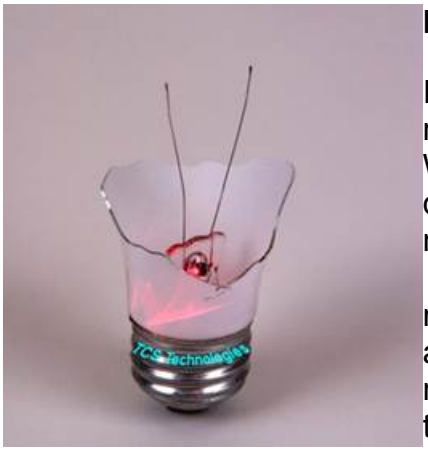
UV Curing Lamp Failure Analysis



My bulb does not work anymore!

Imagine walking into a car dealer saying my car does not run. Is it out of gas? Is the battery missing? Are the tires flat? What about the transmission? One needs to be more definitive when describing the problem. Saying my bulb does not work is too broad a statement defining a problem. Rather than paint the problem with a broad brush, one needs to refine the stroke, narrowing the focus for an accurate diagnosis. The easiest thing in the world for a lamp manufacturer is to blame the other guy. Everyone believes they make a perfect product. If there is a problem it cannot be their fault. Believe me there are bad lamps, bad lamp assemblies and bad power supplies.

There are various reasons why a bulb requires replacement, it doesn't operate, it operates poorly or it simply gets old.

Let's start by defining common bulb failure modes. Once we have analyzed the symptoms, it is much easier to find the cause.

Contaminated bulb envelope. This is indicated by external "junk" on the lamp. If you hold lamp up to the light you can see fingerprints.

Failure to ignite. This is the bulbs refusal to establish a maintained arc.

Explosion or what we would call catastrophic failure. It requires little explanation once you have encountered it.

Low UV output. Usually occurs in lamps that are overcooled or have reached end of productive life. This is indicated by a blackened or dark envelope and is usually prominent around the electrodes.

Contaminated bulb envelope

The contaminated bulb is easy to identify. The outer surface of the glass should feel smooth. If accidentally touched, lamp must be wiped with alcohol or Windex before placing in service. Fingerprint contact with the quartz envelope must be avoided. A single fingerprint will etch the quartz surface eventually causing premature failure that will not be covered under warranty. TCS Technologies ships all lamps clean and sealed in plastic. Sad to say once a fingerprint is burned (etched) into the quartz the damage in irreversible. The adage "an ounce of prevention" applies.

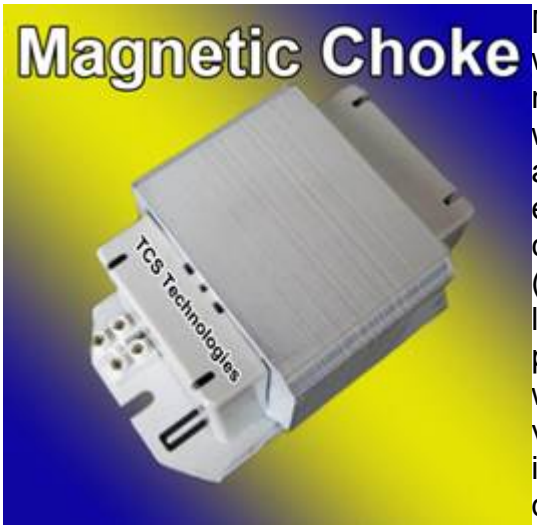
Lamps must be kept clean. All types of dust, powder, grease, smoke and misting ink must be cleaned from lamp. Overheating from a dirty condition will cause warping and can

cause an electrical short. Electrical fittings must also be cleaned to prevent arcing between fitting and lamp ends. Always allow lamp to cool and disconnect all power prior to any cleaning.

Failure to ignite

Failure to ignite is by far the most complex problem to diagnose. One must know what it takes to start a UV curing lamp and the components used to accomplish that desired result. Basically there are three different methods used to power UV curing lamps:

1. Magnetic choke with igniter
2. Electronic ballast
3. Transformer



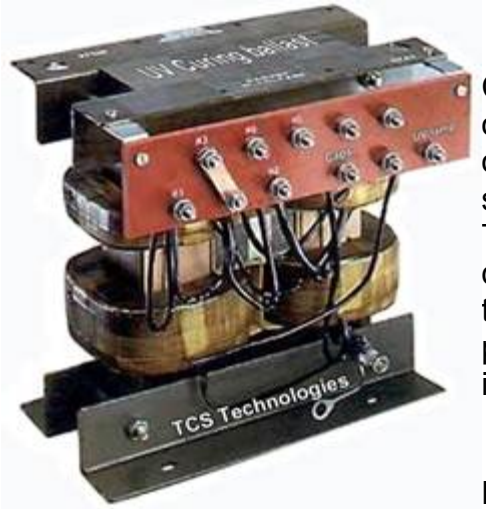
Magnetic choke: for short arc-length lamps (lamps whose arc is under 8-inches) the most popular method is magnetic choke with igniter. They are widely used in the digital printing, CD/DVD replication and narrow web market. It is the simplest most cost-effective method of running medium pressure UV curing and metal halide lamps. Using a single-phase (208-240 volt) supply, choke and ignitor circuit will run lamps with an arc voltage up to 150 volts. A cross phase (360-440 volt) supply, choke and ignitor circuit will run lamps with an arc voltage from 135 to 285 volts. Chokes rely on an external igniter. This device is similar to an ignition coil on an older car. This device uses line voltage and converts it into 2500 to 6000 volt super-imposed pulse which is used to break down the arc gap (space between electrodes). The igniter has only one function, to break down the arc gap. Afterwards the choke maintains the arc and regulates power.

If the arc goes across the electrodes and the bulb does not start the problem is not the igniter. With the power off check lamp lead connections. Make sure they are tight and not corroded.

When you first turn the lamp on if you hear the igniter operate, but the bulb fails to light, it is a good idea to try and see where the arc is occurring. The lead from the igniter to the bulb should be one-quarter (1/4”) inch from any metal lamp assembly component. If the path between the lead and a metal component is too short, the arc will occur between the lead and the lamp housing and not across the bulb’s electrodes.

Electronic ballasts: another popular choice for lamps with arc lengths under 8-inches. Electronic ballasts offer higher efficiency, higher UV output per watt and increased lamp life. Compared to choke driven systems, electronic ballasts offer clear advantages compared to chokes including ballast size, lower energy consumption and positive influence on curing output. TCS Technologies sells several electronic ballasts to operate both conventional and metal halide lamps. Electronic ballasts are not user serviced. They need to be replaced should an internal component fail.

Constant wattage transformers have several benefits when compared to other types of step-up supplies:



Constant wattage transformer: The last method of lamp operation is the constant wattage transformer. This type of device does not require an igniter and normally has a set of capacitors in series with the UV lamp. Transformers normally are the most reliable method of driving a UV lamp. A key advantage of constant wattage transformer over choke/ignitor systems is that for a given power the UV lamp current can be reduced which increases the UV lamp life.

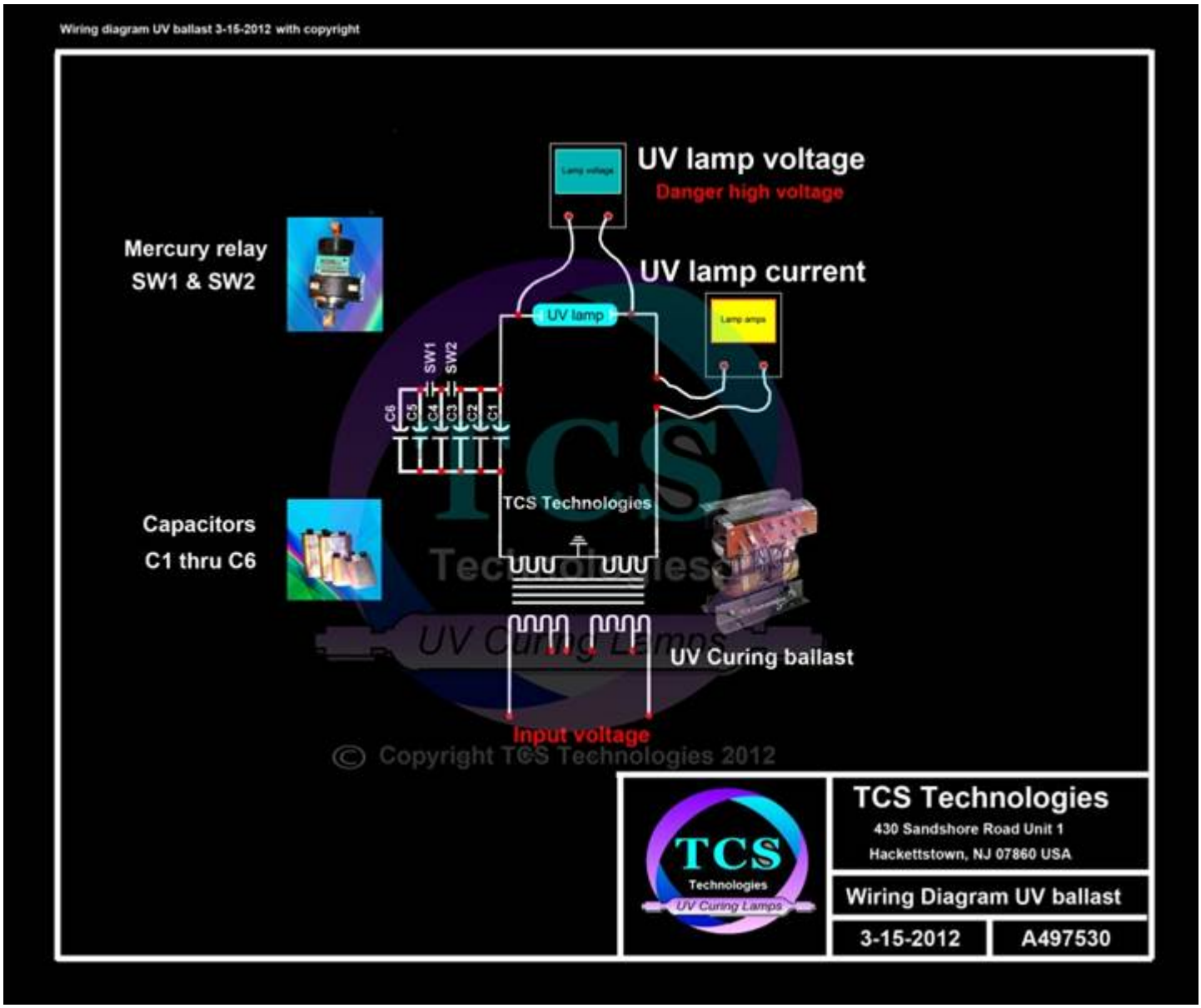
- All transformers are not built alike. Personal experience has shown transformers/ballasts from the USA or Western Europe are the most reliable. Likewise those from the Far East or Central and South America lack consistent voltage output and are fraught with starting issues. For example many of these “inferior” ballast attempt to try and start a lamp at too low a power. The UV lamp starts but has little power to vaporize the mercury. The result is the arc being caught in a glow mode causing the electrodes to sputter tungsten to the quartz wall. Left uncorrected the lamp burns itself out. Likewise poorly constructed ballasts never permit a complete arc. In this case the ballast will not supply enough current immediately on starting to even get the electrodes warm. The lamp flashes on, but, the arc is constricted and looks like the threads on a screw, twisting and turning. The ballast does not provide additional power and the electrodes destroy themselves within minutes. Poorly designed ballasts lack sufficient starting voltage and short circuit current; this is the reason we like to have the starting voltage value of the ballast. This way we can identify possible problems before lamps are placed into the field. If you find yourself using a transformer—ballast that also incorporates an ignitor, watch out! Typically these are an indication of inferior designCan operate at 50 or 60 hertz with only minor circuit modifications
- Excellent current control at lamp start up. Reduces strain on lamp electrodes
- Operates over a wide range of input voltages
- Easy to change lamp power settings
- Eliminates power factor correction
- Extremely reliable and can drive lamps with arc voltages ranging from 200 to 3000 volts

- Lamp power remains constant regardless of input supply voltage fluctuations

If you are making an investment in UV curing, spend the extra 25% and purchase a USA product from TCS Technologies. You will eliminate many headaches.

If you have a transformer and your lamp does not start contact the equipment manufacturer and request the open circuit voltage of the transformer/ballast. You will need this information to accurately diagnose why the bulb will not start. For example, if you have a 25” arc lamp, the minimum starting voltage will be around 1250 volts. If your ballast/transformer only has 1000 volts open circuit (striking voltage), the lamp will never light. You will think you have a defective lamp but the root cause will be a cheaply made transformer. Most ballasts have a 1.4 to 2 times factor of lamp open circuit to operating volts. For example a typical 25-inch arc lamp operating 925 volts will be fired by a ballast/transformer having 1295 minimum available starting voltage (factor of 1.4).

Here is a typical transformer driven UV circuit:



The bulb itself can cause ignition problems. The electrodes contained within the lamp contain an emission material to aid starting. If the bulb is attempted to start at a level less than 80% of its rated power, the lamp may end up igniting for only a few seconds and go out. Always start a lamp at high power and reduce power after lamp has warmed up.

Some lamps have a trigger wire around the outside of the quartz envelope. This wire is usually made from nickel and is used to set up an “E” field during bulb ignition. Do not remove this wire as it is needed for proper startup.

Low UV output

Depending on the lamp operating parameters, useful life can be anywhere from 200 to 1000 hours. There is no blanket lamp life and magic elixir for extended life. Much depends on wall loading defined as the amount of power per unit area. The higher the wall loading

the greater the strain placed on the lamp envelope. Likewise higher the lamp's operating current the shorter the life. For example if one compares a standard HID (high intensity discharge) street lighting lamp of 1000 watts to the same lamp operating at 1500 watts the effect is obvious. The 1000 watt lamp operates 4.3 amps and has an average life expectancy of 12,000 hours. When you take the exact same lamp and operate it at 1500 watts (6.3 amps) lamp life plummets to 1200 hours. Hence an increase in current of 2 amps results in a 90% reduction in lamp life. The lamp is the same only the wall loading changed. Most UV curing lamps operate 6 to 13 amps.

Some with poorly designed power supplies drive a lamp at 20+ amps. Obviously these lamps will have radically shorter life than those operated 6 amps. If you have a choice select a power supply operating a lamp under 11 amps.

Besides end of productive life, low UV output can be caused by lamp overcooling. Improperly cooled lamps are a major cause of premature failure. The area between the tips of the electrodes, within the main lamp body, should be maintained at an operating temperature of 600-800 degrees Celsius. Lamps must have a minimum wall temperature in excess of 357^{o}C, the boiling point of mercury. Below this temperature mercury and other additives will condense on the inner lamp surface turning the tubing dark silver to black. Once this plating has occurred, the effect is irreversible. It only takes a short time for an overcooled–glow mode–lamp to fail. A competent UV system will monitor lamp temperature and reduce cooling accordingly. An overcooled lamp will always operate at reduced voltage resulting in lower UV output. Their light output will appear dim, certainly not as bright as a normal lamp. To complicate matters many UV curing lamps are formulated as metal halide lamps. These halides have a strict temperature profile and are not intended to be dimmed (operated at reduced power). A lamp is designed, electrode chosen and bulb shape specified based on a certain power. In the case of metal halide lamps, lamp output will not remain stable unless operated at high power level. It is not prudent to operate metal halide aka "iron" or "gallium" lamps at reduced power levels. Pure mercury lamps can be operated up to 50% reduction in power providing lamp cooling is adjusted.

Some equipment manufacturers make UV systems that are more prone to lamp overcooling. Many of these systems incorporate multiple "muffin" fans in the lamp assembly.

In general you can keep adding cooling air up until the time lamp voltage drops—see transformer driven UV circuit drawing. While it is easy to measure UV lamp current, it is sometimes difficult to measure UV lamp voltage due to high voltage nature of said equipment.Purchase of a potential transformer will permit safe measurement. A potential transformer is wired in parallel with the UV lamp. A step-down ratio of 100 to 1 is normally used. For example a 700 volt lamp will measure 7 volts on the secondary of the potential transformer. Lamp voltage corresponds directly with lamp UV

output.

Installation of a potential transformer and voltmeter will provide a constant indicator of UV lamp performance.Dropping and unstable lamp voltage is a certain indicator of lamp overcooling. In the example above, a normal lamp operating 700 volts may only be operating 490 volts (30% voltage reduction). This lamp is overcooled and will never reach full power without modifying lamp cooling.

Measuring lamp voltage is an excellent tool to insure proper UV output. Many companies incorrectly state that their lamp will not “work”. The reality is the lamp lights but has low UV output due to overcooling. This is an equipment issue and can be easily overcome with a little knowledge and technical guidance from TCS Technologies.

Contact TCS Technologies for further details on lamp voltage monitoring.

Summary

There are two things certain about UV curing lamps; they are expensive and they eventually require replacement. Should you encounter a problem, it will be much easier to troubleshoot if you have accurate analytical information to accurately define the problem. Do yourself a favor, keep good lamp records. You will be surprised how a little bit of knowledge can derail the “blame train”.

To insure efficient lamp operation:

- Keep lamp clean, free of dust and fingerprints
- Always start lamp at full power
- Delay fan cooling until lamp has warmed up
- Operate within specified voltage range. This is especially true when using chokes
- Keep standby power to minimum 50% for mercury lamps
- Keep standby power to minimum 80% for metal halide lamp
- Inspect and maintain all connectors and cables associated with UV system
- Install potential transformer and voltmeter to insure proper UV output
- Test to see if lamp vacuum is intact. If your budget will allow, you can purchase a high frequency generator from TCS Technologies for under $350.00. With the lamp removed from the UV system, place bulb on a bench-top and touch the generator probe to the lamp. If the bulb glows light blue the lamp vacuum is intact and the lamp is good. What you are doing is ionizing the lamp contents. There will be an insignificant amount of UV present however we still recommend wearing UV safety glasses. Always be sure to clean the lamp prior to reinstallation into your UV system. Please note there are battery powered neon testers on the market however they lack the sufficient power to test UV curing lamps.