

SMPTE STANDARD

Academy Printing Density (APD) — Spectral Responsivities, Reference Measurement Device and Spectral Calculation



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Standards and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative Practices.

SMPTE ST 2065-2 was prepared by Technology Committee 10E.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this standard. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Academy Printing Density (APD) is an optical printing density metric suitable for use with motion picture color negative and internegative films. APD is defined by the spectral responsivities Π_{APD} .

Π_{APD} are based on the spectral sensitivities of contemporary motion picture print films such as those of the Kodak Vision[®] family, of the Fujifilm Eterna[®] family, and of Fujifilm F-CP[®]. Its definition is also based on the spectral power distribution of a Bell & Howell Model C[®] printer lamp house with dichroic filters and the spectral transmittance of an Eastman Kodak Wratten[®] Filter No. 2B.

The spectral responsivities associated with any printing density metric are the product of the spectral power distribution of a printer light source, the spectral transmittance, reflection, and absorbance of the optical components of the photographic printer, and the spectral sensitivities of the print medium onto which the sample is to be printed.

The spectral responsivities used to determine the APD values of a sample are the spectral product (Π_{APD}) of the relative spectral power distribution of the influx (S_{APD}) and the relative spectral response of the receiver (S_{APD}), which includes the photodetector and all intervening components between it and the plane of the sample to be measured.

1 Scope

This Standard defines Academy Printing Density (APD) by specifying the spectral responsivities I_{APD} and the APD reference measurement device.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:".

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ISO 5-1:1984, Photography — Density Measurements — Part 1: Terms, symbols, and notations, First Edition, March 1, 1984

ISO 5-2:2001(E), Photography — Density Measurements — Part 2: Geometric conditions for transmission density, Fourth Edition, June 15, 2001

ISO 5-3:1995(E), Photography — Density Measurements — Part 3: Spectral Conditions, Second Edition, November 15, 1995

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

- 4.1 Academy Printing Density (APD):** printing densities defined by the spectral responsivities Π_{APD} .
- 4.2 densitometer:** device for directly measuring transmission or reflection optical densities.
- 4.3 influx spectrum:** spectrum of the radiant flux incident on the specimen surface or sampling aperture. It is a function of the energy source and the optical system on the source side of the specimen.
- 4.4 optical density:** negative logarithm to the base 10 of the ratio of the integration of the spectral responsivities of a detection system and the spectral transmittance or reflectance of the sample under examination and the integration of the spectral responsivities of the detection system alone.
- 4.5 printing density:** optical density measured according to effective spectral responsivities defined by the spectral power distribution of a printer, including the light source, the spectral transmission, reflection and absorbance of its optical components, and the spectral sensitivity of a print medium.
- 4.6 spectral power distribution:** power, or relative power, of electromagnetic radiation as a function of wavelength.
- 4.7 spectral product:** wavelength-by-wavelength product of two or more spectral power distributions, spectral sensitivities, spectral responsivities, or spectral transmittances.
- 4.8 spectral responsivities:** spectral condition that represents the responses of a detection system, such as a scanner or a densitometer, as a function of wavelength. Spectral responsivities are determined by the spectral power distribution of the illumination, the spectral filtration effects of various optical components, and the spectral sensitivity of the detector.
- 4.9 spectral sensitivity:** response of a detector to monochromatic stimuli of equal radiant power.
- 4.10 spectral transmittance:** fraction of the incident power transmitted as a function of wavelength.

5 Academy Printing Density

5.1 Notation

The spectral responsivities defined in this specification are specified as spectral products rather than discrete spectral components. The spectral product for any densitometric specification, film scanner, or densitometer may be denoted using Equation 1 as provided in ISO 5-3:1995(E).

$$\Pi = S(\lambda)s(\lambda)$$

Equation 1

where:

$S(\lambda)$ is the relative spectral power distribution of the influx.

and

$s(\lambda)$ is the relative spectral sensitivity of the receiver, which includes the photodetector and all intervening components between it and the plane of the sample to be measured.

ISO 5-1:1984 specifies functional notation of the form $D(G; S : g; s)$, where G and g symbolize the influx geometry and efflux geometry respectively. Since this standard is only concerned with spectral conditions, the notation is abbreviated to $D(S : s)$ where the subscripted symbol D_T is used to denote transmission density.

5.2 Specification

The following functional notation, consistent with the notation specified in ISO 5-1:1984, shall be used to denote spectral conditions associated with Academy Printing Density (APD).

By transmission:

$$D_T(S_{APD} : S_{APD_R}), D_T(S_{APD} : S_{APD_G}), \text{ and } D_T(S_{APD} : S_{APD_B})$$

5.2.1 Spectral Responsivities

The spectral responsivities used to calculate APD shall be known as Π_{APD} and conform to the values listed in Table A.1 found in Annex A. The subscripted symbols Π_{APD_R} , Π_{APD_G} , and Π_{APD_B} shall be used to denote the spectral responsivities of the red, green, and blue components of Π_{APD} respectively. Π_{APD} are illustrated in Figure 1.

The subscripted symbol S_{APD} shall be used to denote the relative spectral power distribution of the influx spectrum used in the calculation of the spectral product Π_{APD} .

The subscripted symbol s_{APD} shall be used to denote the relative spectral sensitivities of the print material used in the calculation of the spectral product Π_{APD} . The subscripted symbols s_{APD_R} , s_{APD_G} , and s_{APD_B} shall be used to denote the spectral sensitivities of the red, green, and blue components of s_{APD} respectively.