SIMPLIFIED 2 FRAME $6^{2/3}$ STOP FILM GAMMA TESTING

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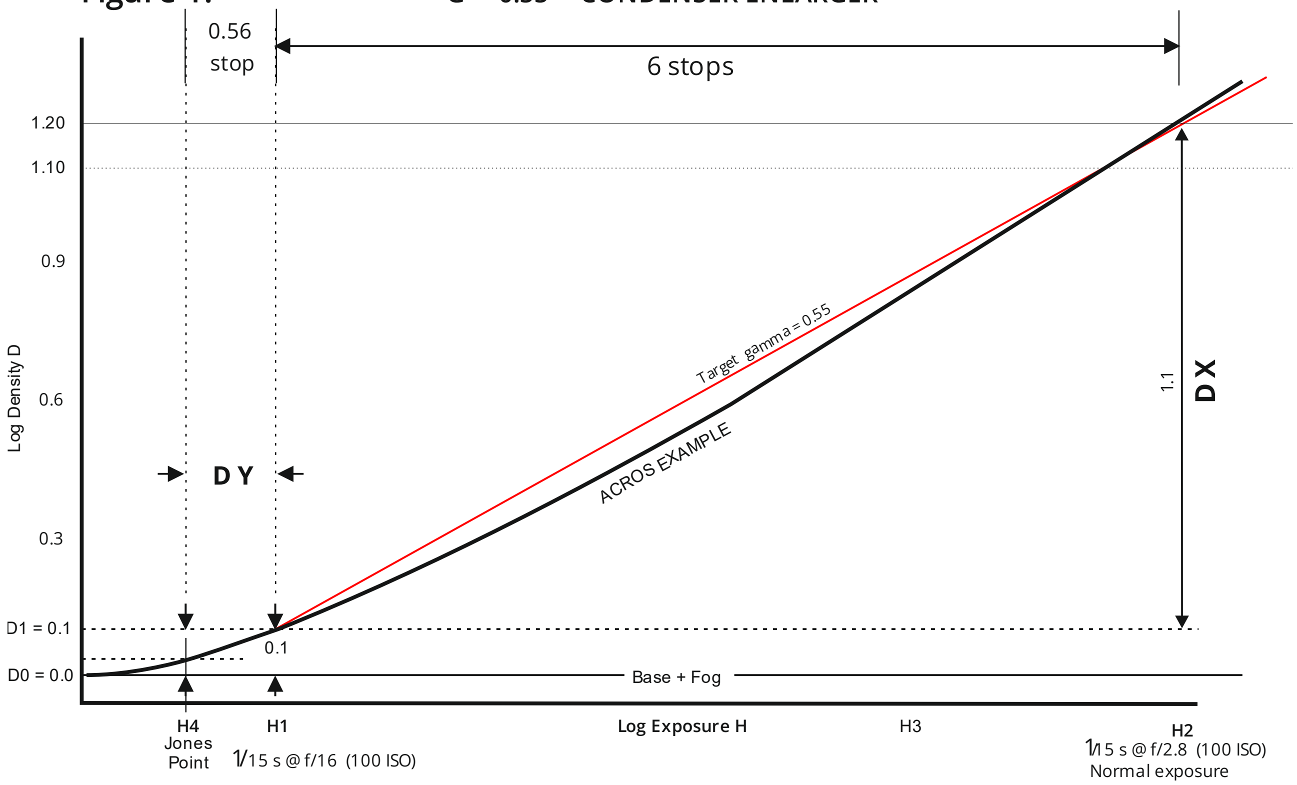
"When an incident light meter with a cosine receiver is used to measure the light from the main source of illumination the indicated exposure is such that the whitest reflecting surface in the subject is located on the characteristic curve at a point about 2.0 Log E units higher than the fractional gradient point."

George L. Wakefield, Practical Sensitometry, 1970

Introduction

The object of the exercise is to align the processed image to make use of the toe region of the characteristic curve, and, with a highlight range not exceeding the maximum printable density.
The specific highlight density depends on the characteristics of the enlarger and is typically a log density of 1.2 above base + fog for a condenser enlarger, or 1.5 for a diffuser enlarger.
In the past, both Fuji, Kodak and Ilford have suggested a film gamma of 0.55 when using the above parameters, which is used as an initial starting point for this system. Figure 1. below is an idealised view of a gamma of 0.55, consistent with Wakefield's statement above.

Figure 1:



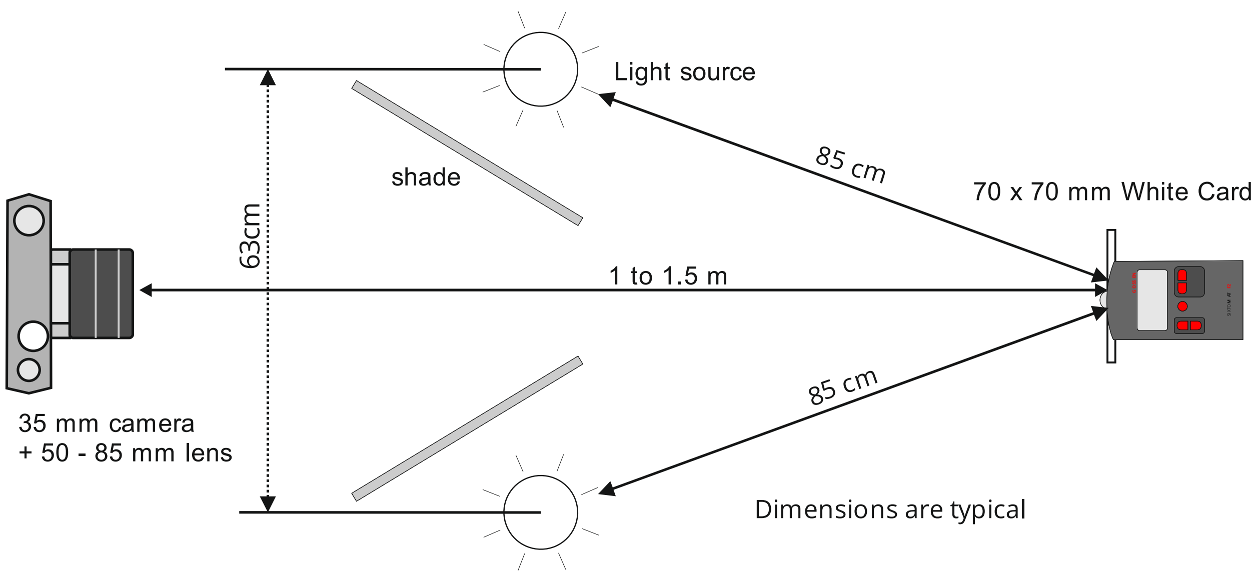
H1 is shown with a density of 0.1 which is the "standard speed point" for film testing. A more interesting parameter is the Jones "fractional gradient point" H4 (See Wikipedia: Film_Speed) giving 6.66 stops from H2 which is the corrected dynamic range. The Jones extension is discussed in detail in George Wakefield's book, "Practical Sensitometry" page 112, and at the end of this article.
Exposure point H2 represents the normal exposure required, measured with an incident light meter or spot meter from a matt white card.

The advantages of the above approach have been listed by Dunn (Exposure Manual page 15) as follows

1. minimum graininess 2. minimum exposure times 3. maximum arresting of subject movement
4. maximum depth of field 5. minimum halation and minimum light scatter in the emulsion
6. short printing time 7. optimum tone reproduction

Figure 2 below represents a typical arrangement for testing purposes.

Figure 2 **PHOTOGRAPHING THE WHITE CARD**



Two exposures are made of the white card representing H2 as the normal exposure reference and H4 where the difference is 62/3 stops.
Aperture settings are regarded as being more accurate than shutter settings hence the emphasis on aperture changes. If a slow lens is used, then a combination of aperture and shutter changes may be required.
Shutter times have been measured for a number of cameras and the general conclusions are as follows:

Using modern focal plane shutters from 1970 onwards, the accuracy is within 1/5 to 1/3 stop over the range from 1/2 to 1/60th second. Examples are Olympus OM range including OM1and OM10 and Canon AE-1.
This means that exposure times of 1/125 and 1/250, if necessary, will also not lead to significant errors.

1. Typical equipment examples but you can improvise:
   70 x 70 mm white card, use gloss or matt inkjet printing paper or similar
   Preferably 2 x 135 or 150 W Spiral Lamps E27 screw fitting, 5500K (see ebay)
   E27 to B22 adapter (ebay) if required
   Table lamps or tripod lamp stands. (ebay)
   35 mm camera with 50 to 85 mm lens
   Spot meter (preferred) or cardioid response incident light meter
   An enlarger densitometer (see b-wtechnik Silicon cell sensor Densitometer)

2. Set up the white card and light source as shown above and adjust the light source to the equivalent of a normal exposure H2 which in this example is 1/15 @f/2.8 at the normal film speed e.g. 100 ISO.

3. On the next frame, expose at $6^{2/3}$ stops less than frame 1 i.e H4. This exposure is at the point on the characteristic curve where the density is expected to be a log value of approximately 0.05 above base + fog

4. Process the film and measure the following, V1 to V4, with the enlarger densitometer lens set to f/4 or f/5.6 to ensure the output voltage is less than 8V with no film in the enlarger. The figures in brackets are typical actual measurements of voltage out :

   (a) Densitometer voltage output, no film V1 (3.47)
   (b) Densitometer output with film base + fog V2 (1.85)
   (c) Densitometer output from white card image, frame 1 .... V3 (0.080)
   (d) Densitometer output from white card image, frame 2 .... V4 (1.376)

   Film base + fog level = log (V1 / V2) (typical value 0.2 to 0.35) D0 (0.273)

   Frame 1 density = log (V2 / V3) (target value = 1.2) D4 (1.364)

   Frame 2 density = log (V2 / V4) (target value = 0.1) D5 (0.129)

   D4 and D5 are calculated with base + fog as a reference.

A spreadsheet is available to record data and complete the gamma calculation using the voltage measurements V1 to V4. See the appendix page 5.

Using any previous development times, this will also calculate an estimated new time to achieve the target gamma and density of 1.2 for maximum highlights.
The results are only applicable to the enlarger being used and will automatically correct any Callier coefficients within the enlarger and film. Varying Callier effects in processed film means that test samples have to be prepared for each film type.
It is appropriate next to discuss the result of applying the above test methods. Below is an extract from the spreadsheet mentioned above which relate to typical results and how they may be adjusted.

"The shape of the characteristic curve leads to a problem. Films tested so far indicate that it is sometimes impossible to maintain a gamma of 0.55 and also to simultaneously reach a density of 1.2 . Consider the following:

> **For a Pan F+ test, the average gradient is 0.53 .**
> **In the center of the curve, the maximum gradient is 0.639**
> **At a density of 1.2 the gradient falls to a value of 0.45**
> **At a density of 0.1, the gradient is 0.3 "**

In the highlights, the curve deviates significantly from a straight line when compared to films like Acros. The result is that with a film like Pan F+, the extreme highlights do not reach a density of 1.2 when the target gamma is set at 0.55 or lower. Both increasing development or the use of a higher paper grade will not solve the problem if we insist on retaining an overall gamma of 0.55.

If the gamma has been adjusted and is close to being correct, the most appropriate solution seems to be to increase the film exposure time to shifts the whole image up the characteristic curve a small fraction of a stop which will not altering the gamma significantly.
It is interesting to note that for Ilford film data sheets, when short development times are quoted, it is necessary to decrease the film speed which is, of course, effectively increasing the exposure time.

The “2 Frame $6^{2/3}$ Stop Spreadsheet” calculates the required exposure shift in either stops or expressed as a new film speed.

It will probably take 3 to 4 attempts to get close to your optimum parameters.

After the testing phase is nearly over, add a photograph of a demanding scene for printing experiments.
Initially, avoid having to use duplex exposure methods or any other kind of compensation. Use the manufacturers normal published speed . Use the substitution method and place a white or grey card in the scene as an exposure reference and a printing reference.

If the film development times are significantly lower than what you have been using before testing began, then you may also be surprised by the negatives having noticeably shorter exposure times and short printing times.

Also, this testing process will highlight any incorrect use of exposure meters, or failures of meters to give correct exposures in difficult scenarios.

Maximum Black Testing

When printing, a question that needs to be addressed is: with my typical enlarger exposure times with a good negative, am I getting close to a maximum black on my prints ?

Let us assume we have been using the system to fine tune the gamma etc and we have taken a test photograph to see how it will print. The “maximum black test” is very easy to do and will tell us whether or not our new printing times (with grade 2) are capable of giving a suitable maximum black on any print.

Cut a 40 x 40 mm photographic paper test strip and tape it to the centre of the enlarger easel.
With a suitable frame of base + fog in the enlarger and using your “latest” print test time, expose all the test strip.

Now place a black card over half the test paper and expose again with at least 5 to10 times the first exposure to ensure a full maximum black on the paper. Process as normal and view when dry using a light source that gives 1000 lux, as recommended by Kodak. (Using a photographic light meter, EV 8.5 is 900 lux)

Repeat with an adjusted exposure time until there is a just noticeable difference and that is your “maximum black” time with the current enlarger settings and base+fog.

Maximum White Testing

The reader can work out part of this procedure from the maximum black test above. The only difference is that a calibrated negative film sample with a nominal log density of 1.2 + base+fog has to be placed in the film holder. Place a coin on to a part of the test paper and find the exposure time where a just noticeable image of the coin can be seen.

The question now is: Is the Maximum Black test time similar or close to the Maximum White test ?
If not then it is likely that the film gamma is not correct.
I would suggest a possible difference of up to 20 % can be tolerated but more testing in this area is required. In the meantime it is best to use the maximum white time plus any dodging or burning in of images bearing in mind the outcome of the above tests.

Maximum black levels are usually at least a log density of 1.8 but according to American Standard PH2.2 -1966, it is difficult to notice any change above 90% of the maximum level of black. A practical level is therefore a log density of 1.62 .

Spreadsheet:
b_w_technik.pp7.uk/2_frame_6.66_stop_gamma_calculations_template_
30-11-25.ods

Main Link to densitometers:
b_w_technik.pp7.uk/densitometer.htm

IF YOU DO NOT HAVE THE SILICON CELL DENSITOMETER ....

An option is to use a densitometer using a Cadmium Sulphide light sensor which can be calibrated against the film sample mentioned in the article above. All that is required is the CdS sensor (£ 3), a low cost voltmeter (£ 5-7) a few bits of wire and some terminal block strip connectors (£ 2) and a small plastic sheet to act as a base. All the parts are available at cost price from b-wtechnik or can be purchased via ebay.

See the “Densitometers” section on the main website for full details.

"JONES POINT" NOTES

The "Jones point" on the film characteristic curve in the toe area is where the curve gamma drops to 0.3 of the average curve gamma in the midrange occurs i.e using Ilford "Gamma" or Kodak "Contrast Index". This point marks the limit at which it is possible to discern detail in the shadow area of a final print.

A Kodak scientist, Loyd A. Jones was responsible in the early 1950's for promoting the "fractional gradient" criteria with regard to the standardisation of film speed. It works in conjunction with the "standardised speed point" of 0.1 density shown on characteristic curves.

The Jones point is always below 0.1 density and is the accepted real limit of film dynamic range. Below this point, the gamma is too low and we cannot discern any detail. In our film gamma testing we have included the Jones point in our estimate of dynamic range. Fortunately, on page 113 of Wakefield's book, a graph is provided that enables this correction to be calculated. (The original source is not mentioned). The graph is shown in Fig. 3 below.

Referring to Figure 1, D Y is 1.1 then D X is seen to be 0.17 . Divide by 0.301 to convert to stops and we get 0.56 stops giving an overall corrected dynamic range of 6.56 stops or 94 : 1 which is used in our test.