

Subject 2802

October 15, 2012

SUMMARY OF TOPICS

The Standard for Performance Testing for Camera Image Quality, UL 2802, is being proposed for review and comment only:

1. Proposed First Edition of the Standard for Performance Testing of Camera Image Quality, UL 2802

COMMENTS DUE: NOVEMBER 14, 2012

This proposal is for review and comment only. Please note that comments on a review document will not receive a response from the proposal author through CSDS. Instead, the proposal author will be asked to review the comments and adjust the proposals and/or supporting rationale as the author determines to be appropriate. The review process is an informal mechanism that provides authors with the opportunity to refine their proposals before they advance to the next stage in UL's standards development process.

In some cases, the author of the proposals may choose to discontinue them. In this case, the author need not do anything after review has ended.

For your convenience in review, proposed additions to existing requirements are shown underlined and proposed deletions are shown ~~lined-out~~.

1. Proposed First Edition of the Standard for Performance Testing of Camera Image Quality, UL 2802

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PROPOSAL

INTRODUCTION

1 Scope

1.1 This standard defines a method to determine video camera image quality ratings through a series of performance based tests that are conducted on production camera units.

1.2 Each camera tested will achieve a Category Class (I – III) based on the minimum features provided on the camera.

1.3 Each camera tested will achieve a Performance Level (I – V) based on the overall cumulative performance score achieved as a result of the test program conducted on the camera.

2 Undated References

2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

2.2 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Terminology

3.1 For the purpose of this standard, the following definitions apply.

3.2 ΔE – Total color difference based on International Commission on Illumination (CIE) color space.

3.3 CENTERED PROCESS (C_p) – Assuming that the process output has a normal distribution, C_p estimates what the process is capable of producing if the process mean were to be centered between the specification limits.

3.4 DARK ROOM ENVIRONMENT – An environment that can be made completely dark with controllable lighting conditions for light intensity and other optical measurements. A darkroom environment requires a quantitative specification about the visible and infrared light emission level under the condition that all light sources are turned off. Generally the light emission in a dark room environment is 1/10 less than the sensitivity level detectable by the camera.

3.5 LINE WIDTHS PER PICTURE HEIGHT (LW/PH) – A unit to measure the video camera resolution. Combined with a given MTF value, the LW/PH number provides a quantitative measure of the video camera sharpness and resolution.

3.6 MODULATION TRANSFER FUNCTION (MTF) – It is the magnitude of OTF.

3.7 OPTICAL TRANSFER FUNCTION (OTF) – It is the most detailed measure of the resolution of an optical imaging system.

3.8 PROCESS CAPABILITY INDEX (C_{pk}) – Assuming that the process output has a normal distribution, C_{pk} estimates what the process is capable of producing, in the case that the process mean may not be centered between the specified limits. (If the process mean is not centered, C_p overestimates process capability.) $C_{pk} < 0$ if the process mean falls outside of the specification limits.

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3.9 SPATIAL FREQUENCY RESPONSE (SFR) – It is widely used as a method to calculate the MTF for an optical system.

3.10 WHITE BALANCE (WB) – White balance refers to the process of removing unrealistic color casts, so that objects which appear white to human eyes are rendered white in the captured image.

PERFORMANCE

4 General

4.1 In addition to the performance requirements contained within this standard, the product shall comply with the applicable safety requirements contained within one or more of the following standards as applicable:

- a) Standard for Information Technology Equipment, Safety – Part 1: General Requirements, UL 60950-1,
- b) Standard for Audio, Video, and Similar Electronic Apparatus – Safety Requirements, UL 60065, or the
- c) Standard for Audio / Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

4.2 Outdoor use requirements are detailed in the Standard for Information Technology Equipment – Safety – Part 22: Equipment to be Installed Outdoors, UL 60950-22.

4.3 Operating parameters such as Supply Voltage, Input / Output circuit parameters, normal operating temperature, and storage temperature are specified by the manufacturer. The suitability of the camera in the end use application shall be determined by the user.

4.4 Products intended for use in air-handling spaces in accordance with Section 300.22 (C) of the National Electrical Code, NFPA 70, are additionally investigated to the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

5 Video Camera Categorization

5.1 Video cameras are designated by three Category Classes (I – III) and five performance levels (I – V). The cameras Category class is determined based on the functional features of the camera. The camera's overall performance is rated by the aggregate of its' performance scores to categorize the video cameras into five performance levels.

5.1 Category III

5.1.1 The video cameras in Category III are fixed focus cameras. They shall have functions listed in the following table.

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Table 1

	Required	Optional
Auto exposure	Yes	Yes
Auto white balance	Yes	
Bad pixel correction	Yes	
Walking 1's test or test image	Yes	
Digital zoom	Yes	
Window of interest	Yes	
Digital focus		
Auto flicker rejection	Yes	
Manual exposure control	Yes	

5.2 Category II

5.2.1 In addition to the functions for Category III cameras, the video cameras in Category II shall have the functions listed in the following table.

Table 2

	Required	Optional
Automatic optical focus	Yes	
Manual optical focus	Yes	
Manual white balance	Yes	

5.3 Category I

5.3.1 In addition to the functions for Category III and Category II cameras, the video cameras in Category Class I shall have the functions listed the in the following table.

Table 3

	Required	Optional
Automatic optical zoom	Yes	
Manual optical zoom	Yes	
Manual flicker rejection	Yes	
Raw data mode	Yes	

5.3.2 The raw data mode in Table 3 is only used during the camera test for single frame capture.

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5.4 Performance level V

5.4.1 The video camera in performance level V shall have an overall performance score greater than 200.

5.5 Performance level IV

5.5.1 The video camera in performance level IV shall have an overall performance score greater than 400.

5.7 Performance level III

5.7.1 The video camera in performance level III shall have an overall performance score greater than 600.

5.8 Performance level II

5.8.1 The video camera in performance level II shall have an overall performance score greater than 750.

5.9 Performance level I

5.9.1 The video camera in performance level I shall have an overall performance score greater than 900.

6 Video Camera Test Parameters

6.1 Image sharpness

6.1.1 This specification measures the image sharpness at the lens hyper focal distance according to Photography – Electronic Still-Picture Cameras - Resolution Measurements, ISO 12233 (also see Image Sharpness Test, Section 7.3). The overall sharpness score is calculated by averaging the sharpness score at the center and the four corners of the image sharpness target.

6.1.2 The camera under test is to be set to the auto exposure mode or video camera frame rate of 30 feet per second (fps) and the video or image shall be captured.

6.1.3 The equation to calculate the sharpness score is:

$$\text{sharpness} = \alpha\tau + b \text{ (Equation 1)}$$

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$$\alpha = \frac{800}{\tau_h - \tau_l}$$

Equation 2

$$b = 200 - \frac{280000}{\tau_h - \tau_l}$$

Equation 3

6.1.4 Where α is the score coefficient, τ is the resolution in LW/PH, τ_h is the high resolution, and τ_l is the low resolution. From Table 4, τ_h equals to 2500 LW/PH in the center, τ_h equals to 2000 LW/PH in the corner, τ_l equals to 350 LW/PH in the center, and τ_l equals to 280 LW/PH in the corner.

Table 4
Image sharpness score

	Sharpness score used to determine overall performance level	Minimum resolution	Note
Image center sharpness	1000	2500 LW/PH	MTF50
	200	350 LW/PH	MTF50
Image corner sharpness	1000	2000 LW/PH	MTF50
	200	280 LW/PH	MTF50

6.1.5 Five cameras of the same model and design shall be tested in accordance with paragraphs from 6.1.2 to 6.1.2 and the lowest of the sharpness score of the five tested cameras will be the model's Image Sharpness Score.

6.2 Field of view confirmation

6.2.1 The field of view shall be calculated from the measurement, per Field of View Test, Section 7.6, as a part of the sharpness test.

6.2.2 Thirty images shall be captured for each lens configuration, and analyzed for average field of view and standard deviation of the field of view. As an example if the average measured resolution for a video camera is 1000 LW/PH and interval field of view variation is $\pm 2\%$, the resolution for performance score calculation will be 980 LW/PH, (2% lower than the average measured resolution of 1000 LW/PH).

6.2.3 The field of view confirmation does not obtain an independent performance score considered by this standard.

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6.3 Signal to noise ratio

6.3.1 For the purpose to quantitatively measure the grey level, the signal to noise ratio shall be measured, per Signal to Noise Ratio Test, Section 7.9 for each grey level in the grey level measurement. Because the noise level is fixed under a given lighting condition, signal to noise ratio is different for each grey level due to the difference of the signal strength. Therefore, this document only specifies the signal to noise ratio measurement method for grey level and other measurements, but does not specify a score for signal to noise ratio.

6.3.2 The signal to noise ratio test does not obtain an independent score, but the test result will be used in the calculation of the performance score of other parameters such as grey level and sensitivity.

6.4 TV distortion

6.4.1 TV distortion shall be measured per TV Distortion Test, Section 7.11.

6.4.2 The distance between the test target and the video camera shall be adjusted, so that the TV distortion can be captured, per TV Distortion Test, Section 7.11, and calculated at 90%, 70%, 50% and 30% of the viewing field.

6.4.3 The total TV distortion score is an average of the TV distortion scores at 90% of the viewing field, 70% of the viewing field, 50% of the viewing field, and 30% of the viewing field. The linear equation to calculate the TV distortion score is as follows:

$$TV\ distortion = \alpha\tau + b \text{ (Equation 4)}$$

$$\alpha = \frac{800}{\tau_l - \tau_h}$$

Equation 5

6.4.4 Where α is the score coefficient, τ is the distortion in percentage, τ_h is the high distortion, and τ_l is the low distortion. From Table 5, τ_h equals to 5%, and τ_l equals to 0.2%.

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Table 5
TV distortion

Performance score	TV distortion (absolute value)
1000	0.2%
200	5%

6.5 Relative illumination

6.5.1 The relative illumination shall be measured per the Relative Illumination Test, Section 7.8, with the camera manufacturer's default lens correction setting.

6.5.2 The linear equation to calculate the relative illumination score is as follows:

$$\text{Relative illumination} = \alpha\tau + b \text{ (Equation 6)}$$

$$\alpha = \frac{800}{\tau_h - \tau_l}$$

Equation 7

$$b = 200 - \frac{320}{\tau_h - \tau_l}$$

Equation 8

6.5.3 Where α is the score coefficient, τ is the relative illumination in percentage, τ_h is the high relative illumination, and τ_l is the low relative illumination. From Table 6, τ_h equals to 90%, and τ_l equals to 40%.

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Table 6
Relative illumination

Performance score	Relative illumination
1000	90%
200	40%

6.6 Color fidelity

6.6.1 Color fidelity is a parameter indicating how well a video camera image can capture the color of the original subject. Because the light source and the color test target can vary, it is necessary to calculate both the tri-stimulus and the sensor response for the given light source and the color test target.

6.6.2 According to Graphic Technology and Photography Colour Characterisation of Digital Still Cameras (DSCs) Part 1: Stimuli, Metrology and Test Procedures, ISO 17321-1, the color fidelity calculation is based on tri-stimulus calculation. The tri-stimulus is a spectrum convolution of the light source $L(\lambda)$, the object reflectance $R(\lambda)$ and the average human eye response. The equations to calculate the tri-stimulus are as follows:

$$X_i = K \sum_{\lambda=380}^{780} L(\lambda) R_i(\lambda) \bar{x}(\lambda)$$

Equation 9

$$Y_i = K \sum_{\lambda=380}^{780} L(\lambda) R_i(\lambda) \bar{y}(\lambda)$$

Equation 10

$$Z_i = K \sum_{\lambda=380}^{780} L(\lambda) R_i(\lambda) \bar{z}(\lambda)$$

Equation 11

6.6.3 Where X_i , Y_i , Z_i are the tri-stimulus for the i^{th} color patch in the color test target, $L(\lambda)$ is the light source spectrum, $R_i(\lambda)$ is the reflectance spectrum of the i^{th} color patch in the color test target, and $\bar{x}$, $\bar{y}$, $\bar{z}$ are the average human eye visible light spectrum response.

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6.6.4 Similar to the tri-stimulus, the sensor output is a convolution represented by the following equation:

$$O_{j,i} = \sum_{\lambda=380}^{780} L(\lambda)R_i(\lambda)s_j(\lambda)$$

Equation 12

6.6.5 Where $s_j(\lambda)$ is the average light spectrum response of the j^{th} sensor channel. For instance, the standard Bayer image sensor has red, green and blue channel, therefore j has a range from 1 to 3. After getting the tri-stimulus and the sensor response, the difference can be calculated and converted into color fidelity score as shown in Table 7.

Table 7
Color fidelity

Performance score	ΔE
1000	1
200	5

6.6.6 The color fidelity shall be measured, per the Color Fidelity Test, Section 7.2, with the color fidelity test target shown in Figure 2 at a distance of one meter from the video camera under the test. The test shall be performed in a dark room environment.

6.6.7 The linear equation to calculate the color fidelity score is as follows:

$$\text{Color fidelity} = \alpha\tau + 1000 \text{ (Equation 13)}$$

$$\alpha = \frac{800}{\tau_l - \tau_h}$$

Equation 14

6.6.8 Where α is the score coefficient, τ is the color distortion, τ_h is the high color distortion, and τ_l is the low color distortion. From Table 7, τ_h equals to 5, and τ_l equals to 1.

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