Measure what you see.

Experience with actual instrumentation

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BYK-Gardner GmbH, 2019

A member of ALTANA

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Correlation study

Axalta study for DCC / SAE Project

DCC/SAE Progress
on
Measurement and Specification
of
Gonioapparent Color and Appearance
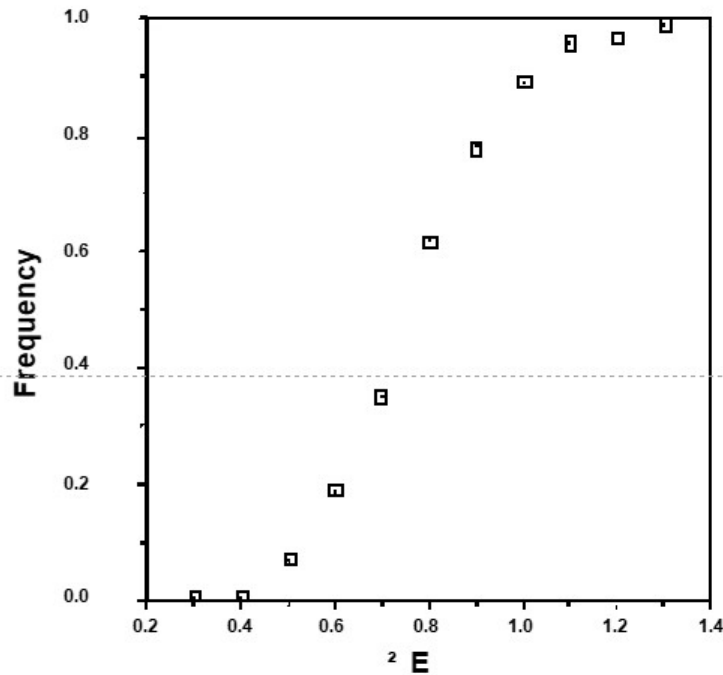
Allan Rodrigues
Jeff Alspach
Larry Steenhoek
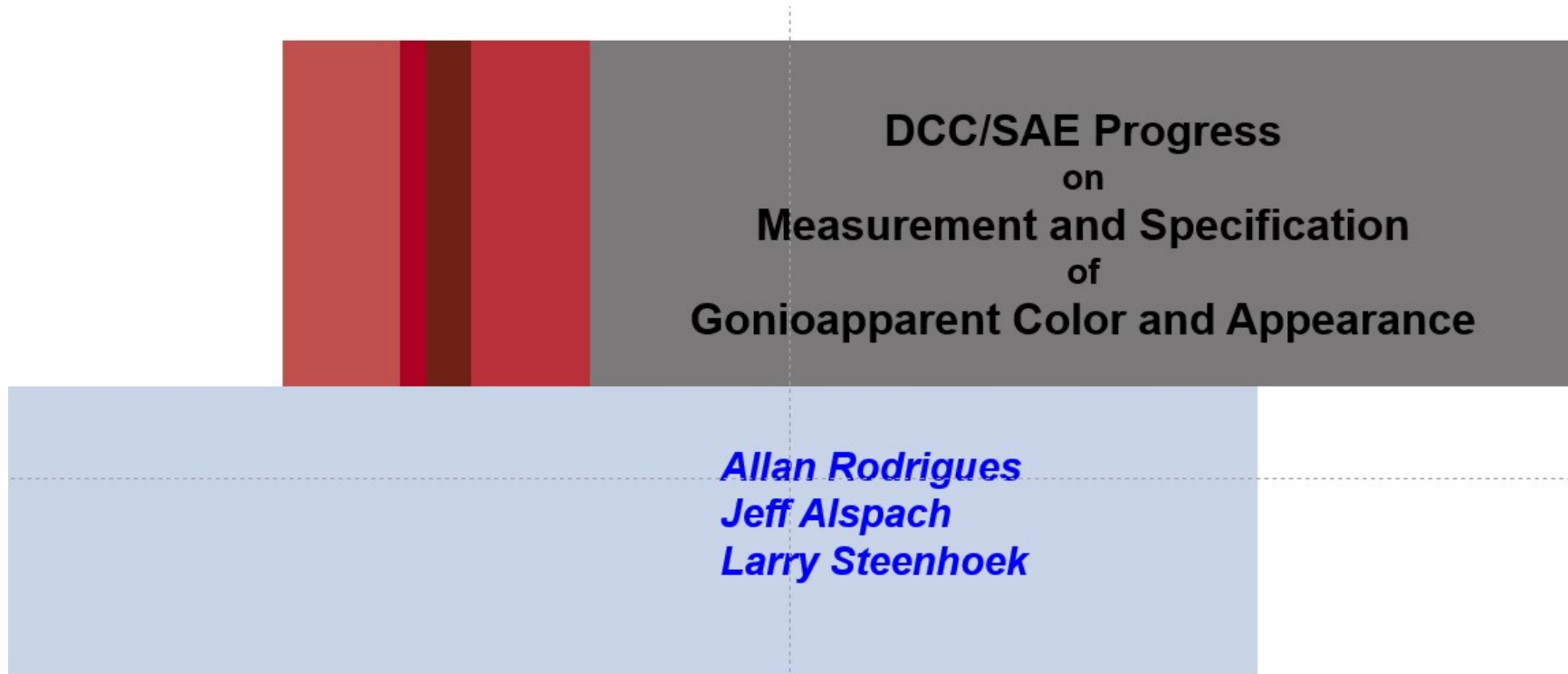
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Logit Analysis

Typical frequency of rejection versus color difference

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

$y = -3.1100 + 4.0714x$ $R^2 = 0.998$

Almost everyone accepts low ΔE pairs
Everyone rejects high ΔE pairs
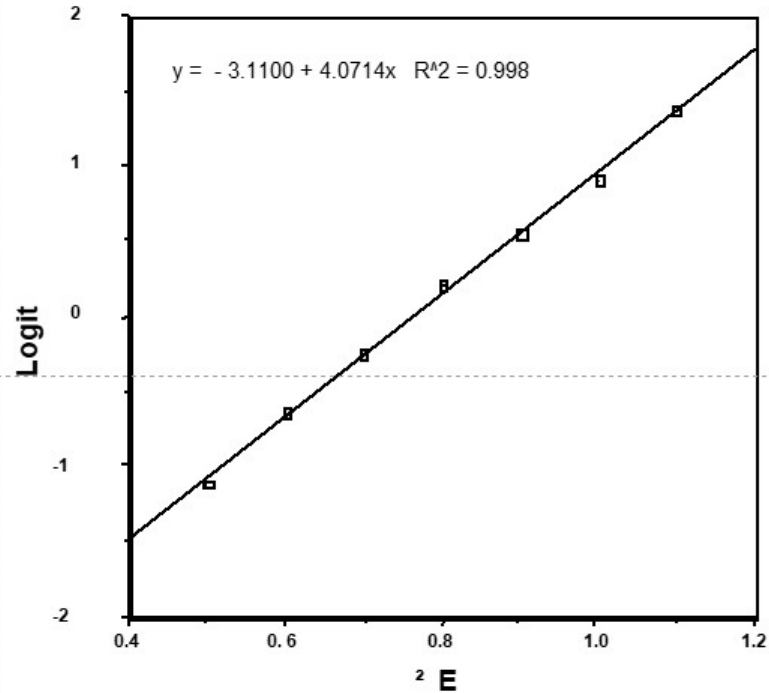
Logit linearizes a cumulative normal distribution allowing determination of a tolerance, ΔE at a reasonable acceptance rate (e.g. 50%)
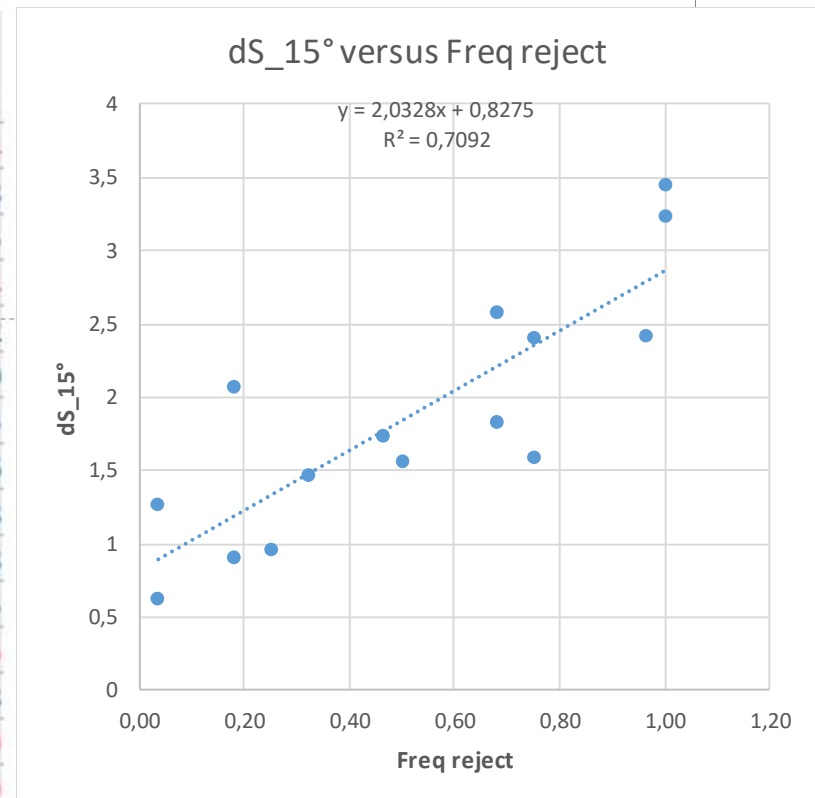
In *Coatings* we mean business

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Visual Assessment Results on dark blue metallic coating

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

Std ID	Btch ID	dE94 15	15dS	dSg1 5	Yes Count	No Count	% Yes	% No	Freq reject
3	4	0.27	0.63	0.29	27	1	96.43	3.57	0.04
5	6	0.3	0.92	0.42	23	5	82.14	17.86	0.18
4	5	0.37	0.97	0.44	21	7	75.00	25.00	0.25
2	11	0.33	1.27	0.51	27	1	96.43	3.57	0.04
2	4	0.72	1.48	0.68	19	9	67.86	32.14	0.32
3	5	0.23	1.57	0.73	14	14	50.00	50.00	0.50
9	10	0.59	1.6	0.79	7	21	25.00	75.00	0.75
6	8	0.47	1.75	0.82	15	13	53.57	46.43	0.46
4	6	0.26	1.84	0.86	9	19	32.14	67.86	0.68
3	11	0.8	2.08	0.9	23	5	82.14	17.86	0.18
2	5	0.51	2.41	1.12	7	21	25.00	75.00	0.75
3	6	0.37	2.43	1.15	1	27	3.57	96.43	0.96
7	9	0.26	2.59	1.26	9	19	32.14	67.86	0.68
2	6	0.74	3.24	1.54	0	28	0.00	100.00	1.00
4	8	0.51	3.46	1.68	0	28	0.00	100.00	1.00

dS_15° versus Freq reject

$y = 2{,}0328x + 0{,}8275$
$R^2 = 0{,}7092$

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Smoothing Observer Data

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

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"		

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Observer Smoothed Results

| Std ID	Btch ID	F Rej	ΔE94	Logit	dS15
5	6	0.11	0.3	-0.92	0.92
4	5	0.11	0.37	-0.92	0.97
2	11	0.14	0.33	-0.78	1.27
2	4	0.29	0.72	-0.40	1.48
3	5	0.54	0.23	0.06	1.57
9	10	0.57	0.59	0.12	1.60
6	8	0.71	0.47	0.40	1.75
4	6	0.46	0.26	-0.06	1.84
3	11	0.61	0.80	0.19	2.08
2	5	0.79	0.51	0.56	2.41
3	6	0.89	0.37	0.92	2.43

$y = 0.7719x + 1.723$

$R2 = 0.8695$
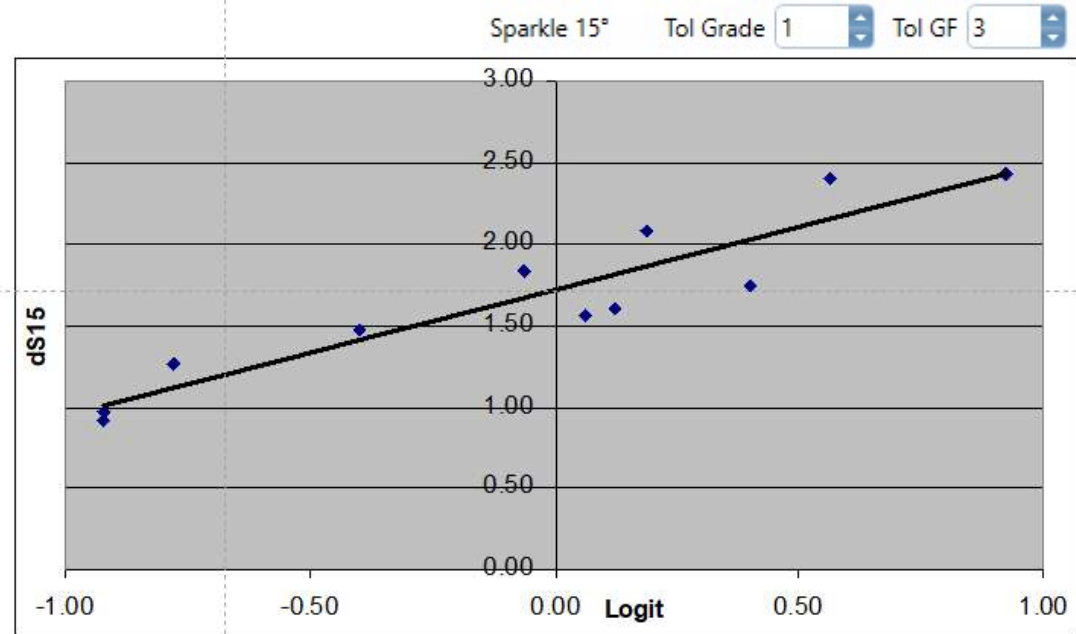
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Alternate Analysis

Binary Logistic Regression in Minitab gave very similar results
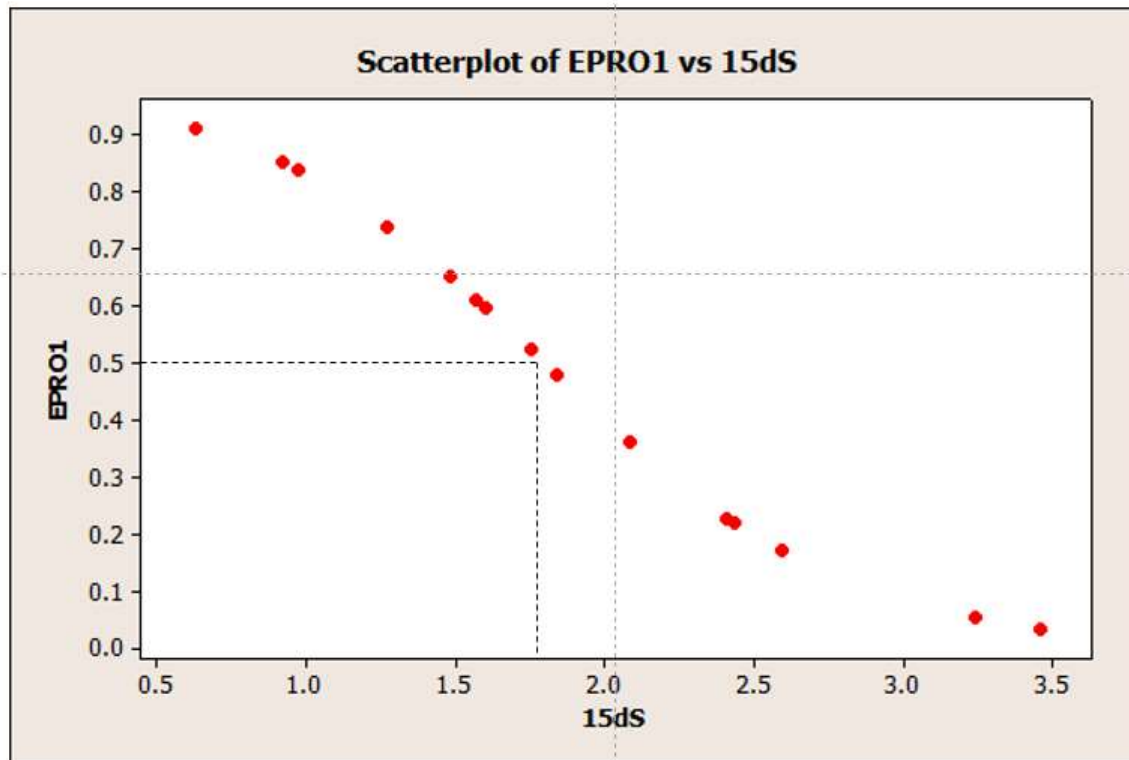
Correlation study

Illumination and observation conditions

Visibility of sparkle in metallic paints

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Correlation study

Illumination and observation conditions

An important concept when investigating visibility of sparkle is the contrast threshold at which luminous stimuli that are brighter than their surrounds become visible to observers.

From the data provided by Blackwell, after applying the correction proposed by Crumey for color temperature and psychophysical method [20], we found a very simple expression for the illuminance threshold:

$$E_{50\%} = L_{surround}^{0.788} \times 4.41 \times 10^{-8} \text{ lm/m}^2. \qquad (5)$$

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Illumination and observation conditions

Visibility of Sparkle in Direct Sunlight

Based on this analysis, sparkle intensity (illuminance) and surround luminance for observing a metallic coating under direct sunlight can be calculated as
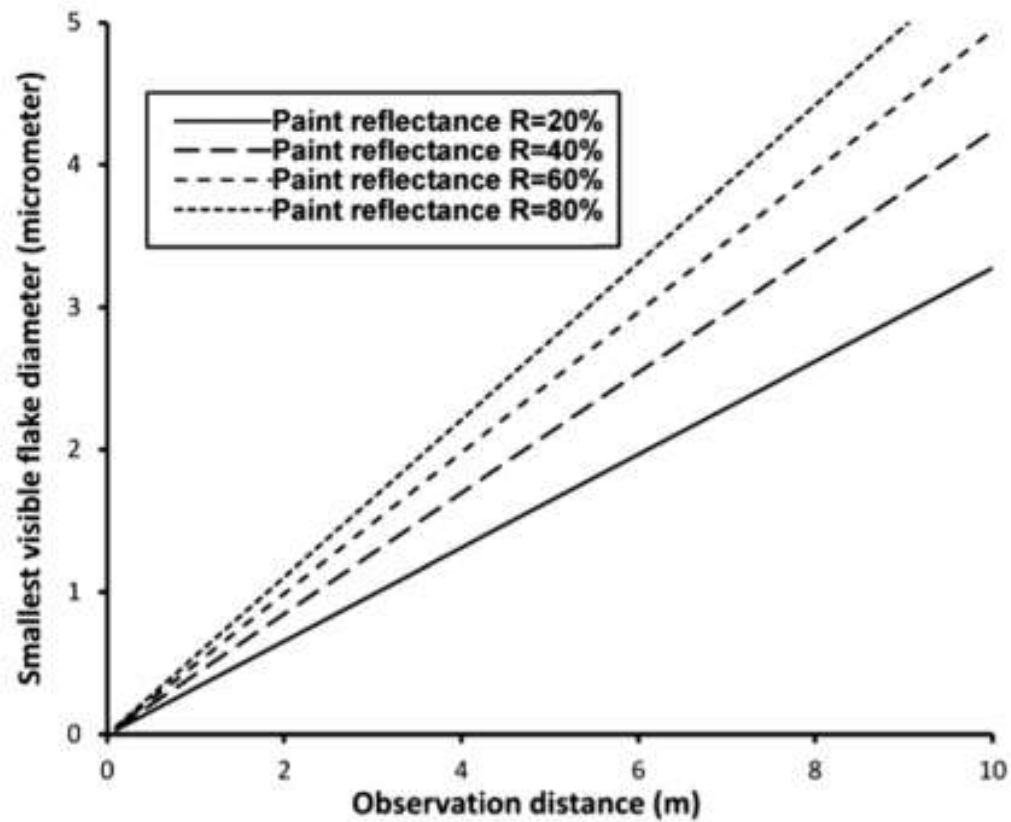
$$E_{sparkle} = (1.87 \times 10^9) \frac{\pi D^2_{flake}}{4d^2_{obs}} \cos \theta_{obs}$$

$$\times \exp(-0.209/ \sin \theta_{sun}) \, \text{lm}/(\text{m}^2), \qquad (10)$$

$$L_{surround} = \rho_{gloss} L_{ambient} + \frac{\rho_{paint} \omega_{sun}}{\pi} (1.87 \times 10^9)$$

$$\times \exp \left(-\frac{0.209}{\sin \theta_{sun}} \right) \, \text{lm}/(\text{m}^2 \, \text{sr}), \qquad (11)$$

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Visibility of Sparkle in Direct Sunlight

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Illumination and observation conditions

Visibility of Sparkle Under Artificial Spot Light

This analysis can be generalized for calculating sparkle intensity (illuminance) and surround luminance under spotlight as follows:

$$E_{\text{sparkle}} = \frac{E_{\text{spotlight}}}{\sin^2\left(\frac{D_{\text{spotlight}}}{2d_{\text{spotlight}}}\right)} \frac{D_{\text{flake}}^2}{4d_{\text{obs}}^2} \cos\theta_{\text{obs}} \ \text{lm}/(\text{m}^2), \qquad (12)$$
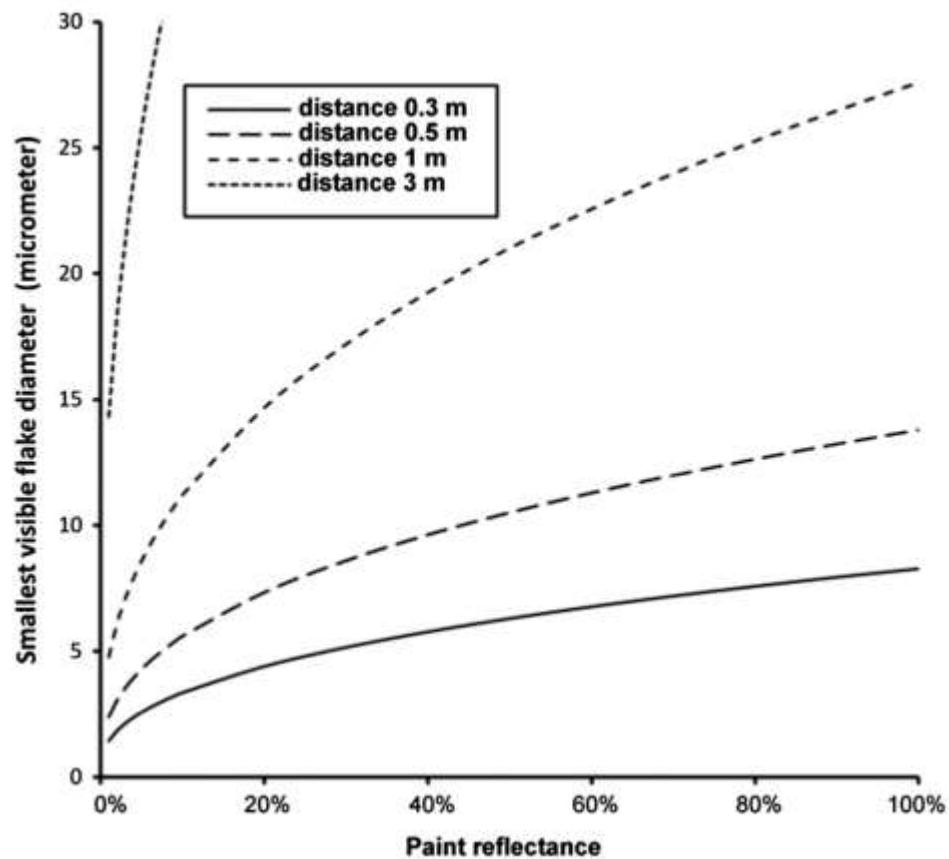
$$L_{\text{surround}} = \frac{\rho_{\text{gloss}} E_{\text{ambient}}}{2\pi} + \frac{\rho_{\text{paint}} E_{\text{spotlight}}}{\pi} \ \text{lm}/(\text{m}^2\,\text{sr}), \qquad (13)$$

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Correlation study

Illumination and observation conditions

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Visibility of Sparkle Under Artificial Spot Light

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Illumination and observation conditions

CONCLUSIONS

The calculations show that under appropriate illumination and observation conditions, metallic flakes of only 1 μm diameter can cause sparkle to be seen. However, we also showed why under typical situations with an intense spot light, sparkle is not seen in fine metallic coatings: under such conditions, only flakes with diameters exceeding 5–7 μm can give rise to sparkle. These predictions agree with common observations of sparkle in metallic coatings.

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Experience with visual evaluation

Natural evaluation conditions

Experience with visual evaluation

Which illumination and observation conditions should be choosen?

- The visual evaluation results and the measurement results will change with the illumination and observation conditions

- The reasons are:
  1. contrast threshold depens on the luminance of the sparkle surrounding.
  2. sparkle / surround ratio depends of illumination conditions like apertures.

- We are faced to an infinite number of illumination and observation conditions every day.

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Status with actual instrumentation

Which illumination and observation conditions should be choosen?

Status at BYK-mac i:

- Focus on the natural extrem situations
    1. Sunny clear sky => Sparkle
    2. Completely cloudy sky => Graininess

Assumption:

- If two samples have similar results under the extrem conditions
    => they will be also similar under all mixed conditions.

- If two samples have different results under the extrem conditions
    $\Rightarrow$ they may appear closer under certain circumstances.
    $\Rightarrow$ But they will not appear more worse as it is under the extrem conditions

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Experience with visual evaluation

Compare actual situation with color metamerism

Color evaluation:

- Color is evaluated at different locations

- Results are almost comparable but sometimes quiet different

- The reason for different results is, different locations use **different light sources** like D65 versus A

- color metamerism

Sparkle evaluation:

- Sparkle is evaluated at different locations

- Results are almost comparable but sometimes quiet different

- The reason for different results is, different locations use **different light distributions and intensities**

„Sparkle Metamerism"

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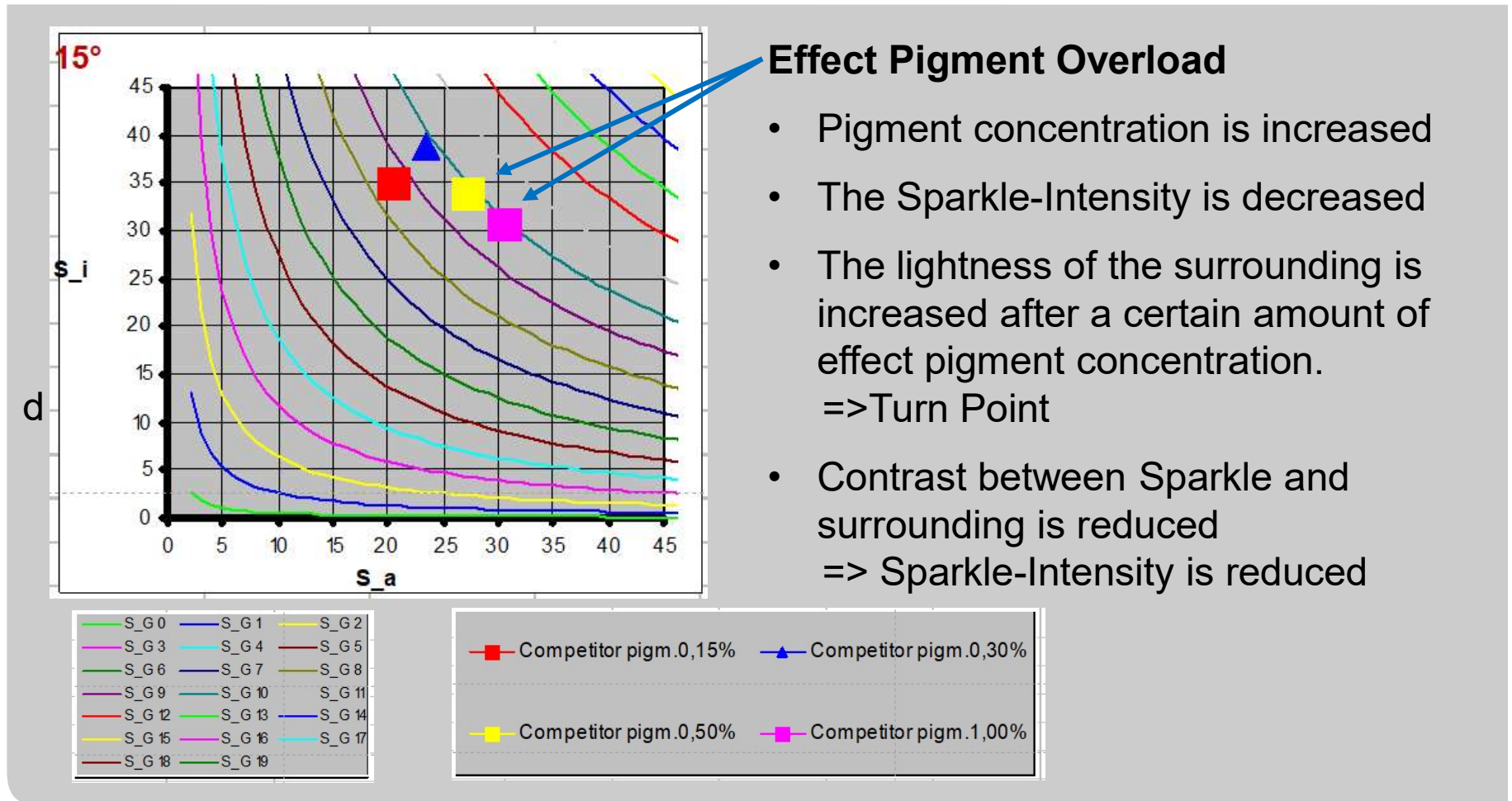
Experience with visual evaluation

Which illumination and observation conditions should be choosen?

Suggestions for next projects

- Definition and control of the illumination and observation conditions

    1. Angle of illumination and abservation

    2. Observation distance

    3. Measurement of direct illumination aperture and intensity

    4. Measurement of diffuse illumination intensity
        => ratio direct / diffuse illumination

    5. Suitable illumination intensity is usually coating specific

    6. Illumination area

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Experience with visual evaluation

Effect Pigment Overload Turn Point

Effect Pigment Overload

- Pigment concentration is increased

- The Sparkle-Intensity is decreased

- The lightness of the surrounding is increased after a certain amount of effect pigment concentration.
  =>Turn Point

- Contrast between Sparkle and surrounding is reduced
  => Sparkle-Intensity is reduced

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Thank you for
your attention.

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