Banding in digital print: understanding the role of gray levels and the balance between calibration, rendering and color management.

In the world of digital print and particularly where smooth tonal transitions are required, managing gray levels from end-to-end in the printing workflow is essential. Paul Dormer and Nigel Wild of Global Graphics explain the importance of gray level handling to avoid banding, and how issues can be exaggerated in multi channels or expanded gamut systems.

The problem of direction banding or stripes

For digital press manufacturers developing an inkjet press, the problem of non-uniformity or banding is a particularly difficult one to resolve. It's especially acute on areas of flat tints with the result that printed output is unacceptable. Left unresolved, it could prevent the manufacturer from going to market with a new press. Out in the field this problem has a severe impact on the print service provider, who can either not run certain jobs on their inkjet press or, in some sectors of the market, are forced to sell their output at a discount.

However, banding, contouring or abrupt transitions are often signs of inefficient gray level handling, so understanding the root causes of these issues can significantly improve both quality and profitability.

From this...

To this.

What are gray levels and why do they matter?

Gray levels refer to the tonal steps between the lightest and darkest parts of an image or gradient fill object. In a digital workflow, these steps are limited by bit depth. For example, an 8-bit image provides 256 levels per channel, while a 10-bit image increases this to 1024 levels, enabling finer tonal transitions. While the theoretical availability of gray levels is determined by bit depth, the effective gray levels that make it through to the printed sheet are then influenced by calibration, screening, and color management decisions throughout the workflow.

Limitations of 8-bit rendering

As mentioned previously, 8-bit rendering provides only 256 discrete gray levels, which can sometimes be insufficient—particularly when extreme linearization curves are required. This is due to quantization, where the available levels are no longer evenly distributed across the tonal range. In certain cases, this can lead to a situation where a 20% change in output is compressed into less than 10 levels, rather than being distributed across the expected 51 steps. This can result in visible banding and a loss of tonal smoothness in the affected areas.

The limitations of 8-bit handling.

The impact of color conversion

Color management involves ensuring that colors are accurately represented across different devices. However, discrepancies in color profiles and rendering intents can exacerbate banding further. When colors are converted from one color space to another, or higher bit depth to 8-bit, the rounding off of color values can lead to visible banding. Again, this is particularly problematic in areas with gradual color transitions, such as skies or skin tones, where smoothness is crucial.

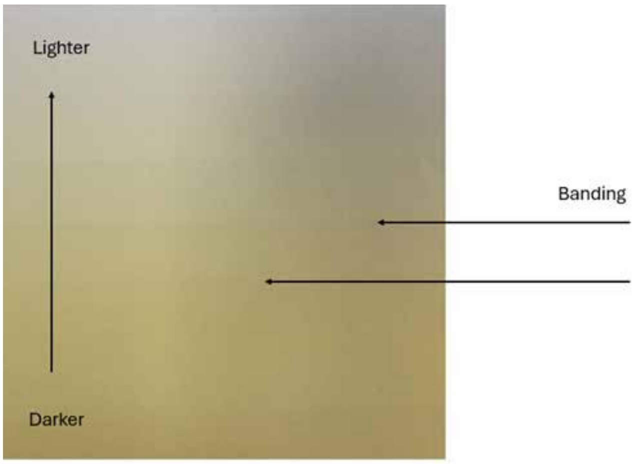
The impact of calibration

The calibration stage determines how tonal input values are translated to physical output. Poor calibration measurements or excessive curve adjustments can compress gray level availability, particularly in the mid-tones and highlights. This results in an uneven tonal distribution and visible banding.

Challenges in multi-spot gradations

When multiple spot colors are blended, which is common in extended gamut workflows, the distribution of tonal values becomes even more complex. Each spot channel has its own calibration and screening behavior. If not carefully balanced, this can lead to uneven banding and inconsistent color transitions and interactions.

For instance, a gradient shifting from yellow to light gray may appear smooth in design software but translate poorly in print due to limited or uneven gray levels between the used colorant channels.



In design software, a gradient from yellow to light gray may look smooth, but in print, it looks ineffective (banding) due to limited or uneven gray levels between the channels of shader used.

Solutions and workarounds

Improve calibration accuracy - Use consistent, validated measurement tools, minimizing external light and vibration during reading. Re-measure if results appear inconsistent.

Keep highlight curves gentle - Avoid excessive curvature in highlight-to-midtone transitions and ensure spot inks are calibrated for linear highlight response.

Balance spot channels - Use common targets for all spots in an EG profile. Ensure tonal resolution is consistent across channels.

Use of 16-bit processing - Increasing bit depth gives more theoretical gray level and improves tonal fidelity by allowing more control over color transitions. However, this significantly slows down rasterization and may be impractical for production environments. For example, a 16-bit rasterized page is four times larger than an 8-bit page.

Convert gradients to images or add noise - To disguise banding in complex vector gradients, one effective method is to add noise by converting the gradient into a raster image during pre-press. This can be done using a PDF editor such as Hybrid Software's PACKZ, or directly in the raster image processor, such as the Harlequin RIP®. While this approach is effective at breaking up visible banding, it can also reduce perceived sharpness—particularly if the noise is applied globally rather than being targeted specifically to the blended areas.

Avoid mid-workflow compression - Use minimum compression or paper-relative intent to preserve tone separation.

Integrate a comparison tool - Adding a visual or numeric diff tool for comparing separations can help identify tonal compression before printing.

Of course, software is also available to help achieve consistent results. For example, as expertise is declining and non-specialists are taking on printing tasks, Global Graphics Software has addressed this by putting the 'smarts' into the software. Its SmartDFE digital front end components include Smart Quality, which combines advanced technologies including ColorLogic color management software, ScreenPro advanced screening software, and PrintFlat, which calibrates each printhead's 'fingerprint' in the screening process, allowing for individual nozzle compensation.

Conclusion

Managing gray levels is critical to achieving professional-quality output in modern print workflows, especially when using extended gamut or multi-spot color strategies. A combination of the recommendations can dramatically reduce visual artifacts.

Remember, while increasing rasterization to 16-bit or adding noise will offer improvements, they come at a cost. Instead, the key is to build a well-linearized system early in the workflow and keep it consistent through to output.

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