Adobe ℠ Customer Services

Creating Smooth Blends in Adobe Illustrator

This technical note discusses how to create smooth blends (*gradient fills*) with the Adobe Illustrator program, and how to avoid breaks in color (*shade-stepping* or *banding*) in printed blends.

To create the smoothest possible blend, you need to consider several factors:

• The total number of gray levels your printer or output device can produce. This number is determined by the resolution and line screen combination of the printer or imagesetter.

• The percentage of change in color from the beginning to the end of your blend. Less than a 50-percent change can cause breaks, or banding, in the shades of color.

• The length of the blend. The length you can use varies with the colors in your blend, but as a general rule, the blend length shouldn't exceed 7.5 inches.

• The colors you use. Blends between very dark colors and white seem to generate the most banding problems. If possible, use lighter colors, or make dark blends short; avoid very dark colors in lengthy blends.

DETERMINING THE BEST RESOLUTION/LINE SCREEN COMBINATION

With most printers, increasing the screen frequency decreases the number of gray levels available to the printer. If the number of gray levels is less than the number required for your blend, the result is a posterized gradation.

Before you create your artwork, determine the number of shades of gray your printer or imagesetter can produce. You need to know both the resolution of the printer, expressed as dots per inch (dpi), and its line screen frequency, expressed as lines per inch (lpi), to determine the maximum number of shades of gray your printer can produce.

Levels of gray = $[(\text{Resolution (dpi)}/\text{line screen (lpi)})]^2$ up to a maximum value of 256

Examples

Low-resolution printer (such as Apple®LaserWriter®IINTX or Hewlett-Packard®Laserjet®with a PostScript cartridge): $(300 \text{ dpi}/53 \text{ lpi})^2 = 32$ levels of gray

High-resolution imagesetter: $(2540 \text{ dpi}/150 \text{ lpi})^2 = 256$ levels of gray (The calculated value gives 286, but the maximum number of grays is 256 for any device.)

Medium-resolution imagesetter: $(1270 \text{ dpi}/100 \text{ lpi})^2 = 161$ levels of gray

CALCULATING THE OPTIMAL NUMBER OF BLEND STEPS

When blending between two colors, the maximum number of usable blend steps (shades of gray) is based on the limits of your printer or imagesetter and the percentage change in the grayscale value of the blend.

Adobe Illustrator assumes that your imagesetter will produce 256 levels of gray. The percentage change in color is derived by subtracting the beginning and ending color values. For example, a blend from 100-percent black to 0-percent black represents a 100-percent change in grayscale value; a blend from 70-percent cyan to 10-percent cyan is a 60-percent change in grayscale value.

Less than a 50-percent change between colors may produce too few blend steps and cause banding. Specifying fewer blend steps than the maximum number may also produce banding; specifying more steps than the maximum produces a larger file that is more difficult to print with no increase in quality.

If your resolution/line screen combination does not produce 256 levels of gray, you can decrease the number of steps in the Blend dialog box to eliminate unused steps in the blend. To reduce the likelihood of banding, however, you must do either or both of the following: adjust the starting and ending colors of the blend to increase the change in grayscale value; reduce the length of the blend (see "Calculating the Best Blend Length" later in this technical note).

To calculate the number of usable steps in your blend, use the following formula:

Number of usable steps = Levels of gray (for the output device) x Change in grayscale value (for the blend)

Examples

For a high-resolution imagesetter, a blend from 40-percent black to 0-percent black:

(40% - 0%) x 256 = .40 x 256 = 102 usable steps

For a low-resolution printer, a blend from a high of 70-percent cyan to a low of 10-percent cyan:

(70% - 10%) x 32 = .60 x 32 = 19 usable steps

For blends with mixed process color, Adobe Illustrator uses the greatest change in grayscale of the component colors. For example, the changes in grayscale values for a blend from 50-percent cyan, 20-percent magenta, 0-percent yellow, and 10-percent black; to 0-percent cyan, 80-

percent magenta, 20-percent yellow, and 0-percent black; are

cyan:	50% - 0% = 50%
magenta:	80% - 20% = 60%
yellow:	20% - 0% = 20%
black:	10% - 0% = 10%

The greatest difference in percentage is in the magenta value (60-percent). Therefore, for an Apple LaserWriter IINTX or an HP Laserjet, the formula would be

60% x 32 = .60 x 32 = 19 usable steps

CALCULATING THE BEST BLEND LENGTH

Whether your blend displays banding is also affected by the length of each usable step, based on the number of steps in the blend and the overall length of the blend. To calculate the step length, measure the distance between the starting and ending colors; divide that distance by the total number of usable steps:

Step length = Blend length/Number of usable steps

If the step length is less than 0.03 inch (or 2.16 points), the blend will usually appear smooth. However, keep in mind that the 0.03 inch value is provided as a guideline only. Although step length is the predominant factor, whether the blend appears smooth or banded is also influenced by the colors in the blend, the dot shape created by the output device, the paper on which the image is printed, lighting, and other factors.

Using the 0.03 inch figure above, you can calculate an approximate maximum length for a smooth blend once you know the number of usable steps for a given situation. Multiply the usable steps by 0.03 inch.

Examples

A 0-percent black to 100-percent black blend on a high-resolution imagesetter:

256 usable steps x 0.03 inch = 7.7 inches

A 0-percent black to 100-percent black blend on a low-resolution printer:

32 usable steps x 0.03 inch = 0.96 inch

USING GRADIENT FILLS CREATED WITH ADOBE ILLUSTRATOR 5

Adobe Illustrator 5.0 introduces a new way to create graduated blends between colors, called gradient fills. You create a gradient fill, and then use it as you would any other color selection option, such as process colors, custom colors, and patterns. (See "Painting with Gradient Fills" in the *Adobe Illustrator User Guide* for information on creating and using gradient fills.)

Printing gradient fills

When you print a file containing gradient fills, the Adobe Illustrator program automatically calculates the maximum number of gray levels possible based on the output device; you no longer need to calculate the exact number of blend steps to create a smooth and efficient blend. However, you still must consider the limits imposed by the total number of gray levels your printer or output device can produce, the percentage change in color, the length of the gradient fill, and the colors you use.

Printing gradient fills using low-resolution printers

When printing gradient fills using low-resolution laser printers (600 dpi or less), Adobe Illustrator 5.0 approximates 256 levels of gray using a dithering technique called Adobe Screens. This technique breaks up the halftone dots on the output device to give the optical effect of 256 gray levels. Some low resolution printers also use their own dithering techniques to simulate more gray levels. If your printer has this capability, you must deselect the Adobe Screens option before you save or print the file. To do this, choose Document Setup from the Edit menu and select the Use Printer's Default Screen check box. When the output device resolution is greater than 600 dpi or when you separate the file, the Adobe Screens feature is automatically turned off.

ADDITIONAL INFORMATION

For a complete discussion of blends, including charts, samples, and techniques for smoothing blends using Adobe Illustrator, see *Design Essentials*, published by Adobe Press, ISBN#0-672-48538-9.

For a thorough discussion of PostScript screening technology, see *Real World Scanning and Halftones* by David Blatner and Steve Roth, published by Peachpit Press, Inc., ISBN# 1-56609-093-8; or see *PostScript Screening* by Peter Fink, published by Adobe Press, ISBN# 0-672-48544-3.