Ean-13 barcode printing using variable plate line screens and plate dots in packaging

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Abstract
Flexography is a major process used to print a lot of packaging materials with variable plate line screens which vary between 55 line/inch to 200 line/inch with different plate dots from 1% to 100%. But when we need to use this printing technology to print linear barcodes as certain printing objects which used to identify the package attached to, by using variable plate line screens and plate dots and not in a solid line structure, we have to be careful, so the research Pursued analytical and experimental methodology to determine which of these plate line screens and plate dots can produce a perfect ink film module to print high quality and valid linear barcodes that can be used to identify the package from the first time and every time by the special barcode scanners.
Experimentally, barcodes can be printed by using various plate screen lines and plate dots, but with special conditions or special plate line screen values of more than 80 line/inch with plate dot values of more than 20%, also the maximum scale reduction from the standard size of EAN-13 barcodes has to be 50% or more but with high values of plate line screen like 90 or 100 line/inch with high values of plate dot like 30% or more.

Keywords:
linear barcode, EAN-13 barcode, barcode printing, flexographic printing, plate dot, plate line screen.

Introduction
The research *problem* is the fear and avoidance of printing linear barcodes by using variable plate line screens and plate dots by flexographic printing technology, and printing them in a solid sharp line structure to ensure printing linear barcodes that can be read easley from the first time and every time by the special barcode scanners.
In the other hand we *aim* to determine the appropriate plate line screen and plate dot values that can be used to print valid linear EAN-13 barcodes by Flexographic printing, that can be read easley from the first time and every time by the special barcode scanners.
So our *methodology* is to make analytical and experimental study to determine which of the values of plate line screens and plate dots can produce a perfect ink film module to print high quality and valid linear barcodes.

Relevance to Design Practice
The research results are useful for the designers in choosing the appropriate plate screen lines and plate dots values in the pre-press stage during preparing the digital files, and for the printers in order to print high quality and valid EAN-13 barcodes by using Flexographic printing.
Flexography is the a process used to print a lot of materials due to the virtues and the versatility of the flexographic printing process. There is indeed almost no material which has not been or cannot be printed by it. The materials on which can be printed are divided into several major groups as follows:
1- Paper and paperboard stocks
2- Corrugated stocks
3- Films
4- Foils
5- Laminates (Flexography printing, gravure, flexo and screen printing, Compiled by AP, P.Tech., AGPC, Sivakasi (page 115,116)
Flexographic and letterpress plates are made using the same basic technologies utilizing a relief type plate. Both technologies employ plates with raised images (relief) and only the raised images come in contact with the substrate during printing. Flexographic plates are made of a flexible material, such as plastic, rubber or UV sensitive polymer (photo-polymer), so that it can be attached to a roller or cylinder for ink application. Nowadays There are three primary

methods of making flexographic plates; Conventional, Digital (Laser Ablation Mask System) and Direct laser engraved plates.

Flexographic inks are very similar to packaging rotogravure printing inks in that they are fast drying and have a low viscosity. The inks are formulated to lie on the surface of nonabsorbent substrates and solidify when solvents are removed. Solvents are removed with heat, unless U.V. curable inks are used.

After printing, the substrate may run through a number of operations to be "finished" and ready for shipment to the customer. Finishing may include operations such as coating, cutting, folding and binding; see Figure 1 (http://www.ade.co.za/howdoesflexowork.htm).

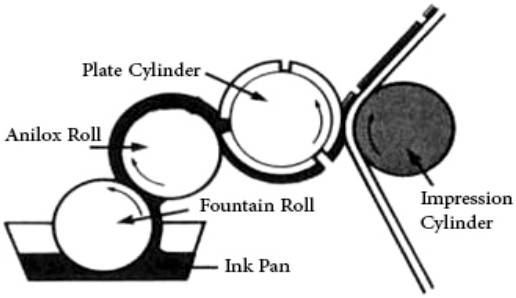

Figure 1: Flexographic Printing Process
Source: (**http://www.brobygrafiska.sewp-contentuploads201302Anilox_rolls)**

Substrate Texture & Porosity

Bars and spaces are most accurately produced on smooth substrates with high ink holdout. The rougher, more textured and more porous a substrate, the greater the potential for printing bars with voids and/or printing spots in the spaces; see Figure 2, either of which can reduce scanning rates. Textured and more porous spots also tend to increase bar edge roughness, bar growth, and bleeding. Any of these substrate characteristics can negatively influence scanning rates (Flexographic technical association - Flexographic image reproduction specifications & tolerances -First 4.1 Supplemental flexographic printing design guide - October 24, 2013).

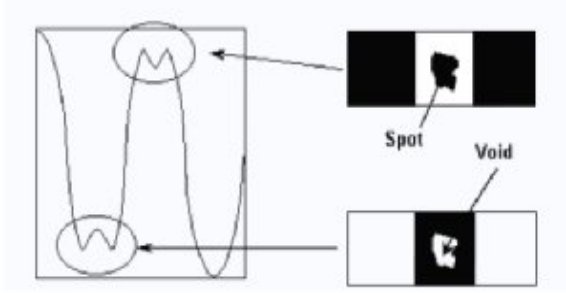

Figure 2a: Bars with voids and spots in the spaces

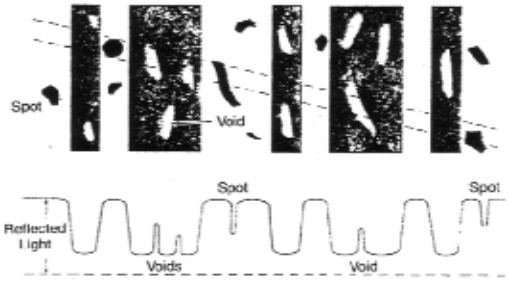

Figure 2b: Bars with voids and spots in the spaces

Background Color & Transparency

Bar codes scan most successfully with an opaque white background that provides white spaces and quiet zones with the maximum reflectance possible. When printing on a transparent or colored substrate, a solid, light-colored (white is optimum) background, with maximum opacity, is recommended in the area where the bar code is to be located. Special consideration for the background ink formulation and press setup (anilox, double bumps of background color and mounting material selection, etc.) may be necessary in order to achieve maximum opacity (Flexographic technical association - Flexographic image reproduction specifications & tolerances -First 4.1 Supplemental flexographic printing design guide - October 24, 2013).

Color Considerations

The optimum bar code color combination is opaque black ink for the bars and opaque white substrate or ink for the background. Bars printed in opaque black, dark blue, or dark green and backgrounds (spaces and quiet zones) printed on an opaque white material or on a white, red, orange, pink, peach, or yellow ink generally scan successfully.

It is important to remember that colors with acceptable ANSI/ISO Symbol Contrast on an opaque substrate may not be acceptable on an opaque substrate of another color or on a translucent or transparent substrate. When printing on a transparent substrate or colored substrate, a solid, light-colored (white is optimum) background with maximum reflectance is recommended in the area where the bar code is located. It is recommended that the bar code symbol not be placed on a printing plate used to print a large solid ink coverage (Flexographic technical association - Flexographic image reproduction specifications & tolerances -First 4.1 Supplemental flexographic printing design guide - October 24,

2013).
Printing plates that print large solid areas typically have requirements for extra impression and higher ink volume, which are not conducive to printing bar codes. Ink color specifications should be evaluated individually for different substrates (Flexographic technical association - Flexographic image reproduction specifications & tolerances -First 4.1 Supplemental flexographic printing design guide - October 24, 2013).

Screen Ruling

Screen rulings vary based on imaging method, plate material, and print conditions (such as press width, anilox configuration, and substrate). The range for both conventionally and digitally imaged plates is determined by print and substrate constraints. The graphics and process images or even linear barcodes to be used should be selected carefully because some print conditions require lower screen rulings. The screen ruling should be specified by the printer and considered by the designer. Line screen guidelines by market segment and substrate category. The designer should consult the prepress and print providers to determine the optimum line screen for a specific design (Flexographic technical association - Flexographic image reproduction specifications & tolerances -First 4.1 Supplemental flexographic printing design guide - October 24, 2013).

Plate Dots and Anilox Screen line

The print quality of all bar codes should meet ISO/IEC bar code print quality test specification Standards for linear symbols (Bar Coding Guidelines- Lowe's Companies, Inc. Revised. April 28th. 2011). The relationship of printing plate dot to anilox line screen cell directly affects the quality of the flexographic prints.
When using a low line screen printing plate (such as 55) you will typically use a lower line screen anilox roll (such as 250 – 500). When using a high line screen printing plate (such as 150) you will typically use a higher line screen anilox roll (such as 600 – 1200). And it is worth mentioning that we used in our research a high line screen anilox roll value of 660 for two reasons, first because this value is a very common value used in the Egyptian market to ensure getting high quality prints, second this value will cover the screen ruling of the printing plate from 70 lpi to 133 lpi.

Table 1: outlines proper anilox line count to printing plate dot relationships

% Plate Dot				
	1%	**2%**	**3%**	**4%**
Plate Screen (per inch)	**Minimum Anilox Line Count (per inch)**			
55	500	330	280	250
65	550	400	330	280
85	700	500	400	360
100	900	600	500	440
110	900	660	550	500
120	1000	700	600	500
133	1200	800	660	600
150	1200	900	700	600
175	N/A	1000	900	700
200	N/A	1200	900	800

For example, in imperial measurements, when you are using a 100 line screen plate and trying to hold a 2% dot, the chart above indicates that you will need a 600 line screen anilox roll. Whereas, if you're using a 100 line screen plate, and you're trying to hold a 4% dot, you'll only need a 440 line screen anilox roll. The reason for this is simple, you do not want the dot on your printing plate to be smaller than the cell on your anilox roll. If that occurs, the dot can actually

enter the anilox cell, picking up excess ink. This phenomena is referred to as "dot dipping" and can lead to very dirty printing situations (http://www.harperimage.com/AniloxRolls/Anilox-Guides/Plate-Dot-vs-Anilox-Cell).

Methods

Materials and Procedures

A black linear EAN-13 Barcode with (*No. of* 6223002230266), was generated by Corel Draw software in a standard size of 2.5X3.3, And was scaled down to 75%, 50%, and 25%, with variable plate screens (from 70 lpi to 130 lpi) and plate dots (from 10% to 90%); see Figure 3. This samples was printed on a PET substrate of 12 micron thickness by a flexographic printing machine with the specs of:

- **Type**: Hemingstone 2007 - Stack Type
- **Speed**: 100 m/min
- **Ink Viscosity**: 18 sec.
- **Plate thickness**: 2.54 mm
- **Plate Hardness**: Shore A:62
- **Plate Type**: flint group
- **Anilox Line Screen**: 660 lpi
- **Anilox volume**: 5 bcm

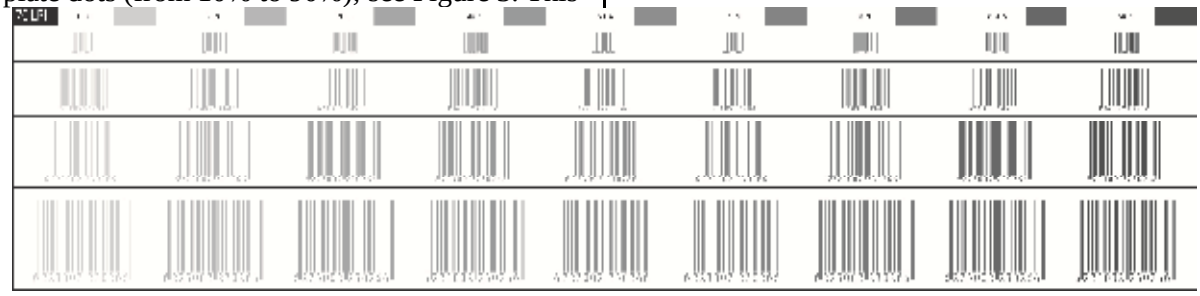

Figure 3: Barcodes with sizes scaled from 25% to 200% from the original one was printed in variable plate screens (from 70 lpi to 130 lpi) and plate dots (from 10% to 90%)

Evaluations

About three readings tries were taken for each barcode sample by Zebra.Inc. barcode scanner to assure the reading stability.

Results and discussion

From this research *The barcode sizes of 100%* which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (from 20% to 90%) are easily readable from the first time. Except the sample which printed with plate screen (70 LPI) with plate dot (20%) it is slightly difficult to read from the first time. While all samples which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (10%) are unreadable definitively; see Table 6.

Also *The barcode sizes of 75%* which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (from 20% to 90%) are easily readable from the first time, except the samples which printed with plate screen (70 LPI) with plate dot (20% and 30%) they are unreadable definitively. But the sample which printed with plate screen (70 LPI) with plate dot (40%) also the sample which printed with plate screen (80 LPI) with plate dot (20%) are slightly difficult to read from the first time. While all samples which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (10%) are also unreadable definitively; see Table 5.

Also *The barcode sizes of 50%* which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (from 30% to 90%) are easily readable from the first time, except the samples which printed with plate screen (70 LPI) with plate dot (from 30% to 60%) they are unreadable definitively, But the samples which printed with plate screen (from 110 LPI to 130 LPI) with plate dot (20%) are slightly difficult to read from the first time. While all samples which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (10%) are unreadable definitively; see Table 4.

Finally *The barcode sizes of 25%* which printed with plate screen (from 70 LPI to 130 LPI) with plate dot (from 10% to 90%) are unreadable definitively; see Table 3.

Barcodes reading results are shown in table (3), table (4), table (5) and table (6).

Table 2: outlines Table Key results

Table Key results: There are three different results		
Read from the first time	**Slightly difficult to read**	**Unreadable definitively**
√	√H	**Î**

Barcodes reading results

Table 3: outlines 25% Size Barcodes reading results

Plate Screen (Per Inch)	Plate Dots (Tints)& Readability (25% Size)								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
70	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**
80	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**
90	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**
100	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**
110	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**
120	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**
130	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**

Barcodes reading results

Table 4: outlines 50% Size Barcodes reading results

Plate Screen (Per Inch)	Plate Dots (Tints)& Readability (50% Size)								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
70	**Î**	**Î**	**Î**	**Î**	**Î**	**Î**	√	√	√
80	**Î**	**Î**	√	√	√	√	√	√	√
90	**Î**	**Î**	√	√	√	√	√	√	√
100	**Î**	**Î**	√	√	√	√	√	√	√
110	**Î**	**√H**	√	√	√	√	√	√	√
120	**Î**	**√H**	√	√	√	√	√	√	√
130	**Î**	**√H**	√	√	√	√	√	√	√

Table 5 Barcodes reading results

Plate Screen (Per Inch)	Plate Dots (Tints)& Readability (75% Size)								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
70	**Î**	**Î**	**Î**	**√H**	√	√	√	√	√
80	**Î**	**√H**	√	√	√	√	√	√	√
90	**Î**	√	√	√	√	√	√	√	√
100	**Î**	√	√	√	√	√	√	√	√
110	**Î**	√	√	√	√	√	√	√	√
120	**Î**	√	√	√	√	√	√	√	√
130	**Î**	√	√	√	√	√	√	√	√

Table 6 Barcodes reading results

Plate Screen (Per Inch)	Plate Dots (Tints)& Readability (100% Size)								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
70	**Î**	**√H**	√	√	√	√	√	√	√
80	√	√	√	√	√	√	√	√	√
90	√	√	√	√	√	√	√	√	√
100	√	√	√	√	√	√	√	√	√
110	√	√	√	√	√	√	√	√	√
120	√	√	√	√	√	√	√	√	√
130	√	√	√	√	√	√	√	√	√

Recommendations

1- The best appropriate plate line screens can be used to print valid linear EAN-13 barcodes by Flexographic printing and can be read by the special barcode scanners are the ones more than 80 line/inch with plate dots more than 20%.

2- The maximum ratio or scale reduction from the standard size of EAN-13 barcodes printed by Flexographic printing technology for reading them correctly and easily is 50%, but with high values of plate line screen like 90

or 100 line/inch with high values of plate dots like 30% or more.

Conclusion

However barcodes have to be printed in solid line structure not in halftone structure to ensure getting valid and scannable ones, It also can be printed by using various plate screen lines and plate dots, but with special conditions or special plate line screen values of more than 80 line/inch with plate dot values of more than 20%, also the maximum scale reduction from the standard size of EAN-13 barcodes has to be 50% or more but with high values of plate line screen like 90 or 100 line/inch with high values of plate dot like 30% or more.

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