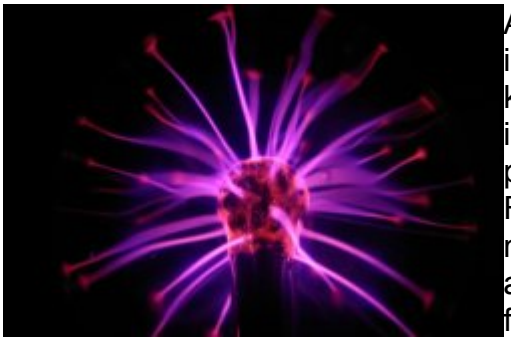
Ultraviolet Lamp Design

Introduction

Ultraviolet curing lamps belong to the general group of electric discharge lamps. This lighting technology replaces the filament of the “light bulb” with a capsule of gas. UV energy is emitted from an arc discharge between two electrodes hermetically sealed inside a quartz glass tubular envelope. Unlike filament lamps, electric discharge lamps have three great virtues: they are efficient UV energy converters; they last a long time; and they have excellent maintenance of UV output. They also have disadvantages: lamps and control gear are relatively expensive; lamps do not function well in short term service; full light output does not occur immediately when power is applied; once lamps have started, a power interruption of 1/4 cycle (1/240th of a second) or more may cause the lamps to extinguish. Once extinguished, it could take up to several minutes before an arc can be re-established and full output attained.



All Ultraviolet curing lamps convert electrical energy into “UV light” by transforming electrical energy into kinetic energy of moving electrons, in turn converted into radiation resulting from electron collision. Light is produced by passing a current through a metal vapor. Free electrons colliding with an atom in the vapor momentarily knock an electron into a higher orbit of the atom. When the displaced electron falls back to its former level, a quantum of radiation is emitted. The wavelength of radiation depends on the energy state of the disturbed electron and on the type of metal vapor used in the arc tube.

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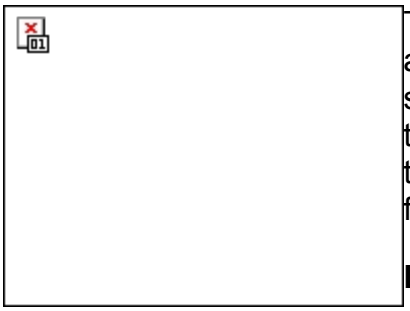
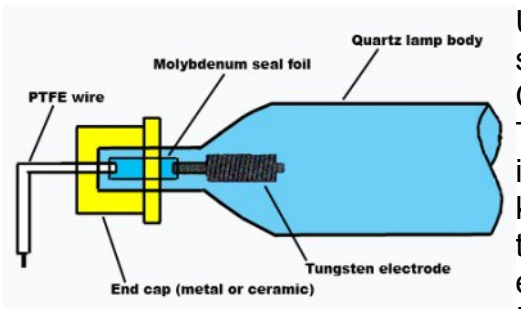


The basic process is comprised of three steps: free electrons are accelerated by an applied potential difference (UV power supply); the motion of electrons being the electric current in the device (lamp current); the kinetic energy of the electrons is transformed and radiation produced as energy states return from high (excited) to lower state.

Lamp construction



UV curing lamps are made from quartz which can be safely operated at temperatures of 1000 degrees Celsius and is highly transparent to UV radiation. There are two tungsten electrodes from which the arc is sustained. The distance between electrodes is known as the lamp arc length. With lamp arc temperatures approaching 3000 degrees Celsius; the entire electrode design process is extremely complex. It is not possible to bond tungsten directly with the

quartz glass. Most UV lamps use a special molybdenum seal foil to provide a hermetic and thermally stable seal. At the outer end of the foil is a high voltage Teflon wire which provides the electrical connection. The lamp end cap which can be metal or ceramic is cemented over the assembly. The end cap provides mechanical support and mounting area.

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The principal limitation in the manufacture of UV curing lamps is the transition of the lead in connector (lamp wire or end cap) to the electrode. This is called the **lamp seal**. There are two types of lamp seals used: **pressed** (sometimes called pinched) and **vacuum** (sometimes called shrink or bonded seal).

Pressed sealed lamps are machine made; are economical to produce and have a filling tip somewhere on the body of the lamp. **The flat seal is fragile and extremely easy to snap**. Care must be used when installing press sealed lamps. This technique is limited to short arc length lamps where cost and lamp size are main issues.

Vacuum sealed lamps are hand made; extremely strong and normally do not require a filling tip. Seal shape is round and can be made any length. In general, the longer the seal the less chance of seal failure. These are by far the best choice for UV curing lamps. Another advantage of vacuum sealed lamps is they allow the lamp to be rotated in any position for maintenance purposes. This extends lamp life especially in long arc length lamps.

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Filling tips (the little bump on the lamp body) pose another problem. They must be always pointed up or to the side, never downward! Sometimes the tip poses an installation problem as it tends to get snagged. See illustration. Often times the fill tip is a weak spot on the lamp and limits lamp positioning. Care must be taken not to strike the fill tip as lamp will immediately fail.

Lamp life

Lamp life depends on many factors including number of starts, thermal operating conditions, burning position, quartz diameter, power rating and proper handling. Under normal conditions, the vast majority of lamps will provide at least 1000 hours of useful life. Some equipment manufacturers utilize power supplies that employ low voltage high current lamps. Lamps operating in excess of 13 amps have greater electrode blackening and generally shorter lamp life. Keeping lamp current between 6 and 11 amps will significantly increase lamp life. Lamps must be kept clean. All types of dust, powder, grease, smoke and misting ink must be cleaned from lamp. Overheating from a dirty condition will cause warping and short life.

Ozone production

Another health concern regarding the ultraviolet lamp is the generation of ozone. The interaction of short-wavelength UV light with oxygen causes the generation of ozone. Although it is possible to use an “ozone free” lamp, the negative impact on curing is significant enough that very few people use these lamps. Most suppliers handle the ozone concern by ducting the ozone away from the work environment. Due to the high reactivity of the ozone, the molecule will typically decompose back to oxygen while traveling through the exhaust system.

Ultraviolet safety

Ultraviolet curing lamps produce intense UV light. Shielding is absolutely mandatory. UV lamps produce harmful UV radiation that can cause serious burns to skin and eyes. While thermal burns are felt immediately, UV burns are not felt for several hours. Short exposure to lamp radiation can cause severe burning to eyes and skin. Fortunately, UV light does not reflect significantly from most surfaces. If one does not have a direct line of sight to the lamp or reflector, there typically is not a significant amount of UV energy to worry about. The fact that visible light can be seen does not mean that significant UV energy is present. Normally, even escaping visible light is minimal with a well-engineered UV lamp system. If a large amount of light is escaping, the system supplier should be notified to determine if a problem exists.

Cleaning of ultraviolet curing lamps

Use a lint free cloth with Windex or Simple Green to clean. Don’t waste your money on special UV lamp cleaners as they have dubious value! If solvents are permitted, use isopropyl alcohol. For extreme cases use a mild abrasive such as Soft Scrub to clean the UV Lamp. Be sure to rinse any residue off the glass before reinstalling lamp. Always allow lamp to cool and disconnect all power prior to any cleaning.