# Contrast Control with Color Enlargers

## Calibration of dichroic heads to ISO paper grades

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The advantages of variable contrast paper over graded paper have made it the prime choice for many photographers today. The ability to get all paper grades from one box of paper, and even one sheet, has reduced darkroom complexity and provided creative controls not available with graded papers.

Variable contrast (VC) papers have two or three light sensitive components, which are combined to behave like one emulsion. Each component is sensitive to a different wavelength of light, providing a different contrast. Yellow filtration produces a soft print and Magenta filtration produces a hard print. By mixing the two, any intermediate contrast can be achieved.

Several options to generate the proper mixture of light required to achieve a specific paper contrast are available. Inexpensive filter sets, numbered from 0 to 5 in increments of 1/2, are available from most paper manufacturers. They can be used in condenser or diffusion enlargers, either below the enlarger lens or in a filter drawer above the negative. The numbers on these filters correspond only approximately to paper grades, because contrast differs from paper to paper and according to the type of light source used. Finer control of up to 1/10-grade increments is available with dedicated VC heads. They come at a modest price, with their own light source, and are typically calibrated only for the more popular paper brands on the market.

Another option is a color enlarger, which can also be a very useful variable contrast B&W printing tool. It is typically equipped with a dichroic filter head, containing Yellow and Magenta filtration. These filters are used to alter the contrast in VC papers, and no additional investment is required. Even minute but precise contrast changes are simple. Manufacturers of enlargers and papers often include tables with Yellow and Magenta filter recommendations to approximate the paper contrast. However, these recommendations are limited, 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 B&W printing.

Usually, the casual printer has 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 equip-

*A color enlarger with dichroic filters can also be a very useful tool for B&W printing. The Yellow and Magenta filters can be used to fine-tune the paper contrast in VC papers.*

ment 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 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 1.5 minutes, 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.

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 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 utilizes 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.1 shows my recommended test settings for a color head calibration utilizing Durst filtration values, with up to 130 units of maximum density. 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 pro-

**Test Settings**

| Test No | 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 |

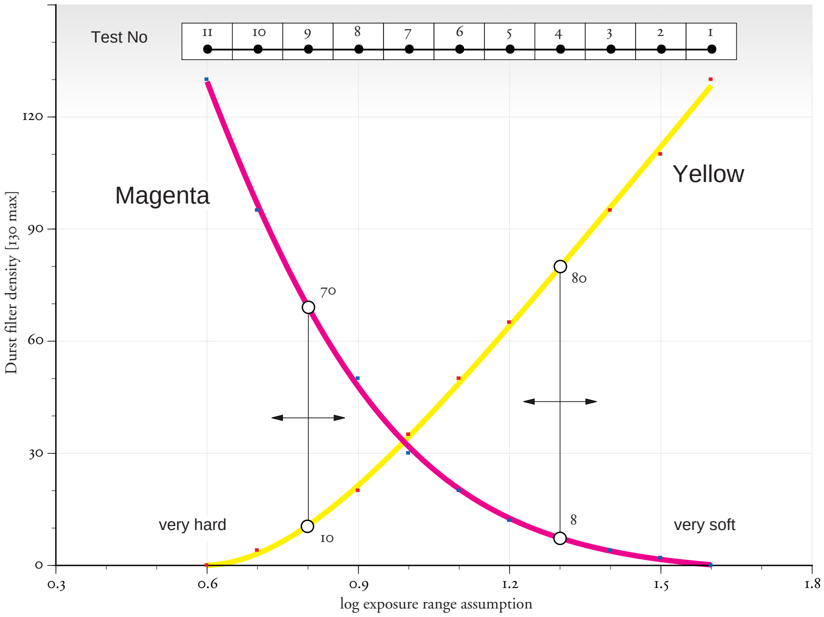


*fig.1* *These are my recommended test values for a color head with 130 units of maximum density. Eleven Y-M filter pairs cover the range from the softest to the hardest grade. The actual log exposure range for each filter pair will depend on the paper tested, but the filter combinations are fixed to maintain an almost constant exposure, independent of filtration changes.*

**Filter Values**

| Durst | Kodak | Agfa |
|---|---|---|
| 0 | 0 | 0 |
| 10 | 15 | 20 |
| 20 | 30 | 40 |
| 30 | 45 | 60 |
| 40 | 60 | 80 |
| 50 | 75 | 100 |
| 60 | 90 | 120 |
| 70 | 105 | 140 |
| 80 | 120 | 160 |
| 90 | 135 | 180 |
| 100 | 150 | 200 |
| 110 | 165 | 220 |
| 120 | 180 | 240 |
| 130 | 195 | 260 |

*fig.2* *Different filtration systems are available. This conversion table shows equivalent values for the most common systems.*

portional values. Fig.2 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.1. 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, explained at the end of this chapter, can be created. Once the data has been collected and charted, it will look similar to fig.3 (test 1) and fig.4 (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. This allows us to select any standard ISO paper grade or range, for the paper tested, with precession and ease. In fig.5, 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, 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

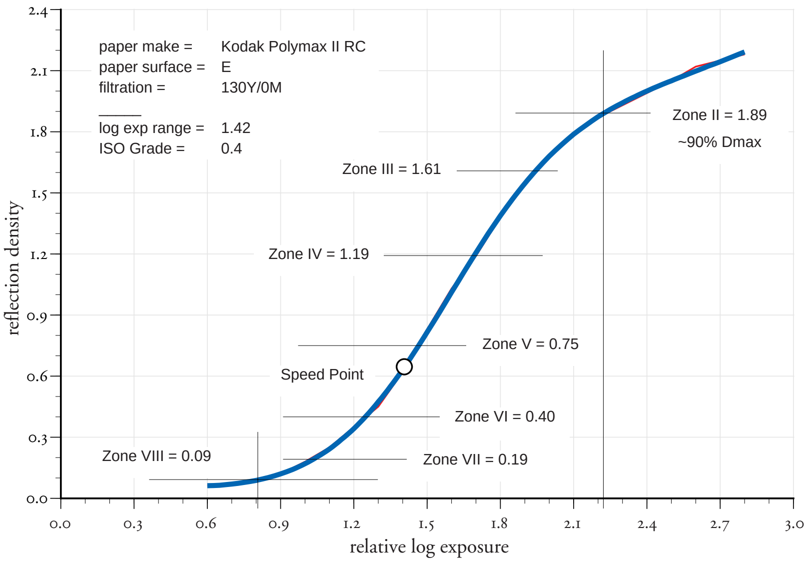


*fig.3* *The results for test 1 are plotted to determine the softest exposure range.*

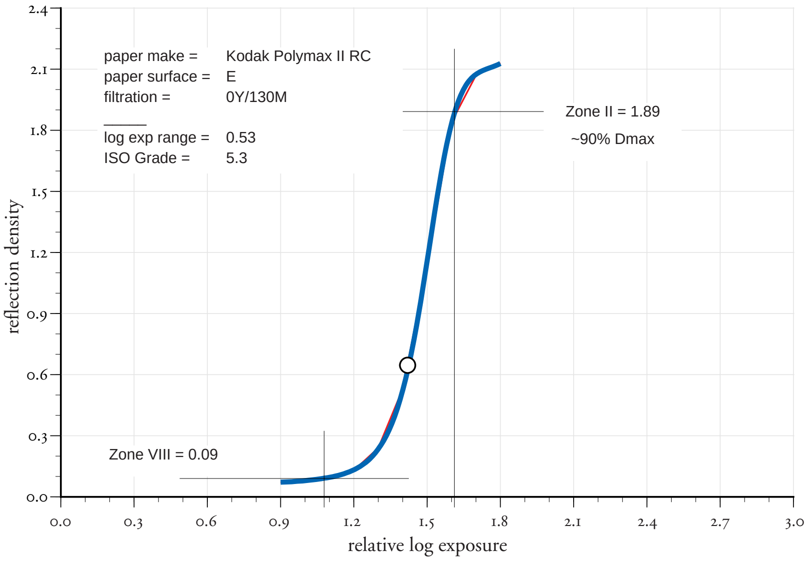
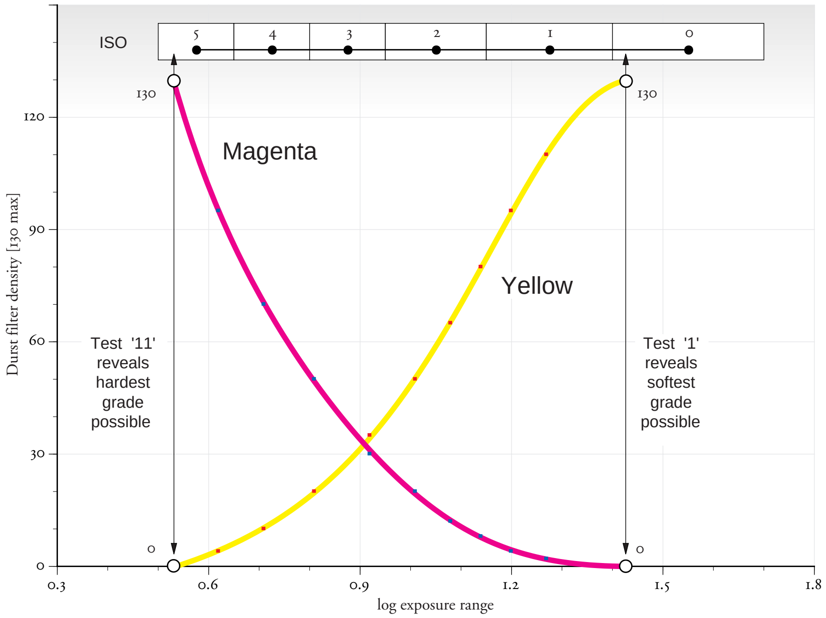


*fig.4* *The results for test 11 are plotted to determine the hardest exposure range.*



**Kodak Polymax**

| ISO Grade | Filter Setting | |
|---|---|---|
| | Y | 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.5* *A dual-filtration chart (left) indicating all test results is shown. The filtration for any log exposure range, paper grade or intermediate step, can easily be determined from it.* *A small table (right) is useful for listing the required filtration of the major paper grades.*

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.5, helps to list the filtrations for the typical paper grade increments. I keep the ones for my favorite papers on the front of my enlarger head, so they are always at hand.

## Exposure Variations

Reference to constant exposure needs to be clarified in terms of target density. The Dual Filter Method was employed for this filter calibration, because it delivers an almost constant exposure for the speed point density throughout the entire paper contrast range. Fig.6 reintroduced us to the ISO speed point, and as you can see in fig.3 and 4, the speed point density remains fairly constant at about 1.6 relative log exposure. However, the log exposures for the highlights (Zone VIII) vary for about one stop (log 0.3 = 1 stop) and the log exposures for the shadows (Zone II) vary for about two stops.

Fig.7 summarizes these exposure variations from Zone II to VIII and the speed point. 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 and the speed point density come closest to that condition. All other zones deviate enough to require exposure compensation. This graph helps us to draw a few conclusions. First, paper, en-

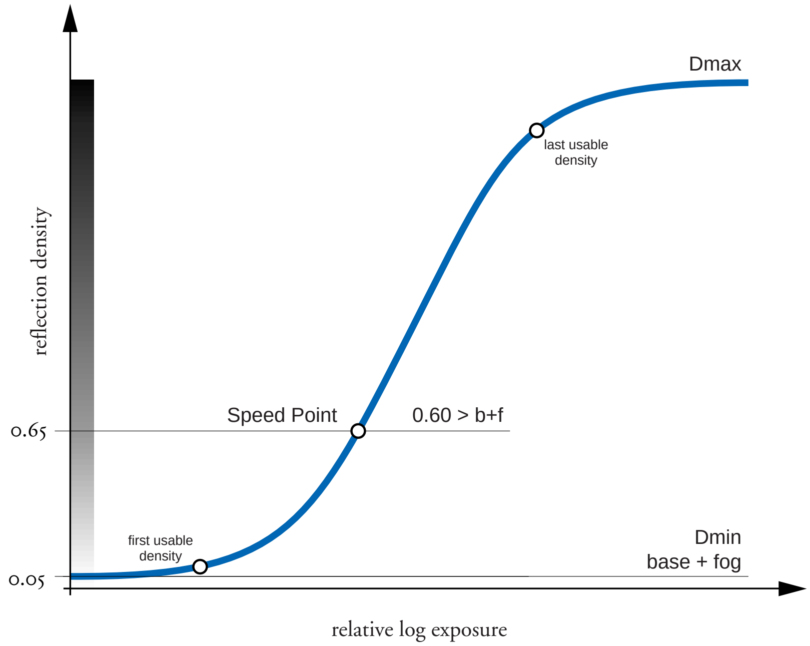


*fig.6* *The ISO standard defines the paper 'speed point' at 0.6 above base+fog density.*

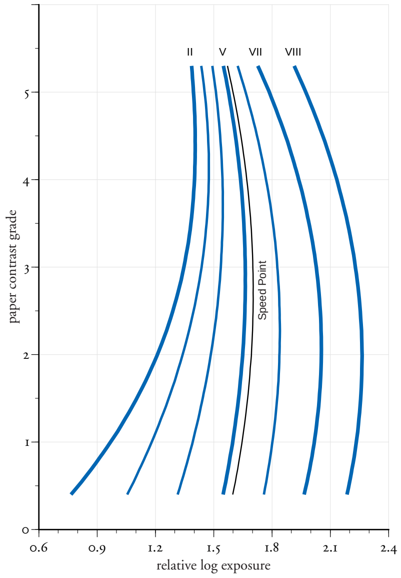


*fig.7* *The amount of exposure required to create a given paper density, changes with paper grade. A perfectly constant exposure would result in a straight vertical line.*

larger, light source and filter manufacturers are most likely referring to the ISO speed point when they promise a filtration system to provide constant exposure throughout the contrast range. Second, the Dual Filter Method only provides constant exposure for one given paper density (tonal value), because highlight and shadow exposures change independently throughout the contrast range. Using a set of Y-M filtrations, based on the ISO speed point, is a practical approach for a manufacturing standard, but it does not support our printing rule 'expose for the highlights and control the shadows with contrast'. A filtration method providing consistent exposures for Zone VII or VIII is much more valuable to us.

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.8, which concentrates purely on Zone VIII exposure. The exposure is within 1/6 stop (±1/12), 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 get a Zone VIII density, is close to grade 2. The exposure could 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.9. The most exposure required, to get a Zone VIII density, is at grade 5. The exposure could be made constant by adding a certain neutral density to all other grades.

In my work, I favor the Least Exposure System in fig.8 for several reasons. The burden of extra density and ultimately, exposure time, to synchronize a rarely used grade, seems like a waste.

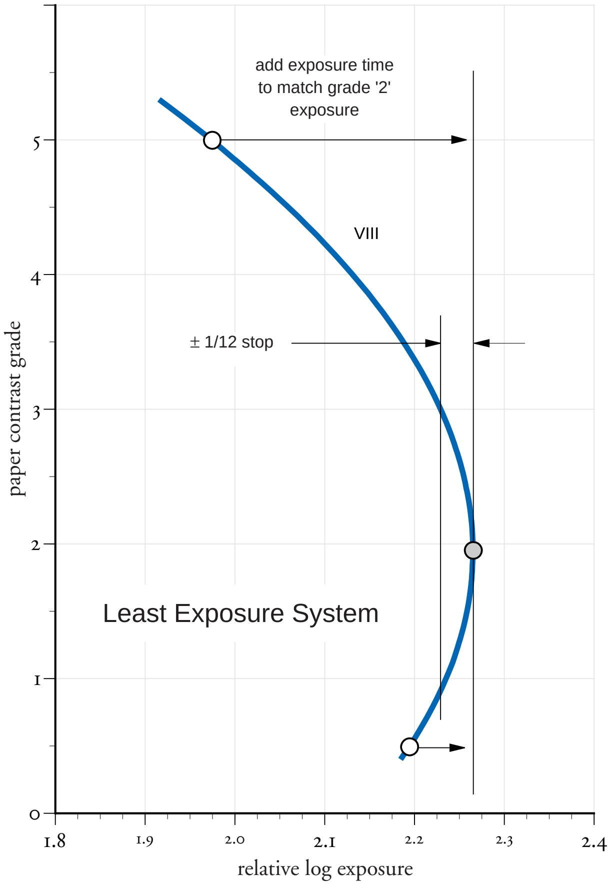


*fig.8* *Similar to fig.7, but determining the amount of additional exposure required to match the Zone VIII exposure at grade 2.*

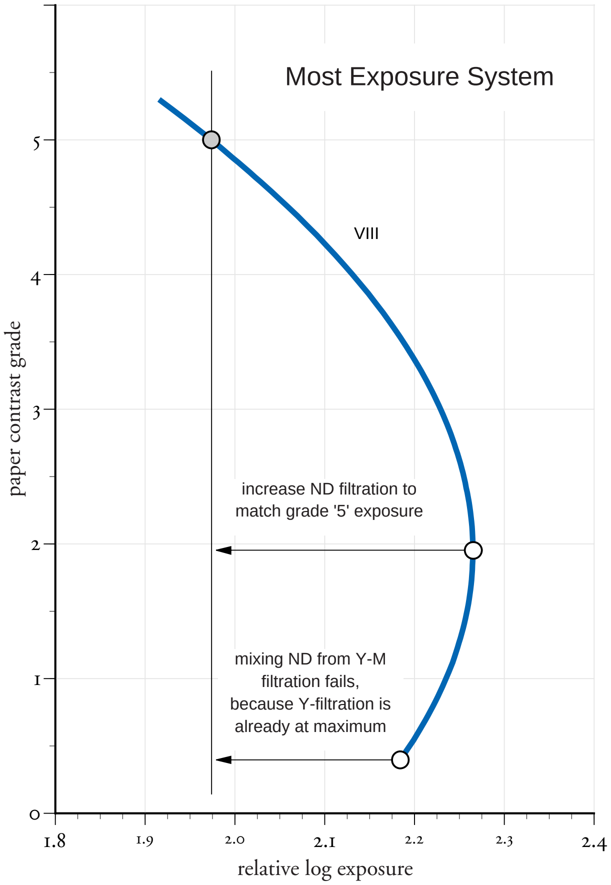


*fig.9* *Similar to fig.7, but determining the amount of additional filtration required to match the Zone VIII exposure at grade 5.*

One author has proposed adding the required neutral density in form of Y-M filtration. Fig.9 clearly reveals this attempt as doomed to failure. Between grade 0 and grade 1, filtration requires less exposure than at grade 5. Neutral density can, of course, be added to lengthen the soft-grade exposures, but not with Y-M filtration, because the Y filtration is already at its maximum at these soft grades.

The Least Exposure System in fig.8 leaves us with the problem of having to correct the exposure slightly, when making changes to the paper contrast. In the normal working range (grade 1 to 3) of Zone VII & VIII, these corrections are often minute and hardly necessary when changing contrast by 1/2-grade increments. They are definitely required though, when larger grade increments are chosen, or 'very soft' or 'very to extra hard' paper grades are needed.

A table, listing the exposure compensations required when changing paper grades, can be designed while concentrating on the significant highlight (Zone VIII) exposure data from the previous test. Fig.8 was plotted to collect this data, and the horizontal axis was scaled to provide maximum exposure resolution. I always estimate and record the relative log exposures for every paper grade, in 1/2-grade increments. In our example, we find the relative log exposures ranging between 1.97 at grade 5 and 2.26 at grade 2.

The tables in fig.10 benefit from this data. They show the exposure compensation in form of density, 1/12 stop and as a linear exposure factor, respectively from top to bottom. You may use the table, which best suits your way of working, but they all work the same way. Imagine that you have a print with the proper highlight exposure, but you would like to change the contrast and still maintain the exposure for the highlights. Select the current paper grade on the vertical axis and find the target paper grade on the horizontal axis. You will find the suggested exposure increase or decrease at the intersection of the two grades.

Using the top table in fig.10, fill the respective, diagonal black squares with the relative log exposure values, copied from fig.8, and calculate the differences, for up to two grades in each direction. I have created a simple spreadsheet to accomplish this laborious task for me. This table can be used with neutral density filtration, to compensate for exposure differences, but I use it as a starting point for the next two tables shown. The center table is similar, but the relative log exposures are translated into 1/12 stop for later use with an f/stop timer. For this table, the equation [1/12 stop = RelativeLogExp / log(2) * 12] was used. Relative log exposure differences of less than 1/12 stop are not visible to the human eye at normal contrast grades. The bottom table is yet another version. The relative log exposures are translated into simple exposure factors for linear timers and their ratios are listed. For this table the equation [expFactor = 10 ^ RelativeLogExp] was used.

The calibration of my dichroic color head was a useful exercise. Selecting ISO grades is now done with confidence, and keeping exposures constant is a simple task.

| **VIII** | 0 | ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | new grade | | | | -.26 | -.23 | -.16 | -.09 | 1.97 |
| 4½ | | | | | | -.19 | -.17 | -.13 | -.07 | 2.06 | .09 |
| 4 | | | | | -.13 | -.12 | -.10 | -.06 | 2.13 | .07 | .16 |
| 3½ | old grade | | | -.07 | -.07 | -.06 | -.04 | 2.19 | .06 | .13 | .23 |
| 3 | | | .00 | -.03 | -.03 | -.02 | 2.23 | .04 | .10 | .17 | .26 |
| 2½ | | .05 | .02 | .01 | -.01 | 2.25 | .02 | .06 | .12 | .19 | |
| 2 | - | .06 | .03 | .00 | 2.26 | .01 | .03 | .07 | .13 | | |
| 1½ | - | .06 | .03 | 2.26 | .00 | .01 | .03 | .07 | | | |
| 1 | - | .03 | 2.23 | -.03 | -.03 | -.02 | .00 | | | | |
| ½ | - | 2.20 | .03 | -.06 | -.06 | -.05 | | | relative log exp | | |
| 0 | - | - | - | - | - | | | | | | |

| **VIII** | 0 | ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | new grade | | | | -10 | -8 | -6 | -3 | 79 |
| 4½ | | | | | | -8 | -7 | -5 | -3 | 82 | 3 |
| 4 | | | | | -5 | -5 | -4 | -2 | 85 | 3 | 6 |
| 3½ | old grade | | | -3 | -3 | -3 | -2 | 87 | 2 | 5 | 8 |
| 3 | | | 0 | -1 | -1 | -1 | 89 | 2 | 4 | 7 | 10 |
| 2½ | | 2 | 1 | 0 | 0 | 90 | 1 | 3 | 5 | 8 | |
| 2 | - | 2 | 1 | 0 | 90 | 0 | 1 | 3 | 5 | | |
| 1½ | - | 2 | 1 | 90 | 0 | 0 | 1 | 3 | | | |
| 1 | - | 1 | 89 | -1 | -1 | -1 | 0 | | | | |
| ½ | - | 88 | -1 | -2 | -2 | -2 | | | 1/12 stop exp | | |
| 0 | - | - | - | - | - | | | | | | |

| **VIII** | 0 | ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | new grade | | | | .55 | .60 | .70 | .80 | 93 |
| 4½ | | | | | | .65 | .70 | .75 | .85 | 115 | 1.20 |
| 4 | | | | | .75 | .75 | .80 | .90 | 135 | 1.20 | 1.45 |
| 3½ | old grade | | | .85 | .85 | .85 | .90 | 155 | 1.15 | 1.35 | 1.65 |
| 3 | | | 1.00 | .95 | .95 | .95 | 170 | 1.10 | 1.25 | 1.45 | 1.80 |
| 2½ | | 1.15 | 1.05 | 1.00 | 1.00 | 178 | 1.05 | 1.15 | 1.30 | 1.55 | |
| 2 | - | 1.15 | 1.05 | 1.00 | 182 | 1.00 | 1.05 | 1.20 | 1.35 | | |
| 1½ | - | 1.15 | 1.05 | 182 | 1.00 | 1.00 | 1.05 | 1.15 | | | |
| 1 | - | 1.10 | 170 | .95 | .95 | .95 | 1.00 | | | | |
| ½ | - | 158 | .90 | .85 | .85 | .85 | | | exposure factors | | |
| 0 | - | - | - | - | - | | | | | | |

*fig.10 The significant highlight (Zone VIII) exposure data of fig.8 is used to create an exposure correction table. Three different versions are shown here, showing the same data in a different way. The 'relative log exposure' table (top) can be used to compensate for exposure differences with neutral density filtration, which is available with some enlargers. The '1/12-stop exposure table' (center) can be used to compensate with a sophisticated f/stop timer and the 'exposure factor table' (bottom) can be used to compensate with a linear timer. You would prepare only the one most convenient for your darkroom and your preferred way of working. Corrections never exceed 5% within the normal contrast range, when altering the contrast in 1/2-grade increments.*