Gray Card Selection

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Introduction

Almost all photographers are very familiar with using an 18% reflectance gray card to set the camera's exposure. Usually these are used by placing the gray card into the scene and pointing the meter or camera at the card and setting the shutter speed and aperture for the exposure. The color balance needed to achieve neutral gray tones in the image is determined by the film manufacturer, set in the balance of the cyan, magenta and yellow dyes in the film. The closest comparison to the film emulsion in a digital camera is the sensor. However, unlike film, the digital sensor is not created with a particular color balance. The balance is determined by the camera circuitry. Some digital cameras have predetermined color balances for different lighting situations such as direct daylight, indirect daylight, flash, tungsten or fluorescent illumination, or a method for automatically adjusting the color balance.

Most, if not all, of the professional digital cameras, and many of the high-end consumer (also known as "prosumer") digital cameras, have a method for setting a custom gray balance. This allows the photographer to adjust to any lighting situation, not just the built-in ones. To make this color balance, also known as a white balance or gray balance, a neutral gray or white card is placed in the scene and the camera analyzes it's measurement of the card to make the settings.

Some camera programs can use several measurements, either from a single gray or from a series of grays, to set the balance. Better Light ViewFinder™ software is an example of a camera control program that can use up to 4 gray points to set the balance.

Since the image's tone is dependent on the card's reflected light, the selection of a gray card is very important. There is no standard for manufacturing these gray cards. Each manufacturer is free to make the gray colorant from whatever they want. Some of the gray references sold for setting the balance are made with paints, dyes, inks, plastics and cloth. Each type of colorant and substrate has its advantages, and disadvantages, which will be examined.

Requirements

Gray cards have several requirements that can be used to evaluate their utility. They should work in a wide variety of lighting environments and still maintain their gray appearance. They must be physically durable, able to withstand the environmental and handling rigors normally associated with photography. They should last long enough to be economical. These needs lead to a set of more specific requirements:

1. *Uniform spectral response*. A uniform spectral response means that the reflectance from the gray material should be the same, regardless of the wavelength, or color, of the illumination. Having a uniform, or flat, spectral response means that as the lighting changes, the gray will appear to remain gray, there will be no color cast to the gray. **This is the most important criteria for selecting a gray card.**

2. *Thermal color stability*. Many photographic situations require many hot lights for illumination or will be exposed in sunlight, thus heating the set and the gray card. The gray card should maintain its gray color as it is heated on the set.

3. *Ultraviolet light stability*. Natural sunlight and some types of artificial lighting, such as HMI, emit large amounts of ultraviolet radiation. Exposure to ultraviolet light can cause a breakdown of chemical bonds in the colorants and other materials in the gray card. This can result in fading, color shifts, yellowing, or sometimes physical changes in the gray card.

4. *Thermal durability*. When the gray card must be used in a hot environment the card should be physically durable. Many grays are produced on a thin material and then affixed to a more durable mount. The glue used for the

fixing should not soften or release the thinner gray material, catch fire, melt, curl, or otherwise physically deform. The gray colorant must not lighten, darken or become colored with the exposure temperatures.

5. *No reflections*. One very important characteristic is the texture of the gray reference surface. Glossy materials produce reflections of the surroundings that can influence the camera's balance. These reflections can be controlled in studio environments by adjusting the lighting or blocking the reflections, but this is not possible outdoors. Matte finish materials produce a uniform gray appearance without the reflectance issues of glossy colors.

6. *No polarization*. In many fine art reproduction situations, it is necessary to use polarized or cross-polarized techniques to remove unwanted specular reflections. Any gray reference that polarizes the light will interact with the polarized lighting to make a gray reference that will change it's darkness as it is rotated. This makes it extremely difficult for setting the color balance and polarizing gray references cannot be used with polarized lighting. However, a polarizing gray card may be perfectly useful in non-polarized situations.

7. *No fluorescence*. Many paper substrates have optical brighteners added to increase their apparent whiteness. The cellulose fibers comprising paper have a natural yellow color that is bleached during manufacturing, but some slight yellow remains, or can return as the paper ages. To counteract this yellowing, a "bluing" agent is added to paper that converts invisible ultraviolet light to visible blue light, the result is that the paper appears to be whiter. Any gray card or grayscale should not allow any of these fluorescing "bluing" agents to be viewed by the camera, or the grays will appear to change their tone as the lighting is changed from lower to higher ultraviolet illumination.

8. *Durability*. Any gray reference must be able to withstand the rigors endured during photographic sessions. References that scratch easily, crease when slightly flexed, or otherwise effect the gray surface during use will not last long. This would be, at the least, a bother and possibly a financial burden to the photographer.

9. *Lightness*. The gray should be in the correct reflectance range for the camera. Using very dark or almost black references can lead to erroneous camera settings due to inadequate light for the camera to get a good signal. Some cameras can use a white reference, some cannot. Some cameras can use either a gray or white reference. Check with the camera manual for the correct reflectance. Traditionally, film has used the 18% reflectance gray card since this approximately corresponds to the midpoint of the human visual response. Most digital cameras allow using these cards and this is a good point to start.

Gray Materials

Now that a set of requirements has been specified, an examination of different gray materials can be conducted to find gray cards that meet these specifications.

Photographic Prints

Some of the gray cards or gray scales are made from photographic prints. The gray color is due to a combination of cyan, magenta and yellow photographic dyes. When combined to make a gray, the spectrum of the resulting mixture is not uniformly level across the visible light spectrum (Figure 1). Due to this non-uniformity, when the lighting is changed the gray may appear to be slightly colored. Camera gray balances based on a non-neutral gray will cause tone shifts in the resulting images. The IT8.7/2 targets are an example of a photographic grayscale that shows these gray color changes as the lighting changes.

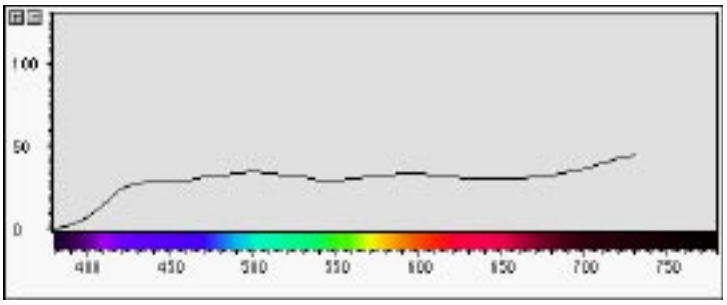

Figure 1. Photographic print gray from a Kodak IT8.7/2, patch GS7.

Photographic paper has physical characteristics that also lower its suitability as gray references. The cards are often supplied as just the photographic print, without a firm substrate, so they must be handled carefully. Photographic gray cards have gloss or semi-gloss surfaces which make their outdoor use very troublesome.

Painted Cards

Gray cards made with paint have many of the characteristics for a good gray card. Gray paints can be as simple as a mixture of white paint and black paint. The most common colorant for white paint is titanium dioxide and for black paint is carbon. Both of these colorants are spectrally uniform and the resulting mixtures are also spectrally flat (Figure 2). Paints designed for outdoor use, such as automobile or house paint, are also designed to be very resistant to fading from ultraviolet light, able to withstand heating from direct sunlight and capable of withstanding moisture. This makes them very good candidates for making gray cards. Usually their durability is mostly dependent on the substrate. An example of a painted gray reference is the GretagMacbeth ColorChecker®. This is a set of 24 patches, 18 color and 6 gray patches that has been available since 1976. It is made with paints applied to a heavy paper then affixed to a cardboard mount. The result is a durable color and grayscale chart that can withstand years of use. The main disadvantage is the slight curvature the chart attains when it is used on a hot set. For depth of field critical applications using hot lights, this can be a slight problem.

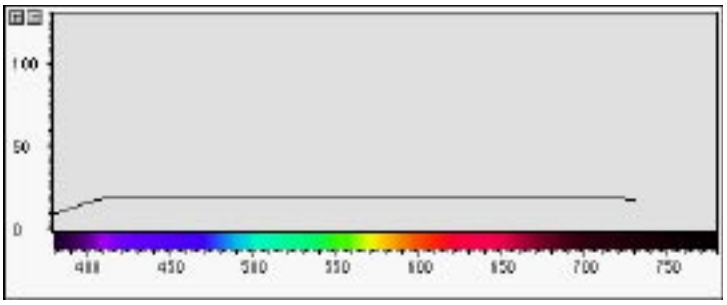

Figure 2. Painted gray from a GretagMacbeth ColorChecker® patch Neutral 5.

Note: A problem has been discovered using the GretagMacbeth ColorChecker DC®, an updated color chart with 240 patches. Many of the patches are polarizing. This makes the ColorChecker DC® unsuitable for polarized light photography. The ColorChecker DC® is, however, useful for non-polarized situations.

Another example of a painted grayscale is the Kodak Gray Scale that comes as part of the Color Separation Guide and Gray Scale set, available in the Q-13 (small) or Q-14 (large) sizes (Figure 3). One source has identified the materials as automobile paint applied to a coated paper substrate. The disadvantage of the Kodak Gray Scale is the substrate. Since it is only a thick paper, it can be bent easily. It can give many years of service if not physically damaged.

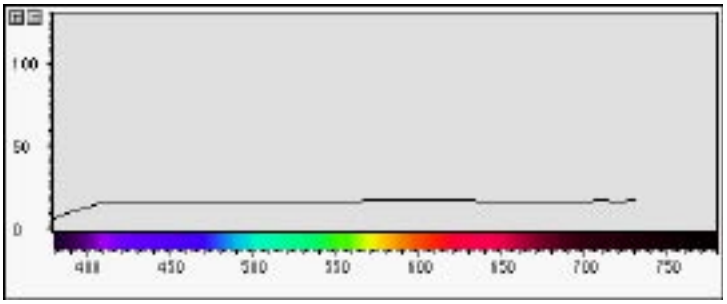

Figure 3. Painted gray from a Kodak Gray Scale Q-13 patch 7 (M).

Inked Cards

Gray references made with ink come in two types; solid gray ink and dot patterned black ink. Solid gray inks are used on some gray cards and can also be found in color guides such as the Pantone® guides. These inks can be as durable as the painted gray cards, depending on the choice of substrate. Often, the same colorants are used in both inks and their paint counterparts resulting in flat spectral response and good colorant durability.

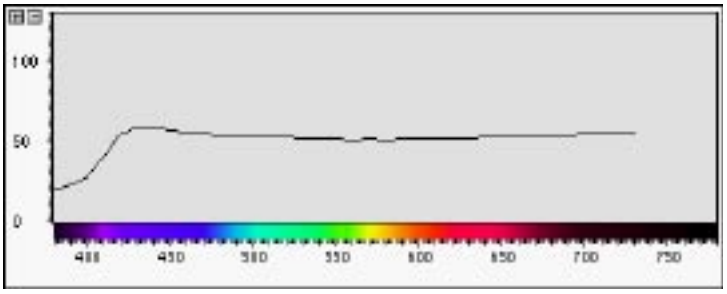

Figure 4. Printed gray from the YxyMaster patch K30.

The second type of ink gray cards are those produced using a halftone or other dot patterning method with black ink on a white substrate. The gray is a result of reflected light from the black ink and the white substrate mixing together to give a gray sensation (Figure 4). However, because a major component of the gray is the white reflectance, if an optical brightener is used in the paper, then there will be a blue cast to the gray card when exposed to ultraviolet light that will be missing in low ultraviolet illumination.

Plastics

Some plastics, such as foam PVC can be used for gray balancing. The natural color of some plastics is white and a black colorant can be added to the plastic to give a gray material (Figure 5). Plastics are very durable, withstanding moisture, moderate heat and a reasonable amount of ultraviolet illumination. Care must be exercised in selecting a plastic material since some plastics cannot take prolonged exposure to ultraviolet without changing color, becoming brittle or experiencing other physical changes. Since the amount of ultraviolet to cause these changes can be fairly high, and the replacement cost for a plastic gray card is very low, plastic gray references are a viable choice.

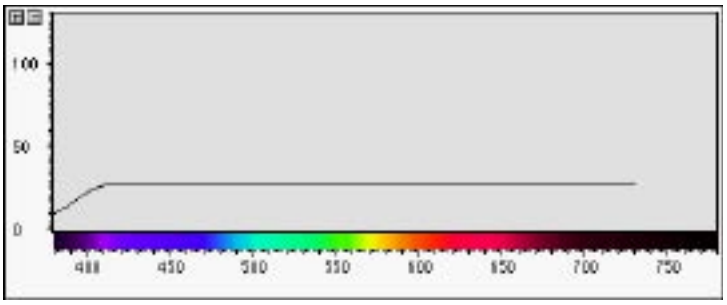

Figure 5. Plastic gray from a sample of foam PVC.

One fault with plastics is that they generally have a semi-gloss or glossy finish. This can make them useless for outdoor photography. However, the surface can sometimes be roughened or treated to reduce the glossiness.

Fabrics

One exhibitor at a recent PMA show was selling a lens cleaning cloth that was also in a neutral gray fabric making it a candidate for a gray reference. This particular cloth uses a shiny fabric with a checkerboard thread pattern that produces some of the reflection issues associated with glossy materials. However, there are fabrics available with suitable matte finishes that could be used for gray references. There are some advantages to using fabrics; color stability, durability and size. Fabric dyes have good fading characteristics and color stability. They have been selected to withstand daily exposure to the sun's ultraviolet radiation, heat and repeated washings. They can also be rolled or folded into small sizes for portable applications.

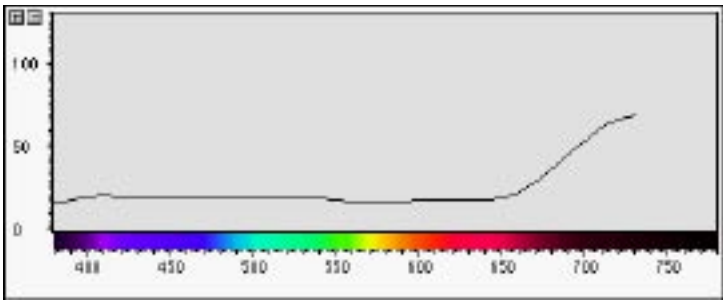

Figure 6. Fabric gray from the Wiko Microstar cleaning cloth.

One potential problem with fabrics is that the dyes used in their manufacture often reflect highly in the far-red and infrared regions of the spectrum (Figure 6). This reflectance can present a problem for digital cameras because they often have a sensitivity to these wavelengths.

Papers

Many photographers have gray backdrop paper rolls or sheets in their studios and use them for gray references. In addition to backdrop papers, other available paper products include matboards, construction paper, art papers, mounting boards, etc. This can be a poor choice since many papers use dyes similar to fabric dyes and are, therefore, subject to the same problems as fabrics. Measurements of the spectral uniformity show a wide variance. Some gray papers are almost flat spectrally, others extremely irregular. At this moment, use of gray papers can only be recommended on a case-by-case basis depending on spectral measurement of the paper.

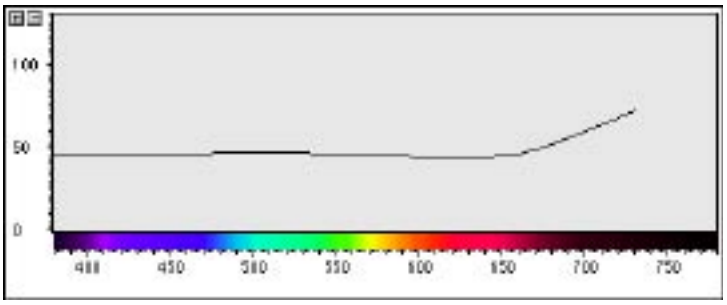

Figure 7. Paper gray from a sample of Savage #60 Focus Gray seamless paper.

Gray Target Comparison

Below is a list of a few commercially available gray references, evaluated according to the described requirements:

Item	Manufacturer	Material	Spectral Uniformity	Thermal Color	UV	Thermal Durability	Reflection	Fluor-escence	Polar-ization	Dura-bility
IT8.7/2	Agfa, Fuji, Kodak	photo print	Good	Poor	Poor	Poor	Poor	Good	Good	Poor
ColorChecker®	GretagMacbeth	paint	Good	Good	Poor	Good	Good	Good	Good	Good
ColorChecker DC®	GretagMacbeth	paint	Good	Good	Poor	Good	Good	Good	Poor	Good
Gray Scale Q-13, Q-14	Kodak	paint	Good	Good	Good	Good	Good	Good	Good	Poor
Foam PVC	Tap, Sintar, various	plastic	Good	Good	Good	Good	Variable	Good	Good	Good
YxyMaster	Intersystem Imaging	ink	Good	Good	Good	Poor	Poor	Good	Good	Good
Microstar	Wiko	fabric	Poor	Good	Good	Good	Poor	Good	Good	Good
Papers	Various	paper	Variable	Good	Unknown	Variable	Variable	Variable	Variable	Poor

Checking a Gray Reference

As outlined in the list of requirements for a good gray reference, spectral uniformity is the most important. To measure the reflectance spectrum of a reference a spectrophotometer is needed. Once found only in laboratories, they are now commonplace for the measurement of printed targets for ICC profile creation. Commonly available instruments include the GretagMacbeth Spectrolino and EyeOne, the X-Rite Colortron II and Digital Swatchbook, and the Spectrostar SpectroCam. Measure the reflectance spectrum of your gray reference and examine a graph of the data. The graph should be as flat as possible from about 420 to beyond 700 nm. Generally there will be lower reflectances below 420 nm due to the white colorant used in making the gray reference, however, they do not effect the resulting camera gray balance settings. **Do not use any gray that has a rise in reflectances at wavelengths above 650 nm!** These grays are reflecting more light in a region where human vision is not very sensitive, but many cameras are extremely sensitive. See the paper "Color Accurate Digital Reproduction of Artworks" on the www.betterlight.com website for more information on how this far red reflectance can effect images.

Summary

There are a large number of commercially available gray references. Each has its advantages, but **the most important feature is spectral uniformity**. Without this, the gray will be useful in only a few, very restricted lighting situations. The final choice of a gray target will be dependent on the shooting situations and the photographer's needs. For tabletop photography, the GretagMacbeth ColorChecker® in the business card size, the 8-inch size Kodak Q-13 Gray Scale or a piece of gray foam PVC make good choices.

For outdoor photography, where durability is very important, the GretagMacbeth ColorChecker® (standard size), the ColorChecker DC®, or a piece of gray foam PVC are good gray references.

Suitable gray references for reproduction photography include the GretagMacbeth ColorChecker® (standard size), the ColorChecker DC®, the Kodak Q-13 or Q-14 Gray Scale, or a piece of gray foam PVC.

Of course, the photographer can always make their own gray reference, paying attention to the desirable attributes discussed in this paper.