Using a flat-bed scanner to measure ink densities and linearize a QTR curve

Many feel the best way to establish ink densities for linearizing a QTR curve is to use a densitometer or spectrometer. That was beyond my budget but a kind member of a Yahoo! Group helped by showing me how he uses an ordinary flat-bed scanner to measure ink densities. This technique lends itself to users who don't wish to or aren't able to lay out the cash for a densitometer. Inexpensive software will work fine and you may already have what is needed. The only expense may be for a gray scale, about $25. If done carefully, these calculated densities should be every bit as accurate as those measured directly with a densitometer.

This process may look complicated but it breaks down to a series of small steps. A familiarity with spreadsheets will be necessary. I used LibreOffice Calc, similar to Excel, and available free at www.libreoffice.org. It comes with a comprehensive help file, and features a friendly user group. Besides the scanner you'll need a gray scale, such as the Kodak Q-13 Gray Scale (sometimes marketed under the Tiffen name), and photo editing software such as Photoshop, Photoshop Elements, or Gimp. Keep in mind the Q-13 is an **uncalibrated** reflectance standard, for critical work you may wish to use a calibrated standard such as the Stouffer R2110.

I'll assume you've made all the steps to creating a curve up to where you enter density values in the linearization table. This seems to be the step that is a stumbling block for many of us. It's helpful to remember that you'll be scanning **two** gray scales: the first is the Kodak Gray Scale and the second is a print of the 21 step gray scale included with QTR. The first one is for **reference** only and the steps' RGB values are measured with your editing software and your scanner – but you don't print **this** scale. The second gray scale is printed with your printer, your ink, and your paper. The steps' RGB values are again measured. The densities entered in the linearization table are obtained by comparing these two sets of measurements as follows:

First Scan: Calibrating your Scanner:

1) Scan the Kodak Gray Scale. The 20 gray patches cover a density range of 0.05 – 1.95 in 0.1 steps. Make sure the scanner's color correction is turned off.

2) Load the resulting file (scan) into your photo editing software. Use the Eyedropper tool and measure the RGB value of the 20 steps. Set the tool's sample size to at least 5x5 pixels (larger is better). If the RGB channels are not equal use the value for the G channel.

3) Open a new spreadsheet. Enter the RGB values measured in step 2 into a column. In the next column to the right (see column OD in the graph on Page 2) enter the corresponding density values from the Q-13 Gray Scale target (0.05 – 1.95). The third column represents how the gray scale labels the patches.

The following steps are specific to LibreOffice Calc, other spreadsheet programs may be slightly different. It's a good idea to save your work every few steps.

4) Select the first two columns by holding down the shift key, then clicking on the upper left cell (the RGB values), and then clicking on lower right cell of the middle column (the Density values).

5) Click on the Chart icon in toolbar, choose XY (Scatter) chart type, then Next, then Finish.

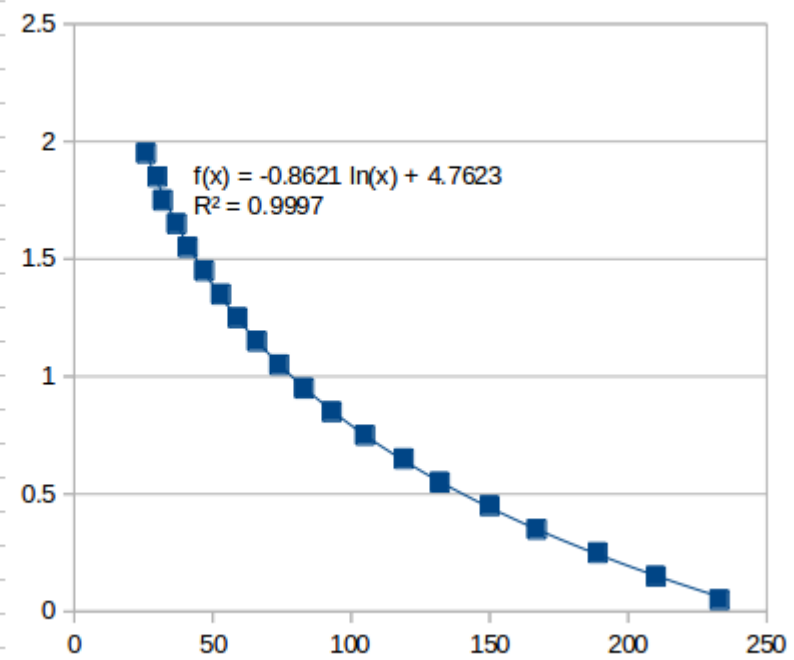
6) Select the chart (not the outline) so green markers appear at all corners and midpoints. Also, click on one of the small squares of the graph so all squares turn green.

7) Choose Insert > Trend Line. Select type/logarithmic, check Show Equation and R-squared.

8) The closer to 1.0 the R-squared value the better, it shows how closely the curve/equation fits the data. If the R-squared number is less than 0.95 the whole procedure should be repeated.

9) Now you have the equation that you will use in the next step: creating the Density values you will enter in the final linearization step of creating a printing curve.

RGB	OD	
233	0.05	A
210	0.15	1
189	0.25	2
167	0.35	3
150	0.45	4
132	0.55	5
119	0.65	6
105	0.75	M
93	0.85	8
83	0.95	9
74	1.05	10
66	1.15	11
59	1.25	12
53	1.35	13
47	1.45	14
41	1.55	15
37	1.65	B
32	1.75	17
30	1.85	18
26	1.95	19



Second Scan: Scanning a gray scale with your printer and your paper:

The equation can now be used to calculate **Density** by measuring the RGB value of an ink patch using your scanner as follows:

10) Print out the 21-step TIFF file supplied with QTR. Use the QTR curve you've created up to this point, but with the linearization table empty. Let it dry 2 - 3 hours, overnight is better. Scan your print, load the scan into PS and get the eyedropper RGB value for each step. Calculate the Density values, **f(x),** by entering the RGB values, **x,** in the equation. Enter these Densities in the final linearization step of creating the QTR curve. You may want to make a note of these values for possible future reference.

Here's an on-line calculator to make the math easier. Just enter the right side of the equation, inserting each RGB value for x:

http://www.symbolab.com/solver/logarithmic-equation-calculator

For those more versed in Calc, you can use the formula to generate a **table**, showing Densities for all corresponding RGB values. Use any two empty columns in the spreadsheet you've created so far - see next page. (Here, the table is formatted into shorter segments for more convenient viewing.) Note that the columns in the illustration are not labeled. The bold numbers are the RGB values and the decimal fractions are Density values. Be sure the tabled values do not exceed the data (RGB = 26 – 233 in this sample case). Find the RGB values you measured, make note of the corresponding Density values and enter them in the linearization table.

Note: your table will be slightly different – and you should make a new table each time you load a new batch of ink or if you re-calibrate the scanner (ie the “reference scan”).

20		**40**	1.58	**60**	1.23	**80**	0.98	**100**	0.79	**120**	0.64	**140**	0.50	**160**	0.39	**180**	0.29	**200**	0.19	**220**	0.11
21		**41**	1.56	**61**	1.22	**81**	0.97	**101**	0.78	**121**	0.63	**141**	0.50	**161**	0.38	**181**	0.28	**201**	0.19	**221**	0.11
22		**42**	1.54	**62**	1.20	**82**	0.96	**102**	0.78	**122**	0.62	**142**	0.49	**162**	0.38	**182**	0.28	**202**	0.19	**222**	0.10
23		**43**	1.52	**63**	1.19	**83**	0.95	**103**	0.77	**123**	0.61	**143**	0.48	**163**	0.37	**183**	0.27	**203**	0.18	**223**	0.10
24		**44**	1.50	**64**	1.18	**84**	0.94	**104**	0.76	**124**	0.61	**144**	0.48	**164**	0.37	**184**	0.27	**204**	0.18	**224**	0.10
25		**45**	1.48	**65**	1.16	**85**	0.93	**105**	0.75	**125**	0.60	**145**	0.47	**165**	0.36	**185**	0.26	**205**	0.17	**225**	0.09
26	1.95	**46**	1.46	**66**	1.15	**86**	0.92	**106**	0.74	**126**	0.59	**146**	0.47	**166**	0.36	**186**	0.26	**206**	0.17	**226**	0.09
27	1.92	**47**	1.44	**67**	1.14	**87**	0.91	**107**	0.73	**127**	0.59	**147**	0.46	**167**	0.35	**187**	0.25	**207**	0.16	**227**	0.09
28	1.89	**48**	1.42	**68**	1.12	**88**	0.90	**108**	0.73	**128**	0.58	**148**	0.45	**168**	0.34	**188**	0.25	**208**	0.16	**228**	0.08
29	1.86	**49**	1.41	**69**	1.11	**89**	0.89	**109**	0.72	**129**	0.57	**149**	0.45	**169**	0.34	**189**	0.24	**209**	0.16	**229**	0.08
30	1.83	**50**	1.39	**70**	1.10	**90**	0.88	**110**	0.71	**130**	0.57	**150**	0.44	**170**	0.33	**190**	0.24	**210**	0.15	**230**	0.07
31	1.80	**51**	1.37	**71**	1.09	**91**	0.87	**111**	0.70	**131**	0.56	**151**	0.44	**171**	0.33	**191**	0.23	**211**	0.15	**231**	0.07
32	1.77	**52**	1.36	**72**	1.08	**92**	0.86	**112**	0.69	**132**	0.55	**152**	0.43	**172**	0.32	**192**	0.23	**212**	0.14	**232**	0.07
33	1.75	**53**	1.34	**73**	1.06	**93**	0.85	**113**	0.69	**133**	0.55	**153**	0.43	**173**	0.32	**193**	0.23	**213**	0.14	**233**	0.06
34	1.72	**54**	1.32	**74**	1.05	**94**	0.85	**114**	0.68	**134**	0.54	**154**	0.42	**174**	0.31	**194**	0.22	**214**			
35	1.70	**55**	1.31	**75**	1.04	**95**	0.84	**115**	0.67	**135**	0.53	**155**	0.41	**175**	0.31	**195**	0.22	**215**			
36	1.67	**56**	1.29	**76**	1.03	**96**	0.83	**116**	0.66	**136**	0.53	**156**	0.41	**176**	0.30	**196**	0.21	**216**			
37	1.65	**57**	1.28	**77**	1.02	**97**	0.82	**117**	0.66	**137**	0.52	**157**	0.40	**177**	0.30	**197**	0.21	**217**			
38	1.63	**58**	1.26	**78**	1.01	**98**	0.81	**118**	0.65	**138**	0.51	**158**	0.40	**178**	0.30	**198**	0.20	**218**			
39	1.60	**59**	1.25	**79**	1.00	**99**	0.80	**119**	0.64	**139**	0.51	**159**	0.39	**179**	0.29	**199**	0.20	**219**			

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