GRACoL
Setup Guide

How to calibrate a press or proofing system to the new 2005 GRACoL specifications

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NOTE: This document is a work in progress and will be re-issued periodically as needed. The version number is listed at the bottom of each page in the file name. To make sure you have the latest version, please contact the author, who will also gratefully receive any comments and suggestions at (don@hutchcolor.com).
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Introduction

This document is primarily written to guide the creation of standardized print appearance characterization data, such as for GRACoL or SWOP. By default it also describes how to calibrate a printing press or pre-press proofing system to match the “appearance” of the master process or device on which the characterization data was produced.

There are two stages to this process. The first stage controls two of the most important appearance variables - neutral tonality (a.k.a. “Print-Density Curve”) and Gray Balance - via 2-dimensional look-up-tables or calibration curves. The second stage produces a 4-dimensional characterization data set from which ICC profiles can be created.

There are three important benefits to this two-stage approach. First, by using the calibration or linearization function inherent in all processes to control print density and gray balance, these two crucial variables can be equalized on all devices without the need for ICC profiles. Grayscale images and near-neutral tones should therefore match very closely, even on devices with significantly different colorants.

Secondly, if the colorants are similar, a very good match should be obtained on various devices without the need for further color management, and there will be less need for custom profiling.

Finally, when an ICC profile is needed (for example in ink-jet proofing) it’s purpose will be reduced to simply adjusting complex 3- and 4-dimensional variables like ink trap, which minimizes the effort needed by the profiling software, and limits the chance of errors in the profile.

The basic curve shape and gray balance aim points described herein are the result of numerous live press tests using commercial materials. By a happy coincidence these data follow very closely the tonality and balance of the well-proven TR001 characterization set. This means that a commercial press or proofing system calibrated according to these new GRACoL specifications will produce a printed image that largely mimics the “appearance” of a standard SWOP press sheet, but with added brightness, contrast and saturation. This in turn means that files prepared for one process should look at least “pleasing” and often optimum on the other, without further pre-press adjustment.

Breaking with tradition

Note that the new process involves some relatively new concepts, at least by traditional standards. For example, TVI is no longer measured, (being replaced with the new variable “Highlight Range”) and gray balance has risen from virtual neglect to one of the most important measured variables.

Where appropriate, the logic behind these changes, and their aim values, are discussed in comparison with traditional methods. The author and the GRACoL committee encourage feedback on these and any other points covered by this document.
Step-by-step summary

This process requires two press runs, one for pre-calibration and one for characterization, which should be made as close as possible to each other on the same press, ideally no more than 60 minutes apart.

Stage 1: CTP pre-calibration

1. Check that plate-making hardware and RIP are in manufacturer’s spec. for exposure, focus etc.
2. EITHER calibrate the CTP system so that a 50% dot measures 50% on the plate OR leave the CTP system in a repeatable, but uncalibrated state. (See Plate Calibration)
3. Image the combined GRACoL calibration / characterization form to plates.
4. Measure the reflected dot percentages on plate at 10% intervals for each screen angle using a video plate analyzer. This provides a base-line calibration curve for the CTP system prior to press calibration.

Stage 2: Press pre-calibration

5. Check that media (inks and paper) are in spec. (see GRACoL Specifications)
6. Check that the press hardware is adjusted optimally, including blanket condition and tension, impression squeeze, etc.
7. Check measuring equipment is in spec and calibrated. A reflection spectrophotometer is required, and a reflection color densitometer (Status T) is desirable. A spectro-densitometer with multi-channel readout is ideal.
8. Check viewing conditions are in spec.
9. Print the calibration run to nominal ink “quantities” (SID)
10. Measure gray balance and adjust press variables (e.g. solid CMY densities) as needed to achieve specified gray balance
11. Measure cross-sheet evenness in terms of SID and gray balance and adjust until maximum deviation at ink-key intervals is as small as possible
12. After reaching goal conditions, run at least 500 sheets at typical production speed, and re-check SID, gray balance and evenness at the end of this speed cycle
13. If metric quality or evenness has decayed beyond specified tolerances, adjust variables until optimum metrics are achieved, then repeat the speed cycle
14. From a good calibration sheet, measure the black-only and CMY gray scales and plot them as either density-vs-dot%, or L*-vs-dot%. Measure at least two scales each, from different parts of the sheet, with one scale at 180° to the other, so as to average out any circumferential ink-starvation effects.
15. Compare the plotted curves with the goal curves and calculate the needed CTP
correction curves to achieve the desired goal curves. One common curve should be calculated for CMY, but usually a separate curve will be needed for black.

16. Create new plates of the combined GRACoL calibration / characterization form through the modified CTP curves.

17. Measure the reflected dot percentages on plate at 10% intervals for each screen angle using a video plate analyzer. This provides an operating target for qualifying plates in daily production.

**Stage 3: Press characterization**

18. Print the characterization run to the same press conditions as the pre-calibration run.

19. Confirm that the desired goal curves are achieved, and that other parameters like gray balance, evenness, ink quanta, etc., are not changed.

20. Run at least 500 sheets (ideally 1000 or more) at normal press operating speed and check that metrics are still in spec.

21. Select a sampling of good sheets and allow to dry naturally.

**Stage 4: Generating characterization data**

22. Measure spectral data from multiple sheets.

23. Combine measured data from multiple sheets either by simple averaging or ideally by some algorithm designed to reject anomalous readings and smooth the characterization data to imitate a theoretically perfect press. This is the subject of ongoing research.

24. Publish the characterization data in standard CIELab (D-50) form as well as in spectral measurements. The latter allows generating Lab values in other than D-50 lighting, often an essential requirement for accurate proofing.
Process details

Substrate

Use paper that conforms to the ISO 12647-2 spec for substrates 1-2

- **Colorimetry:** L* 93.00  a*  0.0  b* -3.0
- **Grade:** No 1
- **Mass:** 100 lb
- **Brightness:** 90
- **Gloss:** 78
- **Roughness:** 0.77
- **Opacity:** 96.5

Inks

The inks should conform to ISO 2846-1, however this standard does not appear to define the printed appearance of these inks. Nevertheless, it’s a starting point.

**Solid ink densities**

Nominal GRACoL SID values are as follows;

- C  1.50
- M  1.50
- Y  1.05
- K  1.90

Note that these are only INITIAL aim points that may be altered as needed in production printing (within tolerances TBD) to achieve gray balance.

**Solid ink colorimetry**

For GRACoL or any other print standard to truly define “print appearance” it needs to state unambiguously what color the inks are supposed to be on the specified paper at specified densities. ISO 12647-2 gives us these starting points:

ISO 12647-2 Aims:

- **C**  54  -36  -49
- **M**  46  72  -5
- **Y**  88  -6  90
- **B**  16  0  0

… but there is uncertainty about what status T densities these Lab values relate to.

In the new GRACoL spec solid ink densities will be quoted along with their equivalent...
Lab values, based on actual press measurement. When the two specs cannot be met simultaneously, for example due to measurement device anomalies, the Lab value should take precedence.

NOTE: Most printing specs define solid ink densities with paper included, which makes actual density range (and thus visual contrast) dependent on paper brightness. It is more useful in the new context to specify and measure solid densities with paper REMOVED.

**Higher ink densities**

To keep pace with trends in higher-quality commercial printing the 2005 GRACoL press tests will experiment with running standard inks at higher densities, typical of what a printer may be asked to do when “pushing color”. A better alternative (if available) would be to run more highly-pigmented at normal ink film thicknesses.

**Approximate higher target ink densities**

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<table>
<thead>
<tr>
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<tr>
<td>C</td>
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<tr>
<td>M</td>
<td>1.65</td>
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<tr>
<td>Y</td>
<td>1.10</td>
</tr>
<tr>
<td>K</td>
<td>2.00</td>
</tr>
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</table>

These are only aim points that will be altered as needed to achieve gray balance.

**Ink sequence**

The standard ink sequence for GRACoL is K, C, M, Y. Deviation from this sequence may affect trapping of 2- and 3-color overprints.

**Ink trapping (overprints)**

Trapping is a very important factor in any meaningful press characterization. The new GRACoL spec will specify target trapping values for 2-color solid overprints in colorimetric terms, based on measurements of the 2004 and 2005 press tests. Where the data differ between runs, some logical method will have to be determined to decide which run most fairly reflects typical trapping.

**Coating**

Due to the widespread use of aqueous coating in 4-color commercial printing, GRACoL characterization data should be applicable to both coated and uncoated press sheets.

Rather than publishing two specs, a single data set produced on coated sheets may be preferable due to apparently easier printing, faster drying, better trapping and greater consistency than uncoated printing. It is hoped that characterization data from a coated sheet may be adapted for uncoated printing by simple XYZ white and black point scaling. This will be tested during the project.
Gray balance

In the past gray balance was an ill-defined by-product of controlling separate TVI values for C, M and Y. In recognition of the key importance of gray balance, GRACoL will henceforth replace separate TVI values with a single gray balance aim point to be measured on a combined CMY “gray patch”.

GRACoL will henceforth define “gray balance” as follows;

**Nominal GRACoL mid-tone gray balance:**

\[
\text{CMY 50, 40, 40} = \text{a* 0.0, b* 0.0 +/- 0.5}
\]

If the press calibration run (or a production run) is not in balance, begin by checking press conditions like packing, ink water ratio, ink sequence, etc. If this does not solve the problem, the recommended CMY solid ink densities may be adjusted to meet gray balance at the mid-tone. If either C or M are already at the high end of their nominal solid density range, the ink which indicates excess on the gray patch should be reduced. Y should then be adjusted up or down till gray balance is achieved.

Gray balance can only be measured on press by spectrophotometry. Suitable control patches must first be inserted in the press control bar with appropriate CMY dot percentages of 50C, 40M, 40Y. Measurements should be taken at make-ready and throughout the run to ensure the printed appearance of the gray patches remain within tolerance.

Gray balance must be checked across the whole sheet, but it is most critical in line with the profiling targets (see Ink Coverage and Evenness).

Print Density Curve (PDC)

After the initial pre-calibration run, the CTP curves are adjusted as needed in order to achieve a pre-defined Print Density Curve for a CMY balanced gray scale and a K-only scale. Adjusting the press to achieve this curve replaces the need to measure dot gain or TVI, as these are simply a sub-set of the print density curve. For run-time process control TVI is now replaced with the new “Highlight Range” metric (see below).

CTP calculations can be accomplished using on a pre-marked graph chart (for density or L*) which will be available free from GRACoL, (see Using a pre-calculated chart) or in an automated workbook being developed by Don Hutcheson (see Using the P2P workbook).

**Print density curve principles**

The basic principles of the current GRACoL print density curve are as follows;

- The neutral contrast range of the device is first analyzed in L*, separately for a balanced CMY scale and a single-ink K-only scale.
- The L* range is divided in two and the mid-tone value is used as a starting point for range compression, which is restricted to the darker half of the L* range.
- The range compression is based on simple exponential scaling in XYZ (or simply Y, as the scaling is calculated on neutral grays only).
• The lighter half of the \( L^* \) range is adjusted to fit a constant linear slope of density vs dot percentage, based on a smoothed version of the neutral slope in TR001. These principles are similar to linear XYZ scaling throughout the whole dynamic range. The subtle difference is that the GRACoL method maintains absolute highlight contrast between devices of widely disparate dynamic ranges, whereas full-range linear XYZ scaling tends to lighten mid-tones on lower range devices and darken mid-tones on longer range devices.

**Highlight Range (replaces TVI)**

Visual “contrast” and “density” used to be controlled by measuring TVI or “dot gain”. This is no longer recommended due to the weak link between TVI or dot gain units and actual visual appearance.

Visual contrast and density are better controlled by maintaining a pre-set neutral density contrast range between the mid-tone gray balance patch and paper (for CMY plates), and between the mid-tone K-only patch and paper (for the black plate only). These values can be measured by any calibrated densitometer in relative density units, or with a spectrophotometer in relative L* units.

Highlight range is the difference between white paper and a middle-tone patch measured in density or L*, as follows...

CMY "highlight range (D)" = visual density at 50c, 40m, 40y, 0k minus paper density.

CMY "highlight range (L*)" = paper L* minus L* at 50c, 40m, 40y.

Black "highlight range (D)" = visual density at 0C, 0M, 0Y, 50k minus paper density.

Black "highlight range (L*)" = paper L* minus L* at 0C, 0M, 0Y, 50k.

**Nominal Highlight Range (D):**

\[
\begin{align*}
\text{CMY} & \quad 50, 40, 40 = 0.57 \\
K & \quad 50 = 0.53
\end{align*}
\]

In production, the nominal Highlight Range (D) - which normally requires two readings - can be converted easily to a single-reading absolute density value, simply by adding the current paper density to the nominal Highlight Range value. The result will be a density value slightly higher than the nominal Highlight Range (D) value.

Likewise, the Highlight Range in (L*) - which normally requires two readings - can be converted easily to a single-reading absolute L* value, simply by multiplying the nominal Highlight Range (L*) value by the current paper L*/100. The result will be an L* value slightly lower than the nominal Highlight Range in (L*) value.

**Ink coverage and evenness**

It is extremely important that each GRACoL press run maintains even gray balance, mid-tone density and solid densities (in that order of importance) across the sheet. To monitor these variables, the press form contains gray bars all the way across the sheet in these values;
Characterization target

Currently the best CMYK characterization targets available are ECI 2002 and IT8.7/4, however both of these suffer from low precision in darker areas. I have developed a new target with 2056 patches with substantially increased precision in darker areas containing black ink.

GretagMacbeth ProfileMaker appears to read this target and build profiles from it, but Monaco at present does not work with this target at all.

Using a pre-calculated chart

1. On a properly gray-balanced press sheet (or proof), measure the visual density or L* value of each step in the “K” and “CMY” print density scales of the P2P target. Ideally these should be measured with paper subtracted, so that paper = zero density or 100 L*.

2. If the values are in absolute density (paper included) subtract the paper density from each reading to get relative density.

3. If the values are in absolute L*, with paper included, multiply each L* value by 100 / paper L* to get relative L*.

4. Plot the paper-removed values on a blank copy of the GRACoL pre-calculated chart. This is your IMITATOR CURVE.

5. Note the pre-printed curve that most closely equals the dynamic range of the device you are calibrating. This is your REFERENCE CURVE.

6. Viewing the “K” and “CMY” graphs separately, determine if any corrections are necessary to make the Imitator graph match the Reference Curve.

7. If corrections are needed, determine the optimum percentages on the horizontal axis at which to make those changes, and make a mark at each point. If your calibration software requires a set number of control points, e.g. every 5% or 10%, mark these values instead.

8. Draw vertical lines from each marked point to intersect the two curves.

9. Where each vertical line intersects the REFERENCE CURVE, draw a horizontal line to intersect the IMITATOR CURVE, then a vertical line down to the x axis.

10. Record the original x-axis percentage value and the new x-axis value for each point in two columns. The new value is called the NEW AIM and is what the old value needs to be changed to in the RIP.

11. Enter the NEW AIM values in the RIP’s calibration interface. The exact procedure varies with each RIP but the goal is to make the indicated increases or decreases in
printed percentages. If you are not sure how to do this on your particular proofing device, ask the manufacturer.

Using the P2P workbook

1. On a properly gray-balanced press sheet (or proof), measure the visual density or of each step in the “K” and “CMY” print density scales of the P2P target. Alternately measure the two scales with the GretagMacbeth Eye-One Pro using the “P2P_GraysOnly i1” target definition file (see Don Hutcheson).

2. Enter the density values in the IMITATOR column of the Data Entry sheet in a fresh copy of the P2P workbook. Alternately open the saved Eye-One file and paste the measured data where indicated in the “measured data” sheet of the workbook.

3. Enter the gray balance delta changes (if any) in the GRAY BALANCE section of the Data Entry sheet.

4. If the displayed graphs indicate corrections are needed, determine the optimum percentages at which to make those changes, and enter those percentages in the Curve Point (%) column of the DATA OUTPUT section of the Data Entry sheet.

5. Enter the NEW AIM VALUES displayed in the sheet in the RIP’s calibration interface. Note that the spreadsheet allows you to display correction values three ways: as correction deltas, as wanted values (new aims), or as Measured Values. The correct method varies with each RIP, but the goal is to make the indicated increases or decreases in printed percentages. If you are not sure how to do this on your particular proofing device, ask the manufacturer.

Plate calibration

Calibrating the plate making process consists of (a) adjusting the exposing hardware and optics to the manufacturer’s recommended settings, including focus, exposure, screen ruling, resolution, etc., (b) adjusting consumable variables such as media selection, batch sensitivity, chemical development, etc., and (c) adjusting the halftone dot linearization curve to achieve the desired dot values (or integrated halftone densities, in the case of stochastic screening) at each step of the tone scale.

Having set up these variables to nominal values it is critical to maintain the same performance on an indefinite basis. This requires some method of checking the effective tone reproduction curve of the plates, or at least a few key tone levels. Tools for this include visual inspection, reflection integrated halftone densitometry and microscopic video analysis. The key here is determining which values should be measured and how often, as well as ensuring that the measuring system does not itself contribute to false error reports.
**CTP process control**

CTP linearization should be CHECKED on every plate or job, but the CTP curves should only be changed if absolutely necessary, as every new linearization introduces a slight error and uncertainty into the system.

Often re-calibrating to cancel a small error can cause a greater error somewhere else! For example, if the linearization tolerance is +/- 2%, then day to day errors as high as 4% could be introduced at any point on the curve. Note that a 4% deviation from job to job or between the profiling run and a live job is a relatively colossal variation in mid tones and highlights.

**CTP linearization aims**

Contrary to common practice, it is NOT recommended to linearize the plate so that reflection halftone percentages match the file values. This will typically result in an excessive tone jump at extreme highlights, causing dirty pastels and other problems in later ICC profiling.

**Proof calibration**

Proofing system calibration and profiling is similar in principle to the previously-described press process, except that gray balance must be adjusted in separate linearization curves within the proofing RIP.

Much of the process of matching a proofer to a reference standard can be accomplished through careful adjustment of proofer’s curves to simulate the same PDC and gray balance as the reference standard. Note that this may NOT achieved by following the manufacturer’s SWOP ADS (Application Data Sheet). In this case, use the ADS as a rough guide only, and fine-tune proofer calibration using the following method.

If the proofing device’s CMYK colorants are close to those of the reference standard, simple curve calibration may be enough to produce a good overall match between the proofer and the reference standard, however usually an accurate match will require an ICC link as well as custom curves.

**NOTE:** If an ICC profile is required it must only be made AFTER the proofer’s curves have been adjusted to establish a good PDC and gray balance match.

**Adjust mechanical and optical variables**

The first step is to make sure the proofer is operating to manufacturer specifications. This involves different parameters for each technology, and is outside the scope of these instructions. The minimum requirement is that the device or process is stable and repeatable, and has an equal or greater color gamut as the standard or device being matched.
Make a ‘base-line’ proof (with default curves)

Produce a proof of the test form (described elsewhere) using a basic proofer setup with no color manipulation other than a basic or default calibration LUT.

Test gray balance

1. With a properly calibrated hand-held spectrophotometer, measure the $a^*$ and $b^*$ values of the central patch in the 50% region of the Gray Finder target (see below).

2. If the $a^*$ value is LOWER than the $a^*$ value indicated for the same 50% gray patch in the calibration standard (nominally 0.0), move the spectrophotometer to the RIGHT until you find the column with the nearest $a^*$ value. If the $a^*$ value is HIGHER than the reference $a^*$ value, move the spectrophotometer to the LEFT.

3. If the $b^*$ value is LOWER than the $b^*$ value indicated for the same 50% gray patch in the calibration standard (nominally 0.0), move the spectrophotometer UP until you find the row with the nearest $b^*$ value. If the $b^*$ value is HIGHER than the reference $b^*$ value, move the spectrophotometer DOWN.

4. Once you have found the gray patch with the nearest $a^*$ and $b^*$ values, record the magenta column value and the yellow row value for that patch.

5. Repeat if desired for other values of Cyan.

6. Adjust the proofer CMY curves to add or subtract the required amount of Y or M to achieve gray balance.

7. Make a new proof and confirm that the central patch in each section of the gray finder target are neutral (same as the gray balance spec – nominally 0.0 $a^*$ and $b^*$).

For a simpler approach see Using the HutchColor P2P Workbook.

Measure gray-scale densities

On a properly gray-balanced proof, measure the visual density of each step in the “K” and “CMY” print density scales of the P2P target.
Choose the Curve Adjustment Points

Viewing the “K” and “CMY” graphs separately, determine if any corrections are necessary to make the Imitator graph match the Reference graph.

If corrections are needed, determine the optimum percentages on the horizontal axis at which to make those changes and draw vertical lines from these x axis values to intersect the two graphs.

If your proofing RIP requires a set number of control points, e.g. every 5% or 10%, draw vertical lines at these values instead.

Where each vertical line intersects the REFERENCE graph, draw a horizontal line to intersect the IMITATOR graph, then a vertical line down to the x axis.

Record the new x-axis value alongside the original value. The new value is called the NEW AIM and is what the old value needs to be changed to in the RIP.

Adjust the calibration LUTs

Enter the NEW AIM values in the RIP’s calibration interface. The exact procedure varies with each RIP but the bottom line is that you want to make the indicated increases or decreases in printed percentages. If you are not sure how to do this on your particular proofing device, see the manufacturer or operator’s manual.

Make a new test proof

Make a new proof through the new calibration LUTs.

Measure and plot the K and CMY gray scales again and evaluate the new graphs. They should closely match the reference graph, however slight variations are likely.

The central patch of the Gray Finder chart should now read the correct a* and b* values. If not, add or subtract the appropriate M or Y values to the RIP curves and repeat the proof until the Print Density graphs and gray balance of the proofer simulate those of the reference device as closely as possible.
Proof Control

Visual Evaluation

A quick way to evaluate the color consistency of proofs and press sheets is to examine the HutchColor Proof Qualifier or the new HutchColor QualifierXT (www.hutchcolor.com) against a standard proof or press sheet. Even a visual comparison should be enough to determine if anything serious is wrong, but instrumented measurements can also be taken.

NOTE: Examining the HC Qualifier is no substitute for formal process control but it is a convenient and easy way to make sure nothing serious is wrong.

Measured Evaluation

Each proof should be measured at least in terms of gray balance, mid-tone density and solid ink densities. In the absence of other proof monitoring software, these parameters can be plotted manually on the HutchColor “PQM” (Proof Quality Monitor) chart available free at http://www.hutchcolor.com/PDF/PQM_chart.pdf.
Troubleshooting

Incorrect pastel tones

One of the most common errors in a proof-to-press match is that very light highlight tones (often referred to as “pastels”) will not match between proof and press. This is often traceable to the linearization or CTP curve on either device being non-linear between paper (0%) and the next heavier dot percent value on the characterization target (usually about 12%).

To prove this error, measure the predicted Lab value in Photoshop for a typical offending percentage (e.g. 5% C) and the actual value printed on both devices. Even a very small Lab error may prove visually unacceptable.

To find out which device is causing the error, carefully measure the density or Lab values of the 256-step spiral “MicroCMYK” target (free at www.hutchcolor.com).

Scum dots in 0 or 100% areas

Most printer profiles fail to create true 100% or 0% values where expected due to a weakness in the basic ICC profile structure. In simple terms, an ICC profile can only accept positive dot percentage values between 0 and 100%, which means the CMM cannot accurately interpolate exact 0 or 100% values when they do not fall exactly on one of the real coordinates of the profiles, or the Link built by the CMM from the two profiles.

User solution

There is no simple user-level solution to the root problem, however if using a device-link based proofing system, options usually exist such as “Keep solid colors clean” which artificially disable LUT-based correction whenever the incoming CMYK value contains percentages of 0 or 100%. The bad side to this solution is that solid ink colors may be inaccurately matched.

Software / CMM solution

Profiling software manufacturers could reduce or eliminate the root problem by temporarily compressing the CMYK values saved in the PCS-Device LUTs so that (for example) 0 = 10% and 100 = 90%, then expanding these values again in the one-dimensional output LUTs of the respective profile so 10% = 0% and 90% = 100. This compansion scheme would effectively allow the profile to hold CMYK values from (in this example) about -10% to +110%, which would allow much more accurate interpolation of exact 0 and 100 values.

The same approach may have to be employed also in the CMM when creating the real-time device link.

Lighting

Evaluating proofs vs. press sheets under non-D50 lighting is NOT recommended and
makes it impossible to assure any standard of accuracy. This is due to the complex effects of “metamerism failure” whereby different light sources have different effects on different colorants (e.g. dyes vs. pigments.)

If a client insists on comparing proof to press under non-standard lighting, for example under “cool white” fluorescent bulbs, the printer or separator cannot guarantee the same matching quality as under D50 bulbs unless the profile of BOTH the imitator AND the reference device are created using measurement values adapted to the specific spectrum of those lights.

Note that “cool white” bulbs from sources like Home Depot are NOT standard or consistent amongst themselves. For example two “cool white” bulbs from different batches may very wildly different spectral curves, with different metamerism effects. Therefore the color a client sees may be very different from what the printer sees, even though the same-named bulbs are in use.

### Expectations

Combining ICC color management with systematic and precise process control in proofing, plate making and pressroom really can improve the ease with which a “match” is achieved between proof and press, simply by “printing to the numbers”.

However, there are so many variables in proofing, plate making and press control that “perfection” is an unrealistic goal. A reasonable expectation is that the degree of error will be significantly reduced between press and proof and that the whole process will become more consistent.

Assuming all variables are optimized and controlled, only small tweaks should be necessary on daily press runs after achieving the make-ready goals of solid ink density, gray balance and highlight range, to match the average press sheet to the proof.

Note that due to the limited number of patches on the profiling test form, some colors may proof less accurately, even with the best profiles and quality control procedures. These colors may be unobtainable due to proofer gamut limitations or they may be wrong due to errors in the profiling software. If certain colors or tonal areas consistently fail to match, try editing either the proofer or the press profile.

If the gamut of the current press inks is too small, some colors on client-supplied proofs may not be reproducible.

### Terms and definitions

It might be useful to define some terms used throughout this document that may be new or used in an uncommon way. This is not a full list and may grow as the document evolves.

**Imitator Device**

The device being calibrated to match another, for example, a proofer being calibrated to match a press, or a press or proofer being calibrated to match a standard.

**Reference Device**

The device to which another is being matched. Can also be standard (or proposed standard) like
TR001 or TR004.

**Print Density Curve**
A graph plotting printed density vs. dot percent values. PDCs can be ‘neutral’ or ‘colored’. In the latter case the densitometer filter status should be specified.

**Neutral Gray**
A gray which when measured with a properly calibrated spectrophotometer has zero values for a* and b*, whether or not it looks “neutral” to the eye.

**Gray Balance**
The CMY percent values or ratios needed to print a neutral gray patch. Note that in this document “gray balance” does NOT necessarily mean that a neutral 3-color (CMY) gray will match the color of a black ink tint, as that would depend on the “color” of the black ink.

**Highlight range**
Highlight range is the difference between white paper and a middle-tone patch measured in density or L*, as follows...

- CMY "highlight range (D)" = visual density at 50c, 40m, 40y, 0k minus paper density.
- CMY "highlight range (L*)" = paper L* minus L* at 50c, 40m, 40y.
- Black "highlight range (D)" = visual density at 0C, 0M, 0Y, 50k minus paper density.
- Black "highlight range (L*)" = paper L* minus L* at 0C, 0M, 0Y, 50k.

**Visual Match**
The word “match” can have many interpretations. For the purposes of this document a VISUAL MATCH is one where, under standard viewing conditions, output from the “imitator” device appears virtually identical to output from the “reference” device, regardless of measured values.

**Measured Match**
A match determined by instrumentation, in which specified color swatches on both devices or samples match within very small tolerances in CIELab terms. A measured match would typically demand an average ∆E CMC of 1.0 or less, and a peak ∆E CMC no greater than 3.0, but these numbers are open to debate.
The number of swatches used for qualifying a measured match between devices is an open issue, but in concept there need to be enough samples to adequately test all the main color angles and lightness levels in the device’s reproduction gamut.