Natural Plate Compensation Curves

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Abstract

Flexography is a conventional relief printing system that makes use of flexible resilient printing forms to transfer fluid inks. The versatility of the flexographic printing system allows for print to be made onto many different types of substrates, such as absorbent and non-absorbent materials. As each substrate has its own unique characteristic, the reproduction of printed graphics can be affected by a rather high tone value increase (TVI). To maintain reproduction of graphics, it is necessary to perform an adjustment to the original tone value. This adjustment is carried out via the use of dot gain compensation curves that are applied during file rasterization, imaging and plate-making operations.

This paper describes a simplified procedure designed to determine and apply plate compensation curves within any flexographic workflow environment. In doing so, it outlines the best use of tonal value measurement according to ISO 20654:2017, also known as SCTV.

Introduction

The calibration of a flexographic process starts with optimization and fingerprint activities. During these phases, the tonal values on the printing plate are adjusted to match a desired printing condition. This condition is either represented by the characteristics of individual colors, or the result of combined colors, with the aim of producing neutral greys.

For individual color adjustments, the target is normally a reference curve that was derived from prints produced onto a paper substrate via the offset printing process. This reference curve has been adapted to the needs flexography and described in earlier editions of ISO 12647-6 Graphic technology - Process control

Flexographic Printing Process Trainer & Consultant

for the production of half-tone colour separations, proofs and production prints - Part 6: Flexographic printing.

The following Table B.1 shows the “aim tone value increase curve” that was published in ISO 12647-6:2012. This TVI curve was provided for all printing colours, both process and spot colours, and it was widely implemented by the flexo industry as a reference curve.

TV	TVI
100	0.0
98	1.5
90	5.8
85	8.4
80	11.0
75	13.2
70	15.1
65	16.9
60	18.0
55	18.5
50	18.7
45	18.7
40	18.2
35	17.2
30	15.7
25	14.0
20	12.0
15	9.8
10	7.6
5	5.5
3	4.6
2	3.9
1	2.8
0.5	1.8
0	0

Table B.1 *– Aim tone value increase curves*

The ISO12647-6:2012 reference curve was supposedly derived from Curve C described in FOGRA27 characterization for offset printing and was adapted to flexography by adding a slight increase or "bump" in highlight values. This "bump" was applied to introduce a tolerance in areas which were affected by the typical variables found in the Flexographic printing process.

Current procedure with standard compensation curves

The calibration procedure of the flexographic process starts with a linear plate. This plate will usually display a solid area (an area to provide full printed coverage), a variety of proportionally spaced tonal areas, and a void area with no print elements to transfer ink onto the substrate. The halftone values on the linear plate correspond to the nominal tone value on the file: a 50% nominal tone value corresponds to a screened plate area that has 50% printable elements (dots) on surface and 50% voids that will not pick and transfer ink.

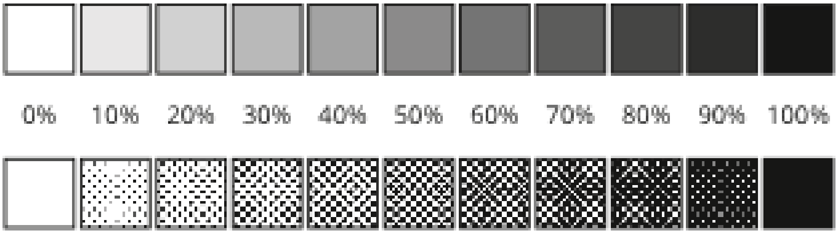


Figure 1 - *Linear printing plate*

When measured with the Murray-Davies densitometric formula, the tonal values that are printed with this linear plate will result in non-proportionally spaced values. For example, when a plate (mechanical) dot area of 50% results in a printed (optical) dot area 80%, a compensation curve is applied. This compensation curve will reduce the value on the plate and allow the nominal 50% to print as 68.7%. This 18.7% TVI corresponds to the value indicated in Table B.1.

Whilst the concept of TVI and dot gain compensation curve is established, it should be noted that this procedure involves the comparison of two "dot areas" that share the same name but have different characteristics.

These two values are similarly expressed as a "*dot percentage*" value, although they actually refer to different instances of area coverage.

The "plate dot area" is a mechanical value representing the area coverage of the "*inkable and printable*" surface of a screened area on the plate that is able to receive and transfer ink onto a substrate.

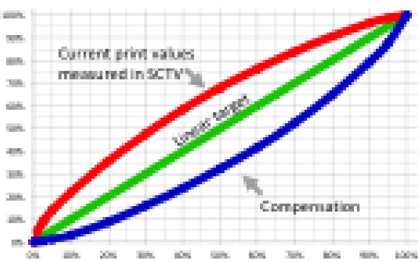
The "printed dot area" is an optical value. This represents the effect of the absorption of light created by the ink, that acts like a filter on the substrate. Ink coverage is influenced by voids, donuts, pinholes, slurring and other issues that may affect lay down of ink. The values of printed dot areas are derived from densitometric measurements made using the Murray-Davies (MD) formula.

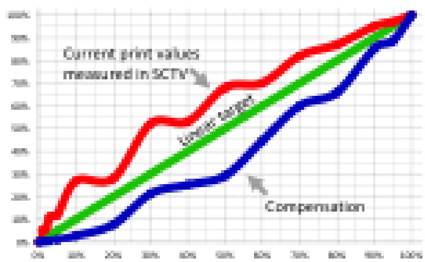
Proposed use of SCTV

The recently published ISO 20654:2017, Graphic technology – Measurement and calculation of spot colour tone value, commonly named “SCTV”, defines a new metric and provides a new formula for the calculation of the tone value of spot colors. The SCTV formula is based on colorimetric measurements, as opposed to densitometric measurements of the MD formula. Its aim is to provide uniform visual spacing of the tones between the unprinted substrate and the 100% or solid ink coverage. Although CMYK is out of scope of ISO 20654, this formula can be used to measure the tone values of just any color, including CMYK, and the recent edition of 12647-6:2020 allows tone value curves calculated using the SCTV formula.

The use of SCTV measurements during plate calibration allows for a common metric for mechanical tonal value on plate and optical tonal value on printed substrate: 50% on plate would read 50% on print, when measured using SCTV.

The reference curve for calibration with SCTV measurements would be a flat line, with compensation values calculated in the same way, using the same “plate curve” functionality in any imaging RIP.





Pandering a natural behavior

Using either SCTV or Murray-Davies formulas, the resultant curves may not be entirely smooth. The measurements may be influenced by any number of imperfect printing conditions such as bouncing, eccentricity, mounting, bushing, gears, vibrations, chattering, slurring, etc. Individually or collectively, these behaviours will introduce a certain amount of distortion or hysteria to both the readings and corresponding compensation curves.

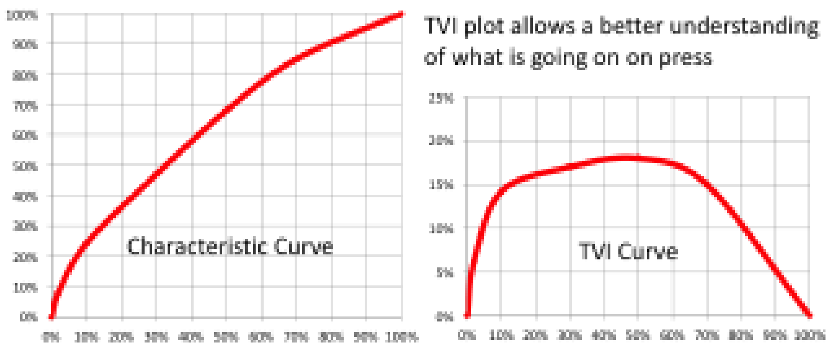
Such hysterias represent on-press issues that produce unexpected printing artefacts which may be inconsistent in future print runs. For this reason, it is necessary to calculate the smoothest possible transition of tonal values on the compensated plate.

Smoothing the values of these curves can prove to be very time consuming and actually produce inconsistencies due to any number of momentary behaviours of the printing condition.

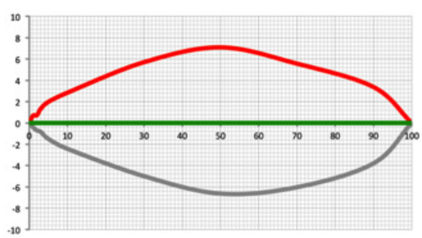
We should nevertheless consider that the TVI resulting from flexographic printing impression is a natural consequence of the interaction between the resilient printing plate, the liquid ink and the impressions.
Ideally, the TVI on printed substrate should naturally follow the proportionality of the tone values of the linear plate and show a smooth progression of printed values. This natural behavior should be pandered with a sequence of compensated values on plate that maintain the same smoothness and proportionality of the values.

Plotting and analysis of TVI curves

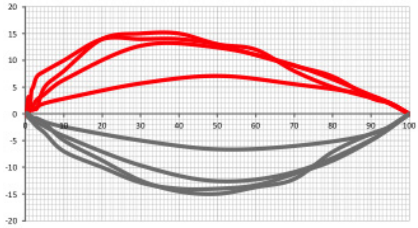
When evaluating printing curves, the TVI plot, rather than the characteristic curve, allows for a better interpretation of what is actually occurring during the print run. The graphs below show a typical result of using plate mounting tape that is too soft. The resultant image shows a flattening in the mid-tones which appears visually better when using a TVI graph.

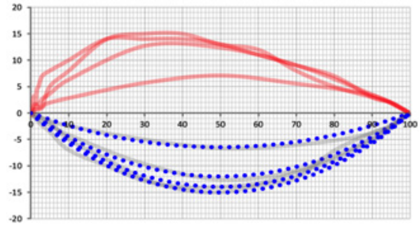


When looking at the plotted graphs of the dot gain curves in the form of TVI, the actual print curve has the shape of a hill; the target is flat, and the compensation curve is a valley as shown in the next image.

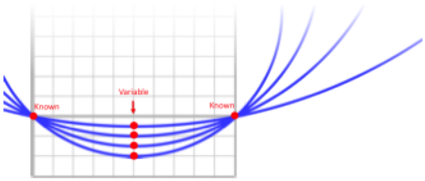


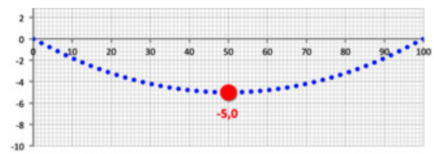
When viewing different compensation curves measured and calculated in SCTV, there is a noticeable similarity in shape; they are all quite symmetric.





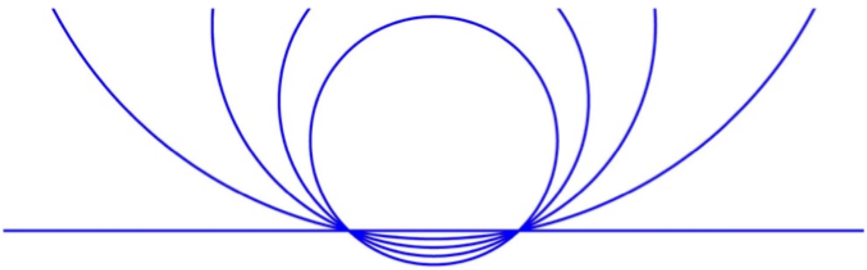
The symmetric shape of those curves produces arcs of circumferences. These arcs are produced as any circumference passes by only 3 points. Two of these points are known and fixed, x0y0 and x100y0. The only other value which needs to be defined is the y value for x50, the compensation point for 50%.





The shape of these curve is easy to be calculated and described: all that is required is the value to be used for 50% compensation point.

Under a theoretical point of view, we could consider that the starting condition with a linear plate is actually an arc with infinite radius and the different compensation curves are arcs that describe circumferences, having different radiuses (radii), that pass by 3 points.



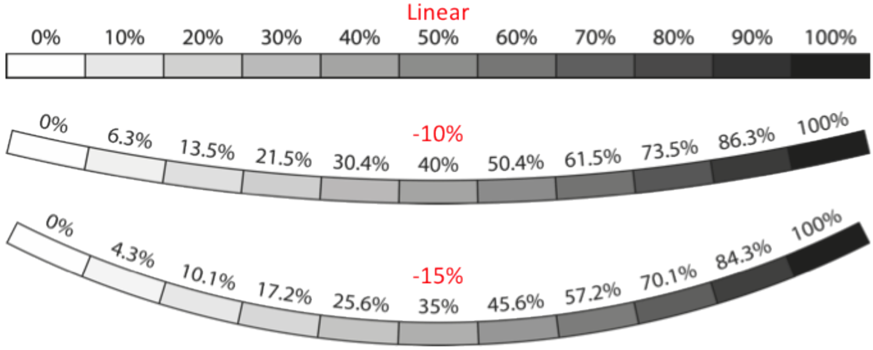
These arcs of circumference can be used to describe the plate compensation values just with the bottom point that is the compensated value for nominal value of 50%.

Natural Plate Compensation Curves

The calibration procedure begins with a linear and proportional condition, with equidistant tone values on a linear plate. The resulting compensation curve, calculated to match a flat target, becomes a sequence of equidistant and proportional tone values that follow a perfectly smooth arc of circumference.

This is the concept of the "***Natural Plate Compensation Curve***". This curve maintains uniform mechanical and visual spacing of the tone values between 0% and 100% area coverage, with a perfectly smooth shape.

The NPC Curve defines a compensated condition that preserves the proportionality and equidistance between the tonal values.



Conclusions and discussion

The usage of Natural Plate Compensation Curves is highly recommended to any flexographic plate-making environment to provide plate compensation values that are perfectly smooth, with equidistant and uncompressed compensated values.

The complete set of values can be described with just 1 number that is the value that is subtracted from nominal 50% to obtain the compensated plate value. Example: NPC-15% = 50%-15% = 35% on plate.

The perfectly numerical smoothness of an NPC Curve, based on an arc of circumference, saves considerable time in editing compensation curves and avoids the uncertainties related to any momentary behaviours of the printing condition.

NPC Curves allow pre-defined compensation curves to be generated for most common printing conditions, which are easy to share and to reproduce across different plate imaging systems:

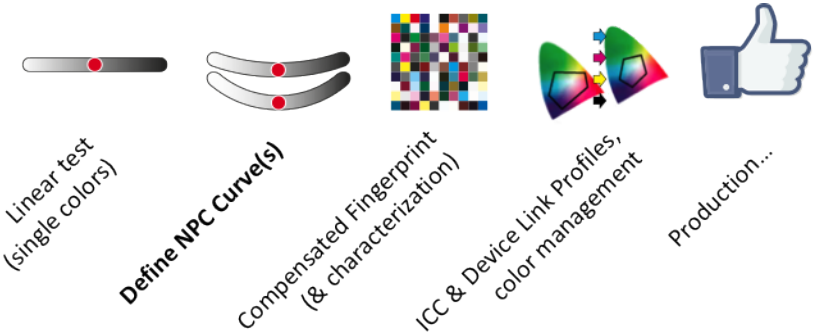
0% ...... linear plate, no compensation, for absorbent substrates
-5% ...... light compensation, lower ink volume, little to moderate absorption from substrate
-10% ...... normal compensation, moderate ink volume, on non-absorbent substrate
-15% ...... higher compensation for higher ink volume on non-absorbent substrates
-20% ...... extreme compensation, very high ink volume, on non-absorbent substrate

Naming the compensation curves as NPC Curves avoids any possible misunderstanding within the flexographic workflow environment.

Previously, a "C31" curve could be interpreted as a 50% nominal that prints 81%, thus having a +31% TVI. This is compensated to 36% on plate. Or it could be a 50% nominal that is compensated to 31% on plate. In both cases, there is no information about the transitions of other tone values.

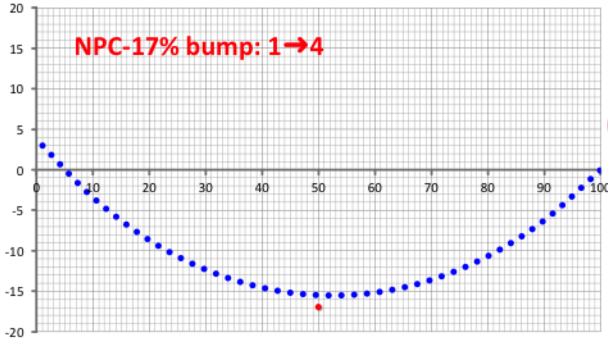
Using the term NPC-15 would clearly define a compensation curve and give clear information of the correct value on the compensated plate: 50% nominal -15% = 35% compensated value on plate.

A workflow based on NPC Curves is fully ISO-TC 10128 compliant: users could simply use NPC in lieu of normal compensation curves; or NPC could be used to compensate before fingerprint to define further adjustment curves for grey balance.



A workflow Rip will normally feature at least 2 curves: one for plate calibration, and one for print dot gain compensation. The ideal usage of NPC Curves is to provide compensated "*plate curve*" tone values to be input into an imaging RIP for plate calibration. The RIP would still have the possibility to enter further "*print curve*" values to further refine the compensation or match other conditions, such as grey balance (ISO TS 10128; G7).

The NPC Curve can also incorporate any highlight bump value in case such a correction is required. This may be necessary when working with plate systems such as LAMS that do not have a 1:1 file/plate reproduction capability. All that is required is to move the x0y0 point to the necessary value that is defined with the bump.

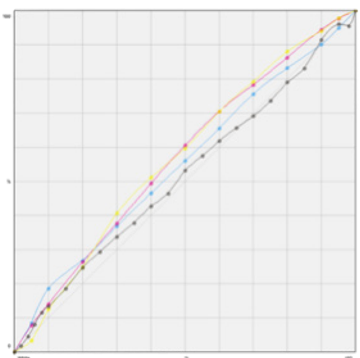


nominal	compensated
0,00	0,00
0,40	0,00
0,80	0,00
1,00	4,00
1,20	4,04
1,60	4,11
2,00	4,19
3,00	4,40
4,00	4,63
5,00	4,90
6,00	5,18
8,00	5,82
10,00	6,54

Since the values of the NPC Curve are calculated from a circumference that passes by 3 known points, any xy values of the compensation curve can be calculated to fulfil the needs of any rasterization platform. These may be in 256 values, 100 values or any other structure or format, including ISO 18620:2016.

Compensating tonal values with NPC Curves brings individual colors closer to their colorimetric linearity. It makes it possible to get closer to grey balance by adjusting single colors with NPC Curves, without the need of printing a CYMK fingerprint.

The image shows a split image (black/colors) from a fingerprint that was compensated with solely NPC.



Examples

For quick reference, the following table shows the calculated compensation values and the effective plate values for the most common printing conditions that require NPC-5%, NPC-10%, NPC-15% and NPC-20%.

NOMINAL	Natural Plate Compensation Curves				Plate compensated values			
DOT%	NPC-5	NPC-10	NPC-15	NPC-20	NPC-5	NPC-10	NPC-15	NPC-20
0	0	0	0	0	0	0	0	0
0,4	-0,1	-0,2	-0,3	-0,4	0,3	0,2	0,1	0,0
0,8	-0,2	-0,3	-0,5	-0,8	0,6	0,5	0,3	0,0
1	-0,2	-0,4	-0,6	-0,9	0,8	0,6	0,4	0,1
1,2	-0,2	-0,5	-0,8	-1,1	1,0	0,7	0,4	0,1
1,6	-0,3	-0,7	-1,0	-1,5	1,3	0,9	0,6	0,1
2	-0,4	-0,8	-1,3	-1,8	1,6	1,2	0,7	0,2
3	-0,6	-1,2	-1,9	-2,7	2,4	1,8	1,1	0,3
4	-0,8	-1,6	-2,5	-3,5	3,2	2,4	1,5	0,5
5	-1,0	-2,0	-3,1	-4,3	4,0	3,0	1,9	0,7
6	-1,1	-2,3	-3,6	-5,1	4,9	3,7	2,4	0,9
8	-1,5	-3,0	-4,7	-6,6	6,5	5,0	3,3	1,4
10	-1,8	-3,7	-5,7	-8,0	8,2	6,3	4,3	2,0
20	-3,2	-6,5	-9,9	-13,5	16,8	13,5	10,1	6,5
30	-4,2	-8,5	-12,8	-17,2	25,8	21,5	17,2	12,8
40	-4,8	-9,6	-14,4	-19,3	35,2	30,4	25,6	20,7
50	-5	-10	-15	-20	45	40	35	30
60	-4,8	-9,6	-14,4	-19,3	55,2	50,4	45,6	40,7
70	-4,2	-8,5	-12,8	-17,2	65,8	61,5	57,2	52,8
80	-3,2	-6,5	-9,9	-13,5	76,8	73,5	70,1	66,5
90	-1,8	-3,7	-5,7	-8,0	88,2	86,3	84,3	82,0
95	-1,0	-2,0	-3,1	-4,3	94,0	93,0	91,9	90,7
96	-0,8	-1,6	-2,5	-3,5	95,2	94,4	93,5	92,5
97	-0,6	-1,2	-1,9	-2,7	96,4	95,8	95,1	94,3
98	-0,4	-0,8	-1,3	-1,8	97,6	97,2	96,7	96,2
99	-0,2	-0,4	-0,6	-0,9	98,8	98,6	98,4	98,1
100	0	0	0	0	100	100	100	100

References

1 ISO 12647-6:2012 (12647-6:2020) Process control for the production of half-tone colour separations, proofs and production prints — Part 6: Flexographic printing
2 ISO 20654:2017 Measurement and calculation of spot colour tone value
3 ISO TS 10128:2009 Methods of adjustment of the colour reproduction of a printing system to match a set of characterization data
4 ISO 18620:2016 Prepress data exchange — tone adjustment curves exchange

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