Colour assessment of prepainted metal

ECCA guidelines

Why is colour management important?


The directionality of metallics should be consistent especially when panels are cut to size


To ensure tonal consistency, all material should come from the same production batch


To ensure tonal consistency, all material should come from the same production batch

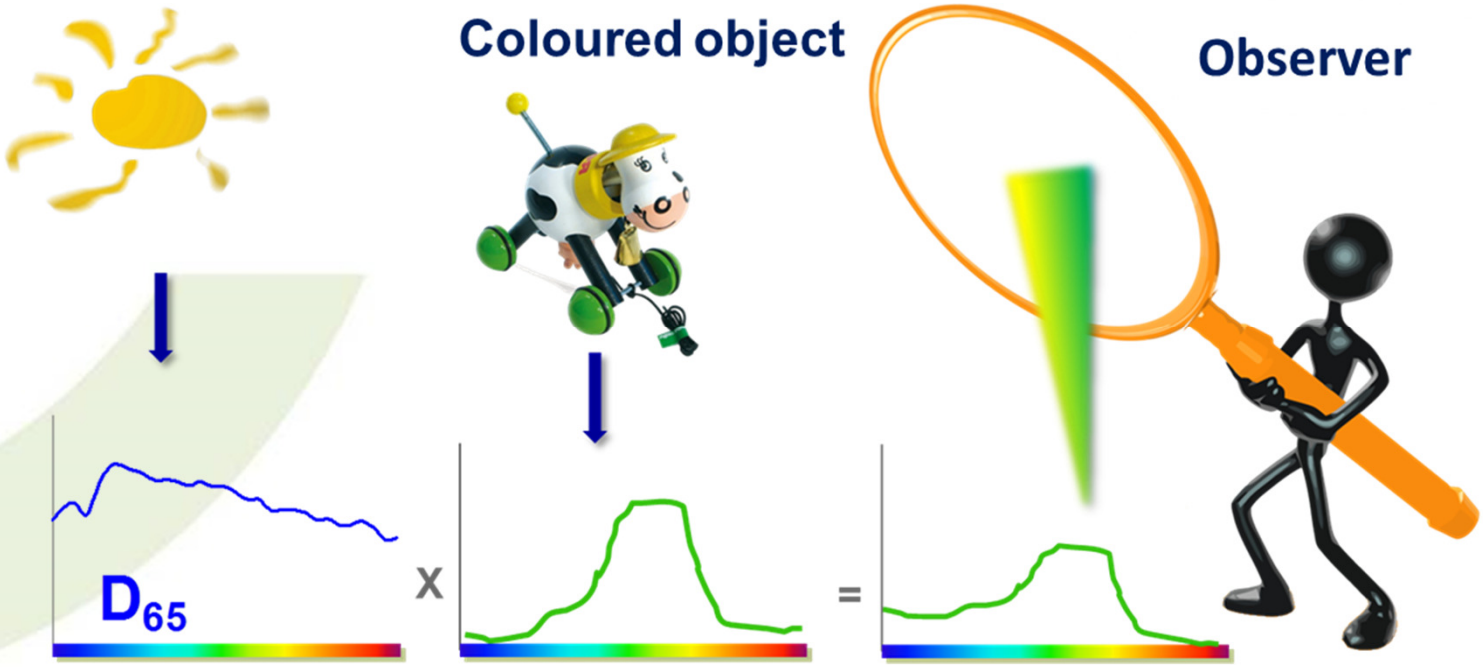
If different materials are used next to each other (e.g. powder coated and prepainted), colour matching of the powder coated components should be done to an actual sample of the cladding material – not to a theoretical value or a RAL reference.

Colour: basic principles

Basic principles

Colour

- Colour stimulus consists of three components
  - The light source sending out light waves (electromagnetic radiation) and the surrounding conditions (environment around the light source and the object)
  - The observed object that reflects a part of the light waves
  - The observer that detects/the eyes that absorb the light waves reflected on the surface of the object



Basic principles

- The light source
  - The light source emits electromagnetic radiation at different wavelengths that all relate to a different colour. All visible light is a mixture of wavelengths, each corresponding to a different colour, which is specific to a light source. Therefore, a colour of an object can seem to vary under different light sources.

- The object
  - Any object reflects certain wavelengths of the incoming light and absorbs the others. Therefore, an object that reflects green light waves and absorbs the others looks green. Other aspects that affect the colour observation are shape and surface. The object can be embossed or textured, or have metallic, pearlescent or phosphorescent effects that all influence our experience of colour.

- The observer
  - The defining observer of colour is the human eye. Thus, the colour experience is highly subjective. The ability of the human eye and brain to detect and handle colours is individual and depends on age, gender, inherited traits, and even mood.

Colour characterisation

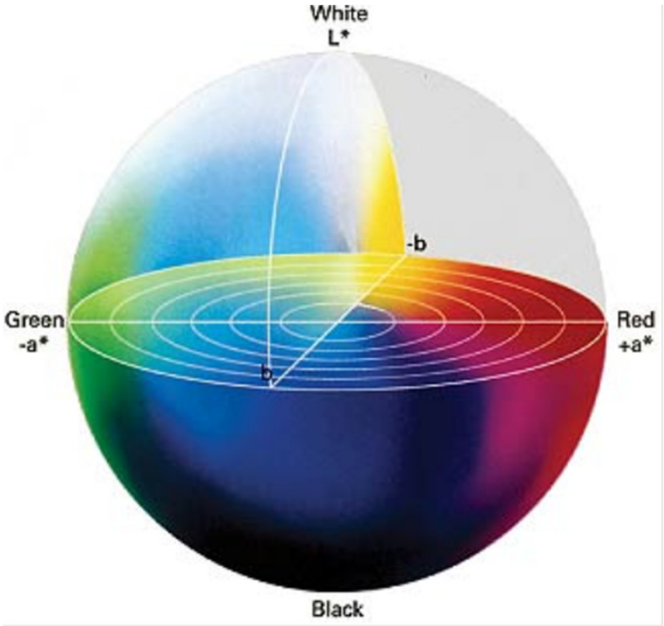
Colour characterisation

What do we measure?

- Different colour spaces can be used to define a colour. Please note that the colour observation is always dependent of illuminant and observer (e.g. D65/10°)

The colour – CIELab

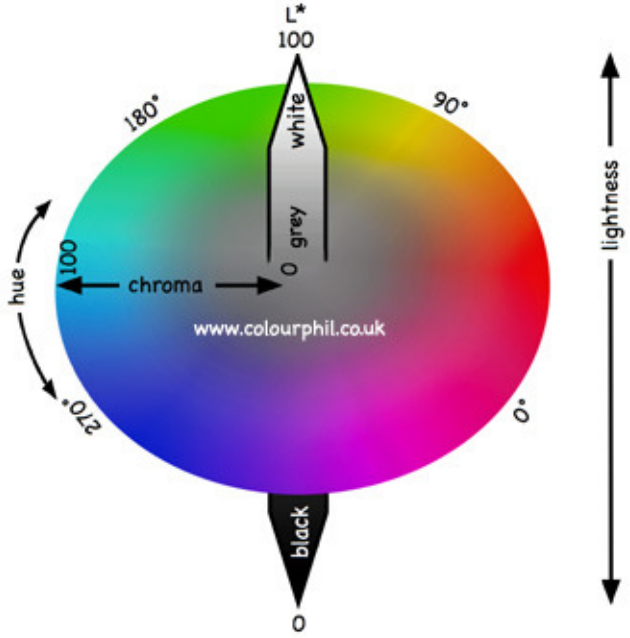
- The CIE L*a*b* colour space is the most used in coil coating industry
- It defines the colour coordinates L*, a* and b*
  - ✓ L* represents the colour lightness
  - ✓ a* represents the colour green-red dimension
  - ✓ b* represents the colour blue-yellow dimension



Colour characterisation

The colour – CIELCh

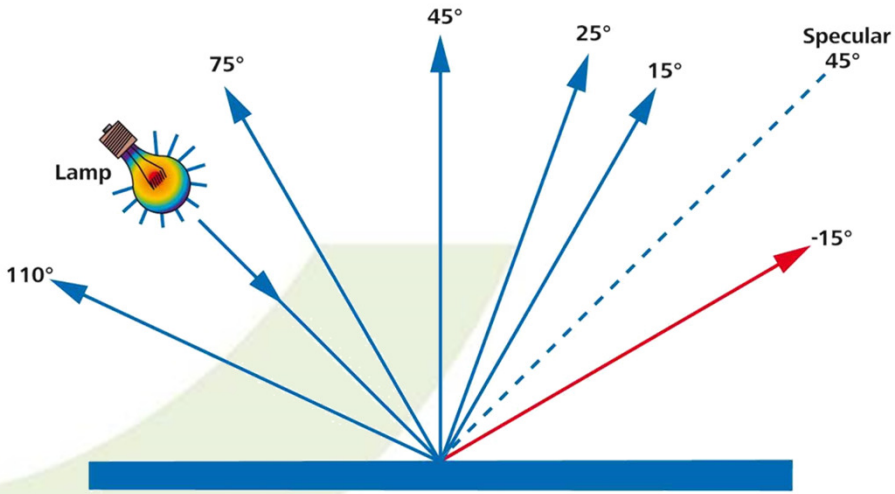
- CIELCh uses the same colour space than CIELab, defining it with three colour coordinates L*, C* and h*
  - ✓ L* represents the colour lightness
  - ✓ C* = represents *Chroma* or saturation of the colour. Its value can be obtained from CIELab by C* = $\sqrt{a^{*2} + b^{*2}}$
  - ✓ h* axis represents hue ranging from 0 (grey) in the centre of the circle to 100 (saturated) around the edge.
  - ✓ All possible saturated colours are present around the edge of the circle. The units are expressed as degrees from 0° (red) through 90° (yellow), 180° (green), and 270° (blue) back to 0°.



Colour characterisation

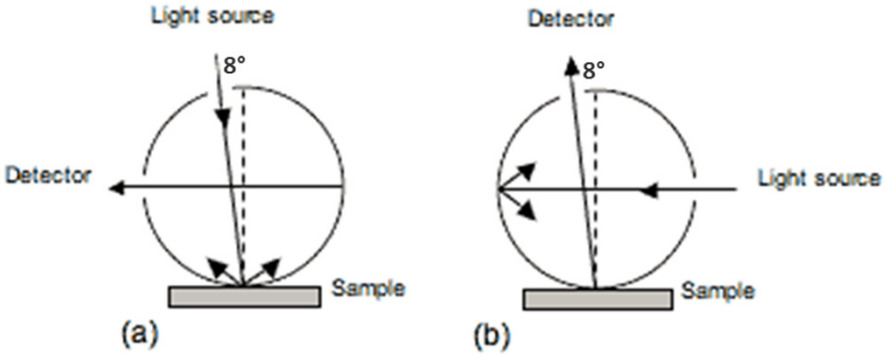
Colour measurement – differences of geometry

Multiangle



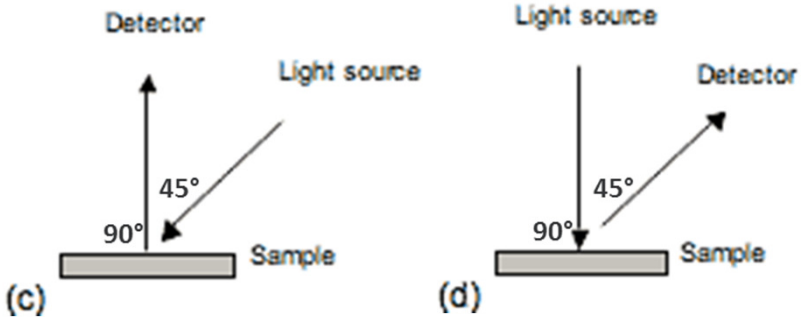
Diffuse geometry

a) 8°/D (0°/D) **b) D/8°** (D/0°)



Directional geometry

c) 45/0° **d) 0°/45**



Colour characterisation

Colour measurement - spectrophotometry

- Different types of equipment available
  - Colorimeter, spectrophotometer, spectroradiometer

Colorimeter
Minolta: CR 400, D/0°

Spectrophotometer
HunterLab: UltraScan, D/8°

Spectrophotometer
BYK Gardner: BYK-mac, multiangle

Colour characterisation

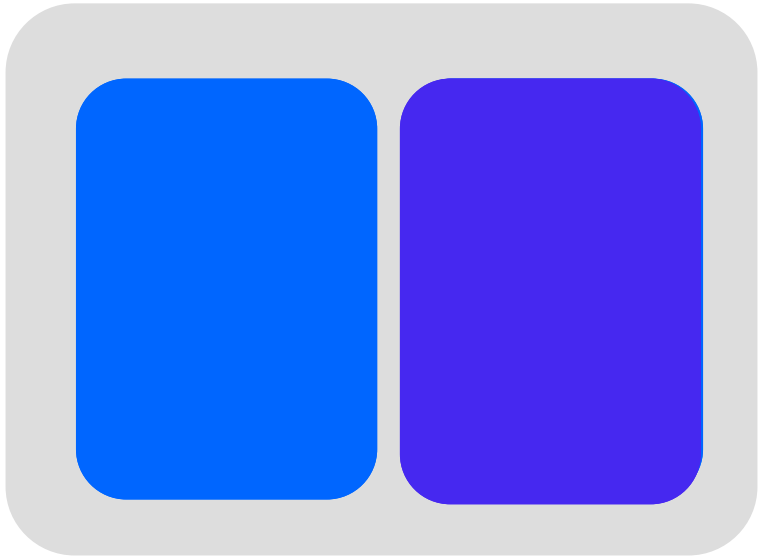
Colour measurement – differences of measurement

- Depending on the **equipment** used
  - Difference between the producers for the same kind of equipment
  - More important with fabrication time
  - Difference between one equipment family and another explained e.g. by different parameters
    - sphere diameter, light source (tungsten, xenon, diode, etc.), pulsed or continuous light, etc.
- Depending on the **geometry** used
  - L*a*b* absolute values depend on the geometry used
  - Always small dispersion in absolute value due to equipment calibration
- ***Mandatory to observe all the equipment conditions before concluding a difference of colour***

Colour characterisation

Metamerism

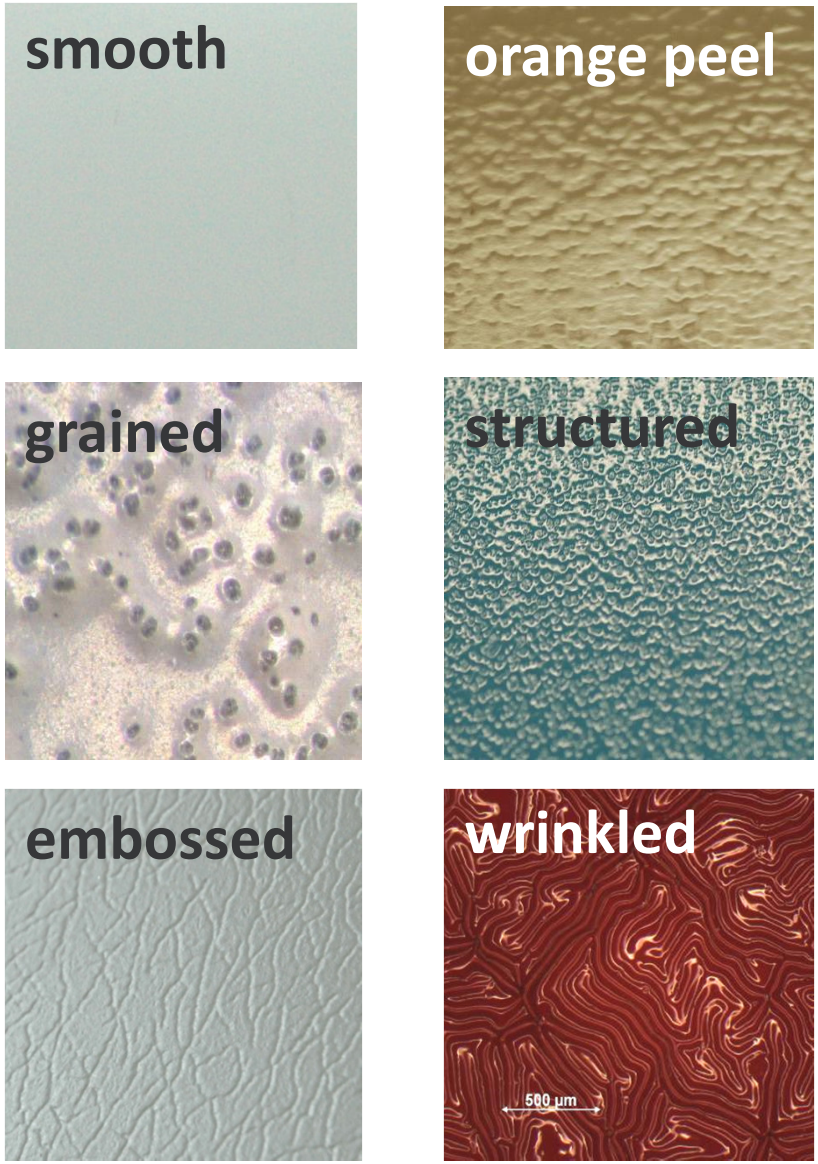
- In some cases two prepainted samples can look exactly the same under one light source, but when transferred under a different light source, their visual appearance differs significantly.
- This is called metamerism.



Colour characterisation

Appearance

- The final appearance of prepainted metal depends also on the type of resin used, film thickness, gloss, and the surface texture (structured, granulated, embossed, metallic,…)



Colour management

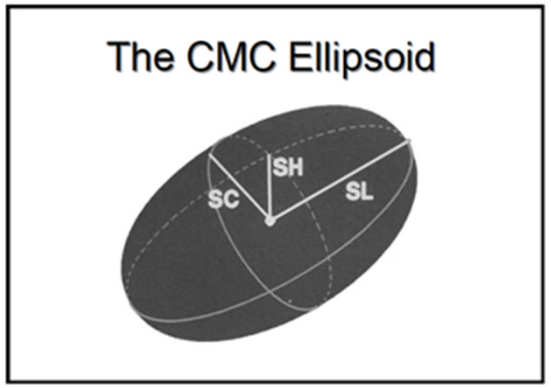
Colour management

Colour difference ΔE*

- The colour difference between a reference and a sample is determined by the deviation on the different axes: ΔL*, Δa*, Δb*
- ΔE* (colour deviation) = $\sqrt{(\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})}$
- Visual evaluation is necessary because ΔE* criteria can be insufficient (metallized colours, colours with high whiteness, limit of the equipment sensitivity, non-uniformity of CIELab colour space…)
- Colour difference is always measured from 2 physical samples (never with absolute values as references)
- **It is practically impossible to have a ΔE* 0.0 colourmatch, a small difference of ΔE* is normal and expected.**

Colour characterisation

The colour - CMC



- CMC is a modification of ΔE of CIELab developed by the Color Measurement Committee of the Society of Dyers and Colorists. It is defined in AATCC Test Method 173, “CMC: Calculation of Small Color Differences for Acceptability.”
- The CMC calculation mathematically defines an ellipsoid around a defined and agreed standard colour. The dimensions of the ellipsoid depends on the colour shade and thus can be expected to better correspond to the sensibility of the human eye.
- This ellipsoid consists of a semi-axis that corresponds to the attributes of hue (h), chroma (C), and lightness (L)
- It represents the area of acceptance in relation to the standard, the same way the CIELab "box" defines acceptable difference limits
- The size of the ellipsoid varies depending on its position in the colour space and its shape is influenced by the CMC ratio l/c lightness/chroma. The c (chroma) tolerance is usually smaller, since human eye is able to detect smaller shifts in chroma than in lightness. Also, in the orange region, ellipsoids are narrower, while in the green region, ellipsoids are wider.

Colour management

Colour category definition

- Colour classification by category is obtained from the colour parameters L*, a*, b*, C*

- Category 1: light colours
- Category 2: medium colours
- Category 3: dark colours
- Category 4: sharp/saturated colours
- Category 5: metallized colours

L* > 80	C* ≤ 10	Category 1
	10 < C* ≤ 20	Category 2
	20 < C* ≤ 30	Category 3
	C* > 30	Category 4
60 < L* ≤ 80	C* ≤ 10	Category 2
	C* ≤ 25 and -11 < a* < 11 and -5 < b* < 25	Category 2
	C* ≤ 30 and -16 < a* < 16 and -5 < b* < 25	Category 3
	C* > 30	Category 4
L* ≤ 60	C* ≤ 30	Category 3
	C* > 30	Category 4

$C^* = \sqrt{a^{*2} + b^{*2}}$

NOTE! Colours that do not fall into any category are classified by the paint supplier.

Colour management

Examples of colour categories

RAL code	Colour	Category
RAL 9001	Cream	1
RAL 9002	Grey white	1
RAL 9010	Pure white	1
RAL 7035	Light grey	2
RAL 1015	Light ivory	2
RAL 7032	Pebble grey	2
RAL 6011	Reseda green	3
RAL 6003	Olive green	3
RAL 8004	Copper brown	3
RAL 8011	Nut brown	3
RAL 3009	Oxide red	3
RAL 3000	Flame red	4
RAL 1018	Zinc yellow	4
RAL 5002	Ultramarine blue	4
RAL 5010	Gentian blue	4
RAL 9006	White aluminium	5
RAL 9007	Grey aluminium	5

Colour difference tolerances
- recommendations

Colour tolerance recommendations

General tolerances to be applied using 45/0°, 0°/45 and D/8° geometries with spectro equipment

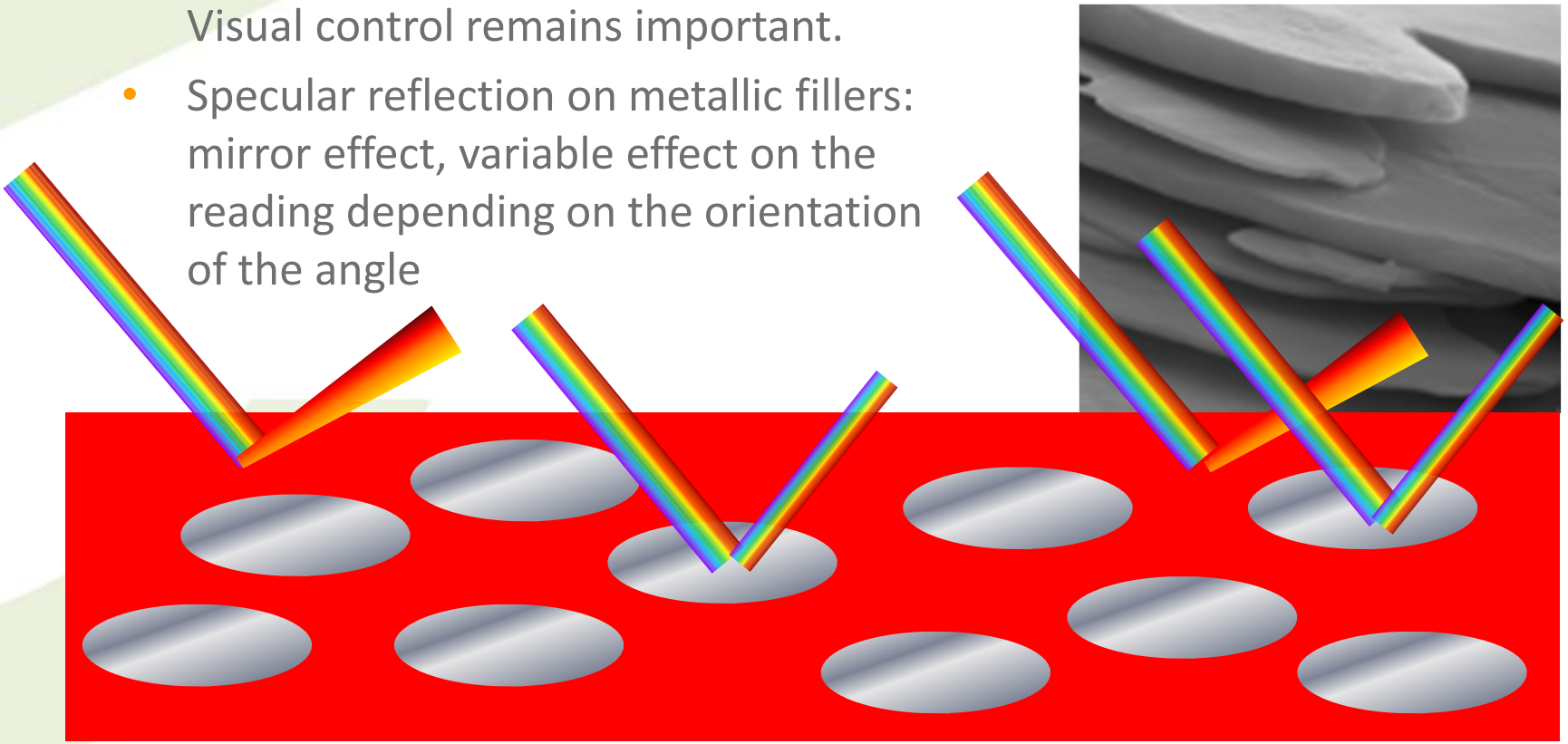
Colour tolerance recommendations	Geometry used		
	45/0° or 0°/45		D/8°
	CIELab	DE_{CMC} CF = 1,00 L:C= 2,00	
Category 1: light colours	ΔE* ≤ 1,0	$\Delta E_{CMC} \leq 1,0$	ΔE* ≤ 1,0
Category 2: medium colours	ΔE* ≤ 1,3		
Category 3: dark colours	ΔE* ≤ 1,5*		ΔE* ≤ 1,5*
Category 4: sharp/saturated colours	ΔE* ≤ 1,5*		
Category 5: metallized colours	visual control required		

** ΔE* ≤ 2,0 can be accepted for specific colours*

Note! The supplier has the final responsibility of defining the colour category of his products. This applies particularly for special, demanding colours and cases where the colour is close to a limit between two categories, or where a colour shade falls out of any category

Colour tolerance recommendations

- Metallized colours: Interaction light-material
  - ΔE* measurement can be disturbed by interaction between the incoming light and the surface of the metallic flake. Visual control remains important.
  - Specular reflection on metallic fillers: mirror effect, variable effect on the reading depending on the orientation of the angle

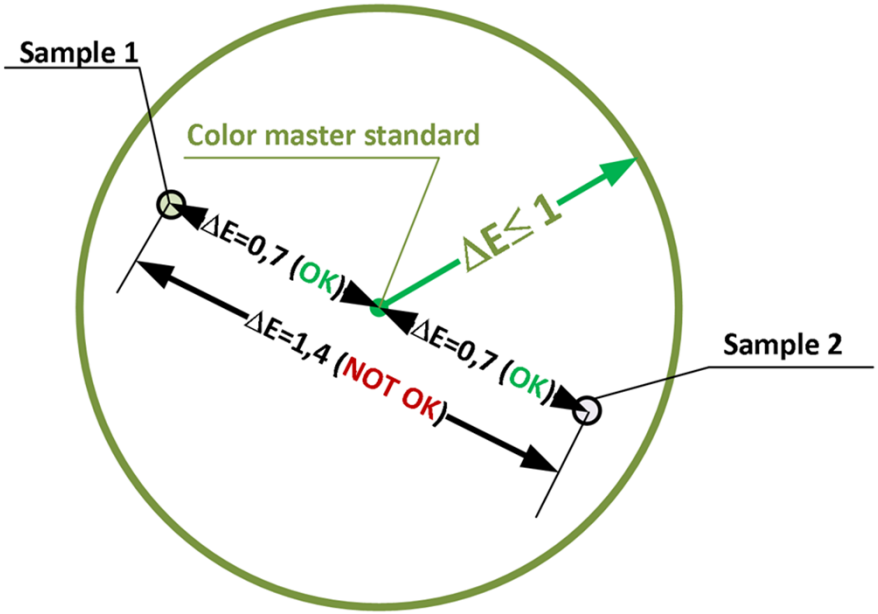


Colour tolerance recommendations

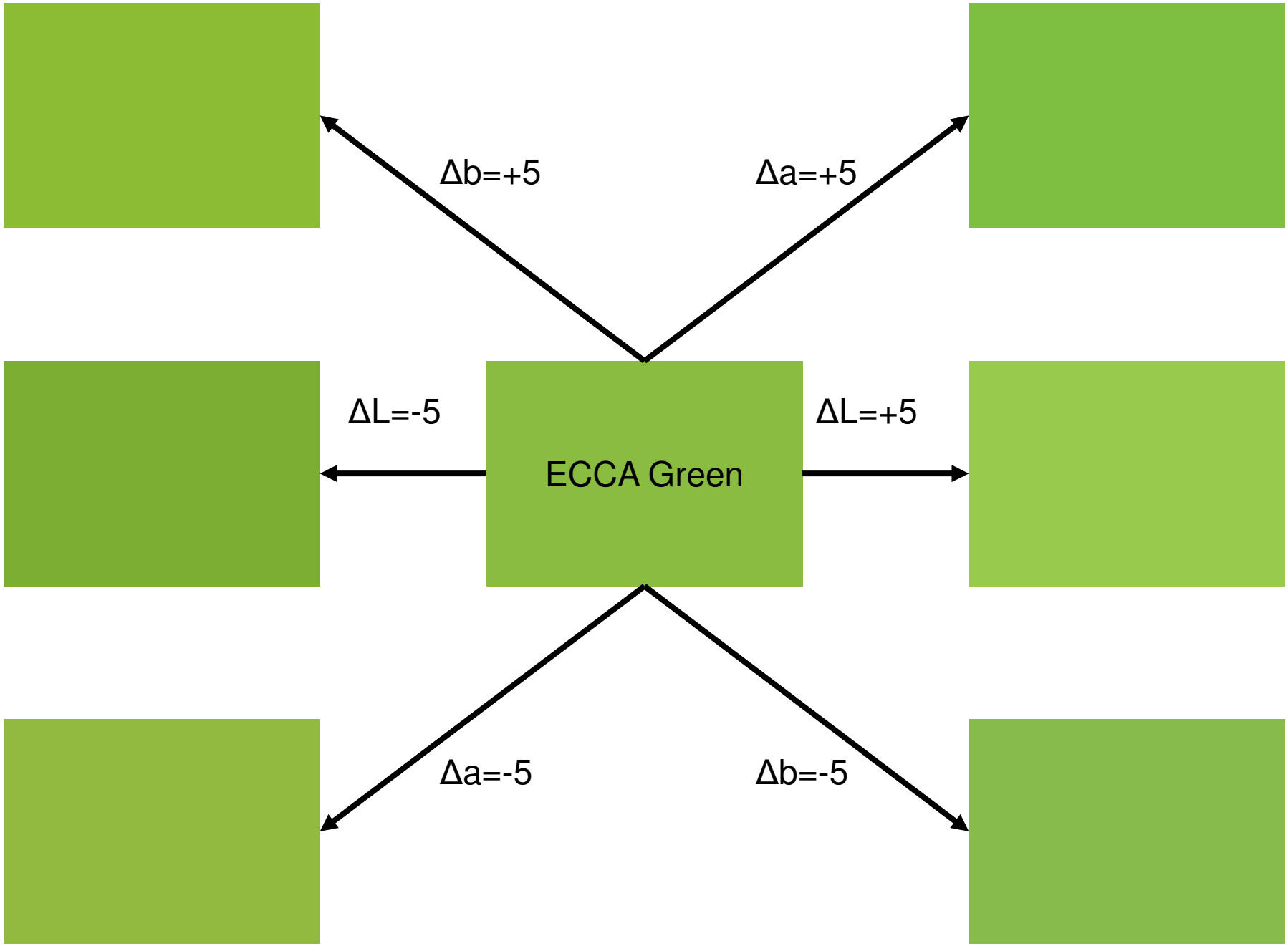
Guidelines to ensure colour consistency

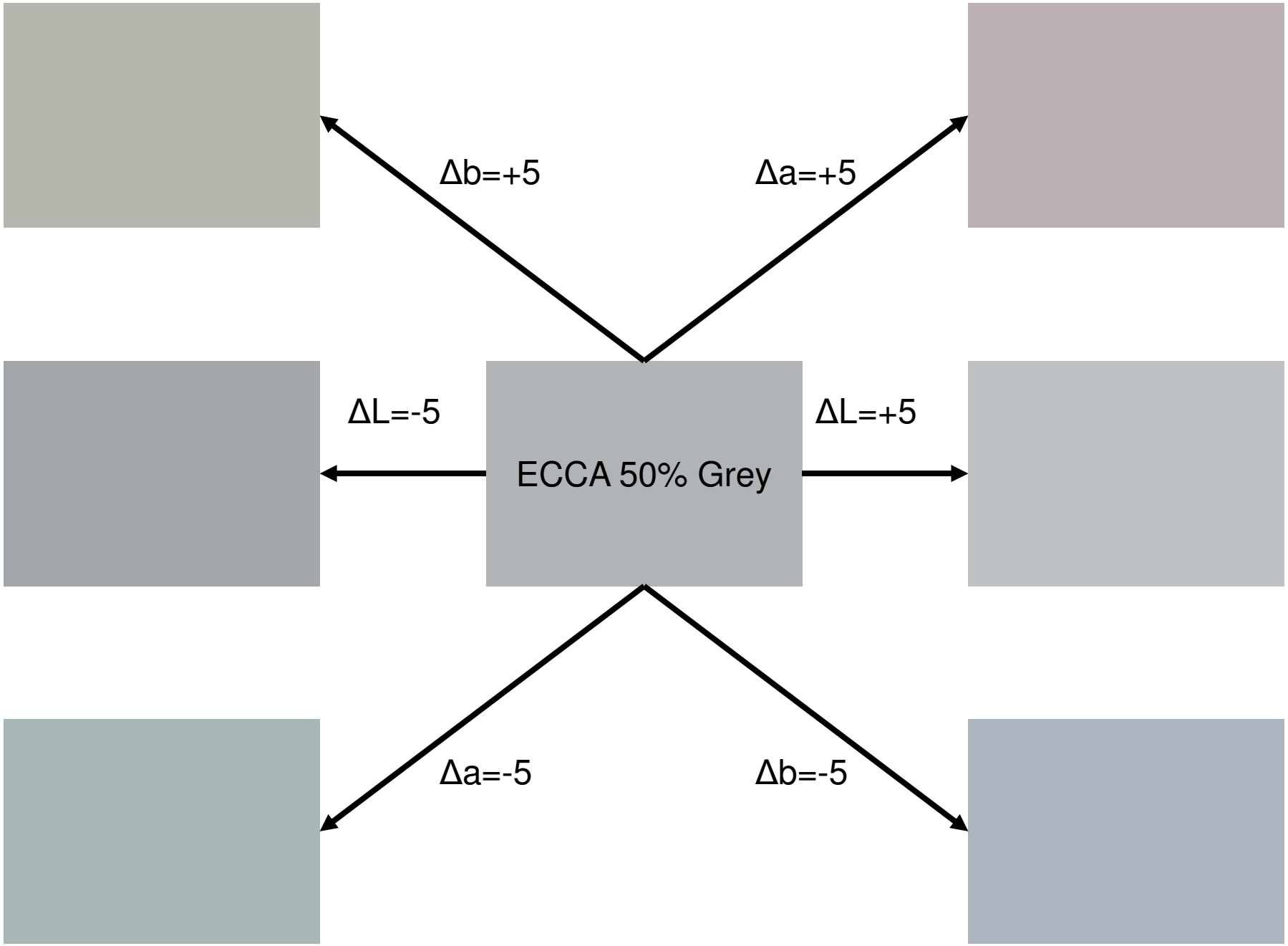
- Different production batches should not be used next to each other even if they are of the same colour AND even though all coils from different orders have the same tolerance compared to the colour master standard.

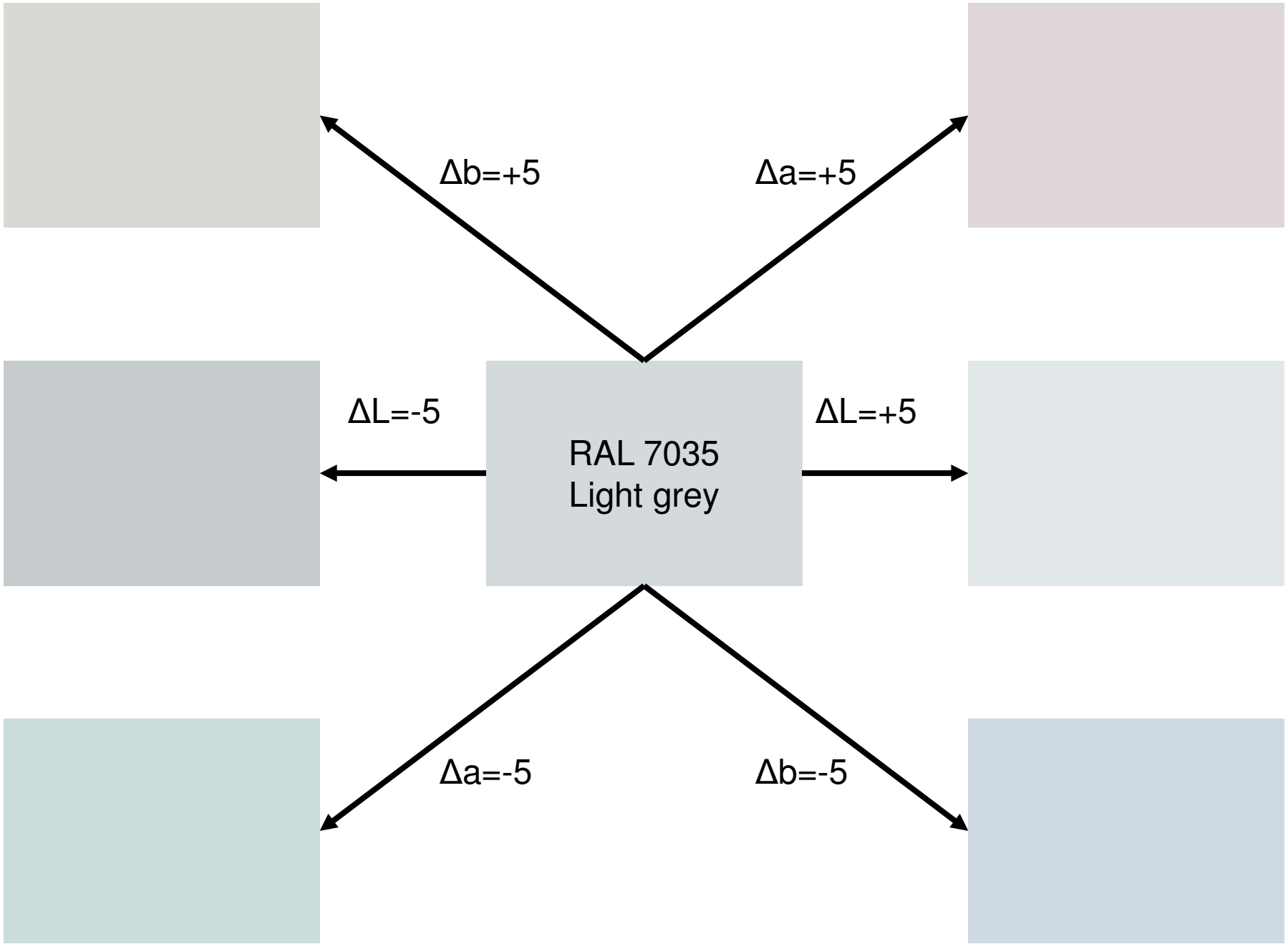
- **ΔE* guaranteed depends on the colour category**

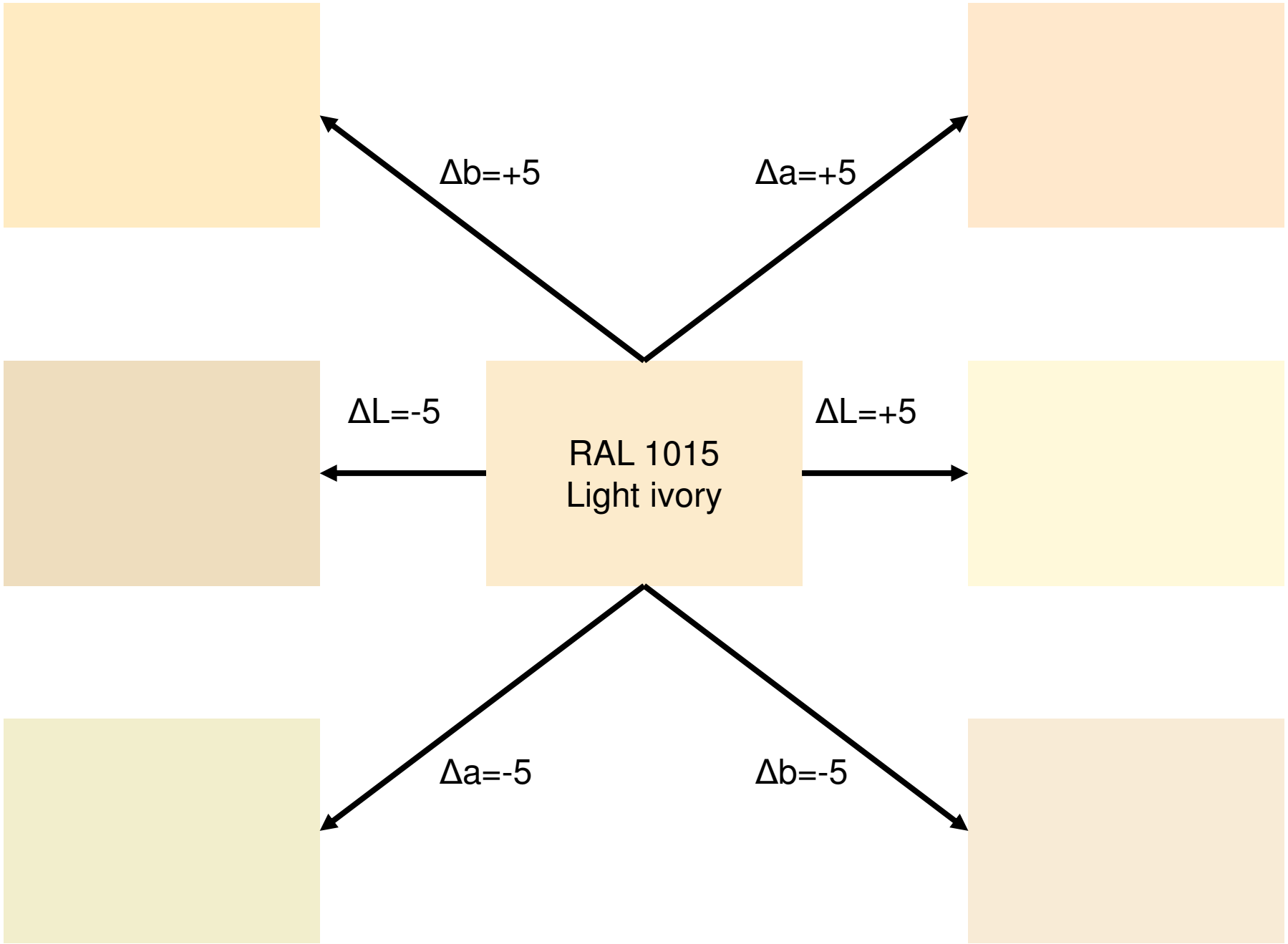


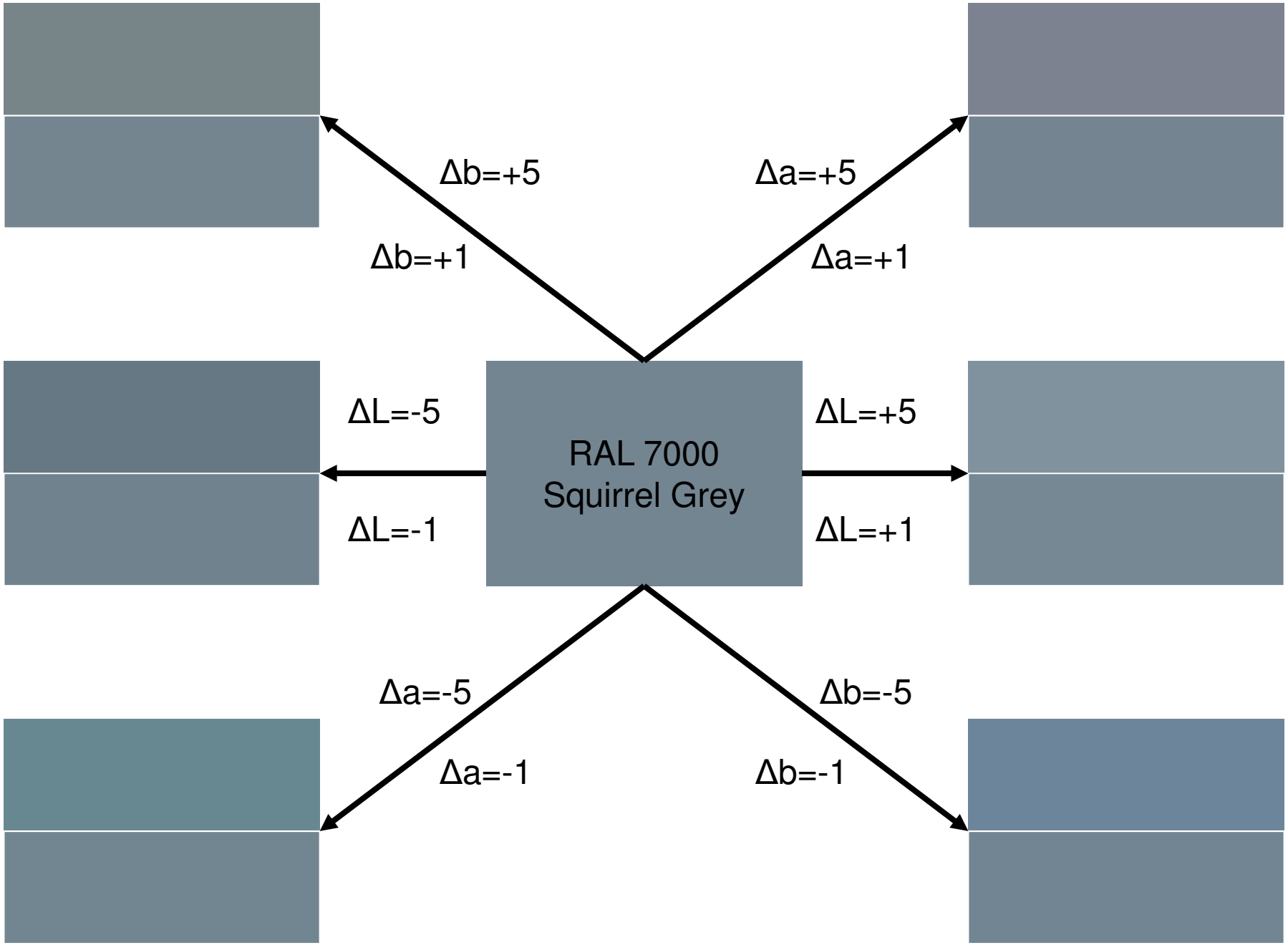
Examples of colour differences


Δb=+5
Δa=+5
ΔL=-5
ECCA Green
ΔL=+5
Δa=-5
Δb=-5


Δb=+5
Δa=+5
ΔL=-5
ECCA 50% Grey
ΔL=+5
Δa=-5
Δb=-5


Δb=+5
Δa=+5
ΔL=-5
ΔL=+5
RAL 7035
Light grey
Δa=-5
Δb=-5


Δb=+5
Δa=+5
ΔL=-5
ΔL=+5
RAL 1015
Light ivory
Δa=-5
Δb=-5


Δb=+5
Δb=+1
Δa=+5
Δa=+1
ΔL=-5
ΔL=-1
RAL 7000
Squirrel Grey
ΔL=+5
ΔL=+1
Δa=-5
Δa=-1
Δb=-5
Δb=-1

Colour matching and specification

Colour match and specification

Procedure

- The colour master is the colour matched by the paint supplier
  - No colour match is based on theoretical values
- A physical colour match is the closest proposition to the colour master: the chemical paint composition is perfectly fixed and reproducible
  - One colour match is kept by the customer and one by the coil coater
- When accepted by the customer, the physical colour match is used as reference for mass production by the coil coating line and in all discussions or possible claims with the customer
- ***A physical colour master is mandatory. A colour master on paper/resin/other substrate/other paint system is never accepted as reference for mass production!***

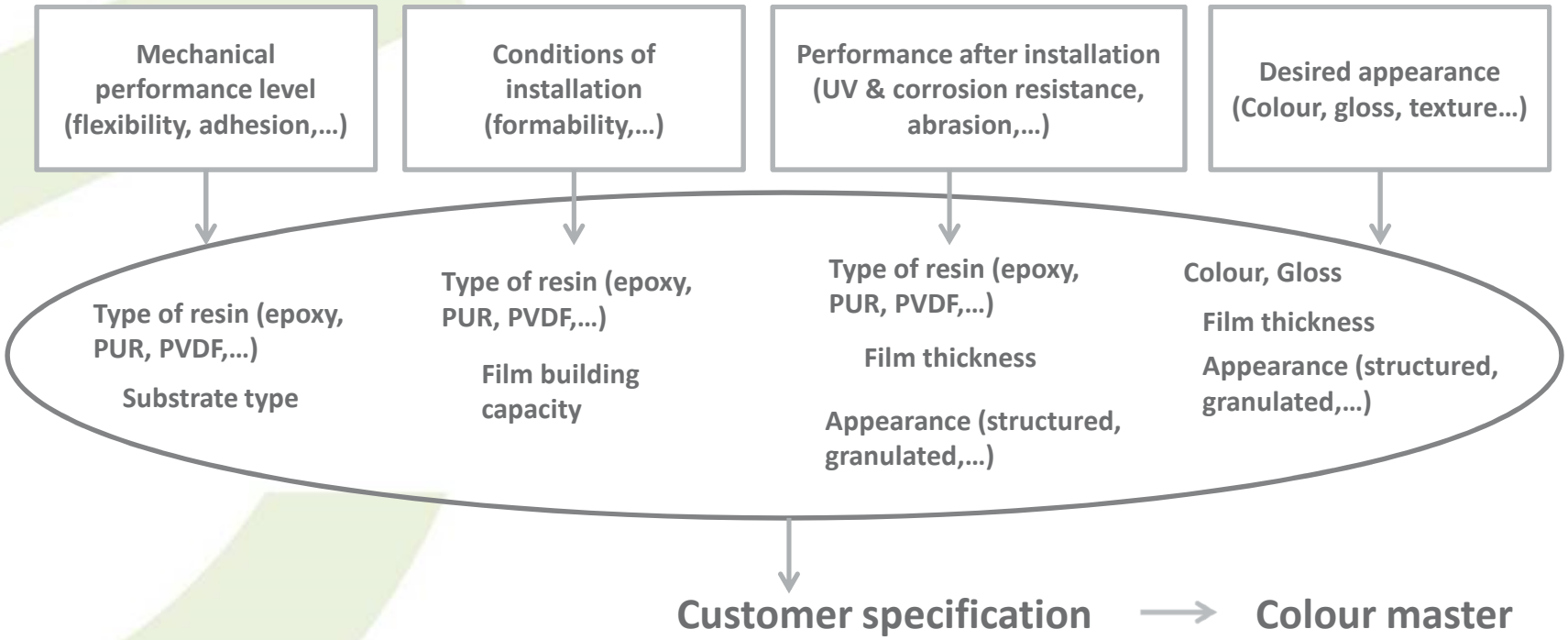
Colour matching and specification

Customer specifications are to be written in common agreement between supplier and the customer

- Colour measurement equipment shall be clearly defined
- Colour evaluation according to EN 13523-3, visual evaluation according to EN 13523-22
- Tolerance on the colour (ΔE^*) is defined by the supplier, but can be discussed with the customer
- Tolerance on each axis (L*, a*, b*) can be fixed for demanding colours or applications (e.g. domestic appliances, electronic devices etc.)

Colour matching and specification

To develop a specification for a prepainted product, the following steps are recommended:



Colour matching procedure should be the last step in the definition of specifications for a prepainted product.