ARCHIVED DECEMBER 12, 2006

RP 180-1999
Revision of
RP 180-1994

SMPTE RECOMMENDED PRACTICE

Spectral Conditions Defining Printing Density in Motion-Picture Negative and Intermediate Films

Introduction

When a motion-picture color negative or intermediate film is printed, the dyes in the negative or intermediate modulate the red, green, and blue exposures of the print material. The printing densities of the negative are a measure of this exposure modulation. Printing density is the density of the negative as "seen" by the printer and print material.

The ISO has defined status M density for the evaluation of color photographic materials intended for printing. Status M density measurements are widely and satisfactorily used in process control in motion-picture, amateur color negative, and reversal printing originals. However, given the large number of films in use, status M densities can only approximate printing densities for most materials. A definition of printing density appropriate to the specific motion-picture negative and intermediate materials being used is needed for the calibration of film scanners and definition of the metric used in computer data files for electronic post-production of film.

Motion-picture films are manufactured so as to reproduce properly a gray scale with matched gammas in the final print, and the negatives and intermediate films are designed to present matched printing density gammas to the print materials. Thus, the printing densities of a negative will correctly measure the relative gammas of the negative. Printing densities can be measured relative to a 100% transmitting reference, to the film D_{min}, or to a reference gray step. In the latter case, an ideal film would have matched, superimposed red, green, and blue gray scale printing densities.

The printing exposures are determined by the product of the spectral power distribution of the printing light source, any spectral filtration in the printer, and the spectral sensitivities of the print material. Ideally, a measure of printing density would exactly duplicate these properties. This is not possible in practice owing to the large variety of printers and materials that exist. The practical goal in specifying a printing density measure is to require that the printing density measurement correctly specifies the printing gammas of typical motion-picture color negative and intermediate materials.

1 Scope

This practice defines the spectral conditions defining the printing density gammas of motion-picture color negative and intermediate materials. It is not intended as a replacement for the status M density spectral conditions given in ANSI/ISO 5-3 and commonly used for the evaluation of color photographic materials used for printing.

2 Spectral conditions for printing density measurements

The spectral conditions defining the printing densities of motion-picture negative and intermediate materials are tabulated in table 1. These spectral responses, labeled R G and B respectively, are arbitrarily normalized to have unit response at the peak sensitivity. In actual use, the densitometer would be adjusted to cause zero density to correspond to a 100% transmitting material or to the D_{min} of the film being measured. This instrument zero adjustment will have the effect of renormalizing the data of table 1.

3 Application

The following equations define the relationship between printing density and printing exposure which is determined by measurements using the spectral responses of table 1:

Copyright © 1999 by the
SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS
595 W. Hartsdale Ave., White Plains, NY 10607
(914) 761-1100

Approved April 23, 1999

Table 1 – Spectral conditions for the measurement of motion-picture film printing density

W.L. (nm)	R	G	B
360	0.0000	0.0000	0.0000
370	0.0000	0.0000	0.0000
380	0.0000	0.0000	0.0052
390	0.0000	0.0000	0.0628
400	0.0000	0.0000	0.1692
410	0.0000	0.0000	0.4141
420	0.0000	0.0000	0.7625
430	0.0000	0.0000	1.0000
440	0.0000	0.0000	0.8754
450	0.0000	0.0000	0.5512
460	0.0000	0.0000	0.2619
470	0.0000	0.0005	0.1075
480	0.0000	0.0012	0.0262
490	0.0000	0.0049	0.0018
500	0.0000	0.0366	0.0000
510	0.0000	0.2714	0.0000
520	0.0000	0.7152	0.0000
530	0.0000	1.0000	0.0000
540	0.0000	0.8779	0.0000
550	0.0000	0.4584	0.0000
560	0.0000	0.1317	0.0000
570	0.0000	0.0079	0.0000
580	0.0000	0.0025	0.0000
590	0.0000	0.0013	0.0000
600	0.0000	0.0000	0.0000
610	0.0010	0.0000	0.0000
620	0.0177	0.0000	0.0000
630	0.0913	0.0000	0.0000
640	0.2223	0.0000	0.0000
650	0.4917	0.0000	0.0000
660	0.8267	0.0000	0.0000
670	1.0000	0.0000	0.0000
680	0.7937	0.0000	0.0000
690	0.4487	0.0000	0.0000
700	0.1907	0.0000	0.0000
710	0.0752	0.0000	0.0000
720	0.0097	0.0000	0.0000
730	0.0000	0.0000	0.0000
740	0.0000	0.0000	0.0000

$$E_R = \frac{\int R_\lambda \times TF_\lambda d_\lambda}{\int R_\lambda \times TS_\lambda d_\lambda}$$

$$E_G = \frac{\int G_\lambda \times TF_\lambda d_\lambda}{\int G_\lambda \times TS_\lambda d_\lambda}$$

$$E_B = \frac{\int B_\lambda \times TF_\lambda d_\lambda}{\int B_\lambda \times TS_\lambda d_\lambda}$$

where R G and B refer to the spectral responses in table 1, TF is the film sample spectral transmittance, and TS is the spectral transmittance of the reference used to normalize the data or to adjust the zero of the measurement.

The printing densities relate to the printing exposures as follows:

$$PD_R = LOG_{10}(E_R)$$

$$PD_G = LOG_{10}(E_G)$$

$$PD_B = LOG_{10}(E_B)$$

Printing densities computed using the above relationships can be used to calibrate film samples which in turn can be used to calibrate film scanners. Also, the computed printing densities can be used to derive a transformation matrix to transform status M density measurements to printing density. Finally, the spectral data listed in table 1 serves as an aim point for designing the spectral responses of film scanners and possibly densitometers.

Annex A (informative)
Bibliography

ANSI/ISO 5-3-1995, Photography — Density Measurements — Part 3: Spectral Conditions

Evans, R.M.; Hanson, W.T., Jr.; and Brewer, W.L. Principles of color photography. New York: John Wiley & Sons, Inc.; 1953. Pp. 191 and 423.

Hunt, R.W.G. The reproduction of colour. London: Fountain Press Ltd.; 1975. P. 237.