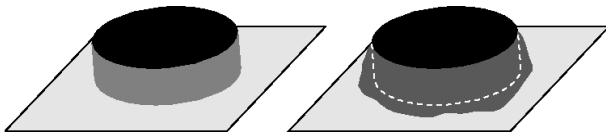


Know thy enemy: understanding dot gain and its effects

by Brian P. Lawler

Dot gain is the effect of halftone dots growing in area between the original film and the printed sheet.

Most printers treat dot gain as an evil demon that acts to deny them of their sleep. Yet, dot gain is a measurable, predictable and controllable effect of the printing process.



The theoretical halftone dot, at left, does not print at its true value. Instead, a tiny amount of ink surrounds the dot, and causes it to grow slightly. The greater the circumference, the greater the amount of gain. In addition, ink can spread on the paper, or be absorbed into the paper, adding additional area to the dots, and causing the measured and illusory dot gain to be greater.

In today's world of computer art generation, those who scan or manage images inherit the responsibility for managing dot gain. A printer cannot control dot gain if the film for printed halftones is generated ahead of the printer's processes.

What causes dot gain?

Dot gain is caused by ink spreading around halftone dots. Factors contributing to this increase in halftone dot area include:

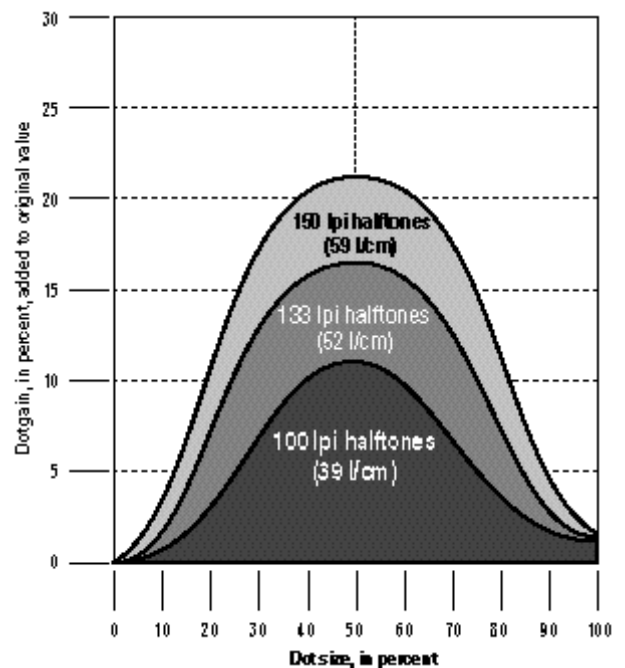
- ✓ Ink absorbing into the paper
- ✓ Ink spreading out onto the paper
- ✓ Circumferential ink "rimming"
- ✓ Halation at any stage in exposure

Different papers cause dot gain from absorption to a varying degree. Coated papers resist absorption, while uncoated sheets allow a great deal of absorption – and thus show more gain.

On coated sheets, the ink is actually squeezed outward of the dot shape by the pressure of printing. This in turn can be affected by varying viscosities of ink, and varying tack, or stickiness, of the ink. More solid inks, and inks with a higher tack will resist the squeezing effect, while lighter inks will show more gain.

The viscosity of the ink, as well as the tack, are not set by gain considerations alone; these factors are set by printing order, press type, and operator experience.

"Rimming" is a tendency for all dots to be



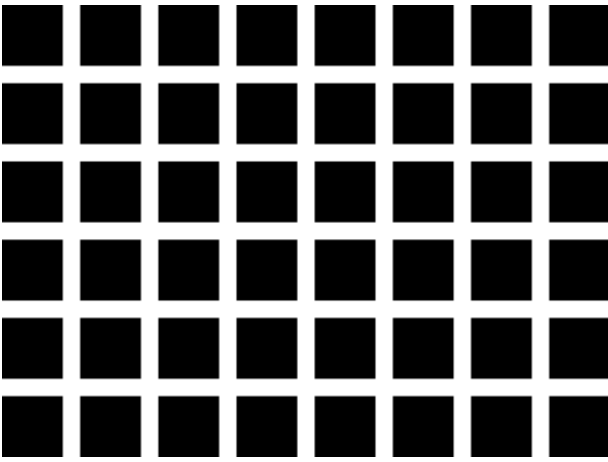
The plotting of dot gain on glossy paper. As the halftone percentage rises, dot gain rises. The circumference of the 50 percent dot is greatest, and thus the gain is greatest at that size. Higher halftone frequencies have more dots in the same area. As the number of dots increases, the gain increases – because there are more circumferences to gain.

surrounded by a tiny extra circumference of ink. Each halftone dot has microscopic relief, and ink will fall-off the edge before being eliminated entirely by the fountain solution (in the case of standard offset printing).

Press problems can contribute to dot gain. In addition to the gains already described; a press in bad condition can make matters worse. Improper press packing can make these normal gains greater, and press feed problems, like slur (a twisting of the sheet from improper press condition) can make dot gains grow excessively.

Dot gain is caused by optical illusion, too! The factors contributing to dot gain are both mechanical and physical. But there is an illusory component in the equation. Called **optical dot gain**, this effect is measurable and must be factored into any measurement of press gains.

Optical gain is created by the optical illusion when squares or other masses are in close proximity to one another (as shown in the illustration on the next page).



If you stare at these squares, you will see gray spots between the squares where no gray really exists. This is the illusory part of dot gain. Even though no real gray is present, we must compensate for the optical illusion of gray. The Murray-Davies formula for dot gain, used by most densitometers, takes illusory dot gain into consideration.

We see gray when no gray is really present. But since we see it, we must take its value into account.

The Murray-Davies formula for calculating dot gain (the most common method used in densitometers) includes a factor for optical dot gain. When you read a density with a densitometer, optical gain is a component of that reading.

So, what's normal?

Printers often feel that dot gain is a measure of personal character (**I gain, therefore I am a bum**), but the truth is that dot gain is as normal as any other photomechanical phenomenon.

I print, therefore I have dot gain would be a better slogan for the printing industry. Every printing process – from laser printers to rotogravure – has dot gain. Every T shirt and every annual report has dot gain.

High quality printers are those who have learned how to measure and control dot gain as well as a number of other production problems encountered when moving an image from one's imagination to the printed page.

Numerous studies have shown an average printing job on gloss paper, printed by an above-average printer will show between 12 and 22 percent dot gain at 50 percent. This is **average**, remember; values may be lower or much higher.

What can be done?

For the electronic prepress professional, measuring and controlling press gains is a scientific process, one where the performance of a printing process is tested, the response is analyzed, and corrective measures are taken.

The method is to create a test file, print that file, and then measure five points on the resulting gray scale. Taking those five measurements

back to the creating computer allows one to make corrections which will make the next pass through the system more successful.

One of the greatest ironies of press gain is that the measurement of gain is usually "what happened to 50 percent?"

The trouble with this has to do with with what mathematicians call **curve-fitting**. Measuring what happened to 50 percent is easy. Knowing how to react is the problem. What sort of correction is needed to adjust for gain, and to get that gain to disappear?

The CheckPoint system I have developed a system, called **CheckPoint**, which provides a solution to the problem of dot gain measurement and response.

CheckPoint is well-tested, and easy to use. It provides a step-by-step procedure for anyone with a sincere interest in generating the best possible images on computer systems.

With CheckPoint, we will look for the following press effects, and react scientifically and responsibly:

- ✓ Gain in midtones and shadows
- ✓ Plugging (gain) in the darkest shadow areas
- ✓ Slight highlight losses

Average dot gain for glossy paper is significant, and responding to it requires a response with the process I outline here.

Shadow plugging is just dot gain that exceeds the remaining value of the shadow dot, making the "dot" a solid.

Highlight losses are caused by two common factors, one is exposure inaccuracy in platemaking, the next is processing abuse, where manual or automatic plate processing removes the smallest dots from the plate.

We can compensate for all of these problems. Here's how:

Begin by creating a test file with 100 discrete tonal steps from one percent to 100 percent. I use Adobe Illustrator for making this file because it has a blend objects tool. Other programs, like FreeHand work equally well.

This example (shown at the top of the next page) uses quarter-inch squares, each filled with one-percent steps of gray. The construction is easy, only the labeling is time-consuming. Under each gray square is a solid square whose only purpose is to provide a clear area in the negative in which to make notes with a pen of the transmission densities.

The imagesetter is a factor

One must be able to trust the imagesetter when



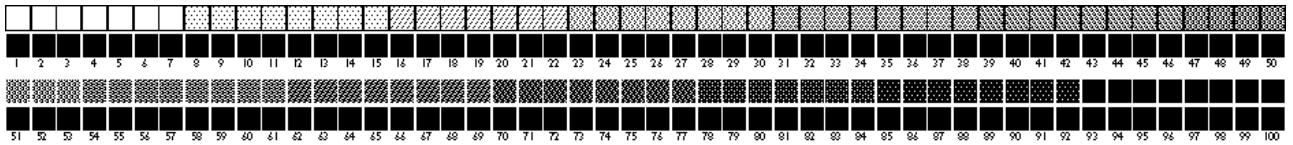
making press gain measurements, as the test file has 100 tonal steps, and each step must be accurate. If you are unsure, measure the dot area of the 100 step scale with a transmission densitometer before proceeding with the test for press gain. Each step should be within one percent of the desired value to be considered correct.

Expose a plate and print to get the results. Once the negative of the test file is made, and we presume accurate, it should be exposed to a printing plate, and that plate mounted on the press. Samples should be printed on both coated and uncoated sheets – use whatever types of paper you will be using in common production, but don't

Waiting for Good Dot...

At the lightest end of the scale we are seeking the value where the halftone dots appear in a regular pattern (see #1 above). This usually occurs between 1 and 4 percent. If it occurs at a much higher value, there is a significant problem in plate exposure and processing that needs attention. Don't proceed with the rest of this test until a reasonable dot pattern can be held in the 1-4 percent range.

At the opposite end of the scale, look for the appearance of a regular pattern of dots reversed out of black (see CheckPoint 5, above). We are seeking the darkest shadow dot possible. Be careful not to



This is the 100-step gray test that is used to measure both imagesetter linearity and press gains and losses. It is made in any application that can create a square with a finite dot area. For this example, I used Adobe Illustrator. The output halftone frequency should be the same as that intended for final reproduction, as dot gains are different for each halftone frequency.

go overboard. A typical gloss and uncoated sheet will suffice for basic measurements. If you print on newsprint or other highly-absorbent papers, or with special non-black inks, test those also.

What happened to 50 percent?

As already mentioned, most printers worry about what happened to the 50 percent dot. It gained to 69 percent! While this may be interesting, it isn't helpful to us in the quest for the control of dot gain.

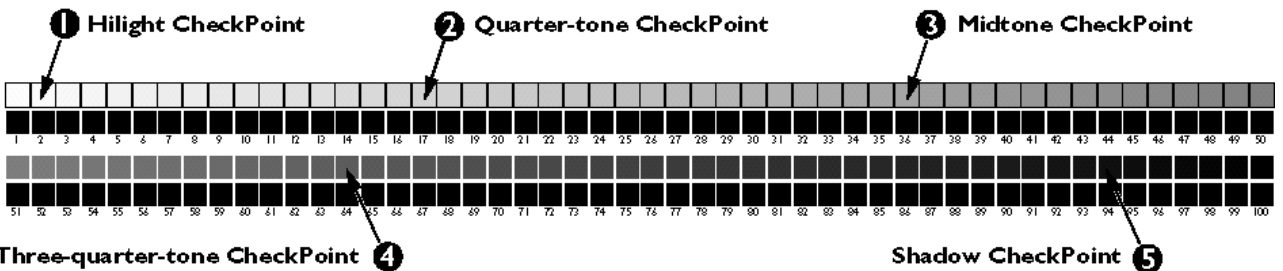
What we want to know is not what happened to 50 percent, but what value produced 50 percent. This, and similar information for the 25 and 75 percent values are the keys to the CheckPoint system of control.

The CheckPoint system relies on hard

mistake paper lint, which is often present in the shadow areas, for halftone dots. We need a pattern to be valid. This pattern will usually occur between 80 in the most absorptive papers to the mid 90s on fine gloss papers printed under the best circumstances.

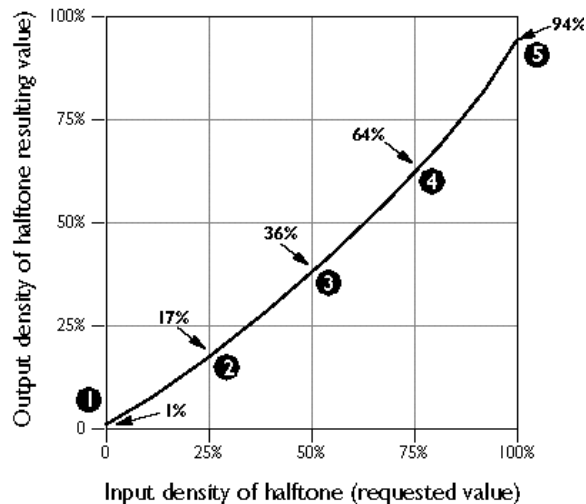
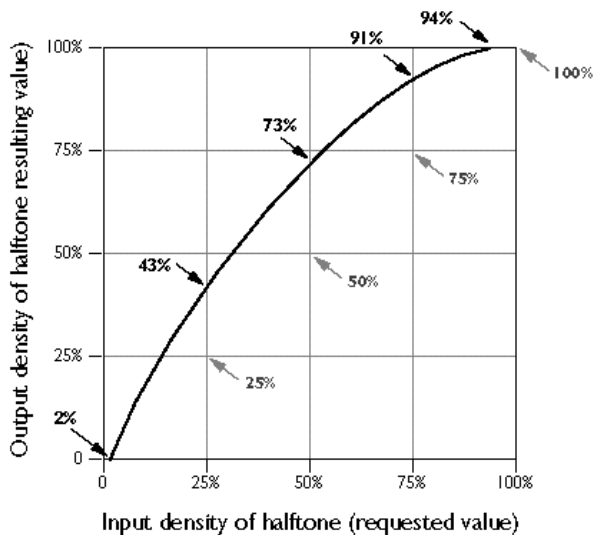
Make note of the highlight and shadow CheckPoints, as they will be used later to build a corrective curve.

The rest is divided into quarter-tones. We then use a reflection densitometer to measure the printed samples to get the values for our three other CheckPoints. I have been using a Lightsource Colortron instrument for several months now, and find its reflection densitometer functions to be extremely accurate.



measurements to pinpoint the gains and losses of printing on any paper with any printing process. To begin, we measure the printed test, looking for the darkest and lightest halftone patterns at the ends of the gray scale. We make this analysis with a magnifier.

Set the densitometer to read reflection density in "dot area" and begin at about the 15 percent range of the printed gray scale step chart. We are looking for the square that yields (actually printed) at 25 percent reflected dot area (plus or minus 1). Make a check mark above the square where this 25 reading occurs.



If we plot the gain from the 100-step gray test chart, on the previous page, it will look like this. Correcting for the gains and losses requires the building of a curve in Photoshop that reverses these gains and losses.

Next, move up into the 30s, and seek the square that printed at 50 percent (plus or minus 1). Make another check mark above this reading. This is the 50 percent CheckPoint and is a critical value in our corrective action.

Last, look for the square that printed at 75 percent dot area. This is the last value we need to build a perfect corrective curve for our images on this press and paper combination.

Make note of the five CheckPoint values. Armed with this information, we now return to the program where photos are processed – Adobe Photoshop – for the adjustments needed to make our printing better.

Throwing a few curves

Since we now know what happens to halftone dot values when they are printed, a corrective curve can be built that will counteract the effects of gain on the press.

This is the corrective curve in Photoshop. The values for positioning the curve come not from the measurement of gains, but from the printed test steps which actually generated the 25, 50, and 75-percent values.

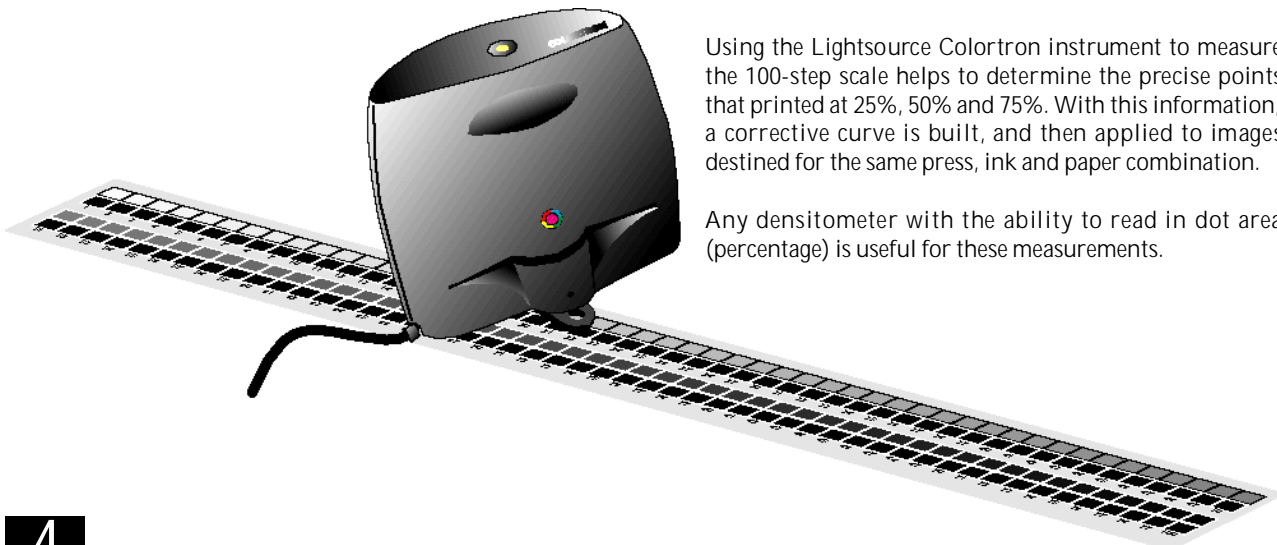
The results of our test require no complicated math, and no translations. These CheckPoints are solid evidence of the press and paper performance, and are reliable for making dot gain controls.

To put our CheckPoint values to work, we will build a curve in Photoshop with the values we have collected. Photoshop offers the best tool for this correction, though it is possible to use similar control in other applications.

QuarkXPress, for example, offers a Calibration XTension that allows curves to be built for individual imagesetters (and, we presume, paper and press combinations). But Quark's XTension does not allow you to control highlight and shadow dots, so it is not as useful as the curve control in Photoshop.

If we plot the effects of press gains and plate losses, the chart would look like this:

The curve that corrects for these gains is



Using the Lightsource Colortron instrument to measure the 100-step scale helps to determine the precise points that printed at 25%, 50% and 75%. With this information, a corrective curve is built, and then applied to images destined for the same press, ink and paper combination.

Any densitometer with the ability to read in dot area (percentage) is useful for these measurements.

almost a mirror of the gain curve – but not quite. It is interesting that an exact mirror is not correct, and that's the trap that catches many people when they try to correct for dot gain using computer programs – they usually overreact.

We will build a curve in Photoshop that uses our five CheckPoint values; this curve will be the perfect corrective tool for images that are to be printed on the same press and paper combination as the test we have printed.

In Photoshop, the Curve tool (Command-M) can be modified with control points, much as a line can be modified in Adobe Illustrator. It can also be modified with the pencil tool, which allows free-form adjustments for tonality, and pretzel-shaped curves (though this isn't very practical).

For this operation, we will use the standard control points to bend the curve through the 25, 50 and 75-percent points we measured with our test image. Be sure that the Curve control is set with black at the upper-right (percent dot area).

We will also push the lower-left corner point up the left wall until it equals your highlight CheckPoint **minus one**.

Minus one?

If we want a pure (often called "specular") white highlight in our image, any area that will be printed as pure white with no halftone dot structure, then we subtract one from the the highlight CheckPoint value we measured.

This minimum value will make the image appear brighter because there will be clear highlights for the brightest elements in the image – reflections for example.

This pure white is a matter of style, though. If you don't want the highlight to be pure white (some call it "blown-out") don't make this one percent adjustment.

Me and my shadow dot

The darkest dot appeared in our example at 94 percent. We acknowledge that no dots darker than that value **can ever be printed** with this paper and ink combination. So we acquiesce!

We limit the curve to 94 percent, in anticipation of that 94 percent becoming 100 percent in reproduction. Since no dots darker than 94 percent will be drawn, the the 94 percent dot will become black.

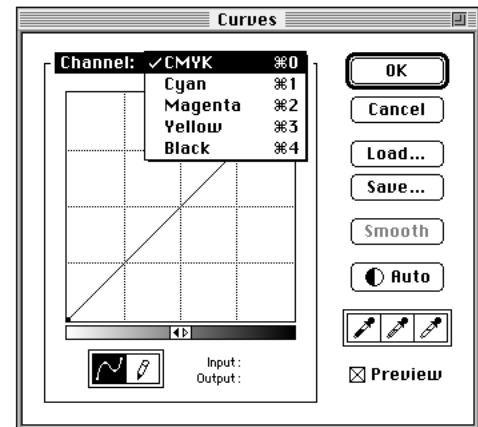
Meanwhile the midtone CheckPoint of 36 will cause any image to which it is applied to become less contrasty, and appear flat on screen, but when printed, the gains we measured will restore the tonal qualities to the image by **adding** dot gain.

Contrast will grow; the 94 percent dots will become black, and the highlights will remain pure white.

Curves ahead!

Save your work, always. When you have built a curve as shown in this example, and you have proved it to be effective in compensating for press gains on your combination of press, paper and ink, use it on all subsequent images that go to that combination.

Using that curve to adjust all subsequent



Photoshop's Curves control, above, allows curves to be built for monochrome or color images. To use Curves, be sure to set the curve so that black is in the upper-right corner (click in the middle of the gray scale at the base to reverse it). Individual color curves can be built with the pull-down menu shown here.

images ensures that you will get an image that is more like the image you saw on the screen of your computer.

Curve now, and in the future

You can build corrective curves for any combination of press, paper and ink, saving them for your production of images for each destination printing process.

Does CheckPoint work for color?

Color printing is really printing four (or more) monochromatic halftones with different colors of ink. Each ink will have slightly different gain characteristics, and the image will exhibit minor tonal shifts as a result of these variations.

To characterize a four-color process printed test, print the 100-step scale in all four colors of ink, and determine the five CheckPoint steps for each color.

Then, in Adobe Photoshop, build a four-color curve with the slightly different gain characteristics of each color entered on separate curves.

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