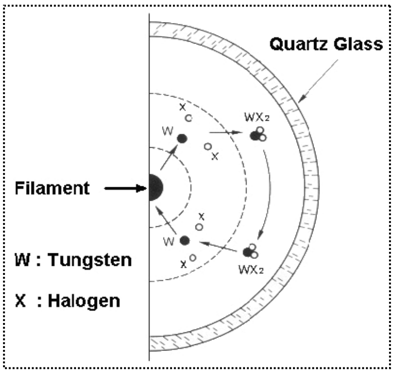
Technical information for Infrared halogen heater lamps

What's halogen lamp?

A halogen lamp is a kind of gas-fillet tungsten filament lamp. Its gas consists of not only inert gas which is commonly use in gas-filled lamp technology, but also small trace of halogen material. Conventional incandescent lamps lose their light flux gradually during the operation, due to tungsten vapor accumulation on inner bulb surfaces (blackening phenomenon). Halogen lamps do not have this slow deterioration thanks to a chemical process that is called "halogen cycle".

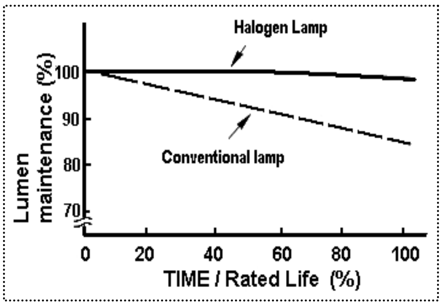
Appendix1: Inside halogen lamp



Halogen cycle

The appendix 1 illustrates chemical reaction inside a halogen lamp. Tungsten atoms W which have evaporated from the filament combine with halogen vapor to form WX2, which traverse towards the quartz glass wall. If the temperature at the quartz glass is above 250 °C, which is over the condensation temperature of WX2, the molecules can not condensate themselves on the wall, therefore circulate back towards the filament. Since the temperature near the filament exceeds 2000°C, WX2 is disintegrated to W and Xs again. The free tungsten atom W can deposit itself onto a cold portion of the filament, but the X remains floated in the gas, repeating the process over and over. In order to achieve good halogen cycle, halogen lamps have generally much compact bodies (made of quartz to withstand the high temperature) compared with conventional lamps. This results in building up higher gas pressure inside, suppressing tungsten vaporization, thus achieving long life as well as better lumen maintenance performance as shown in the appendix 2.

Appendix 2: Halogen cycle (radiation maintenance of halogen in comparison with conventional lamp)



Spectrum vs. Color temperature (Kelvin)

See the appendix 3. Higher filament temperature will increase the ratio of visible light, which belongs to rather short wavelength band of emission from a halogen lamp. Light produced with a higher temperature filament has more bluish spectrum, which gives an impression of whiter light to human eyes.

Appendix 3: Planck's low

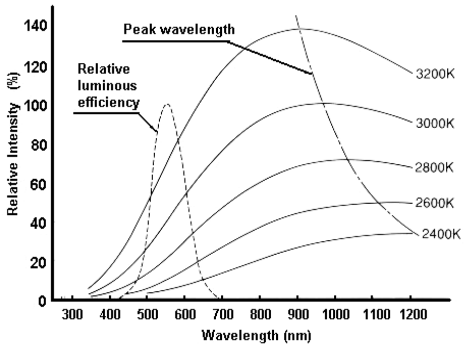
Planck's low

$$Me(\lambda,T)=\frac{C_1}{\lambda^5\{\exp(C_2/\lambda T)-1\}}$$

Me	:	Energy spectrum
l	:	Wavelength (um)
T	:	Absolute temperature (K)
C_1	:	3,7415 x 10^{-16} (W m^2)
C_2	:	1,4388 x 10^{-2} (m K)

Equation to estimate peak wavelength and filament temperature

$$\lambda max\ T=2898\ [\mu m\cdot K]$$



l_{max}	:	Peak Wavelength (um)
T	:	Filament temperature (K)

Lamp voltage vs. Characteristics

Some important characteristics can be estimated with the equation illustrated in the appendix 4. Luminous flux refers visible light using clear quartz glass tube.

Appendix 4

$$\frac{F}{F_0} = \left(\frac{V}{V_0}\right)^K$$

F : Value to be estimated
F_0 : Value at the rated voltage V_0
V : Lamp Voltage
V_0 : Rated Lamp Voltage

F	Current	Power	*Efficiency	Light Flux	Color Temperature
K	0.54	1.54	1.84	3.38	0.42

Ex) Power consumption of a 500W lamp at 105% input voltage.

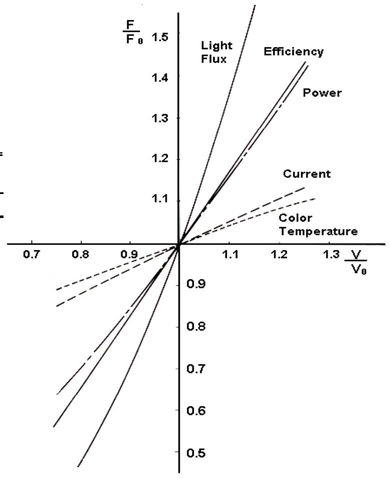
$$\frac{\text{Power}}{500} = \left(\frac{105}{100}\right)^{1,54}$$

$$= 1.078$$

Therefore,

Power = 539 W

* note) Efficiency is given as visible light flux output / input power, not as IR radiation efficiency.

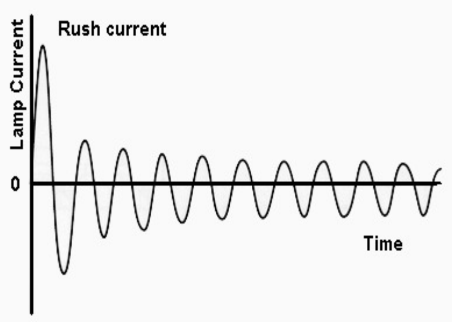


Rush current

Resistance of filament changes dramatically by its working temperature. For example, a tungsten filament designed to operate at 2727°C (with a resistivity of 90,4 x 10-6) decreases its resistivity down to its mere 6% (5,65 x 10-6)at a room temperature. Theoretically, since the filament design is based on its operating temperature, the cold start rush current becomes 13 to 17 times larger than the rated current. In actual applications, the impedance of power supply networks helps to suppress the current to a certain degree, but still 7 to 10 times larger current will be experienced usually.

Power supply capacity should be taken into consideration before installation to protect from halogen lamp rush current. Especially, halogen lamp heater applications, which have rather long time constant, often require big enough margins to power supply capacity and/or current controller capacity.

Appendix 5: Rush current



Sealing part temperature

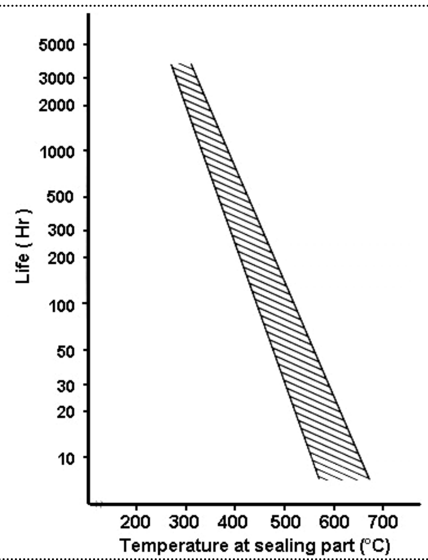
Temperature at the lamp seal must be kept lower than 350ºC, because of the following reasons:

- High temperature accelerates the oxidation on molybdenum foil to damage its electrical conductivity.
- Thermal expansion may create a slow-leak path between the foil and the glass.
- Excessive thermal stress creates unbearable mechanical stress in the glass

The temperature at sealing part is thus important but not very easy to be controlled. Power consumption, lamp current, distance to the nearest coiling element, glass tube diameter, base holding method and other factors affect this temperature.

Upon customer's request, TOSHIBA offers a sample of infrared halogen heater lamp with thermocouples to measure important temperatures (including lamp sealing) in your modules.

Appendix 6: Lamp life vs. Sealing part



Lamp life vs. Lamp voltage

Lamp voltage has a big impact on lamp life. An approximate equation is known as:

$$\frac{L}{L_0} = \left(\frac{V_0}{V}\right)^{10\sim14}$$

L: Life to be estimated

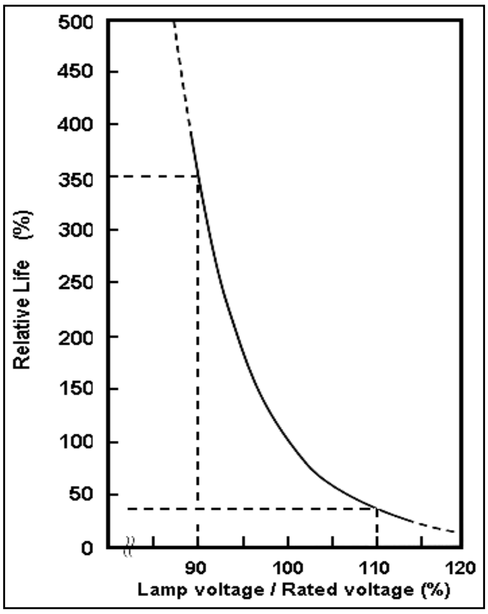
L0: Life as the rated voltage V0

V: Lamp voltage

V0: Rated lamp voltage

This is rather a general rule to understand filament life. Actual lamp life may vary depending on many design parameters. For example, this equation estimates that additional 10% of lamp voltage will accelerate the filament cut by 70%. Practically, before this filament failure, light flux drop may be experienced because of the blackening effect caused by halogen shortage with more active tungsten vapor production.

Appendix 7: Lamp life



IMPORTANT

Operating lamp at a higher than nominal voltage causes a blackening on inner wall of glass tube by excess tungsten vapor. Paradoxically however operating lamp at a lower voltage leads to insufficient temperature of optimum value for the filament, and excess gas may damage the filament. Such operations may therefore result to shorten lamp life.

Allowable temperature for lamp operation