WELCOME

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REVISION LOG

VERSION	EFFECTIVE DATE	DESCRIPTION OF CHANGE
001	2015 10	Module Creation and Release
002	2016 01	Minor Revisions
003	2017 09	Format Update
003.1	2019 02	Added section on Pneumatic and Pressure Pumps in Sub-Module 16.
003.2	2019 05	Corrected incorrect answers in Sub-Module 20.
004	2019 12	Typographic format updated; Sequencing of content to Appendix 1 refined.
004.1	2021 04	Enhanced content of M11A Sub-Module 08(b)
004.2	2023 01	Added Measurement Standards. Improved Figures 13-51, 18-5, and 18-6.
004.3	2023 04	Enhanced content in Sub-Module 14 - Lights.

MODULE EDITIONS AND UPDATES

ATB EASA Modules are in a constant state of review for quality, regulatory updates, and new technologies. This book's edition is given in the revision log above. Update notices will be available Online at www.actechbooks.com/revisions.html

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11.14 - LIGHTS

LIGHT SOURCES

Older aircraft lighting made use mostly of incandescent and halogen lighting. Incandescent lamps produce light with a filament wire heated to a high temperature by an electric current until it glows. The hot filament is protected from oxidation in the air with a glass bulb that is filled with inert gas or evacuated. In a halogen lamp, the filament is protected by a chemical process that redeposits metal vapor onto the filament, extending its life. Incandescent bulbs are less efficient than modern types of light bulbs, converting less than 5% of its energy into visible light with the remainder being converted into heat. On modern aircraft, there are three types of light sources primarily used for external lighting:

- High Intensity Discharge (HID) Bulbs
- Light Emitting Diodes (LED) Lamps
- Xenon Flash Tubes

HIGH INTENSITY DISCHARGE BULBS (HID)

HID lamps have become common as replacements for traditional landing and taxi lights. (***Figure 14-1***) In an HID lamp, instead of heating a filament as in an incandescent lamp, a gas is heated to produce light. They are a type of electrical gas discharge lamp which produces light by creating an electrical arc between tungsten electrodes placed inside a translucent or transparent tube which is filled with both gas and metal salts. Once the arc forms, it evaporates the metal salts forming a plasma, which produces high intensity light with a low power consumption. (***Figure 14-2***)

HID Precautions

HID lamps emit small amounts of UV rays. While most of them are blocked by the outer tube, some precautions should be taken:

- Parts of the body closely exposed to direct light for long periods of time should be covered because of sunburn. Avoid direct eye contact, and when working closely, always wear UV blocking glasses.
- Because the temperature of the outer tube will range from 240°C - 800°C at its base, do not touch the lamp when in operation. The bulb should be allowed to cool for three minutes after switching off.
- Operating pressures inside HID bulbs are approximately 50 bars in its hot state and remain high when cooled. Thus to guard against explosion wear safety glasses and gloves even when bulbs are switched off.
- While less than fluorescent lamps, HID lamps contain mercury. Mishandling can expose the operator through the skin causing neurological problems in the long run. Always wear safety gloves.
- Because of the mercury content, spare and discarded lamps are carefully packed to prevent breakage and then discarded as special waste.

LIGHT EMITTING DIODES (LED)

LED lamps emit light due to photons emitted by the recombining of electrical charges between its diode layers after the application of current. LED lamps produce light into a single color, depending on the semiconductor material used. (***Figure 14-3***) Inside the semiconductor chip, there are three different layers:

- The "n" layer where the material has an excess of electrons.
- The "p" layer where material has a deficit of electrons, thus an excess of positively charged particles.
- The active layer (the junction of "n" and "p" layers), which is the barrier to the flow of electrons.

When voltage is applied, the flow of electrons across the active layer is reduced, leading to the emission of single color photons. This effect is called electroluminescence.

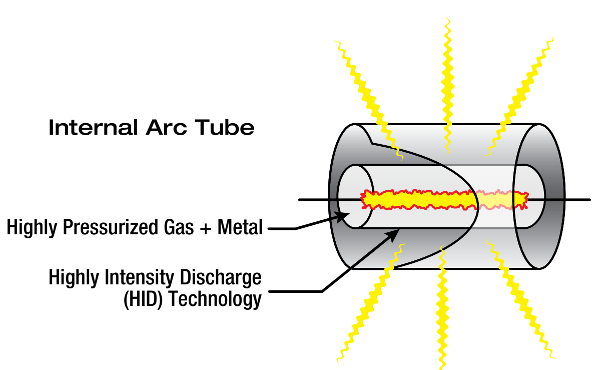

Figure 14-1. The operating principle of a high intensity discharge bulb.

Figure 14-2. Three configurations of HID lamps.

As diodes work with only one voltage direction, LEDs are used only with DC power.

LED technology is a cold light generation technology with almost no heat generation. As such, the lifespan of LED bulbs are significantly longer and so require fewer maintenance actions.

The semiconductor diode is mounted in a reflector cup on one electrode, normally the cathode. The other connection is made by a wire connection from the chip to the second electrode, the anode. This assembly is covered with a lens that helps focus the light and holds the electrical connections in place for power supply.

LEDs are able to produce either red, yellow, orange, amber, green, blue/green, or blue. White LEDs can be produced two ways:

- By combining red, green, and blue chips in one package known as a RGB LED.
- By the use of phosphor coatings, which will be excited by colored LED photons. This method is simpler and has better color integrity but its energy efficiency is less.

XENON FLASH TUBES

Xenon flash tubes are used extensively for beacon and strobe lighting. A flash tube is an electric arc lamp designed to produce intense white light for very short durations.

Flash tubes are made of a length of glass tubing with electrodes at either end and filled with a noble gas, typically xenon, which when triggered ionizes and conducts a high voltage pulse to produce light. As a high voltage power source is needed to energize the gas, a charged capacitor is used to allow very speedy delivery of current when the lamp is triggered.

The electrodes protrude into each end of the tube and are sealed to the glass using a few different methods. Ribbon seals are thin strips of molybdenum foil bonded directly to the glass, which are durable but are limited in the amount of current that can pass through. Solder seals bond the glass to the electrode for a very strong mechanical seal, but are limited to low temperature operation. Rod seals are used in laser applications, where the rod of the electrode is wetted with another type of glass and then bonded to a quartz tube. This seal is very durable and capable of withstanding very high temperatures and currents.

The capacitor, which is charged between 250 and 5 000 volts, uses a step-up transformer and a rectifier. The bulb's gas exhibits very high resistance and the lamp will not conduct electricity until the gas is ionized. Once ionized, or "triggered", a spark will form between the electrodes, allowing the capacitor to discharge. The sudden surge of current quickly heats the gas to a plasma state where electrical resistance becomes low. As the current pulse travels through the tube, it ionizes the atoms, causing them to jump to higher energy levels. As the ionized atoms recombine with their lost electrons they immediately drop back to a lower energy state, releasing photons in the process. (***Figure 14-4***)

FLUORESCENT LIGHTS

Fluorescent lights are made of a glass tube filled with noble gases and mercury vapor which glows when an

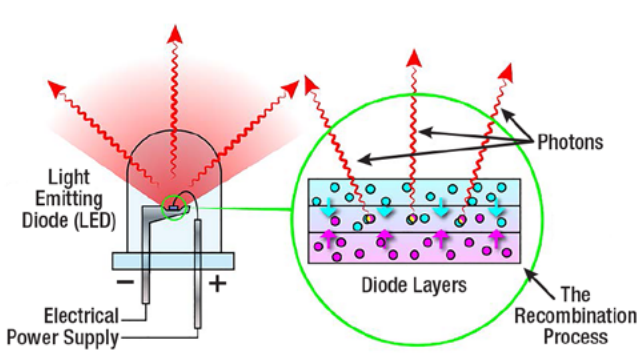

Figure 14-3. The LED light uses the recombination of electrical charges between diode layers.


Figure 14-4. A Xenon flash tube as used with a strobe light.

AC voltage is applied to the electrodes at each end. The electrodes then emit electrons which strike the atoms of mercury vapor in the tube to produce ultraviolet light. The invisible ultraviolet light strikes a phosphorous coating on the inside of the tube which glows white.

Fluorescent lamps are more efficient than incandescent lamps, however because they require the use of a ballast transformer and AC voltage, they are typically found only on large aircraft. Fluorescent lamps can operate in a bright or dimmed position. For the dim position, reduced voltage is applied to the transformer. (***Figure 14-5***)

Fluorescent Lamp Operating Circuit

Fluorescent lamps are negative differential resistance devices. As more current flows through them, the electrical resistance of the lamp drops allowing even more current to flow. If connected directly to a constant voltage power supply, the lamp would rapidly self destruct due to the uncontrolled flow. To prevent this, fluorescent lamps must use an auxiliary device called a ballast to regulate flow through the tube.

The simplest ballast is an inductor placed in series, and consisting of a winding on a laminated magnetic core. The inductance of this winding limits the current flow. Ballasts are rated for the size of the lamp and the power frequency. Where the main voltage is insufficient to start long fluorescent lamps, the ballast acts as a step up autotransformer to limit the current flow. A ballast may also include a capacitor for power correction.

EXTERNAL: NAVIGATION, ANTI-COLLISION, LANDING, TAXIING, ICE

NAVIGATION/POSITION LIGHTS

Aircraft operating at night must be equipped with position lights that meet minimum requirements. A set of position lights consist of one red, one green, and one white light. (***Figure 14-6 and Figure 14-7***)

On some types of installations, a switch in the cockpit provides for steady or flashing operation of the position lights. On many aircraft, each light unit contains a single lamp mounted on the surface of the aircraft. Other types of position light units contain two lamps and are often streamlined into the surface of the aircraft structure. The green light unit is always mounted at the extreme tip of the right wing. The red unit is mounted in a similar position on the left wing. The white unit is usually located on the vertical stabilizer in a position where it is clearly visible through a wide angle from the

Figure 14-5. (A) A fluorescent tube, (B) electrodes and ballast.


Figure 14-6. A left wing tip position light (red) and a white strobe light.


Figure 14-7. A right wing tip position light, also known as a navigation light.

rear of the aircraft. ***Figure 14-8*** illustrates a schematic diagram of a position light circuit. Position lights are also known as navigation lights.

There are, of course, many variations in the position light circuits used on different aircraft. All circuits are protected by fuses or circuit breakers, and many circuits include flashing and dimming equipment. Small aircraft are usually equipped with a simplified control switch and circuitry. In some cases, one control knob or switch is used to turn on several sets of lights; for example, one type utilizes a control knob, the first movement of which turns on the position lights and the instrument panel lights. Further rotation of the control knob increases the intensity of only the panel lights. A flasher unit is seldom included in the position light circuitry of very light aircraft but is used in small twin-engine aircraft. Traditional position lights use incandescent light bulbs. LED lights have been introduced on modern aircraft because of their good visibility, high reliability, and low power consumption.(***Figure 14-9***)

ANTI-COLLISION LIGHTS

Anti-collision lights are safety lights to warn other aircraft, especially in congested areas. Anti-collision lights may be of two types:

- Rotating Beacons
- Flashing Strobe Lights

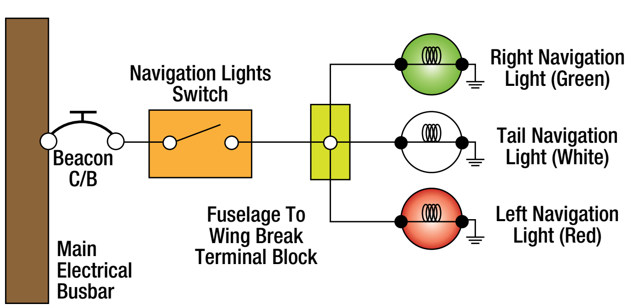

Figure 14-8. Navigation light system schematic.

Figure 14-9. A forward position LED position light from Devore Aviation.

Rotating Beacons

Rotating beacons are usually installed on top of the fuselage or tail and/or under the fuselage. Each is installed in such a location that the light does not affect the vision of the crew member or detract from the visibility of the position lights. ***Figure 14-10*** shows a typical anti-collision light installation in a vertical stabilizer.

The beacon illustrated in (***Figure 14-11A***) employs a V-shaped reflector over the axis of a single sealed lamp. One half of the rotating reflector is flat and emits a narrow high intensity beam towards the horizon, while the other half is curved to increase the up and down spread of its beam to 30° above and below the horizon. The gear and pinion type motor turns the reflector at a constant speed of 40-45 RPM giving an observed flash frequency of 80-90 flashes per minute.

Another type of beacon illustrated in (***Figure 14-11B***) employs two filament lamps, mounted in tandem, each of which is pivoted on its own axis. One half of each lamp forms a reflector by being silvered. The drive from the motor is so arranged that the lamps oscillate through 180° so that the two beams are 180° apart at any instant.

A rotating beacon circuit is shown in ***Figure 14-12***.

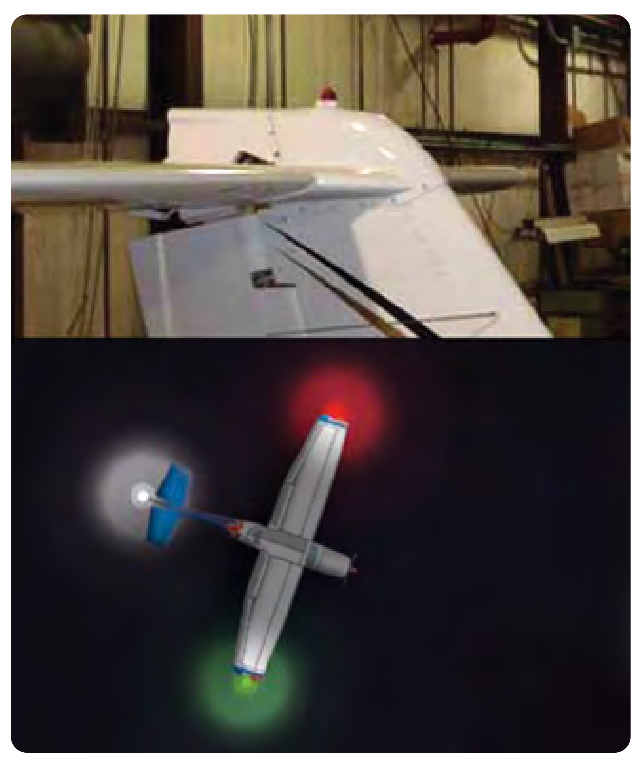

Figure 14-10. Anti-collision lights.

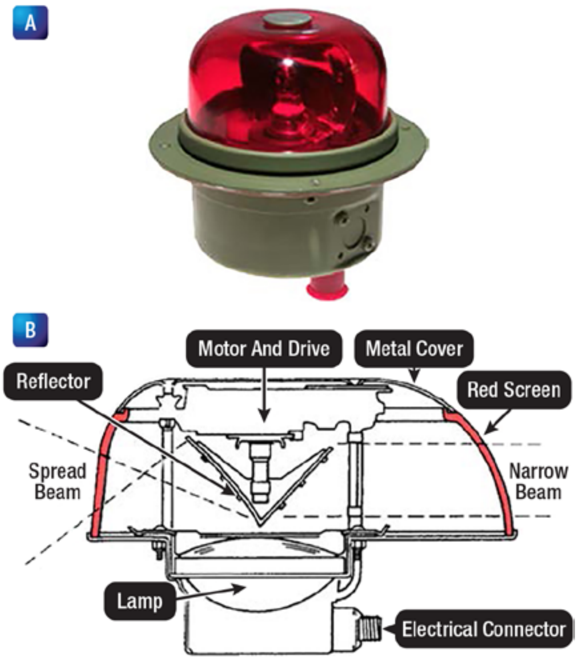

Figure 14-11. (A) A V-shaped reflector over the axis of a single sealed lamp. (B) Two filament lamps mounted in tandem.

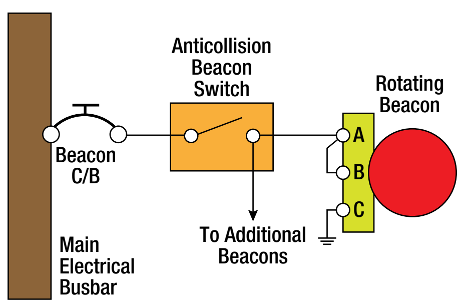

Figure 14-12. A rotating beacon circuit.

Strobe Lighting

A white strobe light is a second common type of anti-collision light. Strobe lights produce an extremely bright intermittent flash of white light that is highly visible. The light is produced by a high voltage (400 volt) discharge of a capacitor which converts an input power of either 28V DC or 115V AC into a high DC output. The capacitor is charged to periodically discharged between two electrodes in the xenon filled tube, producing a high intensity flash having a characteristic blue-white color. (***Figure 14-13***)

High intensity strobe lights can be dangerous to service, as the capacitors are charged to voltages which can be lethal. Accordingly, a minimum of two minutes should be allowed for the capacitors to discharge after the circuit has been deenergized. In addition, damage to the eyes may result from looking directly into the high intensity light. A flashing strobe circuit is shown in ***Figure 14-14***.

LANDING LIGHTS

Landing lights are installed in aircraft to illuminate runways during night landings. These lights are very powerful and are directed by a parabolic reflector at an angle providing a maximum range of illumination. Landing lights of smaller aircraft are usually located midway in the leading edge of each wing or streamlined into the aircraft surface. Landing lights for larger transport category aircraft are usually located in the leading edge of the wing close to the fuselage. Each light may be controlled by a relay, or it may be connected directly into the electric circuit. On some aircraft, the landing light is mounted in the same area with a taxi light. (***Figure 14-15***) A sealed beam, halogen, or high intensity xenon discharge lamp is used.

TAXI LIGHTS

Taxi lights are designed to provide illumination on the ground while taxiing or towing the aircraft to or from a runway, taxi strip, or in the hangar area. (***Figure 14-16***) Taxi lights are not designed to provide the degree of illumination necessary for landing lights. On aircraft


Figure 14-13. An LED anti-collision light from Devore Aviation.

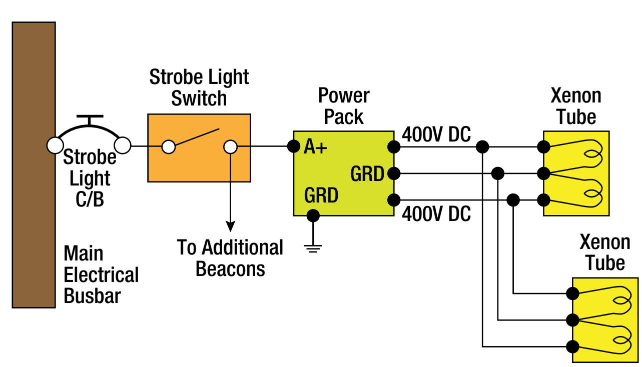

Figure 14-14. A flashing strobe circuit.

Figure 14-15. Landing lights.

Figure 14-16. Taxi lights.

with tricycle landing gear, either single or multiple taxi lights are often mounted on the non-steerable part of the nose landing gear. They are positioned at an oblique angle to the center line of the aircraft to provide illumination directly in front of the aircraft and also some illumination to the right and left of the aircraft's path. On some aircraft, the dual taxi lights are supplemented by wingtip clearance lights controlled by the same circuitry. Taxi lights are also mounted in the recessed areas of the wing leading edge, often in the same area with a fixed landing light.

Many small aircraft are not equipped with any type of taxi light, but rely on the intermittent use of a landing light to illuminate taxiing operations. Still other aircraft utilize a dimming resistor in the landing light circuit to provide reduced illumination for taxiing. A typical circuit for taxi lights is shown in ***Figure 14-17***. Some large aircraft are equipped with alternate taxi lights located on the lower surface of the aircraft, aft of the nose radome. These lights, operated by a separate switch from the main taxi lights, illuminate the area immediately in front of and below the aircraft nose.

WING ICE INSPECTION LIGHTS

Some aircraft are equipped with wing inspection lights to illuminate the leading edge of the wings to permit observation of icing and general condition of these areas during flight. These lights permit visual detection of ice formation on wing leading edges while flying at night. They are usually controlled through a relay by an on/off toggle switch in the cockpit.

Some wing inspection light systems may include or be supplemented by additional lights, sometimes called nacelle lights, that illuminate adjacent areas, such a cowl flaps or the landing gear. These are normally the same type of lights and can be controlled by the same circuits.

INTERNAL: CABIN, COCKPIT, CARGO

Aircraft are equipped with interior lights to illuminate the cabin. (***Figure 14-18***) Often white and red light settings are provided on the flight deck. Commercial aircraft have a variety of independent lighting systems that illuminate the flight deck, instrument panels, passenger cabin, cargo compartments and more. Interior lights incorporate the use of both incandescent and fluorescent lights that operate off a variety of AC and DC electrical buses.

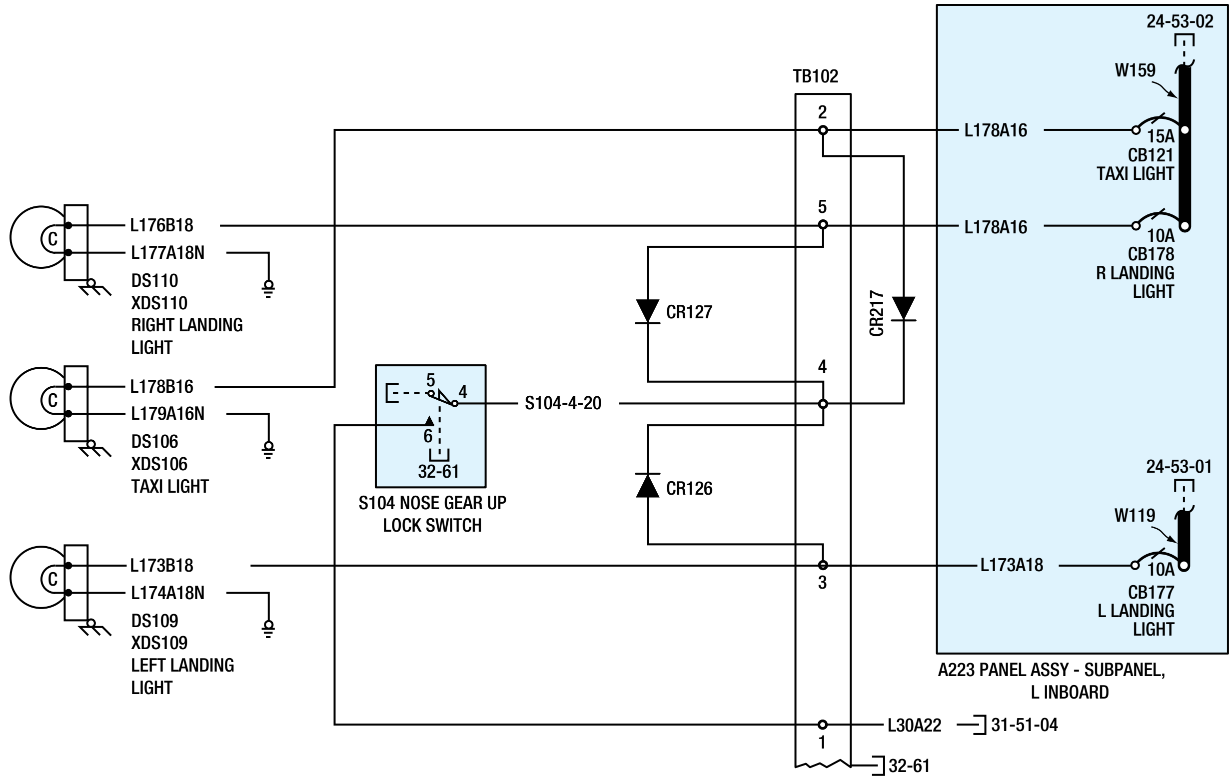

Figure 14-17. Taxi light circuit.

CABIN LIGHTING

The extent to which lighting is used in a passenger compartment is dependent on the decor of that aircraft. It can vary from a small number of incandescent lamps to several fluorescent fittings located in the ceiling to combine pleasing, and functional effects. (***Figure 14-19***)

Each fluorescent tube requires a ballast to provide the momentary high voltage enabling the tube to illuminate. In all commercial passenger transport aircraft, the lights are controlled from panels at the cabin attendant's stations. Cabin lighting is typically provided by The 115V AC bus.

In addition to the general lighting, lights are also provided at passenger service units and for essential information signs, such as "Fasten Seat Belts/No Smoking". The lights for these signs may be incandescent or of the electro-luminescent type. Lights for signs conveying essential information are usually controlled

Figure 14-18. Interior cockpit and cabin light system.

Figure 14-19. Incandescent and fluorescent lights are used to illuminate modern aircraft cabins.

from the cockpit. Passenger compartment lighting also includes those for entry ways, attendant work areas, lavatories and galleys. The typical circuitry for essential information lighting is shown in (***Figure 14-20***)

COCKPIT LIGHTING

On a flight deck, it is normal to have lighting for general illumination as well as local lighting for panels, instruments, and controls. Often red lighting is provided on the flight deck which helps to maintain the pilot's night vision of objects outside the aircraft. Fluorescent background lights are also used.

A central panel, (typically overhead), houses the controls for most internal and external lights. Additional light controls may also be located on appropriate panels. General lighting requirements are met using 28V AC power with certain key lights positioned to operate in partial or no power conditions from a 28V DC bus.

Dome lights provide overhead shadowless general lighting. The 28V DC battery bus usually supplies the operating power. The operation is typically from a three position (DIM-OFF-ON) toggle switch on the overhead panel. A resistor controls the voltage drop for the dimming circuit.

Map holder lighting is provided at the captain and first officer stations. Each is controlled independently and typically via the 28V AC bus. Side console and floor lighting is provided at the captain and first officer stations. The center instrument panel is illuminated by a set of lights below the glare shield. The standby compass is provided with its own integral lighting. Individual reading lights are provided at the captain and first officer stations. A flood light provides illumination of the center pedestal. Each of these is typically powered by the 28V AC bus.

Storm lights are sometimes fitted in the cockpit. These extremely bright lights are switched on during a storm. They raise the ambient light level and cause the iris in the eye to reduce the amount of light entering the eye, thus reducing the chance that a pilot may be temporarily blinded by a bright lightning strike. (***Figure 14-21***)

Integral Instrument Lighting

A common form of integral lighting for instruments is known as 'wedge' lighting; deriving its name from the two wedge shaped portions of glass which make up the instrument cover. Wedge lighting relies on the physical law that the angle at which light leaves a reflecting surface equals the angle at which it strikes that surface. The two wedges are mounted opposite each other with a narrow space separating them. (***Figure 14-22***) Light is introduced into inner wedge (A) from a lamp in its wide end. Some light passes through the wedge and onto the face of the dial while the remainder is reflected into the wedge. The angle at which the light strikes the wedge surface governs the amount of light reflected; the lower

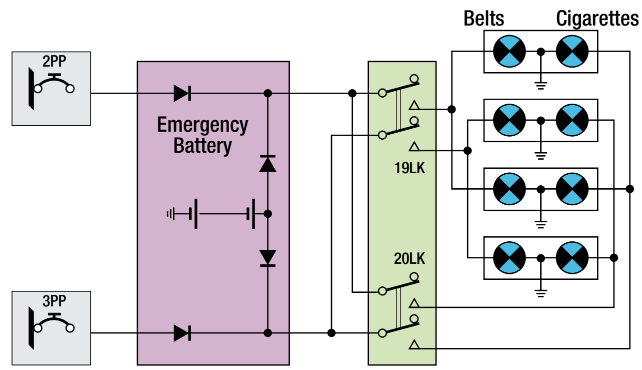

Figure 14-20. Typical circuitry for essential information lighting.

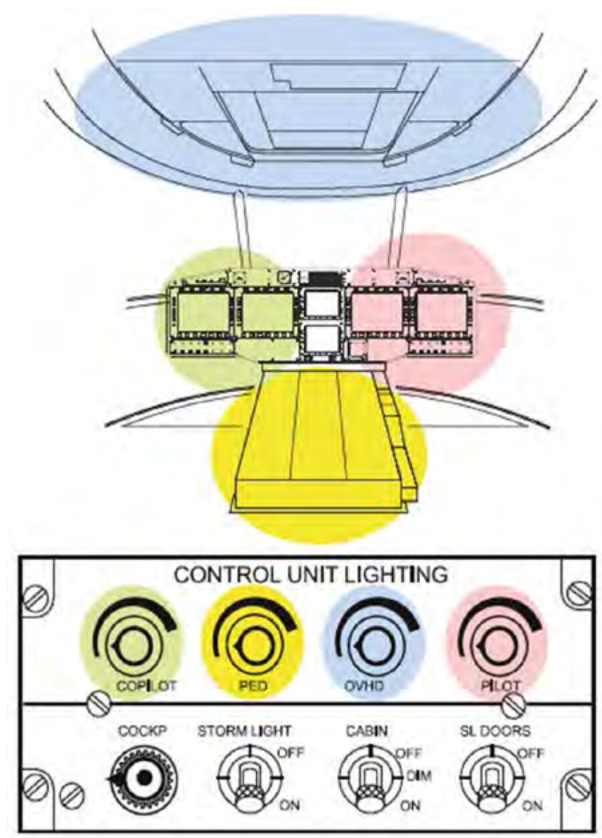

Figure 14-21. Typical cockpit lighting zones.

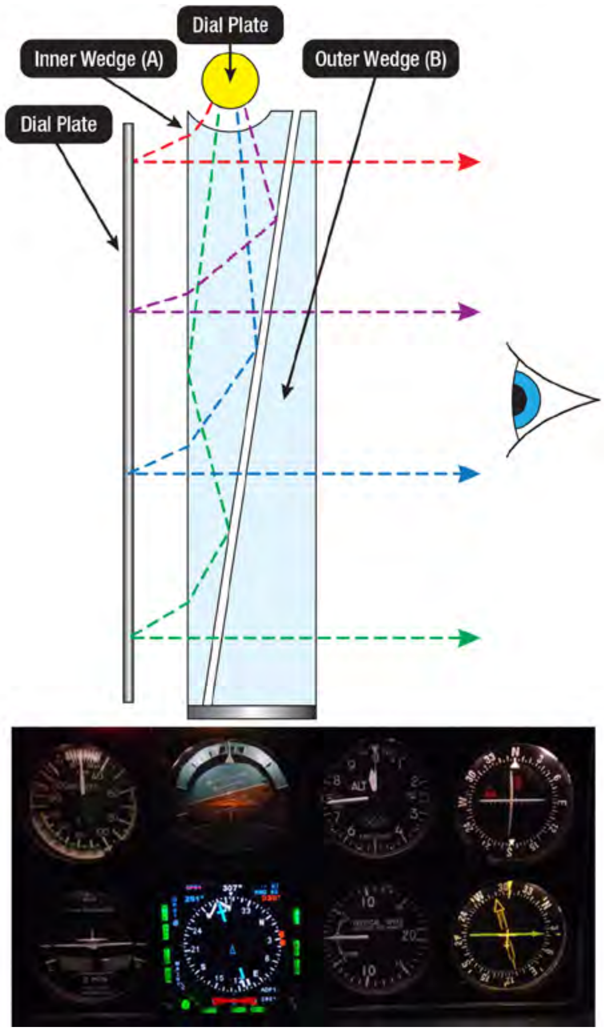

Figure 14-22. Wedge lighting.

the angle, the more light is reflected. The double wedge mechanically changes the angle at which the light rays strike one of the reflecting surfaces, thus distributing the light evenly across the dial and limiting the amount given off by the dial face.

CARGO COMPARTMENT LIGHTS

Cargo and service compartments also have lighting. Dome lights, flood lights and explosion-proof lights as required are installed with independent circuits protected by circuit breakers. The lights are controlled by switches near the entrance to each area or inside the compartments. Often, a control panel for a cargo area includes light switches in addition to door and cargo system operating controls. Sidewall, overhead and door mounted lights are common. Door and door sill lights are positioned so that they illuminate the cargo compartment doorway as well as the area just outside the compartment to facilitate work while loading cargo.

EMERGENCY LIGHTING

Emergency lights are installed in the cabin to illuminate escape routes for passengers and crew during a failure of AC power systems. Lighting strips in the floor and exit lights automatically illuminate when power is lost. (***Figure 14-23 and Figure 14-24***) Emergency lights are used to illuminate the over wing area at the emergency exits and on the escape slides. Lavatories and the control cabin also have emergency lighting.

Various configuration exist for automatic switching of certain emergency lights to the hot DC battery bus (or similar) in case of partial electrical failure. Some interior lighting is designed to always be connected to a DC bus so no switching is required. Total electrical failure causes most emergency lights to revert to dedicated batteries that are an integral part of the lighting installation. Emergency EXIT/area lights for example, may contain

Figure 14-23. Emergency light strips in the aisle floor guide passengers and crew to the exits in case of emergency.

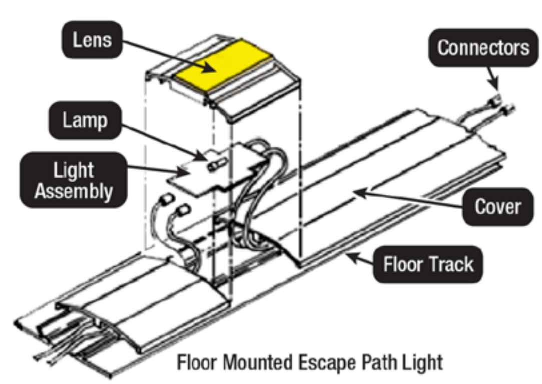

Figure 14-24. A floor mounted escape path light.

a battery in the assembly that includes the lamps, cover lens, solid state switching logic and battery-charging control circuits. In some cases, the light/battery assembly can be removed from its mounted location and used as a portable flashlight. NiCad batteries are typical. In other configurations, the dedicated emergency light battery is remotely located in the same area as the light.

Regardless, emergency lighting is ARMED by a switch on the flight deck or at the passenger cabin lighting control panel. The all-in-one emergency light assemblies also have a switch that must be set to ARMED when the unit is installed. Inspection of an aircraft's emergency lighting system normally includes checking the condition and security of all visible wiring, connections, terminals, fuses, and switches and light units. A continuity light or meter can be used in making these checks, since the cause of many troubles can often be located by systematically testing each circuit for continuity.

ELECTROLUMINESCENCE

Electroluminescent strip lighting eliminates the need for bulbs, sockets, diffusers and reflectors. Without filaments to break, the lighting can withstand extreme shock, vibration and high or low temperatures without failure. Numerous tests and experience has proven that the system will continue operating under very high G forces and/or after considerable structural damage. Electroluminescent lighting is more easily seen through smoke than incandescent or other point sources.

Thin film electroluminescent displays comprise a solid-state glass panel, an electronic control circuit and a power supply. The glass panel consists of a luminescent phosphorous layer sandwiched between transparent dielectric layers and a matrix of electrodes. The circuit board, which contains the drive and control electronics, is connected directly to the back of the glass panel. A pixel on the display is lit by applying voltage to the rows and columns of electrodes, thus causing the area of intersection to emit light. (***Figure 14-25***)

SELF ILLUMINATING SIGNS

Self illuminating signs are entirely self powered. Their brightness is such that they are instantly seen by persons that are not dark adapted, and present no direct radiation hazard.

Each is a small sealed glass envelope internally coated with a layer of phosphor and containing tritium gas. Tritium is an isotope of hydrogen and emits electrons which, on striking the layer of phosphor powder, causes it to emit visible light. Placing the light element behind a diffusing panel provides a good means of conveying emergency instructions in darkened areas.

The lighting for self illuminated signs comes from a radioactive material. They are always on and can not be shut off. Each is a plastic container that holds capsules of radioactive tritium gas. The sign is safe unless it is broken. However, if it does have a hole or a crack, the radioactive gas can be inhaled or absorbed causing injury. Should breakage occur, the aircraft should be evacuated and all doors left open to allow maximum ventilation.

Disposal of signs are subject to the applicable regulations regarding radioactive substances. All self illuminating signs should be checked for luminosity level on initial fitting and at periods specified in its maintenance schedule. Such signs usually have a scrap life of 5 years and should then be returned to the manufacturer for disposal.

EMERGENCY EXIT LIGHTING ACTIVATION

In principle, at least two separate means of activation should be provided:

- By flight crew action, to switch all exit light systems simultaneously.
- Automatically, when the cabin becomes more than half submerged in water, each emergency exit being provided with its own automatic switch.
- Cockpit emergency exit lights should activate automatically, unless it can be shown that reflections or dazzle would be a hazard to the flight crew.

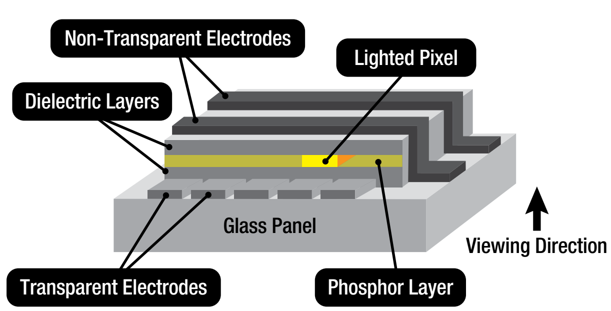

Figure 14-25. A thin film electroluminescence system by the Lumineq Company.