

STAR 013
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Lightning Strikes

Definition

Lightning is a powerful natural electrostatic discharge. Lightning's abrupt electric discharge is accompanied by the emission of visible light and other forms of electromagnetic radiation. The electric current passing through the discharge channels rapidly heats and expands the air into a plasma, producing acoustic shock waves (thunder) in the atmosphere.

Formation of lightning

The first process in the generation of lightning is the forcible separation of positive and negative charges within a cloud or the air. The mechanism by which this happens is called polarization. Falling droplets of ice and rain become electrically polarized as they fall through the atmosphere's natural electric field. Colliding ice particles become charged by electrostatic induction. Once charged, an opposite charge drives them apart and energy is stored in the electric fields between them. Positively charged crystals generally rise to the top – positive charge at the cloud top. Negatively charged crystals and hailstones drop to the middle or bottom layers – negative charge at the cloud base. When the e-field becomes sufficiently strong, an electrical discharge occurs, producing the bolt. These discharges can be triggered amongst others by cosmic ray strikes or by aircraft intrusion into the e-field.

Lightning strikes to aircraft

In more than 90% of cases, lightning is triggered from the aircraft itself by developing two ionized channels progressing in the air starting from the points of highest electric field amplification. One of these discharges propagates in the same direction as the ambient field ('positive' discharge), the other one in the reverse direction ('negative' discharge). This couple represents the initial phase, called 'leader' phase.

The channels develop along several kilometres with a speed between 10 and a few hundred km/h. At first, the current is made of pulse series and generally reaches a continuous level of several hundred Amperes. Afterwards, strong current pulses rating up to 100 kA circulate through these channels with regular intervals. These sudden channel reactivation phenomena are called 'junction discharges' or 'recoil streamers'.

Effects of lightning

- **Aircraft Damage:** structural damage to aircraft from lightning strikes is rare and even more rare is that it threatens the safety of the aircraft. Nevertheless, there have been many incidents of lightning strikes leaving puncture holes in the radomes and tail fins of aircraft (entry and exit holes) and damage to control mechanisms and surfaces.
- **Crew Incapacitation:** momentary blindness from the lightning flash, especially at night, is not uncommon.
- **Interference with Avionics:** a lightning strike can effect avionics systems, particularly compasses.



- Engine Shutdown: transient airflow disturbance associated with lightning to cause engine shutdown on both FADEC and non-FADEC engines with close-spaced engine pairs.

Factors influencing lightning attachment

- Outside air temperature (around 0° C)
- Flight altitude (5,000 to 15,000 ft)
- Within or near clouds
- Rainy days

Factors influencing lightning strike frequency

- Routes flown
- The overall size of the aircraft (larger aircraft receive more strikes in the same environment).
- The shape of the aircraft does **not** influence strike frequency.

Factors influencing where the lightning strike hits

- Airplanes with longer fuselages and proportionately shorter wings experience more strikes to the nose which then sweep along the fuselage.
- Airplanes with shorter fuselages and proportionately longer wings experience more strikes to wing tips, which may be less noticeable than fuselage strikes.

Aircraft protection

- Many planes have their outer areas (skins) made from aluminium. Aluminium is a very good conductor of electricity, meaning that most of the lightning current remains on the exterior of the aircraft, flows along the exterior and away from the plane.
- Newer airliners are made of composites which do not conduct electricity as well, but the outer skin is embedded with a layer of conductive fibres designed to carry the lightning currents.
- Systems have been designed to help protect all of the computers and instruments. Shielding, grounding and surge suppression devices are used to help protect cables, circuits, and equipment. Nevertheless a lightning strike may affect the flight instruments.
- Magnetic fields occur outside and inside the aircraft as a result of the high current which passes through the airframe. During the lightning event, the display units become magnetized because they are located close to the windshield, which is a magnetically exposed area. Displays may change colour or blank out completely.

Crew actions

Should the flight path pass through a thunderstorm area and to prevent temporary blinding in case of a lightning strike:

- Pilots should keep their eyes on the instruments and at night additionally switch on the landing light.
- If the aircraft is equipped with gyro-magnetic compasses, consider selecting one of the compasses to gyro while there is a risk of lightning.

In case a strike is experienced, the pilots should perform the following actions:

- If a crew member has been blinded, determine if other crew member has been blinded too.
- Check attitude and altitude.



- Switch autopilot on (if disconnected) and check operation.
- Check PFD and MFD for flags.
- Check EICAS engine instrument for non-normal indications.
- Check circuit breakers.
- Check navigation indications for accuracy.
- Check communications.
- Confirm with C/A that nothing unusual has occurred in the cabin.
- Report the incident to maintenance personnel, by filling in the TECH LOG.
- Report the incident by filling in an MOR.

Recommendations for aircraft operators

- Review manufacturers' guidelines for action to be taken in the event of a lightning strike.
- Have a policy in place for the release to service an aircraft after lightning strikes
- Have a procedure in place on how to handle lightning strikes at outstations

Recommendations for airports

- Airports should have a notification process in place in order to be prepared for lightning activity. This process may be divided into three parts:
 - Alert phase: lightning activity at a distance of more than 5 miles
 - Stop phase: lightning activity within a distance of 5 miles
 - Resume phase: lightning activity moves away and is at a distance of 5 miles or more
- During the Stop phase personnel should not:
 - Use headsets for communication with aircraft
 - Stay in open areas on the aprons
 - Get out of enclosed vehicles
 - Use portable electronic devices

Sources:

Skybrary.aero, Electrical fun, Embraer lightning strike materials

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