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Application Note

THE WORKINGS OF VARIABLE CONTRAST PAPERS AND LOCAL GAMMA

If you have ever wondered why some images just look better on some papers than on others, and why VC papers so often give blah results, then this paper may be of help to you.

This paper shows how VC paper works and also shows some of the drawbacks and pitfalls of its use. The concept of local gamma for printing papers is introduced and is shown to be a useful tool for picking the right paper for the subject matter. The information is of general interest and not limited to those working with Darkroom Automation produces.

VC paper is made with 2 or 3 emulsions with the following characteristics:

1. All emulsions have the same intrinsic contrast
2. The first emulsion is sensitive only to blue light
3. The second emulsion is sensitive to both blue and green light
4. The third emulsion, if present, is sensitive to blue and cyan light
5. Each emulsion can only produce part of the density required for maximum black
6. The densities of the emulsions add together to produce maximum black

That first point is worth stating again: All emulsions have the same intrinsic contrast - the same range of illumination that takes them from white to their DMax. There is a common misconception that the paper is made from a blue sensitive high contrast emulsion and low contrast green sensitive emulsion - this is not the case.

A two emulsion VC paper will serve as an example of how these papers work. The curves shown are all idealized. Real papers are not nearly as well behaved. The numbers on the charts, while representative, are arbitrary.

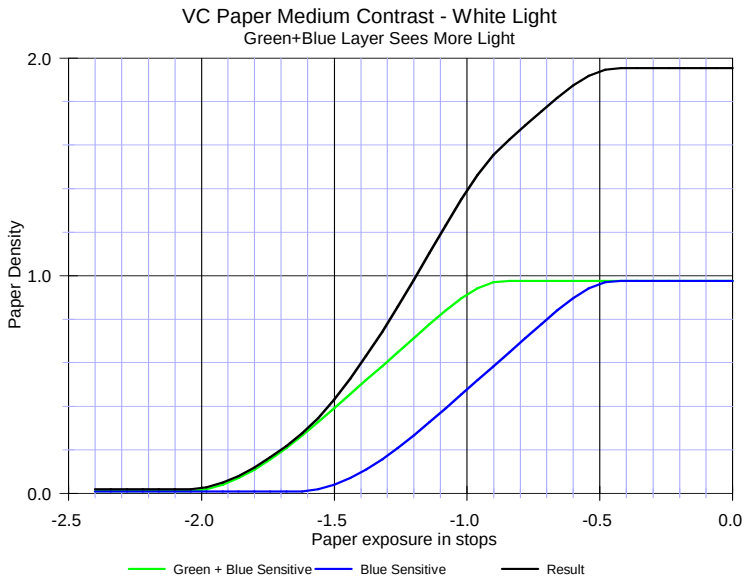
The HD curves of the green and blue emulsions, when exposed to white light, are shown in the figure to the right. The resulting black HD curve is the addition of the densities of the two emulsions.

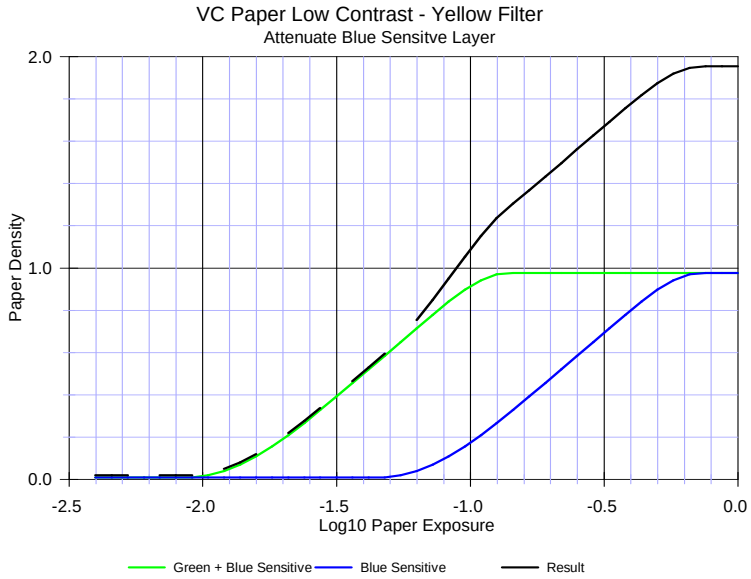
Since the ‘green’ emulsion is sensitive to both the blue and the green components of white light its overall sensitivity is higher: it takes less white light exposure to produce the same density as the blue layer.

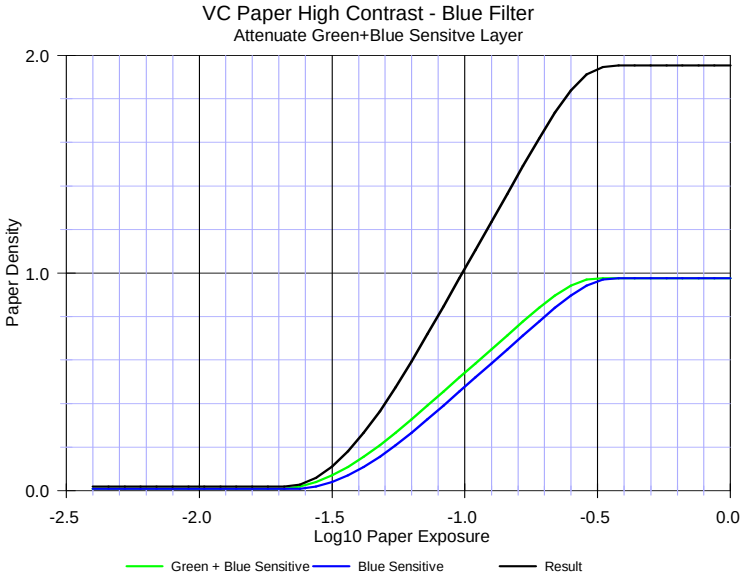
Each layer can only produce a density of 1.0 OD on its own. When the densities of the two layers add the paper density gets to a max black of around 2.0 OD.

If a green or yellow filter is placed in the light path the amount of blue light will be reduced, effectively lowering the printing speed of the blue sensitive layer. More white light is needed to expose the blue sensitive layer because most of the blue has been removed by the filter, as shown in the graph at right. This shifts the position of the blue curve to the right, increasing the spread between the two emulsion curves. The resulting paper curve will now accommodate a negative with a stop more contrast.

If a blue or magenta filter is placed in the light path the complimentary action occurs: now the green light is reduced, reducing the effective sensitivity of the green-blue sensitive layer so it is equal to that of the blue layer. The curve for the green layer shifts to the right so that it is on top of the blue curve. The blue curve remains where it was, as shown in the white light graph shown at the top of the page. The resulting high contrast paper curve now needs less negative contrast to go from black to white on the print.



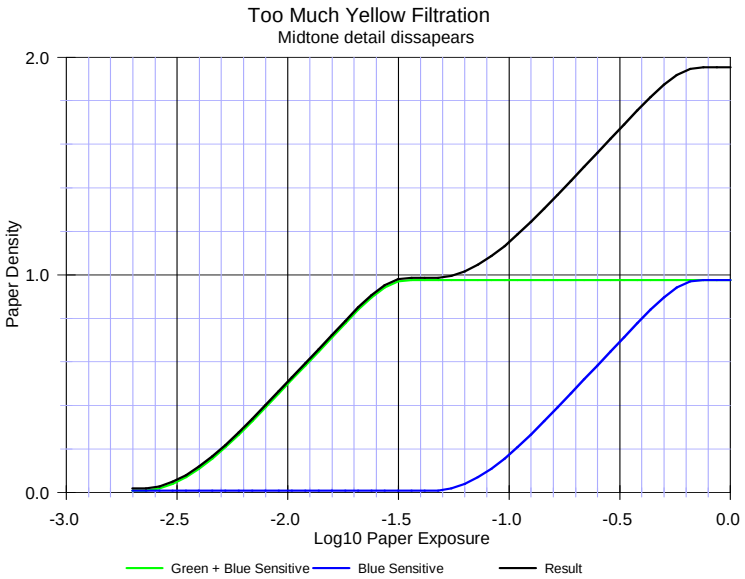




A pathologic condition exists in VC paper when too much yellow filtration is added to produce very low contrast.

In this case, the yellow filter reduces the sensitivity of the blue layer so much that the two emulsion curves have a gap between them.

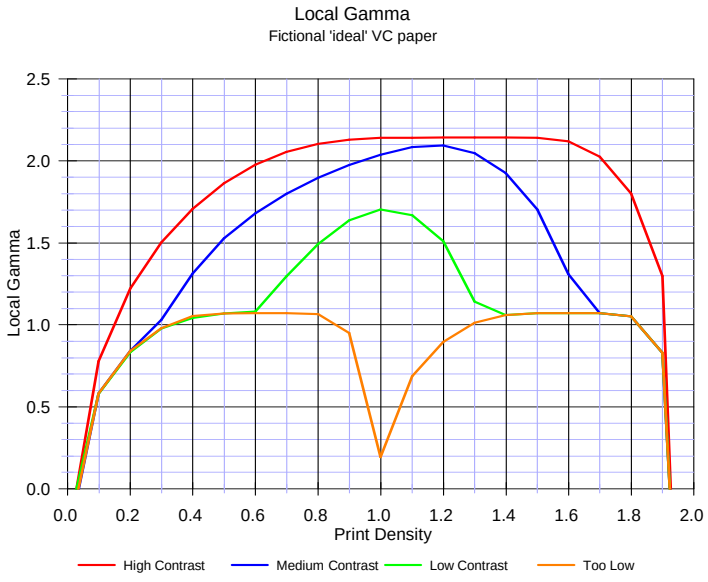
The resultant curve has a flat spot and as a result all detail is lost in the print's midtones. When this happens with a 3 emulsion paper, like Ilford MGIV, there are two flat spots in the resultant curve.



LOCAL GAMMA - 2 EMULSIONS

Because the response of VC paper is the response of a set of paper curves, each with their own toe and shoulder, VC paper exhibits some strange effects when looked at from the perspective of local contrast. Some refer to local contrast as contrast between adjacent elements in a photograph where the contrast difference between them may be large. In this paper, as seems to be the more common usage, local contrast means the contrast of objects that are close to each other on the tonal scale, and may be better termed 'Local Gamma'.

Local Gamma can be found from the HD curve by taking it's derivative - a measure of how fast the tones in the print are changing against how fast the tones in the negative are changing - and seeing how this changes with varying print density. The graph at right shows the local contrast for the idealized curves above.

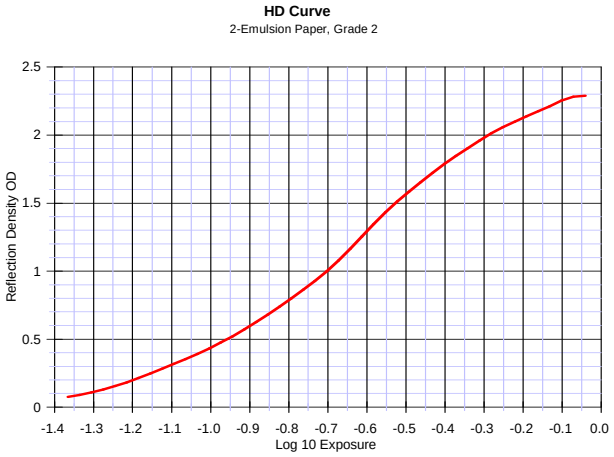


The contrast of VC paper changes the most in the mid-tones as filtration is changed. The toe and shoulder portions of the curve stay constant until the highest contrast grade is reached

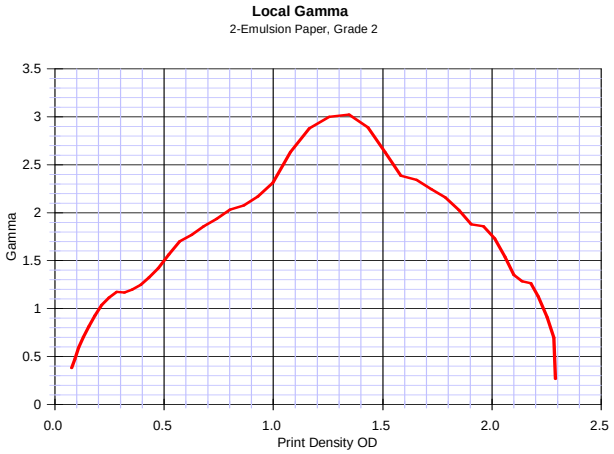
THE REAL WORLD - 2 EMULSION PAPERS

The curves for a real 2-emulsion paper are similar to the idealized examples presented before.

The HD curve at right looks very well behaved, with no obvious artifacts or flat spots.



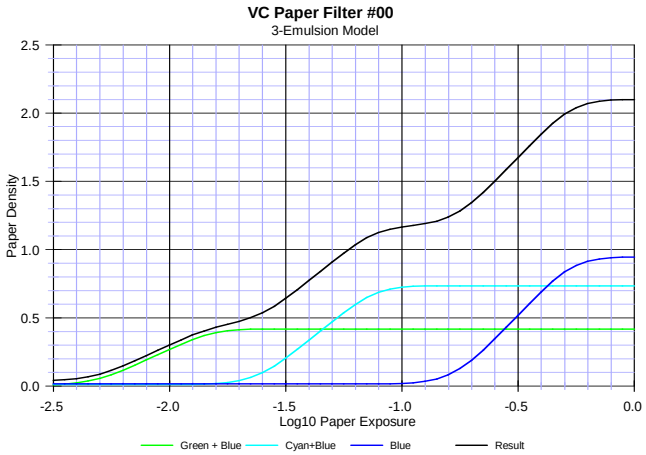
However, when local gamma/contrast is examined the graph clearly clearly shows where the end of one emulsion's HD response overlaps the beginning of the next emulsion's response. The characteristic 'blip' in the local contrast is clearly visible.

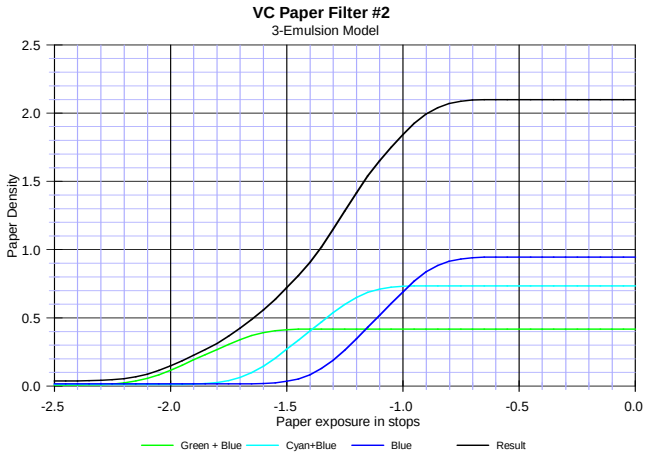


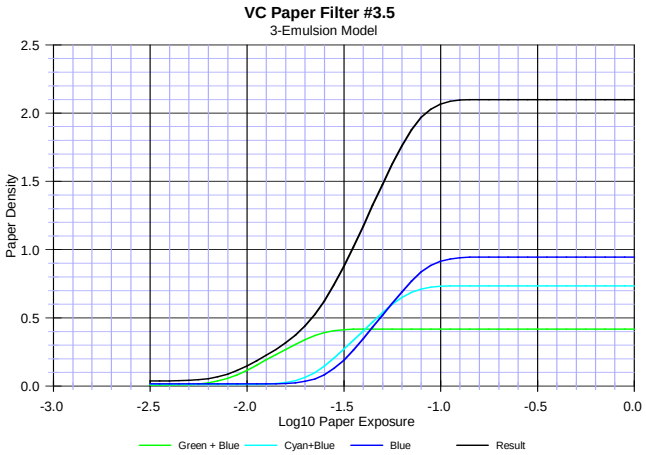
THREE EMULSION PAPERS - THE THEORY

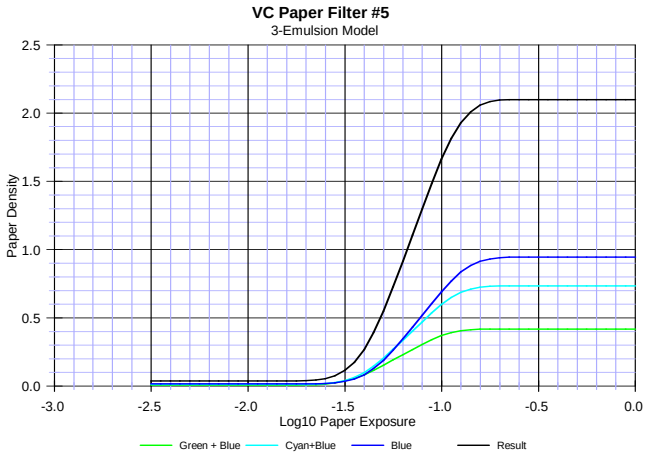
Modern VC papers, Ilford MGIV and Kodak's late Polymax, added a third emulsion to the paper. The third emulsion is described as sensitive to blue but a bit less sensitive to green - for this discussion we will refer to it as the 'cyan emulsion'. The workings of the three emulsions in controlling contrast are as before: green light exposes one emulsion, cyan exposes two and blue exposes all three.

The following HD graphs, though still idealized as mathematical functions, have been mathematically fit to be close to the actual curves of MGIV paper.





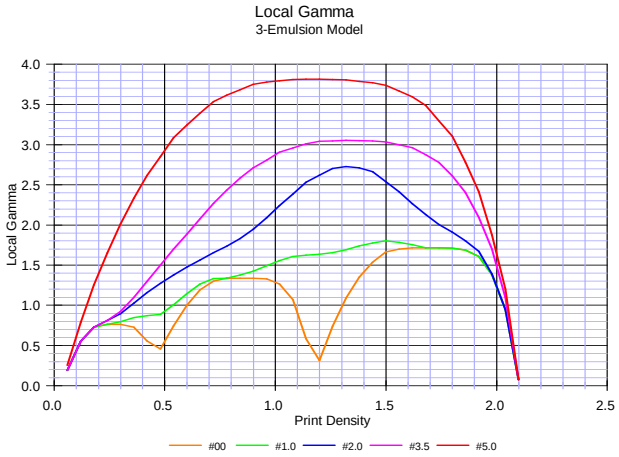




The 00 curve shows the attenuation of the blue emulsion in relation to its position in the grade 2 curve. As the contrast is increased the cyan and green curves are brought towards the blue curve.

LOCAL GAMMA - 3 EMULSION PAPERS

When the local gamma, the slope of the HD curve, is plotted against print density the following graph appears. If local gamma curves are available for a wide variety of papers it is possible to select the paper who's contrast response matches the important tones of the subject of the print. Note that at very low contrast the contrast - and detail - in the print will disappear in the skin (ZVI) and shadow (ZIII) tone. Very little control is available in the highlights and shadows and the grades don't show any real differentiation in print tones from white to skin tones (ZVI) until very high contrast grades are reached.

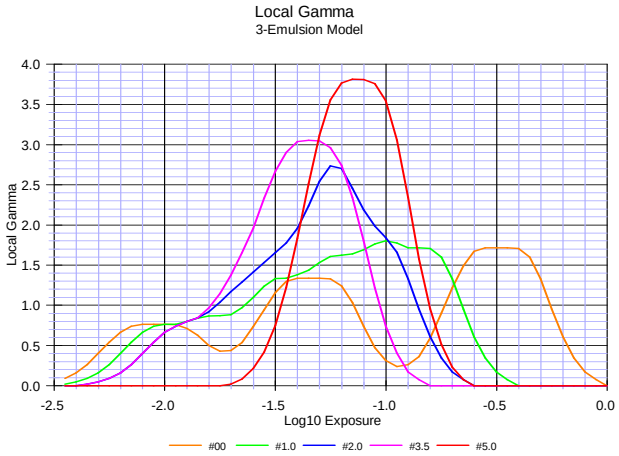


The graph also illustrates why there can be so much value in using a #5 filter to burn in highlights - it is the only way to raise highlight contrast.

Normal contrast prints will have most of their detail in the shadows with only half that contrast in the skin tones. It is likely the reason that portraits on VC paper are lackluster when compared to older work printed fixed grade papers designed for portraiture.

Another way to look at local gamma is as a function of subject luminance or negative density.

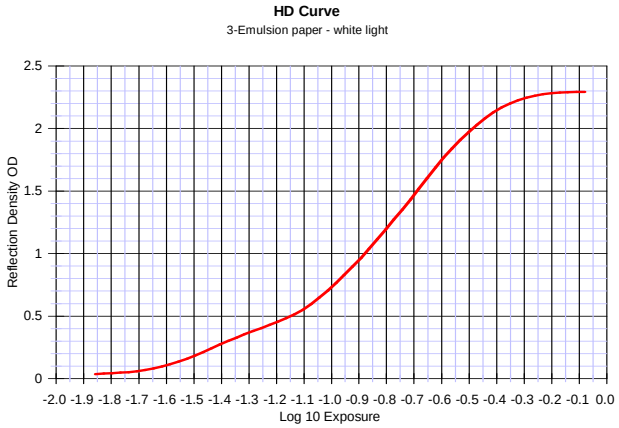
This curve, although interesting, is of less value. It does, however, show the value of fitting negative development to scene contrast for high contrast subjects - if low contrast paper is used then there are pronounced gaps in image detail. Expanded development for low contrast subjects may be of less value, and better results may be obtained from high contrast printing - although high contrast filtration accentuates grain and scratches.



THE REAL WORLD - 3 EMULSION PAPERS

In the real world things are not nearly as pretty as they are in the Platonic word of mathematical objects.

The graph at right shows the HD curve for Ilford MGIV MG RC paper when exposed to white light. The curve shows the characteristic break in the curve where the cyan and blue emulsions kick in and add their density.



The local gamma shown on the right indicates that MGIV in white light isn't quite optimum in the overlap of it's three curves. It shows a horrid dip in contrast at ZVI - right where skin tones should be, and puts most of it's effort into revealing detail in the shadows.

A good pick for low-key portraits, but don't try to emulate Hurrell using this paper.