Application Notes

Printer Linearization

ergosoft

rip solutions

Printer Linearization

ErgoSoft AG
Moosgrabenstr. 13
CH-8595 Altnau, Switzerland

The **ErgoSoft RIP** is available in different editions. Therefore the description of available features in this document does not necessarily reflect the license details of your edition of the **ErgoSoft RIP.** For information on the features included in your edition of the **ErgoSoft RIPs** refer to the ErgoSoft homepage or contact your dealer.

Rev. 1.1

Contents

Introduction

Even before an image is printed, there exists a distinct idea about the look of the image in the print. To achieve this goal the printer must get exact information about the supposed look of the image using some RIP software. But before these guidelines can be established the reaction of the printer without external influence must be analyzed.

Thus, to be able to drive a printer successfully the printing behavior must be analyzed by examining the way it applies the ink to the media. Based on the gathered information, the printer's behavior can be influenced in order to achieve the desired printing behavior. This process is called printer linearization.

This manual should shed some light on how a printer linearization can be accomplished using the **ErgoSoft RIP.**

The first part of this documentation deals with the printer linearization in practice. The linearization process will be divided into three topical sections:

1. Presets

2. Analyzing the printer

3. Setting the target behavior

The second part of this documentation deals with the theoretical backgrounds in order to provide better understanding of the way the process of a printer linearization is supposed to work.

Presets

Basics

The **ErgoSoft RIP** Software has to be installed on the computer that is to be used to conduct the printer linearization.
Also, a suitable measuring device (spectrophotometer) is needed. Further information on the needed presets such as a print environment etc. can be found in the manual parts about e.g. print environments.

Before the printer linearization process can begin, the measuring device that is to be used has to be plugged into the correct port of the computer.

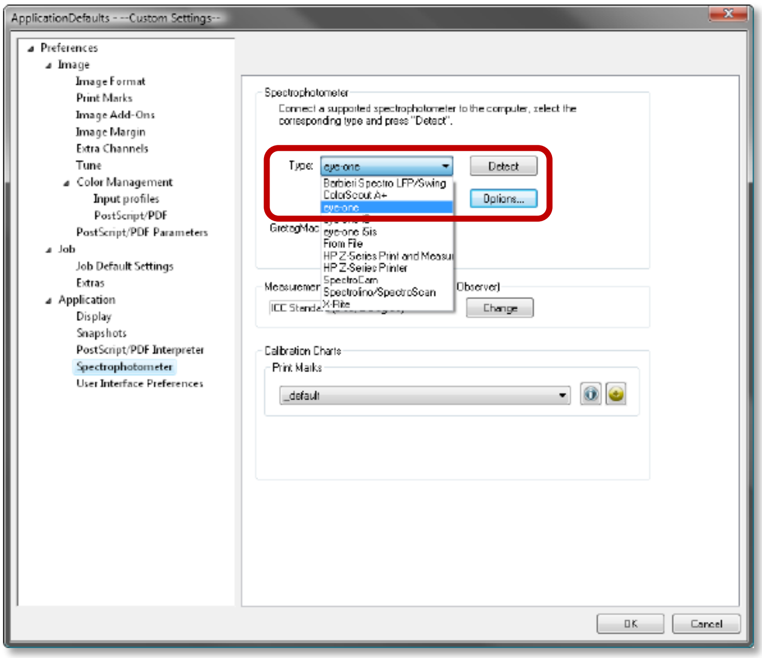
Detecting the Measuring Device

The measuring device needs to be detected and recognized by the software so it can be used to analyze the printer.

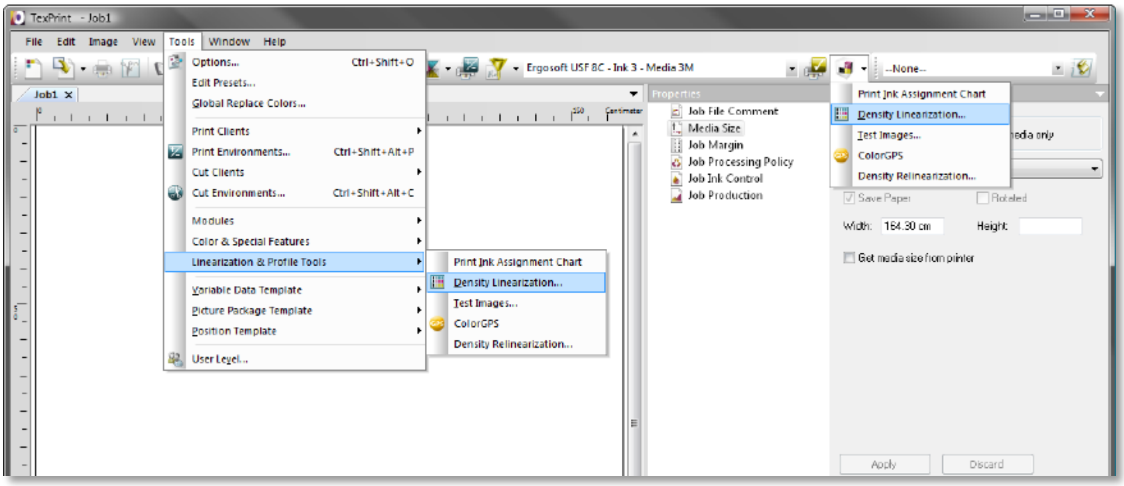
1. To do this, launch menu *Tools > Options > Preferences > Application > Spectrophotometer.*

2. After having selected the spectrophotometer in use in the **Type** field, you can detect it by using the **Detect** button and thus make it available for use in the software.

3. As soon as the measuring device has been correctly detected, you can leave the dialog again using the **OK** button.



Starting the Linearization Dialog

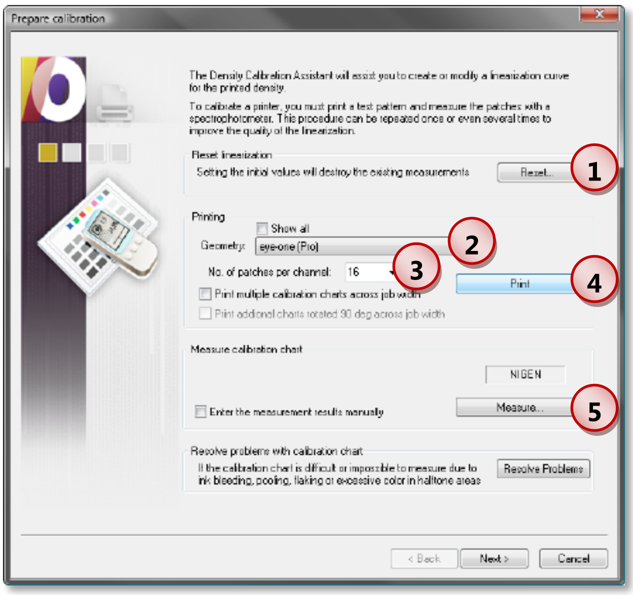


In the main program, open menu *Tools* > *Linearization & Profile Tools* > *Density Linearization* or click the **Density Linearization** button under the *Linearization & Profile Tools* button in the *Print Environment* toolbar.

Analyzing the Printer

The printer analysis is done by printing and then measuring color charts that were especially generated for that purpose.

1. Initial Values / Reset
2. Geometry
3. No. of patches per channel
4. Print
5. Measuring the linearization chart

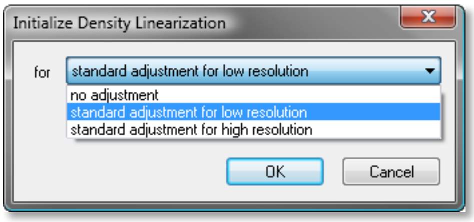


Setting Initial Values

1 The **Initial Values** section allows you to guess an expected behavior of the printer. Such estimates optimize the results of the first measurement. When initial values are already set, e.g. by selecting a default density linearization in the print environment, the button label changes into **Reset.**

The **Initial Values / Reset** button offers three estimates. Choose the one that fits your printer best:

Choose **no adjustment** when you do not want to estimate the printer's behavior. When printing with 540dpi or less, the estimate **standard adjustment for low resolution** is recommended, for 720dpi or more, the estimate **standard adjustment for high resolution** would be the best choice.



Defining a Density Chart

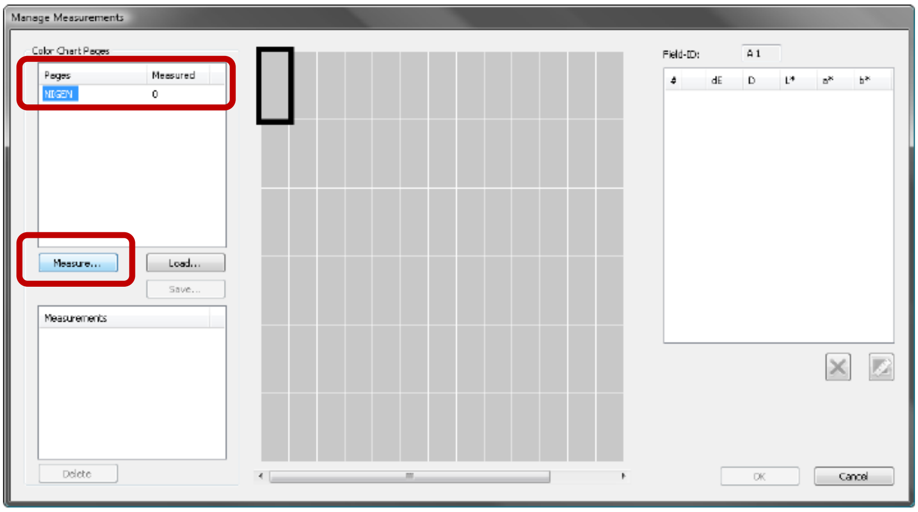
2 The **Geometry** dropdown menu **(Printing** segment) lets you set which **Geometry** (type of chart) should be used. While the **Universal** and **ScanMix** geometries can be used for several measuring devices, the other geometries are device specific constructs that can be recognized by the respective devices name.

3 The dropdown menu **No. of patches per channel** lets you set the number of measurement patches per color channel. You can select a value from the list or enter any value manually.
When using only one dilution per color (e.g. cyan, magenta, yellow, black, etc.) we recommend printing about 30 patches. When using 2 dilutions for minimum one ink color (e.g. cyan, light cyan, magenta, light magenta, yellow, black, etc.) we recommend printing about 40 patches. When using more than 2 dilutions for minimum one ink color (e.g. cyan, magenta, yellow, black, light black, light black 2, etc.), 60 patches should be printed and measured.

Printing the Density Chart

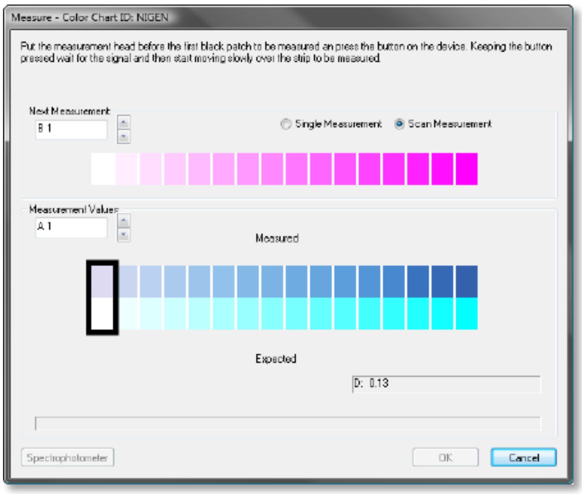
4 When having made these settings, print the density chart using the **Print** button. To be able to clearly identify the printed stripes, a codeword is used. This codeword is printed along with the density stripes and saved in the density file.

Measuring the Linearization Chart



5 After having printed the density chart, click the **Measure** button in the **Prepare Linearization** dialog to open the **Manage Measurements** dialog.

In this dialog, select the chart and again click the **Measure** button. Now, measure the linearization chart.



The upper segment **Next Measurement** displays the next row that is to be measured. Make sure you always measure the row that is displayed.

The lower segment **Measurement Values** shows the progress of the measurement.

After having measured the density chart click the **OK** button to return to the **Manage Measurements** dialog. We strongly recommend starting a second measurement in this dialog.

> To receive a good measurement it is recommended to measure every density chart at least twice.

When having finished all measurements click the **OK** button in the **Manage Measurements** dialog to calculate the average of all measurements and return to the density linearization wizard.

Completing the First Analysis

Now, the first impression of the printer's behavior has been established. The linearization needs to be saved now. Click the **Next** button through the linearization wizard until you reach the **Save** dialog. At this point you should not make changes in the **Measurement results** or the **Target Density** dialog settings.

To save the linearization, fill in all fields in the **Save** dialog and complete the wizard by clicking the **Finish** button. The linearization will automatically be saved into the current print environment.

Conducting the Second Analysis

Start the linearization dialog again. Repeat the steps 2-5 (printing and measuring of the density stripes). Setting the Initial Values again is not necessary since the estimated initial values have now been replaced by actual values from the first measurement.

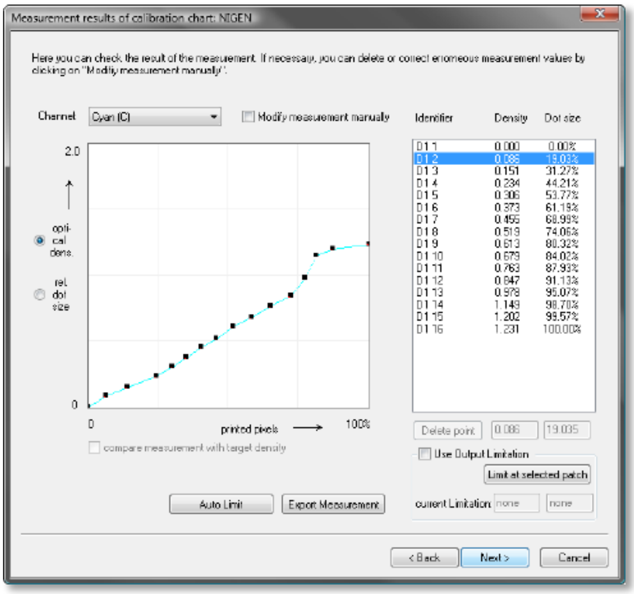
After having measured the density stripes twice, complete the measuring dialog and click the **Next** and then the **Back** button to get to the dialog window **Measurement results of calibration chart.**

Analyzing Measurement Values

In the **Measurement results of calibration chart** dialog, you can analyze the measured values. The analysis of the printer's behavior is completed with this step. The dialog provides the following information:

In the left, graphic display the measurement values are displayed in a curve. By using the dropdown menu **Channel,** you can select the color you wish to look at.

On the right side, the measurement values are listed as density values.



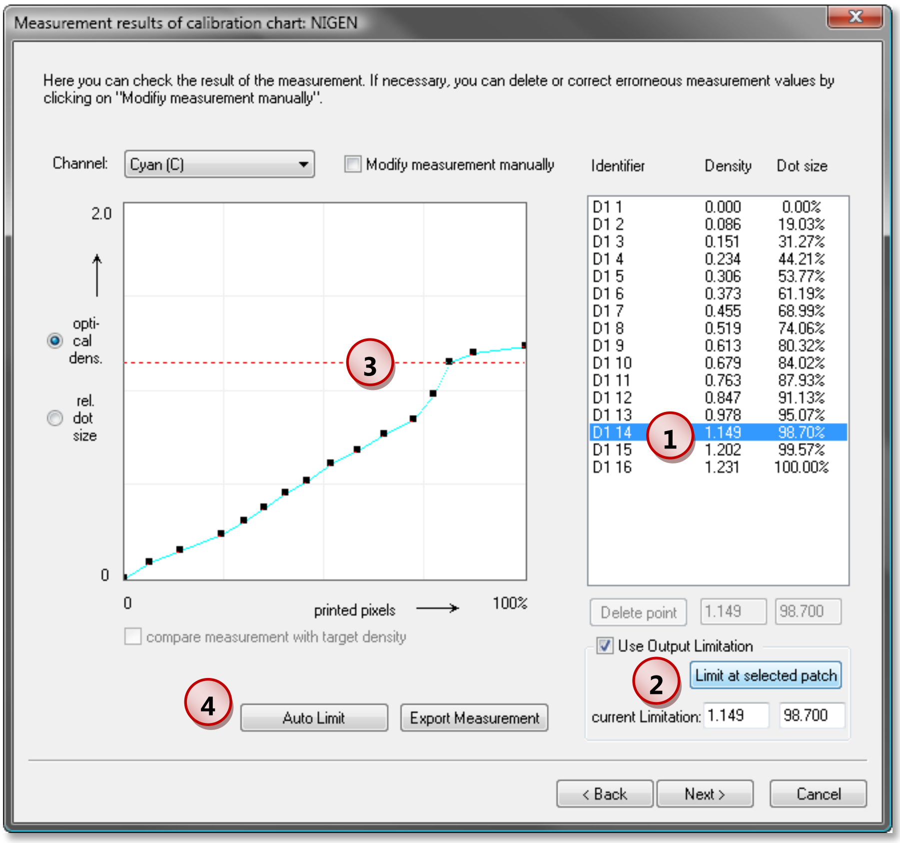
> For further information on the details in this dialog please refer to the second part of this manual.

Setting the Desired Print Behavior

The following steps are needed to define what behavior you want to achieve with this printer. Based on these presets, the tool will calculate the necessary corrections.

Optimizing the Specific Ink Application

The segment **Use output limitation** offers the possibility to optimize the ink application for each color specifically by limiting the output of that color. Such a limitation is recommended if despite increasing use of printed pixels, no additional density is achieved.



1 To set an output limitation you may select the corresponding value in the measurement values table and click the **Limit at selected patch** button.

2 To set the output limitation at any value, check **Use Output Limitation** and enter the desired value into the **current Limitation** field.

3 After having set a limit, a red line representing the limit will appear in the graphic display. This red line can also be moved manually.

4 The **Auto Limit** button will automatically set appropriate limits all color channels.

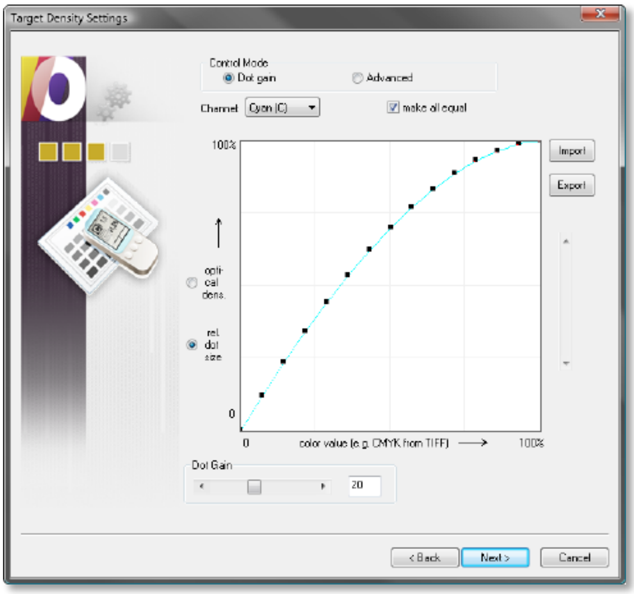
Setting the Dot Gain

Clicking the **Next** button after defining the end value limitation will proceed to the **Target Density Settings** dialog allowing to further define the expected respectively the desired behavior of the printer.
In general the use of the default settings is recommended.
Value 20 is used by default for the dot gain for the following reasons:

1. This value corresponds best to the standards from offset printing and is therefore suitable to print CMYK data without profile.

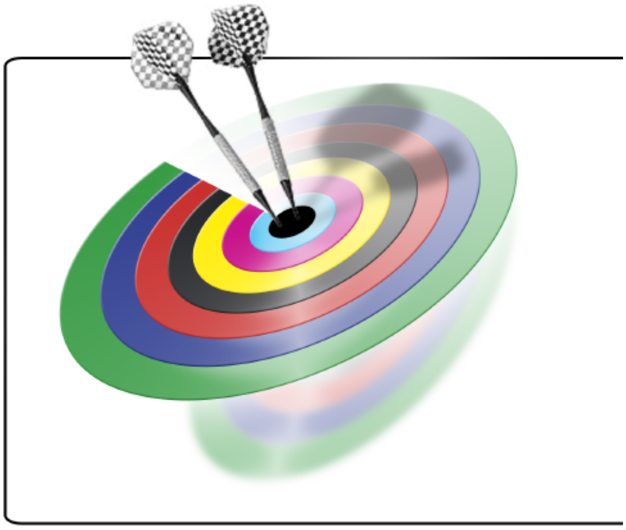
2. It reflects the dynamic of the digital print behavior for the profiling optimally.

Further information on target densities can be found in the second part of the documentation.



Completing the Printer Linearization

After having defined the desired behavior of the printer, save the created density linearization and complete the dialog. The density linearization will now be embedded in the print environment currently in use, or in case of working with external data, saved as a single file.



Basics about Linearization

Benefits of a Printer Linearization

- Through the density calibration the program ensures that the amount of applied inks per color increases evenly from 0% to 100%.

The Printer Linearization contains details about the amount of ink that should be printed. Due to mechanical components such as e.g. the size of the ink dots, the actual area coverage of the ink does not correspond to the desired coverage. This means that without correction it seems optically as if too much ink is applied especially in middle to dark tones:

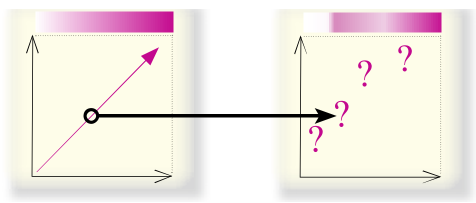
- The image becomes dark and lacks textures in dark areas; in extreme cases the inks start to bleed in dark spots.

The density linearization contains a correction value that adjusts the actual amount of ink for a preset coverage in a way so it corresponds to the desired visual coverage. Middle values are detected using the measured data.
If no density calibration is conducted, the color gradient created by the software is output in a random, uncontrollable fashion.

Without Density Linearization:
The user has no control on how the printer outputs the data sent to it.

When using a density linearization, the printer specific behavior can be analyzed by printing and measuring a test chart, then the expected behavior of the density curve can be set using a so called Target Density.

Preset | Printed Value

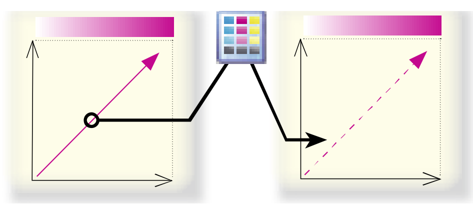


45% color value
1.25 optical density

1.25 optical density
?? pixel value

With Density Linearization:
The values output by the printer correspond to the optical density of the desired color value.

Preset | Printed Value



45% color value
1.25 optical density

1.25 optical density
35% pixel value

Duties of the Printer Linearization

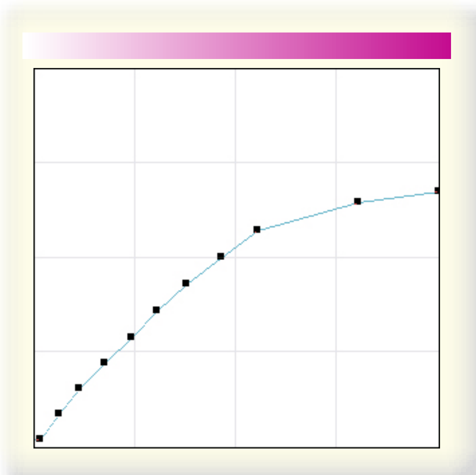
Analyzing the Printer Behavior under a given Combination of Printer, Inks and Medium

This typically non-linear behavior is analyzed by printing and measuring a linearization chart respectively the single measuring patches. A measurement can be displayed in two measures: In “optical density” or “area coverage.

- The **optical density** provides information about how much of the light touching the surface is absorbed by the printed color. Different areas of the spectrum are taken into account for Cyan, Magenta, Yellow and Black, which are defined in the norm DIN 16536. For additional colors, special areas calculated by ErgoSoft are taken into account. The optical density can be calculated directly from the spectrum measured by a spectrophotometer.

- **Area coverage** (sometimes also called relative dot size) is an artificial value that is calculated from the measured optical density (formula by Murray Davis). It corresponds to the relative portion of a surface area that, if printed on homogeneously with a full tone color, leads to the same optical density: e.g. a patch would have area coverage of exact 90% when it has the same optical density as one that is printed with 90% of full tone color and 10% are left unprinted.

The goal of this analysis (meaning the printing and measuring of the density linearization chart) is to document at which number of printed pixels a certain print density is achieved. E.g. how many dots have to be printed so that 50% of the possible optical density is reached, etc. For this purpose a chart is printed, measured and analyzed in the first analysis. In the second analysis, the software adjusts the number of pixels to be printed based on the information gathered in the first measurement. The analysis is repeated until the control points are spread reasonably across the gradient and the printer’s behavior is captured as good as technically possible.



The analysis is conducted the best way possible, measuring-wise, when each segment of the gradient is taken into account.

Specification of the Desired Target Behavior

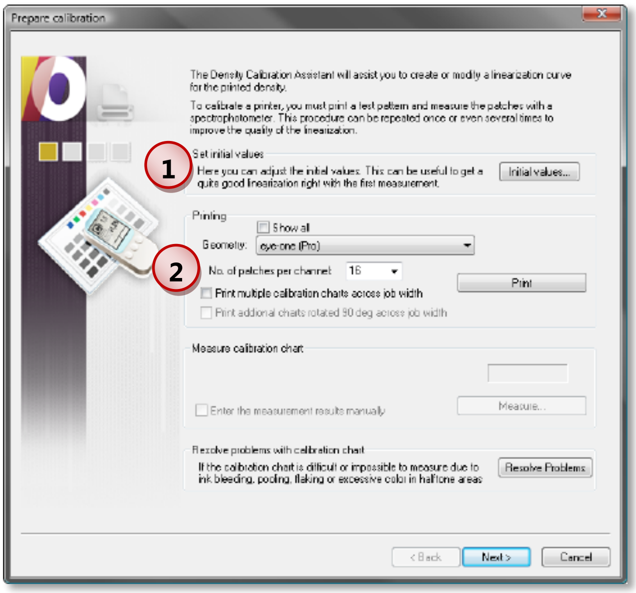
The specification of the desired target behavior is based on the goals described before as well as the notes on dot gain based on the standards in offset printing.

The Density Linearization Dialog

First Analysis

Initial Values

1 The **Initial Values** serve the purpose of being able to preset an already known basic behavior for the printer. The use of initial values reduces the effort of a density linearization. This value can be selected before printing respectively measuring the first density chart. A later change of this value deletes all previous measurements. This is why as soon as a measurement has been conducted, this button is named **Reset.**



Printing the Calibration Chart

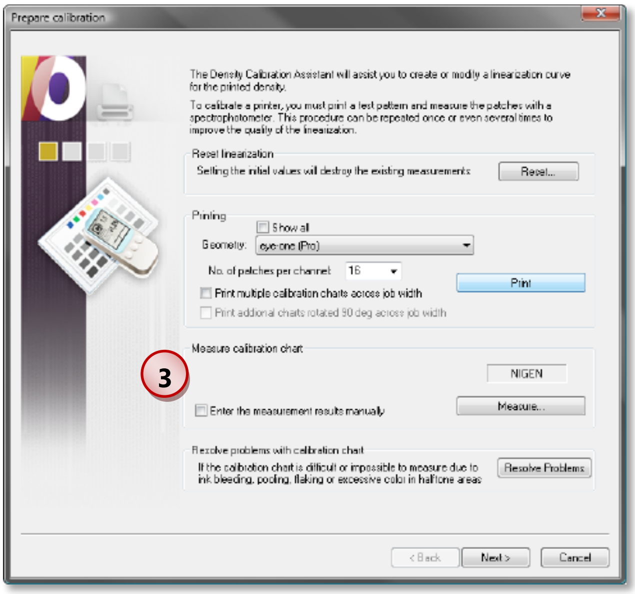
2 To be able to print a calibration chart, the following parameters have to be set: **Geometry** and **number of patches per channel.** The geometry describes the size of the measurement patches as well as the distance between the patches, etc. It also makes sure that the measuring device can read the chart correctly. The number of patches per channel sets how many patches are printed/measured per color channel.

> The number of measuring patches is not limited to the numbers displayed in the list but can be set freely.

The option **Print multiple calibration charts across job width** allows you to print several identical print charts next to each other. In addition to this, there is another option **Print additional charts rotated 90 degrees across job width** available. These options can be helpful with unreliable printers which give varying results across the job width.

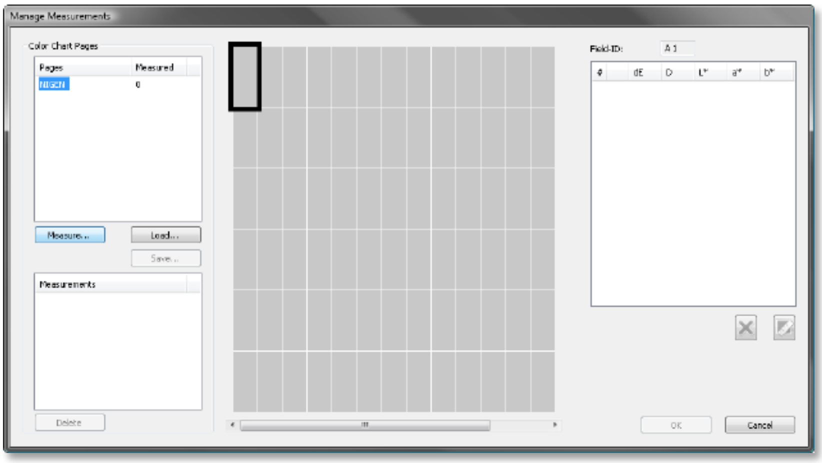
3 Each printed calibration chart automatically receives a name (e.g. KUNOK), which is displayed on the printed chart as well as in the dialog. This is useful so as not to confuse the charts.

If you want to enter the measurement values manually, click the **Enter measurement results manually** checkbox and then click the **Next** button to get to the measuring dialog in which you will be able to enter the values manually.



Measuring the Calibration Chart

The **Manage Measurements** dialog allows you to save measurements and to continue them at a later time. Click the **Save** button to save a measurement. The program will automatically propose the Chart-ID as a filename. We recommend using that one and maybe amend to it if necessary.



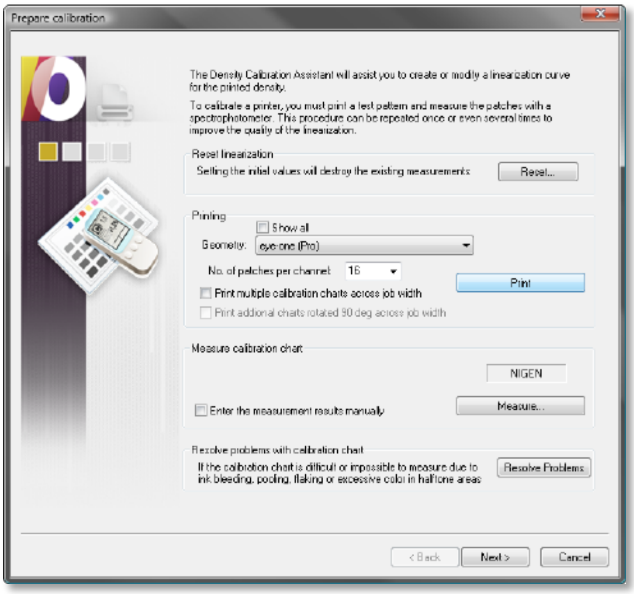
This dialog also allows checking and modifying the selected (marked) measurement as well as comparing all selected measurements.

Completing the First Analysis

After closing the measuring dialog, the first analysis can be considered completed. Click through the dialogs until you reach the **Finish** button and save your density linearization. Afterwards open the density linearization dialog again.

Conducting the Second Analysis

As soon as measurement values are present, the initial values option is not available anymore. The set initial values have now been replaced by the values from the first measurement. The values measured in the first analysis will be used to optimize the next measurement. This allows the measuring points to be spread across the measuring curve optimally and the printer's behavior is acquired ideally. In contrary to the first measurement, where the allocation of measuring patches is based on assumptions, the second analysis can be based on actual measurement values.



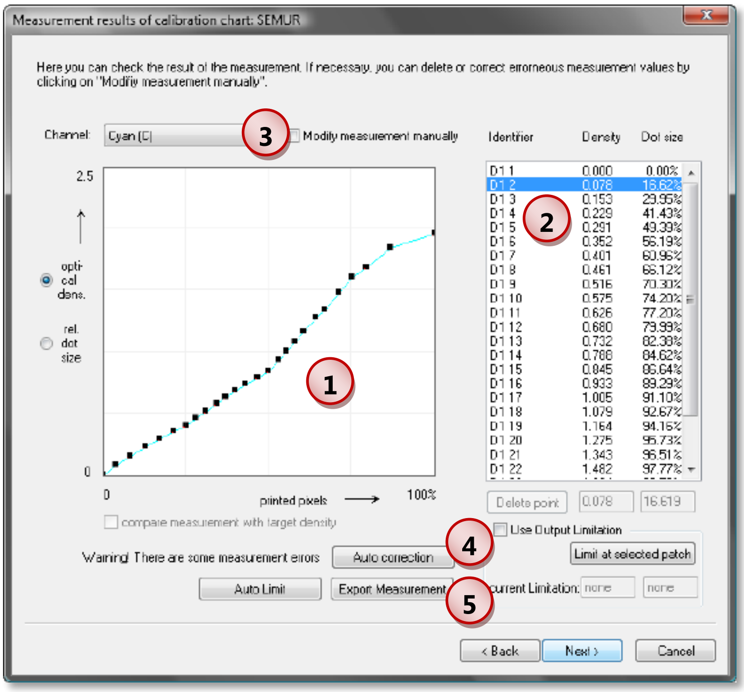
By clicking the **Reset** button, the measured data will be deleted and replaced by initial values again.

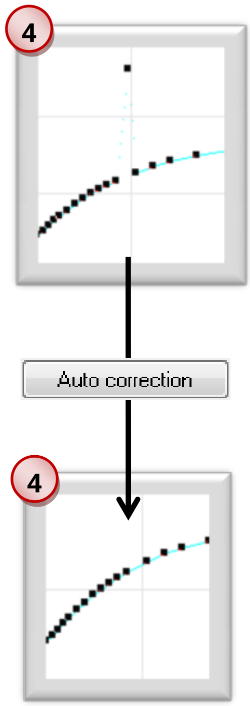
The geometry should also be maintained for the second measurement, respectively be suitable for the device that is used.

For the second analysis, the number of measuring patches should be doubled. Although one has to keep in mind that the number of patches might be increased so far that a line break within a channel becomes necessary while the printer might show different behavior for different lines. Troubleshooting suggestions for these kinds of problems can be found in chapter "Additional Notes".

Checking the Measuring Curve

The dialog **Measurement results of calibration chart** lets you check up on the measured curve. In general, a measurement is successful if the measurement points are allocated across the curve in about the same vertical distance to each other. When using light inks or different dot sizes, it is also important to exactly acquire breaks in the curve.





1 The line seen in above image represents a good analysis. The measuring points are well spread and the breaks respectively transition points of ink type or dot size are well documented.

2 In the list to the right side the measured points are displayed numerically. For every measurement it shows the measured patch, the measured density as well as the dot size that was used.

3 The dropdown menu **Channel** allows you to choose the color channel you want to look at. By using the checkbox **Change measurement values manually** you can also move the points around manually. Usually we do not recommend this; as such an action normally reduces the accuracy of the measurement.

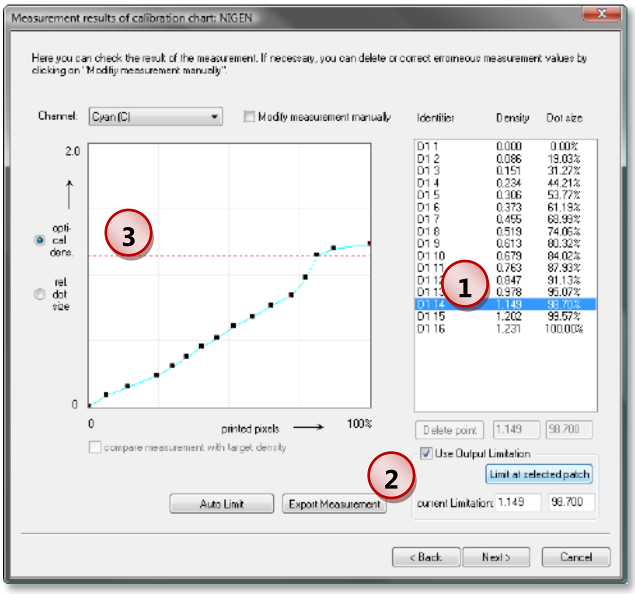
4 Should the curve obvious deviation from the expected curve (see img. 4), the button **Auto correction** will be displayed. If you push that button, all measurement values that do not fit into the expected picture will be deleted and remaining points will be reconnected. It is not mandatory to push the **Auto correction** button, as it simply illustrates the correction that is done anyway when the linearization is saved.

5 Using the **Export measurement values** button, the measurement values can be exported into a .txt file.

Limit Specific Ink Application

1 From the list of measurement values, choose the field you wish to limit your ink application at, using either the patch number or the achieved density as a guideline and click the **Limit at selected patch** button.

2 To use a patch-independent density or dot size value for the limit, you can enter it into the respective field. If you do not have a limitation already active, you can make those limitation fields available by clicking the **Use Output Limitation** checkbox. The limitation can also be activated or deactivated anytime by using this button.



The limitation serves the following purpose:

- Prevention of problems through unnecessary application of Ink
- Economize ink (Financial Motivation)
- Equalization of a group of printers to one and the same, absolute level.
- Creation of a "Reserve" to keep an (unstable or aging) printer on constant absolute level.

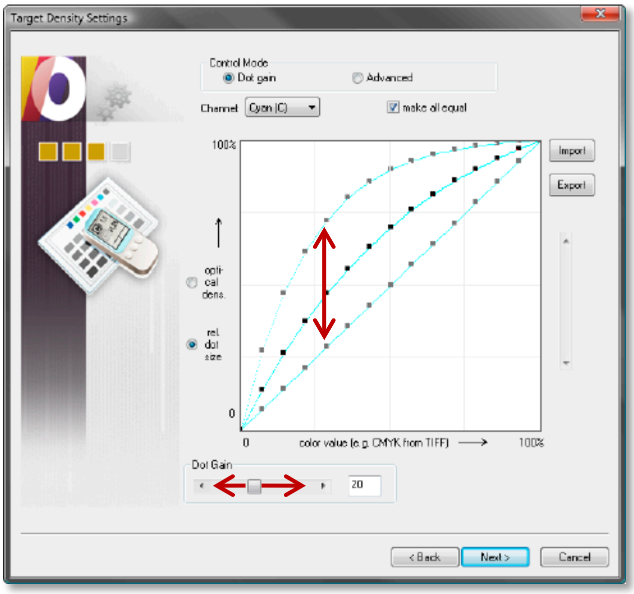
3 It is also possible to move the limitation line directly in the graphic display. However, a limitation must already be active in order to be able to do this.

Setting the Dot Gain

The second part of the desired printer's behavior can be defined in the **Target Density Settings** window, the dot gain. In general, we recommend using the default settings for most applications in digital printing. To define the desired dot gain, you have control modes at your disposal:

Dot Gain Control Mode

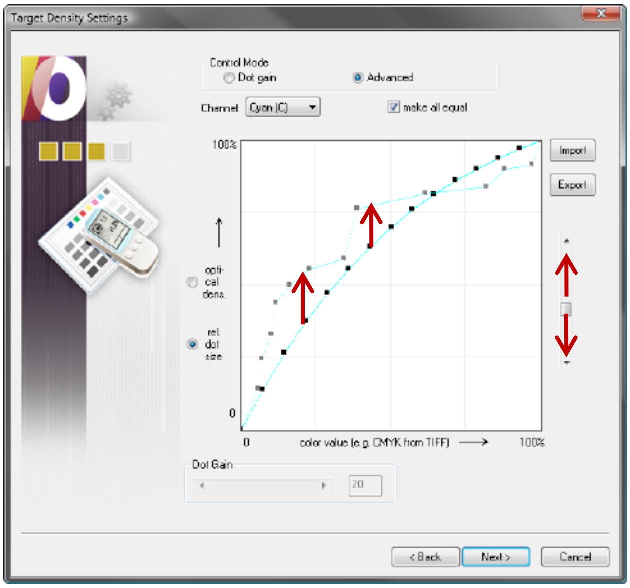
In the **Dot gain** control mode, you have the ruler at the bottom available to make changes. By moving this ruler to the left or to the right you can decrease or increase the dot gain which is applied to that curve.



Using the **make all equal** box, you can apply the changes you make to all channels or simply choose which channel you would like to edit through the dropdown menu **Channel.**

Advanced Control Mode

The advanced control mode allows you to influence the dot gain using the ruler at the right side by dragging it up or down.



Furthermore, it enables the user to move specific points and/or add new points by simply dragging an existing point or clicking into an empty part of the curve. This allows you to achieve an arbitrary and exotic behavior of the printer as e.g. simulating the result of Flexoprint or gravure printing.

If you switch back to **Dot gain** mode after editing the **Advanced** settings, all changes will be lost.

Importing/Exporting a Target Density

The **Import/Export** target density feature allows the user to import the target density of another density linearization. This makes it possible to force the same print behavior onto different printers.

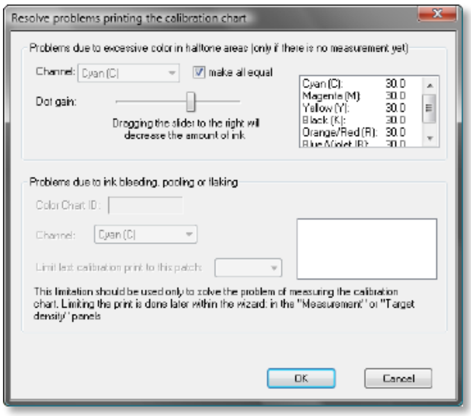
Saving Density Linearizations

Not until this step the actual calibration is created by connecting the measurement values with the target density curve.
This means it is possible to partially change an already existing density calibration and then save it afterwards. It is possible, and also makes sense in some cases to e.g. only change the target density curve without conducting a new measurement. The measurement values and the target density curve are independent from each other! When saving (not before) the program will calculate a new calibration from the new target density curve and the old measurement values.

> Notes about the density linearization wizard
>
> Basics: It is possible to browse back and forth in the wizard and therefore skip single pages; e.g. it is possible to jump to the last page and save everything there. The following day, one can simply resume work by continuing to edit this density linearization instead of creating a new one and restarting.
>
> Technical background: The density linearization creates a table assigning a pixel value to every color value (8bit value). For that purpose, a value for the optical density is determined through the density curve that corresponds to that respective color value. Afterwards, a matching pixel value is determined in the measurement curve. Respectively, in the target density curve a spline interpolation is done, meaning that with a “nice, round“ curve you will need less supporting points. With measurement values the interpolation is usually done linear, since that usually achieves a far more reliable method with the sometimes rather erratic measurement points.

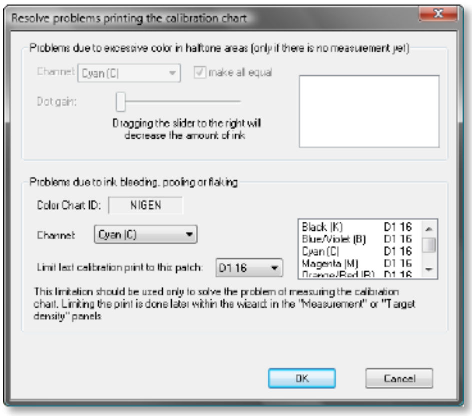
Resolve Problems Dialog for the Calibration Chart

Estimating the Printer’s Dot Gain



The dialog segment **Problems due to excessive color in halftone areas** is only available when no measurement has been conducted yet. Using the ruler, the estimated dot gain respectively the estimated overlap of the printed dots can be set. Basically, specific starting values can be defined here. But in most cases it is recommended to use the settings available in the **Initial Values** dialog.

Problems with Ink Bleeding or Flaking



In the second part of the dialog, a linearization chart itself can be limited, if e.g. the last 10 of 40 printed patches bleed and thus cannot be measured. In this case it is possible to use this dialog to limit the printout/chart to 29 patches, with patch 29 being the maximal value, thus making it possible for the chart to be measured.

The actual end value limitation should not be made here, but rather with the measurement values respectively target density, since in this dialog the linearization is cut down rather than just limited.

Additional Notes

Notes on Solving Measurement Problems with Varying Print Quality

Many printers show the phenomenon of varying print quality. Such as if e.g. the color application is different from one pass to the next due to banding. Such problems are often overlooked while printing due to the total view of the image or distance from where the print is seen. When analyzing the printer's behavior, such circumstances can lead to corruption of the analysis, e.g. if two rows of one color are needed for the analysis, it is possible that the printer loses some color application in the second line, thus creating breaks in the density curve. For these cases, the **ErgoSoft RIP** offers different options to bypass this problem:

Measuring Charts Several Times

Measuring a chart at least twice is part of the basics of a good analysis. With the situation described above in combination with the use of only one chart the results would be barely useable, if at all. This is why we recommend measuring the chart multiple times and to try to measure a different area of the patches every time, this will give you a better average value.

Rotating Measuring Charts and Printing them out Several Times

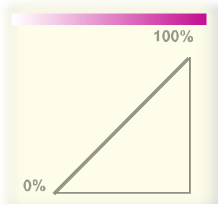
When printing the charts, the options **Print multiple calibration charts across job width** and **Print additional charts rotated by 90 degrees across job width** are available. These options allow you to select the best chart and measure that one. Furthermore, it enables you to measure several charts from the same printout and therefore get an average of the printer's behavior across the entire job. Since e.g. the charts rotated by 90 degrees will show a different banding it can greatly improve the analysis.

Print only one Line per Channel

One possibility to achieve this would be to reduce the amount of patches per channel until they fit onto one line. However this will vastly reduce the accuracy of the analysis.

Printing enough measurement patches into one row is only possible when using an X-Rite DTP 41 or the **Universal** geometry. This geometry is only readable by the measuring devices Spectroscan and Eye-One (without ruler). When using the Eye-One without a ruler, it is recommended to tape up the edges of the optical aperture (e.g. with hole stabilizer tape) so as to not damage the printout with its rough surface.

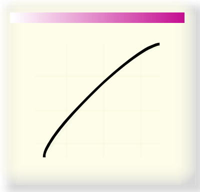
Notes on Dot Gain on the Basis of Standards in Offset Printing



Img. 1
Linear run

We remember that the ideal curve was always defined as a linear curve (Img. 1). If we do now take a look at the ideal curve that is set as target curve by default, we will notice that it is not linear but actually slightly bellied, similar to the actual measured curve and not linear as the original ideal curve. This can be tracked back to the definition of color profile standards in four color printing.

To understand the problems that this standard for digital printing brings, one has to understand the dot gain problem in offset printing and how to solve it.



Img. 2
Ideal curve regarding dot gain

Here is some information on that matter: When dots are printed larger than expected, the colors (or gray tones) automatically become darker than expected. Such a change of size can happen when copying the screens to the printing plate, or while printing through bleeding on more or less absorbent paper. When a dot is printed onto the paper or exposed onto film, the point expands a bit depending on the quality of the paper and the screen laser. This makes the point bigger, causing the color tone to appear darker as a whole. As an example, on coated fine art paper, the dot gain is about 9 %, on newsprint it is at about 38 % (using color). Following the previous description, we can say that the printouts often suffer of a compression of the dots/colors, especially in the middle parts of the curve. This means that instead of e.g. 50 % magenta, the printer created 70 % optical coverage while using 50% of available magenta dots, which of course falsified the printout.

Since the dot gain usually stays constant when using the same media type (such as e.g. 38 % on newsprint), a solution was conceived on which the problems for digital print are based. It was decided to prevent the dot gain by adapting the image to the falsification that happens in print by adjusting a value of e.g. 50% (which would result in 70% when printed) down to 30% (which is then printed as the expected 50%). Even in programs such as Adobe Photoshop, profiles were defined so they had the above mentioned 50% magenta set as 30% etc. Since people wanted to be able to also print CMYK files that were prepared for use with an offset printing machine, inkjet printers had to display similar characteristics as offset printers. In the easiest cases, this could be done by calibrating the inkjet printer to the same dot gain as an offset printer. However, for better output color accuracy we strongly suggest to create a special profile and to apply the correct input profile to the files created for the offset printer.

Using Non-Supported Measuring Devices

In case you wish to use a measuring device that is not supported by the **ErgoSoft RIP,** you have the following possibilities to use the device nonetheless:

Importing ASCII-File

When measuring calibration charts in other programs which allow you to save the measured data into a (text) file, you are able to import these files into the **ErgoSoft RIP:**

In menu *Tools* > *Options* > *Preferences* > *Application* > *Spectrophotometer* select the spectrophotometer **type** “From File”.

Format of the ASCII-File

The ASCII-File has to be set up as follows (spectral format):

- The first line contains comments; it is not processed by the **ErgoSoft RIP**
- All following lines start with ”Spec_400_10_700“, followed by the spectral values of 400 until 700 (incl.) in percent and including 2 decimals after the comma, with a step size of 10 (31 values). The data has to be separated by spaces or tab-stops; empty lines will be ignored. The patches have to be listed in the order that the **ErgoSoft RIP** expects them: color by color beginning with field A1.

Example: Density values
Spec_400_10_700 22.04 27.58 29.44 28.59 27.29 25.29 24.26 29.33 44.71 62.95 74.24 78.47 79.60 80.22 80.89 81.27 81.63 81.88 82.55 83.27 83.72 83.83 84.23 84.91 85.98 86.86 87.24 87.37 87.29 87.04 87.43

Please note that the line with the spectral values in the example is broken, but does actually represent one single line.

If your measuring device cannot measure spectral values but only density values, you can also use another format (densitometer format). But keep in mind that this type of values cannot be used as a basis for printer profiles in the profiling module ***ColorGPS.***

- The first line contains values. It is not processed by the **ErgoSoft RIP.**
- All the following lines begin with the letter ”D“, followed by the density value, which is separated from ”D“ through a space or tab-stop. The patches have to be listed in the order in which they are expected from the **ErgoSoft RIP:** Column-wise from the upper left to the lower right. Only the density values of one color are used.

Example: Density Values
D 0.000
D 0.070
D 0.279
D 0.488
D 0.662
D 0.800

D 0.995
D 1.441
D 1.593

Entering measurement results manually

Mark the **Enter measurement results manually** field in the density configuration window (Prepare Linearization) and click **Next.**

Select channel
Select the channel for which you would like to enter the measured values.

Entering values
Enter the measured values into the field below the **Density** column. Add the entered value to the list by selecting just another entry. In the list, the value for which the next entry is expected is highlighted. You can also move this mark by clicking on the desired value/line with your mouse.

Please keep in mind that densitometric values are expected when entering values