

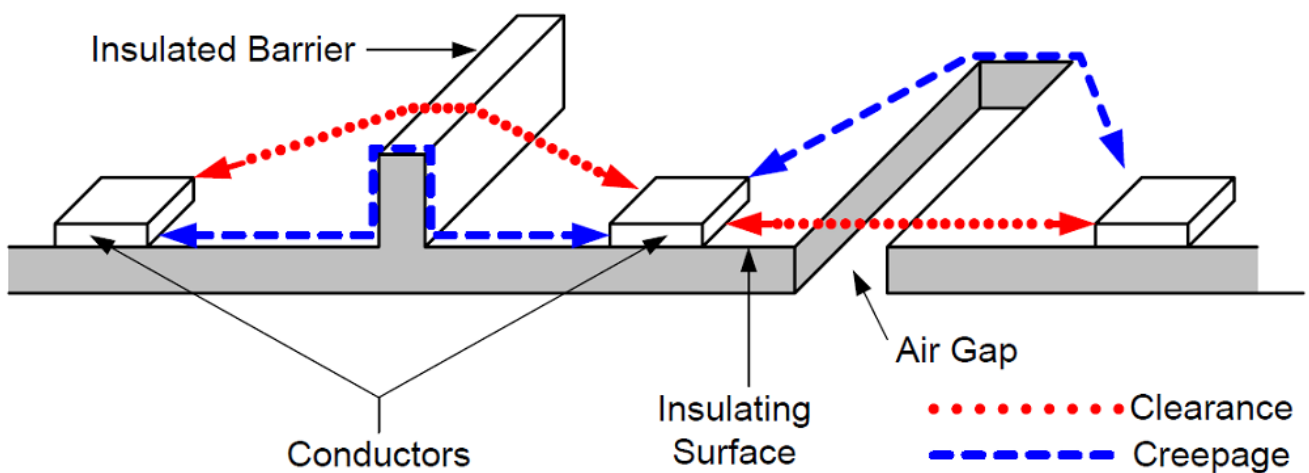
## How Does Altitude Affect AC-DC Power Supplies?



Most AC-DC power supplies that meet the safety standards per UL/EN 60950-1 for ITE (Information Technology Equipment) applications are designed to operate at typical office and factory altitudes, which can vary from slightly above sea level to as high as 2,000 meters (6,562 feet). And, many power supply manufacturers provide units that are designed and rated for operation at higher altitudes, up to 3,000 meters (9,843 feet) so their supplies can be used in major cities located at higher elevations (e.g., Denver, Santa Fe, Mexico City, Bogota). Many broadcasting/communications stations/towers are located at altitudes up to 3,000 meters or higher in order to maximize their range.

Altitude affects the design of power supplies since 'air' is used as an electric insulating medium (aka, dielectric) in the construction of power supplies, as well as most electronic devices. The density and dielectric strength (insulating property) of air is very good at sea level, but at higher altitudes, the thinner air loses some of its dielectric strength, which needs to be compensated for. Switchmode power supplies operate off of high voltages (inputs of 90 to 265Vac) and internally generate even higher voltages (400Vdc or more), which need to be insulated and contained to prevent high voltage arcing or breakdown within the supply, and to protect the end-equipment and operating personnel.

The drawing below shows a cross section of a typical printed circuit board (PCB), which is comprised of copper electric conduction paths that are chemically etched on an insulated (dielectric) fiber board material (e.g., FR4, woven fiberglass cloth with epoxy resin), plus electronic components that are not shown in this drawing. As can be seen, the fiber board and air, combined with the distances between the etched conductive traces are the primary insulation mediums for the circuit board.



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- The term 'Clearance' refers to shortage path between the two conductive parts (circuit traces, components, etc.), measured through air.
- The term 'Creepage' refers to the shortage path between two conductive parts measured along the surface of the insulation (PCB, insulating materials/barriers, etc.).

What does this have to do with altitude? Since 'air' gets thinner (reduced barometric pressure) at higher altitudes and becomes less of an insulator, the PCB and component layouts have to be designed with sufficient safety spacing distances to prevent high voltage arcs or breakdowns between conductors and/or electronic components.

For example, typical power supply design practice may allow 8 mm spacing distance between primary and secondary circuits and 4 mm spacing distance between primary and ground. These spacing distances will vary depending upon the voltage levels between conductors and components and the expected humidity, temperatures, pollution levels, and attitudes.

For those power products that must be approved per the Chinese CCC organization (required to export supplies into China), the new Chinese Safety Standard GB 4943.1-2011, which is similar to

UL/EN 60950, requires strict specs for creepage and clearance distances. As of December 1, 2012, the primary-to-secondary clearances must increase by a factor of 1.48 to qualify the supply for operation up to 5,000 meters, since many regions in China are located at high altitudes. The alternative for CCC certified power supplies is that they must clearly marked with a warning label that states that the power supply must be used below 2,000 meters (see table below).

The base design altitude for ITE power supplies is 2,000 meters. However, as mentioned before, as the altitude increases, the air becomes a poorer insulator and the spacing distances have to be increased per the following table (assuming an 8 mm clearance at 2000m).

Altitude (meters)	Barometric Pressure (kPa)	Multiplication Factor for Clearance	Resulting Clearance (mm)
2000	80.0	1.00	8.00
3000	70.0	1.14	9.12
4000	62.0	1.29	10.32
5000	54.0	1.48	11.84

As can be seen from this table, if a power supply is to be operated at 5,000 meters, its conductor/components clearances must be increased by 48% compared to a supply designed for 2,000 meters.

The other major effect of high altitudes on power supplies is that the less dense air does not conduct heat as well. To compensate for higher altitudes, power supplies need to be derated, or employ larger heat sinks, or have increased forced air flow, or a combination of these to insure proper cooling. In addition, the power supply must be designed with the proper conductor and component clearances as discussed above.

In summary, whenever an application requires that a power supply must operate at altitudes above 2,000 meters (6,562 feet), always check with the manufacturer to determine if this is acceptable, or if an alternate model that is designed for higher altitudes is required.

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