PUBLICATION

Kinetic Instruments Inc.

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1. <u>Conventional Halogen Illumination</u>

1.1 Conventional halogen light source illumination is generally provided by using a lamp module that has a heated tungsten filament inside a quartz glass envelope. These “quartz halogen” lamps are pressurized with up to 7 atmospheres of a halogen gas mixture that permits the filament to be electrically heated to extremely high temperatures that are close to the melting point of the tungsten material.

1.2 Although these lamps are superior in light output and life to a comparable lamp that uses a vacuum environment, they are still very inefficient at producing light vs. amount of electrical energy consumed. In addition, the high operating temperatures produce issues concerning isolation of the heat energy and proper operating parameters to balance light output while achieving acceptable life ratings.

1.3 In order to sustain this rather delicate balance, the lamp must be operated within a very narrow electrical specification. Generally speaking, most quartz halogen lamps require that their operating voltage be well regulated with maximum deviations from the rated voltage not exceeding two to three hundred millivolts (mv). Higher voltages drastically reduce life expectancy while lower voltages cause an undesirable shift in the light output color toward a yellow-red hue.

2. <u>White LED Illumination</u>

2.1 LED illumination of any color is based solely on a physics principle that involves the change of energy state of semiconductor materials that are in intimate contact and form a semiconductor junction. When an electrical current is passed through the junction, the energy state of the material is forced to a higher level. When the energy state reverts back to the lower state, light is emitted. This process continues as long as the electrical source is connected. The color of the light emitted is determined by the chemical composition of the semiconductor material and cannot be altered by changing the electrical characteristics. For this reason, LEDs are considered “somewhat” monochromatic.

2.2 White LED illumination is produced by starting with semiconductor material that will emit blue or near ultra-violet (NUV) light. This material is then coated with a phosphor that will absorb the high energy UV light and re-emit that energy in a spectrum of colors that the human eye perceives as white light. Depending upon the chemical composition of the phosphor, varied appearances can be achieved so that the emitted light will look more “warm” or “cool” as desired. Unlike halogen light sources, varying the applied electrical voltage has absolutely no effect on the perceived color of the light. In addition, “whiter” light can be generated that is impossible with halogen light sources. The degree of “whiteness” in an LED is referred to as “color temperature”.

2.3 Color temperature of white light emitters is a fairly complex issue and deserves a rather basic explanation just for information purposes. Color temperature is a characteristic of visible light that has important applications in lighting, photography, videography, publishing, manufacturing, astrophysics, and other fields. The color temperature of a light source is the temperature of an ideal blackbody radiator that radiates light of comparable hue to that of the light source. Color temperature is conventionally stated in the unit of absolute temperature, the Kelvin, having the unit symbol °K. Color temperatures over 5000°K are called cool colors (bluish white), while lower color temperatures are called warm colors (yellowish white through red).

2.4 The application of the color temperature selection for the LED handpiece light source emitter is largely a matter of preference. Conventional incandescent, including halogen incandescent, light sources can have color temperatures ranging from 2700°K to 3600°K. These would be considered “warm” white illuminators and are probably the most common sources due to their low cost. The other possibility is florescent tubes, coils or rings that typically emit light anywhere from 5000°K to 8000°K and are “cool” white sources. The sun, for purposes of comparison, is about 5500°K on a nice day.

2.5 The emitter used in the LED light source tubing is a “neutral” white at 4500°K. Therefore, generally speaking, the neutral white will appear to be more “natural” to the eye, like sunlight and will not be “harsh” in appearance typical with a “cool” (bluish) light source. It should be noted that the eye is more sensitive to a 4500°K white than a lower color temperature halogen light and therefore will enhance detail oriented procedures that are very common in dentistry.

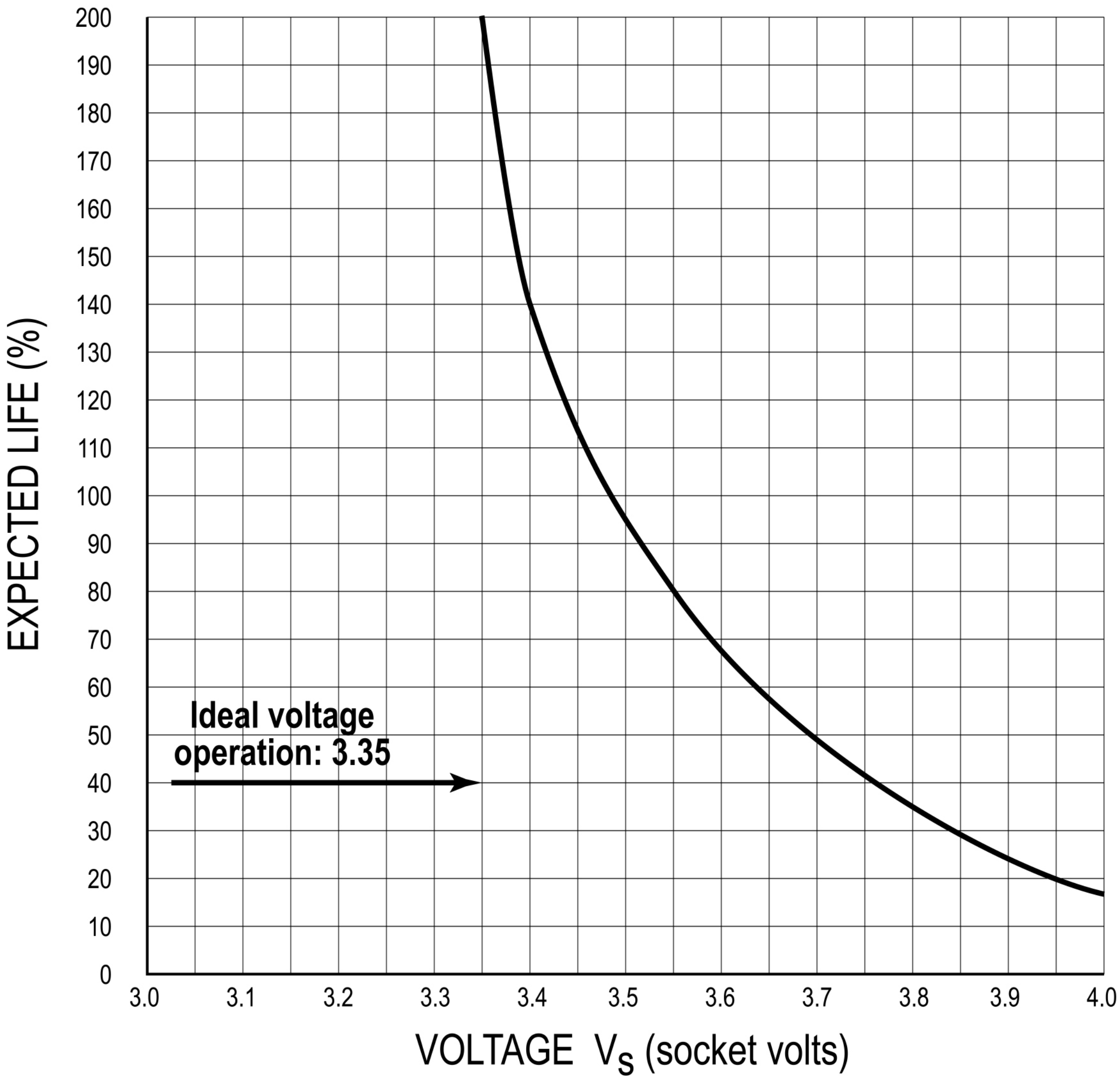
3. <u>Conventional Halogen Lamp Life</u>

3.1 Traditional quartz halogen lamps are manufactured using a tungsten wire filament identical to that of a common household light bulb. This filament is operating at very high temperatures that cause the tungsten material to slowly evaporate. When sufficient material has been lost and the wire becomes progressively thinner, the resistance and subsequently the temperature begin to increase. When the weakest part of the filament becomes too thin, it will melt and the lamp will fail.

3.2 In addition to the degradation due to temperature, a filament is also subjected to the effects of thermal shock. This phenomenon occurs due to the fact that the filament resistance is substantially lower when it is cold and when the electrical voltage is applied an initial high current results (in-rush current) that tries to rapidly heat the filament. This sudden change in temperature “shocks” the filament and can cause failure. This is why most household light bulbs usually fail when they are turned on.

3.3 Typical lamp designs for use in handpiece light source systems are small in diameter and length making them far more rugged than other lamps. In addition, the much shorter filament together with high internal gas pressure make these lamps the most durable in terms of physical abuse. However, the evaporation of the filament is inevitable and, as a result, these lamps are rarely rated for more than 100 hours of continuous operation.

Kinetic Instruments 3.50v Halogen Lamp
Set Voltage (V_S) vs. Expected Life (L_P)



4. LED “Lumen Maintenance” Life

4.1 Since LED light sources do not contain filaments or other materials that can seriously degrade and cause abrupt failure, a different method of life evaluation needs to be employed. The LED’s ability to produce light depends upon the molecular structure of the semiconductor material that can change slightly over time. The method used to determine any change in light output is known as Lumen Maintenance.

4.2 Essentially what is being stated with Lumen Maintenance is that the device will never fail (under normal circumstances), so a level of light reduction must be chosen that is deemed ineffective for the application. Typical charts that track LED performance commonly depict a reduction of light intensity of 10% to 30% as the point at which the LED should be considered at the end of its life.

4.3 For dental handpiece illumination applications, it would be acceptable to designate an LED light loss of 20% as the maximum point of degradation. However, the only factor causing any loss of light from the LED is its operating temperature. The LED module is designed so that the LED is effectively cooled by the drive air, water, water spray air and exhaust passages supplied to the handpiece. As a result of this highly effective dynamic heat sinking, it is possible to keep the LED emitter operating temperature low enough so that the lumen maintenance curve shows no significant depreciation tendency.

4.4 In addition to the low operating temperatures, the LED emitter is normally supplied only a fraction of its rated electrical current capability. When these ideal conditions are substituted into mathematical models depicting lumen maintenance, the result is that it would take in excess of 150,000 operating hours to even approach a 20% light reduction. To put this in perspective, a typical dental operatory application would require a total of about 2 hours of operation a day. Therefore, to lose 20% of the light output would take, on average, about 200 years. Or, about 17 years if the LED was on continuously.

5. Continuously Variable Intensity Control

5.1 Variable intensity is another feature that is directly related to LED technology and not a result of electrical engineering. Everyone is familiar with a household light dimmer … simple enough. However, what is not so apparent when a light dimmer is used to turn down the intensity of regular incandescent or halogen incandescent lamps is that the color of the light changes dramatically toward the red region. Human eyes quickly adjust and we are not bothered by the color change. However, when doing close up work, as in dental procedures, our eyes are not so forgiving and the color shift can be distracting and annoying. Also, the color of the light may no longer closely match that of the overhead light, which further adds to the distraction.

5.2 An LED is a semiconductor that emits a particular quality of light that is relatively constant. The intensity of an LED is directly proportional to the amount of electrical current that is supplied and the characteristics of the light generated do not change with varied brightness. For this reason, a major advantage of any LED light source is its ability to be dimmed without any noticeable effects. Perhaps the K-360 LED module is so well designed that the illumination intensity is exactly perfect for all dentists. However, just in case it is not, the light intensity can be set by simply changing the output voltage of the power supply. Depending on the power supply, however, it is not recommended to set the light source system output voltage any higher than about 5VDC.