



Halogen light sources

Operating tungsten halogen lamps

- High VIS-NIR output
- Smooth spectrum
- Stable output

Tungsten halogen incandescent lamps are thermal radiators. This means that the light is generated by heating a solid body to high temperature. The higher its temperature, the “brighter” the light. In halogen lamps the required temperature is produced by passing a current through an electrical conductor of greater or lesser conductivity. The incandescent material must have a high melting point and slow rate of vaporization in order to reach as high a temperature as possible and be able to maintain it over a long period of time. Although tungsten is limited with melting point of 3383° C and low vaporization rate, no better incandescent material with better properties has been found yet despite intensive research.

Tungsten halogen lamps are useful visible and near infrared sources. They have a smooth spectrum and a stable output. See the spectral curves in “Lamp spectra and irradiance data” on www.lot-oriel.com/lightsources (“Basics”) for a comparison of tungsten halogen and arc lamps.

Halogen cycle

In conventional incandescent lamps the vaporized tungsten is deposited on the glass bulb. This blackens the bulb wall and gradually reduces the light output. To keep the light loss as low as possible the bulb surface is large, keeping the absorbing layer thin. With tungsten halogen lamps the bulb is filled with an inert gas (krypton or xenon) mixed with a low amount of a halogen element (bromine or iodine). The vaporized tungsten from the filament can then be intercepted before it reaches the bulb wall and be returned to the filament. This thermo-chemical process is called “halogen cycle”. As a result the glass bulb stays clean, the output remains equally bright until the end of the lamp life. Converting electrical current to light is also more efficient. As the bulb does not blacken, it can be relatively small compared to conventional tungsten lamps which allows their use in spectroscopy applications.

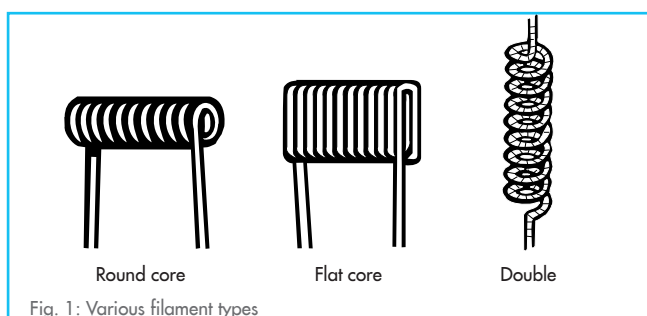
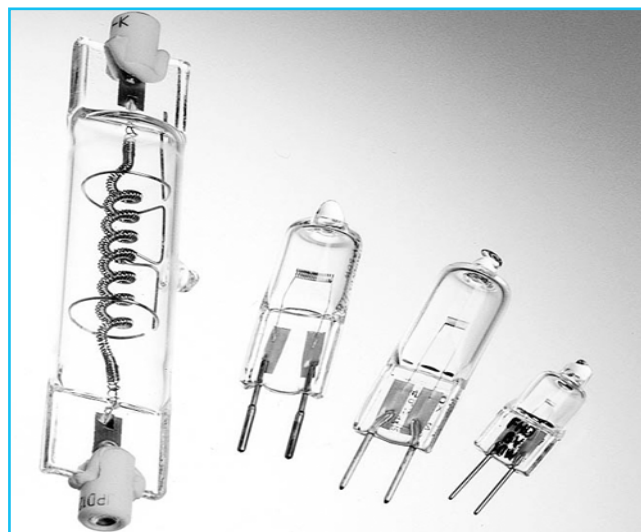


Fig. 1: Various filament types



Lamp design

The bulb material for tungsten halogen lamps is quartz, which allows bulb temperatures of up to 900° C and operating pressures of up to 20 bar.

There is a difference between single-ended and double-ended lamps. In most single-ended type lamps the cylindrical shape is deformed by the pinch at the bottom and the exhaust tube at the top.

The electrical data of a lamp (and to some extent the photometric characteristics) are determined by the dimensions of the wire or filament. The length of the wire is mainly determined by the lamp operating voltage (for 24 V lamps approx. 100 – 140 mm; half of it for 12 V lamps).

Filament geometry

The different types of coil most commonly used and the resulting filament geometries can be seen in fig. 1. Lamps up to 150 W have flat core filaments which can have two orientations in relation to the lamp axis. Very little light is emitted along the cylindrical axis.

The lamps can be operated vertically or horizontally and the orientation of the emitting plane of the filament should be considered in respect to the target geometry. Depending on the orientation of the filament in the lamp bulb the emission characteristic is influenced by the bulb shape. The radiation is approximately isotropic about the coil cylinder.



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Spectral output and color temperature

Tungsten halogen incandescent lamps have blackbody-like emission spectra. Therefore spectrum and tungsten temperature are clearly related to each other. The total radiation output increases like the fourth power of the material temperature as shown in fig. 2 (The influence of the bulb material on the spectral distribution of radiation up to 2.7 μm is negligible).

As the source temperature increases, the curve moves to shorter wavelengths. The melting point of tungsten (3383 $^{\circ}\text{C}$) does not allow the peak to be shifted into the visible. At the highest practicable temperatures, this peak is at about 850 nm. The visible region ends at 780 nm. In this case about 20% of the total radiation is given off as "light", about 0.3% in the UV region, and the rest (the majority) as heat.

The curve shapes of our lamps are similar, but the location and height of the peak depend on the lamp model and operating conditions. The filament temperature, emissivity and transmission of the envelope determine the radiated energy and its spectral distribution.

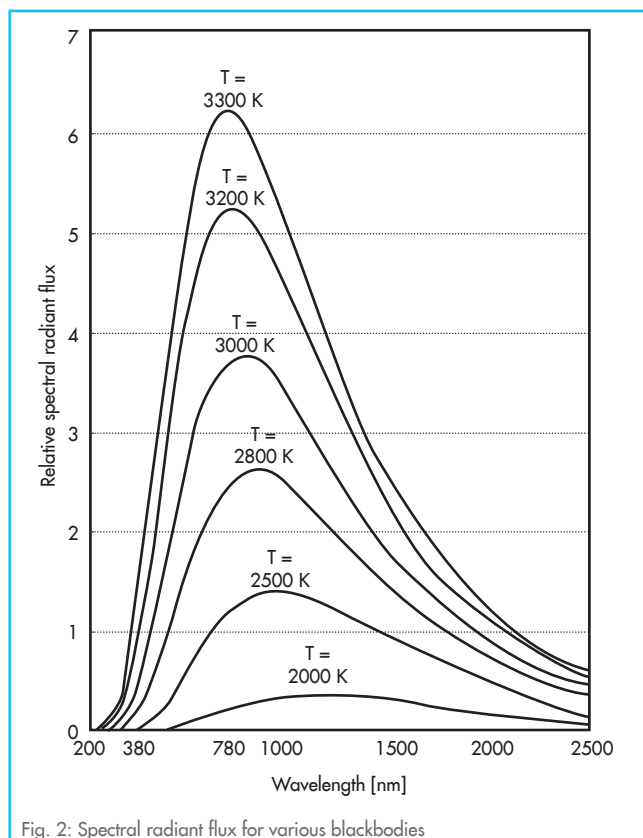


Fig. 2: Spectral radiant flux for various blackbodies

Color temperature and total radiated lumens are useful for the comparison of lamp performance. The higher the color temperature, the whiter the light; the lower the color temperature the more yellow and red is the light.

The luminous output is particularly sensitive to the filament temperature, and the shape of the filament is important for the directional distribution of the radiation. The the 1 kW lamp's total irradiance at 50 cm, is much less than ten times that of the 100 W lamp. This is because of differences in the filament temperature and shape.

Tungsten temperature and color temperature

The ideal blackbody's color temperature is equal to the true temperature. The total radiation from real sources is less than that from a blackbody. The ratio of the radiant power emitted by a source to the radiant power emitted by a blackbody at the same temperature is called emissivity ($\epsilon(\lambda)$). It is a measure of how a source approaches a blackbody in terms of emitted radiation.

The figure below shows that tungsten is a better emitter in the short-wave region than in the long-wave region.

The color temperature of tungsten is higher than its equivalent true temperature. For a filament temperature of 3000 K, the color temperature is approximately 3060 to 3080 K. The color temperature limit is determined by the melting point of tungsten: about 3350 K.

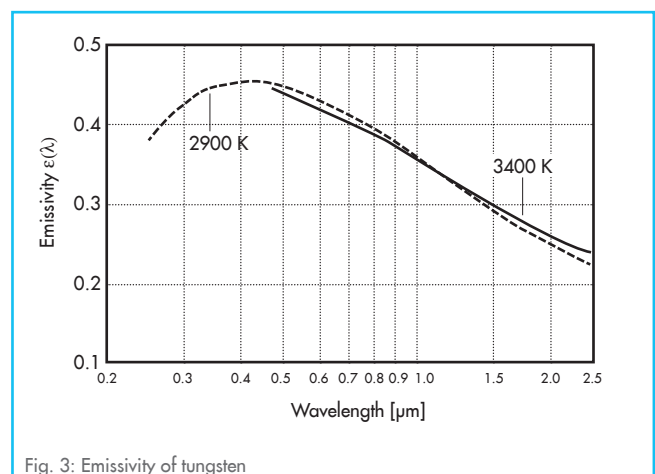


Fig. 3: Emissivity of tungsten



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Lamp life and operating voltage

All lamp parameters depend on a specific operating voltage: the rated voltage. Lamp life is the time after which (on average) half of a determined number of lamps fail (filament burn outs). Operating these lamps at a higher voltage greatly reduces their life time. A 10% increase in voltage reduces the operating life by 35% (fig. 4). Voltage reduction extends the lamp life but a reduction of more than 10% may shorten the life time as the halogen cycle cannot operate properly under these conditions.

The specified lamp life is not a guaranteed feature, but a statistical mean. Individual lamps may fail earlier, others later. The main lamp life reducing factors are:

- Over-voltage (or current)
- Under-voltage (or current)
- High switching frequency
- Incorrect cooling

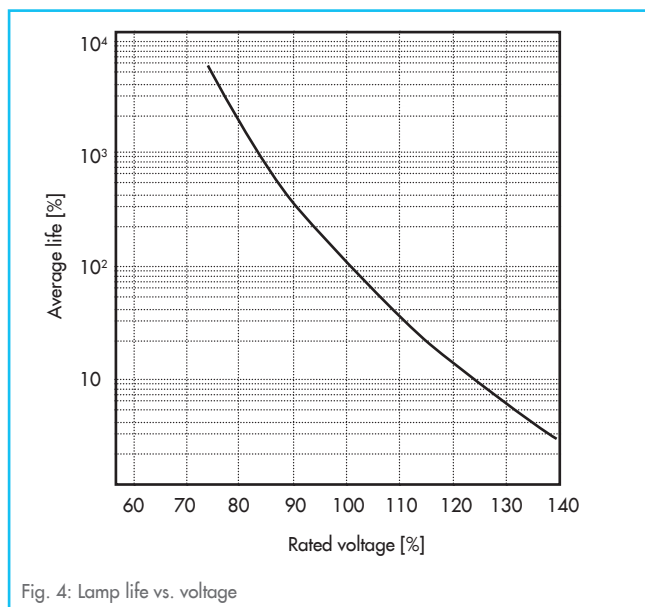
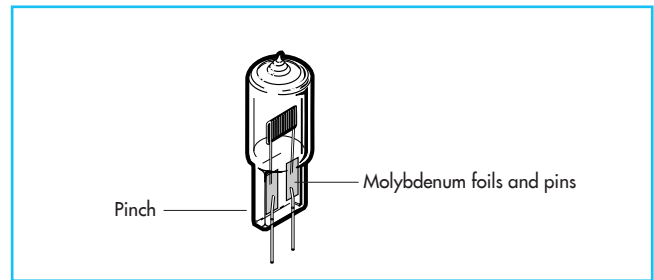


Fig. 4: Lamp life vs. voltage

Handling and operation

Halogen lamps are made of glass, accordingly they should be handled with greatest care. The point where the pins emerge from the pinch is always critical, if force is applied here, the pinch will inevitably break.

If possible, the lamps should only be held by the base or the pinch. Any finger marks – including invisible ones – must be cleaned off with a cloth before the lamp is switched on for the first time. Otherwise they will



burn in at high operating temperatures (between 200 and 600° C) and cause the glass to recrystallize within a few hours of operation. The glass will turn opaque and milky and increasingly lose its strength; the risk of bursting increases.

When fitting lamps in lamp holders, special care must be taken not to exert any shear or torque forces on the lamp or its base. Double-ended lamps must be fitted in the sprung contact socket first at one end and then at the other. It is often more difficult to remove a burnt-out lamp than to fit in a new one, as the lamp holder contacts may have tarnished. In this case, it is advisable to replace the lamp holder together with the lamp, as otherwise the new lamp could suffer thermal damage.

Burning position

Manufacturers always specify a permitted range of burning positions for all types of lamps (specified as angle degrees perpendicular to the long axis of the filament). Operation outside of the quoted burning position will be subjected to highly variable mechanical and thermal loads, with possible deformation of the filament or short-circuit between filament coils.

A word on safety

Tungsten halogen lamps are filled with krypton or xenon at supra atmospheric pressure to reduce the vaporization rate of tungsten. Depending on the lamp type, the pressure can rise up to 20 bar at operating temperature.

During operation bulb temperatures of up to 900° C are reached. Allow the lamp to cool down for 15 minutes before touching it. Some lamps can reach average luminance values of up to 30 cd/mm². Lamps with quartz bulbs emit about 0.2 - 0.3% of the consumed electrical power as radiation below 380 nm. Therefore glare and hazard from the UV cannot be ruled out. For these reasons you should operate halogen lamps only in specially designed, closed housings and wear protective eyewear.