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Technical Notes

Tungsten Halogen Lamps

Tungsten-Halogen lamps are similar to conventional incandescent lamps in that they utilize a tungsten filament in a gas-filled, light transmitting envelope and emit the same type of light. The major differences are that in the tungsten-halogen lamp a trace of one of the elements called 'halogens' (such as iodine or bromine) is added as a vapour to the inert fill gas normally used in incandescent lamps, and the gas pressure and bulb temperature during operation are much higher than in non-halogen incandescent lamps. The higher gas pressure retards tungsten evaporation, allowing the filament to operate at a higher temperature. Therefore, the lamp operates at higher efficiencies than conventional incandescent lamps. To withstand those high operating pressures and temperatures, the lamp bulbs are made of fused quartz or high temperature 'hard' glass. The earliest of these lamps employed fused quartz bulbs and iodine vapour and were therefore called 'quartz-iodine' lamps, but since other high temperature bulb materials and other halogens may be used, the more generic term 'tungsten-halogen' lamp is now used.

Tungsten-halogen lamps operate in a 'halogen regenerative cycle' which maintains nearly constant light output and colour temperature throughout the life of the lamp. The halogen cycle permits the use of more compact bulbs than those of conventional tungsten-filament lamps of comparable ratings. It also permits either increasing lamp life to approximately twice that of conventional tungsten-filament lamps of comparable wattage, colour temperature and light output, or increasing light outputs and colour temperature to values significantly above those of conventional tungsten-filament lamps having comparable life and wattage.

Limitations of Conventional Incandescent Lamps

In conventional gas-filled tungsten-filament incandescent lamps, tungsten molecules evaporate from the incandescent filament, are carried by convection currents of the inert fill gas to the relatively cool inner surface of the bulb wall, and are deposited to form a thin film which gradually increases in thickness during the life of the lamp. These phenomena cause reduction of lumen output and of efficacy (lumens per watt) in two ways. First, evaporation of tungsten from the filament reduces the filament wire diameter and increases the resistance so that (at constant voltage) the amperes, watts, MSCP, efficacy, and colour temperature are all reduced. Second, the tungsten which is evaporated from the filament and deposited on the bulb wall increases in opacity as it increases in thickness, resulting in bulb blackening which absorbs increasing portions of the light produced by the filament, and thus reduces the lumen.

The Halogen Regenerative Cycle

In tungsten-halogen lamps the effects described above are reduced or retarded by the regenerative action of the halogen cycle, which operates by virtue of the temperature gradient between the filament and the bulb as follows:

a. The filament, fill gas and bulb are initially at some low temperature (e.g., ambient), for a cold start.
b. When power is applied, the filament rapidly rises to its operating temperature (2800°K to 3400°K, depending on application), heating the fill gas and the bulb. The bulb wall rises to an operating temperature of 400°C to 1000°C and the fill gas rises to temperatures ranging from that at the filament to that at the bulb wall. This temperature gradient causes convection currents in the fill gas.
c. As the bulb wall rises above some temperature in the range 200°C to 250°C (depending on nature and amount of halogen vapour in the fill gas), the halogen cycle begins to operate. Tungsten molecules evaporated from the filament combine with the halogen vapour to form a tungsten halide (e.g., tungsten iodide or tungsten bromide) which is circulated outward toward the bulb wall by the convection currents in the fill gas. However, the temperature of the hot bulb wall is above the condensation temperature of the

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tungsten halide, which therefore does not condense on the bulb wall but is circulated by convection back to the region of the filament (see figure A).

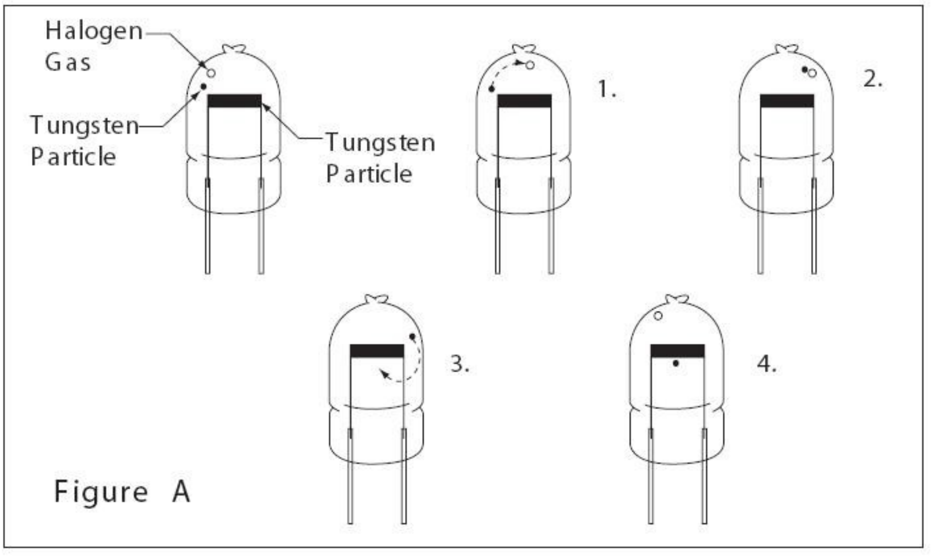

Figure A

d. At the filament, where the temperature exceeds 2500°C, the tungsten halide dissociates into tungsten and free halogen vapour. The regenerated tungsten is re-deposited on the filament from which it originally evaporated, and on its support wires, and the free halogen vapour is recirculated to continue the regenerative cycle.
The halogen cycle thus retards MSCP depreciation by preventing deposition of tungsten on the bulb wall that would progressively reduce light output. Tungsten-halogen lamps continue to emit about 90% of their initial light outputs for 75% or more of their rated life, and thus emit about 50% more total light over that life than do conventional tungsten-filament lamps.

Hard Glass or Quartz

The bulb size/wattage relationship of most of the halogen lamps is such that the bulb can be made of hard glass, which is significantly less expensive than fused quartz. The T-3 aircraft lamps listed in this catalogue, which are approximately the same size as the earlier mentioned lamps, are rated at 100 and 150 watts making it necessary to use fused quartz bulbs.

Design Considerations

While the miniature halogen lamps are just that, miniature lamps, it cannot be overemphasized that they will generate considerable amounts of heat. This must be taken into consideration by the equipment designer. The urge to design a small compact piece of equipment to complement the miniature halogen lamp must be tempered by a prudent design that will allow the lamp to operate within the temperature limitations previously indicated.

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