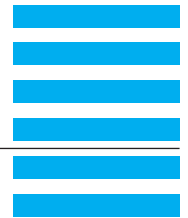


# All you need to know about Arc Lamps



Short arc lamps are the brightest manufactured sources, discounting lasers. Light is generated by a discharge arc burning in gas between two electrodes. This lamp type has two remarkable features:

- high output in the UV-VIS
- small radiating arc region

Because the arc region is very small for many purposes these lamps come very close to the ideal of a point source.

These extremely bright and high radiance sources are very suitable to create a collimated beam or to irradiate small probes with high intensity. Mercury arc lamps emit 60 % of their output in the UV-VIS. Xe arc lamps have color temperature of approx. 6000 K which is close to that of the sun. The main output is below 900 nm.

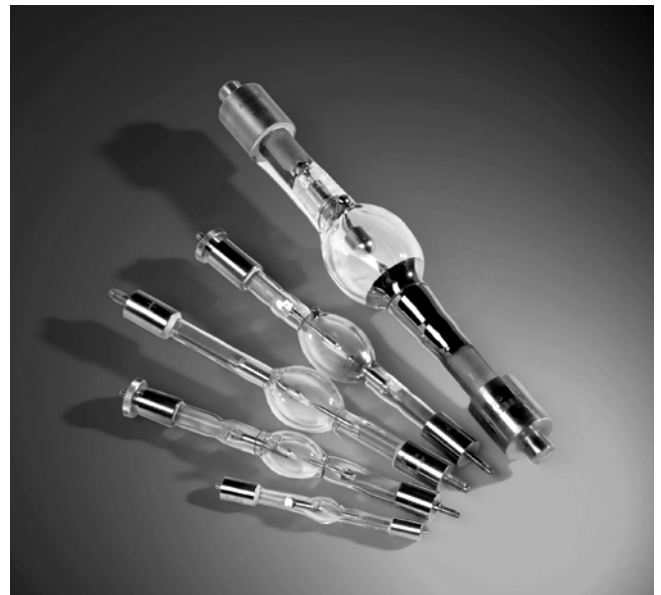
## Arc Lamp Design

The figures on the next page show the design of typical arc lamps. The lamp bulbs are always made of quartz glass. Only quartz glass can withstand the high mechanical load caused by the operating pressure of some tens of bars and the thermal load at surface temperatures of over 700°C. The type of quartz determines the lamp's UV output. Most lamps used doped or coated quartz which absorbs below 250 nm to prevent ozone generation. They are called „ozone-free“ lamps. Others use UV grade quartz to transmit output down to 200 or even 160 nm. Depending on type and dominant application, a more oval or more round cross section is chosen. The quartz wall is a few millimeters thick.

## Electrodes

The electrodes are always made of tungsten. The cathode supplies the electrons. The best materials for performing this task is doped tungsten. The cathode is small with a relatively sharp tip to enhance the emission of electrons. Its shape also has a great influence on arc size and stability.

The **anode** receives the electrons emitted by the cathode. They penetrate the anode at high speed which is converted to heat. This heat must be dissipated, and is mostly radiated away. The anode therefore is bigger to keep its temperature as low as possible to ensure a long lamp life. Hg lamps have coils on one or both electrodes to help in arc formation. The anode-cathode gap can be from 0,25 mm to several mm, depending on lamp power.



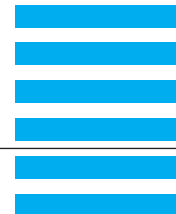
## Gas Fill

Xenon lamps are filled with pure xenon gas at 8 to 10 bars. Mercury lamps are filled with an inert gas with a precisely metered amount of mercury. This amount is calculated in such a way that, depending on power and bulb shape a pressure of up to 75 bar during operation is reached. For Xe lamps the internal pressure rises to about 30- 40 bar during operation. The high operating pressure is related to the high operating temperature of the lamp. This demands special care in handling and operation of the lamps.

## Bases

The two metal bases at the ends of the lamp are for electrical connection and mechanical fixing of the lamp. The bases are connected to the electrodes by a molybdenum foil inside the glass stem, or, for the higher wattage lamps, by tungsten rods. Tungsten has a high thermal expansion coefficient, but quartz does not expand at all when heated. So certain tricks have to be employed to create a seal between the glass and the metal.

# All you need to know about Arc Lamps



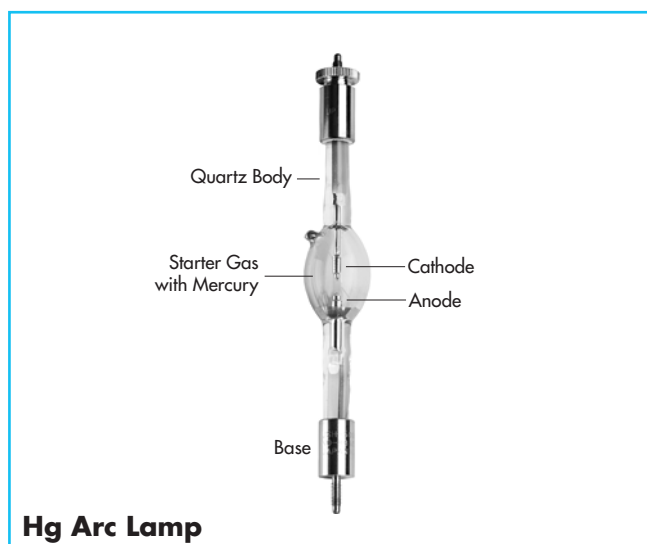
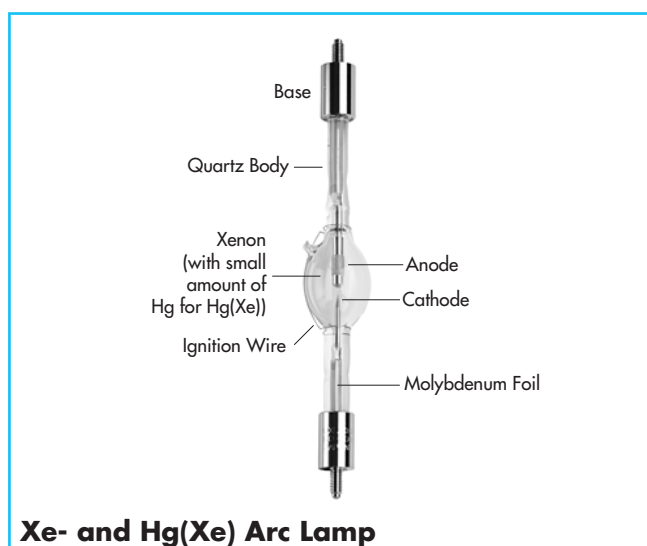
## Xenon Short Arc Lamps

- continuous output from UV-VIS
- simulation of solar spectrum

Xenon lamps are filled with pure xenon gas at 8 – 10 bars. The pressure triples during operation. Xenon lamps operate with the **anode at the top**. With 6000 – 6500 K they closely approach the color temperature of the sun. The xenon lines dominate between 750 and 1000 nm, but the spectrum is almost smooth through the ultraviolet and visible.

Special UV versions emit down to 160 nm. Ozone free lamps have bulbs that absorb below 300 nm and have a cut-off around 250 nm.

Go to „Lamp Spectra and Irradiance Data“ on [www.lot-oriel.com/lightsources](http://www.lot-oriel.com/lightsources) („Basics“).



## Mercury Arc Lamps

- spectral lines of high output in the UV

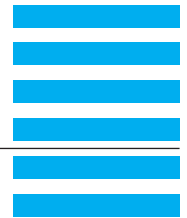
Mercury arc lamps contain a ground gas (such as argon or xenon) and liquid mercury which gets vaporized under high pressure up to several 10 bars by the operating temperature, produced when the discharge is switched on. After ignition, a diffusely shining discharge in the ground gas can be seen which decreases along with the increasing mercury vapor pressure. Hg lamps require a start-up time of up to 20 minutes before the mercury is completely vaporised. Subsequently the lamp is in thermal balance and lamp current is constant. Mercury lamps operate with **anode at the bottom!** This ensures proper vaporization of the mercury. Because the bulb temperature has a great influence on the mercury pressure, these lamps are sensitive to airflow. The output spectrum of these lamps is dominated by strong mercury lines through the visible and ultraviolet with a weak continuum in the infrared up to 2,5  $\mu\text{m}$ .

## Mercury (Xenon) Lamps

- spectral lines of high output in the UV
- deep UV output

Mercury (xenon) lamps are especially designed to provide high output in the „deep UV“ i.e. below 320 nm. Compared to Hg arc lamps the spectrum in the UV is higher in intensity and sharper in width. They definitely have output below 250 nm which Hg arc lamps do not have. These lamps use xenon at above atmospheric pressure as ground gas and operate with the **anode at the top**.

In terms of stability and cooling, Hg(Xe) lamps generally operate more uncomplicated than Hg-lamps. Also life time is higher than with Hg lamps.



## Handling and Running Arc Lamps

Arc lamps must only be operated in suitable closed housings. The lamp housing must protect the environment from UV radiation (also scattered light) and from glare of the arc. The highly pressured short arc lamps may unexpectedly shatter or explode. In case of lamp explosion no glass fragments must leave the housing. Proper handling of the lamp is essential. The quartz body must be protected from scratches and abrasions. Even the smallest size scratch that may not be detectable by the naked eye, can lead to the build up of strain leading to an explosive failure.

Special attention should be paid to the mechanical fixing of the lamp. In order to compensate for expansion of the housing when it heats up, the lamp must be fixed tightly at one end only. The other end should be a flexible cable. Proper cooling of the lamp is essential. If arc lamps are not cooled sufficiently they may explode!

Our lamp housings provide optimal and necessary conditions to operate arc lamps.

### The following points must be observed:

- correct polarity
- correct lamp current
- correct burning position

Our arc lamps are DC-current lamps and are designed for vertical burning position only!

**Xe and Hg(Xe) lamps always with the anode at the top!**

**Hg-lamps always with the anode at the bottom!**

This automatically leads to the right polarity. Our lamp housings are universal. They operate both Xe, Hg(Xe) and Hg arc lamps. Wrong polarity will destroy the lamp immediately, because the cathode will melt. Always pay attention to the correct lamp current. The lamps operate optimal at rated current only. The values can be found in the chapter „Arc Lamps, Specifications“ on [www.lot-oriel.com/lightsources](http://www.lot-oriel.com/lightsources) (Arc Light Sources“).

Don't touch the bulb or shaft with bare fingers. Clean the lamp with a lint-free cloth moistened with alcohol (spirit). Take care not to scratch the glass surface. If fingerprints are not removed will form permanent etching on the quartz surface and act as a seed for ongoing recrystallization of the glass. The glass will lose its strength and this increases the risk of lamp explosion.

## Operating Conditions

Our arc lamps require DC-current. The power supplies must supply a open circuit voltage which is by a factor 3 to 4 greater than the lamp voltage. When cold, arc lamps are electrical isolators. The gas between the electrodes has to be ionized. This is done by applying a high voltage spark which causes a discharge between the electrodes. All type of arc lamps ignite if fast high voltage pulses are applied (typ. 30 – 40 KV). Some mercury lamps also ignite if a >3 KV ramp is applied. The arc between the electrodes can only be maintained by a high DC-current. Lamp current and voltage are determined by each lamp type. By changing the lamp current (**max. 5 % above and 20 % below the rated current**) light output can be controlled in a limited range. Compared to other lamp types this does not change the lamp spectrum or color temperature.

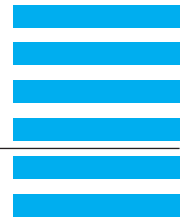
## Cooling

Within a small region arc lamps convert relatively high electrical power into radiation and heat. If these lamps are not cooled properly, individual lamp components will reach temperatures which cause damage of the lamp.

The thermal operation conditions always appear to be a compromise. Concerning arc brightness and effectivity, operation of Hg lamps for example is wanted at high mercury vapor pressure. High mercury vapor pressure results in higher stress of the envelope material and is only reached at high temperatures which themselves weaken the bulb material. Lamp voltage drops with excessive cooling and partial condensation of the mercury will occur and therefore a reduction of output intensity. With excessive cooling the lamp can even stay in the start-up phase and the bulb will blacken rapidly. Too little cooling will result in lamp explosion.

Xe lamps reach their operation temperature just after ignition. Excessive cooling will cause lamp current to rise but will not blacken the bulb. Nevertheless light output is reduced. Too little cooling will result in lamp explosion.

Our lamp housings deal with sufficient heat transportation up to the specified lamp power. Do not install higher powered lamps even if they fit into the housing because of their size. Not only the lamp, but also the housing could be damaged because of too high temperatures. Our lamp housings have a built-in temperature sensor which shuts down the power supply if a certain temperature is exceeded.



## Lamp Life

Arc lamps normally reach the end of their life when the luminous flux drops as a result of bulb blackening. This is caused by tungsten gradually evaporating from the electrodes. It deposits on the inside of the lamp envelope. This reduces the radiated output in fact a little more in the UV than in the visible. In addition blackening has the disadvantage that it increases the amount by which the quartz heats up due to absorption of radiation.

The main factors reducing lamp life are:

- over-current
- under-current
- high ignition frequency
- incorrect cooling
- incorrect burning position, tilt

**Therefore it is advantageous to keep the amount of ignitions low** and to limit the lamp current to the rated value. Typically lamp life is shown in „Arc Lamps, Specifications“ on [www.lot-oriel.com/lightsources](http://www.lot-oriel.com/lightsources) („Arc Light Sources“). This value is a statistical mean. So individual lamps can fail earlier, others later. The specified lamp life is the average operating period for the (visible) output to fall to 70 % of the initial value.

It is based on running the lamp for min. 30 minutes between ignitions. In principle arc lamps can be operated beyond the average life time. They should however be replaced after exceeding this time by 25 %. After such a time the quartz glass has usually recrystallized to such an extent that there is a considerably increased risk of lamp explosion.

Operating arc lamps above the rated power or current (max. 5 %) shortens lamp life. On the other hand lamp life is increased if rated power or current is decreased to 80 % of rated value.

Operating the lamps below 75 % of rated power (or current) reduces lamp life due to greater lamp wear caused by electrode damage.

## Safety Considerations

Arc lamps operate at very high pressures (up to 100 bar) and temperatures, and emit ultraviolet radiation. They must be operated in a fully enclosed housing. All arc lamps must be handled properly to prevent contamination of the bulb and resultant thermal stress. Xenon and mercury (xenon) lamps have supra atmospheric pressure even when cold. (Hg lamps about 1,5 bar; Xe and Hg(Xe) lamps up to 8 bar). Handle these with appropriate safety equipment. Heavy gloves and impact resistant goggles are recommended.

### UV

These UV sources emit dangerous levels of ultraviolet radiation and, depending upon the lamp, ozone. Exposure to UV, even for short periods, can cause severe skin and eye burns. Always wear protective eyewear and gloves or coverings, when working near these sources. If you do not need output below 260 nm choose an ozone free lamp; otherwise vent the ozone to the outside. For more about UV safety go to [www.lot-oriel.com/lightsources](http://www.lot-oriel.com/lightsources) („Basics“).

### Electrical

A high transitory voltage is used to ignite arc lamps. The lamp terminals have a potential difference of up to 200 V prior to lamp start. The ignition pulses and high starting currents are sources of radiated and conducted electromagnetic interference. It is minimized if the ignitor is built into the lamp housing. EMI shielding may be necessary to protect sensitive digital circuitry from these pulses.