



Engineering Standard

SAES-P-123

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Lighting

Document Responsibility: Electrical Systems Designs & Automation Stds. Committee

Saudi Aramco DeskTop Standards

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1 Scope

- 1.1 This SAES covers the minimum mandatory requirements for lighting installations.

Exception:

Except where specifically mentioned, this SAES does not apply to residential and security lighting.

- 1.2 Requirements for residential lighting are found in the IESNA Lighting Handbook.
- 1.3 Security lighting requirements shall be in accordance with the [SAES-O-204](#).
- 1.4 Aviation and Navigation Aids
- 1.4.1 For high structures and stacks, special obstruction **luminaires** and warning **luminaires** shall be provided in accordance with [SAES-B-063](#).
- 1.4.2 Piers, offshore platforms and similar structures extending into navigable waters must be furnished with obstruction lighting as required by [SAES-M-005](#).

2 Conflicts and Deviations

- 2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or international standard, codes, and forms shall be resolved in writing by the company or buyer representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this standard in writing to the company or buyer representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below unless otherwise noted.

- 3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

[SAEP-302](#)

Instructions for Obtaining a Waiver of a Mandatory

Saudi Aramco Engineering Requirement

Saudi Aramco Engineering Standards

<u>SAES-A-112</u>	<i>Meteorological and Seismic Design Data</i>
<u>SAES-B-063</u>	<i>Aviation Obstruction Marking and Lighting</i>
<u>SAES-M-005</u>	<i>Design and Construction of Fixed Off-Shore Platforms</i>
<u>SAES-M-100</u>	<i>Saudi Aramco Building Code</i>
<u>SAES-O-204</u>	<i>Security Lighting Systems</i>
<u>SAES-P-100</u>	<i>Basic Power System Design Criteria</i>

Saudi Aramco Materials System Specification

<u>14-SAMSS-600</u>	<i>Material, Manufacture and Preservative Treatment of Wood Poles</i>
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Saudi Aramco Standard Drawing

<u>AB-036398</u>	<i>Details - Street Lighting</i>
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3.2 International Standards and Codes

<i>IEC 62471</i>	<i>Photobiological Safety of Lamps and Lamp Systems</i>
<i>SASO IEC 61347</i>	<i>Particular Requirements for d.c. or a.c. Supplied Electronic Controlgear for LED Modules</i>
<i>IEC 62504</i>	<i>General Lighting – LEDs and LED Modules – Terms and Definitions</i>
<i>IEC 62031</i>	<i>LED Modules</i>
<i>IEC 62560</i>	<i>Self-ballasted LED Lamps (>50V)</i>
<i>IEC 62384</i>	<i>Performance Requirements for Electronic Control Gear for LED Modules</i>
<i>IEC 62717</i>	<i>LED Modules Performance</i>
<i>IEC 61000-3-3</i>	<i>Electromagnetic Compatibility (EMC) - Part 3-3</i>
<i>IEC 62722-2-1</i>	<i>LED Luminaires Performance</i>
<i>IES/IESNA LM-79-08</i>	<i>Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products</i>
<i>IES/IESNA LM-80-08</i>	<i>Approved Method for Measuring Lumen Maintenance of LED Light Sources</i>
<i>IEEE STD 1453</i>	<i>Recommended Practice for Measurements and Limits of Voltage Fluctuations and Associated</i>

Light Flicker on AC Power Systems

National Fire Protection Association

<i>NFPA 70</i>	<i>National Electrical Code (NEC)</i>
<i>NFPA 101</i>	<i>Life Safety Code</i>

Illuminating Engineering Society of North America

<i>IESNA</i>	<i>Lighting Handbook</i>
<i>IESNA LEM-3</i>	<i>Design Considerations for Effective Building Lighting Energy Utilization</i>
<i>IESNA LM-5</i>	<i>Guide for Photometric Measurements of Area and Sports Lighting Installations</i>
<i>IESNA LM-64</i>	<i>Guide for Photometric Measurements of Parking Areas</i>
<i>IESNA RP-1</i>	<i>Practice for Office Lighting</i>
<i>IESNA RP-7</i>	<i>Practice for Industrial Lighting</i>
<i>IESNA RP-8</i>	<i>Practice for Roadway Lighting</i>
<i>IESNA RP-16</i>	<i>Nomenclature and Definitions for Illuminating Engineering</i>
<i>IESNA RP-20</i>	<i>Lighting for Parking Facilities</i>
<i>IESNA RP-24</i>	<i>Practice for Lighting Offices Containing Computer Visual Display Terminals</i>
<i>IESNA RR-96</i>	<i>Lighting Ready Reference / Energy Management</i>

American Association of State Highway and Transportation Officials

<i>AASHTO LTS-2</i>	<i>Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals</i>
<i>AASHTO GTB-77</i>	<i>Guide for Selecting, Locating, and Designing Traffic Barriers</i>

4 Definitions

Ambient Temperature: Average temperature of air or another medium in the vicinity of the luminaire. Ambient temperature is expressed in degrees Celsius.

Operating Temperature Range: Ambient temperature range within which the luminaire with regard to the specification can be operated. The operating temperature range is expressed in degrees Celsius.

Luminaire: Apparatus which distributes, filters or transforms the light emitted from one or more lamps and which includes all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply. The words “luminaire” and “lamp system” are often assumed to be synonymous. For the purposes of this standard, the word “luminaire” is restricted to apparatus used for distributing light in general lighting, while “lamp system” implies use of lamps in other than general lighting applications.

Luminaire Lifetime: Length of time during which 70% of the measured initial luminous flux value are provided, as a function of maximum operating temperature range. The luminaire lifetime of the module is expressed in hours.

Lumen Maintenance: Value of the luminous flux at a given time in the life of a luminaire divided by the initial value of the luminous flux of the luminaire and expressed as a percentage x of the initial luminous flux value. The lumen maintenance of a luminaire is the effect of decrease of lumen output which is sometimes referred to as depreciation or lumen loss factor.

Luminaire Efficacy: Quotient of the luminous flux emitted by the power consumed by the luminaire. The efficacy is expressed in lm/W.

5 Lighting Requirements

5.1 General

5.1.1 In order to optimize the effective utilization of lighting energy, interior and exterior lighting design requirements for new buildings shall be in accordance with the IESNA Lighting Ready Reference / Energy Management IESNA RR-96. Design components for lighting energy management shall be per considerations in IESNA LEM-3.

5.1.2 Lighting design shall be in accordance with IESNA RP-7, as supplemented by this SAES.

5.1.3 Lighting systems shall be designed for energy efficient operation.

Commentary 5.1.3:

Lighting systems should be designed to automatically turn off or minimize lighting when it is not required. In buildings, lighting in areas that are not continuously occupied should have accessible manual switches and/or occupancy sensors to insure that lighting turned off when the area is not occupied.

5.1.4 Lighting design for parking facilities shall be in accordance with IESNA RP-20.

5.1.5 Photometric measurements of sports lighting, when required shall be performed as per the IESNA LM-5, supplemented by this SAES.

5.1.6 Photometric measurements of parking areas, when required shall be performed as per the IESNA LM-64, supplemented by this SAES.

Commentary Note 5.1.6:

Point by point lighting calculation methods should be used to confirm that lighting levels satisfy the minimum levels specified in Table 4.

5.1.7 Lighting levels stated in this specification refer to minimum maintained illuminance.

5.1.8 Lighting system power supplies consisting of 400/230 Volt, three-phase, three-wire or four-wire; and 400 Volt, two-wire shall be acceptable. The choice of voltage and distribution system for lighting installations shall depend on the area to be supplied and the required lighting load.

5.1.9 Direct-control switches and switching contacts used on lighting circuits –other than fluorescent **luminaires**- shall have a continuous current rating of at least 1.5 times the steady-state current of the lighting load.

5.1.10 Direct-control switches and switching contacts used on fluorescent lighting circuits shall have a continuous current rating of at least twice the steady-state current of the lighting load.

5.1.11 Outdoor non-plant area and street **luminaires** shall be individually controlled by a photocell –or other controller/sensor- mounted on the fixture.

5.1.12 Photocell switches shall be of the twist-lock type and shall incorporate an inherent time delay to prevent spurious operations. Photocell switches shall be suitable for continuous operation in an ambient temperature specified in [SAES-P-100](#).

5.1.13 Where floodlights are installed on steel towers, the towers shall be equipped with steel service platforms located 1.5 m below the **luminaires**.

5.1.14 Poles for area lighting and street lighting shall meet the following requirements:

5.1.14.1 Poles used in process areas shall be hot-dipped galvanized steel.

Poles outside process areas shall be hot dipped galvanized steel or seamless aluminum alloy.

Exception:

Outside plant areas, fiberglass poles in accordance with Standard Drawing [AB-036398](#) may be used.

- 5.1.14.2 Aluminum, steel, and fiberglass poles shall be provided with a suitable wiring compartment located at a height of not less than 150 mm nor more than 900 mm from the base.
- 5.1.14.3 Poles and foundations shall be designed to withstand wind loading due to a basic wind speed value stated in [SAES-A-112](#) and a gust factor of 1.3 acting on the effective projected area of the pole, bracket, and **luminaires**.
- 5.1.14.4 Lighting poles installed within 5 meters from roads having a speed limit in excess of 50 km/h and up to 65 km/h shall have breakaway bases per AASHTO LTS-2. For higher speed limits, wider zones per AASHTO GBT-77 shall apply. Poles with breakaway bases shall not have traffic guards.

- 5.1.15 Mounting method of **luminaires** shall be based on the best arrangement for illuminance, as well as easy and safe access during installation and maintenance.

Commentary Note 5.1.15:

The use of existing structural steel, equipment structure and building walls for mounting general area floodlight fixtures is desirable.

5.2 **Luminaires**, Components and their Utilization

- 5.2.1 **Luminaires** shall be marked, listed or labeled by an independent third party laboratory (notified body) the associated certificate shall state either that the **luminaires** meet appropriate designated standards or have been tested and found suitable for use in a specified manner. **Luminaires** for hazardous areas shall meet certification requirements of [SAES-P-100](#).
 - 5.2.2 If fluorescent luminaires are selected, energy-efficient type T5 or T8 and compatible energy efficient electronic ballasts having less than 10% THD (voltage total harmonic distortion) shall be used in **luminaires** for offices, control buildings, and in industrial areas. Efficacy of Compact fluorescent lights (CFL) shall not be less than 80 Lumen / Watt.
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- 5.2.3 Ballasts and capacitors for fluorescent and HID **luminaires** shall be Polychlorinated Biphenyl (PCB) free.
- 5.2.4 High-pressure sodium **luminaires** shall be used for outdoor area illumination, except for sports and recreational facilities. High-pressure sodium or Metal Halide **luminaires** shall be used for high-bay or low-bay indoor-industrial applications. Metal halide **luminaires** shall also be permitted in workshops, repair shops and maintenance shops where a high Color Rendering Index (CRI) is essential.

Exception:

*LED (Light Emitting Diode) **luminaires** meeting requirements in Section 5.3.*

- 5.2.5 The use of energy-efficient **luminaires** like High Pressure Sodium Metal Halide, and LED shall be maximized. Mercury vapor **luminaires** and incandescent **luminaires** shall not be used.

Exception:

*Incandescent **luminaires** rated below 40 Watts.*

Commentary Note:

Use of efficient luminaries such as fluorescent, compact fluorescent or LED shall be maximized to phase out or eliminate in-efficient lighting.

- 5.2.6 Battery rooms shall be provided with enclosed and gasketed (i.e., vapor-tight) corrosion-resistant **luminaires**.
- 5.2.7 **Luminaires** shall be suitable for the environment where they are installed. **Luminaires** installed outdoor shall be approved as weather proof and dust tight.

Commentary Note 5.2.7:

IEC, NEAM, and UL may have differences in classifying and defining weather proof, rainproof, wet locations, etc. The intention of this requirement is to have luminaire suitable for the application.

- 5.2.8 **Luminaires** shall be marked (tagged) with circuit number and panel board number.

5.3 LED **Luminaires**

- 5.3.1 Economical assessment based on lifecycle cost analysis and applicable electrical energy tariff shall be conducted to ensure feasibility of using LED **luminaires**.

5.3.2 LED **luminaire lifetime** of the shall not be less than 80,000 hours associated with the following conditions:

- **Ambient temperature** of 56°C and **operating temperature range** between -15°C to 65°C with direct sun exposure for outdoor applications.
- Failure rate not more than 3% for the entire **luminaire lifetime** period.
- Other performance figures specified in [Section 5.8](#).

5.3.3 Designer is responsible for selecting the LED **luminaire** system components. This includes as applicable; LED driver and **luminaire** controls, heat-sink, self-ballasted or non-self-ballasted, etc.

5.3.4 The **luminaire** manufacturer shall provide certificate issued by third party agency (notified body) verifying the **luminaire's** performance including declared **luminaire lifetime** and **lumen maintenance** based on the **operating temperature range** specified in this standard.

5.3.5 Reflectors or filters shall be provided to control the glare and harmful light spectrum to safe level. Guidelines and limits of IEC 62471 and /or the IES handbook shall be applied.

5.3.6 Additional Requirements for LED

- The LED circuitry shall prevent flicker perceptible to the unaided eye over the voltage range specified as per IEC 61000-3-3 or IEEE 1453.
- All LED components to be designed to tolerate between -20°C and +80°C at 100% Relative Humidity (RH) during non-operating/daytime.
- Voltage THD induced into an AC power line by a **luminaire** shall not exceed 10%.
- Thermal management shall be passive by design. The use of fans or other mechanical devices shall not be allowed.

5.4 Plant Lighting

5.4.1 Street lighting design shall be in accordance with IESNA RP-8, as supplemented by this SAES. As a minimum requirement, lighting shall be provided at all street intersections in plants.

5.4.2 Series street lighting shall not be used.

Exception:

Existing series street lighting systems may be maintained and extended if this does not require additional series lighting transformer capacity.

- 5.4.3 **Luminaires** positioned over stairways, platforms, elevated walkways and landings shall be positioned at a height of 2030 mm. Lower mounting height shall be permitted for stanchion mounted **luminaires** provided the **luminaire** is positioned outside the handrail vertical plane. The mounting height shall be measured from the bottom of the **luminaire** to the floor directly beneath.
- 5.4.4 Lighting of unmanned offshore platforms is at the option of the operating proponent.
- 5.4.5 Area lighting of remote and unmanned on shore oil and water wells is at the option of the operating proponent.
- 5.4.6 To determine suitability of **luminaires** for use in hazardous areas where the maximum daily ambient temperature exceeds 40°C, the temperature code (T-rating) shall be based on an ambient test temperature of 50°C or higher. The installation shall be in accordance with NFPA 70 and the area classification drawings.
- 5.4.7 Outside area and street lighting shall be controlled by photocells. In plant areas photocell control of area and street lighting shall be through a lighting contactor with a hand-off-automatic switch and provisions for remote operation. See [SAES-O-204](#) for blackout requirements.

5.5 Task Lighting

Task lighting is lighting directed to a specific surface or area to provide illumination for visual and/or manual tasks. When general area lighting provides the required illumination on a visual task, it shall be considered as task lighting. Local supplementary **luminaire(s)** shall be required when a specific amount or quality of lighting cannot readily be obtained by general lighting. In outdoor areas where tasks are not required to be performed at night, task lighting is not required.

5.6 Emergency Lighting

- 5.6.1 In the event of a power failure, emergency lighting must be provided to enable operating personnel to follow planned operating and shutdown procedures. Sources of emergency lighting power include emergency stand-by generators; station batteries, where available, providing 125-volt direct current; battery-operated self-contained floodlights (these are the most economical for general lighting); battery-operated **luminaires**.
 - 5.6.2 Minimum duration of emergency lighting in the event of normal power failure, shall be one-and-one-half hours.
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- 5.6.3 In manned switchgear rooms and control rooms where essential activities continue during failure of the normal lighting, a minimum emergency illumination level of 100 lux (10 fc) shall be provided at 760 mm above the floor.
- 5.6.4 Normal and emergency task lighting of at least 200 lux (20 fc) shall be provided for the following:
 - A. In plant areas to illuminate equipment required for use in emergencies, such as: emergency telephones, shutdown and emergency isolation stations, fire water pump areas, central foam concentrate mixing areas, fire control panels, Breathing Apparatus & Fire Extinguisher Station, and stand-by generators.
 - B. In evacuation assembly areas and in off-shore platform escape capsule areas and boat landings.
- 5.6.5 Illuminated exit signs shall be manufactured and installed in accordance with NFPA 101 requirements.
- 5.6.6 Emergency egress lighting shall be provided for the floors of required means of egress, as per [SAES-M-100](#) and this Section:
 - 1. Control Rooms
 - 2. Process Areas
 - 3. Switchgear Rooms
 - 4. In-Plant Buildings
 - 5. Offshore Platforms

Luminaires required for emergency exit illumination shall be supplied from separate sources of power for items 1-5 above and where required by [SAES-M-100](#).

- 5.6.7 The floors of means of egress shall be illuminated at all points including angles and intersections of designated corridors and passageways, stairways, landings of stairs, and exit doors. Emergency lighting shall provide initial illumination that is no less than a maintained maximum of 10 lux (1 fc) and a minimum at any point of 1 lux (0.1 fc) measured along the path of egress at floor level. A maximum to minimum illuminance uniformity ratio of 40:1 shall not be exceeded.

5.7 Building Lighting

- 5.7.1 **Luminaires** installed in the control room shall provide shadowless illumination.
- 5.7.2 Lighting for control rooms shall be designed for maximum flexibility to permit flicker-free variation of illumination levels above each group of operator workstations. **Luminaires** shall be installed to minimize reflections and glare at operating screens.
- 5.7.3 General illumination for offices, computer rooms, interface rooms and general service areas shall be provided by fluorescent, CFL, or LED **luminaires**. Office lighting shall be designed as per IESNA RP-1. Offices containing computer visual display terminal (VDT) shall be designed as per IESNA RP-24. **Luminaires** for suspended ceilings shall be recessed mounted and shall be self-supporting in accordance to NFPA 70.
- 5.7.4 **Luminaires** for offices and equipment rooms shall be controlled by manual switches located at the entrance to every room.

5.8 Luminaires Performance

5.8.1 Light Loss Factors

Table 1 containing Light-Loss Factors that shall be used in computing illuminance levels.

Table 1 – Light Loss Factors

Lamp Lumen Depreciation		Luminaire Dirt Depreciation	
HPS	0.90	Outdoor Industrial	0.71
MH (above 400 W)	0.83	Indoor Non-Industrial	0.86
MH (400 W and below)	0.77	Indoor Industrial	0.79
Fluorescent	0.86		
LED	0.7	Outdoor Industrial	0.71

5.8.2 Efficiency Requirements

Table 2 containing the allowable minimum efficiency.

Table 2 – Luminaire Efficacy

Minimum Acceptable Efficacy	
HPS	87 lumens/watt
LED* < 50 Watt	120 lumens/watt
LED* > 50 Watt	140 lumens/watt
MH (above 400 W)	58 lumens/watt
Fluorescent	82.5 lumens/watt
Incandescent	16 lumens/watt

* The classification and efficacy figures are based on the total rated power of the LED **Luminaire** (not internal LED modules).

5.8.3 Color Rendering Index (CRI) and Correlated Color Temperature (CCT) Requirements

Table 3 summarizes the CRI and CCT requirements.

Table 3 – CRI and CCT Requirements

Lighting Type	CRI		CCT
	Indoor		
LED	90 or greater		4,000 K to 6000 K
Fluorescent	82		3,500 K or greater

6 Illuminance Levels

The following minimum maintained (in service) illuminance levels in [Table 4](#) shall be used. The initial field measurement after installation shall be no less than the specified illuminance divided by the light loss factor (LLF) from [Table 1](#) and other factors utilized in the design.

Commentary Note 6:

The illumination levels outlined in [Table 4](#) are the required maintained minimum lighting levels (e.g., not average values) at the specified work plane for each location.

Table 4 – Minimum Maintained Illuminance Levels

Location	Illuminance Lux (fc)		Working Plane (mm) Related Notes [#]	
<u>Aircraft Hanger [10]</u>				
General Area	500	(50)	(900)	H [1]
<u>Area Lighting</u>				
General Area	10	(1)	Ground	H
Under Pipe-ways, Trestles & Walkways	30	(3)	Ground	H
Piers	200	(20)	Ground	H
<u>Street Lighting</u> (See Residential)				
<u>Offices</u>				
Regular	500	(50)	(760)	H
CAD Work Station	500	(50)	Task	-
Conference Room	500	(50)	(760)	H
Elevators	200	(20)	Floor	H
Corridors	75	(7.5)	Floor	H
Stairways	75	(7.5)	Floor	H
Washrooms	150	(15)	(900)	H
<u>Control Rooms</u>				
General	500	(50)	Floor	H
Instrument Panels	500	(50)	(1700)	V [2]
Consoles	500	(50)	(760)	V
Back of Panel	100	(10)	(900)	V
<u>Process Interface Buildings</u>	100	(10)	(760)	V
<u>Dining Facilities</u>				
Dining Area (leisure, light environment)	150	(15)	(760)	H
Dining Area (quick service; normal surroundings)	300	(30)	(760)	H
Service Area	300	(30)	(900)	H
Food Preparation	500	(50)	(900)	H
Entrance Halls	200	(20)	Floor	H
<u>Electrical Rooms</u>				
Vertical Face of Switchgear	300	(30)	(1700)	V
Battery Room	300	(30)	Floor	H

Table 4 - Minimum Maintained Illuminance Levels (Continued)

Location	Illuminance Lux (fc)	Working Plane (mm) Related Notes [#]
<u>Electrical Substations and Switch Yards</u>		
Outdoor Switch Yards	20 (2)	Ground H
General Substation (outdoor)	20 (2)	Ground H
General Substation (indoor)	50 (5)	Floor H
Indoor Substation Operating Aisles	150 (15)	Floor H
<u>Telephone Equipment Room</u>	500 (50)	460 (synch with T-916) V
<u>Powerhouse</u>		
Platform, Stairs (draft fans level)	200 (20)	Floor H
Burner Platform	150 (15)	Floor H
Control Area	300 (30)	(760) H
Vertical Instrument and Control Panels	300 (30)	(1700) V
Control Desk	500 (50)	(760) H
Gauges (by supplementary lighting)	300 (30)	Task -
<u>Water Wells</u>	30 (3)	Ground H
Control Panel	50 (5)	(1700) V
<u>Garage (non-residential)</u>		
Traffic Area	200 (20)	Floor H
<u>Plant Process Areas [11]</u>		
Walkways, Stairs, Platforms	50 (5)	Floor H
Pump Rows, Valves, Manifolds	50 (5)	Ground H
Heat Exchangers	50 (5)	Ground H
Separator	50 (5)	Top of Bay -
Cooling Towers (equip areas)	50 (5)	Ground H
Compressor Areas	50 (5)	Ground H
Task Lighting for Gauges, valves, instruments, control panels, push-button stations	50 (5)	(1700) V
General Area	10 (1)	Ground H

Table 4 - Minimum Maintained Illuminance Levels (Continued)

Location	Illuminance Lux (fc)		Working Plane (mm) Related Notes [#]	
<u>Plant Non-Process Areas and Buildings</u>				
<u>Tank Fields (Tank Farms) [9]</u>				
Ladders and Stairs	15	(1.5)	Floor	H
Gauging Area	30	(3)	Floor	H
Manifold Area	15	(1.5)	Ground	H
<u>Loading Racks</u>				
General Area	50	(5)	Floor	H
Tank Truck (Loading Point)	100	(10)	Task	H
<u>Firehouse</u>				
General Area (Interior)	200	(20)	(900)	H
Repairs & Service Area	750	(75)	Task	-
Storage (parts)	300	(30)	Floor	H
<u>General Machinery (A.C. Plants, etc.)</u>				
General Aisles	200	(20)	(900)	V
Gauges	200	(20)	(1700)	V
Instruments and Relays on Panels	300	(30)	(1700)	V
<u>Laboratories</u>				
Qualitative, Quantitative and Physical	500	(50)	(900)	H
Tests, Glassware, Washrooms	300	(30)	(900)	H
Fume Hoods	300	(30)	Task	-
Stock Rooms	150	(15)	Floor	H
<u>Turbo Generators</u>				
Turbine Floor	300	(30)	Floor	H
Condenser, Pump, Aux. Floor	200	(20)	Floor	H
Gauges (by supplementary lighting)	300	(30)	Task	-
<u>Warehouses</u>				
Bulk Storage (outdoor)	10	(1)	Ground	H
Bulk Storage (indoor)	100	(10)	Floor	H
Small Bin Storage	100	(10)	(760)	V
Small Parts Storage	200	(20)	(760)	V
Counter Tops	300	(30)	(1200)	H

Table 4 - Minimum Maintained Illuminance Levels (Continued)

Work Shop (Repair Shop)

Large Fabrication	200	(20)	Floor	H
Bench and Machine Work	500	(50)	(760)	H
Crane-way, Aisles	150	(15)	Floor	H
Small Machine	300	(30)	(760)	H
Sheet Metal	200	(20)	(760)	H
Electrical	200	(20)	(760)	H
Instrument	300	(30)	(760)	H

Change House

Locker Room, Shower	100	(10)	Floor	H
Lavatory (Hammam)	200	(20)	Floor	H

Plant Roads, Bikeways, Parking Lots & Alleys

Roads, Bikeways (where used)	10	(1)	Ground	H [3]
Parking Lots, Alleys	10	(1)	Ground	H [3]

Schools

Classrooms	750	(75)	(760)	H
Manual Training	1000	(100)	(900)	H
Library	750	(75)	(760)	H
Corridors	200	(20)	Floor	H

Sports and Recreation

Swimming Pools (outdoor)	100	(10)	Ground	H
Football	200	(20)	Ground	H [4]
Gymnasiums (general)	300	(30)	Floor	H [5]
Softball (infield)	300	(30)	Ground	H [4]
Softball (outfield)	200	(20)	Ground	H [6]
Tennis Courts (outdoor)	300	(30)	Ground	H [5]
Golf Driving Range (tee)	100	(10)	Ground	H
Golf Driving Range (180 m)	50	(5)	Ground	V
Volleyball (indoor)	100	(10)	Floor	H [4]
Basketball (indoor)	300	(30)	Floor	H [4]
Squash, Racquetball	500	(50)	Floor	H [5]
Handball	150	(15)	Floor	H [4]

Residential Street Lighting

Local Road (residential)	10	(1)	Pavement	H
Parking Lots, Alleys	10	(1)	Ground	H [7]

Sidewalks (Roadside)

Residential (Camps and Community Centers)	10	(1) or	Ground	H
	10	(1)	1800	V [8]
Walkways Distant from roadways, and Bikeways	10	(1) or	Ground	H
	10	(1)	1800	V [8]

Notes:

[1] H is the horizontal plane

[2] V is the vertical plane

[3]
$$\frac{E_{avg}}{E_{min}} \leq 6.0$$

[4]
$$\frac{E_{max}}{E_{min}} \leq 3.0$$

[5]
$$\frac{E_{max}}{E_{min}} \leq 2.5$$

[6]
$$\frac{E_{max}}{E_{min}} \leq 3.5$$

[7]
$$\frac{E_{avg}}{E_{min}} \leq 4.0$$

[8] For pedestrian identification at a distance.

[9] The letter E in formulas Notes [3] to [6] represents the illumination level.

[10] Refer to IES Handbook/Chapter 20/Industrial Lighting/Figures 20-11 for Illuminance Values for Aircraft Maintenance and Manufacturing (Maintained on Tasks).

[11] Illuminance for other area of activities not mentioned here shall be referred to in IES Handbook/Chapter 20/Industrial Lighting/Figures 20-29.

16 June 2013

Revision Summary

Major revision.