Specification of Gonioapparent Color & Appearance

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June 18, 2014

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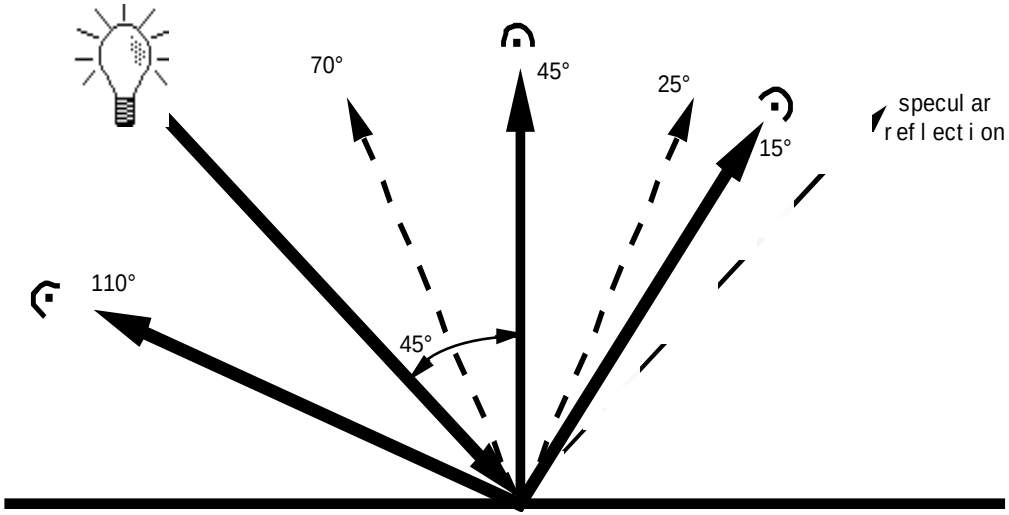
Presentation Outline

- Multiangle Color Measurement Summary
- DCC Committee Purpose
- Project Background
- Experimental Procedures
- Data Analysis
- Results
- Graininess Study
- Pathforward
- Acknowledgement

ASTM Geometry for Multiangle Color Measurement

E2194 recommendation for metallic colors. Solid lines are the preferred angles for critical measurements



E2539 Specified geometries for measuring the color range due to Interference. The E2194 geometries are used for measuring color due to scattering or orientation

Illumination Angle	Detection Angle	Aspecular Angle	Designation
45°	-60°	-15°	45°:-60° (as -15°)(ca 52.5)
45°	-30°	+15°	45°:-30° (as +15°)(ca 37.5)
15°	-30°	-15°	45°:-30° (as -15°)(ca 22.5)
15°	0°	+15°	15°: 0° (as +15°)(ca 7.5)

Note—This table gives the minimum geometries for the quality control application. For other applications, additional geometries; such as 65°:-50° (as15°), may be desirable or needed.

Committee Purpose: Upgrade SAEJ1545 with the goal of standardizing automotive industry practices for establishing color and flake appearance measurement and methodology for setting meaningful tolerances.

Membership

Chairman: Jeff Alspach, Axalta, Mt. Clemens, MI
Car manufacturers: Audi, Ford, GM(need others)
Coatings Suppliers: AkzoNobel, Axalta, BASF, PPG
Instrument Manufacturers: BYK-Gardner, X-Rite, GTI
Includes members from ASTM, CIE, DIN

March 2013 Sub-committee Meeting Attendees

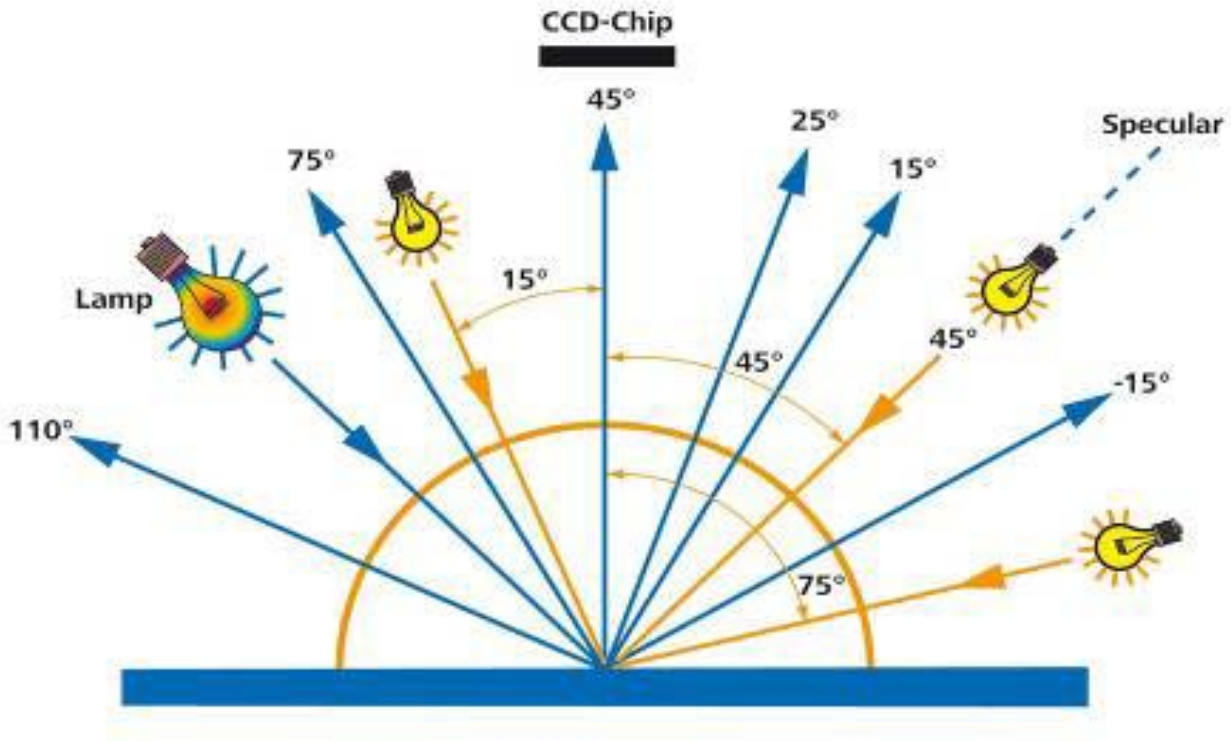
Project Background

- The BYK-mac multi-angle spectrophotometer is applied in measuring the color and flake appearance differences of automotive paints.

BYK-mac

- Previous experiments on metallic blue color and black color
- Process : estimate sparkle difference tolerances for several colors by visual assessment and using “Logit Analysis”.

BYK-mac Geometry



Courtesy of BYK-Gardner, GmbH

Basic Equations and Terms

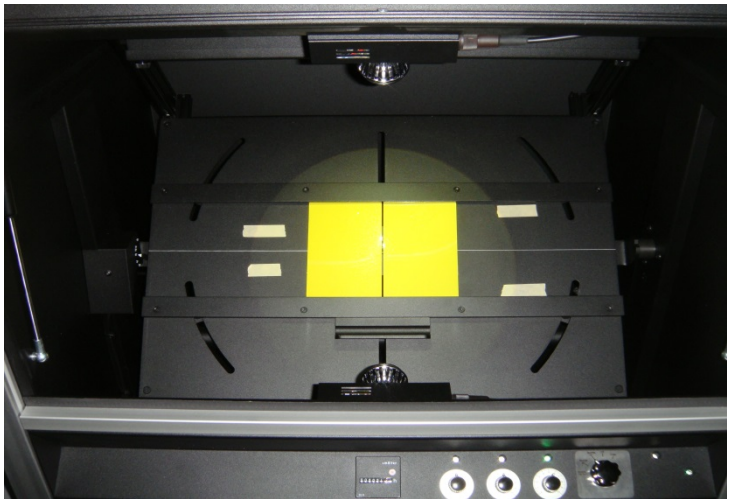
- Used ΔE94 color differences with the gonioapparent S_L Lightness correction

- Sparkle difference dS as provided by the BYK-mac

- Sparkle definition (ASTM E12.01):
  Sparkle, n- The aspect of the appearance of a material that seems to emit or reveal tiny bright points of light that are strikingly brighter than their immediate surround and are made more apparent when a minimum of one of the contributors (observer, specimen, light source) is moved.

Experimental Procedures

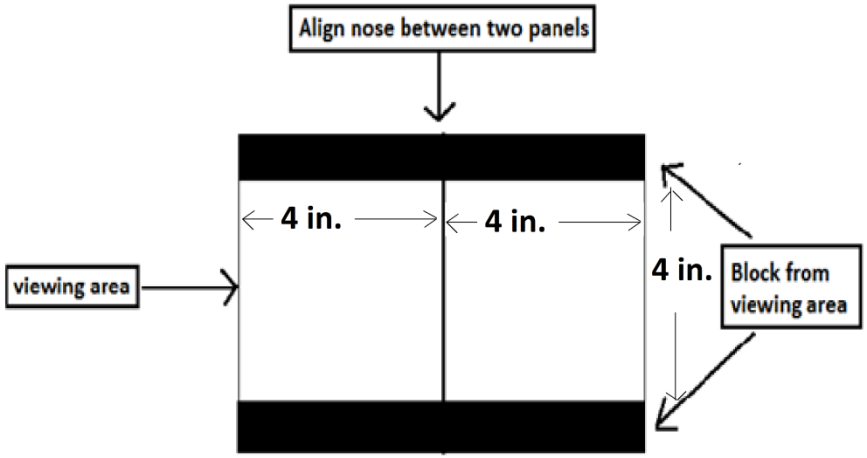
- The panels are observed in the BYKO-Spectra Effect lightbooth.

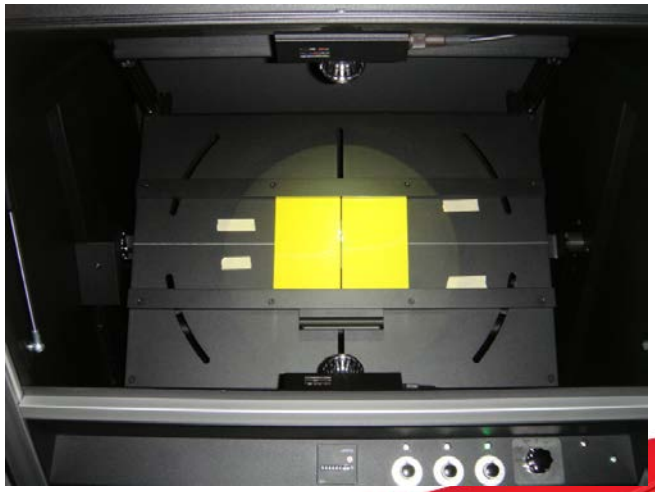


- The viewing window on the lightbooth is shortened from 20 in. width to 5 in. width (helps focus on the center of the panels)

Experimental Procedures

- 30 observers were asked to make visual assessments of sparkle difference acceptability. All of the observers had experience in judging automotive color and appearance acceptability.
- Panel pairs were randomly presented.
- Panels supporting board set at 45 degree, allowing viewing perpendicular to the panels with the sparkle light at 15, 45 or 75 degrees. The light intensity is adjusted to 7 (1 to 10 scale).
- Tapes at four corners help focus on the center





Experimental Procedures

Following is an example of the process used in selecting sample pairs for visual assessments:

11 panels combined to a total of 55 pairs of panels with known dE94 and dS measured by BYK-mac at the appropriate angle

↓ dE94 < 1

39 pairs of panels left

↓ dS < 1.3 (assumes 1.3 close to 100% rejection)

23 pairs of panels left

↓ choose pairs evenly spaced for

0.30< ds <1.30, dE94 < 0.85

12 pairs left

(Add dS pairs close to expected high and low rejection)

Experimental Procedures

- **Observers were asked:**

  "Ignoring any color differences, would you accept this sparkle difference between two adjacent car parts on your car?"

  --Accept, **"YES"**

  --Reject, **"NO"**

- **Assessment Template**

Bright Yellow			Observations of Sparkle Difference at 15 Degree								Date: 7/25/2013		
Question: Ignoring any color differences, would you accept this sparkle difference between two adjacent car parts on your car?													
Std ID	Bch ID		Std ID	Bch ID		Std ID	Bch ID		Std ID	Bch ID	
6	10		5	6		3	4		8	9	
8	10		3	4		5	6		5	6	
2	11		2	11		5	9		2	11	
4	6		8	9		8	9		3	4	
5	9		5	9		2	11		5	9	
3	4		8	10		8	10		8	10	
7	9		7	9		3	11		4	6	
4	5		5	7		5	7		5	7	
3	11		3	11		7	9		7	9	
9	10		9	10		4	6		3	11	
5	7		4	5		6	10		6	10	
8	9		4	6		9	10		2	3	
2	3		2	3		2	3		9	10	
5	6		6	10		4	5		4	5	
Observer:			Observer:			Observer:			Observer:		

Observer Data Smoothing

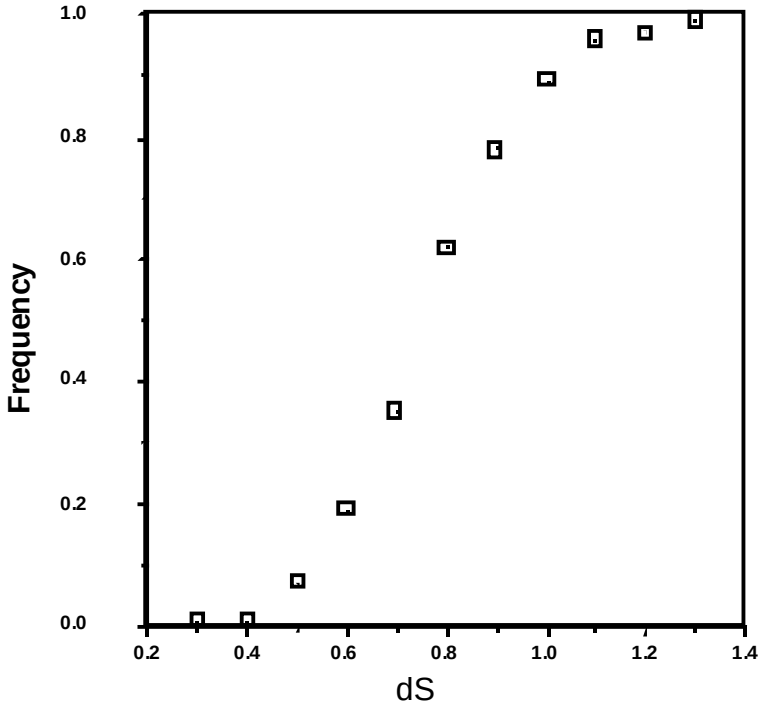
This process compensates for subjective variation in each observer's assessment

dS	Original Response	Add "0"		Integer Divide by 2	
		0			
1.48	y	0	0	0	OK
1.57	y	0	1	0	OK
1.60	n	1	1	0	OK
1.75	y	0	2	1	Rej
1.84	n	1	2	1	Rej
		1			
		Add "1"			

Berns et al, Visual Determination of Suprathreshold Color-Difference Tolerances Using Probit Analysis. Color Res Appl 1991; 16:297-316

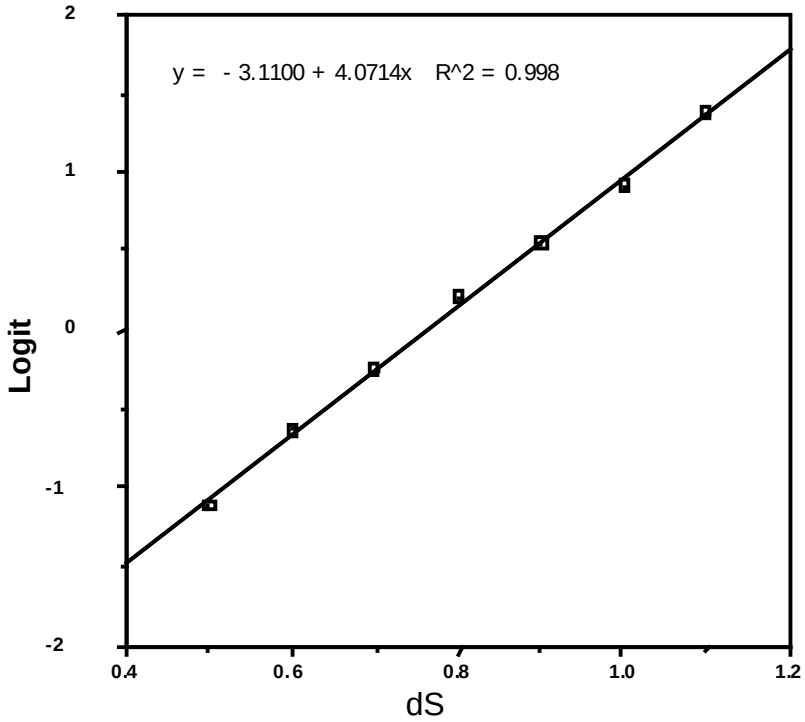
Logit Analysis

Typical frequency of rejection versus metric difference



Almost everyone accepts low dS pairs
Everyone rejects high dS pairs

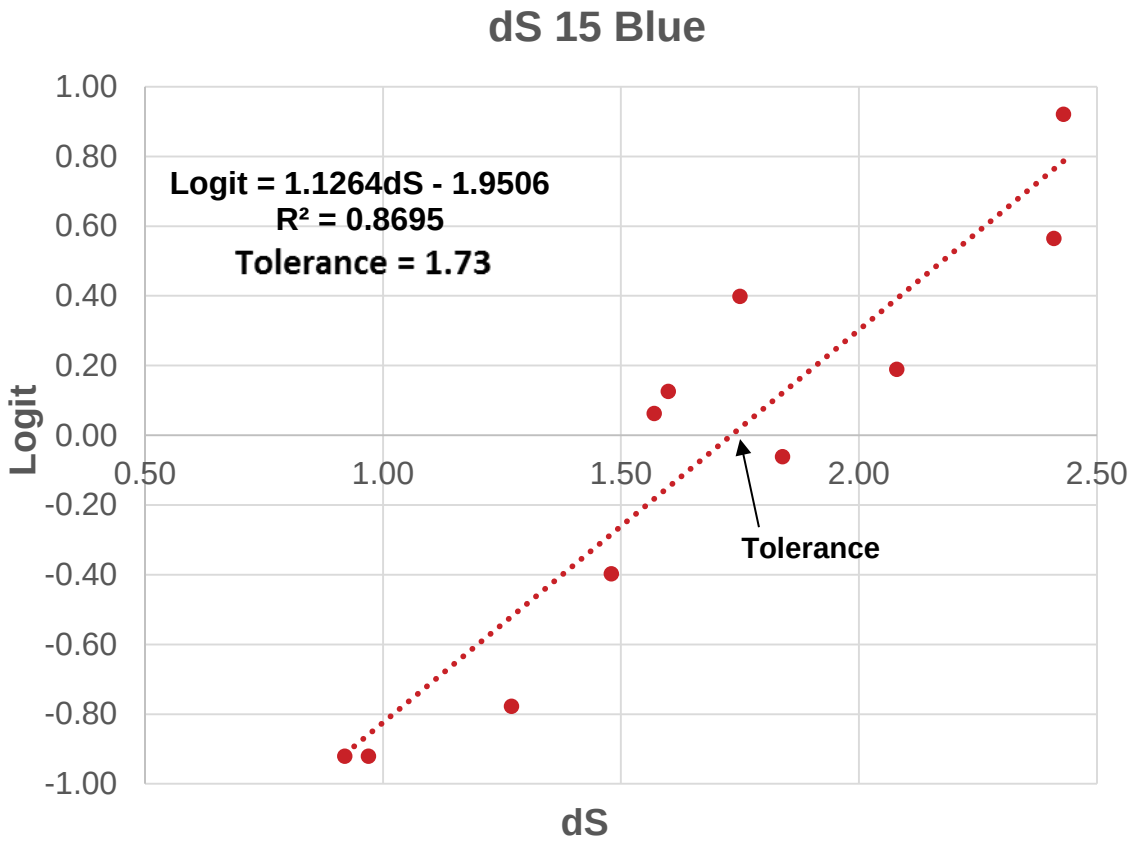
Logit function linearizes region of interest
Logit = log f/(1-f)



Logit linearizes a cumulative normal distribution allowing determination of a tolerance, dS at a reasonable acceptance rate (e.g. 50%)

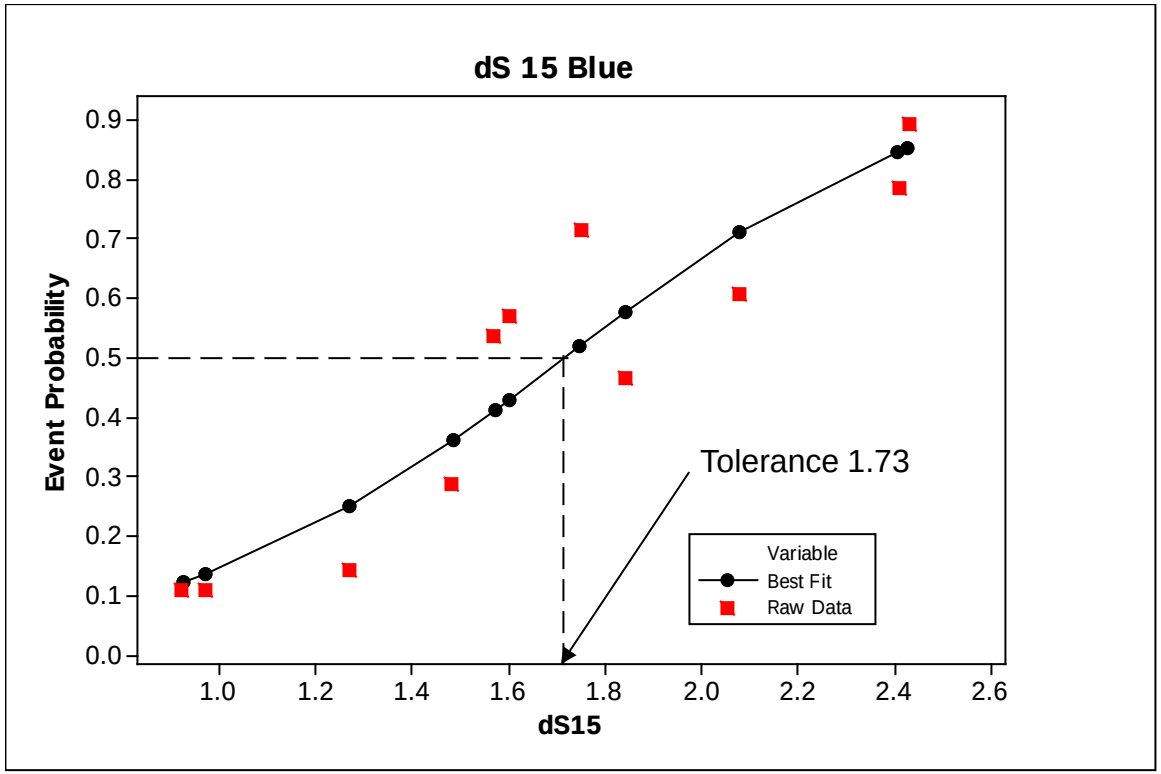
Typical Visual Assessment Results

Std ID	Bch ID	dE94 15	15 ds	Rej Freq	logit
5	6	0.30	0.92	0.107	-0.92
4	5	0.37	0.97	0.107	-0.92
2	11	0.33	1.27	0.143	-0.78
2	4	0.72	1.48	0.286	-0.40
3	5	0.23	1.57	0.536	0.06
9	10	0.59	1.60	0.571	0.12
6	8	0.47	1.75	0.714	0.40
4	6	0.26	1.84	0.464	-0.06
3	11	0.80	2.08	0.607	0.19
2	5	0.51	2.41	0.786	0.56
3	6	0.37	2.43	0.893	0.92



A 50% frequency of rejection (Logit = 0) is the recommended tolerance

Binary Logistic Regression (w / Logit link function)



Summary of Sparkle Studies to-date

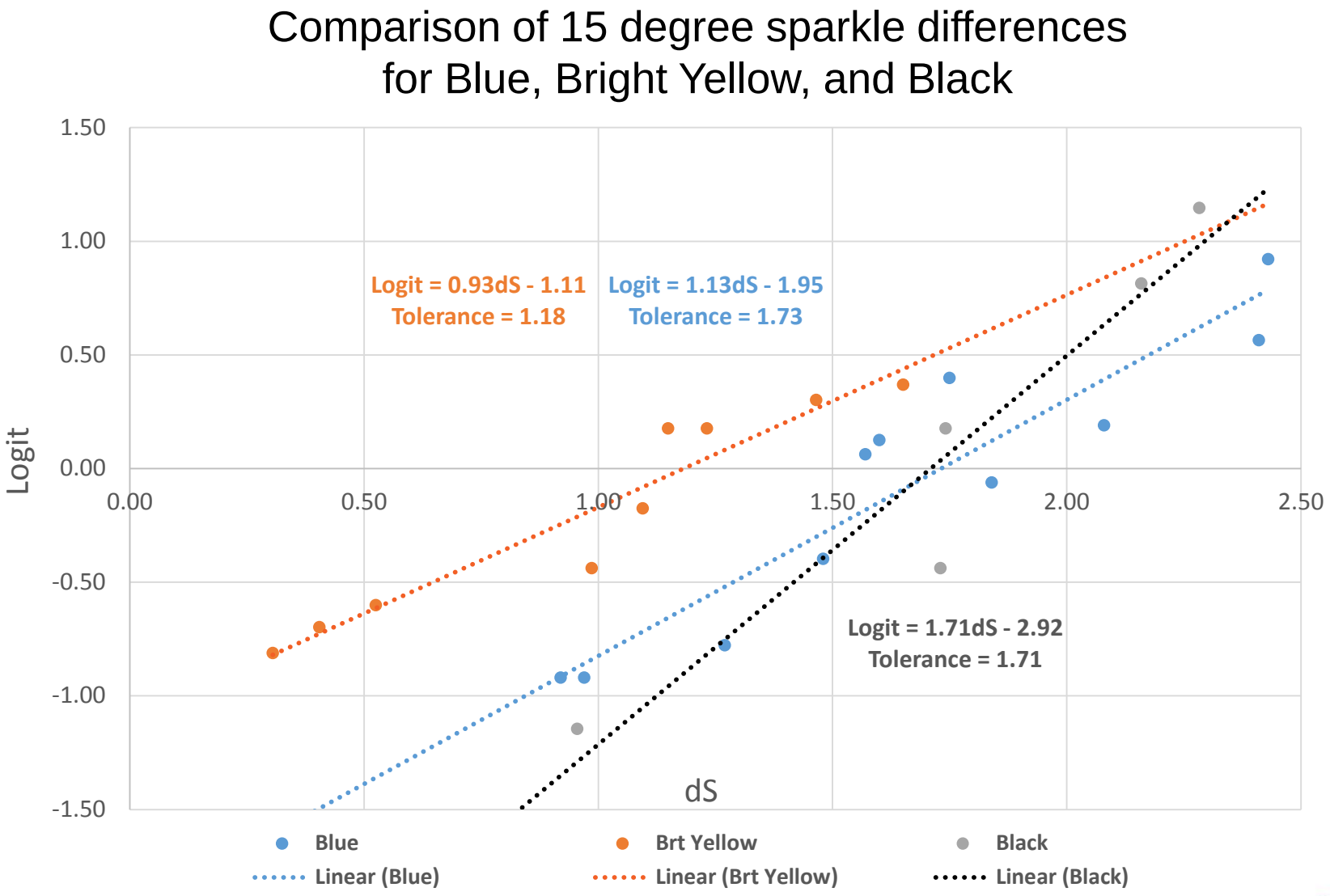
	ds15	ds45	ds75	dG
Cyber Gray	?	✓	✓	NO
Black	✓	✓	✓	✓*
Blue	✓	?	?	?
Brt Yellow	✓	?	NO	NO

* *Graininess results discussed later*

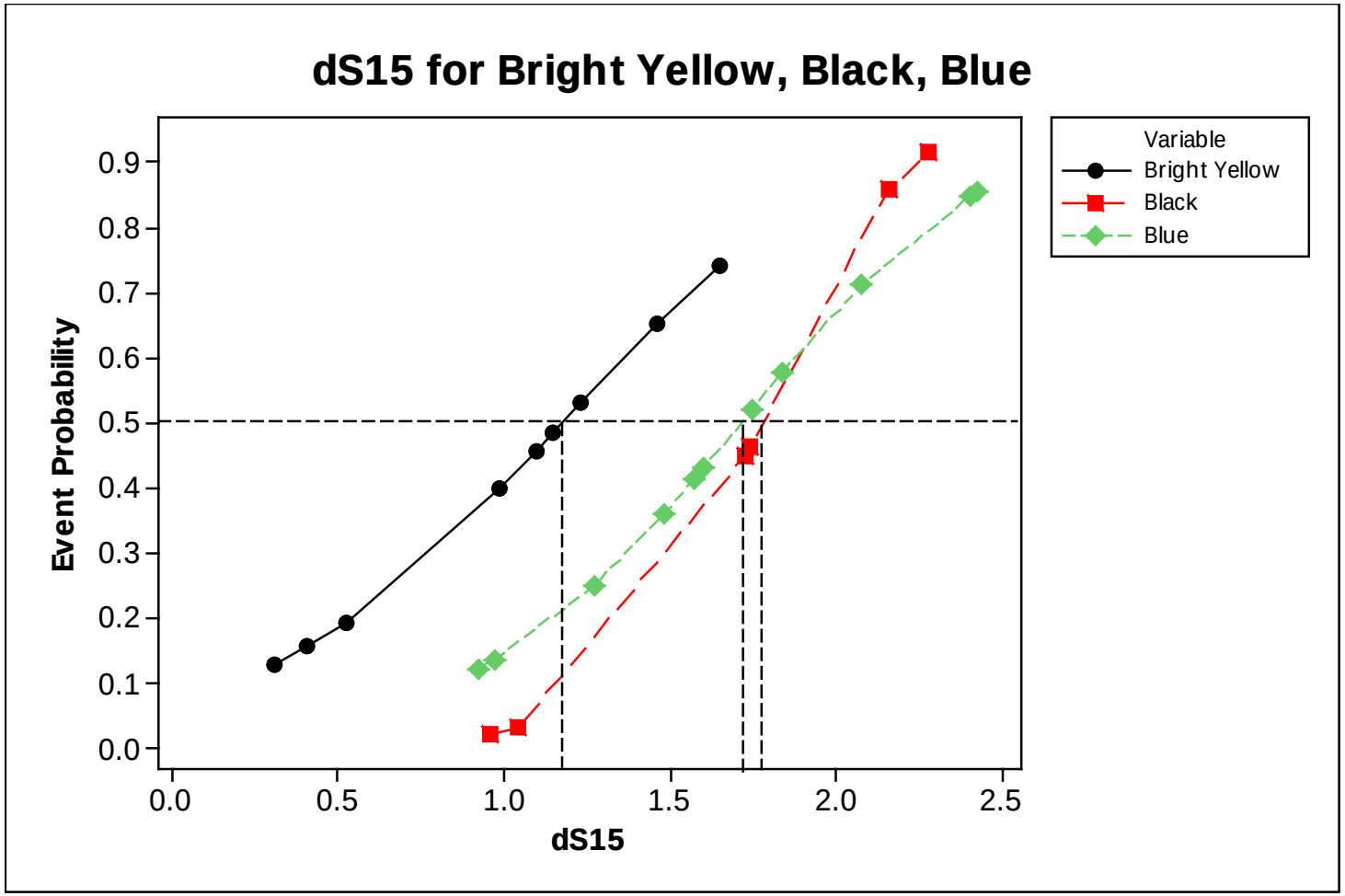
Results

	Avg L*	Avg C*	Tolerance	
Cyber Gray				
45	18.27	1.91	0.79	Logit = 2.29dS - 1.86
75	7.22	1.54	1.08	Logit = 2.63dS - 2.85
Black				
15	18.61	2.87	1.71	Logit = 1.71dS - 2.92
45	4.79	0.5	1.50	Logit = 1.38dS - 2.07
75	2.67	0.53	0.77	Logit = 1.25dS - 0.96
Blue				
15	54.42	58.43	1.73	Logit = 1.12dS - 1.95
Bright Yellow				
15	77.79	59.75	1.18	Logit = 0.93dS - 1.10

Results:

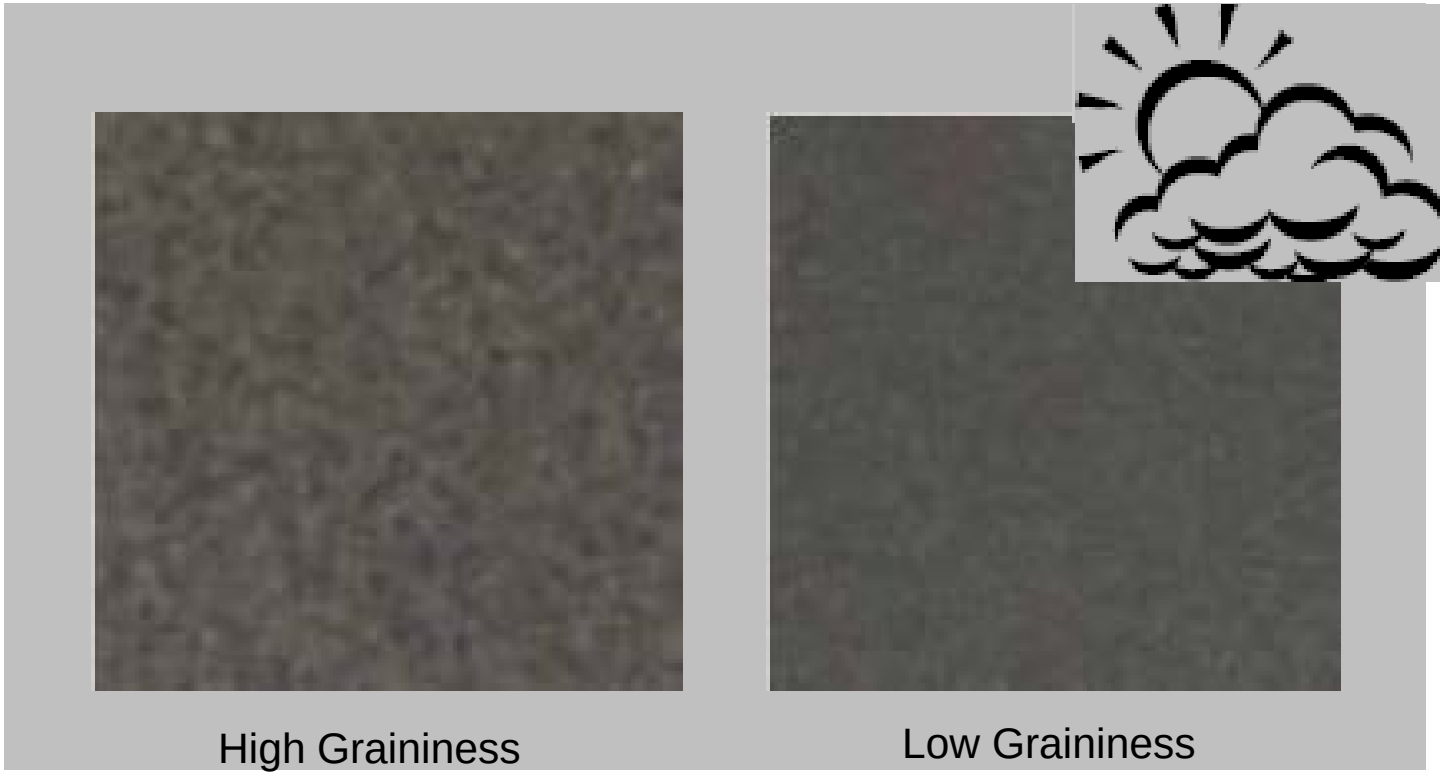

Comparison of 15 degree sparkle differences for Blue, Bright Yellow, and Black
Logit = 0.93dS - 1.11
Tolerance = 1.18
Logit = 1.13dS - 1.95
Tolerance = 1.73
Logit = 1.71dS - 2.92
Tolerance = 1.71
Logit
dS
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
0.00
0.50
1.00
1.50
2.00
2.50
Blue
Brt Yellow
Black
Linear (Blue)
Linear (Brt Yellow)
Linear (Black)

Equivalent results using binary linear regression



Graininess Study

- Graininess: Visual texture observed under cloudy day with diffused illumination

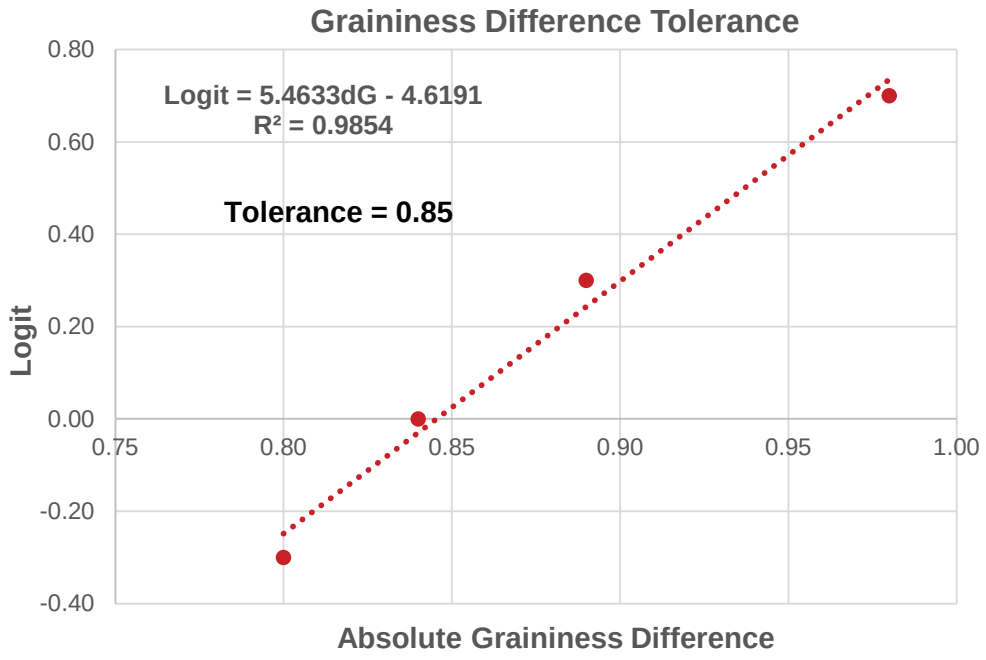


Images Courtesy of BYK-Gardner, GmbH

Graininess Study

Preliminary limited study on black

- BYKO-Spectra Effect lightbooth: color evaluation source at 45 degrees. Light diffusion was enhanced with two layers of white tissue over light source.
- Six observers as a start using the same visual assessment process and analysis method, total 11 panels and 14 pairs



dE 45	Abs ΔG	Freq. Rej.	Logit
0.45	0.8	0.33	-0.30
0.52	0.84	0.50	0.00
0.48	0.89	0.67	0.30
0.55	0.98	0.83	0.70

Note: 6 observers are not sufficient. More data points and a better estimate of graininess acceptability will be available as observers are added.

Overall Progress on Specification of Gonioapparent Color & Appearance

Color

- ✓ Definitions in ASTM E284
- ✓ Measurement of metallic – ASTM E2194
- ✓ Measurement of pearls – ASTM E2539
- ✓ Update SAE J5145

Spatial Appearance

- ✓ Definitions in ASTM E284
- ? ASTM standard on measurement of spatial appearance
- ? Revision of SAE J1545

Pathforward

- Additional visual assessments for additional sparkle angles and other metallic colors to estimate the sparkle and graininess difference tolerances.
- Include observers from OEM’s and other coatings suppliers.
- Explore generalized tolerances, e.g., possible relationship to color, lightness, hue, chroma, contrast, etc.

Acknowledgements

- BYK-Gardner for their support and providing the BYKO-Spectra Effect lightbooth for the visual assessments
- Members of the DCC Committee
- DCC for their sponsorship
- Our colleagues in Axalta Coating Systems for their inputs and participation in visual assessments
- In advance to suppliers of future color sets and participants in on-going experiments

Thank You!
Any Questions?

ASTM E12.01 Definitions

sparkle-intensity, *n*—the contrast between the appearance highlights on the particles of a gonioapparent pigment and their immediate surround.

sparkle-area, *n*—the area segment of the illuminated portion a sample surface with light-spots that are strikingly brighter than their immediate surround.

sparkle, n—The aspect of the appearance of a material that seems to emit or reveal tiny bright points of light that are strikingly brighter than their immediate surround and are made more apparent when a minimum of one of the contributors (observer, specimen, light source) is moved.
Discussion**—** Sparkle is perceived under intense directional illumination only

graininess, *n*—the perceived contrast of the light/dark irregular pattern exhibited by gonioapparent coatings when viewed under diffuse illumination, scale typically < 100 micrometers.
Discussion**—** Also referred to as **diffuse coarseness**.

ASTM E12.01 Definitions

texture, *n*—the visible structure depending on the size and organization of small constituent parts of a material; typically, the surface structure of a woven fabric, or subsurface structure of a gonioapparent material. (C460)***C***

glint, *n*—see preferred term **sparkle**.

diffuse-coarseness, *n*—see preferred term **graininess**.

Spatial appearance, *n*—those attributes of appearance that have a spatial component including texture, graininess, sparkle, etc.

Discussion— For fabrics the spatial dimension is usually <10 mm, for painted materials the spatial dimension is usually, < 1mm.