

# Standards and Recommended Practices

## Approved SMPTE Engineering Guidelines

Two SMPTE Engineering Guidelines were approved by the Society's Executive Committee for Standards Approval: EG 1-1990, Alignment Color Bar Test Signal for Television Picture Monitors; and EG 2-1990, Edge Identification of Motion-Picture Raw Stock Containers. These and other SMPTE Engineering Guidelines may be obtained from Society Headquarters for \$3.00 each.

## Proposed American National Standards

Published here for a trial period and public review are two Proposed American National Standards: SMPTE 192, Motion-Picture Equipment — Shipping Reels for 35-mm Prints; and SMPTE 254, Motion-Picture Film (35-mm) — Manufacturer-Printed Latent Image Identification Information. The proposals will be submitted to the Society's Executive Committee for Standards Approval if no adverse comments are received from publication. Comments should be addressed to Sherwin H. Becker prior to December 1, 1990.

## Approved International Standard

The International Organization for Standardization (ISO) has approved an International Standard, the technical content of which is published here for your information. ISO 2910:1990,

Cinematography — Screen Luminance for the Projection of Motion-Picture Prints in Indoor Theatres and Review Rooms, is in accord with American National Standard for Motion-Picture Film — Screen Luminance and Viewing Conditions — Indoor Theater Projection, ANSI/SMPTE 196M-1986. This material is reproduced with permission from the ISO and is copyrighted by the American National Standards Institute, 1430 Broadway, New York, NY 10018, from which copies are available.

## Proposed Withdrawal of American National Standard and SMPTE Recommended Practice

On the recommendation of the Committee on Television Recording and Reproduction Technology, the Standards Committee has approved withdrawal of an American National Standard, ANSI V98.34M-1984, Video Recording — 1/2-in Type G Cassette — Records; and an SMPTE Recommended Practice, RP 119-1984, Reference Carrier Frequencies, Pre-emphasis Characteristics and Audio and Control Signals for 1/2-in Type G Helical-Scan Video Tape Recording Cassette Systems. Withdrawal was initiated because the documents are out of date and need significant revision to cover the various format permutations presently in use. Comments should be addressed to Sherwin H. Becker at Society Headquarters prior to December 1, 1990. All comments from *Journal* publication will be reviewed prior to submittal of the proposed withdrawal to the Society's Executive Committee for Standards Approval.

—*Sherwin H. Becker, Director of Engineering*

## **SMPTE Standards Subscription Service**

The Society provides a Standards Subscription Service to assist firms, libraries, and individuals in establishing and maintaining a complete and current file of approved American National Standards, SMPTE Recommended Practices, and SMPTE Engineering Guidelines in the motion-picture, television, and video magnetic recording fields. Through this service, the Society makes automatic distribution to standards subscribers of all new and revised standards, recommended practices, and guidelines that are approved during the calendar year in these fields.

For further information, write to: Standards Subscription Service, Engineering Dept., Society of Motion Picture and Television Engineers, 595 West Hartsdale Ave., White Plains, NY 10607.

Alignment Color Bar Test Signal for  
Television Picture Monitors



1. Scope

This guideline specifies the purpose, format, and usage of a television picture monitor alignment color bar test signal with chroma set and black set signals.

2. Purpose

2.1 The alignment color bar test signal is intended to standardize the adjustment of chroma gain, chroma phase, and black level monitor controls.

2.2 Chroma gain and chroma phase for picture monitors are conventionally adjusted by observing the standard encoded color bar signal (see Fig. 1) with red and green monitor guns switched off. The four visible blue bars are adjusted for equal brightness. This procedure is prone to error because of the subjective judgment necessary and especially because the blue bars are widely separated on the screen. The use of the chroma set signal portion of the alignment color bar test signal greatly increases the accuracy of this adjustment since it provides a signal with the blue bars to be matched vertically adjacent to each other. Because the bars are adjacent, the eye can easily perceive any difference in brightness. It also eliminates effects due to shading or purity from one part of the monitor to another.

2.3 Black level for picture monitors is conveniently adjusted by observing a known black portion of the signal and matching it to a blanked area of the signal. This procedure is prone to error because of the subjective judgment necessary to make the match. The use of the black set signal portion of the alignment color bar test signal greatly increases the accuracy of this adjustment since it provides a positive go-on-go criterion for the proper setting. It also minimizes errors due to variations in ambient light.

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3. Format

3.1 Fig. 1 shows the appearance of the EIA Standard RS-189-A, Encoded Color Bar Signal, on a picture monitor. Fig. 2 shows the appearance of the alignment color bar test signal on a picture monitor. Note that Fig. 2, the Alignment Color Bar Test Signal, is the same as Fig. 1 except for the addition of chroma set signal (X-X') and black set signal (within Y-Y').

3.2 The chroma set signal is a small band of bars displayed in place of the bottom portion of normal color bars. The bars are displayed in reverse order. Only the four bars which contain blue are necessary; the remaining three bars may be black. Fig. 3 shows the appearance of one line of the chroma set signal on a waveform monitor.

3.3 The black set signal is located in the bottom right-hand portion of the raster. Two bars, one slightly whiter-than-black and the other slightly blacker-than-black, are included. Fig. 4 shows the appearance of one line of the black set signal on a waveform monitor.

4. Usage

4.1 To set chroma gain and phase, the picture monitor red and green guns are switched off. Chroma gain is adjusted by matching the brightness of the outer left or right main blue bar with the chroma set bar just below. In a similar manner, chroma phase is adjusted by matching the brightness of either center main blue bar with the chroma set bar just below.

4.2 To set black level, the picture monitor brightness control is adjusted so that the whiter-than-black bar is visible with respect to the black surround but the blacker-than-black bar is not visible.

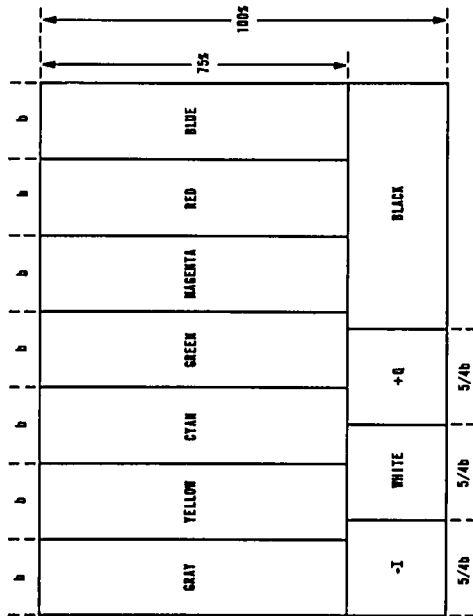


Fig. 1  
EIA Standard RS-189-A, Encoded Color Bar Signal

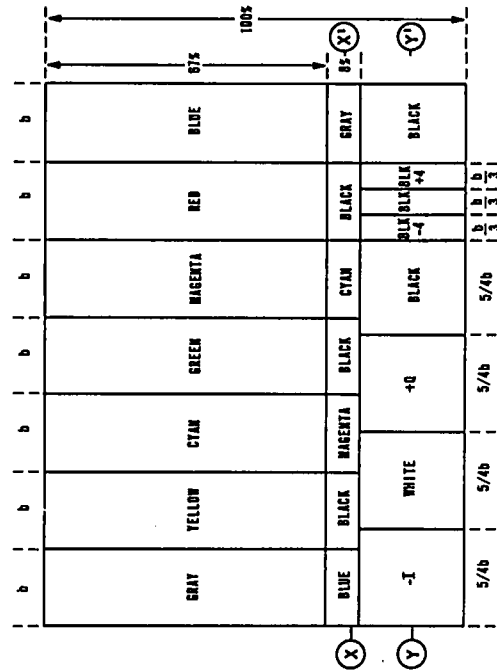


Fig. 2  
Alignment Color Bar Test Signal

b = 1/ ACTIVE LINE TIME



Proposed American National Standard  
for motion-picture equipment—  
shipping reels for 35-mm prints

SMPTE 192  
Revision of  
ANSI/SMPTE 192-1985

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Appendix

(This Appendix is not part of the American National Standard, but is included for information only.)

A1. The use of shipping reels with small hubs (those resulting in a flange-to-hub ratio of 3:1 or greater) on projectors and rewind equipment already adjusted for reels with large hubs (flange-to-hub ratio of 3:1 or less) can subject film tension to drastic increases which may result in perforation damage by the sprocket.

A2. Some auxiliary projection equipment, such as make-up tables for platters, have an adjustable noncentral spindle and a special hole may need to be placed in plastic and metal reels to accommodate the spindle. Figs. 2 and 3 specify the spindle holes on 2000-ft steel and plastic shipping reels in current use. The use of plastic shipping reels is deprecated because they produce static electricity which attracts dust to the film surface.

Page 1 of 2 pages

**1. Scope**  
This standard specifies the dimensions of shipping reels for 35-mm motion-picture prints having a nominal film capacity of 2000 ft (610 m). The use of 1000-ft capacity shipping reels is not recommended for the reasons specified in Appendix A1.

**2. Referenced American National Standard**  
This standard is intended for use in conjunction with the following American National Standard:  
ANSI/SMPTE 241-1989, Motion-Picture Equipment—35- and 70-mm Projection Reels

**3. Dimensions**  
3.1 The dimensions shall be as given in Fig. 1 and the table.  
3.2 Dimension F defines the area over which the reel thickness, specified by Dimension C<sub>1</sub>, applies.

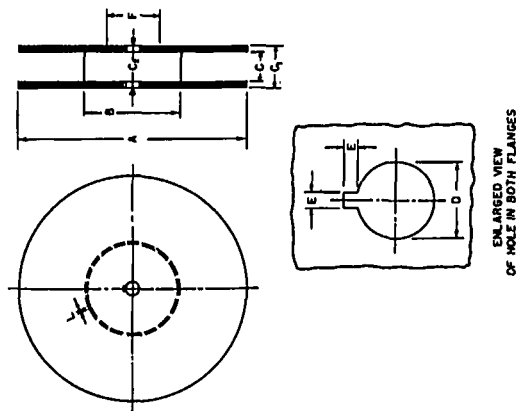


Fig. 1  
Plan View and Cross Section of Reel

Dimensions	Inches	Millimeters
A	14.50 ± 0.03	368.3 ± 0.8
B	4.10 ± 0.00	104.1 ± 0.0
C	1.53 ± 0.15	38.9 ± 3.8
C <sub>1</sub>	1.885 ± 0.030	47.88 ± 0.76
C <sub>2</sub>	1.625 ± 0.030	41.28 ± 0.76
D	0.317 ± 0.002	8.05 ± 0.05
E	0.150 ± 0.010	3.81 ± 0.25
F	2.25 min	57.2 min
L	0.035 nom	0.89 nom

Note: Dimensions of 35-mm projection reels for motion-picture and television applications and 35- and 70-mm projection reels intended for use on combination 70/35-mm projectors and rewinds are specified in ANSI/SMPTE 241-1989.

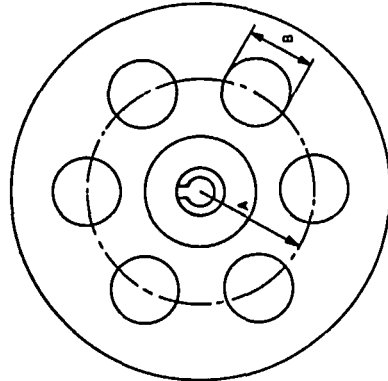


Fig. 2  
2000-Ft Steel Reel Hub

Dimensions	Inches	Millimeters
A	1.313 ± 0.002	33.35 ± 0.05
B	0.803 ± 0.002	20.40 ± 0.05

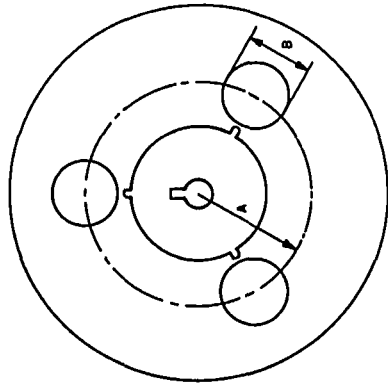


Fig. 3  
2000-Ft Plastic Reel Hub

Dimensions	Inches	Millimeters
A	1.379 ± 0.002	35.03 ± 0.05
B	0.805 ± 0.002	20.45 ± 0.05

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SMPTE 192



supplied to the user with the lowest number at the outside of the roll.

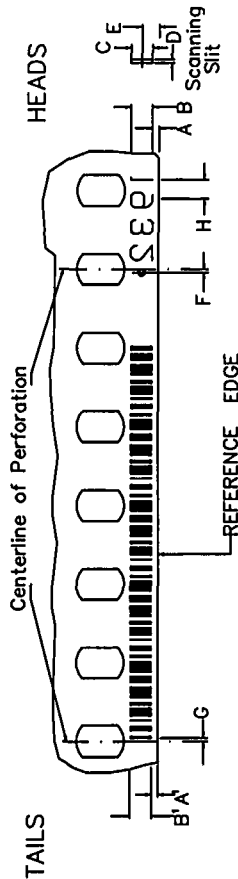
5.2 Dimensions. The height and width of the human-readable key numbers shall be as specified in Fig. 2 and Table 1.

5.3 Reference Mark. A zero frame reference mark shall be printed adjacent to the digit of the human-readable key number that is closest to

4.3 Film. This identification information is intended to be printed onto film cut and perforated in accordance with ANSI/SMPTE 93-1986.

5. Human-Readable Key Numbers

5.1 Key Number. An incrementing, human-readable key number shall be printed onto the film at the time of manufacture. The film shall be



NOTE: This drawing shows emulsion towards the viewer. Normal film travel is from left to right.

Fig. 2 Position and Dimensions

Table 1

Dimensions	Inches	Millimeters
A Edge of film to bottom of characters	0.009 ± 0.005	0.23 ± 0.13
A <sup>1</sup> Edge of film to bottom of bars	0.009 + 0.005 - 0.009	0.23 + 0.13 - 0.23
B Height of characters	0.060 ± 0.002	1.52 ± 0.05
B <sup>1</sup> Height of bars	0.060 + 0.010 - 0.002	1.52 + 0.25 - 0.05
C Scanning slit length	0.050 max	1.27 max
D Scanning slit width	0.005 max	0.13 max
E Edge of film to centerline of scanning slit	0.035 ± 0.002	0.89 ± 0.05
F Zero frame mark displacement	0.00 ± 0.04	0.0 ± 1.0
G Barcode displacement	0.00 ± 0.04	0.0 ± 1.0
H Character to character spacing	0.060 nom	1.52 nom

the tail of the film as shown in Fig. 1. The zero-frame reference mark shall be a filled circle with a diameter of approximately 0.025 to 0.030 in (0.64 to 0.76 mm).

5.4 Alignment with Respect to Perforations. The numbers shall be printed so that the centerline of the zero-frame reference mark is aligned with the centerline of a perforation, within the tolerance shown in Fig. 2.

5.4.1 This alignment is intended to facilitate frame identification with a minimum of confusion, even though the picture frame may have one of several positions relative to the key number. The following rule shall be applied to frame identification:

The frame immediately above the zero-frame reference mark is the one referenced by that key number. Other frames are specified by an offset which is written as an additional digit(s) separated from the key number by a plus sign. Fig. 3 shows an example of this rule.

5.5 Repeat Frequency. The spacing from one key number to the next shall be 64 perforations.

5.6 Format and Orientation

5.6.1 Number and Grouping of Digits. The human-readable key number shall consist of 2 alphabetic characters and 10 digits. This alphanumeric code shall be separated into groups of 2 characters and 2, 4, and 4 digits, which in turn shall be separated by spaces (see Fig. 1). For the 10 digits, only the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 shall be used, and they shall be in normal counting sequence. It is recommended, although not required, that the ten thousandths place not be allowed to increment within a single roll of film.

5.6.2 Orientation. The number may be placed in one of several orientations at the discretion of the film manufacturer. When the original negative film is held with the emulsion toward the viewer and the head toward the right, the numbers may be in any one of the following orientations:

Right side up, reading from head to tail  
Upside down, reading from head to tail

TRAVEL

EMULSION TOWARDS VIEWER

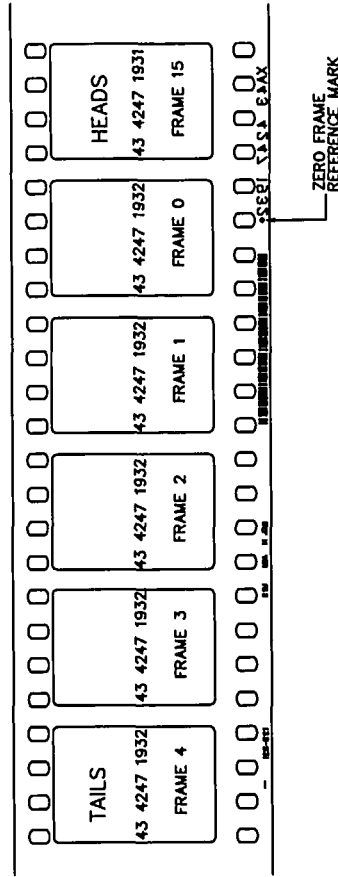


Fig. 3 Alignment of Zero Frame Reference Mark

Right side up, reading from tail to head  
Upside down, reading from tail to head

In all cases, regardless of the orientation, the dot is to the left (closer to the tail) and adjacent to the trailing (closest to the tail) character, as shown in Fig. 1. The key number shall precede the machine-readable key number; i.e., the human-readable key number shall be closer to the head of the roll.

**5.6.3** Contents of the Alphabetic Characters. The first two characters of the key number identify the manufacturer and film type. The character set used shall be the normal uppercase letters A through Z. The first character shall identify the film manufacturer according to Table 2. Other letters are reserved for future assignment by the SMPTE.

The second character shall be a film-type identifier. The character is chosen at the discretion of the film manufacturer.

**Table 2**  
Manufacturer Alphabetic Code

Manufacturer	Code
Agfa-Gevaert N.V.	A
Eastman Kodak Company	K
Fuji Film Company	F
Other or nondesignated	(nothing)

**6. Machine-Readable Key Numbers**

**6.1** The machine-readable key numbers are intended to be a machine readable version of the immediately adjacent human-readable key numbers.

**6.2 Dimensions**

**6.2.1** The dimensions and lateral location of the machine-readable identification numbers shall be as specified in Fig. 2 and Table 1.

**6.2.2** The nominal width of the narrowest bar or space shall be 0.0075 in (0.190 mm). All

other bars and spaces are to be integer multiples of the narrowest bar as specified in USS 128. The total bar code message, which consists of 123 elements (not counting the quiet zones), shall have a width of 0.9225 in  $\pm$  0.0400 in (23.432 mm  $\pm$  1.016 mm).

**6.2.3** The message shall be printed so that the trailing edge of the last character (the stop character) shall be longitudinally aligned with the centerline of a perforation, that perforation being six perforations displaced from the perforation specified in 5.3, within the tolerance shown in Fig. 2.

**6.2.4** The recording shall be made so that the azimuth of the record is at an angle of 90°  $\pm$  1° to the reference edge of the film.

**6.2.5** The lateral location, length, and width of the scanned area shall be as specified in Fig. 2 and Table 1.

**6.2.6** The reproducing (scanning) slit image shall be positioned at an angle of 90°  $\pm$  1° to the reference edge of the film.

**6.3** Repeat Frequency. The machine-readable message shall be immediately adjacent to the human-readable key number and shall repeat at the same frequency.

**6.4 Format**

**6.4.1** The machine-readable numbers shall consist of a series of bars and spaces of varying width that meet the bar code specification of USS 128. Code subset C of this specification, which allows double density numeric digits, shall be used.

**6.4.2** The data portion of the message shall be of fixed length and shall consist of 16 digits. Since code subset C encodes two digits per bar code character, this corresponds to 8 bar code characters. In addition, quiet zones, a start character (for code C), a check sum character, and a stop character shall be recorded. Including the start and stop characters, the entire message shall be 11 bar code characters.

**6.4.3** The start character shall be nearest the head end of the film and the stop character shall be nearest the tail end of the film, regardless of the orientation of the human-readable characters; i.e., when the film is transported in the normal direction of travel past a fixed scanning position, the start character shall be read first.

**6.4.4** The 8 bar code characters (16 data digits) are defined as follows:

**6.4.4.1** The first character shall be encoded with a two-digit manufacturer code. These codes shall be assigned as per Table 3. Other codes are reserved for future assignment by the SMPTE.

**Table 3**  
Manufacturer Codes

Manufacturer	Code
Agfa-Gevaert N.V.	01
Eastman Kodak Company	02
Fuji Film Company	03
Other or nondesignated	00

**6.4.4.2** The second character shall be a two-digit product specification code assigned at the discretion of the manufacturer. If the manufacturer does not wish to identify the product, the digits 00 shall be encoded.

**6.4.4.3** The third through seventh characters shall be encoded with the 10 characters of key number information. These shall be the same information as in the immediately adjacent human-readable key number. The third character shall contain the most significant digits and the seventh character shall contain the least significant digits.

**6.4.4.4** The eighth character shall be encoded with a two-digit offset in perforations from the preceding key number. This offset shall be 00 for the key numbers described above and 32 for the mid-foot key number described in 6.5.

**6.4.5** The check sum is equal to the modulo 103 sum of the value of the start character and

the weighted values of the eight data characters as specified in USS 128.

**6.5** Mid-Foot Key Number. A mid-foot key number, as shown in Fig. 1, shall be placed halfway between each key number. The mid-foot key number shall have two parts: a mid-foot human-readable key number and a mid-foot machine-readable key number.

**6.5.1** Mid-Foot Human-Readable Key Number. The mid-foot human-readable key number shall consist of a zero-frame reference mark, an adjacent key number that is to be nearer the head end of the roll, and an offset in perforations which is to be 32 always. The mid-foot key shall thus have the format "XA 12 3456 7890 + 32." The mid-foot key number shall have the same orientation as the standard human-readable key number (see 5.6.2). All characters are to be small in size (approximately 1/2 size).

**6.5.2** Mid-Foot Machine-Readable Key Number. The mid-foot machine-readable key number shall consist of a bar coded message in exactly the same format as specified in 6.4. The offset-in-perforations digits will be set to 32.

**7. Optional Frame Index Mark**

**7.1** An optional frame index mark may be placed on the film in the form of a hyphen placed every four perforations except where it would overlay some other edge information, as shown in Fig. 1. The index marks shall be aligned midway between the perforations coincident with a possible position of the frame line.

**7.1.1** A "reference space" is defined as being the space between the perforation above the zero-frame reference mark and the perforation immediately to its left (toward the tail of the film).

**7.1.2** The frame index marks shall be printed at 4-perforation intervals and shall be aligned longitudinally such that, were it to be printed, a mark would fall on the reference space.

## 8. Optional Manufacturer-Identification Information

8.1 Additional manufacturer information may be printed along the edge of the film as shown in Fig. 1. This information is to be printed in small size characters (approximately 1/2 size).

### 8.2 Recommended Minimum Information

8.2.1 **Manufacturer's Name.** The first piece of information shall be the name of the manufacturer. This, in general, shall be an abbreviated name, rather than the full company name.

8.2.2 **Film Type.** The second piece of information, separated from the manufacturer's name by a space, shall be the film type. Its form, whether numeric, alphabetic, or mixed, shall be at the discretion of the manufacturer.

8.2.3 **Additional Information.** The manufacturer may place additional information following the film type, if so desired. This may include batch numbers, for example. It is recommended that the length of this information be limited so the entire string of manufacturer-identification information is no more than 12 perforations long.

8.2.4 **Repeat Distance.** The repeat distance of this information is at the discretion of the manufacturer, but the repeat distance shall be a multiple of 64 perforations, and a distance of no more than 192 perforations is recommended.

## Appendix

(This Appendix is not part of the American National Standard, but is included for information only.)

The orientation of the human-readable key numbers has been left to the manufacturer's discretion in this standard. However, it is suggested that in the next review of this

## 9. Bar Code Scanner and Density Specifications

9.1 **Spectral Scanner Sensitivity.** The peak or maximum response of the combination of the light source, filters, and photo receptor shall be at 680 nm  $\pm$  60 nm. In addition, the lower wavelength at which the response is down to 10% of peak response shall be equal to or greater than 600 nm and the upper wavelength at which the response is down to 10% of peak response shall be equal to or less than 760 nm. Notwithstanding these specifications, the spectral response of the scanning system must be designed for good differentiation between bars and spaces with existing conventional color and black-and-white films.

9.2 **Density of Machine-Readable Messages.** The edge print applied by the manufacturer shall be exposed so that, when the film is processed through the manufacturer's recommended process, the bars have a status M red density of  $D_{\min} + 0.75 \pm 0.25$  and the spaces have a nominal density no more than 0.05 greater than the minimum density of the film.

9.3 **Density of Printed Machine-Readable Messages.** When the machine-readable message is printed onto a conventional color print film, it is recommended that the edge lights on the printer be controlled to produce a status M red density of the bars of  $2.00 \pm 0.30$ .

When the machine-readable message is printed onto a conventional color intermediate film, it is recommended that the edge lights on the printer be controlled to produce a status M red density of the bars of  $D_{\min} + 0.75 \pm 0.10$ .

# Cinematography — Screen luminance for the projection of motion-picture prints in indoor theatres and review rooms

## 1 Scope

1.1 This International Standard specifies the screen luminance level and chromaticity, as seen by a seated viewer, for theatrical projection of 70 mm, 35 mm and 16 mm motion-picture prints at 24 frames per second in indoor theatres and review rooms used in judging the quality of prints for international distribution.

For the purposes of this International Standard, the term "screen" is the screen-picture area appropriate to the film format and projection system in use.

1.2 It is also recommended that this International Standard be followed for non-theatrical presentation of 70 mm, 35 mm and 16 mm motion-picture prints intended for projection at 24 frames per second.

## 2 Measurement of luminance

### 2.1 Main conditions

The luminances specified are measured with the projector operating at a nominal projection speed of 24 frames per second with the shutter running and without film in the gate.

NOTE 1 Measured luminance is affected by the lens in use, and other optical components.

### 2.2 Measuring device

The screen luminance shall be measured with a photometer having an acceptance angle not greater than 2° (recommended value 1.5°), having the spectral sensitivity of a Standard Observer,<sup>1)</sup> agreed to by the International Commission on Illumination in

1924, and adopted in 1933 by the International Committee of Weights and Measures.

### 2.3 Position of measuring device in theatres

In theatres, the measurements shall be taken with the photometer located approximately 1 m above the floor on the longitudinal axis of the theatre in the centre of the main seating area. To ensure satisfactory performance in all parts of the theatre, measurements shall also be taken with the photometer located approximately 1 m above the floor at two points on a transverse line across the theatre at a position two-thirds of the distance from the screen to the back row of seats (measured from the screen), and at a distance of one-third of the theatre width to each side of the longitudinal axis of the theatre.

### 2.4 Position of measuring device in review rooms

In review rooms, the measurements shall be taken with the photometer located approximately 1 m above the floor on the centre-line of the review room, at the viewing location(s) where print quality decisions are normally made.

## 3 Luminance level of screen centre

3.1 For review rooms used in judging prints for international distribution, the luminance level of the screen centre shall be  $50 \text{ cd/m}^2 \pm 7 \text{ cd/m}^2$  for each format in use.

3.2 For indoor theatres, the luminance level of the screen centre shall be  $50 \text{ cd/m}^2 \pm 15 \text{ cd/m}^2$  for each format in use (see annex A).

1) Publication CIE No. 15.2, *Colorimetry*, 2nd edition, 1983.

#### 4 Luminance distribution

##### 4.1 Measurement of screen edges

The luminance of the screen edges shall be measured on the horizontal centre-line of the screen at a distance from the screen edges equal to 10 % of the width of the screen. When measured from the points specified in 2.3 and 2.4, the two edge measurements shall be within 10 % of each other and not less than 50 % and not more than 85 % of that at the centre, with a recommended value of 75 %.

##### 4.2 Evenness of luminance distribution

Over the complete screen area, the luminance shall appear to be even, and substantially symmetrical about the screen centre. This should be checked from multiple positions of the seating area, especially along the extremes (sides and balconies) when using "high gain" screens.

#### 5 Spectral distribution

When using xenon or carbon-arc light sources, the light reflected from the screen shall have a spectral distribution comparable to that of a black body at a colour temperature of  $5\,400\text{ K} \pm 400\text{ K}$ .

NOTE 2 Certain special 35 mm prints and some 16 mm prints are made for projection with incandescent tungsten source illuminants. Such prints should be clearly labelled as intended for tungsten illuminants.

#### 6 Multiple projector adjustment

##### 6.1 Luminance match for projector units of same formats

The luminance resulting from all projectors intended for use in the continuous viewing of material of the same format shall not vary by more than  $7\text{ cd/m}^2$  at the screen centre.

##### 6.2 Luminance match for projector units of different formats

The luminance resulting from projectors intended for use in the sequential viewing of materials of different formats shall not vary by more than  $14\text{ cd/m}^2$  at the screen centre.

##### 6.3 Colour temperature match

The difference in correlated colour temperature of the light reflected from the screen when using projectors intended for sequential operation shall not be more than  $400\text{ K}$ . For 16 mm projection with sources having a correlated colour temperature of  $3\,500\text{ K}$  or less, the range shall be limited to 7 % or  $200\text{ K}$ , whichever is the greater.

#### 7 Stray light

7.1 No stray light or illuminated source with a luminance in excess of  $3.5\text{ cd/m}^2$  shall be visible from the standard observing area of a review room.

7.2 Light on the screen from stray light or flare shall be kept as low as possible. In review rooms, stray light on the screen shall not exceed 0.4 % of the screen luminance from the projector. In theatres, the stray light shall not exceed 1.0 %.

### Annex A (informative)

#### Acceptable limits of screen luminance

The range of screen luminance acceptable for indoor theatres is based on practical experience and limitations. It should be understood that the nominal light level in review rooms has been established at  $50\text{ cd/m}^2$  for all formats (3.1). Therefore, it follows that in order to reproduce the pictorial qualities seen in the review room, the value for theatres should also be  $50\text{ cd/m}^2$ . However, satisfactory performance can be obtained within the stated limits. The

lower limit of  $35\text{ cd/m}^2$  is dictated by the need to maintain sufficient luminance to perceive colour and detail, especially in dark scenes. The upper limit of  $65\text{ cd/m}^2$  is the maximum before significant perception of flicker occurs (assuming 48 interruptions per second by the projector shutter).

For non-theatrical use, a lower limit of  $25\text{ cd/m}^2$  may be dictated by light output limitations of portable projection equipment, especially 16 mm.