VIAVISION

VOLKSWAGEN GROUP • SHAPING THE FUTURE OF MOBILITY

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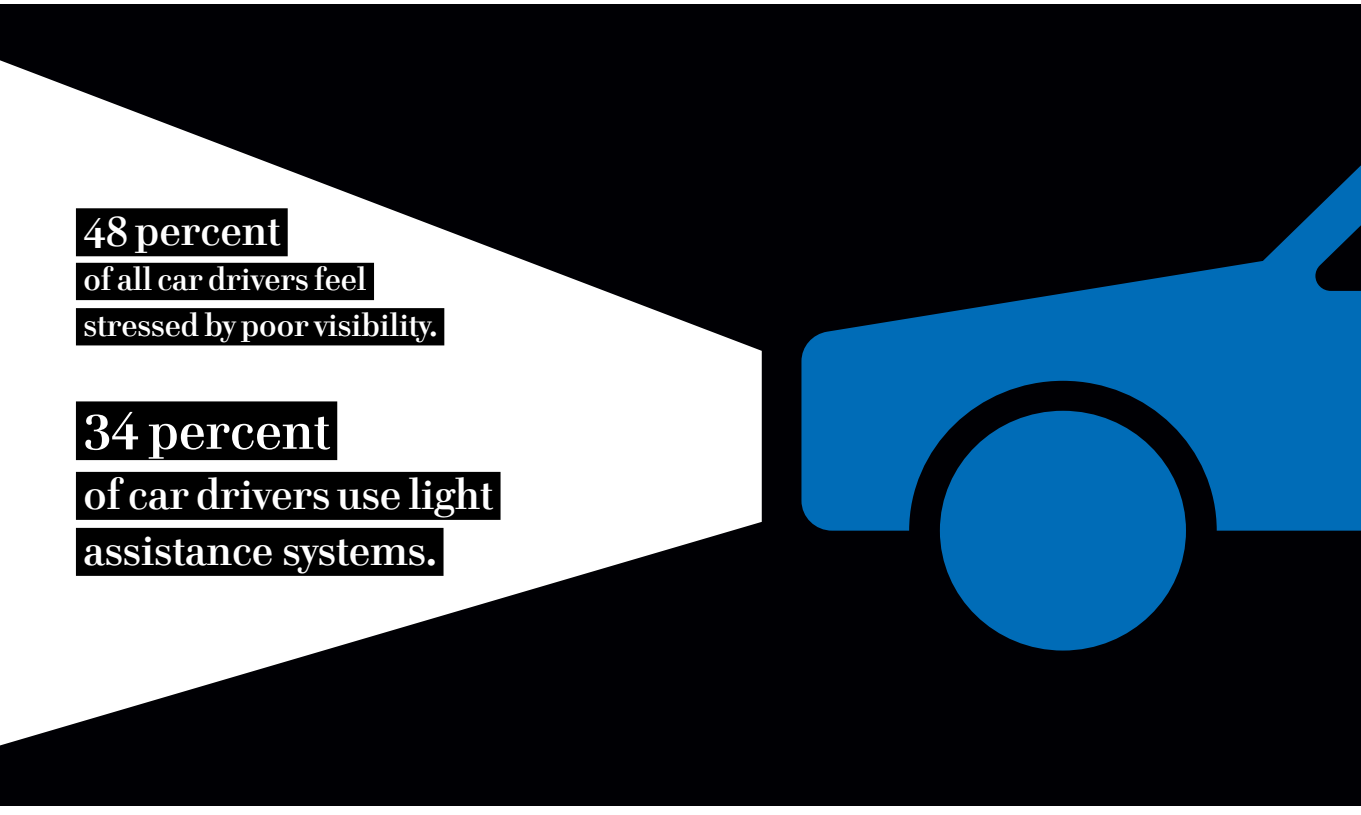
Light Technology
To See and to Be Seen



Editorial

Dr. Ulrich Hackenberg, Member of the Board of Management of Volkswagen Brand with responsibility for Research and Development.

A car's headlights are used more often as the days become shorter and shorter. In this issue of *VIAVISION*, you can discover which different types of light are used, how bright they are, how much electricity they consume, and how intelligent light systems improve your security and comfort.

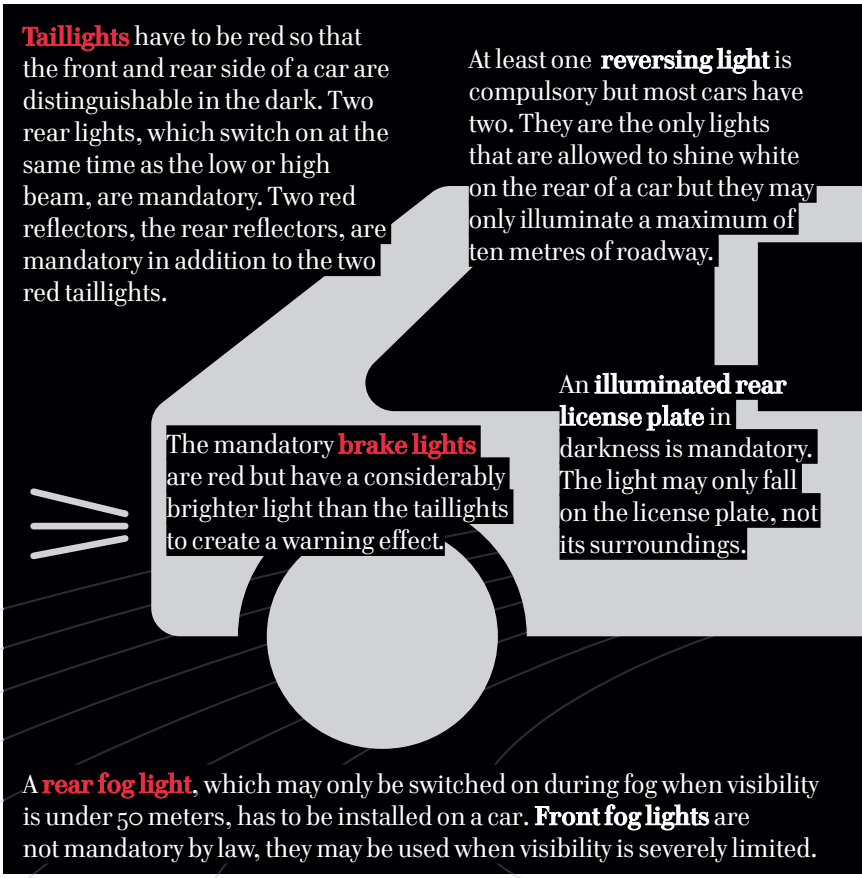
Happy Reading.

Illumination

The Right Light at All Times

Of all the lights on a car, headlights, indicators and taillights are the most noticeable. However, a total of several hundred lights can be built in, and on, a car. There are clear regulations on which lighting devices are mandatory and which are discretionary. Their installation height and width are also regulated. There are almost no limits to the imagination of car producers as regards the car's interior. Only the colours of the dash indicator lights for the high beam (blue) and the rear fog light (yellow) are compulsory.

Light sources on the car:



Sources: German Federal Motor Vehicle Safety Standards (as of 2009); Henning Wallentowitz

Compulsory daytime running light:

Since February 2011 an EU regulation stipulating that all new cars have to be equipped with daytime running lights took effect. These turn on automatically when the car is started. They are of lower light intensity and electricity consumption than dimmed headlights. A retrofitting in older cars is not necessary since daytime running lights are not mandatory in Germany. This is different in some countries: Daytime running lights may or may not be mandatory, depending on the country, the road or even the time of year.

Sources: German Road Traffic Act (StVO) (as of 2010); EU Commission; ADAC (both as of 2011)

3 percent of all traffic accidents could be avoided by driving with lights during the daytime.

Source: Federal Highway Research Institute (as of 2009)

- **On all roads:** Bosnia and Herzegovina, Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Macedonia, Montenegro, Norway, Poland, Sweden, Slovakia, Czech Republic
- **Out of town:** Italy, Romania, Russia, Hungary
- **On only one road in the country:** Portugal (on the highway IP5, where there is often low visibility because of fog)
- **Only during a certain time period:** Bulgaria (November to March), Croatia (October to March)

The yellow **indicator lights** show other road users that a car is changing its driving direction and also, when used in combination, act as hazard lights.

The **low beam** is the most commonly used setting for headlights. It has to be switched on during darkness or bad visibility, if the high beam cannot be used. Cars have an asymmetrical dimmed light, which illuminates 80 to 120 meters of roadway to their right, and only around 60 meters to their left, in the case of right hand drive vehicles.

It is mandatory for new cars to have a **daytime running light** installed. This light is noticeably darker than the low beam. This is why it may not be used as a driving light during darkness, serving simply to aid visibility.

The **parking light** is integrated within the headlights and always lights up simultaneously with the low and high beam. On its own, it is used mostly when a car is parked.

The **high beam** is supposed to be the normal setting outside built-up areas during night time. Its use, however, is prohibited when other road users could be dazzled. The high beam ranges at least 100 meters and can reach up to 500 meters depending on illuminant and model.

The German Road Traffic Licensing Regulations (StVZO) regulates which lamps, in which quantity, of what colour, and where, have to be installed on a car. The vehicle lighting systems presented here, except the front fog lights, are mandatory. When and which light has to be switched on is regulated by the Road Traffic Act (StVO).

and Konrad Reif, "Handbuch Kraftfahrzeugelektronik: Grundlagen, Komponenten, Systeme, Anwendungen"; ADAC (both as of 2010); DELVIS (as of 2011)

Longer, Brighter, Further

Not All Lights Are Equal

Light consists of nothing else but electromagnetic waves. Such light waves can be created in a number of ways. Halogen lamps have been used in car headlights since the '60s. They have a longer lifespan and consume less electricity, compared to normal filament light bulbs. A new light has been shining on roads since the beginning of the '90s: the bright, daylight-like, xenon light. Meanwhile, light diodes, so called LEDs, have been installed into headlights. Their light comes closest to natural daylight.

Picture: OSRAM

Halogen

A halogen filament lamp consists of a glass bulb in which a metal filament made out of tungsten, through which electricity is conducted, is installed. When used the filament gets so hot that it glows and emits electromagnetic waves in the spectrum of visible light. The filament is surrounded by a gas mixture of halogen compounds. It causes the evaporating tungsten particles to reattach to the filament. This is why a halogen lamp lasts longer than a normal lamp and converts a larger share of supplied energy into light.

Source: OSRAM (as of 2011)

80 percent of all cars in Germany have halogen headlights.

Source: wallstreet:online (as of 2009)

Picture: OSRAM

Xenon

The xenon headlight utilizes a high intensity discharge lamp. Its glass bulb is filled with the noble gas xenon. Two tungsten electrodes, a cathode and anode, are melted into the bulb. A high voltage of 20,000 volts is required to ignite the noble gas and create an arc of light - meaning a self-sustaining gas discharge - between the cathode and anode. An electronic control gear is used for this. In order to avoid dazzling oncoming traffic with the bright light of the xenon lamps, they may only be used in combination with automated headlight leveling.

Sources: Automotive Lighting; VerkehrsRundschau (both as of 2011)

32 percent of all new cars are equipped with xenon headlights. The share of passenger cars with xenon headlights in Germany is currently around 17 percent.

Source: DAT-Report 2011

Wavelength:

400 Nanometers 700 Nanometers

Electromagnetic waves with a length between 380 and 780 nanometers – that is a millionth of a millimeter – fall within the spectrum of visible light. They are labeled infrared when they are longer. Shorter waves are called ultra violet rays. Both are invisible to the human eye. Source: OSRAM

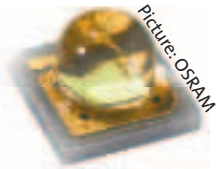
LED technology at Volkswagen

Volkswagen is the first car manufacturer in the world that has equipped a series production vehicle with LED headlights: the Audi R8. The technology has been further optimized in the Audi R15: The LEDs are cooled solely by the airflow. Source: Audi

LED

Light emitting diodes, also called LEDs, are semiconductor elements, meaning a solid body, which is conductive or non conductive depending on temperature. When electricity is supplied, electrons travel through the semiconductor chip and thereby create light. LEDs emit light within a small spectrum, this means of a specific color, depending on the material the semiconductor chip is made of. Usually several LEDs are bundled together since each individual illuminating diode emits only a little light. Illuminating diodes have been used for taillights and daytime running lights for a while but now there are also headlights which are based exclusively on LED technology.

Sources: OSRAM; Automotive Lighting (both as of 2011)

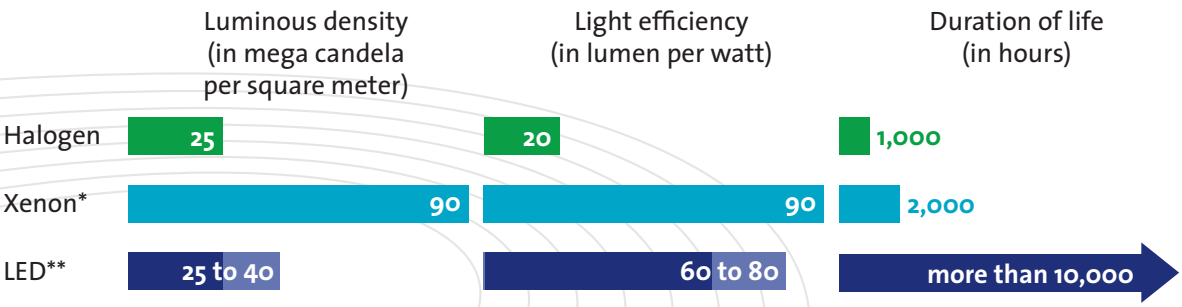


Picture: OSRAM

34 percent of the global market for car lighting is the estimated share for LEDs in 2020 – in 2010 it was 12 percent.

Source: McKinsey & Company, Lighting the way: Perspectives on the global lighting market (as of 2011)

Illuminants compared:



* Values correspond to a xenon headlight with 35 watts output.

** Values correspond to white LEDs.

Xenon has the highest light density of the three common types of light. This means the light intensity per unit area, which is perceived as brightness by the human eye, is highest. The light efficiency per watt is best for xenon as well and accordingly it has the lowest energy consumption. LEDs however have by far the longest lifespan.

Source: Technische Universität Darmstadt, Laboratory of Lighting Technology (as of 2011)

Intelligent Light

Smart Headlights

The first automobiles where left parked during the hours of darkness because the drivers could barely see where they were driving. Lanterns with candles were the only source of light. Electric lights were not invented until the '20s of the last century. The only choice a car driver had for a long time was to switch the lights on or off. This is different today: The headlights think with the driver, sometimes even faster than him. They can illuminate corners, automatically switch between high beam and low beam and even leave out or especially brighten certain areas.

48 percent of all car drivers feel stressed by poor visibility.
Source: Frost & Sullivan (as of 2009)

34 percent of car drivers use light assistance systems. Source: Puls Market Research, Fahrerassistenzsysteme (as of 2011)

Adaptive light

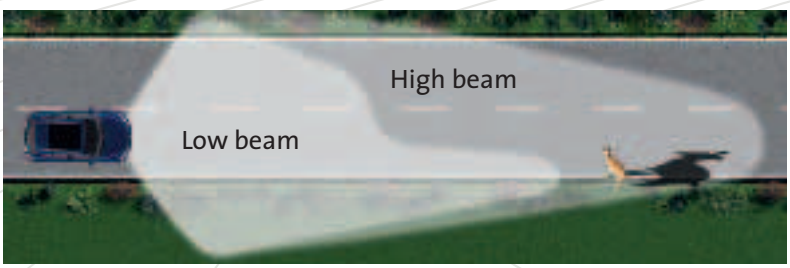
Shine around the corner? This is possible – at least almost. The idea has existed for a long time: The first car with adaptive lights was already built in 1918. The adaptive light entered series production in the '60s. The headlights were connected to the steering axle and followed the steering motions through a simple pulley system. Today this is all managed electronically: Either using additional headlights which switch on simultaneously with the indicator lights or swiveling headlights.

Sources: Konrad Reif, "Fahrstabilisierungssysteme und Fahrerassistenzsysteme"; Konrad Reif, "Bosch Autoelektrik und Autoelektronik: Bordnetze, Sensoren und elektronische Systeme" (both as of 2010)

25 percent of all new German cars were equipped with adaptive lights in 2010, in 2009 it was just 15 percent. Source: DAT-Report 2011

Light development

The intelligent light assistant adjusts the cone of light of the high beam to road conditions and dips the beam wherever needed. This ensures the driver always has the best vision of his surroundings without distracting other road users.



High beam assistant

High beam assistants lower the beam automatically, the driver does not have to dip his headlights for oncoming traffic himself. A camera which functions as a light sensor is installed in the inside mirror. It recognizes both oncoming traffic and vehicles driving ahead, and measures if there is sufficient light on the road – making the use of the high beam unnecessary. The assistant can be overridden manually at any time.

Sources: Hella; Valeo; Continental (all as of 2011)

50 percent of driving time can be undertaken with the high beam in effect using the automatic control compared to just 20 percent using manual control.

Source: Zeitschrift für Verkehrssicherheit 2/2009

Advanced high beam assistant

Advanced high beam assistants go even further: Not only do they control the use of the high beam but also make for a smooth transition. Different producers have developed systems that make the cone of your headlight always end close behind the car driving ahead as well as close in front of oncoming traffic and are able to leave out certain areas. The range of the high beam is only decreased when other road users could be dazzled.

Sources: Hella; Valeo; Continental (all as of 2011)

14 to 78 meters is how far further the research participants were able to see with the advanced high beam assistant than with the low beam, depending on test conditions.

Source: Zeitschrift für Verkehrssicherheit 2/2009

Light assistant at Volkswagen

The Xenon headlights in the current Touareg ensure maximum security and comfort: They feature the assistance system Dynamic Light Assist. This camera based continuous high beam remains permanently active, recognizes oncoming traffic and vehicles driving ahead, and is able to individually dim each headlight within its corresponding field, thanks to an adaptive light module. In addition, this advanced high beam assistant can make the light cone follow the rear of the car driving ahead, starting at a speed of 60 kilometers per hour. Dazzling other drivers is therefore impossible. The Area View assistance system improves security even more, with the help of four cameras that scan the surroundings of the Touareg, and Side Assist, which additionally warns the driver about cars approaching from behind that would otherwise be in the blind spot during lane changes.

Source: Volkswagen

See in the Dark

Safe at Night with Infrared Light

40 percent of all fatal accidents happen at night or twilight, even though only 20 percent of journeys take place at night.

Sources: German Federal Statistical Office; Konrad Reif, "Fahrstabilisierungssysteme und Fahrerassistenzsysteme" (both as of 2010)

Road visibility for car drivers is especially low at night. Persons or unlighted objects in particular enter the field of vision late. Night vision systems provide help: They extend driver viewing range in the dark. They make persons, animals or obstacles visible on a screen in the car, using an infrared camera, long before they enter the cone of light of the headlights. This can avoid accidents.

Passive systems

An infrared camera creates a thermal image of the surroundings. Thus people or animals, which would not be visible to the human eye, can be displayed on a screen in the car at night.

Source: TÜV Nord (as of 2011)

Active systems

In addition to the camera, active systems feature an infrared light that projects a beam ahead which is reflected by objects back into the camera. This is how objects that do not emit heat can be recognized by the camera and displayed on the screen.

Source: TÜV Nord (as of 2011)

150 meters is how far a driver can see in the dark with a night vision system. This equates to the range of the high beam.

Source: Karlsruhe Institute of Technology (as of 2010)

Picture: Bosch

The infrared camera is based on the principles of thermography. Lifeforms or objects emit infrared radiation, depending on their temperature, which is invisible to the human eye. The infrared camera can measure this radiation and converts it into a black and white picture in which objects appear brighter the warmer they are.

Source: Fraunhofer Institute for Microelectronic Circuits and Systems IMS (as of 2010)

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