CAMERA CALIBRATION

Mike McNamee goes chasing sheep

QUALITY MATTERS

In September we wrote on the matter of calibration right through to high-end kit from the likes of GretagMacbeth and X-Rite. A number of issues were inadequately resolved and it was always our intention to revisit the matter.

There seem to be two schools of thought on colour accuracy (for that is what we are talking about) – one school frets and fusses over it, the other takes the view that if the customers are happy and they (the photographers) prefer to tweak their colour anyway then it matters not a jot. I do not propose to take sides on the matter, only to point out some of the issues and pitfalls.

The first issue is this. If you habitually increase your saturation in your portraits (usually for Caucasians), any residual colour bias in the shot will be mercilessly revealed. The second is the problem of allowing your colour balance to drift slowly, so that you only notice after a break or perhaps when a laboratory prints your images or, especially, if you try to colour match a pair of prints.

The previous comments apply mainly to wedding and portraiture where the expression, mood and capture of "the moment" are of paramount importance. If the shot is for a garment catalogue (or similar) then colour accuracy becomes paramount and different rules apply. Blue garments require accurate blues and so on. If the image is going to press output (rather than ink-jet or silver halide) another set of hurdles may have to be jumped before everybody is happy, including accurate colour proofing.

This second part of calibration aims to compare the effect of three correction workflows, all via RAW files. They are:
1. Grey Balancing only via
   - A grey card
   - An expodisc
2. Profiling – a repeat of the "September" methods
3. Use of the freeware ACR-Calibrator

The sting in the tail is that we are to attempt a fiendishly difficult reproduction of some paint pigments, provided by artist, Penny Warden (see call-out box). Penny provided the four pigments, which she routinely uses for her iconic imagery, all in the yellow/red quadrant of the *Lab* plot. They are subtly different and are very metameric (ie they change colour quite a lot when viewed in different types of light).

The Methods

The RAW image was shot under overcast sky at 1/80th at f8 at 200ISO on a Nikon D100, through a 55mm f2.8 MicroNikkor. The exposure was assessed using a Gossen Mastersix incident light meter of known accuracy, but proved to be so difficult to pin down to our aim of 1/10th of a stop that we ended up bracketing (in 1/3 stops). We shot in very weak overcast daylight, at a (measured) colour temperature a little short of 5000K. The time was 2pm (January) and the direction of the light was quite low and straight at the test images. We used Macbeth 24 swatch and SG targets along with Penny Warden's pigments in the same shot. The D100 was set for "cloudy" white balance but because we were anticipating only RAW files, the slight mismatch was no a problem.

Grey Balancing

We balanced the RAW file in Photoshop CS2 using the mid tone grey of the Macbeth chart (for consistency, you might ordinarily only have a grey card). We reported on the variations possible in part one of this series and they include Macbeth Charts, Kodak Grey Cards, and the Dave Newman collapsible target.

The expodisc

The expodisc was designed by the late George A Wallace. It works by integrating all the light being received by the lens so that a more representative exposure and colour balance may be obtained. It comes with a reassuring quality control card, which informed us that our sample had a density of 0.75 compared with the aim value of 0.745 for a true 18% grey – quite accurate then!

It is equipped with a lanyard (handy on cliff tops) so that it is readily available and (also for speed) it is simply held over the lens front when in use. Various sizes are available and we tested the smallest 58mm one, about right for our 52mm-throated Nikkors.

In use, you may use the expodisc to determine both the exposure and the white balance. Alternatively you may use the expodisc to obtain the correct exposure setting, take a shot with the disc in place and then white balance in Photoshop's RAW file handler (or its equivalent, say RawShooter).

Obviously the resulting colours are influenced by the accuracy of the camera's metering and the characteristic of the individual chip. Therefore, if you find that the expodisc consistently over- or under-exposes, then you can set an exposure compensation permanently in your camera. To do this, open the plain grey exposure through the expodisc in RAW and adjust the Exposure slider until the RGB value reported in the top right is 121 points. The exposure compensation may then be read off from the box to the right.

In use, the expodisc is fast and easy – indeed when Monte Zucker demonstrated it at his seminar last year, if you blinked, you missed it! In essence it is used like an integrating incident light meter. You point it at the sun (**with** the expodisc in place
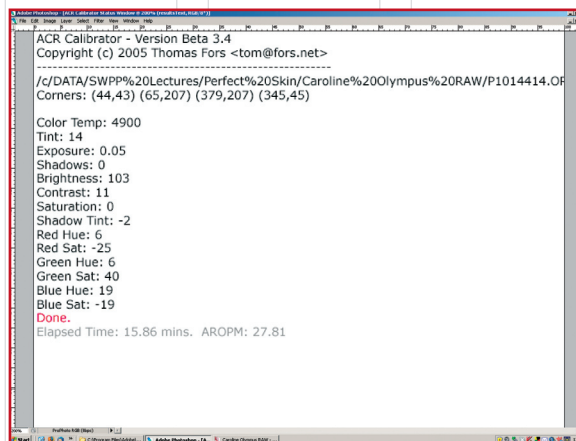
ABOVE: The expodisc is available from www.flaghead.co.uk and www.bobrigby.com

or you will damage your eyes, your camera, or even both) to measure the colour of the sunlight; you point it directly opposite to the shooting direction for front-lit scenes and one-third of the way towards the main light source for side-lit shots. For back-lit shots the instructions recommend that you take a colour balance and exposure value as for front lit and then increase your exposure by a stop.

ACR-Calibrator

This is a java script, which is run from within Photoshop. It is the work of Thomas Fors from Denmark, who benevolently makes it available for free download from http://fors.net/chromoholics/. Also at this site you will find a first-class screen movie, demonstrating just how to use the script. We will therefore save a bit of space and keep it brief. You shoot with a 24-Swatch Macbeth ColorChecker in your scene and balance the RAW file using the first grey swatch (preferably). Having opened the file into Photoshop you draw a path from the dark skin to the white across to the black and then back up to the turquoise swatch. You then run the script and go for a cup of tea. By a mathematical process, known as *iteration,* the script keeps opening the file, testing its accuracy, making an adjustment and looking to see if the result is better. This enables it to home in on the optimum values for all the sliders in the Adjust and Calibrate panels and, when it has finished, it lists them for you. All you do then is type the values in and save them as a *calibration setting* for your camera and lighting set-up. Obviously the calibration is true only for the test light conditions, however because the RAW handler adjusts the settings with reference to its sidecar file, you are at liberty to go and tweak them anyway if the light varied slightly – you are still in a stronger position. For a studio pack shot, or a single important shot, the 15 to 30 minutes it takes to calibrate may be time well spent – and it's free!

```
ACR Calibrator - Version Beta 3.4
Copyright (c) 2005 Thomas Fors <tom@fors.net>
------------------------------
/c/DATA/SWPP%20Lectures/Perfect%20Skin/Caroline%20Olympus%20RAW/P1014414.OR
Corners: (44,43) (65,207) (379,207) (345,45)

Color Temp: 4900
Tint: 14
Exposure: 0.05
Shadows: 0
Brightness: 103
Contrast: 11
Saturation: 0
Shadow Tint: -2
Red Hue: 6
Red Sat: -25
Green Hue: 6
Green Sat: 40
Blue Hue: 19
Blue Sat: -19
Done.
Elapsed Time: 15.86 mins.   AROPM: 27.81
```

LEFT: Just 14 typed entries are required to enable Adobe RAW to perfect your image files. This can then be saved as a preset for your camera/lighting system.

Putting it in to practice!

We have already mentioned the frustrations of working in varying sunlight, which caused us to switch to using bracketing. With a few pieces of kit to test, we spent most of the time measuring and remeasuring the changing light! Our only imperative was that we wanted the purity of the sunlight, to eliminate other sources of error in the response of the pigments – studio lighting was not an option for this test. Also, daylight was a better mimic of an outdoor wedding shoot.

It is worth remembering that shooting when aiming to separate very similar colours is painstaking and extremely frustrating at times. In ordinary shooting you tend to quit and accept a pleasing result – this was not an option for us as we were going to subject both our images and prints to detailed analysis and had nowhere to hide! At times the colours

seemed to be behaving like belligerent sheep, unpredictable and difficult to pin down – once we got a couple of them into the pen, the others had run off! However, persevere we did, and here are the results.

The metamerism errors in the Penny Warden pigments ranged from 8.4 to 16 *Lab* points, this against a backdrop of striving to get the actual colours within 4 *Lab* points! In other words the error due to lighting variation was four times the error we were shooting for. Initially we ignored the pigments so as to get our bearing on the performance over the whole gamut of the Macbeth Chart.

Metamerism Index *Lab* ΔE D65 to Tungsten		
Colour	Oil Pigment	Epson K3
Orange	12.1	11.2
Orange red	16.0	15.2
Red	15.8	15.3
Deep red	8.4	5.0

Penny Warden

Penny Warden began to paint at a very early age and indeed was highly commended for her work by the Royal Drawing Society – The Children's Royal Academy, London, when only 12 years old. Despite the protests of her art teachers she did not continue in her art studies after leaving school but pursued various careers in the city of London and finally in teaching, after graduating in 1984, with a degree in Theology from Westminster College, Oxford. However, she continued to paint, even when heading a Religious Studies Department and raising two children. Finally after beginning a degree in Fine Art in the late 1990's she became a full-time artist in 2001.

The sense of movement and vibrancy which is Penny's trademark, is especially evident in her oil paintings of ballet dancers. She also paints and draws, with the same lively expression, still life, musical instruments and flowers. All these paintings are available in galleries throughout the UK.

As well as her gallery work, Penny is now well known for her spiritual paintings. Her major project at Blackburn Cathedral created intense media interest as has her Phoenix Series – figurative works based on the crucifixion. Supported in this, with a grant from the Christian Arts Trust, the paintings have been seen by many thousands of people whilst on a solo tour of 10 English cathedrals, three churches, and college chapels, including Lady Margaret Hall, Oxford. They are 6ft oil paintings and are normally displayed down the nave for up to two months for each exhibition. She was commissioned for two of these paintings by St John's Church, Waterloo in London.

visit www.pennywarden.com

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Corrected files were made and transferred to Photoshop for further analysis. The best exposure was adjusted for both white balance and exposure in Adobe Camera Raw placing the 18%, mid-grey swatch on 121 RGB points in the red, green and blue channels before saving as an Adobe RGB, TIFF file for the calibration software. This file was examined using five refinements:

1. As received, corrected in RAW for both white balance and exposure.
2. Corrected according to the settings called up by the use of the expodisc.
3. Corrected using the settings created by ACR-Calibrator.
4. Corrected by assigning the purpose-built profile made with Monaco Profiler Platinum (4.7.2) using a 24-Swatch Macbeth ColorChecker (CC24).
5. Corrected by assigning the purpose-built profile made with Monaco Profiler Platinum (4.7.2) using a Macbeth ColorChecker SG (CCSG).

With apologies for the masses of statistics, the summary data table is shown (right). A number of points emerged from the analysis:

1. The ACR-Calibrator and the SG ColorChecker created the most accurate result.
2. On balance, the ACR-Calibrator just produced the best data set, with a smaller mean error and smaller variations across the range of colours.
3. The CCSG profile was very close to the ACR result and actually came out on top using the more perceptually accurate measure of the ΔE2000 reading.
4. Whilst the CC24 profile colours were in general accurate, there was a completely unacceptable level of posterisation in the skin tones of the assistant holding up the charts. This mimics the result found in part one of the article.

Ignoring the data and judging purely on the skin tones of our assistant, the CC24 profile damaged the file beyond repair, the CCSG profile dulled and desaturated a little. The ACR-Calibrator produced a slightly desaturated rendering but spectacularly accurate greyscale neutrality (although the others were very good indeed).

The expodisc revealed some serious vignetting either from itself or the MicroNikkor. There was also a colour shift such that the recorded colour temperature varied from 4550K in the centre to 4900K at the image edges. The other calibrators put the colour temperature at 4850K.

It is important to stress that, with the exception of the CC24 image, all others would form a sound basis for a really first-class print and any additional tweaks made for aesthetic reason would outweigh residual errors in the calibration. If we could get all our shots as close as the set, life would be very much easier. On this basis the ACR-Calibrator comes out top because it is free. The expodisc was probably the easiest route to follow and a workflow in which the expodisc was used for outdoor general photography and the ACR-Calibrator for critical indoor studio work would suit even the most critical observer. The need for high-end calibration software is only crucial if you need to use the very sophisticated profile editing software, which allows you to surround zones of colour with a "bubble" and tweak them independently of other colours – time did not allow us to pursue this course of action, much as we would have loved to!

COLOUR	Expodisc	Adobe RAW	ACR	CC24	CCSG
dark skin	3.7	5.4	3.5	3.8	3.1
light skin	5.1	8.4	4.7	4.9	3.4
blue sky	9.6	4.6	1.3	2.1	2.4
foliage	7.1	3.0	2.5	2.4	4.8
blue flower	6.8	3.0	2.8	3.7	0.6
bluish green	11.3	5.2	5.6	0.9	1.4
orange	3.4	10.2	4.2	5.6	5.5
purplish blue	11.4	8.0	5.0	6.9	1.5
moderate red	5.8	12.7	4.9	4.7	4.1
purple	5.4	5.2	4.2	0.5	4.7
yellow green	5.1	3.6	4.1	3.7	5.8
orange yellow	2.6	7.4	2.2	7.0	5.9
blue	11.4	9.9	8.3	7.3	5.1
green	7.9	2.4	4.8	5.7	4.1
red	5.6	13.7	5.0	8.0	7.9
yellow	6.3	7.0	5.0	7.5	6.4
magenta	2.2	9.9	3.4	4.1	2.3
cyan	14.4	9.7	4.9	4.9	2.0
white	7.7	2.3	4.3	6.3	0.9
neutral 8	5.8	2.7	0.5	1.0	0.7
neutral 6.5	6.5	2.8	0.9	2.1	0.4
neutral 5	6.8	1.4	1.0	1.6	1.0
neutral 3.5	7.9	2.5	1.0	0.8	2.2
black	6.6	2.8	1.6	0.9	7.6
Mean	**6.9**	**6.0**	**3.6**	**4.0**	**3.5**
Std Dev	3.0	3.6	1.9	2.4	2.3
Biggest	14.4	13.7	8.3	8.0	7.9
Smallest	2.2	1.4	0.5	0.5	0.4
MEAN ΔE2000	4.6	3.8	2.2	2.5	1.8
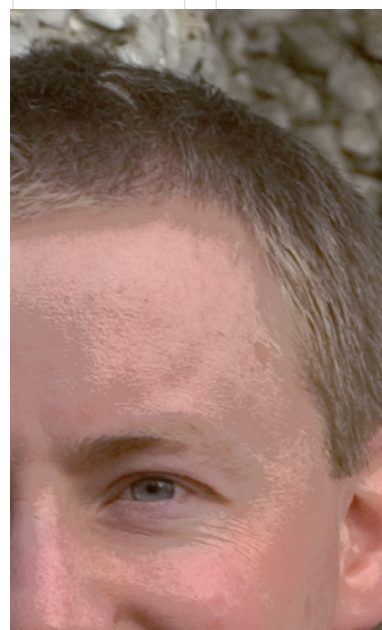
ABOVE: Although there is a mass of data, the table is a good record of just how the errors vary by different methods and across the range of colours in the Macbeth Chart.

LEFT: The posterisation seen in part one of this series was repeated when a profile from the 24-swatch Macbeth chart was used.
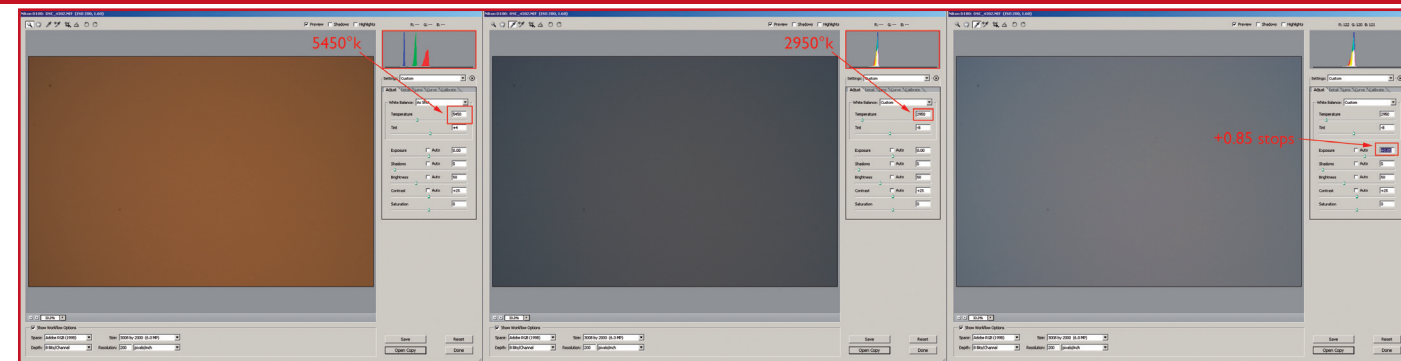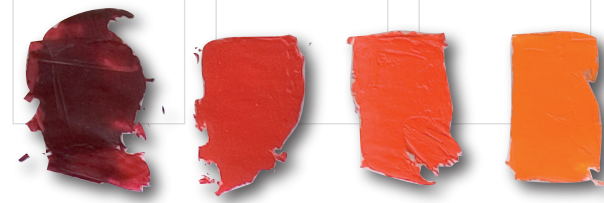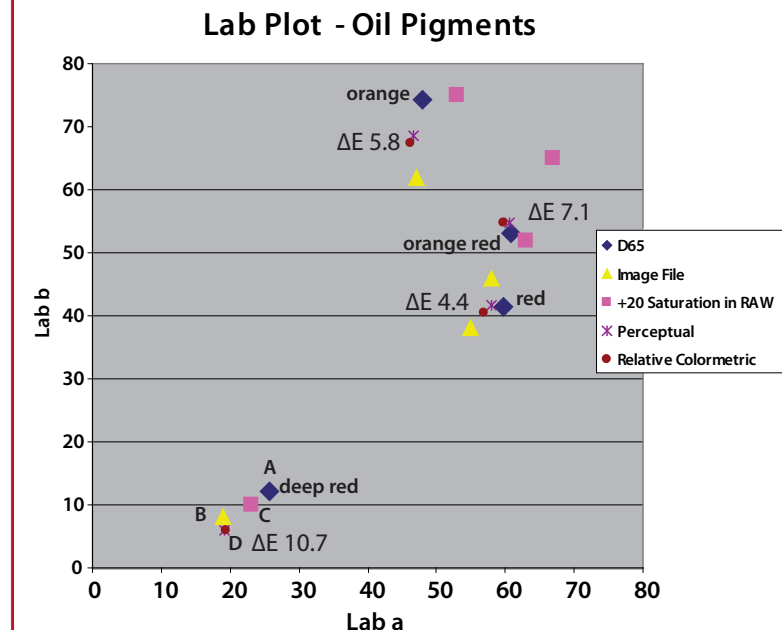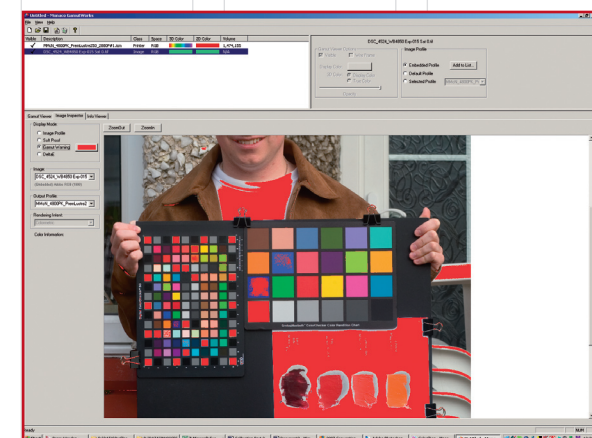

ABOVE: The expodisc in use to correct for both white balance and exposure level. Note that the warm white balance at 2950K is brought back to a neutral 5450K by click balancing in Adobe RAW and that the histogram is centred by the 0.85 stop exposure shift.

Pigment reproduction

In order to create the optimum starting files for reproduction of the pigments we found it best to increase the saturation in Adobe RAW by 20 points. This took account of the slight desaturation produced by the printer/paper/profile combination in use. Printing was carried out with a bespoke-profiled Epson 4800, using Photo Black ink onto Epson Premium Lustre Photo Paper (250). The latter was chosen because it had a measured printing error of 2.5ΔE2000, about the best it is possible to achieve. We tried various tweaks to improve the accuracy of the rendering and the colour errors are plotted on the graph.

With the images that had been calibrated or assigned accurate profiles, we found that the printed result lacked a little saturation which is why we increased the saturation by 20 points in Adobe Camera RAW. This lifted the more saturated pigments closer to our true pigment colour but tended to leave the deep red under saturated in the print. Our conclusion is that the +20 saturation was leveraging the saturated colours more than the deep red, leaving it behind. This was the frustration we spoke of earlier, we got most of the sheep into the pen but one was always slipping away – at no stage could we get all of them in the pen together! The pigments seem well inside the printing gamut of the Epson K3 in set and the metameric index for the K3 inks was, in every instance, lower than that of the oil paint. Changing between a relative colourmetric and perceptual rendering intent had little effect, again suggesting that the colours are within gamut. The Monaco Gamut Works confirmed that we were just within gamut for Premium Lustre on all the pigments. For Epson Ultrasmooth Fine Art paper we were outside gamut mainly on the lightness channel but also on the colour parameters as well. For Epson Watercolor Radiant White we were almost in gamut for all pigments. We recognise that our testing of the calibrations on a non-art paper was a slightly false premise but we were curious to find if the pigment set was impossible or just plain difficult! It is also quite interesting that increasing saturation of the image in order to tune the pigment colours also drove much of the Macbeth SG chart out of gamut.

LEFT: The pigments are all within gamut when the Epson Premium Luster paper is used. This is a grab from Monaco Profiler Gamut Works which highlights out-of-gamut colours in red.

Lab Plot - Oil Pigments

Legend:
- ◆ D65
- ▲ Image File
- ■ +20 Saturation in RAW
- ✕ Perceptual
- ● Relative Colormetric

orange ΔE 5.8
orange red ΔE 7.1
red ΔE 4.4
A deep red
B
C
D ΔE 10.7

Lab b / Lab a

ABOVE, Pigment Progress: In order to understand what is happening as colours are adjusted, you have to follow a *Lab* plot (start by doing your homework at the end of the Paper Chase feature). In this *Lab* plot, the pigment locations are plotted as blue diamonds and named. Follow the progress of the deep red pigment. The starting colour A is desaturated to position B by the camera. The +20 saturation shift in Adobe RAW moves the colour back up the saturation curve to position C. The printer then desaturates the colour so that it ends up close to its original position and this is the residual error we were left with. The progress of the other colours follows the same pattern except that the shifts are somewhat greater but the final result is actually more accurate. The final errors from pigment to print are shown alongside each colour and range from 4.4 to 11.2.

Conclusions

Overall we seem to have proved that these particular oil pigments are all within gamut, although difficult, are possible to render satisfactorily. Quite rightly, it would be necessary to reproduce a full painting to the satisfaction of the artist to bring the experiment to a truly successful conclusion. On the way however we have completed our testing of ACR-Calibrator and expodisc, two issues that were left behind in part one of the series. Finding out just how good ACR is was a major step, validating the several days testing it required.