FEDERATION INTERNATIONALE DE L'AUTOMOBILE

CIRCUITS COMMISSION

FIA PERFORMANCE SPECIFICATION 2010

Motor racing circuit floodlighting for competition vehicles without headlights

The following Performance Specification for floodlighting is not constraining and is independent from FIA regulations. It can freely be used by circuit owners and motor sport promoters and providers.

ISSUE 1.0
Published on 22.10.2010

Based on the Performance Specification and Lighting Guidelines, 19.07.09, drafted by Urbain du Plessis

Contents

1. Scope

This document considers the power supply, structural elements required to physically carry the lights, as well as lighting levels and verification procedures as part of the lighting system.

A glossary of terms as used in the various FIA lighting guidelines is to be found in:
Appendix A: Definitions and Recommended Principles

2. Objective

The primary aim of this document is to provide a guide for the design, approval, and verification of lighting systems that meet, in safe conditions, the performance criteria to deliver a quality of illumination of motor racing circuits necessary for drivers and officials to perform their tasks.

The secondary aim of this document is to provide a guide for the design, approval, and verification of lighting systems that meet the performance criteria to deliver the required level and quality of illumination on a motor racing circuit for high quality television broadcast.

3. Risks

In general sport lighting practice it is assumed that once sufficient provision has been made for the visual needs of spectators and or broadcast television that the lighting will also meet the participant's requirements. However the risks associated with lighting for participants and officials in motor sport are such as to claim priority over the spectator and or television lighting requirements.

The mitigation of the fundamental risks to the participants forms the core of this specification, however due to the high performance targets set in this document the resultant visual conditions for spectators and broadcast television cameras would be superior those required in more typical sport lighting specifications.

The main concerns are

- Dazzling of participants
- Insufficient and or poorly distributed light
- Poor TV image quality
- System & component failure
- Accidents
- Interference
- Logistics
- Weather

4. Priorities

The performance targets in this document are set to produce a safety driven design outcome based on the following fundamental principles in order of priority:

- Minimize the risk of damage or injury to participants, officials and the public by the lighting system.
- Minimize the risk of dazzling or disorientation of a driver by the lighting system.
- Minimize the risk of causing effective darkness on all or part of the track during a race due to a failure of some part of the lighting system or by a reasonably foreseeable event on the circuit.

- Provide the quantity and quality of lighting required by drivers and officials to make consistently accurate visual judgments under the dynamic conditions of motor sport regarding the condition of the circuit and the position, speed and direction of the cars.

5. Lighting Equipment specification

In addition to the normal safety procedures associated with large lighting systems in public places it is vital to ensure that the lighting system does not introduce new impact risks to competitors.

The design must minimize the possibility that competitors might come into contact with the mechanical and electrical equipment in the lighting system, its supporting structures or the power supply during an accident.

Standard electrical, structural and mechanical regulations and good practice are considered as the minimum required for any competently designed system. The installation must legally comply with such safety regulations as are in force at the location.

5.1. Electrical:

- All electrical equipment, cables and controls should be physically located where they cannot come into direct contact with an out-of control competitor, or debris caused by an accident.
- Where it is impossible to locate the equipment as specified in the above, additional passive physical barrier safety measures must be provided to deliver the same protection.
- All electrical equipment must be designed and located so that it does not impede operational safety of the race officials, media and other support staff.
- All electrical equipment must be located out of reach of the public.
- Circuits and connectors must be designed so that exposure to live electrical equipment will not occur in case of the accidental detachment of exposed elements of the system.

5.2. Mechanical & Structural:

- All equipment must be designed and located to operate safely in normal contact with the race officials, media and other support staff.
- The equipment must remain safe after damage by an accident to allow operational safety of the race officials, media and other support staff.
- Where it is foreseeable that a car or parts of it could contact the lighting equipment, it must be designed to minimize the possibility of elements falling on the track or any occupied areas.

5.3. Thermal

- The equipment must be designed to ensure that all elements exposed to normal contact with the race officials, media and other support staff remain sufficiently cool not to cause harm to exposed skin contact.
- Components that operate at elevated temperatures must be protected from contact by suitable enclosures, where forced ventilation is used the system must include at least one level of redundancy.
- Equipment outside normal contact must be clearly marked with warning labels.

5.4. Colour

- The CRI of the lighting system should be > 90 to allow accurate and consistent recognition of colour. This is not only important for the race control cameras but also for emergency medical staff and TV broadcasting (some broadcasters do accept CRI of 80, but it is generally deemed insufficient for High Definition broadcast requirements).

- The CCT of all the lamps in the lighting system should not vary by more than 200K from the nominal value: this ensures consistent colours from all cameras.

- The nominal CCT for lighting system of venues that host a race that starts in late afternoon and continues into darkness is preferably 4000K - 5000K; where races are run only under artificial lighting 6000K is preferred.

5.5. Location & Aiming

The lighting equipment should be designed to allow accurate and repeatable adjustment of orientation to occur, to ensure that the system meets the specification requirements in section 7, to within a tolerance of ± 10% at all times.

5.6. Materials

- All lighting equipment, cables and controls should be produced from materials that will not introduce new fire or pollution risks in case of an accident.
- The materials must be able to withstand exposure to race fuel, fire suppression and cleaning chemicals with no reduction in the safety of the equipment.
- Insulation materials must not produce any toxic smoke and must be flame retardant.

5.7. Maintenance Requirements

- The equipment must be designed to allow immediate safe repair to ensure that an accident in one race does not affect the lighting to following events on the same day.
- **Maintained illuminance:** if a lighting installation is installed for a significant period or permanently it is important to make design allowances for the effect of dirt, lamp degradation and other factors that will diminish the light output over time. The performance of the lighting system after allowance for these factors is the “maintained illuminance”.

5.8. Operation, Control & Procedures

- Clear and comprehensive manuals should be established for the installation and operation of the structural, lighting, electrical, control and communication equipment under normal as well as emergency conditions.
- The necessary documentation must be made available and the systems tested and demonstrated to the satisfaction of the relevant approval authority before an event is held using the lighting system.
- **Atmospheric effects:** the effects of dust, fog, rain, snow and pollution on light transmission can be significant but are dynamic by nature and it is thus hard to make specific allowances; race officials will apply existing practice relating to acceptable visibility.

6. Electrical Power Supply

Specific measures are required to ensure that the system will remain safe and continue to operate normally under most reasonably foreseeable race conditions, and some level of lighting will be delivered under abnormal conditions.

6.1. Damage and insulation

The design must demonstrate proof against current leakage and lighting interruption from foreseeable damage, or measures to prevent damage under at least the following conditions:

- Support vehicles crossing cable ways.
- Damage to lighting equipment by an on-track accident
- Water exposure from heavy rains or fire-fighting equipment
- Minor impacts with generating equipment and lighting support structures caused by service vehicles for example

6.2. Redundancy

- At least two power sources each with capacity to carry the full load connected to each circuit must be available.
- Change-over of supplies under full load without interruption of the lighting during the loss of one supply must be demonstrated
- The cabling system to the lights must be redundant and allow the removal and replacement of one supply cable in a circuit without interruption of the lighting in that circuit to be demonstrated
- The lighting system must be designed so that the loss of any one light source (lamp/globe) will not cause the illumination on the section of track serviced by it to be affected by more than 15%
- The lighting system must be designed so that the loss of any section of dual supply cable or power supply point will not cause the illumination on the section of track serviced by it to be affected by more than 50%
- The system must include fail-safe back up lighting capable of immediately delivering not less than 15% of the normal Eh ave on the track for 30 minutes if the main system fails catastrophically

6.3. Voltage regulation

The power supply voltages must be regulated to ensure the lighting system meets the specification in section 7 under the conditions set out in Section 8.2.

7. Lighting specification

7.1. Illumination levels (E ave) – Recommended minima

Average illumination level (maintained)	Track	Pit lane	Garages (if TV)	Track including 2m shoulder each side	Run-off area	Official area behind safety fence
Horizontal Eh ave at ground level	1250 lux	1250 lux	800 lux	800 lux	500 lux	250 lux
Vertical Ev ave 0.7m above ground level	750 lux	750 lux	---------	---------	---------	---------

For High Definition TV						
Horizontal Eh ave at ground level	2000 lux	2500 lux	1500 lux	1500 lux	1000 lux	500 lux
Vertical Ev ave 0.7m above ground level	1500 lux	2000 lux	---------	1000 lux	750 lux	---------
Vertical Ev ave 1.5m above ground level	1000 lux	--------	1000 lux	---------	---------	---------

Note1:Lighting in run-off areas and escape roads should be lower, such as to show that they are not part of the track.

Note 2: Particular attention should be paid to the illumination of high speed braking areas.

7.2. Lighting Distribution

The distribution and variance of light in the defined illuminated area is an important factor, contributing substantially to the ability to make accurate judgments of speed, and minimizing the need for adaptation changes.

Considering the speed at which participants must view and judge their environment uniformity of illumination may be considered more important than absolute illumination levels.

In general terms our eyes will adapt to the highest luminance in view – poor uniformity will then render some areas in practical darkness; regardless of actual light level.

Uniformity (U1)

E min / E ave	**Track** **Pit lane** **Garages (if TV)**	**Track including 2m shoulder each side** **Run-off area** **Officials' area behind safety barrier**
Horizontal at ground level	0.7	0.5
Vertical where 0.7m above ground level	0.5	0.3

Diversity (U2)

E min / E max	**Track** **Pit lane** **Garages (if TV)**	**Track including 2m shoulder each side Run-off area** **Officials' area behind safety barrier**
Horizontal at ground level	0.5	0.3
Vertical 0.7m above ground level	0.3	0.3

7.3. Glare

Two categories of glare are defined in lighting engineering terms: discomfort glare and disability glare.

Discomfort glare does not affect the observer's ability to see and it is not a safety risk – hence it is not considered further in this context.

Disability glare is a significant safety risk due to its involuntary physiological nature: the loss of retinal image contrast as a result of intraocular light scatter from a source outside the current adaptation level. The impact of disability glare is prolonged because the eye takes a considerable time to re-adapt to the ambient light after the excessive light has passed.

Based on the key risks stated in Section 3, minimizing, and wherever possible elimination of disability glare is a design priority. Applying typical sports lighting glare criteria is not sufficient in this context.

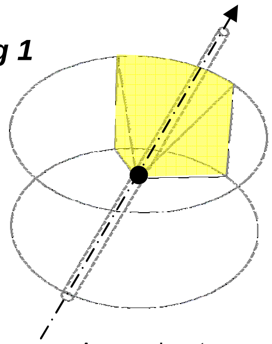
To overcome the limitations of other specifications and standards this document limits the luminance of all objects in the drivers' field of view – managing the risk at origin. This approach also enables the regulators and operators to manage the impact of lights in locations outside the racing zone but visible to the participants.

Recommended maximum average luminance of any 1° cone field of view facing observer in the defined field of view:

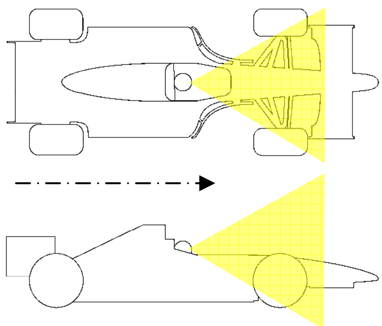
Driver view	**Position**	**Field of view**	**Max average luminance**
In direction of racing	0.7m above track on race line including pit lane.	± 30° horizontal and ± 30°vertical (Fig 1)	200 kcd/m^2
All other directions	0.7m above track on race line including pit lane	± 150° horizontal and ± 30°vertical (Fig 1)	500 kcd/m^2

Important Note: The luminance limitations should not only be applied for all track illuminating equipment, but also to secondary lighting in public areas etc since the disability glare impact on participants is the same regardless of origin.

Fig 1



Arrows denotes race direction



Driver Field of View in race direction

7.4 Stroboscopic effects

For TV filming purposes electrical power supply should ensure that adjacent lights illuminating the track are operated from different supply phases if the lighting system uses conventional control gear operating at supply frequency.

If high frequency "Flicker Free" electronic control gear is used this requirement is superfluous from a stroboscopic effect, but remains good electrical engineering practice.

7.5. Flicker

Flicker is the effect of individual lights on the peripheral vision of drivers as they circulate around the circuit.

Flicker in the 5Hz to10 Hz range is disturbing and should be avoided, the effect is physiological and while it is possible to cope with flicker it will diminish visual acuity of the drivers. Lighting equipment should be spaced so that drivers will not experience flicker in the disturbing range over the full range of race speeds. This may require different light spacing around the track

Example for light spaced 15m apart

Race speed 90km/h → 25m/sec Flicker frequency = 1.7 Hz (<5 Hz)
Spacing is OK

Race speed 350km/h → 97m/sec Flicker frequency = 6.5 Hz (>5Hz & <10 Hz)
Spacing is too close

7.6 Shadows

- The lighting system should not cast solid shadows onto the track of either the track infra structure or the participants on the track, see Fig 2.
- The lighting system should ensure that the track and runoff area is not covered by a solid shadow if a competitor stops on the track, see Fig 3.
- The lighting system should not cast long shadows across the track as shown in Fig.4.
- To minimize the disturbing effects of shadows on competitors it is preferable to ensure that shadows falling *across* the track are short with the longer shadows *along* the race track see Fig 5

Fig 2

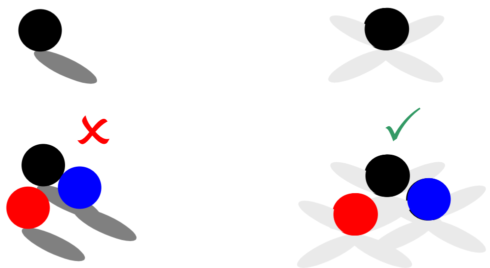


Fig 3

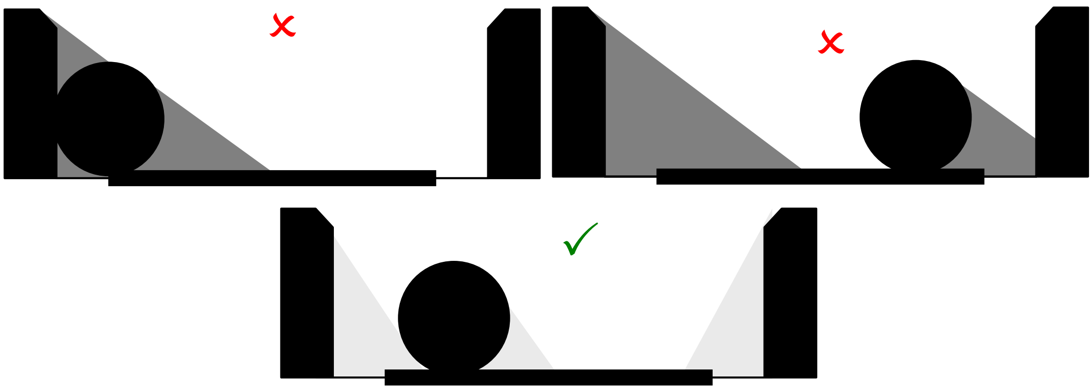


Fig 4

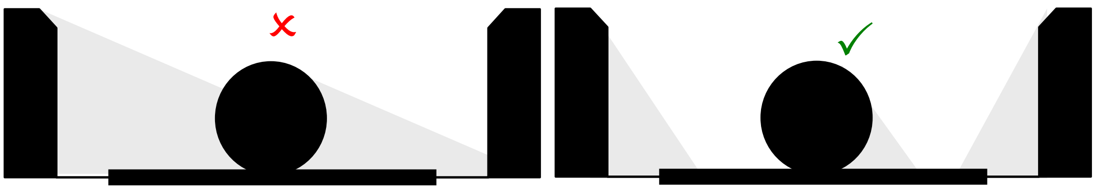
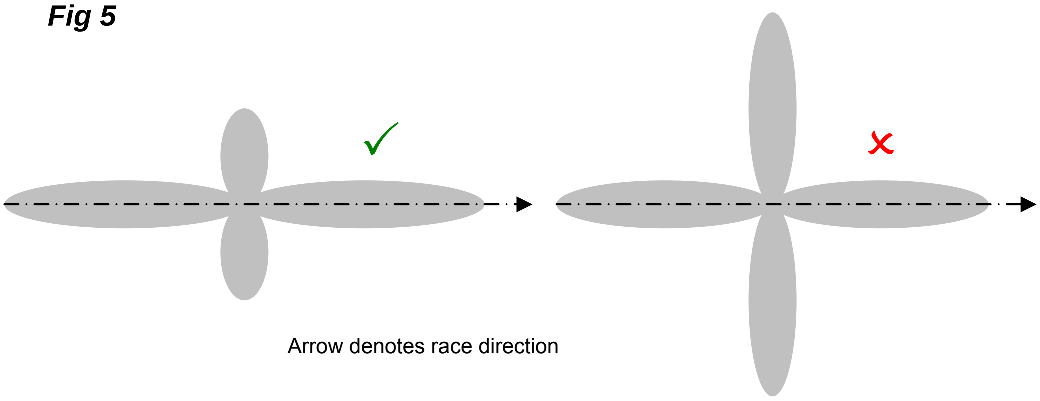


Fig 5



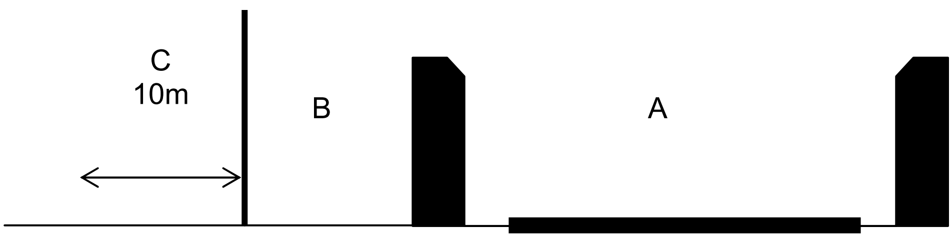
7.7 Spill light control

The illumination levels specified in section 7.1 apply to the track “Area A” and “Area B” where race officials and support staff operate.

The public area outside the safety fence “Area C” (Fig 6) is not covered by the section 7.1. Due to the high illumination levels specified in Areas A & B some light will spill into Area C.

The illumination in the 10m closest to the safety fence “Area C” need not exceed 20% of the requirements for area B (Eh ave of 100 lux).

Fig 6



8. System Performance Verification

Due to the risks of injury in motor sport and the complex high-value contracts associated with broadcast rights, race track operators should be able to demonstrate compliance of the lighting system after the fact and under conditions of legal discovery.

Permanent and temporary installations should be capable of demonstrating and documenting the following:

- The supplied equipment conforms to the equipment specified in the design approved by the client.
- The equipment is installed as per the design approved by the client.
- The system met all the performance specifications approved by the client.
- Permanent installations should have the additional requirement to document repairs and maintenance carried out after commissioning to the same level.

Recommendations concerning contractual requirements and tools for verifying that systems perform in conformity with their Specification are available from the FIA.

APPENDIX A

Definitions and recommended principles

Intensity cd (candela)
A finite amount of (light) radiation emitted in a finite cone surrounding the direction – for many practical applications the source is considered a point and the cone infinitely small i.e. a simple direction.

Flux lm (lumen)
The radiation of light into a 4π solid angle / sphere. Typically used to define the output of a light source or a luminaire.

Illuminance: lux (lumen/m²)
The luminous flux per unit area falling on a surface is called the *illumination* or illuminance of the surface.

Horizontal illuminance (Eh):
Illumination of an actual or imaginary plane/s parallel to the ground (this can become more complex in real life when the ground surface is rarely perfectly flat).

Vertical illuminance (Ev):
Illumination on an actual or imaginary plane/s perpendicular to the ground. The plane may be orthogonal or facing a specific point like a camera or observer.

Luminance (cd/m^2)
Illuminated surfaces differ greatly in their response to incident light. A specular reflecting surface, such as that of a metal, reflects the light according to the laws of reflection and forming a distinct image while a diffuse surface scatters light into all directions. Most surfaces behave somewhere in between – and the relative specular behaviour changes with viewing angle. The combined effect of reflective type with surface colour determines on the incident light determines the actual luminance to the observer.

Modeling
To make adequate depth and shape judgment of objects requires suitably supportive lighting that highlights the surface shape and texture, this largely subjective aspect is termed modeling.

Calculation grid
Illuminance is normally calculated and measured for a grid of points of sufficient density to provide a suitably accurate representation for the task. It is possible to calculate Eh as well as Ev values (often multiple Ev values) for each grid point. Practical limitations generally impose more limits on the measurement grid density, and it is thus common practice to measure to lower grid densities than the design density.

Uniformity (U_1)
Uniformity is generally defined as Emin / Eave and a limit is specified, example: $U_1 \geq 0.7$; it is important to note that it must be used in context to a defined area and measurement grid to have any value. Changes in the grid density, origin, and area will make most likely comparisons meaningless.

Diversity (U_2)
Diversity is closely related to Uniformity is generally defined as Emin / Emax and a limit is specified, example: $U_2 \geq 0.5$; it is important to note that it must be used in context to a defined

area and measurement grid to have any value. Changes in the grid density, origin, and area will make most likely comparisons meaningless.

Horizontal Illuminance uniformity in a defined grid:
Horizontal illuminance uniformity is important to avoid adjustment problems for both humans and cameras. It is important also that there is not too great a change in horizontal illuminance over a given distance.

Vertical illuminance uniformity in a defined grid facing a particular point:
Different vertical illuminance values across the circuit can be disturbing when tracking an object or panning a camera from a specific point, especially when covering rapid action sports.

Vertical illuminance at a grid point facing different points
The uniformity of vertical illuminance at a single grid point over the four orthogonal planes facing the sides of the track should not exhibit large differences. Fulfilment of this requirement will ensure that the vertical planes facing an actual observer or camera position somewhere in that area or areas will have sufficiently high illuminance. It also enables multiple cameras to make shots of the same object / area that appear equally bright. Finally the fulfilment of this requirement guarantees adequate modelling of the objects.

Relation between Horizontal and Vertical Illuminance
As the illuminated area forms a major part of the field of view of the observer and camera alike, an adequate horizontal illuminance is important. A sufficiently good balance between the horizontal and vertical lighting levels is required for ensure good modeling and to ensure that the large top surface of cars appear to be of similar brightness as the vertical sides.

Colour temperature (CCT)
In the case of outdoor installations with a significant daylight contribution, the colour temperature of the artificial lighting must minimise apparent colour changes in the scene when daylight is replaced progressively by artificial where floodlighting is used during the day and into dusk.

Colour temperature and colour rendering are connected in incandescent lamps but these aspects are not related in discharge lamps. Colour temperature is normally quoted in degrees Kelvin (K) and stated as Correlated Colour Temperature (CCT) for discharge lamps.

Colour rendering (CRI)
The colour-rendering index (CRI) of the lighting is the ability of the lamp to produce light of which it's colour content allows accurate and consistent rendition of colour. In the present context it is important that the lighting system should ensure that the colour balance system of the camera minimises visual differences between direct viewing, day-light events and night time viewing on television.

High quality colour rendering of artificial lighting has also been shown to reduce fatigue and improve response times in drivers, and is thus a secondary contributor to safety.

Stroboscopic effects:
Discharge lamps switch on and off with each cycle of the electrical supply (50hz / 60hz) normally our visual system integrates the discrete light pulses into a continuous scene, but film and television cameras do not.