Projected Image System
Contrast Ratio
Abstract

This Standard defines projected image system contrast ratio and its measurement. It applies to both permanently installed systems and live events. It applies to front and rear projection. This Standard defines four contrast ratios based on content viewing requirements. System contrast ratio refers to the image as it is presented to viewers in a space with ambient light. Practical metrics to measure and validate the defined contrast ratios are provided.

Keywords

Analytical decision making; audiovisual; audiovisual standard; AV; AV system performance; basic decision making; contrast; contrast ratio; detail; digital signage; front projection; full motion video; image contrast; image quality; InfoComm; information; informational display; inspection; passive viewing; presentation; projected image; projector; projection; projection screen; rear projection; system contrast ratio; videoconferencing

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Foreword

A projected image is often the centerpiece of an installed audiovisual system or a live event. Viewers depend on a projected image to convey information in adequate detail and quality to achieve the content viewing requirements relative to their stated purpose or application while avoiding eyestrain or fatigue. Image contrast, a relative metric (expressed as a ratio), is one of the most important measurable criteria when assessing projected image quality. Historically, definitions of image contrast and the way contrast is measured have generated confusion. This Standard provides a clear definition of the projected system contrast in practical applications. It complements subjective assessment with new objective measurement techniques.

It is important to note that no singular contrast ratio will satisfy the wide range of projected image system viewing requirements. Contrast ratio requirements vary, depending on intended purpose. As such, this Standard defines four viewing categories based on their stated purpose and establishes the required minimum contrast ratios for each viewing category.

The human visual system perceives light differently than a light meter measures it. The eye is a sensitive instrument, working within a dynamic range of luminance greater than 1,000,000:1. The magnitude of this dynamic range requires significant mediation by the human visual system. Light meters are typically linear instruments while the human visual system’s responses to light are typically logarithmic (a similar distinction occurs in the case of sound and hearing). These factors are considered in this Standard.

The quality of a projected image is not determined by contrast alone, however. Image quality can be assessed using other criteria such as luminance, color rendition, resolution, video motion rendition – and even how glossy a screen is. Nevertheless, contrast remains the fundamental metric to determine image quality because significant elements from other criteria are often implicit in, or connected to, contrast. Acceptable contrast levels usually imply – although not guarantee – other performance metrics.

Neither contrast ratio nor this Standard determines the preferred white or black levels relative to the luminance levels from surfaces adjacent to a projected image, which can influence eyestrain for users in the given environment. Users of this Standard are urged to include such ergonomic factors within their wider project considerations.

This Standard is not designed to be used for competitive positioning between manufacturers or technologies. It is the system that is tested and evaluated, without reference to the component elements.

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1. Scope, Purpose, and Application

Scope

This Standard addresses the image contrast ratio of display systems typically used in presentation environments utilizing front and rear projection. Although these methodologies and procedures can be applied to many display system types and applications, this Standard pertains to audiovisual presentation systems including permanently installed systems and live events.

This Standard is limited to image contrast ratio measurements and does not include testing and measurement of related display factors such as display luminance, image size, display resolution, or other factors relating to the overall performance of the projected image. This Standard does not use any kind of on/off or sequential tests, typically found in sales specifications and brochures. Measurement is of contrast achievable on the same image at the same time using a 16-zone black-and-white intra-frame (checkerboard) test pattern.

Purpose

The purpose of this Standard is to define acceptable minimum contrast ratios for projected images, relative to their stated purpose or application. By defining the projected image system contrast ratio and providing suitable measurement and reporting methodologies, metrics for system specification and verification can be applied.

The contrast ratios defined in this document comprise a combined output of a “projected image system,” defined within the Standard as a projector, projection screen, and the impact of ambient light. The term “contrast” is further qualified as “projected image system contrast ratio” (PISCR) because the individual performance factors of the projector and screen are only contributory factors to the delivered contrast ratio of the installed system. It is also termed as “system” contrast ratio because the maximum contrast ratio a projector and screen can deliver is ultimately affected and thus determined by ambient light.

In this context, contrast is defined as the absolute difference in luminance between the peak white and black levels, where white and black luminance is displayed simultaneously. The definition and its measurement is commonly referred to as “ANSI contrast ratio.” However, the original ANSI standards, retired in July of 2003, ANSI/NAPM IT7.228-1997 Electronic Projection – Fixed Resolution Projectors and ANSI/PIMA IT7.227-1998 Electronic Projection – Variable Resolution Projectors, measured illuminance (i.e., measurement of direct light from the projector). This Standard uses the 16-zone black-and-white checkerboard intra-frame test pattern used in the aforementioned standards to measure luminance reflected from or transmitted through the projection screen.

Application

This Standard is designed to facilitate informed decision-making for projector and screen selection, relative to location and stated purpose. Requirements of this Standard apply to:

- Planning and designing projected image system installations;
- Setting minimum and optimum contrast ratios relative to stated purposes;
- Testing and signing off completed projected image system installations; and
- Assisting in determining possible remedial solutions where a system is out of conformance with this Standard or otherwise inadequate for the stated purpose.

This Standard defines four viewing requirement categories. These categories define the required contrast ratio relative to stated purpose or application.
A viewer is defined as a person with normal/corrected vision, or normal visual acuity as defined in the normative reference, *The International Council of Ophthalmology, Visual Acuity Measurement Standard*, 1984. Visual acuity is the capacity of the eye to see fine detail measured by determining the finest detail that can be detected.

The four viewing requirement categories defined by this Standard are:

A. **Passive Viewing**

The viewer is able to recognize what the images are on a screen and can separate the text or the main image from the background under typical lighting for the viewing environment. The content does not require assimilation and retention of detail, but the general intent is understood. There is passive engagement with the content (e.g., non-critical or informal viewing of video and data).

B. **Basic Decision Making**

The viewer can make basic decisions from the displayed image. The decisions are not dependent on critical details within the image, but there is assimilation and retention of information. The viewer is actively engaged with the content (e.g., information displays, presentations containing detailed images, classrooms, boardrooms multi-purpose rooms, product illustrations).

C. **Analytical Decision Making**

The viewer can make critical decisions by the ability to analyze details within the displayed image. The viewer is analytical and fully engaged with these details of the content (e.g., medical imaging, architectural/engineering drawings, forensic evidence, photographic image inspection).

D. **Full Motion Video**

The viewer is able to discern key elements present in the full motion video, including detail provided by the cinematographer or videographer necessary to support the story line and intent (e.g., home theater, business screening room, broadcast post-production).

A more detailed discussion of each viewing requirement category and a summary chart can be found in Appendix 3.

**Exceptions**

A. This Standard is limited to projected image contrast ratio measurements and does not include related factors such as display luminance, image size, or display resolution.

B. This Standard does not apply to direct view luminous “flat panel” displays (e.g., LCD, plasma, LED, OLED, CRT).

C. This Standard does not apply to reflective technology displays (e.g., “electronic paper” displays).

D. This Standard defines contrast ratio as a relative metric and measurement. It does not prescribe actual white or black luminance levels of an image since those levels should be determined relative to the ambient light level of the viewing environment. Users of this Standard should address image luminance levels as part of the system design process.

E. This Standard does not use any kind of full-on/off or sequential tests (typically found in sales specifications and brochures).

F. Systems for which the criteria and procedures outlined in this Standard may not apply include specialized applications such as broadcast, military, entertainment and museum display.
these and other specialized cases, contrast ratio criteria and measurement procedures may need to deviate from the requirements and guidelines in this document. Care should be taken when attempting to apply the methods and procedures included in this document to audiovisual systems with special or unusual purposes, including systems for which the primary function is not presentation of visual information to an audience.

G. This Standard should be used with caution in outdoor installations where there may be large variations of uncontrollable ambient light.

H. This Standard does not address the projected image contrast ratio required for digital cinema. The requirements of this viewing category go beyond Full Motion Video to realize the artistic vision of the videographer or cinematographer.

I. This Standard does not use other contrast formulae, such as \[\text{white level} + \text{black level}\]/black level.

2. Referenced Publications

Normative References
The following standards contain provisions that, through reference in this text, constitute provisions of this document. At the time of approval, the editions indicated below were valid. Because standards are periodically revised, users should consult the latest revision approved by the sponsoring Standards Developing Organizations:


Informative References
The following publications contain information that supports the design and application of this Standard, but are not required provisions of the standard:


3. Definitions
For the purpose of this Standard, the following definitions apply:

a. **16-zone Checkerboard**: The test pattern made up of alternating black-and-white rectangles forming 16 equal zones in four rows.

b. **Ambient Light on Screen**: The illuminance level affecting the projection screen.


d. **Black Level**: The lowest level of luminance a system is capable of producing.

e. **Brightness**: A subjective term for the way light intensity is perceived by the human visual system. Referring to our experience and impression of light, it is not a metric of its magnitude. As used in this Standard, the term brightness is not to be confused with “brightness” controls on a projector.

f. **Center Line**: A notional horizontal or vertical line that bisects the screen, referenced in the example Viewing Area Plans provided in this Standard. Used for defining location of objects relative to the screen.

g. **Closest Viewer**: Viewer positioned at the shortest distance from the screen as defined by the viewing area.

h. **Contrast**: Absolute difference in luminance between the peak white and black levels, where white and black luminance is displayed simultaneously. As used in this Standard, the term contrast is not to be confused with “contrast” controls on a projector.

i. **Contrast Ratio**: The numeric ratio of the highest and lowest luminance levels simultaneously present within an image.

j. **Farthest Viewer**: Viewer positioned at the farthest distance from the screen as defined by the viewing area.

k. **Full On/Off Contrast**: Also known as “Sequential Contrast Ratio.” The difference in intensity between the “FULL ON” and “FULL OFF” intensities of the display device. Contrast is measured in two separate tests. This version of contrast is not used in this Standard.

l. **Illuminance**: Light falling on a surface, measured in Lux (lx) or Foot-Candle (ft·c or fc) [1 lux = 0.09 fc]. Not visible to human eye other than in the form of reflected luminance.

m. **Incident Light Meter**: A type of light meter used to measure illuminance (i.e., ambient or environmental light). Also known as an illuminance meter, an incident light meter uses a white sphere, similar to an

n. **Luminance**: Light emitted or reflected from an object, measured in Candelas per square meter (cd/m², also referred to as a ‘nit’) or foot-Lambert (fl). [1 nit = 0.292 fl].


4. Requirements

Four minimum contrast ratios are defined based upon the proposed use or uses identified by the viewer. A system may comprise one or more of these viewing requirement categories. The user of this Standard shall determine the appropriate viewing requirement category contrast ratio or ratios before beginning measurement procedures.

Viewing Requirement Categories and Minimum Contrast Ratios

The four viewing requirement categories and their required minimum contrast ratios are as follows:

- **Passive Viewing** requires a minimum contrast ratio of 7:1.
- **Basic Decision Making** requires a minimum contrast ratio of 15:1.
- **Analytical Decision Making** requires a minimum contrast ratio of 50:1.
- **Full Motion Video** requires a minimum contrast ratio of 80:1.

These contrast ratios shall be achieved within the viewing areas defined by the usable space and application.

The minimum contrast ratio shall be achieved at five points of measurement. Measurement locations are defined below.

Measurements taken shall be luminance measurements and shall be taken under conditions that reflect the conditions at time of application or under conditions that simulate the application environment (i.e., if projecting at night, test at night, if viewers are seated, take measurements at seated positions).
Preparation of a Viewing Area Plan Is Required.
The required Viewing Area Plan must identify:
A. Image width and height
B. Center of image (horizontal center line of screen)
C. Plane of screen (vertical)
D. Height of screen from floor
E. Five viewing locations identifying distance to plane of screen and center line of screen.

The viewing location positions shall be defined as follows:

1. **Viewing Location 1**: Viewing location closest to the screen and farthest to the left in the plan view. (The viewing location closest to the screen, situated laterally to the left of the vertical center line axis of the screen).

2. **Viewing Location 2**: Viewing location closest to the screen and farthest to the right in the plan view. (The viewing location closest to the screen, situated laterally to the right of the vertical center line axis of the screen).

3. **Viewing Location 3**: Viewing location at the central point of viewing locations 1, 2, 4 and 5. In the case where this central viewing location is obstructed (e.g., by a conference table) the measurement location shall be the first available viewing location on the screen center line behind the obstruction.

4. **Viewing Location 4**: Viewing location farthest from the screen and farthest to the left in the plan view. (The viewing location farthest from the screen situated laterally to the left of the vertical center line axis of the screen).

5. **Viewing Location 5**: Viewing location farthest from the screen and farthest to the right in the plan view. (The viewing location farthest from the screen situated laterally to the right of the vertical center line axis of the screen).

At each of the five viewing locations identified, 16 luminance measurements shall be taken, ensuring that each measurement is taken at the average eye level for the viewer.

Mandatory Projected Image System Criteria
The projected image system shall meet the following criteria:

A. Screen: Screen shall be installed according to the designer’s and manufacturer’s specification;
B. Lighting: Luminaires shall be on and functioning, and if a room dimming system is present, the appropriate lighting pre-set should be selected;
C. Projector setup: Projector shall be set up and operating as it would be for intended usage. The following items shall be checked and adjusted according to the manufacturer’s procedures:

1. **Warm-up**
   Allow projector lamp to reach standard operating temperature according to manufacturer’s recommendations.

2. **Setup**
   a. Check image size and geometry;
   b. Select projector’s internal color settings as required (or perform colorimetry calibration according to the manufacturer’s or otherwise recognized procedure);
   c. Set pixel clock and phase as required;
Contrast measurement shall follow the procedure below using the 16-zone black-and-white checkerboard (intra-frame) pattern.

**Equipment Required:**
- Photometer (luminance meter or spot photometer with up-to-date calibration) with spectral luminance response of the standard observer with photopic vision as defined in CIE S002. The acceptance angle of the meter shall be 2° or less.
- Completed Viewing Area Plan
- 16-zone black-and-white checkerboard test pattern (4 columns by 4 rows)
- Measurement form
- Tape measure or rangefinder

**Measurement Procedure**
This procedure shall be documented for each lighting environment that may be required of a venue based on the viewing category requirements.

**Step 1** Display a 16-zone black and white checkerboard test pattern on the projection screen as illustrated in the figure below under conditions that represent actual viewing environment.

**Step 2** From the first measurement position identified on the Viewing Area Plan (Viewing Location 1), measure and record the luminance values at the center of each of the eight white rectangles.

**Step 3** From the same measurement position, measure and record the luminance values at the center of each of the eight black rectangles.

**Step 4** Calculate the average of the eight white measurements and the average of the eight black measurements.

**Step 5** Divide the resulting average white value by the average black value to obtain the contrast ratio at that measurement position.

\[
\text{Contrast Ratio} = \frac{\text{Luminance average max}}{\text{Luminance average min}}
\]
Step 6  Repeat the contrast measurement procedure at each of the five measurement positions identified on the Viewing Area Plan.

Step 7  Record the resulting contrast ratios for each of the measurement positions on the Viewing Area Plan and determine the level of conformance as defined:

- Passive Viewing requires a minimum contrast ratio of 7:1.
- Basic Decision Making requires a minimum contrast ratio of 15:1.
- Analytical Decision Making requires a minimum contrast ratio of 50:1.
- Full Motion Video requires a minimum contrast ratio of 80:1.

5. Verification

Verification of conformance to this Standard includes completed measurements of the contrast ratio at the five locations identified on the Viewing Area Plan using the required measurement procedure and mandatory projected image system criteria, previously defined in Section 4 (Requirements) of this Standard.

Based on the contrast ratio determined by the documented measurement results, the projected image system

**CONFORMS:** The contrast ratios at all five measurement (viewing) locations meet or exceed the contrast ratios required by the identified viewing category.

**PARTIALLY CONFORMS:** The contrast ratio of one but no more than four measurement (viewing) locations falls below the required contrast ratio for the identified viewing category by no more than 10%. Should the space partially conform, probable cause shall be noted on the measurement form.

**FAILS TO CONFORM:** The contrast ratio at any one of the measured locations falls below the identified viewing category by more than 10%. Should the space fail to conform, probable cause(s) shall be noted on the measurement form.

Examples of Viewing Area Plans

Three examples showing the required elements of the Viewing Area Plan for possible viewing scenarios follow.
Viewing Area Plan: Home Theater

NOTE: All dimensions for viewer position refer to horizontal center line, vertical center line, and plane of screen.

SCREEN DIMENSIONS: 3.48 M (147") WIDE X 1.77 M (70") HIGH (127" W X 60") APF

CENTRE LINE OF SCREEN

(130.00")
3048 mm

SCREEN

HORIZONTAL CENTER OF SCREEN 1.61 M (60") APF

POINT OF PLANE

(49.41")
1250 mm

(51.91")
1315 mm

(31.9"")
340 mm

(23.6")
609 mm

(24.9")
635 mm

(40.5")
894 mm

(90.4")
2400 mm

(100")
2500 mm

(101")
2540 mm

(102")
2580 mm
## Sample Measurement Conformance Form

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<th>Location</th>
<th>C conform</th>
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<td>Client</td>
<td>Test Ref#</td>
<td>P partial</td>
</tr>
<tr>
<td>Viewing Category</td>
<td>Time of Test:</td>
<td>F fail</td>
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</table>

### Viewing Location 1

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<th>Luminance</th>
<th>White 1</th>
<th>White 2</th>
<th>White 3</th>
<th>White 4</th>
<th>White 5</th>
<th>White 6</th>
<th>White 7</th>
<th>White 8</th>
<th>Avg</th>
<th>Contrast</th>
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### CONFORMANCE RESULT

- Conforms
  - Partially Conforms
  - Fails to Conform

**Notes**

**Explanation**

**Test Equipment**

**Tester’s Name**
Sample Form With Optional Detailed System Information

Although this form exceeds the requirements of this Standard, should the system fail to conform, additional information may prove to be a valuable analysis tool for potential remediation.

<table>
<thead>
<tr>
<th>Location:</th>
<th>Date of Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewing Requirement Category:</td>
<td></td>
</tr>
<tr>
<td>Ambient Light:</td>
<td></td>
</tr>
<tr>
<td>Viewing Location Contrast Ratios: 1) : 2) : 3) : 4) : 5) :</td>
<td></td>
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</tbody>
</table>

| Projector Make and Model | |
|-------------------------| |
| Native pixel resolution | |
| Projector lens throw ratio or distance | |
| Lamp hours elapsed | |
| Comments | |
| Lens model | |

| Screen Make and Model | |
|----------------------| |

| Front/Rear | |
|------------| |
| Type of material | |
| Aspect ratio of screen | |
| Image height | |
| Image width | |
| Focal length (if Fresnel type) | |
| Comments | |

| Lighting | |
|----------| |
| General description | |
| Lighting type near the screen | |
| Is lighting near the screen independently controllable? | |
| Main room or working area lighting description: type; dimmable? Pre-set lighting levels and/or scenes? | |
| Number of lighting scenarios to be measured | |

| Room | |
|------| |
| Primary purpose of room | |
| Possible hours of use (time of day) | |
| Room dimensions | |
| Ceiling height | |
| Description of room, including color and main surfaces | |
| Distance of closest viewer to screen (from center line) | |
| Distance of farthest viewer to screen (from center line) | |
| Angle of end seat, front row, to screen center (plan view) | |
| Description of windows and known influences on screen | |
| Description of type of window coverings and control (e.g., manual, powered, etc.) | |
Appendix 2: Test Rationale, Procedure, and Results

The goal of the Projected Image System Contrast Ratio (PISCR) Task Group was to establish an easy-to-follow methodology by which the system contrast ratio of a projected image system could be established and evaluated. The task group conducted extensive evaluations of the key elements affecting the performance of a projected image system including the variables of ambient light, the projector, and the screen. These three variables were analyzed from the perspective of the viewing criterion using researched testing methods, accurate instrumentation, and appropriate test patterns to measure and evaluate the findings.

Preparation

The group researched, examined, and discussed ANSI, ISO, IEC, and other existing standards and best practices relating to projected image contrast. Joseph Bocchiaro provided the group with information about standard development and the broader requirements that the research, writing, deliberation, and delivery entails to satisfy the rigorous requirements of the ANSI standard development process. Members of the group with highly regarded expertise on specific subject matter made presentations as a basis for group deliberations.

Consensus and Unanimity

The task group determined that agreement upon the acceptable contrast ratio for each of the identified categories should be unanimous. The group then began by reaching consensus on a set of qualitative viewing criteria with the goal to determine what the minimum system contrast levels would be for each criteria level. The task group developed metrics for evaluation of how much ambient light versus detail or information loss was acceptable in relationship to the viewing criteria. Extensive research and group time was spent determining the testing criteria and test materials.

Procedure

Different testing setups and procedures were trialed, discussed and refined until the group came to consensus on the testing processes that would provide the required data, meet the demands of the Standard, and be replicable. Once the testing procedures and materials were agreed upon, the tests were conducted at different locations and on different occasions using different screens and projectors to generate sufficient data as a basis for an informed decision about acceptable minimum contrast ratios for each viewing requirement category and also to highlight irregularities in outcome. Tests were performed under controlled and reproducible conditions where image contrast could be adjusted by means of ambient light controls. Numerous tests were performed to provide the committee with enough data to reach consensus on the minimum and optimum contrast ratios for each of the four viewing requirement categories.

Screen

For the purposes of this Standard, testing utilized a 1.0 gain reference screen. This screen was used to conform as closely to a Lambertian surface as possible (i.e., that it should reflect all incident light [illuminance]) so that measured luminance is equal, regardless of the angle of view. The surface could be magnesium oxide (MgO), barium sulfate (BaSO₄), magnesium carbonate (MgCO₃), or Spectralon®; the task group used the latter material.

The screen measured 2794mm (110") diagonal (1372mm x 2438mm or 54"x 96"). The material used was Stewart Snomatte 100.

Projector

All projectors used in these tests were black level and white level calibrated (brightness and contrast) to optimize dynamic range. The group used a PLUGE pattern to set proper black level and grayscale pattern to set proper white level. Several projectors were used in this testing, and the make, model, and lumen output were noted in the test data.
To eliminate any variance in the testing results, a regulated power supply with ability to maintain the projector specified voltage ±1% was used. This is important because a 1% change in voltage equates to approximately 4% change in light output from the projection lamp. In a real world scenario, the brightness difference can affect overall system contrast ratios at various times of operation, but such a power supply is not typically required.

**Light**

In this test, the area where the system testing was performed was equipped with control over ambient light. With the projector off, ambient light measured off the screen was at 1 lux [0.01 foot candle] or less.

Dimmable stage lighting was provided to simulate the effect of ambient light on the projected image. Four 100-watt PAR lamps in lighting instruments attached to T-bar mounts and light stands were positioned at 45 degrees from center axis, 5.64 meters (18’ 6”) distance from the screen.

Lamps were regulated by a dimmer to allow for discrete lighting control.

Irrespective of location, tests were conducted using a portable lighting system with variable and preset dimming controls as well as lighting controls in the rooms themselves. Tests were performed at multiple locations, but in each case the room could be brought down to an illumination level of less than one lux, or dark enough that a standard light meter would read zero illumination, or raised to the level where the image on screen was completely invisible due to ambient light overcoming the projector’s illumination.

Lighting instruments were placed at 45-degree angles to the screen, at a constant distance equal to the projector lens throw. The instruments were focused and aimed to provide an even, general illumination wash over the screen, and the dimmer control panel could adjust them as a single unit to keep illumination even.

**Luminance Measurement Equipment**

Calibrated photometers with spectral luminance response of the standard observer with photopic vision as defined in CIE S002 were used. The acceptance angle of the meters needed to be 2° or less. The measurement equipment used for testing met the equipment specifications for this Standard. Minolta LS100, Minolta LS110, Sekonic L-558 Cine, and Minolta CS200 were used, all conforming to the CIE S002 specification.

**Test Procedure Used by Task Group**

1. Allow projector to warm up to full brightness (30 minutes minimum)
2. Adjust ambient light to appropriate level for selected viewing criteria
3. Display evaluation image to verify that loss of data is acceptable for viewing criteria level
4. Using a laser protractor, measuring tape, and masking tape, mark out a measurement location directly behind the projector and on axis to the screen for performing contrast ratio test
5. Utilizing test pattern generator, display 16-zone black and white checkerboard test pattern
6. Measure displayed system contrast ratio using 2-degree spot photometer
   a. Measure white squares and average
   b. Measure black squares and average
   c. Divide high luminance (white) by low luminance (black) to determine actual contrast ratio
7. Display evaluation image a final time to verify acceptance of image quality

**Signal Source for the Projector and Test Patterns**

A number of still images were evaluated to determine which would be the most appropriate to judge image contrast levels. In the case of Analytical Decision Making, a Native American portrait black-and-white photo...
was selected from the InfoComm Projection Shoot-Out® software disc. The group displayed the chosen test image, then raised and lowered the light levels. This allowed the group to verify the point at which information was lost in the photo test image due to reduced contrast. The task group then worked to achieve consensus upon the acceptable image contrast ratio relative to the specific viewing criteria under consideration. Measurements were then taken to record these acceptable contrast ratios, providing the overall contrast ratio number for each.

In addition to the viewing of static images, the task group tested full motion video. The task group utilized the same environments, variable lighting, and setup test procedures as used in the static image testing. The group recruited the services of a published video and movie critic and reviewer, Leonard Norwitz, who selected test footage containing key elements in the scenes that were necessary to understand the story line of the film. The group established the criterion that if certain elements were not visible in scenes, the viewer would experience incomplete visual information relative to the content of the film and the communication requirements of the filmmaker.

The task group did not know in advance the film or the scenes and members were not told what information or detail in the scene to look for. With no comments or discussion, the film was shown and the task group made observations. Adjustments were then made to the ambient lighting to provide system contrast ratios from 7:1 to 15:1 to 50:1 to 80:1, and then to 100:1. The group observed the loss of information at 7:1, at 15:1, and at 50:1. When the ambient light was reduced further to generate even higher contrast ratios, the group focused on more detailed observation to determine the acceptable minimum contrast ratio for this category.

The content selections used were scenes from North by Northwest, 2001 a Space Odyssey, The Dark Knight, and finally Cars; the content spanned the last few decades and represented a variety of film rendered via telecine into video, footage shot in digital, and computer generated animation. In each instance, the film expert provided scenes that needed specific details to be sufficiently visible in order for the viewer to experience the scene in such detail that the filmmaker intended.

**Results**

Test results confirmed that at 7:1, detail was sufficient to meet the viewing requirements of basic, non-critical passive viewing. Test results confirmed that at 15:1, detail was sufficient to meet the viewing requirements for basic decision making.

Test results also confirmed that both 7:1 and 15:1 provided inadequate contrast for critical viewing of full motion video. When the group tested 50:1, there was still insufficient detail in any footage (other than that in Cars, which is computer generated animation) for critical analytical viewing. The subject matter experts (SMEs) agreed that this was due to the nature of computer graphics (CG) and the “perfect” filming, lighting, and editing environment for that medium. The group was able to see the minimum detail required at 50:1 in CG for analytical viewing. In all other cases the need to provide a contrast of 80:1 to “reveal” what could and could not been seen at 50:1 or less was evident. Many hours of task group evaluation time spent looking at and discussing the footage brought consensus that 80:1 is the minimum for Full Motion Video.
Appendix 3: Viewing Requirement Categories Rationale

When InfoComm initiated development of this Standard, one of the initial tasks was to define viewing requirement categories with strong definitions using defensible metrics against which minimally acceptable contrast ratios could be defined, based on the intended purposes for which an image is to be used. At the earliest point, the task group concluded that multiple categories were appropriate and that an initial task would be to decide the quantity of categories necessary and associated definitions that this Standard would require. The widely-used InfoComm Academy® “best practices” screen size categories were adapted for this purpose.

All subject matter experts (SMEs) comprising the task group agreed upon recognition of Contrast Sensitivity Function as a founding principle: a building block of visual perception that explains and informs the selection of contrast as the key metric in defining image acuity.

Contrast Sensitivity Function (CSF) describes a person's ability to see objects in terms of size and contrast. Small objects, for example, can be perceived only when their contrast is high. Medium-sized and large objects, on the other hand, often can be perceived when their contrast is low. Thus, CSF is a metric describing perceiving—“seeing”—objects against contrasting background.

Group deliberations included practical tests under controlled conditions with a panel of SMEs. Additional research and publications were consulted. This panel reached unanimous agreement on both the quantity of viewing categories and their definitions.

A. Passive Viewing

The viewer is able to recognize what the images are on a screen and can separate the text or the main image from the background under typical lighting for the viewing environment. The content does not require assimilation and retention of detail, but the general intent is understood. There is passive engagement with the content (e.g., non-critical or informal viewing of video and data).

This is a minimally acceptable contrast ratio, primarily for passive presentations or passively watching images on a screen.

Passive viewing environments are locations where images are displayed to an audience as a means of providing informal information. Business presentations may fall into this category if they are informally informational but not dependent on a high level of detail.

In a typical passive viewing environment, ambient light may be high and system contrast may be challenged by room features like task lighting, windows, bright (reflective) surfaces, or projectors with insufficient light output.

B. Basic Decision Making

The viewer can make basic decisions from the displayed image. The decisions are not dependent on critical details within the image, but there is assimilation and retention of information. The viewer is actively engaged with the content (e.g., information displays, presentations containing detailed images, classrooms, boardrooms multi-purpose rooms, product illustrations).

The viewer should be able to understand what is being communicated. Graphic images and text are legible to the extent that the viewer can make basic decisions on the basis of what is being seen. Decisions made are based on comprehending the informational content itself and are not dependent on the resolution of every element of detail.

Basic decision-making viewing applications include the presentation of photographs, detailed graphic images, product illustrations and information displays such as airline departures, sports scores or stock
quotes. In this scenario, the information obtained from the projected image informs a basic decision by a fully engaged viewer.

In a typical basic decision-making environment (e.g., classrooms, multi-purpose rooms, board rooms), there may be some degree of ambient light control, such as window shades and zoned task lighting.

C. Analytical Decision Making

The viewer is fully engaged with minute detail present in the content and needs to be able to resolve every element of the projected image. Analytical decision-making environments support professional assessments, such as the examination of medical imaging, engineering or architectural drawings, electrical schematics, photographic image inspection, forensic evidence or failure analysis.

Analytical decision-making viewing environments typically have controlled ambient light—particularly on or by the screen—often with darkened or anti-reflective surfaces and highly focused task lighting.

The minimum system contrast ratio for analytical decision-making was determined to be 50:1. The task group observed that, in practice, although achievable, close attention to both the system design and environmental characteristics will be necessary to achieve the desired contrast.

D. Full Motion Video

In this category, movies or other full motion videos are projected in a controlled viewing environment with an audience that has a high level of engagement with the content. The viewer is able to discern key elements present in the full motion video, including detail provided by the cinematographer or videographer necessary to support the story line and intent (e.g., home theater, business screening room, broadcast post-production).

Most home theaters and business screening rooms would fall into this category.

To test this viewing requirement category, film historians selected scenes from critically-acclaimed commercially available movies on DVD and Blu-ray to illustrate important levels of detail that can only be perceived with adequate contrast ratios. The evaluation content included classic scenes from Alfred Hitchcock’s *North by Northwest*, Christopher Nolan’s *The Dark Knight*, and many others.

Initially the task group was not told what to look for in a scene, only to respond to something they had not noticed in a prior viewing (i.e., when the system contrast was set to a lower level). As in the other categories, ambient light was adjusted to generate image contrast ratios.

*(Please note: This category does not include professional or commercial digital cinema or Hollywood-level film screening rooms since the criteria for those rooms is more rigorous than is necessary for private rooms. The contrast ratio for commercial digital cinema is established in other publications.)*
### Viewing Requirement Categories Summary Chart

<table>
<thead>
<tr>
<th>Viewing Category</th>
<th>Minimum System Contrast Ratio</th>
<th>Viewer's Requirements</th>
<th>Environment – Example Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Viewing</td>
<td>7:1</td>
<td>- Images and text distinguishable from background</td>
<td>- May have little control of ambient light</td>
<td>Retail stores, family (TV) rooms, presentations of non-critical or informal information</td>
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<td>- Passive engagement with content</td>
<td>- Ambient light may be high</td>
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<td>- Assimilation and retention of detail not required</td>
<td>- Task lighting may not be ideal</td>
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<td>- Informal viewing of video and data</td>
<td>- Windows may have insufficient blinds or curtains</td>
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<td>- May be reflective surfaces (e.g., furniture)</td>
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<td>- Projector light output may be inadequate</td>
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<td>Basic Decision Making</td>
<td>15:1</td>
<td>- Actively engaged with content</td>
<td>Improvements relative to the above category are often in evidence</td>
<td>Information displays, presentations containing detailed data and images (e.g., classrooms, boardrooms, multi-purpose rooms, product illustrations)</td>
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<td>- Assimilation and retention of detail</td>
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<td>- Images and text are legible to the extent that basic decisions can be made</td>
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<td>- Decisions based on content itself, not resolution of detail</td>
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<tr>
<td>Analytical Decision Making</td>
<td>50:1</td>
<td>- Images and text contain finest detail</td>
<td>- Highly controlled environment</td>
<td>Engineering and architectural drawings, electrical schematics, forensic evidence, failure analysis, photographic evaluation (e.g., courtrooms, medical galleries)</td>
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<td>- Assimilation, retention and analysis of finest detail</td>
<td>- Controlled ambient light</td>
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<td>- Analytical image assessment</td>
<td>- Focused task lighting</td>
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<td>- Mission-critical image displays</td>
<td>- No ambient light directly affecting screen, black-out window treatments</td>
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<td>- Professional analysis of detail</td>
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<td>Full Motion Video</td>
<td>80:1</td>
<td>- High level of engagement with content</td>
<td>Precisely controlled ambient light</td>
<td>Controlled viewing environment (e.g., home theater, business screening room, broadcast post -production)</td>
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</table>
Appendix 4: Optional HTML-Based Test Pattern and Operation Instructions

You must download the optional test pattern HTML files to use this application: http://docdev.infocomm.org/apps/group_public/documents.php or email standards@infocomm.org

Purpose

This test pattern was designed to allow a system installer to perform a simple verification test, without requiring additional equipment, to determine if the projected image system in question is within the range of the desired contrast ratio per the requirements of this Standard. It is not meant to replace this Standard; it provides a way to estimate the system’s contrast ratio.

Operation Principle

This HTML test pattern generator was designed to eliminate as many technical challenges and human factors as possible, providing as objective a verification test as can be established using the human eye as a test instrument. The test pattern generator operates entirely within a web browser, and is compatible with all major web browser platforms. The patterns are not pre-generated and stored, but generated on the fly from HTML code. This eliminates the need to store many different test patterns, at different levels of resolution, to allow for optimal display on a given projector. The computer being used to display the test pattern shall be set to the projector’s native resolution, and the test pattern, when loaded, will render to match. The pattern consists of a black background with several different grayscale “chips” or windows appearing on a series of consecutive screens. The viewer will use these chips to determine the performance of the system, as they correspond to differing levels of contrast ratio.

Directions for Use

Use this test pattern under typical operational conditions. The computer being used to display the source should be set to the native resolution of the projector. The test pattern is best displayed using a current web browser. At the time of writing, this includes browsers such as Google Chrome, Mozilla Firefox, Safari, or Internet Explorer 7 or newer.

1. Load the test pattern HTML file.

2. Using the “Section #” button in the upper right, advance through the grayscale values until the rectangular “chip” in the center of the screen is completely visible.

3. Verify that the rectangular “chip” is completely visible by reading the random text string displayed in the center of the “chip.” It is 10 characters long, and can be upper or lower-case English letters and Arabic numerals.

4. Note the number of the section currently showing on screen, and refer to the table below to confirm that the correct section is able to be seen for the chosen viewing criteria.

<table>
<thead>
<tr>
<th>Chip</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>7:1</td>
</tr>
<tr>
<td>3</td>
<td>15:1</td>
</tr>
<tr>
<td>2</td>
<td>50:1</td>
</tr>
<tr>
<td>1</td>
<td>80:1</td>
</tr>
</tbody>
</table>

Note: Grayscale “chip” must be seen distinctly and completely. All text should be completely legible.
APPROVAL VERIFICATION

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