76.4%	42.6	66.5%	37.0	57.7%
		FS-40	0.48	61.6	42.0	68.2%						
	PPG	UVA-340	0.9	49.0	44.3	90.4%	29.9	61.0%	15.7	32.0%	3.3	6.6%
GY6	SW	UVA-340	0.9	49.9	43.9	88.0%	25.3	50.7%	3.7	7.4%	1.5	2.9%
	PPG	UVA-340	0.9	98.0	93.2	95.1%	14.7	14.9%	5.5	5.6%	3.9	3.9%
GY7	SW	UVA-340	0.9	95.7	92.5	96.7%	10.3	10.7%	2.6	2.7%	2.1	2.1%

UVA-340 - Gray


120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Gloss Retention
0
500
1000
1500
2000
2500
Hours
Series1
Series2
Series3
Series4
Series5
Negative Powder (PPG)
Negative Liquid (SW)

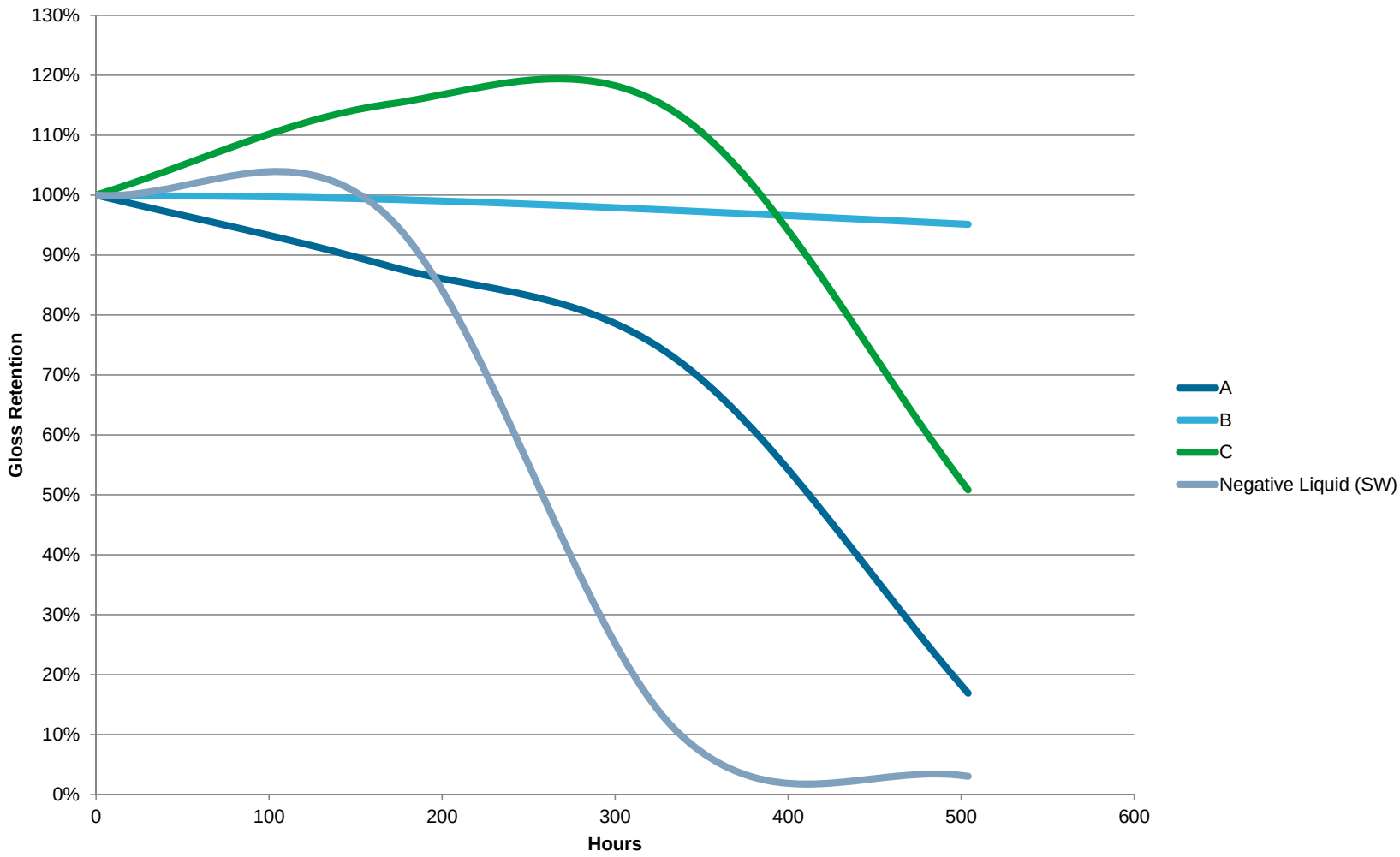
Conclusions – Gray Topcoats

- The gloss retention of most of the manufacturers panels was >50% after 504 hours exposure to UVB-313EL and FS-40 bulbs
- The gloss retention of the negative controls (GY6, GY7) was <10% after 504 hours exposure to UVB-313EL bulbs
- The gloss retention of the manufacturers panels was >70% after 1008 hours exposure to UVA-340 bulbs
- The gloss retention of the negative controls (GY6, GY7) was <65% after 1008 hours exposure to UVA-340 bulbs
- The gloss retention of the manufacturers panels was >50% after 1512 hours exposure to UVA-340 bulbs
- The gloss retention of the negative controls (GY6, GY7) was <35% after 1512 hours exposure to UVA-340 bulbs

Black Topcoat UVB-313EL vs. FS-40

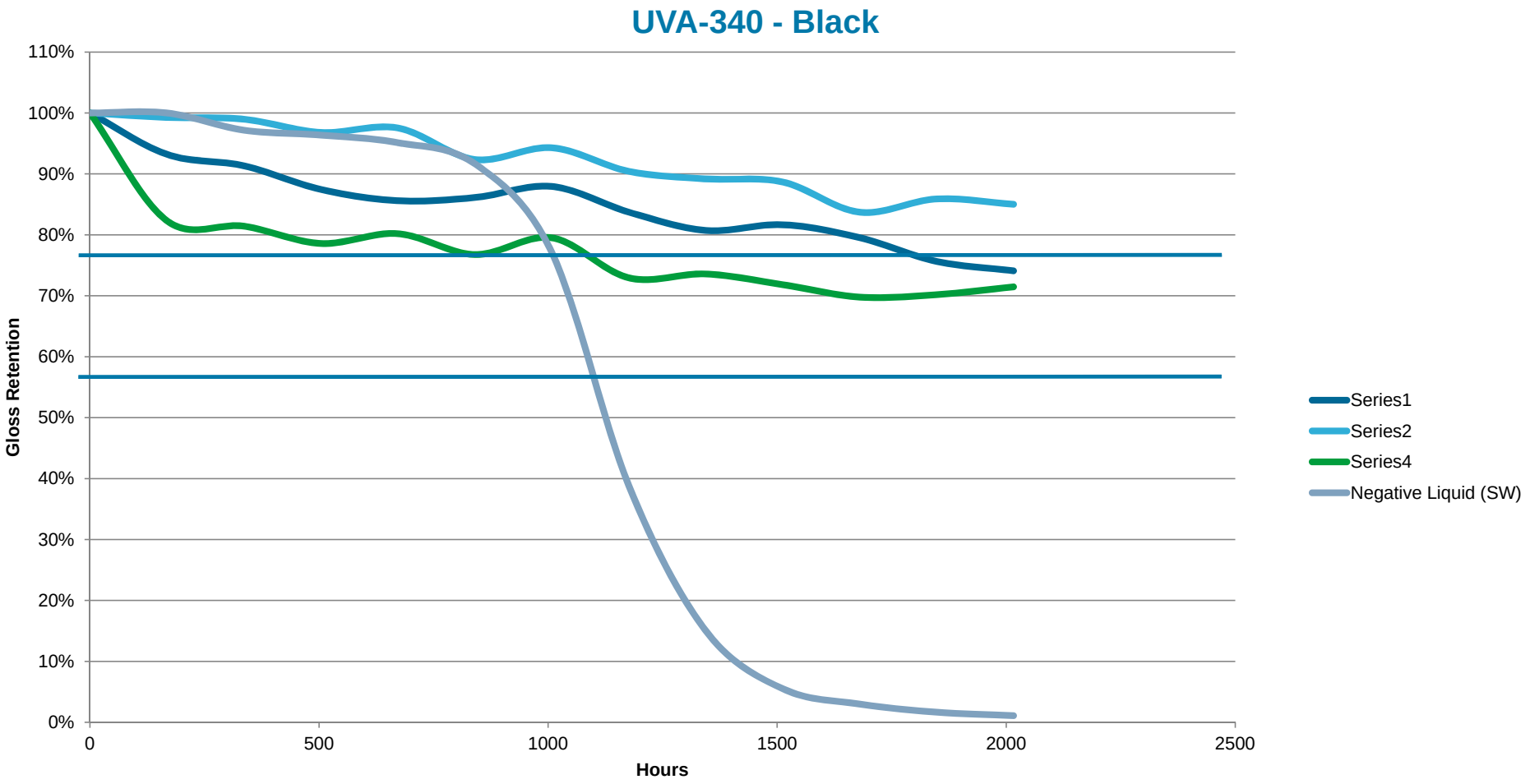
Panel ID	Test Lab	QUV Bulb	Irradiance	Initial Gloss	504 Hours Gloss	504 Hours % Ret.
	PPG	UVB-313EL	0.48	24.0	23.4	97.5%
BK1	SW	UVB-313EL	0.48	23.2	21.5	92.7%
		FS-40	0.48	23.1	23.5	101.7%
	PPG	UVB-313EL	0.48	68.0	17.4	25.5%
BK2	SW	UVB-313EL	0.48	61.2	5.1	8.3%
		FS-40	0.48	73.3	63.1	86.1%
	PPG	UVB-313EL	0.48	25.5	15.8	62.0%
BK3	SW	UVB-313EL	0.48	18.9	7.1	37.6%
		FS-40	0.48	28.7	14.9	52.0%
	PPG	UVB-313EL	0.48	96.5	4.9	5.0%
BK4	SW	UVB-313EL	0.48	94.7	1.0	1.1%

UVB-313EL - Black



Black Topcoat UVA-340 vs. FS-40

Panel ID	Test Lab	QUV Bulb	Irradiance	Initial	504 Hours		1008 Hours		1512 Hours		2016 Hours	
				Gloss	Gloss	% Ret.	Gloss	% Ret.	Gloss	% Ret.	Gloss	% Ret.
	PPG	UVA-340	0.9	27.0	25.8	95.6%	26.3	97.2%	23.5	86.9%	22.4	82.8%
BK1	SW	UVA-340	0.9	23.5	23.0	97.9%	21.4	91.3%	21.2	90.2%	20.4	87.0%
		FS-40	0.48	23.1	23.5	101.7%						
	PPG	UVA-340	0.9	68.5	59.4	86.6%	58.8	85.8%	52.9	77.2%	44.6	65.0%
BK2	SW	UVA-340	0.9	54.4	47.6	87.5%	48.9	89.9%	46.6	85.6%	45.2	83.0%
		FS-40	0.48	73.3	63.1	86.1%						
	PPG	UVA-340	0.9	25.5	17.8	69.6%	18.0	70.6%	14.8	58.0%	14.3	56.1%
BK3	SW	UVA-340	0.9	16.5	14.4	87.5%	14.6	88.4%	14.1	85.7%	14.3	86.9%
		FS-40	0.48	28.7	14.9	52.0%						
	PPG	UVA-340	0.9	96.0	94.7	98.6%	68.1	70.9%	5.2	5.4%	1.1	1.1%
BK4	SW	UVA-340	0.9	96.0	90.4	94.2%	80.0	83.4%	5.5	5.7%	1.0	1.0%


UVA-340 - Black
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Gloss Retention
0
500
1000
1500
2000
2500
Hours
Series1
Series2
Series4
Negative Liquid (SW)

Conclusions – Black Topcoats

- Gloss retention of most of the manufacturers panels was >50% after 504 hours exposure to UVB-313EL and FS-40 bulbs
- Gloss retention of the negative control (BK4) was <10% after 504 hours exposure to UVB-313EL bulbs
- One set of panels with poor gloss retention when exposed to UVB-313EL bulbs exhibited good gloss retention when exposed to FS-40 and UVA-340 bulbs
- Gloss retention of all panels was >70% after 1008 hours exposure to UVA-340 bulbs
- Gloss retention of the manufacturers panels was >50% after 1512 hours exposure to UVA-340 bulbs
- Gloss retention of the negative control (BK4) was <10% after 1512 hours exposure to UVA-340 bulbs

QUV Bulb Comparison

- **UVA-340**
  - Proposed requirement: >70% gloss retention at 1000 hours or >50% gloss retention at 1500 hours
  - Pros:
    - Best correlation to outdoor environment
  - Cons:
    - Requires longer test cycle (1000-1500 hours) to differentiate between acceptable and unacceptable topcoats
    - Little to no experience for conditioning panels for SCAB testing
- **UVB-313**
  - Proposed requirement: >50% gloss retention at 500 hours
  - Pros:
    - Requires shorter test cycle to differentiate between acceptable and unacceptable topcoats
    - Significant experience for conditioning panels for SCAB testing
  - Cons:
    - Very aggressive test, may eliminate some products / technology that would perform well in outdoor environment
- **FS-40**
  - Pros:
    - Bulbs currently used by manufacturers
  - Cons:
    - Bulbs are difficult to find
    - Testing variability due to lack of irradiance control
    - Bulbs need to be changed more frequently due to wear and lack of irradiance control

Summary

- Variability observed between panels exposed to different bulbs
- Results indicate that longer test duration and/or higher % gloss retention requirements above 500 hour duration and 50% gloss retention requirement using FS-40 bulbs would be recommended if using UVA-340 bulbs
- Proposed requirements using UVA-340 bulbs (two options):
  - 70% gloss retention at 1000 hours
  - 50% gloss retention at 1500 hours
- Additional testing would be needed to verify proposed parameters using UVA-340 bulbs would be comparable to current parameters using FS-40 bulbs for conditioning panels for SCAB corrosion testing

Acknowledgements

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  - Mulkey Engineering – Dan Mulkey
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