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MILITARY STANDARD

IMAGE INTENSIFIER ASSEMBLIES,

PERFORMANCE PARAMETERS OF

FSC 5855

DEPARTMENT OF DEFENSE
Washington, DC 20301

Image Intensifier Assemblies, Performance Parameters of

MIL-STD-1858

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletions should be addressed to: Commander, US Army Electronics Research & Development Command, Night Vision & Electro-Optics Laboratory, ATTN: DELNV-SE, Bldg 305, Fort Belvoir, VA 22060.

FOREWORD

1. In furtherance of the Defense Standardization Program, this document furnishes standardized parameters and definitions.

2. This standard contains performance parameters for Image Intensifier Assemblies operating in the visible-light and near-infrared region.

3. For additional test methods and performance parameters, internal documents of individual Government activities may be used to supplement this document.

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PERFORMANCE PARAMETERS

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1. SCOPE

1.1 Purpose. This standard establishes uniform performance parameters for determining the performance characteristics of Image Intensifier Assemblies. It provides performance parameters in order to obtain, as much as possible, reproducible test results.

1.2 Application of standard. Performance parameters contained in this standard apply to all Image Intensifier Assemblies.

1.3 Numbering system. The parameters are numbered sequentially as they are introduced into this standard, with the first parameter as 100.

1.4 Revision of standard. Any revision of this standard which results in a revision of Sections 1 through 6 will be indicated by a revision letter after the standard number, together with the date of the revision.

1.5 Revision of performance parameters. Any revision of performance parameters will be indicated by a decimal following the parameter number. For example, the original number assigned to the first parameter is 100; the first revision of that parameter is 100.1; the second revision is 100.2.

1.6 Method of reference. Performance parameters contained herein shall be referenced by specifying this standard and the parameter number:

For example: MIL-STD-1858, parameter 100.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The issues of the following documents in effect on date of invitation for bids form a part of this standard to the extent specified herein:

QSTAG-414 - Uniform Standards for Specifying Performance Parameters of Image Intensifier Tubes

3. DEFINITIONS

3.1 The following definitions are basic to the use of this standard:

Equivalent brightness input (EBI) - the additional input illuminance required to provide an output luminance increase equal to the mean background screen luminance due only to the tube's dark current.

Fixed pattern noise - discernible spatial gain variation between peripheral and interior channels of a multi-pattern or group of channels associated with the MCP or fiber optics. Also called multi-to-multi gain variation. Appears on the screen as a pattern of adjacent hexagonal areas with different output intensity.

Image tube - an active device having a photocathode, a phosphor screen, and with or without an MCP. The device, when operated in its linear region, amplifies the low light level imagery on its cathode and displays the amplified imagery on its phosphor screen.

Microchannel plate (MCP) - that internal component of an image tube located between the photocathode and phosphor screen and composed of millions of tiny holes (approximately 10-micrometer), or channels, each acting as an electron multiplier.

Multi - one hexagon shaped section of an MCP, easily seen with a 10-power magnifier.

Phosphor screen - that component of an image tube which converts high energy input electrons to visible light at the image tube output.

Photocathode - that component of an image tube which is sensitive to radiation in the 0.5 to 0.9 micrometer wavelength region. This component converts light input to an electron output within the image tube.

Veiling glare - all image induced output flux outside of the ideal image field of an image tube. Various portions of veiling glare have also been termed haze, halo, glare, blooming and flare.

4. GENERAL REQUIREMENTS

4.1 General. Applicable procurement documents for the procurement of image intensifier assemblies shall include the parameters described herein with consideration given to the component parts of the intensifier assembly. The procurement documents shall also contain additional parameters and controls, if any, required for assurance of interchangeability in specific applications. The procurement documents shall also identify those parameters to be tested on a 100 percent basis and those which allow sampling. Accept/reject limits for parameter values and acceptable quality levels, where applicable, shall also be included. The terminology and symbols used in the procurement documents shall conform to those used herein.

4.2 Photocathode performance. The following parameters shall be considered in specifying photocathode performance: 100, 101, 103, 108.

4.3 Microchannel plate (MCP) performance. The following parameters shall be considered in specifying MCP performance: 104, 105, 108.

4.4 Phosphor screen performance. The following parameter shall be considered in specifying phosphor screen performance: 111.

4.5 Image intensifier assembly performance. The following parameters shall be considered in specifying performance of the image intensifier assembly: 102, 106, 107, 109, 110.

5. DETAILED REQUIREMENTS. Not applicable.

6. NOTES

6.1 International standardization agreement. Certain provisions of this standard are subject of international standardization agreement QSTAG-414. When amendment, revision, or cancellation of this standard is proposed which affects

or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

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Army - ER

Review activities:
Navy - AS
Air Force - 11
Coast Guard - CG

User activity:
Marine Corps - MC

Preparing activity:
Army - ER

International interest:
ABCA - QSTAG-414

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PARAMETER 100

PHOTOCATHODE LUMINANCE SENSITIVITY

1. Purpose. To measure the ratio of the emitted photocathode current to the luminous input flux.

2. Procedure:

a. The radiation illuminating the photocathode shall have a color temperature of 2856, ±50 K.

b. The photocathode current shall be measured on the tube element prior to assembly with the power supply and its housing. The sensitivity shall be measured over the specified area of the photocathode and at a specified light level. The photocurrent in the tube shall be collected using voltages such that the electric field strength at the photocathode does not exceed that which is found during normal steady-state field operation. At least one measurement shall be performed at normal operating voltages.

3. Measurements. The measured photocurrent, corrected for leakage currents, divided by the actual input lumens is the 2856 K photocathode luminance sensitivity. The units of this test are microamperes per lumen (μA/lm).

4. Summary:

Note 1: The actual area over which photocathode luminance sensitivity is measured shall be specified, depending upon image tube format.

Note 2: The input luminance at which the test is performed shall be specified.

Note 3: The field strength at the photocathode shall be specified for each measurement if different from normal operating potential.

PARAMETER 101

PHOTOCATHODE RADIANT SENSITIVITY

1. Purpose. To measure the ratio of the emitted photocathode current to the radiant flux input at a specific wavelength.

2. Procedure:

a. The radiation illuminating the filters described below shall have a color temperature of 2856, ±50 K.

b. The photocathode radiant sensitivity shall be measured on the tube element prior to assembly with the power supply and its housing. The sensitivity shall be measured over the specified area of the photocathode using a specified input of radiant power. The photocurrent in the tube shall be collected using voltages such that the electric field at the photocathode does not exceed that which is found during normal steady-state field operation. At least one measurement shall be performed at normal operating voltages.

c. The filters used for measurement of the sensitivity at the specified wavelength shall have the following characteristics:

(1) Far infrared blocking out to 4 micrometers and ultraviolet blocking below 0.3 micrometer.

(2) The specified peak wavelength shall have a tolerance of ±0.001 micrometer.

(3) The filter bandwidth at the 10 percent points shall be 0.5 micrometer.

3. Measurements. The measured photocurrent, corrected for leakage currents, divided by the actual input radiation in watts at the specified wavelength is the photocathode radiant sensitivity. The units of this test are milliamperes per watt (mA/W).

4. Summary:

Note 1: The actual area over which the radiant sensitivity is measured shall be specified depending upon image tube format.

Note 2: The wavelength(s) at which photocathode radiant sensitivity is measured shall be specified depending upon anticipated field use.

Note 3: The input power at which the test is performed shall be specified.

Note 4: The field strength at the photocathode shall be specified for each measurement if different from the normal operating potential.

PARAMETER 102

LUMINANCE GAIN

1. Purpose. To measure the ratio of the luminance at the image tube output to the illuminance at the tube input.

2. Procedure:

a. The radiation illuminating the photocathode shall have a color temperature of 2856, ±50 K.

b. The photometer used for screen luminance measurement shall be a Pritchard Model 1970 PR, or equivalent. This photometer shall be corrected and calibrated for the standard photopic eye response.

c. Tolerance on the specified illuminance levels at the photocathode of the image tube shall be ±10 percent.

3. Measurements. Illuminate the photocathode of the operating image tube with the specified light level(s). Measure the image tube screen luminance using a photometer having a 2 degree or less acceptance angle. Position the photometer so that the acceptance angle of the photometer subtends a specified area on the phosphor screen of the image tube. The luminance gain is determined by dividing the screen luminance by the actual input illuminance at the photocathode. The units of this test are nits per lux, or (candelas/square meter) per lux.

4. Summary:

Note 1: The light level(s) at which luminance gain measurements are made shall be specified.

Note 2: The area over which the luminous output of the image tube screen is measured shall be specified, depending upon image tube format.

Note 3: All image tube voltages shall be specified if different from normal operating potentials.

PARAMETER 103

EQUIVALENT BACKGROUND INPUT (EBI)

1. Purpose. To measure the mean phosphor screen luminance due only to the image-tube dark current.

2. Procedure:

a. The radiation measurement format shall be as described in Parameter 102.

b. Measurements shall be made at room temperature of 23°C, ±2°C. Actual room temperature shall be recorded at the time of measurement.

c. With the normal operating potential applied to the image tube assembly and no illumination incident on the photocathode, hold for a stabilizing period of not more than 15 minutes.

3. Measurements:

a. At the end of the stabilizing period and with no illumination incident on the photocathode, measure the screen luminance with a photometer and record the photometer reading R_1. Illuminate the photocathode at a level between 3.5×10^{-7} and 7.0×10^{-7} lux uniformly distributed over the full useful diameter of the photocathode and record the photometer reading R_2.

b. Determine the equivalent background input (EBI) using the following formula:

$$EBI = \frac{R_1}{R_2 - R_1} \times (\text{actual input illumination})$$

The units of this test are lux.

4. Summary:

Note 1: The input luminance at which the test is performed shall be specified.

Note 2: All image tube voltages shall be specified if different from normal operating potentials.

PARAMETER 104

MULTI-TO-MULTI FIXED PATTERN NOISE
(Tubes with MCP's only)

1. Purpose. To measure the luminance variation as seen on the phosphor screen due to gain variation from one multi to another.

2. Procedure. With normal operating potential applied to the assembly, illuminate the entire photocathode uniformly at a level of 2×10^{-3} lux. Observe the phosphor screen with a 10 power magnifier for multi-to-multi pattern variation. If multi-to-multi pattern variations are observed, perform the following measurement.

3. Measurements. Choose an area of the screen where the multi-to-multi pattern appears most noticeable. Search this area for the most contrasting adjacent multi-bundles and measure each diameter equal to 1/3 the dimension of a multi-bundle diameter, or 1/3 the distance from flat-to-flat for hexagonal multies. The units of this test are percent.

4. Summary:

Note 1: The percentage variation from mean luminance shall be specified.

PARAMETER 105

MULTI-BOUNDARY FIXED PATTERN NOISE

1. Purpose. To measure the spatial nonuniformity in luminance from the phosphor screen due to gain variation at the boundaries of the multi-bundles of the MCP.

2. Procedure. With the normal operating potential applied to the image tube assembly, illuminate the photocathode uniformly at a level of 2×10^{-3} lux. Observe the phosphor screen with a 10-power magnifier for multi-boundary noise (webbing). Choose an area of the image screen where the multi-boundary pattern noise is most noticeable.

3. Measurements. Measure the multi-boundary luminance using an aperture of effective diameter equal to 1/3 the dimension of a multi-bundle diameter, or 1/3 the distance from flat-to-flat for hexagonal multies. The average value of the luminance deviation of the multi-boundary shall not deviate from the mean value of the adjacent multi-intensities by more than the specified amount. The mean value shall be established from three adjacent multies containing the multi-boundary. The units of this test are percent.

4. Summary:

Note 1: The percent variation of luminance at the multi-boundary from the mean value shall be specified.

PARAMETER 106

RESOLUTION (NOISE LIMITED RESOLUTION)

1. Purpose. To measure the maximum spatial-frequency target pattern which is resolvable at the output screen for a specified input illuminance and pattern contrast.

2. Procedure. The target is a negative contrast 1951 Air Force chart using a 3-bar, 5:1 aspect ratio pattern. The specified contrast of this target is defined as the background illuminance minus the target illuminance divided by the background illuminance. The illumination source for this test shall be as described in Parameter 102. In the case of an image tube using a flat fiber optic input, the resolution pattern may be butted to the fiber optics. For all other image tubes, the resolution pattern shall be focused onto the photocathode (or fiber optic) using a high quality projection lens system.

3. Measurements. Illuminate and focus the resolution pattern on the photocathode using the specified target contrast and illuminance. Focus the specified-power eyepiece on the image tube screen. Examine the image of the resolution pattern on the screen and determine the highest spatial frequency at which both horizontal and vertical resolution bars can be seen as three distinct lines. The units of this test are line pairs per millimeter (lp/mm).

4. Summary:

Note 1: The following shall be specified:

a. F-number of the projection lens system

b. Illuminance on the photocathode

c. Target contrast

d. Magnification of the eyepiece

e. Axial location of the viewed pattern

PARAMETER 107

MODULATION TRANSFER FUNCTION (MTF)

1. Purpose. To measure the modulus of the complex Fourier transform of the point spread function for isoplanate and linear imaging devices.

2. Procedure. In order to improve signal-to-noise, employ spatial integration in one dimension and determine the one dimensional MTF by measuring the modulus of the complex Fourier transform of the line spread function which is the convolution of the point spread function and a narrow slit, typically not greater than 10 millimeters (10 mm) in width. (The one-dimensional MTF of the slit alone shall be not less than 60 percent at the highest spatial frequency measured.) It is important to account for several parameters in actual measurements, such as: imaging tube linearity, regions of spatial invariance, fixed pattern noise, temporal noise, background radiation, scanning region, and veiling glare. Operate the tube in a linear range and analyze the image in an isoplanatic region. Eliminate fixed pattern noise by changing target dimensions and analyzing aperture consistent with the isoplanatism requirement. Use signal averaging techniques to reduce temporal noise. Background radiation can most easily be removed automatically by providing a sampling aperture equal to one cycle of the lowest spatial frequency analyzed, which shall be as close to 0 line pairs per millimeter (lp/mm) as possible. The most difficult parameter to consider is the veiling glare of the tube, since it requires a sufficiently wide aperture to avoid errors due to spatial truncation.

3. Measurements. Illuminate at 2856, ±50 K; focus the slit pattern upon the photocathode in a region that takes into account the parameters of spatial invariance and fixed pattern noise; and align the image on an isoplanatic region. Focus the image onto the analyzer through a suitable objective lens of effective viewing aperture consistent with the maximum required measurement aperture. Spatially convolve the image output with the analyzer pattern at the specified discrete spatial frequencies. Convert the convolved signal to the temporal domain by scanning the analyzer pattern across the image and integrate the convolution by intercepting the full aperture with a suitable photomultiplier tube (PMT). Analyze the PMT output by temporally filtering each discretely convolved signal through a bandpass filter matched to the fundamental temporal frequency of the corresponding discrete spatial pattern to eliminate, if necessary, all energy in the frequency sidelobes, and to pass only the energy in the fundamental component of frequency. Normalize each of the convolved, filtered peak amplitudes to the lowest spatial frequency (calibrate frequency) peak amplitude measured, which is in turn normalized to 100 percent modulation. Should the system MTF be less than 95 percent at the highest spatial frequency measured, the measured value at each discrete spatial frequency point shall be modified to eliminate the contribution of the system's own MTF to the measurement.

PARAMETER 107

MODULATION TRANSFER FUNCTION (MTF) - Continued

4. Summary:

Note 1: The input slit dimensions shall be specified.

Note 2: The input light level through the slit shall be specified.

Note 3: The sampling aperture of the analyzer shall be specified.

Note 4: The lowest spatial frequency (calibrate frequency) shall be specified.

PARAMETER 108

SIGNAL-TO-NOISE (S/N)

1. Purpose. To measure the ratio of the average signal at the output of an intensifier tube to the true root-mean-square (rms) value of the signal fluctuations about the average at a specified electronic measurement system bandwidth.

2. Procedure. Uniformly illuminate a circular area of the photocathode, approximately 0.2 millimeter (mm) diameter, at a specified light level in the order of 3×10^{-6} to 3×10^{-5} nit (candelas per square meter) and at a color temperature of 2856, $\pm$50 K. Analyze the output intensity for average signal level and for the rms signal level variations about the average over a specified electronic system bandwidth (around 10 Hz noise equivalent). Minimize the contribution of equivalent brightness input (EBI) by sampling the output signal through a specified aperture only slightly larger than the input area of illumination. Normalize the true rms signal level variations about the average to the specified measurement bandwidth. Perform the same measurement with no input illumination and subtract the corresponding background statistics to obtain the true signal mean and rms levels.

3. Measurement. With the intensifier tube's cathode illuminated uniformly over the specified area at the specified color temperature and light intensity, align and focus the output image through a suitable lens and through the specified sampling aperture onto a suitable photomultiplier tube (PMT). Analyze the PMT's output signal to determine the following statistics:

a. Signal mean amplitude - Determine the signal mean amplitude by averaging the signal over a suitable time ensemble. This value is S.

b. Signal rms amplitude - Determine the true rms signal level about the mean (S) by first band-limiting the signal through a specified electronic low pass filter (about 10-Hz noise-equivalent bandwidth) and then measuring the resultant rms value of the signal over a suitable time ensemble. This value is σ_S.

c. Background mean amplitude - Determine background signal mean amplitude by averaging the background signal over a suitable time ensemble. This value is σ_B.

d. Background signal rms amplitude - Determine the true rms background level. Normalization of the true rms signal and background level about the mean (B) as done for the signal rms amplitude. This value is σ_B. Determine the variations to the specified measurement bandwidth by computing the actual system measurment noise equivalent bandwidth (NEB) and calculating the normalization factor (K) of the true rms signal and background level:

PARAMETER 108

SIGNAL-TO-NOISE (S/N) - Continued

$$K = (B_F/NEB)^{\frac{1}{2}}$$

Where B_F is the specified measurement NEB (approximately 10 Hz noise equivalent), and NEB is the actual value measured for the system.

The resultant S/N of the intensifier tube can then be calculated as:

$$S/N = \frac{1}{K} \quad \frac{S - B}{\sqrt{\sigma_S^2 - \sigma_B^2}}$$

4. Summary:

Note 1: Input light level illumination shall be specified to within ±5 percent.

Note 2: Both input circular area and output sampling area shall be specified.

Note 3: The measurement NEB shall be specified.

Note 4: The actual system NEB shall be specified.

Note 5: The time ensemble of the measured parameters shall be specified in the unit of seconds.

PARAMETER 109

TIME-DEPENDENT BRIGHT SOURCE (FLASH RESPONSE)

1. Purpose. To measure the time required for an image intensifier tube to recover to within 40 percent of its steady-state luminance output after being subjected to an intense periodic or aperiodic source of illumination.

2. Procedure:

a. Uniformly illuminate the photocathode with steady-state illumination in the range 0.3 to 1.7 x 10^{-4} nit (candelas per square meter).

b. Apply the operating voltage to the assembly and illuminate the photocathode with the specified periodic or aperiodic flash profile. When using the periodic flash profile, apply a minimum of three full periods before measuring the flash response.

c. Locate two photodiodes so that one measures the input flash profile and the other measures the output luminance of the image tube.

3. Measurement. Measure the recovery time of the output luminance after application of the specified flash profile. The units of this test are milliseconds (ms).

4. Summary:

Note 1: The time to recovery to within ±40 percent of the steady-state output luminance shall be specified.

Note 2: The illuminance profile of the flash simulation for both periodic and aperiodic flash profiles shall be specified either in terms of illuminance at the photocathode or in terms of photocurrent from a specified photocathode.

PARAMETER 110

HALO
(Tubes with MCP's only)

1. Purpose. To measure a form of veiling glare defined as the circular pattern of light which is formed around an intense point source of illumination.

2. Procedure. Uniformly illuminate an aperture, and focus the image of this aperture onto the photocathode of the image tube. The field of view of the lens, its focal length, f-number, and T-number shall be specified. The image of the aperture shall produce a spot 0.35 millimeter in diameter on the photocathode. The illumination within the spot shall be not less than 2×10^{-6} nit (candelas per square meter).

3. Measurement. Measure the diameter of the halo using a 10-power or greater traveling microscope which is equipped with a suitable reticle. The units of this measurement are millimeters (mm).

4. Summary:

Note 1: The following shall be specified:

a. Projection lens field of view

b. Projection lens focal length

c. Projection lens f-number

d. Projection lens T-number

PARAMETER 111

TEMPORAL RESPONSE

1. Purpose. To measure the decay characteristics of an image tube when exposed to a source of illumination within its dynamic range.

2. Procedure:

a. With the normal operating potentials applied to the image tube, illuminate the photocathode of the tube with 0.3 to 2.0 x 10^{-4} nit (candelas per square meter) using a shutter with open time of 125 milliseconds (ms). The shutter shall have an opening time of not more than 1 ms and a closing time of not more than 0.1 ms.

b. The output luminance of the phosphor screen shall be measured using a suitable photomultiplier tube with its output fed into a signal analyzer. The shutter system shall produce a trigger pulse which is coupled into the signal analyzer. The total dynamic range of the measuring system shall be from 100 percent to less than 0.1 percent. Response time of the entire measuring system shall be less than 0.3 ms.

3. Measurement. Apply the illumination to the photocathode of the image tube and record the percentage decay at the specified time intervals.

4. Summary:

Note 1: The percentage decay of the phosphor luminance at specific times shall be specified.

Note 2: Photocathode illumination shall be specified.

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