Tunnel and underpass lighting
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What you ought to know about tunnel lighting

For smooth traffic flow, in bright daylight and total darkness, and in all weather conditions, tunnel lighting should be such that the drivers’ sense of safety and comfort is not diminished compared with the experience on the open road. This means that drivers should have adequate visual information concerning the behaviour of other road users, the course of the road ahead, and the presence of any obstacles in the tunnel, to be able to react in time within a safe stopping distance. Guidelines for tunnel lighting according to B.S. 5489 pt 7 & the CIE 88 can be found below and in the references.

When to light by day

Being adapted to the relatively high luminance outside, drivers will not be able to see details in a long tunnel, which appears on approach as a ‘black hole’. For a short tunnel details may be visible in negative contrast when the tunnel appears as a dark frame around a bright background.

The decision whether a tunnel or underpass has to be lit during the day depends on the length of the tunnel, the visibility of the exit, the amount of natural light in the tunnel and the traffic density. A guideline in this decision is offered by B.S. 5489 pt 7 & the CIE 88.

How to light by day

Good tunnel lighting takes care of good visibility conditions for the road users; this requires lighting levels that are matched with the adaptation level of the users’ eyes. As this adaptation level gradually changes while travelling through the tunnel for lighting purposes the tunnel can be divided lengthwise into five zones: the access, threshold, transition, interior and exit zone. (Fig. 1)

The access zone

The access zone is not a part of the tunnel itself, but the approach road immediately before the tunnel entrance, from where drivers need to be able to see and stop in front of obstacles in the tunnel. The length of the access zone is consequently equal to the Safe Stopping Distance (SSD).

The maximum light adaptation condition of the drivers’ vision in this zone, determines the luminance in the threshold zone at the beginning of the tunnel.

B.S. 5489 pt 7 & CIE defines the adaptation state as L20, the average luminance in a conical field of view of $2 \times 10^\circ$ centred in the tunnel opening at the safe stopping distance from the entrance.

L20 measurements and recordings for the access zone over a long period are the most solid basis for the entrance lighting design (Fig. 2).

### Table 1 Recommended threshold/access zone luminance ratios

<table>
<thead>
<tr>
<th>Stopping distance (m)</th>
<th>Symmetrical lighting system $L_{th}/L_{20}$</th>
<th>Counter-beam lighting system $L_{th}/L_{20}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>100</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>160</td>
<td>0.10</td>
<td>0.07</td>
</tr>
</tbody>
</table>

### Table 2 Recommended interior zone luminances (cd/m²)

<table>
<thead>
<tr>
<th>Stopping distance (m)</th>
<th>Traffic density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;100 veh/h</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>160</td>
<td>5</td>
</tr>
</tbody>
</table>

Fig. 1 The five tunnel zones defined for the purposes of lighting design.
The threshold zone
The required luminance level in the first section of the threshold zone, which length is equal to the safe stopping distance, is related to the L20, the outside luminance level, the stopping distance and the applied optical system as shown in table 1. Daylight screens, louvres and other measures that reduce the L20 will proportionally reduce the amount of light and energy needed in the first zones of the tunnel. In the second half of the threshold zone the luminance level is decreased rapidly to 40% of the initial level (see fig. 3 for a schematic representation).

Transition zone
In the transition zone the lighting level is gradually reduced towards the level as required in the interior zone (fig. 3). The reduction speed is related to the adaptation speed of the eyes and thus time dependent. The reduction steps should not exceed a ratio of 3:1.

Interior zone
In the interior zone, which is often the longest section of the tunnel, the required lighting levels are related to traffic speed and traffic density as shown in Table 2.

Exit zone
Visual adaptation from low to high level takes place instantaneously, but there are other reasons for installing an increased lighting level in the exit zone:
1. To make small cars following behind large lorries visible when the daylight at the exit is glaringly bright,
2. To make following cars visible in the rear-view mirror of a car leaving the tunnel and
3. To convert the exit into an entrance (at reduced speed) in case of an emergency or for maintenance.

Emergency lighting
Emergency lighting is normally part of the night-time lighting, but is fed from an uninterrupted power supply.
Tunnel and underpass lighting

Birth-Velbert tunnel, Germany.
1: threshold zone.
2 and 3: transition zones.
Lighting system
- Symmetrical lighting is used for the entrance and interior lighting.
- Asymmetrical lighting (counterbeam) is used for entrance lighting when high contrast values are required or when the tunnel is not too short.
  Counterbeam lighting is adapted when high luminance levels are required. (high Lth/L20 or high stopping distance)

Symmetrical-transversal lighting
The light is mainly radiated at right angles to the axis of the tunnel. This results in good visual guidance, minimum glare, and light between the cars.

Symmetrical-axial lighting
The light is mainly radiated parallel to the tunnel axis, resulting in high efficiency and allowing wide luminaire spacing. However, occasional shadowing and uneven distance wall luminances can occur.

Asymmetrical-counterbeam lighting
The light is radiated parallel to the tunnel axis, mainly against the direction of the traffic flow, resulting in high efficiency and improved contrast, but with possible shadowing and uneven wall luminances.

Which lamp to use
The entrance of a tunnel needs high lighting levels of SON-T lamps. For other areas needing lower light levels, such as the interior zone or at night, compact fluorescent lamps can be used. Philips Lighting recommends TL-D/PL-L for the symmetrical-transversal lighting system and QL induction lamps for the symmetrical-axial lighting system. These white light sources are preferred for their good colour rendering over the more efficient SOX lamps. The light output of (compact) fluorescent lamps however is temperature dependent. In general, luminaire photometry is conducted at 25 °C, but the average operating temperature in a tunnel can be much lower and therefore influence the efficacy.

<table>
<thead>
<tr>
<th>Lighting system</th>
<th>Max. Spacing Ratio</th>
<th>Preferred Lamp Type</th>
<th>Efficiency (q0=0.1) cd/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetrical-transversal</td>
<td>1.5</td>
<td>TL-D/PL-L</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>SOX-E</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>SOX-N-T</td>
<td>2.8</td>
</tr>
<tr>
<td>Symmetrical-axial</td>
<td>3.5</td>
<td>SOX-E</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>QL</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>SOX-N-T</td>
<td>3.5 - 4</td>
</tr>
<tr>
<td>Asymmetrical-counterbeam</td>
<td>2.25</td>
<td>SOX-N-T</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Fig. 4 Tunnel lighting systems
Tunnel and underpass lighting

**Tunlite CRX202/203/204/206**


**Main applications**
- Tunnels

**Features**
- Range of 4 standard housings of high-quality extruded AlMgSi alloy profiles and die-cast aluminium rounded corners, argon-welded in an automated process.
- Finishing of the housing by chromatization according to DIN 50939 followed by 60 µm polyester powder coating RAL 7016.
- A self-adjusting removable front glass frame of extruded aluminium, hinged on stainless steel inside the housing and holding a 5 mm toughened security glass. The IP 66, tightness is secured by two silicone gaskets fitted in the extruded aluminium frame.
- A removable optical and gear unit consists of a dedicated optical system of high-purity anodized aluminium (99.9 %) and an electrical tray containing all the required control gear. These modular units are easily interchangeable without the need for tools which simplify installation and maintenance.
- Plug-and-socket connection for the optical and gear units.
- Cable gland and a terminal block for wires up to 3 or 5 x 16 mm² per lamp.
- Four glass fibre reinforced polycarbonate knobs (1/4 turn) for tool-less opening and closing of the glass cover.
- Quick-fastening devices for tool-less securing of the optical and gear units.
- All units equipped with 230 V/50 Hz gear. Other voltages and frequencies optional.
- The luminaires are approved according to IEC 60598-1/2-3.
- Packing quantity: 1 unit per box.

**Mounting brackets (optional)**
- A set of stainless steel mounting brackets with stainless steel bolts, nuts and washers for adjustable mounting.
- A set of nylon washers between the aluminium profile and stainless steel bracket to prevent electrochemical corrosion.

**Options**
- Dimming gear
- Self-stopping ignitor
- Fuse (10 x 38 mm)
- Through-wiring
- Class II insulation for SON-N-T lamps only
- Entrelec™ terminal block for 2 x 2.5 to 6 mm² wire with or without fuse 5 x 20 mm (optional)
- ZRX 208 set of four brackets for ceiling-mounting
- ZRX 209 set of two tilt adjustable brackets for wall-mounting
- ZRX 210 set of two brackets for continuous line-mounting.
Tunnel and underpass lighting

Tool-less front opening
Tool-less removable front glass.
Tool-less removable optic/gear unit

Easy accessible optic and gear
Terminal blocks
Entrelec™ terminal block (optional)

Mounting brackets for ceiling-mounting ZRX208
Mounting brackets for wall-mounting ZRX209
Mounting brackets for ceiling continuous line-mounting ZRX210

Tunlite CRX 202/203/204/206
# Tunlite™ Modular Product Matrix
## CRX 202/203/204/206

<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Optical and Gear Unit</th>
<th>CRX 202</th>
<th>CRX 203</th>
<th>CRX 204</th>
<th>CRX 206</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp type</td>
<td>3420</td>
<td>3412</td>
<td>3451</td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>Gear wattage</td>
<td>100 - 400 W</td>
<td>100 - 400 W</td>
<td>100 - 400 W</td>
<td>70 - 150 W</td>
<td></td>
</tr>
</tbody>
</table>

### Light technical data

| CRX 202 3420 1xSON-T PLUS 400W |
| CRX 203 3412 2xSON-T PLUS 400W |
| CRX 204 3451 1xSON-T PLUS 400W |
| CRX 206 305 2xSON-T PLUS 400W |

### Unit shape

- **CRX 202**: 3420 (1-lamp)
- **CRX 203**: 3412 (2-lamp)
- **CRX 204**: 3451 (2-lamp)
- **CRX 206**: 305 (1-lamp)

### Unit type

- **TYPE I**

### Housing type

- **CRX 202**: 1x optical and gear unit type I
- **CRX 203 (2-lamp)**
- **CRX 204**: 1x optical and gear unit type I
- **CRX 206 (2-lamp)**
- **CRX 206 (1-lamp)**
### Type II
- Optical and gear unit type II
- Optical and gear unit type II
- Optical and gear unit type II

### Type III
- 1x optical and gear unit type III
Short tunnel and underpass lighting

What is a ‘short tunnel’?
A short tunnel is a road or rail over bridge and underpass of more than 25 m, for motorized traffic including entrances to multi-storey car parks, for example. The height may be 2.5 m or more and the width from 5 to 20 m. If the tunnel is shorter than 25 m no additional tunnel lighting is required. When the underpass is longer than 25 m a dark frame or a dark hole may appear around the bright exit. Here an obstacle may completely be invisible for an approaching driver at a distance equal to the Save Stopping Distance (SSD).

When to light by day
This depends on a number of factors including the length of the tunnel, visibility of the exit, penetration of daylight, brightness of the walls, and traffic density.

When to light by night
During the night, CIE recommends a minimum light level equal to the light level of the approach roads. BS 5489 recommends where approach roads are lit, a level of not more than 3 times the approach road level.

Recommended day time lighting levels (CIE 88-1990)

<table>
<thead>
<tr>
<th>Tunnel length (m)</th>
<th>Is exit fully visible when seen from SSD?</th>
<th>Is daylight penetration good or poor?</th>
<th>Is the wall reflectance high (&gt;0.4) or low (&lt;0.2)?</th>
<th>Is traffic heavy or light (or including bikes and pedestrians)?</th>
<th>% of normal threshold zone lighting level required</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>Yes</td>
<td>Light</td>
<td>Light</td>
<td>Heavy</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy</td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>25-75</td>
<td>No</td>
<td>Good</td>
<td>High</td>
<td>Heavy</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor</td>
<td>Low</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>75-125</td>
<td>Yes</td>
<td>Light</td>
<td>Light</td>
<td>Heavy</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Good</td>
<td>High</td>
<td>Heavy</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor</td>
<td>Low</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>&gt;125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
BS 5489 shows 4 lighting classes for tunnels.

<25 m: No lighting.
25-50 m: Limited day light lighting of 15 cd/m² or 3 times the interior light level, as given in above table for long tunnels, whichever is the greater. To be operated when the ambient luminance has reduced to 10 % of the maximum L₂₀.
50-100 m: Constant lighting level over the tunnel length, like the threshold zone lighting level for long tunnels.
>100 m: A class with complete lighting as for long tunnels. BS recommends a night-time lighting of 3 times the outside road light level.

Daytime lighting

Dusk/Dawn lighting

Nighttime lighting
Wallring tunnel, Hamburg, Germany