As our road networks become more crowded, the use of tunnels and underpasses is expanding, to improve traffic flow, and also to protect local environments from increased traffic exposure.

Within tunnels, where maintenance access can be limited, and where corrosive atmospheric conditions are common, reliable performance of the lighting system is critical, as is the need for absolute minimum maintenance operational requirements.

**The objectives of tunnel lighting**

The aims of tunnel lighting are:

- Firstly, to allow traffic to enter, pass through and exit the enclosed section safely.
- Secondly, to do so without impeding the through-flow of traffic.

These aims are achieved by the adequate illumination of the tunnel interior, which allows drivers to quickly adjust to the light within, identify possible obstacles, and negotiate their passage without reducing speed.

These requirements apply during the day when the contrast between outside and inside is significant and at night when it is less, but reversed.
Tunnel lighting criteria

Good tunnel lighting allows users to enter, pass through and exit the enclosed section safely and comfortably.

The 5 zones of tunnel lighting
CIE guidance (CIE 88-1990), and UK standard (BS5489-2:2003) state that the amount of light required within a tunnel is dependent on the level of light outside and on the point inside the tunnel at which visual adaptation of the user must occur.

When planning the lighting of a tunnel, there are 5 key areas to consider:

1 Access zone
Not within the tunnel itself, this is the stretch of road leading to its entrance.

From this zone, drivers must be able to see into the tunnel in order to detect possible obstacles and to drive into the tunnel without reducing speed.

The driver’s capacity to adapt in the access zone governs the lighting level in the next part of the tunnel. One of the methods used by CIE to calculate visual adaptation is the L20 method, which considers the average luminance from environment, sky and road in a visual cone of 20°, centred on the line of sight of the driver from the beginning of the access zone (see below).

2 Threshold zone
This zone is equal in length to the ‘stopping distance’. In the first part of this zone, the required luminance must remain constant and is linked to the outside luminance (L20) and traffic conditions. At the end of the zone, the luminance level provided can be quickly reduced to 40% of the initial value.

3 Transition zone
Over the distance of the transition zone, luminance is reduced progressively to reach the level required in the interior zone. The reduction stages must not exceed a ratio of 1:3 as they are linked to the capacity of the human eye to adapt to the environment and, thus, time-related. The end of the transition zone is reached when the luminance is equal to 3 times the interior level.

4 Interior zone
This is the area between transition and exit zones, often the longest stretch of tunnel. Lighting levels are linked to the speed and density of traffic, as outlined in the table below.

Luminance to be maintained in interior zone

<table>
<thead>
<tr>
<th>Area</th>
<th>Traffic conditions</th>
<th>Luminance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra urban, low traffic, low speed (&lt;70km/h)</td>
<td>1.5 to 3 cd/m²</td>
<td></td>
</tr>
<tr>
<td>Extra urban, high traffic and/or speed (&gt;70km/h)</td>
<td>2 to 6 cd/m²</td>
<td></td>
</tr>
<tr>
<td>Highway</td>
<td>4 to 10 cd/m²</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>4 to 10 cd/m²</td>
<td></td>
</tr>
</tbody>
</table>

5 Exit zone
The part of the tunnel between the interior zone and the portal. In this zone, during the day time, the vision of a driver approaching the exit is influenced by brightness outside the tunnel.

The human eye can adapt itself almost instantly from low to high light levels, thus the processes mentioned when entering the tunnel are not reversed. However, reinforced lighting may be required in some cases where contrast is needed in front of or behind the driver when the exit is not visible, or when the exit acts as entrance in case of emergency or maintenance works where part of a twin tunnel may be closed. The length is a maximum 50m and the light level 5 times the interior zone level.

Visual adjustment
The visual adjustment from high luminance to low luminance while driving is not instantaneous. This is because of two disability phenomena:

1. Spatial adaptation: the large difference in luminance between the outside and the inside of the tunnel will impede the vision of the driver when he is at the adaptation point (‘A’, opposite). The “Black Hole” phenomenon engenders a feeling of discomfort and insecurity.

2. Temporal adaptation: human eyes need more time to adapt from brightness to darkness than the reverse. During this period of adaptation, the distance travelled is a critical factor.
The entrance portal of the tunnel is the part of the tunnel construction that corresponds to the beginning of the covered part of the tunnel, or - when open sun-screens are used - to the beginning of the sun-screens. The exit portal corresponds to the end of the covered part of the tunnel, or - when open sun-screens are used - to the end of the sun-screens.

**Definitions**

**Access zone luminance \( L_{20} \)**
The average value of the luminance in a 20° cone of the driver's visual field from the access zone and centred on the tunnel entrance.

**Contrast revealing coefficient \( q_c \)**
The ratio between the luminance at the road surface and the vertical illuminance \( E_v \) at a specific location in the tunnel \( q_c = L/E_v \). The method of tunnel lighting may be defined in terms of the contrast ratio in two ways: symmetric lighting and counterbeam lighting (see pages 6 - 7).

**Entrance and exit portals**
The entrance portal of the tunnel is the part of the tunnel construction that corresponds to the beginning of the covered part of the tunnel, or - when open sun-screens are used - to the beginning of the sun-screens. The exit portal corresponds to the end of the covered part of the tunnel, or - when open sun-screens are used - to the end of the sun-screens.

**Exit zone**
The exit zone is the part of the tunnel where, during the daytime, the vision of a driver approaching the exit is predominately influenced by the brightness outside the tunnel. The exit zone begins at the end of the interior zone. It ends at the tunnel’s exit portal.

**Interior zone luminance \( L_{in} \)**
The average luminance in the interior zone which constitutes the background field against which objects will be visible to users.

**Parting zone**
The parting zone is the first part of the open road directly after the exit. The parting zone is not a part of the tunnel but it is closely related to the tunnel lighting. It is advised that the length of the parting zone equals two times the stopping distance. A length of more than 200m is not necessary.

**Stopping point (SP)**
The position within the access zone on the approach road at a distance equal to the stopping distance \( SD \) from the tunnel entrance.

**Stopping distance (SD)**
The theoretical forward distance required by a driver at a given speed in order to stop when faced with an unexpected hazard on the carriageway.

This takes into account perception and reaction time as well as road surface.

**Threshold zone luminance \( L_{th} \)**
The average luminance in the threshold zone which constitutes the background field against which objects will be visible to drivers in the access zone between the stopping point and adaptation point.

**Traffic flow**
The number of vehicles passing a specific point in a stated time in stated direction(s). In tunnel design, peak hour traffic, vehicles per hour per lane, will be used.

**Transition zone luminance \( L_{tr} \)**
The average luminance in the transition zone which constitutes the background field against which objects will be visible to drivers.

**Veiling luminance**
The overall luminance veil consisting of the contribution of the transient adaptation and stray light from optical media, from the atmosphere and from the vehicle windscreen.
Types of tunnel lighting

Tunnel road lighting must provide comfort and safety and maximise the visual performance of users.

Symmetrical and asymmetrical lighting
Used generally for transition and interior zones for long tunnels, and in short tunnels, or low speed tunnels for all zones.

Asymmetrical lighting can also be a means of reinforcing the luminance level in one way tunnels.

Asymmetric counter beam lighting
To reinforce the luminance level and at the same time accentuate the negative contrast of potential obstacles. Counter beam lighting is achieved with asymmetrical light distribution facing into the traffic flow, both in the direction of the on coming driver and in the run of the road. The beam stops sharply at the vertical plane passing through the luminaire. No light is directed with the flow of traffic. This generates negative contrast and enhances visual adaptation.

Other factors
As well as the above, further factors must be taken into consideration when preparing tunnel lighting. These include the shape of the portal, type and density of traffic, traffic signage, contribution of wall luminance, orientation of tunnel, and many others. National, European and International legislation and guidance sets out minimum standards for tunnel lighting.

Relevant legislation

Day time lighting of tunnels for different lengths
(CIE Guide for the lighting of tunnels and underpasses)

When lighting a tunnel, its length, geometry and immediate environment must be taken into account as well as traffic densities. Differing light levels are set for each project, according to the governing standards summarised below:

<table>
<thead>
<tr>
<th>Length of tunnel</th>
<th>125m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is exit fully visible when viewed from stopping distance in front of tunnel?</td>
<td>yes</td>
</tr>
<tr>
<td>Is daylight penetration good or poor?</td>
<td>good</td>
</tr>
<tr>
<td>Is wall reflectance high (&gt;0.4) or low (&lt;0.2)?</td>
<td>high</td>
</tr>
<tr>
<td>Is traffic heavy (or does it include cyclists or pedestrians) or light?</td>
<td>light</td>
</tr>
</tbody>
</table>

Lighting required

| No day time lighting | 50% of normal threshold zone lighting level | normal threshold zone lighting level |

Typical tunnel lighting arrangements
The table below outlines some of the mounting options available and their respective advantages/disadvantages:

<table>
<thead>
<tr>
<th>Mounting constraint</th>
<th>Arrangement type</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Tunnel profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling mounting</td>
<td>Above road on several rows</td>
<td>- best utilisation factor for luminaires</td>
<td>- luminaires concealed by signs</td>
<td>- Arched type with or without fan tubes</td>
</tr>
<tr>
<td></td>
<td>1 row above road</td>
<td>- less investment and maintenance</td>
<td>- heavy fixings</td>
<td>- Framed type with or without fan tubes</td>
</tr>
<tr>
<td>Wall mounting</td>
<td>Twin opposite</td>
<td>- easier access to luminaires</td>
<td>- utilisation factor downgraded</td>
<td>- Arched type with fan tubes</td>
</tr>
<tr>
<td></td>
<td>Single sided</td>
<td>- less investment and maintenance</td>
<td>- high glare</td>
<td>- Framed type with or without fan tubes</td>
</tr>
</tbody>
</table>
Wall mounting: asymmetrical lighting

Ceiling mounting: transverse symmetrical lighting

Ceiling mounting: longitudinal symmetrical lighting

Wall mounting: asymmetrical lighting

Ceiling mounting: asymmetrical counter beam lighting
Tunnel lighting must allow vehicles to enter, pass through and exit the enclosed section safely without impeding the through-flow of traffic.
Thorn expertise - creating the best tunnel lighting and visibility

Our development programmes employ specialised software to help develop highly engineered optics, to optimise lighting systems, and to allow our lighting engineers to provide maximum safety and comfort for tunnel users.

Lighting a tunnel is a complex and specialised task. Thorn has developed dedicated lighting systems and services to assist planners from concept to implementation, management and servicing.

While luminance levels are used for accurate theoretical assessment, in practice, illuminance is more often used. Thorn assessment studies, therefore, are executed using luminance values, with results presented as illuminance values.

It is commonly accepted in road lighting that, even with the most accurate calculations and modelling to give the lighting levels required by the most stringent standards, there is a substantial difference between what the mathematical lighting conditions are, and what each individual driver subjectively sees in reality. This is especially true for tunnel lighting, where such sharp contrasts in light levels prevail.

**Thorn in-house visibility modelling software**

At Thorn we have addressed this problem head on. Continuous research and development has led to more sophisticated and detailed understanding of lighting and its effects on vision. Along with rapid advances in IT, this has allowed us to develop dedicated in-house software which combines mathematical models of physiological stimuli with conventional lighting modelling parameters to generate results which are, visually, as well as mathematically, accurate beyond alternative visual modelling techniques.

Thanks to an impressive number of variables, our software is a unique and accurate tool. It verifies the ability of a given lighting system to meet the visual criteria set by all national and international standards regarding detection of obstacles on the road, within the allocated time.

Thorn software measures anticipated light falling on a series of facets, in order to calculate luminance gradients on target objects.

**Helping lighting designers and tunnel users**

Taking into account criteria from the tunnel exterior and interior, the software generates a table of visibility levels (VL) that shows the extreme influence of daylight on the values of VL on targets in the entrance and threshold zones of the tunnel.

Experiments demonstrate that the minimum Level of Visibility (VL) should have a value equal to or greater than 7 to ensure detection of planar or spherical targets. Though in Thorn’s current calculations, the target size may not exactly represent a potential obstacle in a tunnel, they show the behaviour of light on real, multifaceted objects whose diffuse reflectance can be modified and therefore they represent a real visual scenario for tunnel users.

The design of the lighting system needed for a tunnel is the job of experienced designers who define the scheme, the choice of the lighting system, the type and number of luminaires and their appropriate light distribution. Thorn’s visibility software provides invaluable new input into the design of optics for tunnel fittings making it easier for designers to create lighting systems and light distribution schemes for tunnels that maximise the visual performance and comfort of users.
Controlling tunnel lighting

For the critical approach areas and interiors of tunnels, close control of light levels is essential. Levels of light outside the tunnel, time of day, speed and density of traffic, all influence the lighting requirements within. We offer fully integrated control systems to meet this demand.

Thorn tunnel lighting control
Thorn offers a comprehensive range of tunnel luminaires paralleled by an advanced, highly innovative control system which is adapted to tunnel applications:

- From basic to technologically advanced, highly innovative systems
- Fluorescent and HID lamp solutions
- Integration of up to date gear options
- Easy to install and operate systems
- Cost efficient systems
- Optimisation of safety conditions

From simple standard on/off operation, to complex step dimming or security networks, Thorn provides the best professional assistance in advising and offering the right system to meet the requirement.

DSI and DALI controls for fluorescent lamps
- Digital dimming for HF gears operating fluorescent lamps
- Unique cabling

Benefits
- Group management
- Extendible installation
- Capability to interface DSI and DALI controls with analogue 1 - 10V command on existing installations
- Ease of installation thanks to non-polarised command wires
- Enhanced safety of operation as signals not subjected to interference

Power switch controls for HID lamps
- Manual or automated power reduction for HS lamps

Benefits
- Ease of installation as integrated in control gear
- Cost efficient options
- Suitable for threshold and central zones

Power line controls for HID lamps
- Automated but re-programmable controls
- Detailed feedback on supply, status logs, dates, times and burning hours

Benefits
- Group management
- Individual control and monitoring
- Upgradable installation
- Possible remote access option via central server
- Capacity to interface the system with data base
- Low installation and operation costs
- Reduced maintenance schedules

Thorn tunnel lighting control
Thorn offers a comprehensive range of tunnel luminaires paralleled by an advanced, highly innovative control system which is adapted to tunnel applications:

- From basic to technologically advanced, highly innovative systems
- Fluorescent and HID lamp solutions
- Integration of up to date gear options
- Easy to install and operate systems
- Cost efficient systems
- Optimisation of safety conditions

From simple standard on/off operation, to complex step dimming or security networks, Thorn provides the best professional assistance in advising and offering the right system to meet the requirement.
Tough luminaires for tough environments

Salts, sulphur pollutants, exhaust fumes consisting of hydrocarbons and organics in tunnels can result in the presence of sulphuric or nitric acid.

In any given tunnel environment, there may be moisture, salts, sulphur pollutants, exhaust fumes consisting of hydrocarbons and organics, fuels and oils, soot, dust and strong washing detergents from jet cleaning. Furthermore, analysis of water samples identifies the following compounds: toluene, sulphate, zinc, sulphide, molybdenum, cadmium, beryllium and mercury.

Clearly some of these compounds are the result of corrosion products. Sodium chloride and other chlorides used for road de-icing can add to the chemical cocktail. Depending on the region (marine atmospheres or long mountain tunnels, for instance), these chemical combinations can result in the presence of sulphuric or nitric acid.

Luminaires installed in such environments can get rapidly contaminated. There is no rainfall to wash away the deposits that settle, condense or get splashed on their surfaces. Regular maintenance can alleviate the conditions, but, in general, this is usually impractical due to the logistics of access, tunnel closure and cost. In such hostile environments, it is vital to choose designs and materials that create luminaires whose function and effectiveness will not be compromised.

Thorn’s tunnel luminaire ranges are designed to withstand ‘tunnel life’ and are made of the highest quality materials, integrating the latest developments in terms of ingress protection, shock and vibration resistance as well as a range of features to facilitate ease of access and maintenance.
**Titan**

- Sturdy construction
- Quick change gear tray design
- Shallow profile
- Set of attachments

**Applications**

Ideal for lighting service or emergency areas. Suitable for traffic, pedestrian and train tunnels.

**Equipment**

Glare hoods, wire guards, pole mounting brackets.

**Lamps**

Max. 70W HSE-I (SE/I) High pressure sodium internal ignitor. Cap: E27
Min. 70W/Max. 100W HST [ST] High pressure sodium. Cap: E27/E40
Min. 70W/Max. 100W HIE [ME] Metal halide. Cap: E27/E40
Min. 80W/Max. 125W HME [QE] Mercury. Cap: E27
Min. 2x18W/Max. 2x26W TC-D (FSQ) Compact fluorescent. Cap: G 24d-2/G: 24d-3
Max. 1x200W A80/m [IAA-80/m] Incandescent. Cap: E27

**Materials/Finish**

Housing - LM6 marine grade aluminium powder coat finish
Hinges, locks and fixings - stainless steel
Enclosure - borosilicate glass lens.

**Standards**

Class 1 Electrical
IP65/ IP66

**Dimensions**

370x254x179mm

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**Titus**

- Dedicated to FDH 49W lamps
- 4 long closing plates
- Slim lightweight profile
- Axial or lateral surface mounting

**Applications**

Symmetrical and asymmetric light distribution. Suitable for urban tunnels, underpasses and galleries.

**Equipment**

Louvres, dimming devices, mounting brackets supplied to meet project requirements.

**Lamps**

Max. 2x49W T16 (FDH) Linear fluorescent. Cap: G5

**Materials/Finish**

Housing - powder coated galvanised steel with anodised aluminium locking plates, or stainless steel with anodised powder coated locking bars.
Enclosure – 4mm thick toughened flat glass. Reflector in 99.8% pure aluminium.

**Standards**

Designed to comply with EN60598-1/IEC598-1 and EN60598-2-3/IEC598-2-3
Class I Electrical
IK08/5 Nm

**Dimensions**

135x248x1534mm

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Sturdy one piece bulkhead
Titan DIP with wire guard
Titan with glare hood
Emergency version of Titan
Titan - galvanised steel version
Louvre attachment for light control
Adjustable mounting bracket
Easily operated, strong locking bar offers security and ingress protection
**Aluminium Gothard**

- Lightweight construction
- Continuous closing clip
- Front opening without tools
- Removable gear and easy access to lamp and connections

**Equipment**
Terminal block, fuse, cable glands, sockets, cable length, fixing brackets supplied to meet project requirements.

**Materials/Finish**
Housing – extruded AlMgSi aluminium powder coated 80 microns
Hinge and locking bar of extruded AlMgSi anodised aluminium.
Enclosure – 5mm thick, toughened flat glass.
Reflector – 99.8% pure aluminium.

**Standards**
Designed to comply with EN60598-1/IEC598-1 and EN60598-2-3/IEC598-2-3
Class I Electrical
IK08/5 Nm
IP66

**78236 series**

**Applications**
Asymmetrical light distribution and counter beam.
For road tunnels, urban tunnels, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40
Min. 36W/Max. 66W LST-H (LSE) Low pressure sodium.
Cap: BY22d
Min. 28W/Max. 54W T16 (FDH) Linear fluorescent.
Cap: G5
Min. 36W/Max. 58W T26 (FD) Linear fluorescent.
Cap: G13
Min. 55W/Max. 80W TC-TEL (FSDH) Compact fluorescent.
Cap: 2G7

**78248 series**

**Applications**
Symmetrical light distribution.
For road tunnels, urban tunnels, underpasses, galleries, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40
Min. 36W/Max. 66W LST-HY (LSE) Low pressure sodium.
Cap: BY22d
Min. 28W/Max. 54W T16 (FDH) Linear fluorescent.
Cap: G5
Min. 36W/Max. 58W T26 (FD) Linear fluorescent.
Cap: G13
Min. 55W/Max. 80W TC-TEL (FSDH) Compact fluorescent.
Cap: 2G7

**7826 series**

**Applications**
Symmetrical light distribution.
For urban tunnels, underpasses, galleries.

**Lamps**
Min. 1x50W/Max. 1x100W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 35W/Max. 55W LST (LS) Low pressure sodium.
Cap: BY22d
Min. 42W/Max. 57W TC-TEL (FSWH) Compact fluorescent.
Cap: GX24q4/GX24q5

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**78238 series**
Continuous locking bar
Counter beam optics
Easily accessible gear tray and lamp

**7823B series**

7823B series Applications
Asymmetrical light distribution and counter beam.
For road tunnels, urban tunnels, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40
Min. 36W/Max. 66W LST-HY (LSE) Low pressure sodium.
Cap: BY22d
Min. 28W/Max. 54W T16 (FDH) Linear fluorescent.
Cap: G5
Min. 36W/Max. 58W T26 (FD) Linear fluorescent.
Cap: G13
Min. 55W/Max. 80W TC-TEL (FSDH) Compact fluorescent.
Cap: 2G7

**7824B series**

7824B series Applications
Symmetrical light distribution.
For road tunnels, urban tunnels, underpasses, galleries, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40
Min. 36W/Max. 66W LST-HY (LSE) Low pressure sodium.
Cap: BY22d
Min. 28W/Max. 54W T16 (FDH) Linear fluorescent.
Cap: G5
Min. 36W/Max. 58W T26 (FD) Linear fluorescent.
Cap: G13
Min. 55W/Max. 80W TC-TEL (FSDH) Compact fluorescent.
Cap: 2G7

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**7826 series**

Asymmetrical light distribution.
For road tunnels, urban tunnels, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40
Min. 36W/Max. 66W LST-HY (LSE) Low pressure sodium.
Cap: BY22d
Min. 28W/Max. 54W T16 (FDH) Linear fluorescent.
Cap: G5
Min. 36W/Max. 58W T26 (FD) Linear fluorescent.
Cap: G13
Min. 55W/Max. 80W TC-TEL (FSDH) Compact fluorescent.
Cap: 2G7
Steel Gothard (Galvanised or Stainless)

- 3 reinforced high strength closing clips
- Front opens without tools
- Removable gear and easy access to lamp and connections
- Shallow profile

**Equipment**
Terminal block, fuse, cable glands, cable length, fixing brackets supplied to meet project requirements.

**Materials/Finish**
Housing – stainless steel (EN1.4404) powder coated 80µm.
Hinges and locks – stainless steel.
Enclosure – 5mm thick toughened flat glass.
Reflector – 99.8% pure aluminium.

**Standards**
Designed to comply with EN60598-1/IEC598-1 and EN60598-2-3/IEC 598-2-3
Class 1 Electrical
IK08/5 Nm

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### 7827 series
**Applications**
Asymmetrical and counter beam light distribution.
For road tunnels, urban tunnels, underpasses, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 36W/Max. 66W LST-HY (LSE) Low pressure sodium.
Cap: BY22d
Min. 55W/Max. 80W TC-SEL (FSDH) Compact fluorescent.
Cap: 2G7
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40

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### 7828 series
**Applications**
Symmetrical light distribution.
For road tunnels, urban tunnels, underpasses, adaptation and transition zones.

**Lamps**
Min. 1x50W/Max. 2x400W
HST (ST) High pressure sodium.
Cap: E27/E40
Min. 36W/Max. 66W LST-HY (LSE) Low pressure sodium.
Cap: BY22d
Min. 55W/Max. 80W TC-SEL (FSDH) Compact fluorescent.
Cap: 2G7
Min. 1x250W/Max. 2x400W
HIT (MT) Metal halide.
Cap: E40

### 7830 series
**Applications**
Symmetrical light distribution.
For road tunnels, urban tunnels, underpasses, adaptation and transition zones.

**Lamps**
Min. 28W/Max. 54W T16 (FDH) Linear fluorescent.
Cap: G5
Min. 36W/Max. 58W T26 (FD) Linear fluorescent.
Cap: G13
Case study 1
Chiptchak Mosque Tunnel, Turkmenistan

Tunnel type
Urban underpass
2 way traffic
One tube

Technical data
Length: 74m
Width: 24m
Speed limit 80km/h

Lighting system
Aluminium asymmetric Gothard
Wall mounted, tilted 15º
20x 7823B ST 400W [55klm]
10x 7823B ST 250W [33klm]
56x 7823B ST 100W [10klm]

Day time lighting layout
Threshold zone
Transition zone
Interior zone 12m

Night time lighting layout
Threshold zone
Transition zone
Interior zone 12m

Plan schematic showing day time lighting layout
Case study 2
Katerini Tunnel, Greece

The national motorway, when completed, will run across Greece from Patras to Evzoni, via Athens and Thessaloniki. Three tunnels requiring a full tunnel lighting system are constructed in the Katerini area.

Tunnel description
Long motorway tunnel.
2 tubes - 3 lanes carriageway.

Technical data
Length: Right tube - 1100m
Left tube - 1100m
Speed limit: 100 km/h
Traffic flow: medium less than 1,000 vehicles per hour.
Stopping distance (SD): 180m on wet road.

Determination of \( L_b \):
Right tube entrance: \( L_{20} = 3.500 \text{cd/m}^2 \)
Left tube entrance: \( L_{20} = 5.000 \text{cd/m}^2 \)
Lighting system: counterbeam and symmetric
Type of fitting: counterbeam and symmetric fittings
\( k = \frac{L_b}{L_{20}} = 0.072 \) for counter beam lighting system and for SD = 180m
Maintenance factor: 0.70

Right tube details
Threshold zone
\( L_b \) to be maintained: \( L_{20} \times k = 252 \text{cd/m}^2 \)
Length = 180m = SD
Threshold zone 1: 132m \( L_b = 252 \text{cd/m}^2 \) maintained
Threshold zone 2: 48m \( L_b = 176 \text{cd/m}^2 \) maintained

Transition zone
The end of the transition zone is reached when the luminance is 3 times the interior luminance level.
As the traffic flow is medium, the maintained level in the interior zone shall be 10cd/m² or 4% of the threshold zone level.
Length = 220m = given by CIE curve
Transition zone 1: 30m \( L_i = 100 \text{cd/m}^2 \) maintained
Transition zone 2: 55m \( L_i = 58 \text{cd/m}^2 \) maintained
Transition zone 3: 135m \( L_i = 28 \text{cd/m}^2 \) maintained

Interior zone
Length = 524m
\( L_i = 10 \text{cd/m}^2 \) maintained

Exit zone
Luminance of the exit zone is equal to 5 times the interior zone luminance
Length = 180m
\( L_{ex} = 50 \text{cd/m}^2 \) maintained

Lighting fitting arrangement

Day time
Threshold and transition zones are lit by counter beam fittings. Interior and exit zones are lit by symmetric fittings.

Night time
All zones are lit by symmetric fittings.
### International references

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Fittings</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faeroe Islands</td>
<td></td>
<td>150</td>
<td>(ST 1x250W, LSE 1x35W)</td>
</tr>
<tr>
<td>Norway</td>
<td>Lerdal Tunnel</td>
<td>1,400</td>
<td>(ST 1x70-400W, LSE 1x35W, FD 58W)</td>
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<tr>
<td>Sweden</td>
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<td>3,100</td>
<td>(ST 1x70W, 1x150W, 1x250W, 1x400W, FD 58W HF)</td>
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<td>Iceland</td>
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<td>500</td>
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<td>UK</td>
<td>Medway Tunnel</td>
<td>1,149</td>
<td>(ST 1x400W, FD 58W HF dimmable)</td>
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<td>France</td>
<td>Gometz la Ville</td>
<td>386</td>
<td>(ST 2x70W, 2x250W, 2x400W)</td>
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<td>Croatia</td>
<td>Sopac</td>
<td>655</td>
<td>(ST 150/100W, power reduction)</td>
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<td>Greece</td>
<td>Taxiarctia Tunnel</td>
<td>1,054</td>
<td>(ST 1x150W, 1x250W, 1x400W)</td>
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<td>U.A.E.</td>
<td>Kalba Tunnel (Sharjah)</td>
<td>464</td>
<td>(ST 2x250W, 2x400W, 150W+400W, ST 1x150W, 1x250W)</td>
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<td>Taiwan</td>
<td>2nd Freeway Part II</td>
<td>1,025</td>
<td>(ST 1x150W, 1x400W)</td>
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<td>Singapore</td>
<td>Holland/Farrer Road Tunnels</td>
<td>350</td>
<td>(FD 58W HFD)</td>
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<td>Brunei</td>
<td>Pusar Ulak radial road</td>
<td>740</td>
<td>(ST 1x400W, 2x400W, 428 FD 58W HF)</td>
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<td>Hong Kong</td>
<td>KCRC West Rail CC</td>
<td>1,474</td>
<td>(ST 2x400W, 250W, FD 58W HF2)</td>
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