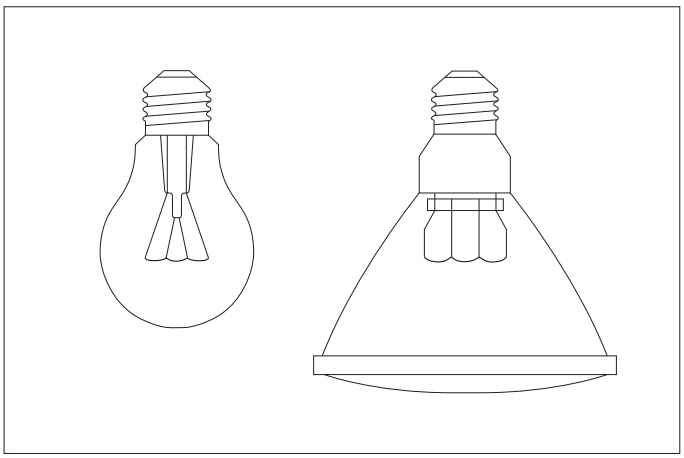
2.3.1 Incandescent lamps

The incandescent lamp is a thermal radiator. The filament wire begins to glow when it is heated to a sufficiently high temperature by an electric current. As the temperature increases the spectrum of the radiated light shifts towards the shorter wavelength range – the red heat of the filament shifts to the warm white light of the incandescent lamp. Depending on lamp type and wattage the temperature of the filament can reach up to 3000 K, in the case of halogen lamps over 3000 K. Maximum radiation at these temperatures still lies in the infrared range, with the result that in comparison to the visible spectrum there is a high degree of thermal radiation and very little UV radiation. Lack of a suitable material for the filament means that it is not possible to increase the temperature further, which would increase the luminous efficacy and produce a cool white luminous colour. As is the case with all heated solid bodies – or the highly compressed gas produced by the sun – the incandescent lamp radiates a continuous spectrum. The spectral distrbution curve is therefore continuous and does not consist of a set of individual lines. The heating of the filament wire results from its high electrical resistance – electrical energy is converted into radiant energy, of which one part is visible light. Although this is basically a simple principle, there are a substantial number of practical problems involved in the construction of an incandescent lamp. There are only a few conducting materials, for example, that have a sufficiently high melting point and at the same time a sufficiently low evaporation rate below melting point that render them suitable for use as filament wires.

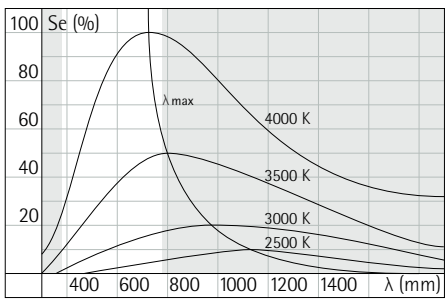


Incandescent lamps with tungsten filaments in an evacuated or gas-filled glass bulb. General service lamp (left) and pressed-glass lamp with integrated parabolic reflector (right).

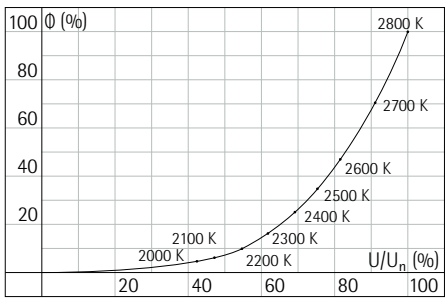
Nowadays practically only tungsten is used for the manufacture of filament wires, because it only melts at a temperature of 3653 K and has a low evaporation rate. The tungsten is made into fine wires and is wound to make single or double coiled filaments.

In the case of the incandescent lamp the filament is located inside a soft glass bulb, which is relatively large in order to keep light loss, due to deposits of evaporated tungsten (blackening), to a minimum. To prevent the filament from oxidising the outer envelope is evacuated for low wattages and filled with nitrogen or a nitrogen-based inert gas mixture for higher wattages. The thermal insulation properties of the gas used to fill the bulb increases the temperature of the wire filament, but at the same time reduces the evaporation rate of the tungsten, which in turn leads to increased luminous efficacy and a longer lamp life. The inert gases predominantly used are argon and krypton. The krypton permits a higher operating temperature – and greater lu-

Spectral distribution S_e (λ) of a thermal radiator at different filament temperatures. As the temperature increases the maximum radiation shifts into the visible range.

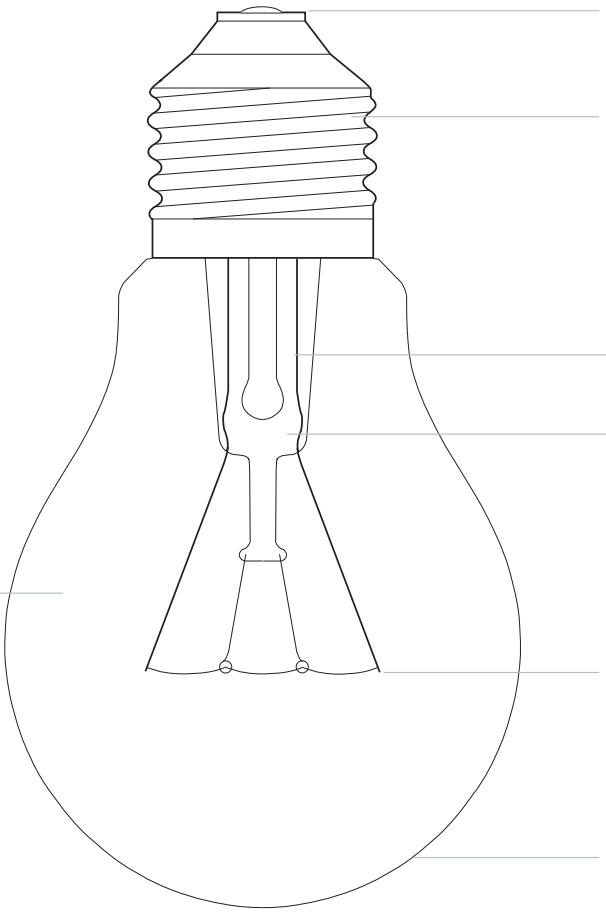


Dimming characteristics of incandescent lamps. Relative luminous flux Φ and colour temperature as a function of the relative voltage U/U_n. A reduction in voltage results in a disproportionate decrease in luminous flux.



General service lamp: the principle of producing light by means of an electrically heated wire filament has been known since1802. The first functional incandescent lamps were made in 1854 by Heinrich Goebel.

The real breakthrough that made the incandescent the most common light source can be ascribed to Thomas Alva Edison, who developed the incandescent lamp as we know it today in 1879.



Insulated contact for connection to the phase

Screw cap to secure lamp mechanically, also serves as a contact to the neutral conductor

Connection wires with integrated fuse

Glass stem, with insulated filament supports

The inside of the lamp is either evacuated or filled with inert gas

Filament, usually a double coil of tungsten wire

Clear, matt or coloured glass bulb. Parts of the glass bulb can be provided with a silver coating to form a reflector