Profile conversion using the Prinect Profile Toolbox
Prinect Color Solutions

Prinect Color Solutions – User Guide

In the publication series *Prinect Color Solutions – User Guide* we aim to take a closer look at individual aspects of the color workflow. The focus here is on practical applications.

The aim of Prinect Color Solutions is to optimize printing press presets and monitor the printing process before, during and after print. This is achieved essentially by improved integration of the printing press in prepress workflows. The following data is exchanged between prepress and press to this end:

- Printing material parameters,
- Parameters of printing inks and consumables,
- Target values of the printing process for making presets on the Prinect CP2000 Center,
- Zonal dot area values on the printing plate and
- Thumbnail images and target values for print monitoring on Prinect Image Control.

This allows printing presses to be set up fast following a job change. For print monitoring using Prinect Image Control and Prinect Axis Control, information about the printing process and the contents of the print sheet is made available via the Prinect Prepress Interface.

Prepress supplies the parameters for presetting and monitoring the print. The parameters are generated by the Prinect SignaStation, Prinect Printready and Prinect MetaDimension applications. The Calibration Manager is responsible for creating the correct calibrations of the platesetter and the printing process. PrintOpen for profiling printing and proofing processes and QualityMonitor for monitoring all the components involved.

There is a complex interaction between the individual components. *Prinect Color Solutions – User Guide* is designed to make this interaction more transparent for the user.
Profile conversion using the Prinect Profile Toolbox

The aim of the publication *Profile conversion using the Prinect Profile Toolbox* is to illustrate the functions of PrintOpen for profile modification. Alongside direct modifications of the profile, these also include indirect modifications, conversion of the measured values, right up to recalculation of the profile.

Direct modifications of the profile include changes to the color values of the paper white, to dot gain and to gray balance (each of which affects all tables of a print profile globally) as well as the changes to print gradation and lightness, which only affect the separation tables locally. These modifications are applied when generating a print profile if adjustments have to be made for tone value transfer. The inking values of the process colors cannot be modified with these corrections. This requires conversion of the measured values.

The following functions can be applied in this context:

- Correct measurement data – Smoothing
- Correct measurement data – Optical whitening
- Convert measurement data – Color values
- Convert measurement data – Test chart values
- Convert measurement data – Calibration data

Alongside a description of the individual functions, the creation of generic characterization data is also discussed in particular detail. Generic characterization data describes a standard printing process, such as the one defined in the ISO process standard. The creation of the FOGRA39 characterization data is an example of this.

Software Versions

The present publication refers to the following software versions of Prinect products:

<table>
<thead>
<tr>
<th>Prinect Profile Toolbox</th>
<th>Version 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrintOpen</td>
<td>Version 5.2</td>
</tr>
<tr>
<td>QualityMonitor</td>
<td>Version 2.0</td>
</tr>
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</table>

More recent versions of the software generally also support the functions described, although the look of the actual user interface may vary slightly. Information about this is given in the respective product and user documentation. The products and options described here are not always supplied as standard, so some of them may have to be purchased separately.
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Introduction

ICC Profiles are standardized descriptions of the color characteristics of devices, images and graphics using colorimetric standards. Devices are image scanners, digital cameras, monitors and all types of printers and printing processes. Images and graphics are files that may appear in a very wide range of media-neutral or device-dependent color formats. ICC profiles (hereinafter referred to simply as profiles) provide color management systems with the information needed to transform color data between different color spaces.

There are various classes of profiles. Input profiles describe image scanners and digital cameras, monitor profiles describe luminous or projection output devices and output profiles describe printing processes, printers, proofers and photosetters from a wide range of technologies. In addition to the device profiles, there are also other profile classes. The conversion profiles for color spaces are the most important of these.

Profiles allow images and graphics to be clearly and accurately described colorimetrically. The description is created either using calculation rules (matrices and gamma curves or predistortion curves) or with multidimensional look-up tables. The profile format has been standardized by the ICC (International Color Consortium) and is generally accepted in the graphic arts industry. It has also been laid down in a standard (ISO 15076-1:2005).
The procedure for creating profiles for printing and proof printing processes consists of the following steps:

- Selection and output of a suitable test chart on a printing press or a proof printer
- Colorimetric measuring of one or more test charts using a color measurement device (spectrophotometer)
- Checking and preparing the measured values (comparison of the measured values to the target values, averaging, smoothing and conversion of the measured values)
- Calculation of a profile, taking into account process-specific basic conditions such as total area coverage, black generation and color gamut mapping
- Checking the profile and, if necessary, modifying individual process properties such as dot gain, gray balance and gradation
- Creation of profile documentation and release of the profile for the application

The individual steps each require special measures to ensure the quality of the characterization data and of the profiles.

Complete print process profiling is time consuming and expensive. This option should therefore be carefully considered and planned before any implementation. In certain circumstances it is easier to use existing profiles and characterization data and then adapt these to your own special requirements. The ways in which this can be achieved are described in the following chapters. The focus is on printing processes here. Proof printing processes generally require different approaches and are not described further here.
Profile conversion using the Prinect Profile Toolbox

This chapter describes how existing profiles can be adapted to altered printing conditions using the PrintOpen application from the Prinect Profile Toolbox. The next chapter deals with how PrintOpen can be used to adjust existing profiles and characterization data to new printing conditions.

Functions of profile conversion and their application

The functions for direct profile conversion of output profiles for printing and proof printing are summarized in the main program function Edit. These include the functions

- Importing and saving profiles,
- Displaying and editing profile parameters,
- Displaying and editing profile color tables,
- Correcting dot gains,
- Correcting gray balance
- Correcting the global gradation and
- Correcting the lightness.

The functions are available after opening a profile.
Profile conversion functions in detail
The following gives a brief description of the individual functions and notes on how to use them. You can find more details in the PrintOpen manual.

Profile information
In the Profile info. dialog window we can see the adjustable values of the paper white (media white point) and the editable profile description alongside various administrative information.

Under media white point we can enter either new XYZ color values or new Lab color values. With the color separations that have the rendering intents 'Perceptual' or 'Relative Colorimetric', the value for media white point is not important. However, the value is important for proof printing if the rendering intent 'Absolute Colorimetric' is used. The media white point value is used to perform a simulation of the printing material here.

Manual changes to the media white point value can become necessary for visually adjusting the media white point of the current printing material to that of the proof printing paper due to differences in the optical lighteners.

It is generally a good idea to enter the white point value of the proof printing paper here. This approach has delivered good results in practice. We can achieve the same results by using the 'relative colorimetric' instead of the 'absolute colorimetric' rendering intent for proof printing.
The profile description must always be altered when a modified profile is saved under a new name. Otherwise certain applications will not recognize the profile. Different profiles with the same profile description are not shown correctly in the applications in the profile selection.

**Dot gain**

Tone values and dot gain in printing are typically calculated from the measured density values of defined quality control fields of the process colors. With spectral color measurement the density values and XYZ and Lab color values are calculated from the spectrums. Since the spectrums no longer match the new values following a change to the XYZ and Lab color values due to averaging, smoothing or conversion, the spectrums themselves and the density values calculated from them are discarded. So to make statements on the actual dot gain, we can calculate tone values and dot gain from the XYZ color values as specified in ISO 12647-1:2004. In some cases, the numerical values determined in this way differ greatly from the densitometric values, although they do have the same curve shape with the exception of one factor. This factor can be determined from the measured data by means of comparison. For selected values in the midtone range (for example for 30%, 40%, 50%, 60% and 70%) the quotients are calculated and averaged from densitometric and colorimetric dot gains. Typical quotients or correction factors for paper types 1 and 2 in offset printing (coated paper) for conventional screening in the range of 60/cm to 80/cm are 1.25 for cyan, 1.05 for magenta and 1.0 for yellow and black. These values have been determined as averages over a large number of different prints and, assuming no other values can be determined, serve as a very good approximation.

The correction factors depend on the media and printing conditions (for example paper, ink, screening process and screen frequency). They may therefore have to be calculated in advance.
The dot gains displayed in PrintOpen from version 5.2 onward are based on the XYZ color values. The values displayed have to be multiplied by the calculated factors to get the actual dot gain here. In the event of changes to the dot gain, the desired change has to be divided by the correction factor first.

The following images show examples of the differences in the dot gain curves and the corresponding values. Evaluating the values for the color cyan in the midtone range in this example gives a correction factor of 1.32.
The Dot gain dialog window with dot gain values of the process colors calculated in line with ISO 12647-1:2004.
Gray balance

The gray balance is used to accurately reproduce gray tones and is dependent on the printing inks and printing conditions. When printed together in equal proportions, the three printing ink colors do not produce gray, but rather brown. The optimum gray scale is generally included in the print table. Changes are necessary for different processes (altered print sequence), different materials (paper or ink) or for basic corrections.

The gray balance can be altered both via a global gradation change of individual inks (see the next section) and directly via a correction. A first approximate setting should first be made by altering the gradation, with a subsequent fine adjustment via the gray balance. This prevents severe changes from occurring near the gray axis and the possible "steps" this causes.

The changes only have an effect in the output tables for printing and proof printing and can be set separately. As more and more users are using the proof printing table for separations (with/without depth compensation) instead of generating their own better matched tables, the changes to the printing table have to be made here as well.
Global gradation

The gradation (tone value reproduction) determines the relationship between the values of the original and the reproduction (density or percentage screen values). The gradation of the printing process is contained (implicitly) in the color transformation tables of the ICC profile. If the gradation of the printing process is to be changed, the gradations in place can be corrected by a global gradation correction.

A linear curve is shown at the start of the correction. The curve of the global gradation correction in the CMYK separations can be adjusted by dragging the curves or entering specific points and values.

The changes only have an effect in the output tables for printing and proof printing and can be set separately.
Lightness

The global gradation (tone reproduction) affects the individual color separations. The lightness (or lightness gradation) affects all color separations at the same time in that the lightness is changed between the original and the reproduction values. This special lightness correction only changes the lightness gradation of the printing process and not the color tone of color values.

The ideal lightness value (L) is applied in the horizontal axis of the profile color space. The actual lightness values in the print or proof print are displayed in the vertical axis. Measured L color values from prints or proof prints can be used for correcting specific lightness ranges.

The changes only have an effect in the output tables for printing and proof printing and can be set separately.
This chapter deals with how to use PrintOpen from the Prinect Profile Toolbox to adjust existing characterization data to new printing conditions. Characterization data can be extracted from profiles using the functions of PrintOpen.

**Functions of the measured value conversion and their application**

The functions for converting characterization data for printing and proof printing are summarized in the Measure main program function and the Special menu. These include the functions

- Correct measurement data – Smoothing
- Correct measurement data – Optical whitening
- Convert measurement data – Color values
- Convert measurement data – Test chart data
- Convert measurement data – Calibration data

The functions are available after opening a measured data record.
Measured value conversion functions in detail

The following gives a brief description of the individual functions and notes on how to use them. You can find more details in the PrintOpen manual.

Correct measurement data – Smoothing

We can distinguish between two basic types of errors in measured color values: The first kind concerns errors which have a local effect (i.e. in a limited section within the color space) and the second concerns errors which have a global effect over the entire color space.

The plausibility check corrects errors of the first type. They are characterized by the fact that measurement fields of the test chart do not match the other neighboring fields in the color space. This can be caused by measuring fields, scratches or the localized effects of print deviations.

Global smoothing helps combat errors of the second kind. All measuring points are correlated with empirical models for typical printing processes here. The effect achieved here is a smoothing of the dot gain throughout the entire color space. The color values of the process color solids and, if possible, those of the overprints are not altered.

Global smoothing is only really suitable for use with measured values from a relatively uncorrupted physical printing process. You should not use these or at least only use them partially if the color data is converted in a non-controllable way, for example by a printer driver or an additional color management system that cannot be switched off when printing the test chart. This is often the case on proof printing devices or digital printers.
Correct measurement data – Optical whitening

This correction function is significant when using paper with optical lighteners (for example color copiers and proof printers).

The optical lighteners have a fluorescent effect, which makes the paper appear particularly white, although the media white actually displays a slightly bluish cast when measured. If we then reproduce this precisely, the result appears too yellowish.

The function can automatically reduce the influence of the optical lighteners when calculating the proof print separation in the profile. It is switched off as standard. When switched on, errors can occur in the measured evaluation.

There are two ways of making a correction – via automatic alteration of the media white or using spectral conversion of the color data.

The first kind of correction uses an analysis of the white values to convert the measured color values. The second kind of correction requires spectral measured color values. With this process, all spectral values are corrected before profile calculation.
Convert measurement data – Color values

This correction function uses the simplest method for converting color data. The new Lab measured color values are specified for the solid tone colors and the media white here. These values can, for example, be determined by measuring the corresponding colors on a proofprint sheet.

The values are entered in the "New value" input fields for white or in the "New values" input fields for cyan, magenta, yellow and black. It is important to note here that changing printing material normally also alters the measured color values of the solid tone colors, even if the printing inks remain the same.

It is possible to take an altered tonal gradation into account by entering new values for dot gain at 40%.
Convert measurement data – Test chart data

In this dialog window the second method is used to convert the color data. The measured color values, for example of a quality control strip or a small test chart (MiniSpots), are used to characterize a new printing process here. The measured color values can also be specified manually. An example of this is given in the next chapter.

This kind of small test chart can also be printed together with customer orders on an unused section of a sheet without having to sacrifice much space. Quality control strips are generally used for ink zone monitoring anyway. The test charts then describe the current behavior of the printing process at a number of selected points in the color space.

When converting the comprehensive measured data, all the measured values are distorted in the Lab color space in such a way as to find the best match for the color patches of the test chart. This way, an altered dot gain or an altered print sequence (with specific effect for secondary and tertiary colors) can be taken into account.
Convert measurement data – Calibration data

In this dialog window the third method is used to convert the color data.

The entire path, from digital image data right up to printed sheets, contains two important components, each of which has to be set and monitored separately: the platesetter and the printing press.

The standard procedure is to first create a printing plate with linearization wedges and then do a proof print. The printed linearization wedges are measured, and the Prinect Calibration Manager then calculates the platesetter curves from the measured density values. These give the total printing process the desired tonal gradation. These platesetter curves are then copied to the system, a second printing plate is created with a test chart for generating ICC profiles and this is then used to produce a proof print. The measured color values of this test chart are then used to calculate the ICC profile for the entire printing process.

The function *Conversion of color data – Calibration data* simplifies this procedure so that you just need to produce one printing plate. This saves both material and time.

The test chart for the ICC profile is then also imaged on the one remaining printing plate together with the linearization wedges for the platesetter. Once a proof print has been performed with this plate, the platesetter curves are determined as described above. At the same time, the Calibration Manager saves the curves in a format that PrintOpen can read.
The test chart for the ICC profile is measured in the standard way and is therefore available in the standard format. If this data were now used directly for profile calculation, the platesetter curves would have no influence, since these were determined from the same sheet and therefore had no effect on the measured data.

We therefore use the "Convert calibration data" option to open the file saved by the Calibration Manager for PrintOpen in addition to the measured data. This allows the program to 'backwards correct' the CMYK values for the color patches. If, for example, the platesetter curves increase a cyan value from 35% to 40%, PrintOpen can replace a 40% value in the original test chart with a value of 35% with the help of the platesetter curves. In this way the system accounts for the anticipated effect of the platesetter curves in the CMYK values of the test chart in advance when printing with a second plate. The Lab measured values are not changed and the color data looks the same on the monitor. However, if you move the cursor across the test chart display, you will notice on the CMYK values displayed at the bottom right that the original CMYK values have been adjusted in accordance with the platesetter curves.

You can then calculate an ICC profile for the entire printing process as usual, including the calibrated platesetter, from the measured data converted to CMYK.

When using data that has been converted in this way, it is important to note that the color patches typically no longer correspond to a 'standard' (for example ISO 12642 or IT8.7/3) in terms of their CMYK values. So it can no longer be compared directly to the measured values of a 'standard test chart'. It would in principle be possible to adjust the Lab values instead of the CMYK values. However, this would require additional interpolation and scanning of the data. The process described here has been selected to limit potential losses in quality to a minimum.
Creating generic characterization data

Generic characterization data is calculated from characterization data of real printing processes through precise adjustment to international or national standards. This data and the profiles derived from it are then directly linked to specific production conditions, which in turn were derived from the standard. They are then applied for a specific paper type, the inking of the process colors on this paper type, a defined printing color sequence and a fixed dot gain. They also demand a specific screening process and defined screen frequencies.

The general procedure is described in the following together with an example of how to generate FOGRA39 characterization data.

**General procedure**
The process is based on the PrintOpen functions "Conversion of color data – Test chart values" and "Conversion of color data – Color values". These functions are generally used to convert a 4-color printing process with process colors to a similar printing process with slightly different printing inks. These functions can also be used to adjust a printing process for which no measured characterization data is available to precise values.

**Specifying the target values**
The target values are generally the values of international or national standards, although in principle any specifications can be used.

**Selecting the characterization data**
When generating generic characterization data, it is a good idea to select a printing process that is already very close to the planned target values as a basis. The FOGRA values for the paper types 1 to 5 can be used as a good starting point for adjustments to meet ISO 12647-2:2004 / Amd 1 (Amendment 1 from 2006). In the case of paper type 1 and 2, data from current printing tests can also be used.
Creating a reference file

The smallest test chart data record for conversion of measured data consists of the values for media white (1), the solids of the process colors C, M, Y and K (4) and the dot gain of the process colors (indirectly specified through test chart data for continuous tone patches) (4), the solids and continuous tones of the 2-color combined prints of the process colors C & M, C & Y and M & Y (6) and the solid and continuous tone patches of the composite gray (C+M+Y) (2). This is a total of 17 data records. The media white and solid values of these data records are known from the standard. The continuous tone values are taken from the existing characterization data. The inaccuracy resulting from this is corrected through subsequent adjustment of the dot gain.

Test chart data records with more continuous tone patches can also be used, and the adjustment of the dot gain is slightly more accurate here. Using the FOGRA media wedge as a real data record is not ideal here, since the solids are missing in the 3-color combined print (C+M+Y). The Heidelberg media wedges PCS40 and PCS60 are better suited.

Converting the measured values – Color values

In PrintOpen the characterization data record is first opened in the "Measure" section. The "Special" function and the menu item "Conversion of color data – Test chart values" are then used to open the reference file. When you hit "OK", the conversion is started. Once it is complete, you will see a short message that confirms successful completion. The new, converted data record can then be saved.

Converting the measured values – Dot gain

The dot gain is adjusted using the functions of PrintOpen. First of all, an ICC profile with standard settings is calculated from the characterization data. In the "Edit" functional group, the "Dot gain" function performs correction at individual points. The corrected profile is saved and characterization data is extracted from the profile with PrintOpen.

Completing the new characterization data

The adjusted characterization data contains minor inaccuracies (rounding errors from the calculation) with regard to the specifications for inking of the process colors and secondary colors. These are adjusted to match the exact values in a final step using a text editor. It is important to note that several values can occur multiple times in the characterization data (media white, C, M, Y, K).
Calculating the FOGRA39 characterization data

Characterization data for the paper types 1 and 2 were drawn up in 2003 by Fogra, bvdm, ECI and Ugra within the scope of the Altona Test Suite. These were then made available by Fogra with the name FOGRA27. The standard profile ISOcoated.icc was generated on the basis of this. Despite the fact that this offered high quality, much criticism came from those actually using the profile, since it was very difficult to achieve the target values for cyan while remaining within tolerances.

While revising the ISO standard ISO 12647-2:2004, which was subsequently published as Amendment 1 in 2006, the organizations named above decided to issue new and improved characterization data. This data was published at the end of 2006 as FOGRA39. These new specifications allow the ISO values to be reproduced precisely for all primary colors and the media white. Slight deviations from the ISO values made sense in the secondary colors green and blue.

Specifying the target values

The target values for the new characterization data were the values of ISO 12647-2:2004/Amd1 with changes in the secondary colors green and blue. These changes were necessary to create a better match to the printing inks generally used in Europe and their combined printing behavior. The following table shows the old and new (light green) values as well as the further modified target values for FOGRA39 (dark green).

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>$L^<em>$ $a^</em>$ $b^*$</td>
<td>$L^<em>$ $a^</em>$ $b^*$</td>
<td>$L^<em>$ $a^</em>$ $b^*$</td>
</tr>
<tr>
<td>Cyan</td>
<td>55.0 0.0 -0.0</td>
<td>55.0 -3.0 -0.0</td>
<td>55.0 -3.0 0.0</td>
</tr>
<tr>
<td>Magenta</td>
<td>40.0 74.0 -3.0</td>
<td>40.0 74.0 -3.0</td>
<td>40.0 74.0 -3.0</td>
</tr>
<tr>
<td>Yellow</td>
<td>91.0 6.0 83.0</td>
<td>-90.0 6.0 83.0</td>
<td>-90.0 6.0 83.0</td>
</tr>
<tr>
<td>Black</td>
<td>16.0 0.0 0.0</td>
<td>16.0 0.0 0.0</td>
<td>16.0 0.0 0.0</td>
</tr>
<tr>
<td>Red</td>
<td>45.0 66.0 0.0</td>
<td>47.0 66.0 0.0</td>
<td>47.0 66.0 0.0</td>
</tr>
<tr>
<td>Green</td>
<td>50.0 0.0 0.0</td>
<td>50.0 0.0 0.0</td>
<td>50.0 0.0 0.0</td>
</tr>
<tr>
<td>Blue</td>
<td>25.0 -25.0 45.0</td>
<td>-24.0 -25.0 -46.0</td>
<td>-24.0 -25.0 -46.0</td>
</tr>
</tbody>
</table>

Selecting the characterization data

Fogra carried out a project entitled ’Drucken nach Standard’ or "Printing to Standards" in 2006. More than 20 data records from various print shops were produced. Heidelberg also performed a range of ”Prinect Color Management” services between 2004 and 2006, during which a large number of data records were produced for various paper types and printing ink sets.

A number of suitable data records were selected from both projects. In selecting the best options, the data records were imported into the Quality Monitor of the Prinect Profile Toolbox and investigated using the time series analysis functions. Data that deviated severely from the average value was not included in the final averaging.
In the following image we can see the average color deviations across all color patches of the ECI2002 test chart compared to a test chart that has been averaged over all files. Several data records (for example numbers 17 and 23) show significant deviations from the average value.

Of the 26 data records, the ones with the greatest error were deleted one after the other until no more appreciable changes occurred. You can see the result in the following image. A total of 19 data records from the Fogra project was used.

14 files were selected from the Heidelberg PCM data records. The Fogra data and the PCM data were smoothed after averaging and then used as the basic data record for generating FOGRA39.
The evaluation of the averaged and smoothed basic data record is shown in the following images. Here we can see the reason for altering the target values for the secondary colors green and blue. Without these changes, the error in blue would again become greater than $dE = 5$ and the green would tend severely toward cyan.

The color locations of the process colors in the data record are a very good match with the target values. However, we can clearly see that the average media white is outside the ISO standard.

The specified dot gain curves for the paper types 1 and 2 have not changed compared to FOGRA27. Since no spectral information is available following averaging and smoothing of the data records, the display can only be based on the colorimetric values.
If we apply the process described earlier in the dot gain section and the corresponding correction factors, we get the following image.

The dot gains of the averaged and smooth basic data record match the specified values exactly.

If we look at all the figures, the deviations from the target values of FOGRA39 are very small, with the exception of the media white. This data therefore forms an outstanding basis for calculating generic characterization data. The following contains an except from the characterization data.
Creating a reference file

The reference file consists of the 17 data records described above in the same data format as the characterization data.

The values of the 40% color patches were taken from the basic data record. The media white and the solid ink patches are the target values for FOGRA39.
Converting the measured values

In the window Conversion of color data – Test chart values, the measured data of the altered printing process is imported.

The measured data is displayed in color in the window. Press the OK button to convert the original measured data. When performing the conversion, the software attempts to perform as harmonious and smooth a transformation of the measured values as possible. In certain circumstances, individual values may not match the specified values with the expected accuracy here.

The evaluation of the converted measured data is shown in the next image. The process color black still has a relatively bad error.

There are now two ways to further improve this. The first option is to perform the measured value conversion multiple times using test chart values. This option is necessary if the secondary colors have to be adapted. The other option is to adjust the color values of the process colors that display bad errors in a targeted manner using the section Conversion of color data – Color values.

In some cases, the best results when converting measured values can only be found by trial and error.
Results of measured value conversion using test chart values

The relatively bad error in the process color black when performing measured value conversion using test chart values is reduced with a targeted correction.

The new values for black are entered in the window Conversion of color data – Process color black. The dot gain is not corrected at this point, since the new values are not known and they will change anyway with the conversion.

After performing the conversion, the results are as shown in the following image. The deviation of the new characterization values from the target values is less than a \( \Delta E \) of 0.3 across the board. The next step is to analyze and adjust the dot gain.
Converting the measured values – Dot gain
Since no spectral data is available following conversion of the measured values, the dot gain can only be calculated on the basis of the colorimetric XYZ values in line with the ISO standard ISO 12647-1:2004. You can see the result in the following image.

The necessary corrections of the process colors cyan and magenta are not included in the values of the table, since PrintOpen cannot know these values. An external evaluation is necessary if we wish to compare the dot gains in the conventional way. This is shown in the next image. We can see that both cyan and yellow display significant deviations from the specified values.
To perform a targeted correction of the dot gains with PrintOpen, a profile has to be calculated. Since this profile is only needed temporarily, the profile can be calculated with standard settings for gamut mapping and black generation. We can then make a correction in the Edit – Dot gain menu.

The necessary corrections to the dot gains can be calculated from the dot gain values of the converted measured values and the correction factors between colorimetric and densitometric tone values. For cyan the midtone (50%) value is +0.7 and for yellow +1.6. These values are entered in the right-hand section of the menu and the profile is then saved.

New characterization data is calculated with the saved profile. A new measurement file is selected in the Measure menu. In this case we are using the file ECI2002 of the type “Visual”.

Dot gains following corrections

The dot gain curves
Once the measurement file has been selected, we can use the option *Calculation of reference data from a profile* to select a profile. In this case we select the profile with the corrected dot gains.
A corrected dot gain can then be calculated from the calculated characterization data. You can see the result in the following image.

![The corrected dot gain curves](image)

The dot gain curves are adjusted in the light section as described above. Further correction points are set and corresponding values altered in the Edit – Dot gain menu here. The process can be performed iteratively until sufficient accuracy is achieved.

**Completing the new characterization data**

Due to unavoidable inaccuracies in the individual stages of calculation, the target values of the process colors and the overprints of the solids cannot be achieved precisely. In the following table we can see that the media white deviates from the target values of L = 95, a = 0 and b = –2 in the second decimal place. This is also true of the XYZ values, although this is not as obviously apparent here.

To make the data “more palatable”, the specifications were adjusted precisely for FOGRA39 using a text editor. It is important to note here that several values, such as the media white and the process colors, occur multiple times in the file.

```
ECI2002
ORIGINATOR "HEIDELBERG"
DESCRIPTOR "MearCoated"
CREATED "Sept. 2004"
BEGIN_DATA FORMAT
SAMPLE_ID CMYK CMYK CMYK CMYK XCMYK XCMYK XCMYK Y XYZ_Z LAB_L LAB_A LAB_B
END_DATA FORMAT
NUMBER_OF_SETS 1485
BEGIN_DATA
1 0 0 0 0 84.43 87.56 74.53 94.97 0.01 -2.02
2 0 0 0 0 77.85 77.72 68.31 90.65 5.89 -1.93
3 0 26 0 0 71.44 68.33 61.53 86.17 12.06 -5.23
4 0 36 0 0 64.97 59.13 54.53 81.36 18.67 -6.36
5 0 46 0 0 58.79 50.56 47.45 76.41 25.67 -7.01
6 0 55 0 0 50.20 38.86 37.28 68.65 37.62 -7.53
7 0 76 0 0 42.87 29.02 27.90 60.80 50.56 -6.93
8 0 85 0 0 37.05 21.59 20.39 53.59 63.57 -5.55
9 0 106 0 0 32.95 16.75 15.10 47.94 73.93 -3.30
10 10 0 0 0 75.33 79.67 73.33 91.53 -2.94 -6.90
```
The administration part (ORIGINATOR, DESCRIPTOR, etc.) of the characterization data has also been adapted. A slight adjustment to the color of the pure black gradation is not shown here. Inaccuracies in the measured values and calculations led to a slight cast, which was corrected. The color tone now runs linearly between the media white (a = 0, b = –2) and the black (a = 0, b = 0).

If we open the FOGRA39 data in PrintOpen or the Quality Monitor, it is easy to see that the color values do not match the values in the file precisely. This is due to rounding errors as well as slightly different definitions and accuracy of the D50 reference white. Since the XYZ color values take priority over the Lab color values in the programs named above, the XYZ values are imported and then converted to Lab. In the following image you can see the results of importing the data and the calculations. Minor deviations can again be seen, although these are of no practical relevance.

The deviations in the dot gains \( \Delta \tau \) in the following image are due to the correction factors (cyan and magenta) not being taken into account and the less accurate calculation of the specified values based on just 4 digit numbers.
The CIELAB color values of FOGRA39 compared to the process standard

The dot gain values of FOGRA39
Summary

It is possible to generate generic characterization data such as FOGRA39 through profile conversion using only PrintOpen. In practice we used additional programs and supporting tools. These included programs for formatting the characterization data and tools such as table calculation spreadsheets for automated calculation of correction factors and dot gain corrections.

In performing the calculations, we exploited the ability of PrintOpen to use non-standard reference points for the process colors. The reference points for the measured values do not have to be 10%, 20%, etc. in all channels. It is also possible to use 8.8% and 20.1% in cyan as well as 10.2% and 19.7% in magenta. This allows corrections of the dot gain curves to be made in the characterization data. After recalculating a profile, the standardized characterization data can in turn be generated from this profile in line with the ISO standard.

Overall we can say that PrintOpen is not only an extremely powerful instrument for calculating and modifying profiles, but also an extremely powerful instrument for calculating and modifying characterization data.
Glossary

**Characterization**
Colorimetric description of a (printing) process.

**Characterization data**
Specification of a clear relationship between digital tone values and measured color values in the print (process color values CMYK / color values CIEXYZ or CIELAB). Characterization data is used in workflows based on color management to describe different input and output processes. It represents the starting point for calculating device profiles or printing process profiles and may also be used for process monitoring.

**Characterization data record (table)**
Data format for transferring characterization data. The international standard ISO 12642 defines the digital tone values to be used as well as the measuring conditions and file format for printing processes.

**Characteristic printing curve**
Graphic display of the transfer function of a printing process. The tone values of the data record or film are on the horizontal axis, while the vertical axis is used for the tone values measured on the print sheet.

**Gray balance**
Set of tone values for cyan, magenta and yellow in the data record which gives an achromatic color when printed under defined printing conditions and viewed under defined conditions.

**Lightness**
Subjective, "feeling-based" variable which describes an area that absorbs or gives out more or less light.

**ICC International Color Consortium**
The ICC is a consortium of manufacturers and users from the graphic arts industry. The aim of the ICC is to develop solutions for the transfer of color data in heterogeneous and diversified open color systems.

**ICC profiles**
ICC profiles or device profiles are standardized files that describe the color characteristics of devices, images and graphics using colorimetric standards. ICC profiles provide color management systems with the information needed to transform color data between diverse color spaces.
**Characteristic curve or line**
Graphic display of the transfer function of a device or process.

**Process standard**
Specification of the process parameters and their values that should be used when generating color separations for 4-color prints or proof prints.

**Rendering intents**
Rendering intents are definitions to describe the intended rendering of images and graphics on an output device or output process. Rendering intents are closely associated with gamut mapping.

*Absolute colorimetric*

The "absolute colorimetric" rendering intent is used for precise and measurable rendering of color values. This rendering intent is used in the simulation (proof print) of an output process on a different output device or when outputting defined color values in the print.

*Relative colorimetric*

The "relative colorimetric" rendering intent is used for precise media-specific rendering of color values. This rendering intent is used for partial simulation of an output process on another output device based on the white of the medium.

*Perceptual*

The "perceptual" rendering intent is used for harmonious rendering of color values in the print, taking into account the different gamuts of the original and the print. This rendering intent is mainly used for color separation of images.

*Saturation*

This rendering intent is used for rendering color values of the original with an emphasis on maintaining the saturation of the color values of the original. It is mainly used for color separation of graphics and charts (business graphics).
**Tone value**
Percentage area coverage on a substrate (film, printing form, print sheet) or percentage ratio of a value in a data record relative to the maximum value. Units: %

**Dot gain / tone value increase**
The difference between the tone values before and after one or more processing steps. Dot gain can also be negative (dot shrinkage). Details are generally given for a tone value of 40%. Units: %

**Dot gain characteristic curve**
Graphic display of the dot gain of a printing process. The tone values of the data record or film are on the horizontal axis, while the vertical axis is used for the dot gain.