# All you need to know about arc lamps

### Xenon short arc lamps

- Continuous output from UV-VIS
- Simulation of solar spectrum


Xe lamps are filled with pure xenon gas at 8 – 10 bars. The pressure triples during operation. Xe 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. For lamp spectra go to "Lamp spectra and irradiance" on Basics.

### Mercury (Xenon) lamps

- Spectral lines with 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 provide output below 250 nm which Hg arc lamps do not. 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 are generally less complicated to operate than Hg lamps. Also, their life time is higher.

### Mercury arc lamps

- Spectral lines with high output in the UV

Mercury arc lamps contain a ground gas (such as argon or xenon) and liquid mercury. The mercury vaporizes 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 vaporized. After that the lamp is in thermal balance and the lamp current is constant.


Mercury lamps operate with the 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 of up to 2.5 µm.

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Not considering lasers, short arc lamps are the brightest manufactured sources. 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 applications these lamps come very close to the ideal of a point source. The extremely bright and high-radiance sources are very suitable for creating a collimated beam or for irradiating small probes with high intensity. Mercury arc lamps emit 60% of their output in the UV-VIS. Xe arc lamps have a color temperature of approx. 6000 K which is close to that of the sun. The main output is below 900 nm.

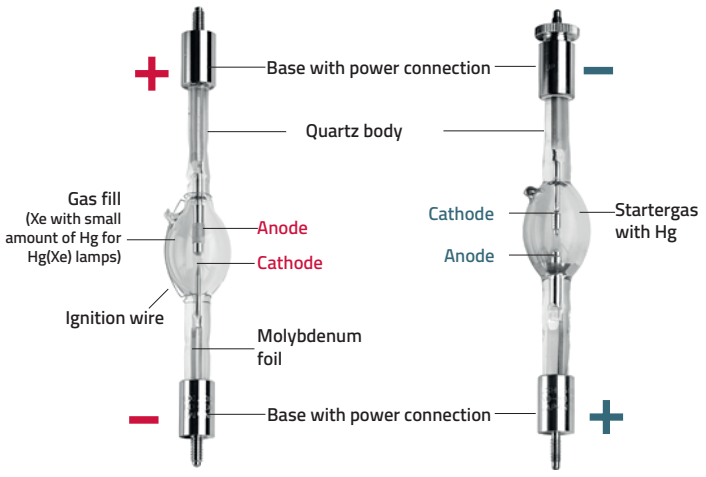
**Arc lamp design**
The figures on the next page show the design of typical arc lamps. The lamp bulbs are always made of quartz glass. Only quartz glass can withstand the high mechanical load caused by the operating pressure of some tens of bars and the thermal load at surface temperatures of over 700 ° called „ozone-free" lamps. Others use UV grade quartz to transmit output down to 200 or even 160 nm. Depending on the 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 material 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 the 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. To keep the anode's temperature as low as possible the anode is bigger than the cathode. This ensures a long lamp life. Hg lamps have coils on one or both electrodes to help with the arc formation. The anode-cathode gap can be from 0.25 mm to several mm, depending on the lamp power.

**Gas fill**
Xe lamps are filled with pure Xenon gas at 8 to 10 bar. 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 is reached during operation. For Xe lamps the internal pressure rises to about 30 to 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.




Xe- und Hg(Xe) arc lamp

Hg arc lamp

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**Handling and operating of arc lamps**
Arc lamps must only be operated in suitable closed housings. The lamp housing must protect the environment from UV radiation (and scattered light) and from glare from 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 visible to the naked eye, may lead to the build-up of strain which can lead to an explosive failure.

Special attention should be paid to the mechanical fixing of the lamp. To compensate for the 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 a vertical burning position only.**
- **Always operate our Xe and Hg(Xe) lamps with the anode at the top.**
- **Always operate our Hg-lamps with the anode at the bottom.**

Following these rules will automatically lead to the right polarity. Our lamp housings are universal. They operate both Xe, Hg(Xe) and Hg arc lamps. A 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.

Never 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 they will cause permanent etching on the quartz surface and act as a seed for ongoing recrystallization of the glass. The glass will loose its strength and this increases the risk of lamp explosion.

**Operating conditions**
Our arc lamps require DC-current. The power supplies must supply an open circuit voltage which is greater than the lamp voltage by a factor 3 to 4. 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. Partial condensation of the mercury will occur and therefore a reduction of output intensity. With excessive cooling the lamp can even remain 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 the 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. 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 when a certain temperature is exceeded.

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**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, which reduces the radiated output (a little more in the UV than in the visible). On a blackened bulb, radiation is absorbed, which leads to further heating of the quartz.

The main factors that reduce lamp life are:

- Over-current
- Under-current
- High ignition frequency
- Incorrect cooling
- Incorrect burning position, tilt

It is therefore advantageous to keep the number of ignitions low and to limit the lamp current to the rated value. Typical lamp life is shown in "DC short arc lamps, specifications". This value is a statistical mean.

Some lamps may fail earlier, others later. The specified lamp life is the average operating period it takes for the (visible) output to fall to 70% of the initial value.

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

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

Operating the lamps below 75% of the rated power (or current) reduces the lamp life. This is 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 UV 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. Xe 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 on the lamp, ozone. Exposure to UV, even for short periods, can cause severe skin and eye burns. Always wear protective eyewear and gloves or clothing, when working near theses 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 "Ultraviolet safety considerations".


**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.

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