COLOUR REPRODUCTION ON BACKLIT SUBSTRATES

measuring, profiling and final viewing

ProcessStandard Digital fogra PSD

Highlights

For later reading

PRINTING THE EXPECTED

- **From happy to get colour to colorful it is not enough anymore**
- **Not just THE EXPECTED, but across**
  - Different locations
  - Different printing technologies
  - Different substrates
  - Production batches
  - Different viewing environments
- **Example**
  - Various samples printed using dye-sub, latex, solvent and UV curable printing technologies

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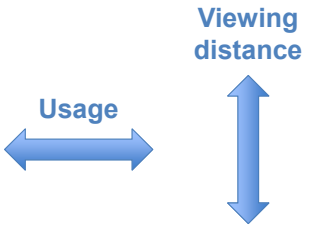
LFP BACKLIT SUBSTRATES – TYPICAL BUT NOT LIMITED TO

Thickness property

- **Thin substrates**
  - Backlit Film
  - Backlit Textile
  - Self-Adhesive Vinyl
  - Citylight Paper
  - Backlit PVC
- **Thick substrates**
  - Glass
  - Plexiglas
  - Acrylic

Opacity property

- **Transparent (clear)**
- **Translucent**



- **INDOOR**
- **OUTDOOR**

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TYPICAL BACKLIT PRINTING COMBINATION

- **The printing systems**
  - Most of the printing technology including latex, water-based, solvent, UV and dye sublimation
- **Substrates**
  - Transparent to translucent substrates with good scattering properties (acts as a diffuser)
  - Thin (flexible) and thick (rigid) substrates
- **Inks**
  - Strong chromatic inks
  - Split colour inks (lc/C, lg/g/MK/PK) with small size droplets may be used to enhance sensitive close viewing range prints, but also strong black channel
  - Special purpose inks (white) may be used for backlit applications
- **Printing workflows settings (Driver)**
  - Printing modes ⇔ High printing resolution, High number of passes, interlacing to minimize banding (advance, over inking, curing), etc.
  - Special printing modes ⇔ Double Strike, High Density, Double Density, etc.
- **Lamination**

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PRINTING THE EXPECTED = MEASURE AS WE SEE

- **The printing combination**
  - Printer and its printing technology
  - Ink
  - Substrate
  - Printing mode
- **Tools**
  - Measuring instruments
  - Measuring protocol
  - Charts
  - Profiling application
  - Validation application
- **Visual judgment**
  - Standard D50 viewing booth (P1) and light box (T1) as described by ISO 3664:2009
  - Actual backlit light box (actual light source)

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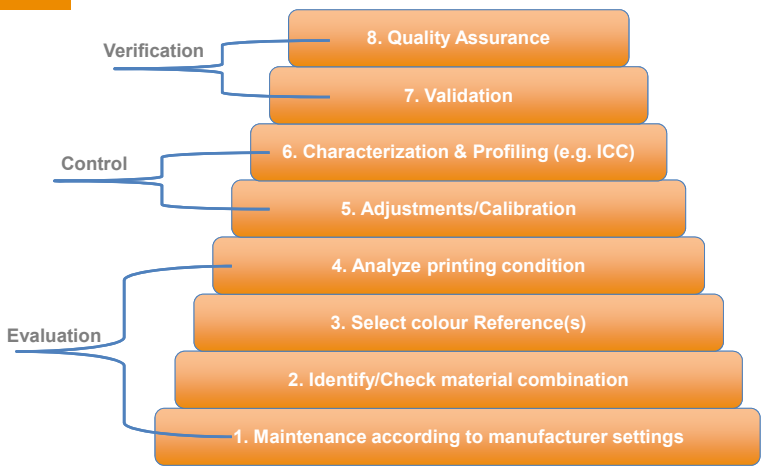
THE PSD PRINTING COMBINATION CAPTURE CONCEPT



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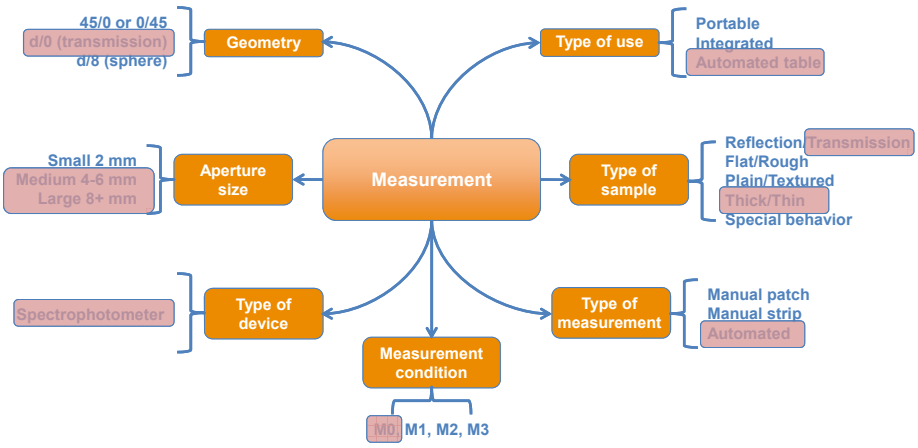
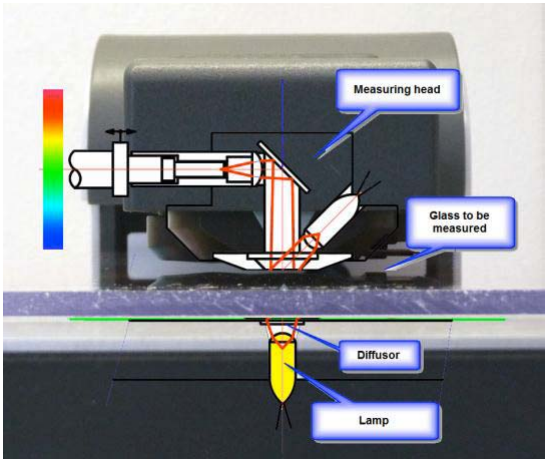
CHOOSING THE RIGHT MEASURING INSTRUMENT



D/0° TRANSMISSIVE GEOMETRY



Source: Barbieri

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MEASURING PROTOCOL – BASED ON ISO 13655:2009

- **Data**
  - Spectral whenever possible
  - No M conditions, M conditions applies only to 45/0 and 0/45 reflectance measurement
  - But usual transmittance d/0 devices are using a type A illuminant, similar as M0
- **Backing**
  - No backing (of course) or transparent backing
- **Specific consideration**
  - Measurements are taken media relative – device is calibrated on the substrate white resulting in a relative white point with the L*a*b* value of 100/0/0
  - Side-by-side comparison between reflective and transmissive comparison of the substrates as described by ISO 3664:2009
- **Data quality and consistency**
  - Averaging and smoothing

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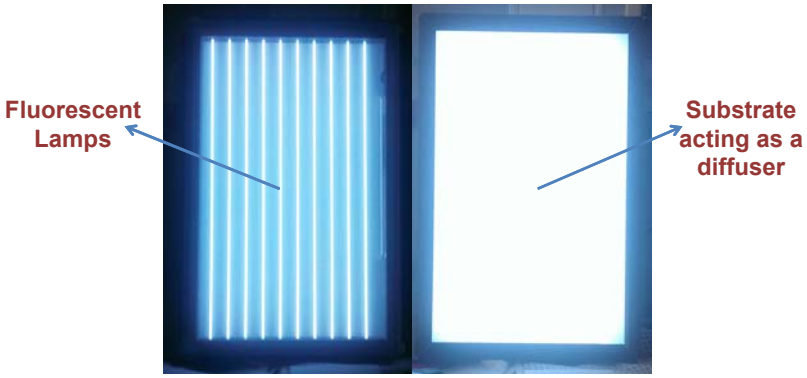
CHROMATIC ADAPTATION TO THE LIGHT BOX

- **Relative substrate measurement count toward measure as we see**



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THE CHOICE OF DEVICE AND ITS SETUP

- **Barbieri Spectro LFP**
  - 6 or 8 mm aperture (2 mm is too small for area averaging)
  - If possible no holder for flexible pass-thru substrates – its quality (scratches and others) may lead to false measurement results (detached the right side, use the left side to attach the chart with tape)
  - Up-Down measuring mode (Fast mode may scratch or fold the target/holder due to the friction between head and chart)
  - Manual positioning choice (for the same reasons as above)
  - High accuracy calibration (every 2nd row)

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MEASURING THIN SUBSTRATES

- **General**
  - Most substrate from this category are 80 µm – 500 µm thick
  - Watch out for curled corners that may fold the target under the head when the table is moving
  - Watch out for electrostatic charging of the substrate due to movement friction resulting in chart getting stuck instead of moving
- **Stiff substrates (Backlit Film, Backlit PVC, Citylight Paper etc.)**
  - No major issues
- **Self-adhesive substrates (Self-adhesive Vinyl)**
  - Use a thin transparent PVC foil (100 µm – 300 µm) to transfer the SAV from the paper liner

- **Very flexible substrates**
  - If the substrate doesn't move and simply gets stuck on the table, use the holder for flexible pass-thru substrates as the last resort

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MEASURING THICK SUBSTRATES

- **General**
  - Most substrates from this category are over 1 mm thick
  - The thicker the substrate, the greater the distance between measuring head and the lamp/diffusor, prone to external influencers:
    - Stray light coming from outside
    - Substrate internal reflection
  - For the measurement purpose try to use the thinnest possible substrate of the same type in order to obtain better and more consistent measurements
  - Depending on the substrate opacity (transparent to translucent to milky), recommended thickness is less then 3 mm and is preferably less then 1 mm
  - Measurement of some substrates falling into this category are simply not resulting into meaningful visual correlated measurement data or simply put – "we don't measure as we see"

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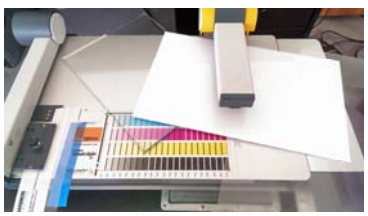
WHEN MEASURING THICK SUBSTRATES FAILS – WORKAROUND

- **Background**
  - Most of the substrates from this category are printed using hybrid or flatbed presses with UV curable printing technology and inks
  - In general, UV ink is less sensitive to the ink/substrate interaction process, most of the ink is cured on top of the printed substrate
  - Since we actually aim to measure the media relative response (colour w/o substrate) …
- **A surrogate substrate may be used for such cases**
  - Transparent PVC foil, similar as the one we used for SAV transfer
  - Choose the appropriate thickness that is usable with your printing system, but keep in mind that optimum range is 100 µm – 300 µm



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OTHER USEFUL INFORMATION

- **Understand the general limitations and requirements of the measurement process and choose the appropriate meanings of capturing the intended substrate/ink response**
- **Any substrate should be measured in the same way as the final printed product will be looked at (device diffusor -> side of the light source and the measuring head -> side of view)**
  - Normal print = Print side towards measuring head
  - Reverse print (mirror) = Print side towards device diffusor
  - If both instances may be used, create two separate sets

- **Measuring time**
  - Up-down measuring mode combined with higher than usual opaque backlit substrates (like citylight paper) may take more time to measure due to instrument getting lower light levels that requires patch measuring time adjustment
  - In general, measuring in transmissive mode is time consuming so make sure your measurement setup, charts and protocol are properly prepared

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PRINTING MODE

- **A backlit printing combination is requiring colour vividness and richness, strong contrast and dynamic range**
  - High chroma C* value for both primary colours and for their secondaries
  - Recommended black point optical (visual) density is higher than 2.2 (translated into L* of at least 6) and preferably is higher than 2.5 (translated into L* of at least 3)
- **In general, most printing systems will have dedicated settings to achieve these requirements comprising of one or a combination of types of printing modes:**
  - High resolution
  - High inking
- **Examples**
  - Latex: HD mode, 150% or 250% mode
  - Solvent: Hi-res modes 720x1080 dpi, 720x1440 dpi w/ or w/o 2x ink layers
  - UV: Max DPI mode, Quality Density, Double Strike, HR mode, Double Density
  - Pigment: Backlit Mode (Matt K)

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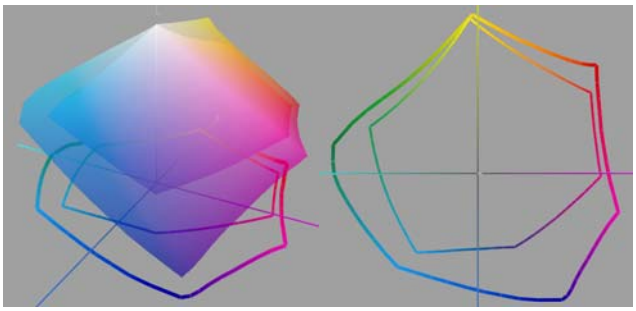
TYPICAL TRANSMISSIVE COLOUR GAMUT

- **Gamut similarity can be estimated based on white point and black point differences between source and destination**
- **Due to nature of the measurement (media relative), high optical density (low L* for black point) and the aim of strong chromatic primaries/secondaries, there will be always (almost) a scaled up relation between source and destination**



ISO_coated_V2 (FOGRA39) vs. Backlit Film printing condition

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ADJUSTMENTS/CALIBRATION

- **This stage is the first and most important part of the resulting media set**
- **It is foundation on which the ICC colour profile will rely and is directly linked to the output quality**
- **Parameters to set**
  - Ink Limit per Channel
    - Obvious physical limit or workflow tool automated suggestion (starting point)
    - Analogy to offset over and under inking
  - Linearization
    - Optimal/defined behavior between paper and solid for each channel by meanings of ISO Status density, spectral density or colorimetrical TVI
    - Actual linearization may be different from the meaning of the “Linearization”
  - Total Ink Limit
    - No ink amount behind this value
- **The process is influenced by the driving RIP workflow, so while the general concept may be applied independently, in particular each workflow may have different approach and tools**

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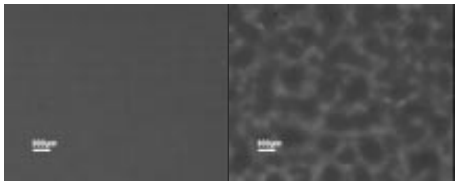
INK LIMIT PER CHANNEL: PREPARATION

- **A chart with a 5% increment patches will suffice**
  - Always print it repeated over the entire width of the substrate for practical reasons
  - Check visible printing defects like mottle caused by bleeding and coalescence = over inked areas will not be taken into account after measurement
  - A good sign of over inking is a darker thin frame of ink close to the patch edge
  - Make sure the target is safely dried before measuring it
  - For a printing system without curing/drying, it can take up to 30 min for drying ink to stop drifting colour after printing



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INK LIMIT PER CHANNEL: MEASURING

- **Practical tips**
  - Apply all aspects we've been already parsed in relation to the measuring device and protocol
  - If necessary average several measurements from different charts coming from different parts of the printer width for XXL printers
  - Resulting measured file should include spectral data useful for both colour and density assessment
- **Density (spectral or ISO Status) still has its usage**
  - Correlates well with ink film thickness and represents a sensitive tool to show ink film layer stability
  - Visible mottle effects shown by the patches will be also reflected by measurement when checking density
- **Determine the trend and optimal aim value based on the correlation of a* and/or b* rather than of C* / h* (like C/b*, M/a*, Y/b*, K/L*, etc.)**
- **When the aim values have been determined, our printing combination becomes a printing condition**

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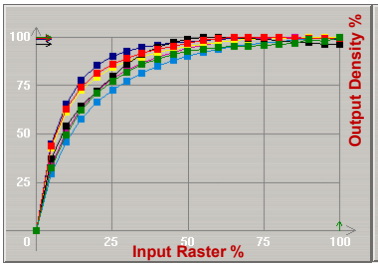
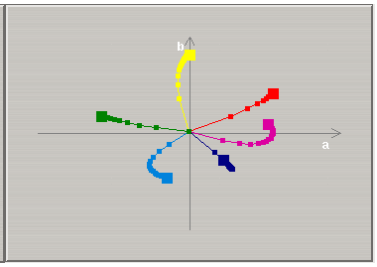
INK LIMIT PER CHANNEL – TRADING INK % FOR ΔE

- **Best Aim – from the same data you can correlate density and colour for a meaningful interpretation of the measured data and a proper determination of the ink limit**
  - How much more ink % are you willing to allow for just 1 ΔE increase?
  - Leave room for re-linearization
  - Take into account printing system drifting over time (print heads, environment …)

Spectral density



Hue (a*b*)



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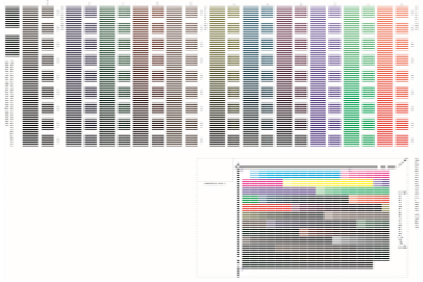
TOTAL INK LIMIT

- **Influence over the colour gamut on both vertical (Black Point) and horizontal directions (secondaries M+Y, C+Y, C+M)**
  - Usually is determined by visual inspection of specially designed charts, but some workflows allow measurement as well
  - Same considerations will apply as per channel ink limit
  - Since the Black Point will be composed mostly from K component, the L* value of K will be a good indication of the L* value of the Black Point



EFI XF Advanced Ink Limit Chart

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INK LIMITS AND INK CONSUMPTION

- **Both limits (channel and total) will have an impact over the resulting ink consumption**
  - Other factors are Drop Size (pl) and Printer Resolution (X x Y dpi)
  - Most workflows are able to calculate and report mathematical ink consumption based on image channel coverage %
  - Some printers are even reporting the actual ink consumption
  - While drop size and printer resolution are constants, the ink limits may be optimally adjusted
- **Aim: best size stable (printability & runnability) colour gamut with the least amount of ink used**
  - How to: mostly from experience and understanding how your printing system works
  - A custom made media set (with optimal calibration and characterization) may reduce overall ink consumption up to 25% from a generic or not optimized media set

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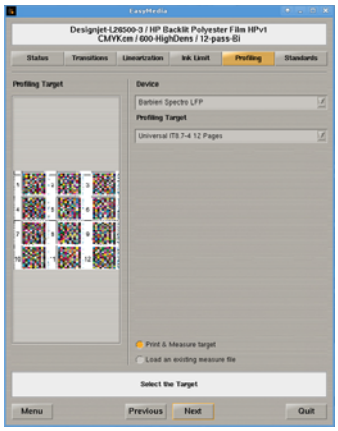
CHARACTERIZATION & PROFILING

- **Use ISO 12642-2 chart IT8.7/4 (random layout preferred) or the Universal LFP based IT8.7/4**
  - As per any printed chart in the process control, print it repeated over the entire width of the substrate for practical reasons
  - If necessary average with optional interpolation and smoothing
  - This is your characterization data set for the selected printing combination, basically a fingerprint of your printing system for the chosen parameters
- **Our printing condition becomes a fully characterized printing condition**



Caldera EasyMedia Profiling

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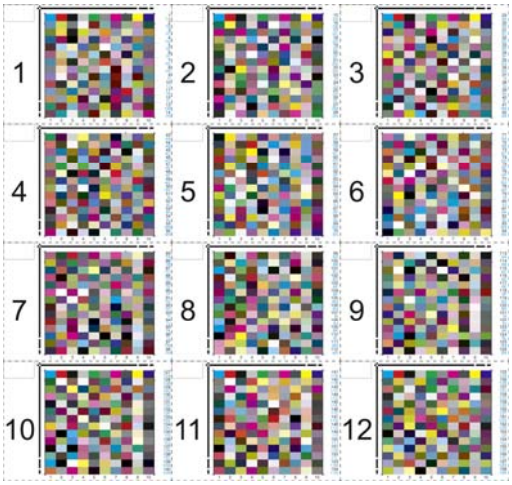
UNIVERSAL LFP CHART

- **Patch size 19,2 x 13 mm**
- **12 A4 pages or one big layout 891 x 840 mm**
- **No contrast bars, patches randomized for max ΔE* (Konica Minolta FDC app)**
- **1680 patches**
  - IT8.7/4 (ISO 12642-2)
  - Some additional patches
- **Successfully read by all devices from the list**
- **References for different measurements file schemas**
  - horizontal by page
  - vertical by whole chart
  - vertical by page



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PROFILE GENERATION

- **Second stage of the media set based on previously made adjustments and calibration**
- **Any modification on the previous stage requires re-printing and re-measuring of the profiling chart (except re-linearization)**
- **Typical ICC Output Profile will be generated, but Device Link Profile may be also used**
  - Profile generation parameters
  - May be optimized thru iterative printing and measurement
- **Lighting**
  - Usual Standard D50
  - Custom light may be used (e.g. Backlit from the Lightbox) – no scientifically feedback available yet to show how the current ICC framework allows profile generation illuminants to correlate with the actual viewing environment
  - UV component impact is due to both backlit substrate OBA's but also there may be quite an important UV component in the light box illuminant

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CUSTOM VIEWING ENVIRONMENT

- **Beside CIE Standard illuminant D50, spectrally based profilers allows the usage of any other standard illuminants or custom SPD's**
- **For backlit applications this is handy if the backlit light is always the same for a given lightbox type**
- **How to, using with X-Rite i1Profiler**
  - Use i1Pro/i1Pro2 with the ambient head for measuring
  - Put a blank substrate that will be used for printing in the lightbox and turn it on
  - Inside i1Profiler, go to your profiling workflow, Lighting icon
  - Allow the lightbox to warm up at least 30 min and then do several measurements over different parts of the lightbox (for averaging, requires MS Excel help)
  - Generate your profile using the resulting SPD

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QUALITY ASSURANCE

- **Put all the know-how into simple and well designed SOP for this purpose, it will save a lot of time and money when it comes to corrective actions**
- **Press side – process check**
  - Periodically calibration or re-calibration recommended
  - If it fails a new characterization may be required
  - Monitor and record the Pass/Fail evaluation for tracking purposes, it will show up trends useful to fix issues before they become problems
  - Track other variables like environment temperature and humidity
  - Monitor your substrates supplier new batches
- **Jobs side – print check**
  - In order to facilitate a proper understanding of "what we see" tag one copy of the print run or a selection of the printed area (for larger jobs) with a proper job ticket
  - Attach the MediaWedge 3.0 LFP to the printed reproduction
  - Store safely this proper identified copy for each major job in order to deal with later complains in a professional objective matter
  - Define the evaluation method (media relative) and the colour accuracy tolerances based on the appropriate reference set

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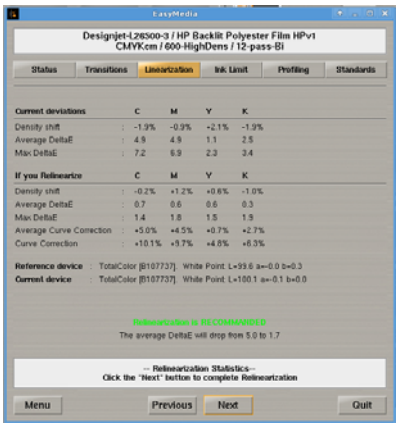
RE – LINEARIZATION

- **Most modern workflows allow re-linearization in order to compensate for printing system drifting over time**
  - A proper procedure for creating media set
  - Reliable capturing of the fully characterized printing condition
  - Process control is much easier with the help of relinearization
- **Example:**
  - HP Designjet L26500
  - HP Backlit Polyester Film
  - One year later
  - 3 sets of print heads changed due to worn out
  - Same media set still in use



Caldera EasyMedia Relinearize

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BACKLIT APPLICATIONS EVALUATION

- **Due to the nature of measurement protocol and also the aim of colour reproduction, backlit applications may be only evaluated using the media relative concept**
- **The recommended intent to be used for conversion is perceptual in order to scale up the reproduction to the whole extent of the available colour gamut**
- **PRO's**
  - Best balanced approach considering the wide variety of substrates used for backlit applications
  - Allows the printing of the same data across different digital LFP technologies and substrates
- **CON's**
  - Problematic if requires a very good visual match with a reflective viewed proof or conventional printed sheet
  - No numerical evaluation (not yet), further study is required to understand how to correlate visual and numerical assessment – one possible option being the Black Point Compensation integrated in the FCR-Media relative evaluation

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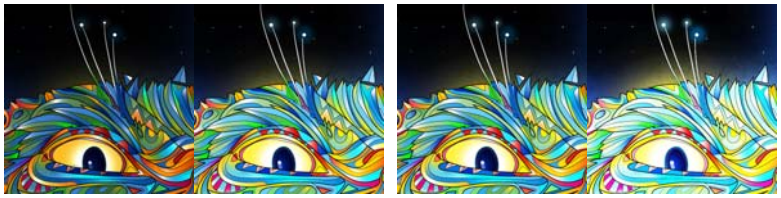
BACKLIT ON VS. BACKLIT ON/OFF

- **The challenge:**
  - Reproductions based on transmissive measurements will look correctly under backlit light and too dark (no details, dull colours) under reflective light only
  - Reproductions based on reflective measurements will look correctly under reflective light and too bright (no contrast, no chromatic colours, low optical density) with backlit light on



Backlit off Transmissive setup | Backlit on Transmissive setup | Backlit off Reflective setup | Backlit on Reflective setup

Backlit on/off – One setup ?

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BACKLIT ON/OFF TYPICAL PRINTING APPLICATIONS

- **Double sided printing**
  - Usually roll-to-roll/roll-to-free-fall presses with double side feature to allow registration of the front and back side
  - Example: Backlit PVC or Textile
  - Setup mode: Reflective setup/Front side, the Front content is mirrored, ink % is either in full or scaled down % and printed on the Back side
- **One sided printing using an white ink layer between two colour layers**
  - Usually flatbed presses with White ink either one time printing or multiple times printing with accurate positioning
  - Example: most of the transparent substrates like Acrylic, Plexiglas, Glass, Transparent SAV
  - Setup mode: Reflective setup/1st layer, White layer/2nd layer (ink % need to be determined for optimum scattering – not too opaque, not too transparent), Reflective setup/3rd layer

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ADJUSTMENTS FOR BACKLIT ON/OFF

- **Print according to the intended way (double sided or one side with 3 layers)**
- **Measure both reflective** (double sided printing usually requires white backing because material has high opacity while transparent substrate printed with white ink requires black backing because of lower opacity) **and transmissive response this time**
- **Same approach and considerations as previously presented CMY channels, plus …**
  - Try to find the ink % with smallest Δh° between the two responses because we are more sensitive to hue differences, than chroma and lightness
- **For K channel**
  - Try to find the ink % that fulfils L* selection criteria for both responses
- **This way the colour gamut will scale as uniformly as possible between reflective and transmissive**
- **Then use only the reflective response for the setup (both adjustments and characterization/profiling)**

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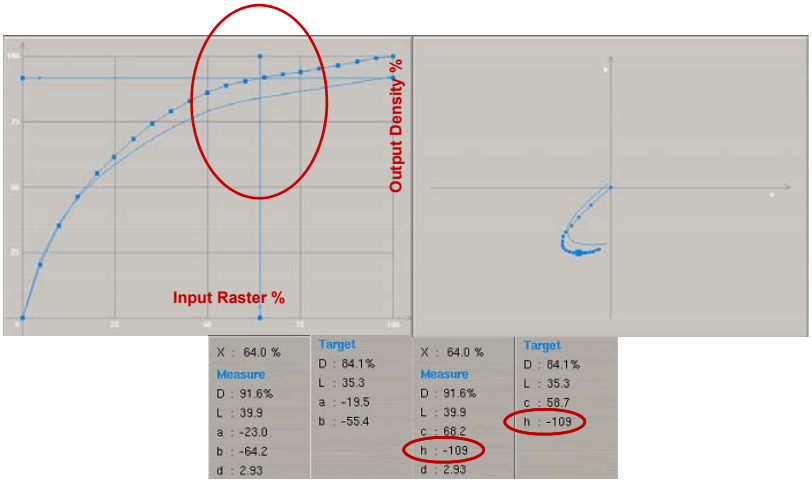
CYAN CHANNEL REFLECTIVE/TRANSMISSIVE RESPONSE



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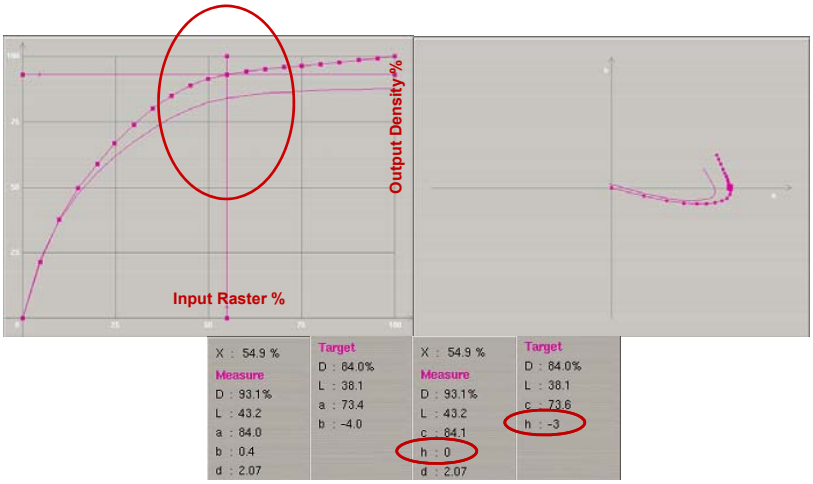
MAGENTA CHANNEL REFLECTIVE/TRANSMISSIVE RESPONSE



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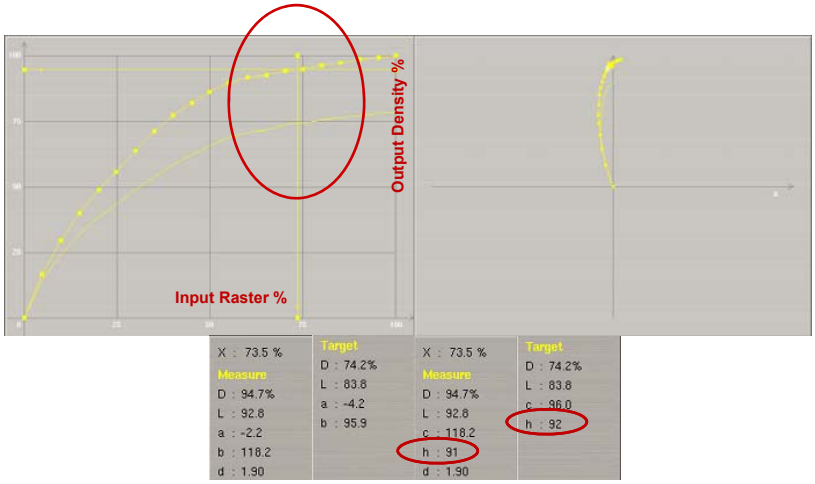
YELLOW CHANNEL REFLECTIVE/TRANSMISSIVE RESPONSE



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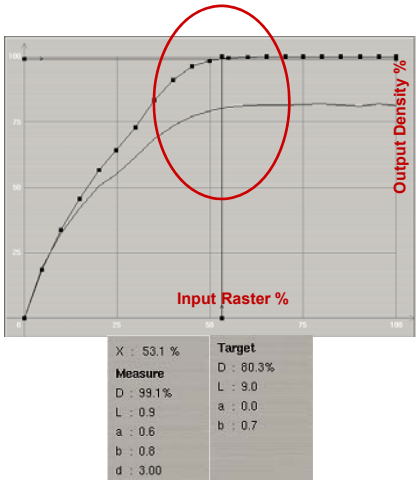
BLACK CHANNEL REFLECTIVE/TRANSMISSIVE RESPONSE



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BACKLIT ON/OFF COMPROMISE

- **What if only one sided printing?**
  - One setup based on same adjustments done in Transmissive mode
  - ICC profiling chart measured twice: Reflective and Transmissive
  - Average the two data sets
    - Some data alteration of the measurement file using MS Excel
    - Reflective set will have to be transformed media relative, by dividing each spectrum collection to the substrate spectrum
    - The resulted measurement file will be average with the Transmissive one
  - Generate the ICC profile from the resulted averaged data set
- **This way one sided printing with the help of a Hybrid setup, will reflect a compromise between backlit light on viewing and backlit light off viewing**
  - Adjustments/Calibration – Transmissive mode
  - Characterization – Averaged Reflective/Transmissive
  - ICC profiling – Based on the averaged data set

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Thank you for your attention
Q & A

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