Contrast Control with Color Enlargers

Calibration of dichroic heads to ISO paper grades

The advantages of variable contrast paper over graded paper have been discussed in previous chapters. The most important benefit is the ability to get all paper grades from a single sheet of paper, which provides creative controls otherwise not available. All this is possible, because variable contrast (VC) papers are coated with a mixture of separate emulsions, which have different sensitivities to blue and green light. By varying the ratio of the blue to green light exposure, any intermediate paper contrast can be achieved.

Cistercian Abbey of Fontenay
Passage to the Cloister, France 2006

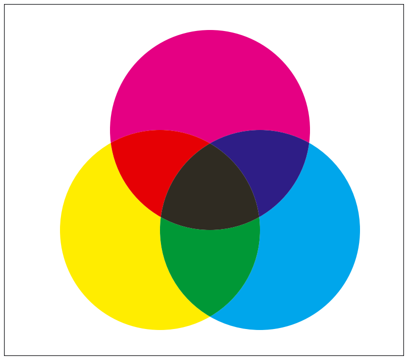


fig.1 A subtractive color system starts with white light and uses yellow, magenta and cyan filters in appropriate concentrations to control the amounts of blue, green and red light respectively.

Working with a color enlarger is a convenient way to generate a proper blend of green and blue light in order to achieve a specific paper contrast. Color enlargers are designed to provide a subtractive color system, and for that reason, they are typically equipped with a dichroic filter head, containing yellow, magenta and cyan filtration. A subtractive color system starts with white light and uses yellow, magenta and cyan filters in appropriate concentrations to control the amounts of blue, green and red light respectively (fig.1). The yellow filter absorbs blue and transmits red and green light, and the magenta filter absorbs green and transmits blue and red light. The red-light transmission of both filters is of no consequence to monochrome printing, because VC papers are insensitive to red light, but the yellow and magenta filter settings also control the amount of green and blue light transmitted. This successfully alters the contrast in VC papers, and even minute but precise contrast changes are easily made with either filter or a combination of the two filter settings.

The remaining cyan filter, on the other hand, is of little use to monochrome workers, because cyan is a mixture of green and blue light, and consequently, cyan filtration absorbs red and only transmits green and blue light. VC papers are sensitive to green and blue, but since cyan filtration alters their contribution in equal amounts, there is little reason to use cyan filtration for monochrome printing, unless its minute neutral-density effect (1/3 stop max) is utilized to fine-tune the print exposure. Even if we ignore the cyan filter altogether, the possibility of yellow and magenta filtration makes a color enlarger a very useful piece of equipment to control the contrast in monochrome printing. Note that the maximum contrast is usually slightly lower than that achievable with customized filter sets, which are optimized for variable-contrast papers. Fortunately, this is of little practical consequence, since full magenta filtration typically achieves maximum standard ISO grades of 4.5 to 5.

fig.2 A color enlarger with dichroic filters is a very useful piece of equipment for monochrome printing. The yellow and magenta filters can be used to fine-tune the paper contrast in VC papers, and even minute but precise contrast changes are simple by altering the two filter settings. A custom calibration allows precise paper grade settings in accordance with ISO standards.

Manufacturers of enlargers and papers often include tables with yellow and magenta filter recommendations to approximate the paper contrast. However, these recommendations are to be taken with a grain of salt, because they are based on assumptions about the light source and papers used. A custom calibration allows precise paper-grade settings in accordance with ISO standards. This calibration turns the dichroic color head into a precision VC diffusion light source, ideally suited for flexible and consistent monochrome printing.

Many casual printers see no need for this level of precision. The published filter suggestions for dichroic color heads vary, but mostly by less than one grade. The technique of simply dialing in more yellow or magenta to adjust the contrast works for most darkroom enthusiasts. However, calibrated dichroic color heads provide a few real advantages over other methods and are favored by discriminating workers. By using standard ISO grades, the future validity of printing records is protected against upcoming material and equipment changes. Once an ISO grade is recorded and filed with the negative for future use, prints with identical overall contrast can be made on any material, even in years to come. In addition, contrast changes are consistent through use of standard ISO grades. Going up or down a grade always yields the same change in contrast on any material and with any equipment. VC filters and VC heads do not offer this level of flexibility, precision and control. They are made for today's materials and may not work reliably with future products.

test settings		
test number	filter setting	
	Y	M
1	130	0
2	110	2
3	95	4
4	80	8
5	65	12
6	50	20
7	35	30
8	20	50
9	10	70
10	4	95
11	0	130

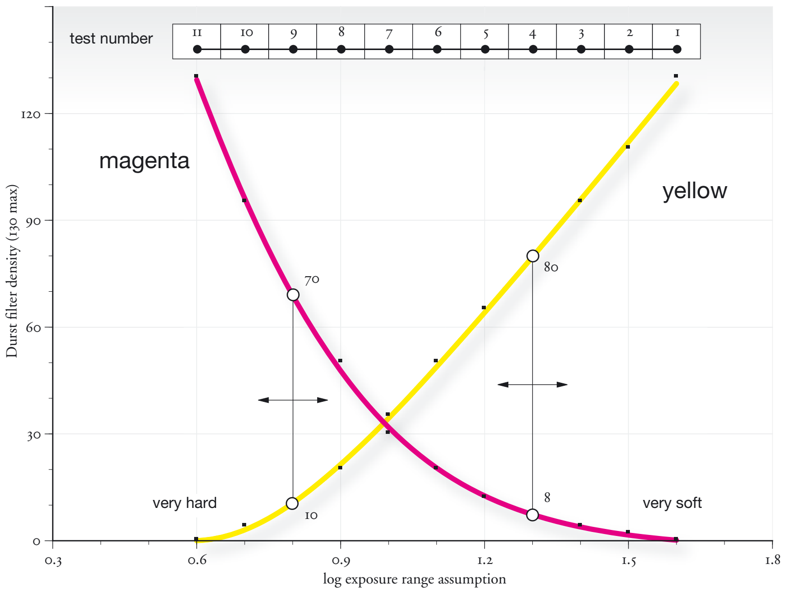


fig.3 These are my recommended test values for a color head with 130 units of maximum density, listed in form of a table (far left) and illustrated in form of a graph (left). Eleven Y-M filter pairs cover the range from the softest to the hardest grade. The actual log exposure range for each filter pair depends on the paper tested, but the filter combinations are fixed to maintain an almost constant exposure, regardless of filtration changes.

Test Procedure

The goal in creating your own custom calibration is to produce standard paper contrast grades with color enlarger filter settings. The sample calibration described here, was conducted for the following significant variables. The light source was the diffusion dichroic color head CLS 501, fitted to a Durst L1200 enlarger. The Y-M-C filters have continuous density settings from 0 to 130. The paper tested was Kodak's Polymax II RC-E, which is resin-coated (RC) and has a surface often referred to as 'luster' or 'pearl'. The developer used was Kodak's Dektol at a dilution of 1+2 and at a temperature of 20°C (68°F). The agitation was accomplished by constantly rocking the tray for 90 seconds, followed by normal processing without toning. The paper contrast was determined following the technique described in 'Measuring Paper Contrast'.

This test procedure follows the general printing rule of 'expose for the highlights and control the shadows with contrast'. After finding the correct exposure for the significant highlights, the paper contrast is altered until the image shadows exhibit the desired level of detail and texture.

filter values		
Durst (max 130)	Durst (max 170)	Kodak (max 200)
0	0	0
10	15	15
20	25	30
30	40	45
40	50	60
50	65	75
60	80	90
70	90	110
80	105	125
90	120	140
100	130	155
110	145	170
120	155	185
130	170	200

Single and dual-filter settings are two possible ways to modify the paper contrast. The single-filter method uses either yellow (Y) or magenta (M) filtration, but never both. The dual-filter method, as its name implies, always uses a combination of both filtrations. The single-filter method has the benefit of minimizing exposure times, by minimizing the total filter density. It has the disadvantage, however, that every contrast modification must be compensated by a substantial exposure adjustment in order to achieve a consistent highlight density. The dual-filter method, on the other hand, uses Y and M filtration in harmony in an attempt to maintain exposure, while altering paper contrast. The disadvantage is that the combined filter density reduces the light output, resulting in longer exposure times. This disadvantage

fig.4 Different filtration systems are available, and they use different filtration values. This conversion table shows equivalent values for the most common systems.

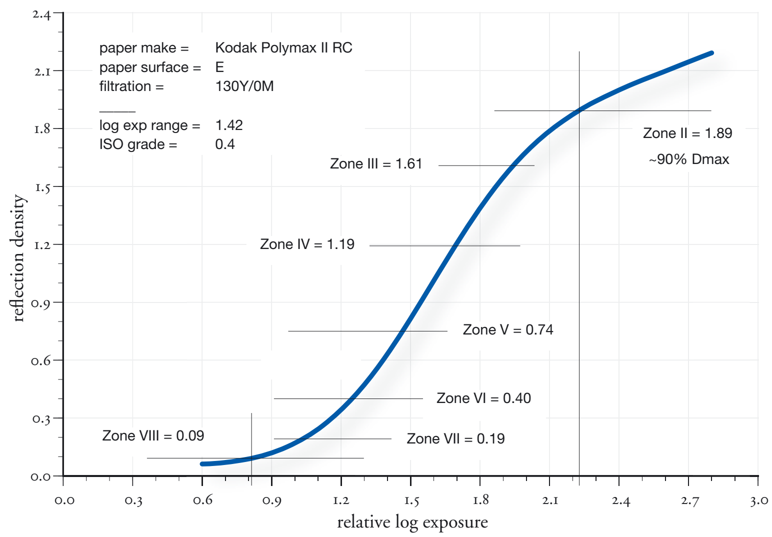


fig.5 The results for test 1 are plotted to determine the softest exposure range.

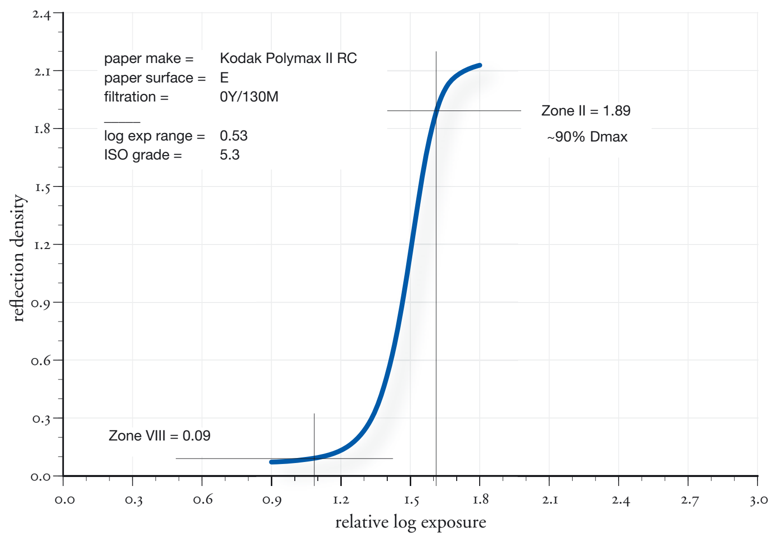


fig.6 The results for test 11 are plotted to determine the hardest exposure range.

has proven to be insignificant in my work, and the promise of almost consistent highlight exposure is just too good to give up on. Therefore, this test uses the dual-filter method exclusively to calibrate a dichroic color enlarger head.

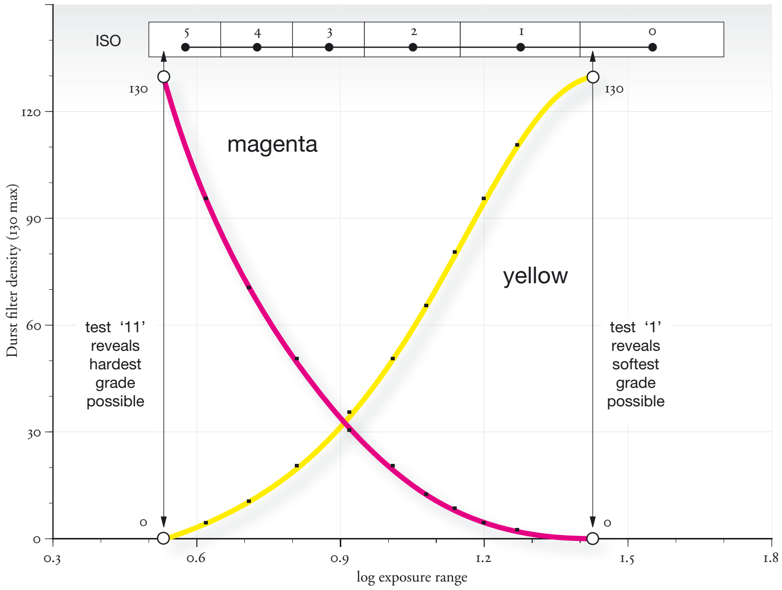
The task at hand is to determine the required amount of Y and M to achieve a certain paper contrast, while simultaneously maintaining adequate highlight exposure. Fortunately, we benefit from the research conducted by Agfa, Ilford and Kodak in this field. Fig.3 shows my recommended test settings for a color head calibration utilizing Durst filtration values, with up to 130 units of maximum density, listed in form of a table and illustrated in form of a graph. Eleven Y-M filter pairs evenly cover the assumed exposure ranges from the softest to the hardest grade. Some enlargers use different maximum density values than Durst, but it is not too difficult to choose proportional values. Fig.4 provides a conversion table for the most common filtration systems used.

Generating the Data

Conduct eleven tests with varying yellow/magenta filtration as shown in fig.3. Determine the paper contrast from each test following the technique described in 'Measuring Paper Contrast'. Start with the filter settings for test 1 (130Y/0M), to produce the lowest grade possible. Expose the paper in a way that the whole scale fits on the paper. The highlight area should have several paper white wedges, and the shadow area should have several maximum black wedges before any tonality is visible. Record the filter settings and the exposure time on the back of the print. Then, process the paper normally, while keeping development time, temperature and agitation constant. Repeat the process for the remaining ten tests at their different filter settings. Keep the exposure time constant, so an exposure compensation table can be created later. See 'Exposure Compensation for Contrast Change' to make such a table. Once the data has been collected and charted, it will look similar to fig.5 (test 1) and fig.6 (test 11). The x-axis shows the relative log exposure values and the y-axis indicates the reflection densities as read with the densitometer. The results are typical paper characteristic curves, and the test evaluation clearly shows that magenta filtration results in greater paper contrast than yellow filtration and that paper contrast can be altered by combining the two filters.

Calibration

Chart the results from the eleven tests on a sheet of graph paper or with the help of a computer. This allows us to select any standard ISO paper grade or range, for the paper tested, with precision and ease. In fig.7, we see that test 1 returned a log exposure range of 1.42 (grade 0.4) for the filter combination (130Y/0M). The filtration is aligned with the log exposure range,



Kodak Polymax II RC		
ISO grade	filter setting Y	filter setting M
0	-	-
0.5	129	0
1	111	2
1.5	84	8
2	59	15
2.5	40	25
3	27	37
3.5	18	51
4	11	68
4.5	6	88
5	3	112

fig.7 (far left) A dual-filtration chart illustrates all test results, and the filtration for any log exposure range can easily be determined from it. A small table (left) is useful for listing the required filtration of the major paper grades for future use.

as indicated by the arrows on the right-hand side of the graph. Test 11 returned a log exposure range of 0.53 (grade 5.3) for the filter combination (0Y/130M). This data is shown by the arrows on the left-hand side. Plot the point pairs for all tests this way, and draw two smooth lines through the points to create a curve for magenta and yellow filtration.

You can now determine any filter combination required to simulate any standard ISO paper grade or range. A vertical line connects paper grade with Y-M filtration. A small table, as shown on the right in fig.7, helps to list the filtrations for the typical paper grade increments. I keep the ones for my favorite papers taped to the front of my enlarger head, so they are always at hand.

Exposure Variations

Switching from one grade of paper to another may require a change in print exposure. The dual-filter method is far more consistent in print exposure than the single-filter method, but references to print exposure deviations need to be expressed in respect to target density. The dual-filter method delivers an almost constant exposure for Zone-V densities throughout the entire paper contrast range. However, the highlight exposures (Zone VIII) vary for about one stop, and the shadow exposures (Zone II) vary for about two stops (log 0.3 = 1 stop).

Fig.8 summarizes these exposure variations from Zone II to VIII. The relative log exposure was plotted for all zones in all eleven tests against their respective ISO grades. A constant exposure would be represented by a perfectly vertical line. Zone V comes closest to that condition. All other zones deviate enough to require exposure compensation when changing paper contrast. This graph helps us to draw a few conclusions. First, paper, enlarger, light source and filter manufacturers need to tell us what target density they are referring to when they promise a filtration system to provide constant exposure throughout the contrast range. Second, the dual-filter method provides an almost constant exposure only for Zone-V densities. Highlight and shadow exposures, on the other hand, change independently throughout the contrast range. Improving this filtration method to provide more consistent exposures for Zone VII or VIII, would make it more valuable to us and support our printing rule 'expose for the highlights and control the shadows with contrast'.

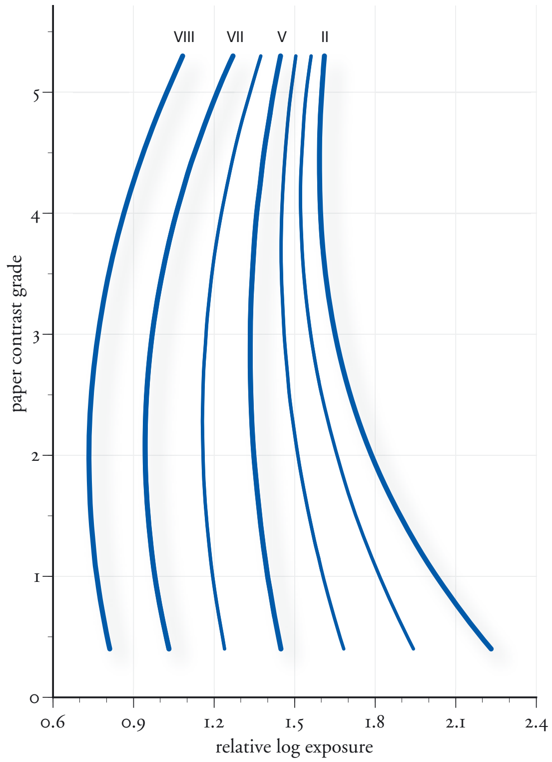


fig.8 The exposure required to create a given paper density changes with paper grade. A constant exposure would be represented by a perfectly vertical line.

In the past, two different systems were proposed to address this challenge. The first system is based on the least exposure required. It is demonstrated in fig.9, which concentrates purely on Zone-VIII exposures. The exposure is roughly within 1/12 stop and, therefore, nearly constant from grade 1 to grade 3. Outside of this range, and particularly towards the harder grades, the exposure drops off significantly. The least exposure required to create a Zone-VIII density, is close to an ISO grade 2. The exposure can be made constant by adding extra exposure time to all other grades. The second system, based on the most exposure required, is demonstrated in fig.10. The most exposure required, to create a Zone-VIII density, is at grade 5. The exposure could be made constant by adding a certain neutral density to all other grades.

I favor the least exposure system in fig.9 for my work for several reasons. The burden of extra density, and ultimately exposure time, to synchronize a rarely used grade 5, seems like a waste. One author has proposed adding the required neutral density in the form of Y-M filtration. Fig.10 clearly reveals this attempt is doomed to failure. Soft-grade filtration requires far less exposure than grade-5 filtration. Neutral density (or cyan filtration) can, of course, be added to lengthen the soft-grade exposures, but not with Y-M filtration, because the Y filtration is already at or around its maximum at soft grades.

Calibrating color enlargers to control print contrast consistently is a useful exercise for monochrome workers. It enables confident ISO-grade selection and makes for more meaningful printing records.

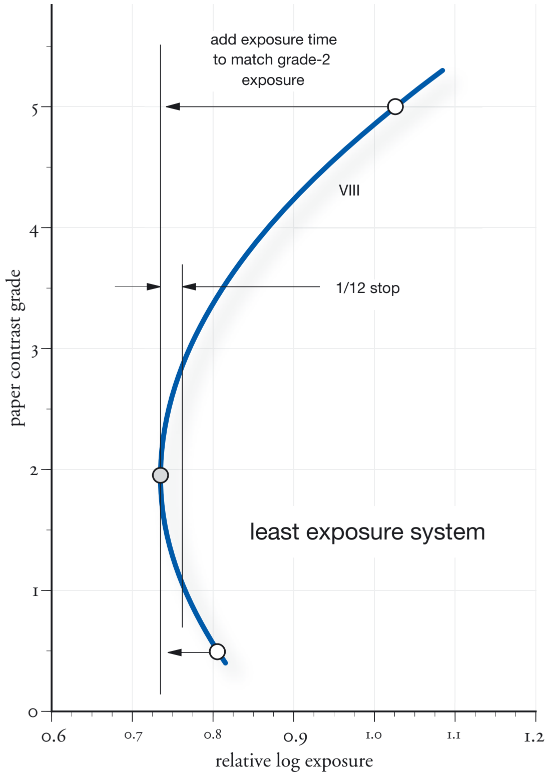


fig.9 This illustration is similar to fig.8, but it shows the amount of additional exposure required to match the Zone-VIII exposure at grade 2.

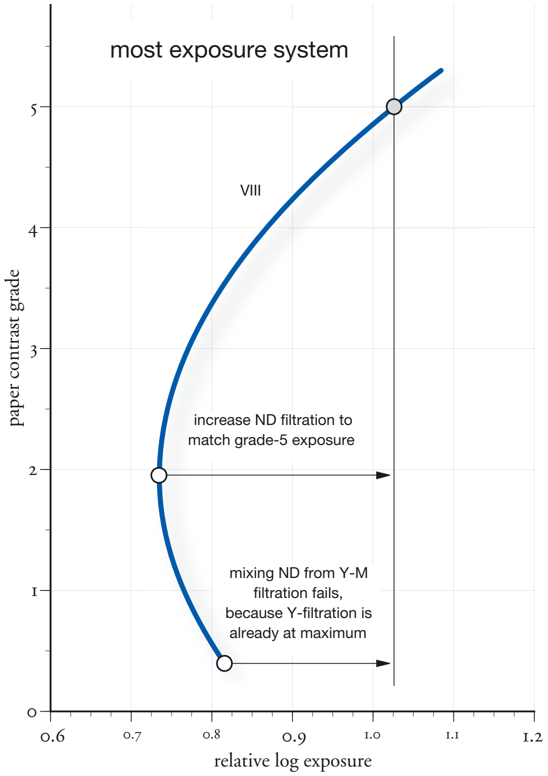


fig.10 This illustration is similar to fig.8, but it shows the amount of additional filtration required to match the Zone-VIII exposure at grade 5.