Integral Effects and CIE *L *a *b Colour Space

OPTICAL PROPERTIES OF INTEGRAL THERMOPLASTIC SHEET

Without the knowledge of how integral colourants behave (flakes from various sources used to create a metallic, peralescent, or frost appearance in plastic), it is difficult to describe and illustrate the visual changes that are perceived as well as how to accurately measure integral colours. The optical properties of integral sheet are determined by a number of individual effects, which could include all of the following characteristics:

- Opacity
- Brilliance (degree of sparkle or gloss reflecting from surface)
- Pigment loading (concentration)
- Flop (observed change in colour/brightness with a change in viewing angle)

These individual characteristics are influenced by properties of the integral colourants, which include the type of pigment, particle size, particle distribution, smoothness, and shape. When all these individual components are introduced into extruded plastic, it makes for a complex combination of possible appearances.

KEY CHARACTERISTICS OF INTEGRAL SHEET

Flop (variations in appearance):

Be aware that the same qualities creating depth and brilliance also can cause variations in appearance. Specifically, metallics and pearlescent products can have variation in the level of brightness creating dark and light areas. The highly reflective properties of special effect pigments mean that the same surface will look different depending on the viewing angle and the intensity and type of the light source. In addition, the general orientation and direction of the integral flakes in the plastic will affect the brightness of the colour. This is typically an undesirable but necessary reality of integral colourants, and is sometimes referred to as “flop.”

Special effect pigments act as tiny mirrors, Figure 1. The visual intensity of these pigments change in relation to the viewing angle. Maximum intensity is achieved at the angle of reflection. Minimum intensity is achieved for an angle far away from the reflection angle. The factors affecting flop are the shape and size of the pigment particles, their surface smoothness, particle distribution, and particle orientation.

To help minimize the appearance of “flop”, a directional laser etch, video jet, or sticker is used to indicate the direction of flake orientation. This will help designers and thermoformers to properly match sheet and part directionality for a more consistent appearance.

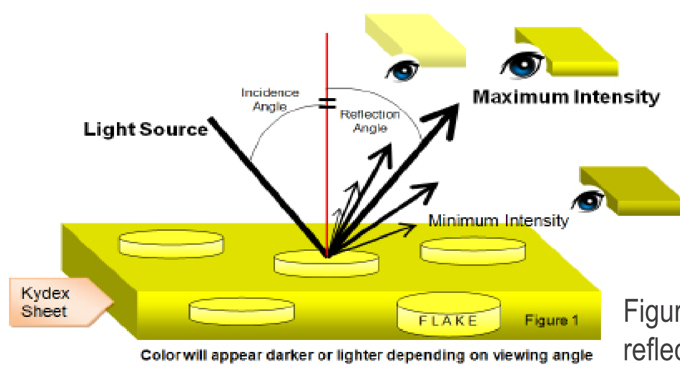

Figure 1: Integral pigments reflection of light source

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KEY CHARACTERISTICS OF INTEGRAL SHEET

Flop: Direction Matters

Extrusion directional arrows for consistent colour and effect on parts. All sheets must be thermoformed in the same orientation. When not formed in the same direction, the sheet may appear to be a different colour.

- Observed (visual) change in colour or brightness with a change in viewing angle
- Same qualities creating depth and brilliance can also cause variations in appearance
- More visible as special-effect loading increases

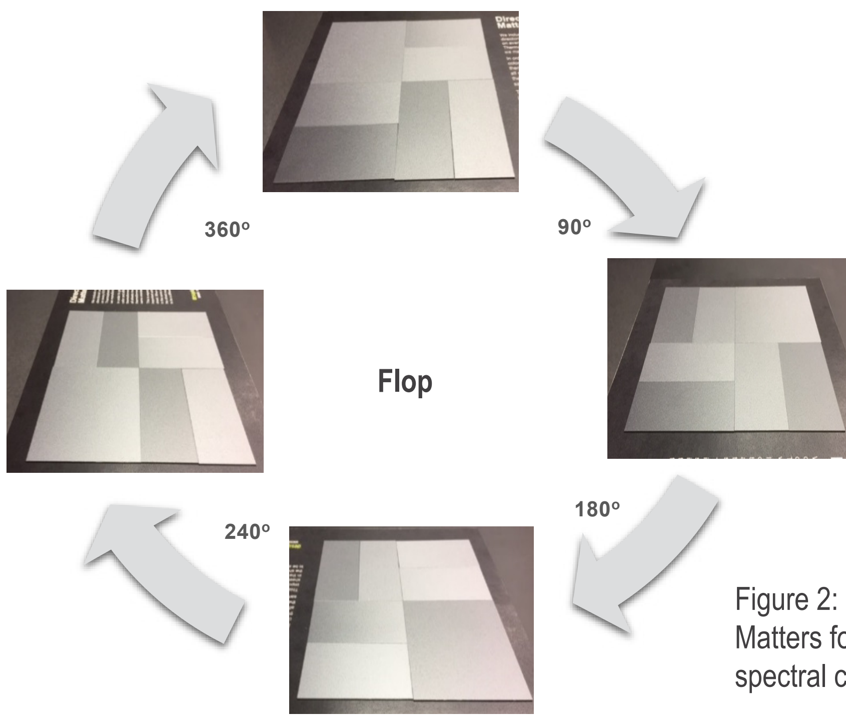

Figure 2: Sheet Direction Matters for both visual and spectral color

Flop: Integral Sheet Orientation

- Use directional laser-arrows to align parts or blanks when thermoforming
- Any change in direction will cause a visual difference
- Helps designers and thermoformers properly match sheet and part for a more consistent appearance.

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KEY CHARACTERISTICS OF INTEGRAL SHEET

Opacity: To achieve an opaque/solid colour, pigments must absorb sufficient light to prevent it from reaching the substrate, or underlying material thus changing the appearance.

In contrast, to achieve high-quality integral properties, the colourants rely on their lack of opacity (transparency), highly reflective characteristics, and particle orientation. Highly reflective particles create layers in the plastic matrix (Figure 3) that reflect some light but remain translucent enough to allow some light to pass through the surface. The thickness of the sample will determine the visual colour. If thin enough, some of the substrate colour will tint the actual integral colour.

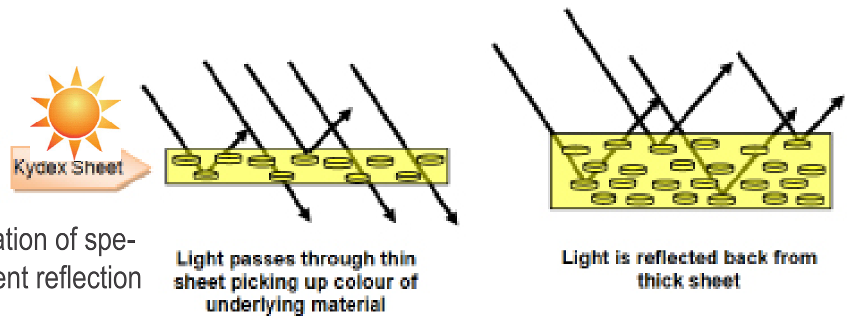

Figure 3: Illustration of special effect pigment reflection and opacity

For example, thin gauges of KYDEX® 110 can be subject to a visual colour shift based on the substrate colour. Most metallic colours thicker than 3.2mm (.125") should have minimal colour shift. However, if thermoformed to a thinner gauge, the same phenomenon will occur. On the other hand, KYDEX® 6503 is naturally more opaque than KYDEX® 110, so little or no light will pass through thin material. The additional opacity also mutes the highly metallic effect of KYDEX® 110 and gives KYDEX® 6503 a pearlescent effect.

MEASURING INTEGRAL COLOURS

The inability to accurately measure special effect materials has long been a problem. Conventional spectrophotometers for determining solid colours cannot handle texture differences as well as the optical properties of special effect sheet. Formulators, therefore, have relied mainly on their eyes to evaluate the effect level.

At Sekisui-SPI, integral colours are measured with a standard spectrophotometer.

- Samples are measured on the back surface of the material
- Extrusion direction pointing toward the ceiling.
- Every integral production run is measured utilizing CIE *L*a*b and CMC colour space.
- The "effect-level" is controlled through the colour formulation to ensure that every run of the same colour contain the same level of effect pigment.
- This removes the need for continued visual controls.

For more information on CIE *L*a*b and CMC colour space, please refer to Technical Briefs 130-A and 130-C respectively.

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MEASURING INTEGRAL COLOURS

Colour measurement is based solely on the energy that is reflected and returned to the instrument sensors. Energy from the source light of the instrument will pass through translucent special effect samples with differing results based upon thickness (Figure 3 on page 3). Thin sample measurement varies the most due to bleed-through from substrate colour or sample holder.

Not only does transparency influence colour measurements, gloss and texture can interact as well to produce various effects on the primary surface of the sheet. Large differences in gloss will affect the colour measurement; a higher gloss produces a superior metallic, peralescent, or frost effect. On the contrary, mechanical matting typically reduces the quality of the effect.

To minimize this perceived difference, KYDEX® 110 is run as a high-gloss product, which minimizes the mechanical matting from the texture rolls. Other textures may differ greatly between the primary and secondary surface colour readings, but look visually similar. Because of this, comparisons for quality purposes are done using the secondary surface. The secondary surface is the same for every lot, which minimizes differences between the machine and transverse directions.

Note: Thermoforming KYDEX® 110, KYDEX® 6503, KYDEX® 6523HI will change the thickness, texture, and gloss level creating a slightly different appearance from the unformed flat sheet.

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