



Interior Emitted Color and Luminance Requirements

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Scope. This standard applies to GM Global A architecture and beyond.

This specification applies to interior illuminated parts and components, mainly controls, displays and ambient lights.

The scope is to specify the characteristics and performance of illumination: Target and allowed tolerances for color, intensity and intensity uniformity to ensure good visual harmony, quality of appearance and good readability in different ambient lighting conditions.

This specification is valid for incandescent light sources as well as Light Emitting Diode (LED), Vacuum Fluorescent Display (VFD), Cold Cathode Fluorescent Lamp (CCFL), etc.

Out of scope is:

- Optical characteristics and performance of graphical displays. These requirements can be found in GMW15327. The nominal color specification of monochrome displays text and graphics is, however, included into this specification.
- Non-illuminated daytime colors.
- Use of different colors for different functions and parts. These requirements are found in Design Appearance Requirement (DAR), Graphic Lighting Appearance Document (GLAD), Human Machine Interface (HMI) guidelines and Component Technical Specification (CTS).

1.2 Mission/Theme. The arrangement of the various sub-assemblies should produce qualitatively high-grade, homogeneous appearance with regard to overall impression, luminance and color.

1.3 Classification. All illuminated elements shall have been clearly categorized on the Graphic Lighting Appearance Document (GLAD) according to the categories in 3.7.2.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ISO 7724-1

2.2 GM Standards/Specifications.

GMW3059

GMW14298

GMW15327

GMW14118

GMW15246

2.3 Additional References.

- CG2101 - Appearance, Lighting, Color (ALC) Measurement Report
- CIE 1931
- CIE Publication 69
- Device Specifications

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3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. See 1.2.

3.1.2 Content. Not applicable.

3.1.2.1 Physical Content. Not applicable.

3.1.2.2 Functional Content. Not applicable.

3.1.3 Ambient Environment. Not applicable.

3.1.4 Interfaces. Not applicable.

3.1.5 Usage Definition. Not applicable.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Observation/Viewing Angle. The luminance shall not drop below 50% from nominal intensity over 0 to 60 degrees in all directions from nominal viewing angle. Nominal viewing angle is defined as perpendicular to the main surface of the component on which graphics are placed, unless otherwise specified in the CTS or as shown on the component drawing.

Supplier shall measure and document fulfillment of viewing angle performance. On request, brightness distribution shall be verified with International Organization for Standardization (ISO) brightness distribution diagram (see ISO 7724-1) and documented in the Appearance, Lighting, Color (ALC) Measurement Report.

3.2.1.2 Light Leakage. No visible light leakage is allowed within components, between components or surrounding parts. This applies for all possible viewing angles from inside and outside of the vehicle. Light leakage is also not allowed during operation of a control, e.g., when pressing a button. Light is only allowed where specified on the part drawing. Further, visible light scatter into a non-illuminated area is not allowed, e.g., stray light from backlighting that makes a non-lit indicator glow dim. The non-illuminated areas of a component shall not show any bleed-through of light.

3.2.1.3 Colors. The color values shall meet the coordinates specified in Appendix A.

Note: A spectroradiometer, as described in 4.1.1.2, shall be used to validate this requirement.

The requirements also apply for all components throughout the entire production process.

Further, a pre-requisite to be approved is to pass the subjective assessment by the ALC engineer at the Touch, Appearance, Lighting, Color (TALC) review according to GMW14298. The subjective assessment will pay attention to perceived color differences within and between components.

3.2.1.4 Illumination Intensity.

3.2.1.4.1 Definitions.

3.2.1.4.1.1 Illuminated Element. An illuminated element is defined as an illuminated area that is identified by the customer as a single separated symbol or word.

A component can consist of many illuminated elements. Examples are faceplates with many buttons; rocker switches with one symbol at each end; and every number on a speedometer scale are separate illuminated elements. Illuminated elements can also be an indicator, halo ring, and CD-slot guidance light.

3.2.1.4.1.2 Mean Intensity and Standard Deviation. The mean intensity is defined as the arithmetical average of a large number of light measurements made on an illuminated element.

The mean intensity is calculated as follows.

$$\frac{1}{N} \sum_{i=1}^N x_i$$

x_i are the different measurement points on an illuminated element.

The standard deviation is calculated as sigma (σ).

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$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2}$$

x_i are the different measurement points on an illuminated element.

Guidelines on how measurements shall be performed and what equipment to use (see Section 4).

Note: Only applicable for luminance surface measurement.

3.2.1.4.1.3 Illumination Uniformity. Illumination uniformity is defined as the distribution of illumination intensity of all measured points on a single illuminated element. It is related to the measured mean value. Standard deviation is a quality measure of the uniformity. The lower the standard deviation, the better is the illumination uniformity.

Note: Only applicable for luminance surface measurement.

3.2.1.4.2 Requirements. Supplier shall measure and document fulfillment of all requirements.

3.2.1.4.2.1 General. When a component includes more than one illuminated element (e.g., faceplates and clusters), each of them shall individually fulfill every requirement for illumination intensity.

The requirements also apply for all production variations.

3.2.1.4.2.2 Illuminated Elements, Intensity. One of the following requirements according to 3.2.1.4.2.2.1 or 3.2.1.4.2.2.2 shall be fulfilled for all illuminated elements. Note that a photometric camera, as described in Section 4 Validation, shall be used to verify this requirement.

Further, a pre-requisite to be approved is to pass the subjective assessment by the ALC engineer at the TALC review according to GMW14298. The subjective assessment will pay attention to hot spots, shadows, and other unevenness that may not have been captured in the measurements.

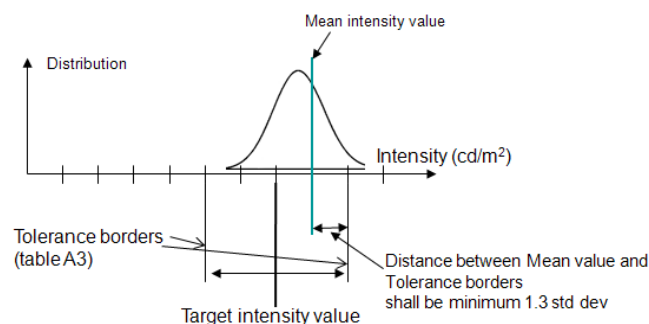
3.2.1.4.2.2.1 The illumination intensity of all single points on the illuminated element shall be within the tolerance of the target intensity specified in Table B1.

Note: Photometric “point measurement” equipment, as described in 4.1.1.1, shall be used to verify this requirement.

3.2.1.4.2.2.2 If not all measured points are within the Table B1 tolerance band, then the measured mean value shall be within the tolerance band and be at least 1.3 standard deviations away from each of the borders of the tolerance band (see Figure 1).

Note: Photometric “surface measurement” equipment, as described in 4.1.1.1, shall be used to verify this requirement.

Figure 1: Mean Intensity Value, Standard Distribution, and Tolerance Limits



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Note: A consequence of the requirement according to 3.2.1.4.2.2.2 is that individual pixels of an illuminated element are allowed to be outside the tolerance borders, given that all other pixels show uniform distribution that is within the specified standard deviation and mean intensity to the target value (i.e., ≤ 1.3 standard deviations and the mean intensity value is within the specified tolerance of $\pm 30\%$).

3.2.1.5 Color Shift and Intensity Shift. The emitted color of the led will shift when transmitted through plastic and paint. Also, LEDs have an inherent variation in the emitted color and are sorted into bins. The supplier needs to demonstrate with plots that the chosen LED color bins will shift entirely within the target color tolerance window. The plots would include the target color tolerance window, the color bins of the chosen LEDs, and the LED color bins as shifted because of the plastic and paint. The plots shall include all different areas of the part. Details on how documentation and measurements shall be done are described in ALC Measurement Report (CG2101).

3.2.1.6 Dimming. All continuously dimmable illuminated elements shall show a smooth and linear behavior versus dimming value. For general dimming requirements, see GMW15246.

3.2.2 Physical Characteristics. Not applicable.

3.2.2.1 Dimensions and Capacity. Not applicable.

3.2.2.2 Mass Properties. Not applicable.

3.2.3 Reliability. Not applicable.

3.2.3.1 Reliability Evaluation Point. Not applicable.

3.2.3.2 Reliability Requirements. Not applicable.

3.2.4 Serviceability. Not applicable.

3.2.5 User System/Subsystem/Component/Part Interface. Not applicable.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts Selection Guidelines.

3.3.1.1 Material Guidelines. See 7.1.

3.3.1.2 Processes Guidelines. Not applicable.

3.3.1.3 Parts Guidelines. Not applicable.

3.3.2 Design Guidelines and Constraints. Not applicable.

3.3.3 Identification and Marking. Not applicable.

3.3.4 Workmanship. Not applicable.

3.3.5 Interchangeability. Not applicable.

3.4 Documentation. Suppliers shall present documentation from measurements and analysis of production variations according to the ALC Measurement Report (CG2101).

3.5 Support of System/Subsystem/Component/Part After Sale. Not applicable.

3.6 System/Subsystem/Component/Part Operator Training. Not applicable.

3.7 System/Subsystem/Component/Part Characteristics.

3.7.1 System/Subsystem/Component/Part Definition. All parts and components which illuminate or are illuminated at night for improved discernibility and operation shall be designated as night design components. This includes components and status indicators.

3.7.2 Component Definition.

3.7.2.1 Graphic Illumination. All illuminated elements (graphics on buttons, scales, etc.) that are depending on illumination at nighttime, but are clearly visible at daytime without illumination.

3.7.2.2 Graphic Illumination with Dead Front Appearance. All illuminated elements (pointers, scales, etc.) that are depending on illumination both at nighttime and daytime. Examples are cluster graphics and pointers behind a smoked outer cluster glass.

3.7.2.3 Information Displays. Information displays in all installation areas, e.g., odometer and Driver Information Displays, Infotainment and Navigation Displays, and Heads-Up Displays.

3.7.2.4 Other Lighting. Illumination that does not fall in under the categories above should be specified separately on the component's GLAD.

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3.7.2.5 Indicator Illumination. Status indicators of switches and controls which give information on the current operating condition of an internal vehicle system, e.g., seat heating **ON**. Typically, this is a small window in a switch where the light of an LED is coming out. The night time intensity may or may not be dimmable. There are two types of illumination control of indicators:

3.7.2.5.1 Indicators with Day and Night Mode. This type has at least two levels of illumination controlled by the day or night setting or by ambient light intensity. This type is preferred because it provides good visibility at daytime and harmonic appearance at nighttime.

The daytime intensity value in Table B1 is selected to ensure good visibility under various lighting conditions. This value may be adapted to the specific conditions where the component is located and to the technique used for illumination, e.g., risk of direct sun exposure, washout risk, and size and color of the indicator. Also the importance of the indicator shall be taken into consideration.

3.7.2.5.2 Indicators with Fixed Illumination. This type has an intensity selected to give reasonable readability and harmony at daytime and nighttime. The value given in Table B1 shall be followed unless there are reasons to change the value to give a better optimization between day and night appearances, as requested by the ALC engineer.

3.7.2.6 Telltales. Telltales are status indicators that give information on the operation of a vehicle system, e.g., turn signal, fog light **ON**, or warning and fault lights which indicate functional readiness and capability of a vehicle system, e.g., seatbelt warning and Antilock Brake System (ABS) fault light.

Telltales show the status by illuminating a symbol or text. Telltales have different requirements depending on their position, importance and use. The applicable requirements regarding a specific telltale are written in Table B1.

For telltales that can be exposed to direct sunlight, the daytime intensity value needs to be validated for each application due to potential risk for glare/washout. This should be done before Engineering Sign Off (ESO) and approved by the ALC engineer. If the daytime intensity value needs to be adjusted upwards to ensure readability, the new value shall be documented in the CTS.

Some warning telltales that informs about a critical fault, or a situation that requires immediate action from the driver, may remain at daytime intensity also in night time lighting condition. These telltales are specified in the CTS.

4 Validation

4.1 General. Suppliers shall submit color and intensity measurements using the latest version of the GM ALC Measurement Report (CG2101). Verification measurements of the supplier data shall be submitted by the General Motors lighting lab. Appearance shall be subjectively evaluated by the ALC Engineer. For detailed TALC process information see GMW14298.

All measurements shall be taken at 13.5 V DC and by using the appropriate Local Interconnect Network (LIN), General Motors Local Area Network (GMLAN) and Pulse Width Modulation (PWM) signals.

4.1.1 Intensity and Color Measurement for Graphics.

4.1.1.1 Surface Measurement Equipment Specification. Photometer with V (Lambda-correction) according to CIE Publication 69 for LED application (Class A) and non LED application (Class B).

- Measurement Resolution: $< 0.01 \text{ cd/m}^2$
- Measurement Uncertainty: $(k = 2) \pm 3.5\%$
- Measurable Intensity: $0.1 \text{ to } 10\,000 \text{ cd/m}^2$
- Local resolution: 10 pixel for the smallest dimension of an illuminated symbol
- Viewing Angle: ± 10 degree maximum

Example: TechnoTeam LMK 98-4 Light Density Camera

4.1.1.2 Point Measurement Equipment Specification. Spectroradiometer with the following specification shall be used:

- Measurement Uncertainty: $(k = 2) \pm 3.5\%$
- Accuracy of the Color Coordinates x and y According to CIE 1931: ± 0.002

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