



UL 2802

STANDARD FOR SAFETY

Performance Testing of Camera Image Quality

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UL Standard for Performance Testing of Camera Image Quality, UL 2802

First Edition, Dated September 20, 2013

Summary of Topics

This revision of UL 2802 is being issued to update the test procedures.

The requirements are substantially in accordance with Proposal(s) on this subject dated May 16, 2014.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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UL 2802

Standard for Performance Testing of Camera Image Quality

First Edition

September 20, 2013

This UL Standard for Safety consists of the First Edition including revisions through July 16, 2014.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

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INTRODUCTION

1 Scope

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

1.2 The camera images analyzed for this test program are digital images that are generated by individual video frames or still image captures.

1.3 Each camera tested will achieve a Performance Score for each of the individual tests (except Signal to Noise Ratio and Field of View), based on the test data generated.

1.4 Typical applications of this document applies to security video cameras, digital video cameras and or analog cameras with associated digital encoders and related image viewing / configuration software, as applicable.

1.5 The safety requirements that apply to cameras covered by this standard are defined in Section 4.

1.6 Section 6 of this standard defines the test criteria and Section 7 defines the test methods used.

1.7 The suitability of the camera for a specific use case is not determined by this standard. The resulting test scores are intended to provide objective information that will be useful when determining camera use applications (i.e. a camera that performs well in sensitivity and grey level tests may be a good choice for low light use cases).

1.8 This standard performs an evaluation on a specific camera configuration that utilize image sensors, processors and software, operating system, lens, camera housing / body and the like. Changes to any of the cameras critical components may require reconducting the performance tests for each camera configuration.

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 ALIASING – The effect of different video signals that are being sampled becoming indistinguishable from each other.

3.3 APERTURE STOP – An aperture in an optical system is an opening in the optical path. The aperture in a digital camera controls the amount of light reaching the image sensor. In the case when an optical system has a variable aperture, the aperture will have a number of aperture stops, which refer to the opening size of the aperture. In photography, one aperture stop refers to an aperture area ratio of two, which is equivalent to light intensity ratio of two. The aperture stop is also referred as “Optical Stop” or “Stop”.

3.4 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.

3.5 CRITICAL COMPONENTS – Components of the camera that when changed or replaced will have an effect on the safety or performance of the camera. Examples include but are not limited to: image sensors, processors and viewing software, operating system, lens, camera housing / body and the like.

3.6 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 is 0.001 lux or 1/10 of the lowest light sensitivity test level detectable by the camera.

3.7 FULL SCALE SIGNAL – Maximum pixel value for each type of image format. For example an 8 bit image format has a pixel value range of 0-255. The full scale value for this format is 255.

3.8 LINE PAIRS PER PICTURE HEIGHT (LP/PH) – A unit of measure of video camera resolution.

3.9 MODULATION TRANSFER FUNCTION (MTF) – The magnitude component of OTF.

3.10 OPTICAL TRANSFER FUNCTION (OTF) – The most detailed measure of the resolution of an optical imaging system.

3.11 PROCESS CAPABILITY INDEX (C_{pk}) – An index that measures an adjustment of C_p for a non-centered distribution.

3.12 SATURATION – Overly bright colors or grey levels which result in loss of details of a target image. A saturated digital image would be at maximum full scale (see 3.7).

3.13 SPATIAL FREQUENCY RESPONSE (SFR) – A measure of MTF.

3.14 WHITE BALANCE (WB) – White balance refers to the process of adjusting colors in an image to be as accurate as possible relative to what appears to the human eye.

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, or
- b) Standard for Audio, Video, and Similar Electronic Apparatus – Safety Requirements, UL 60065, or
- c) Standard for Audio / Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, or
- d) Standard for Commercial Closed Circuit Television Equipment, UL 2044.

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.

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

4.5 The camera must be configured for optimum results for each test. For example, this includes setting the camera to full resolution, optimizing exposure and gain during each test program. The test lab shall record the camera settings for each test.

4.6 The manufacturers' image viewing / configuration software must be utilized for capturing images for the test program. The software is considered a critical aspect of image quality measured during the tests.

4.7 Camera configurations that utilize different image sensors, processors and software, operating system, lens, camera housing / body and the like may require conducting the performance tests for each camera configuration.

5 Individual Performance Score Per Tests

5.1 Results of video camera image quality tests are designated by scores which range from 0 – 100 for each test. 0 being the lowest level of performance and 100 being the highest level of performance. Because of dynamic variables such as lighting conditions and viewing angles associated with Field of View Confirmation (see Section 6.2) and Signal to Noise Ratio (see Section 6.3) Tests, individual performance scores are not associated with these two tests.

6 Video Camera Test

6.1 Image resolution

6.1.1 This specification measures the image resolution at the lens hyper focal distance (also see Image Resolution Test, Section 7.1 and Appendix example, A3). The overall resolution score is calculated by averaging the resolution score at the center and the four corners of the image resolution target.

6.1.2 The equation to calculate the resolution score is:

$$\text{Resolution score} = \tau/20 - 5$$

6.1.3 τ is the measured resolution in LP/PH. The following table illustrates the relation between the measured resolution and the performance rating values at MTF 50.

Table 1
Examples of calculated image resolution score

Performance score	Measured resolution	Note
100	2100 LP/PH	MTF50
75	1600 LP/PH	MTF50
50	1100 LP/PH	MTF50
25	600 LP/PH	MTF50
0	100 LP/PH	MTF50

6.2 Field of view confirmation

6.2.1 Because the lens parameters vary significantly at different viewing angles for variable optical zoom lens, it is necessary to specify the lens parameters for a given viewing angle for this test. Therefore, it is important to measure the field of view before measuring other camera performance parameters.

6.2.2 For cameras with variable zoom lenses, images shall be captured at a single specified zoom value per the manufacturer, and analyzed for the field of view. The camera performance shall be measured and rated for the specific viewing angle utilized for the test. Cameras may be tested and analyzed at multiple zoom values and the Field of View rating is designated at each zoom value as identified by the manufacturer.

6.2.3 The field of view is calculated with the following equation:

$$\theta = 2 \tan^{-1} \left(\frac{2d}{w} \right)$$

6.2.4 Where θ is the video camera field of view, d is the distance between the video camera and the test target, w is the width of the test target.

6.2.5 Since field of view is based on use cases, the field of view confirmation does not obtain an independent performance score considered by this standard. The field of view parameter is recorded for distortion, sensitivity, and resolution tests.

6.3 Signal to noise ratio

6.3.1 The purpose of this test is to quantitatively measure the grey level related performance. The signal to noise ratio shall be measured, per Signal to Noise Ratio Test, Section 7.3, 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 used within this document. Signal to Noise Ratio does not result in an independent performance score since this is an abstract parameter. The signal to noise ratio is used as an element for grey level and sensitivity tests.

6.4 TV distortion

6.4.1 The purpose of the TV distortion measurement is to quantify how much the image geometrically deviates from the two dimensional projection of the actual subject captured by the image. TV distortion shall be measured per the TV Distortion Test, Section 7.4 (also see Appendix example A4).

6.4.2 The total TV distortion score is determined by the largest measured TV distortion between 80% and 90% of the image field. The linear equation to convert the measured distortion to the TV distortion score is as follows:

$$TV \text{ distortion score} = -1000\tau + 102$$

Where τ is the distortion in percentage

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Table 2
Examples of calculated TV distortion score

TV distortion performance score	TV distortion
100	0.2%
80	2.2%
50	5.2%
30	7.2%
0	10.2%

6.5 Relative illumination

6.5.1 The purpose of measuring the relative illumination is to quantify the illumination degradation in the image corners with respect to the image center. The relative illumination shall be measured per the Relative Illumination Test, Section 7.5, with the camera manufacturer's default lens correction setting.

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

$$\text{Relative illumination score} = -400(\tau - 0.9)^2 + 100$$

Where τ is the relative illumination

Table 3
Examples of calculated relative illumination

Performance score	Relative illumination
100	90%
96	80%
84	70%
64	60%
0	40%

6.6 Dynamic range

6.6.1 The purpose of the dynamic range measurement is to quantify how well a camera can function under the condition with very strong light sources (examples include sunlight reflection, or strong artificial light for image recognition applications). This specification characterizes the video camera dynamic range by measuring the video camera grey level under different lighting conditions. For example, if a video camera can work properly under a maximum illumination of 200 kLux and under a minimum illumination of 1 Lux, the dynamic range of the video camera is 200 thousand times.

6.6.2 The dynamic range shall be measured, per the Dynamic Range Test, Section 7.6 with the dynamic range test target (also see Appendix example A5). This test is conducted in a dark room.

6.6.3 The linear equation to calculate the dynamic range score is as follows:

$$\text{Dynamic range score} = 100\log_{10}(\tau) - 447.71$$

Where τ is the luminous emittance in Lux

Table 4
Examples of calculated dynamic range

Performance score	Dynamic range
100	300,000 Lux
82	200,000 Lux
67	140,000 Lux
37	70,000 Lux
0	30,000 Lux

6.7 Maximum frame rate

6.7.1 The purpose of the maximum frame rate testing is to measure how well a camera can capture images of a subject in motion. Because different video cameras may have different resolutions, and the image size is larger for higher resolution, for the purpose to compare the video camera performance, the maximum frame rate shall be measured at a fixed resolution, per the Frame Rate Test, Section 7.7.

6.7.2 The linear equation to calculate the frame rate score is as follows:

$$\text{Frame rate} = 10 (\tau - 10)/11$$

Where τ is the frame rate

Table 5
Maximum frame rate

Performance score	Frame rate
100	120 fps
64	80 fps
45	60 fps
18	30 fps
0	10 fps

6.8 Grey level

6.8.1 Grey level is an important camera parameter to quantify image quality. Images with more grey levels can reveal more details of the subjects in the image. This specification quantifies the video camera's grey level by measurements of the grey level patches with a luminous emittance ratio of the square root of two between adjacent grey level patches. Because there is no statistical difference in the case when the noise level is higher than the difference of the two adjacent grey levels, the noise level shall be measured for each grey level per the Signal to Noise Ratio test, Section 6.3. This specification also uses a 95% confidence interval to determine the noise level and differentiate the adjacent grey levels.

6.8.2 Grey level shall be tested per the Grey Level Test, Section 7.8. This test shall be conducted in a dark room.