Scientific Facts for You

All light sources make photons in specific ways. How each type of luminaire physically works determines how useful it is in any application. The physics controls the output. That spectral output in visible light impacts the presentation and preservation (damage rate).

Fast facts are brief articles designed to arm you with information.

A Halogen Tungsten Lamp for Fiber Optics

Remember how a halogen tungsten lamp works? If not, see the other pdf. This discussion leans on you have a basic knowledge of the quantum electrodynamics of light.

Tungsten is a dense, tightly-bound molecular material that resists free electrons with a high melting temperature. As a thin, coiled wire it has resistance and area. The coiling puts more atoms in less area.

Crowd an electrical current into this filament. The orbits of the tungsten atoms get excited. The shuffling and size of the orbits gets more erratic and avoiding other electrons is more difficult especially with the inrush of more and more electrons as electricity.

The outer rings of the atoms are the most agitation. They scramble. They gimbal. They get messy in their paths. The electrons so crowd, they start bumping into each other. Suddenly one electron physically kisses another and slides sideways in an effort to avoid another electron. The rotation turns. And the near encounter is enough that the electron flips backwards as its pole is destabilized.

The electron still spins. It is still an electron. But it is spinning backwards. This changes the electron’s charge from negative to positive.

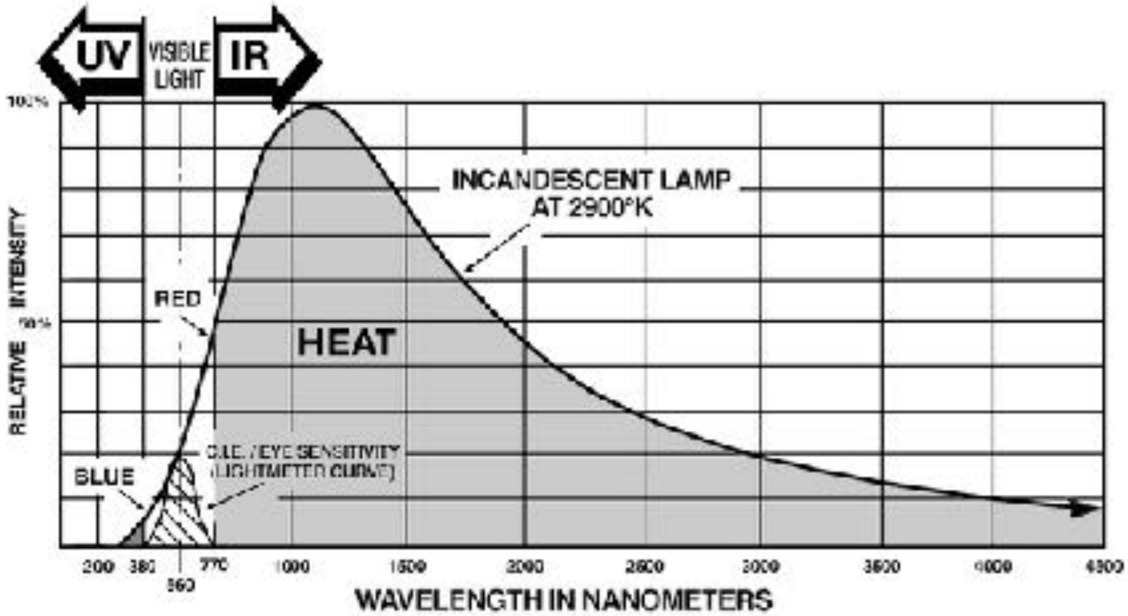
It has become a “positron”. A neighboring negatively-charged electron within the orbit ring matches the positron’s orbit. But the positron wants out. It is surrounded by too much negativity. As it swings away, the electron follows, attaches itself to the positive particle and together the pair rotate.

The photon is born.

It races away at the speed of light. It is made of an electron and a positron. Its wavelength is the original electron orbit translated into spin around each other. The distance between the electron and the positron is the wavelength.

As more and more electrons crowd in closer and closer to the nucleus, more and more orbits of the atom produce and spin out photons. The visible photons come from the more inner rings.

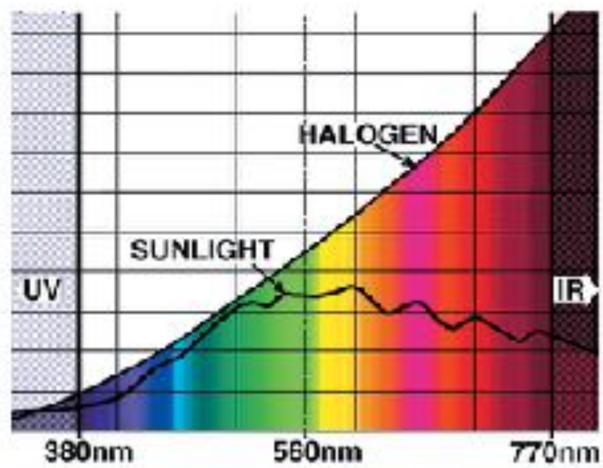
The wavelengths get shorter. Eventually the rings closer to the atom are producing visible light. Halogen lets the system be driven hard enough without breaking the filament that the tungsten will produce an even, beautiful output of all the colors of visible light with a small amount of ultraviolet. The UV is the tightest spinning photon. It comes from the orbits even closer to the nucleus.



The massive amount of infrared is simply the product of the most active photon pairing. It is the nature of the outer rings of an atom to be less stable and be easier to influence. Tungsten will create a lot of visible light. But it creates much more infrared.

Full Color in Fiber Optics

The color for fiber optics is vital. For superior presentation, the lamp produces ALL the colors. No color is missing. It has a color rendition index of 100 meaning 100% of visible colors can be correctly identified.



But there is more red than blue. All the photons are there. But as an incandescent light, it has roughly 4 times the red light of the visible solar spectrum giving it poor color balance.

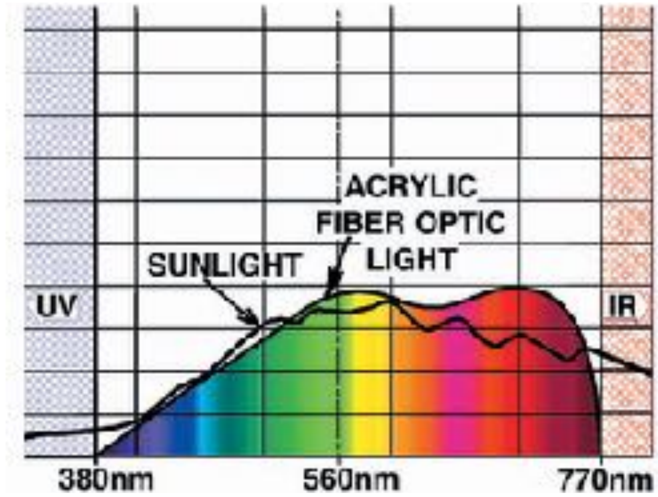
Filtering can trim the colors to a better balance. Many light sources do not make photons in every visible wavelength. Or have such a ragged output that filtering into a smooth spectral output for the visible light is impossible.

It is all about what you see. Missing colors turn things gray. Over represented colors bias things towards that color.

The photon of each wavelength has to exist. The color has to be produced by the quantum physics of the lamp. The lamp needs a complete and full spectrum for visible light.

A halogen tungsten lamp has all the colors. They need to be balanced. The color balance should look like sunlight.

NoUVIR fiber optic systems carefully control what photons are passed through the COLD-NOSE® optics of the projector and what photons are absorbed to be radiated out the nose's fins. NoUVIR fiber optic lighting matches the visible spectral output of sunlight to within 96%.



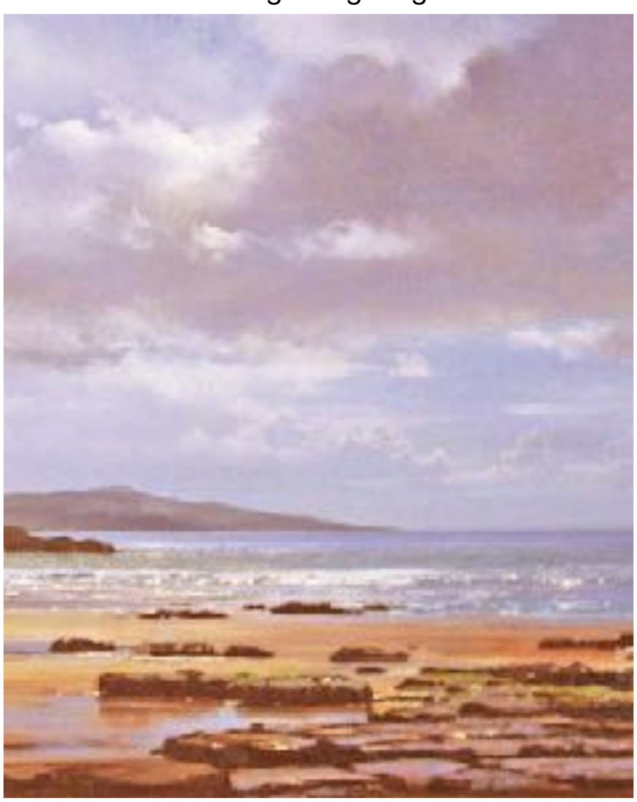
This distribution of photons impacts what people see.

The human eye converts photons to electrical signals that the brain interprets. These enzymes at the back of the eye are designed to break apart the photon pair into electrons. Six electrons produce an impulse that travels through the nerves and is processed as data as sight.

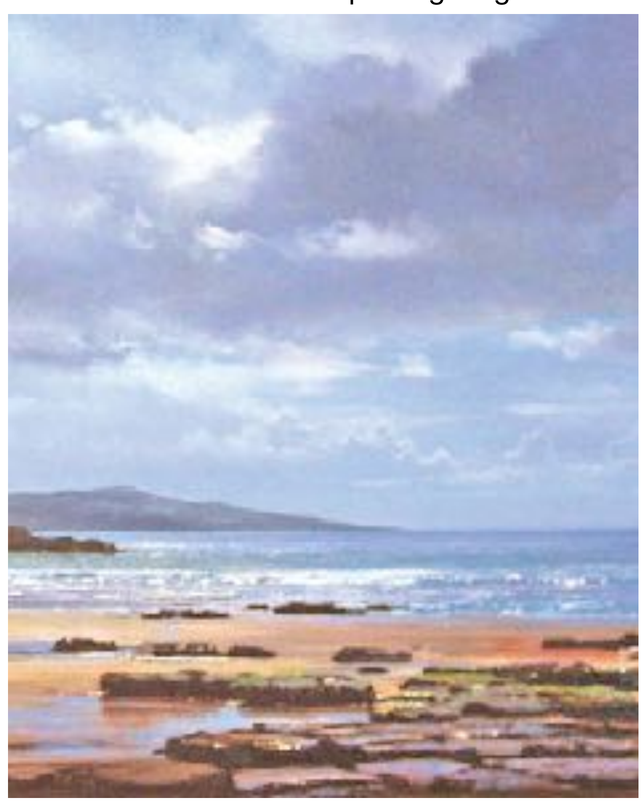
Though the enzymes in the eye are oriented towards interpolating red, green and blue photons, the physiology and the ability of the mind to process photons is so complex that we see a difference between a color that is reflecting a specific photon with its spin diameter and a faked color of three photons in RGB of weaker strength blending a RGB color.

The halogen tungsten lamp presents all the colors. But the colors over the spectrum are biased towards red. The presentation is good. We see every color. But things are warm in tone. And the interpretation of the date can change. This seascape shifts focus from the sea to the rocks and sand. Correcting the balance makes the artwork look as it was intended under an artist's definition of balance light.

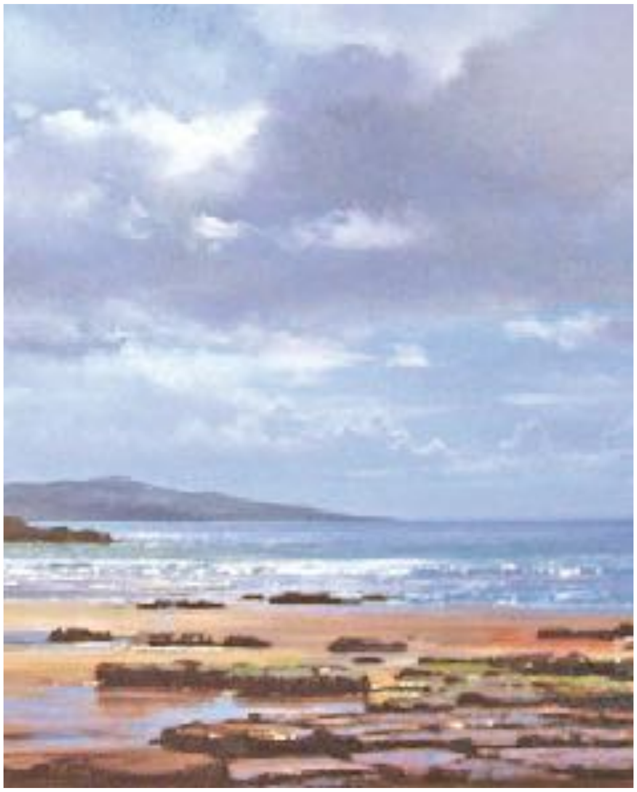
Halogen Lighting



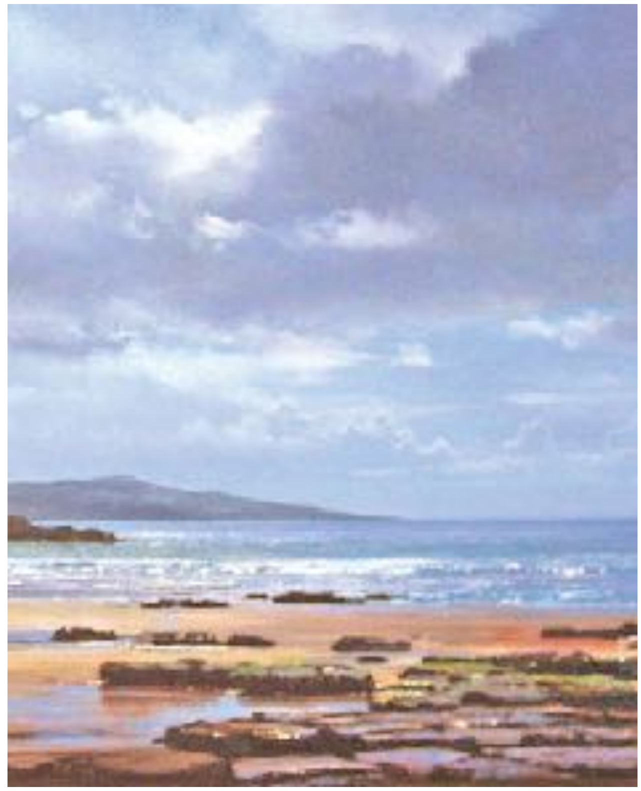
NoUVIR Fiber Optic Lighting



Indirect “Artist” Sunlight



NoUVIR Fiber Optic Lighting



Light Output for Fiber Optics

Other good news for fiber optic lighting is that a filament is in a very specific, exacting place compared to other lamps and their output. The wire is held by support wires. Projector lamps tend to all be filament based. The optics never vary. The optics are exacting. The coils of the filament make the photons come from a very compact point source.

Therefore, a halogen tungsten lamp is ideal to focus onto fiber. A filament produces useable light. There is no processing photons through some other material to make visible light

Better said, a point source focuses into fiber whereas other sources have problems getting photons oriented or aimed so the fiber will transmit them. A halogen tungsten light has tight, exacting optics. Other lamps have fuzzy optics and control.

A filament source for fiber optic lighting is more effective and more efficient. Photon entrance angles into the fiber are superior. More light makes it to the other end of the fiber.

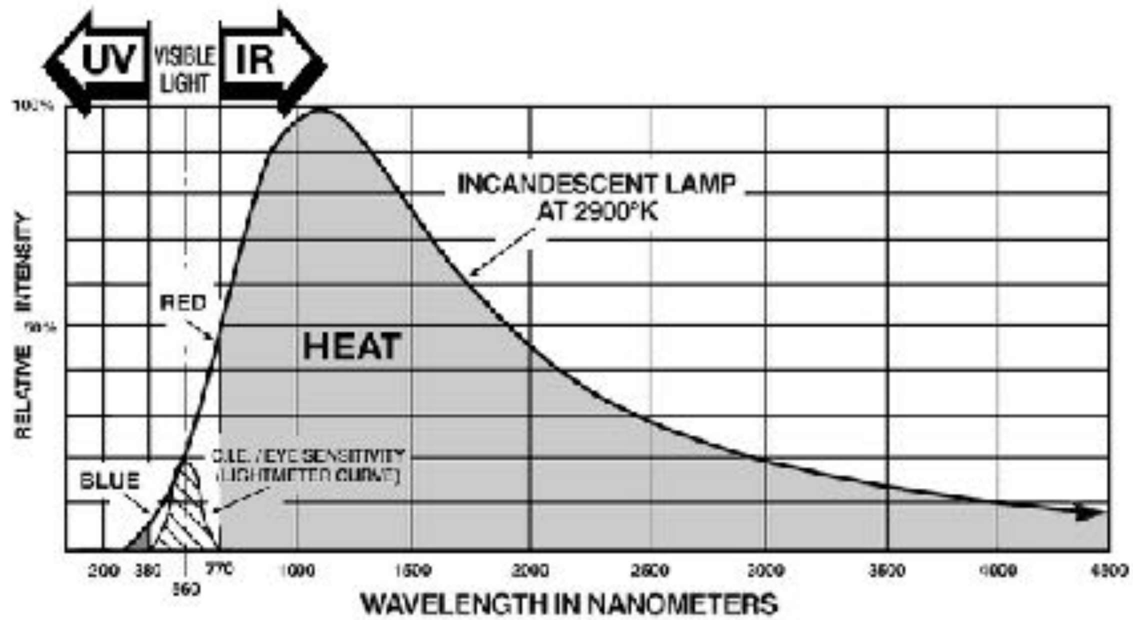
Using a halogen tungsten source as a lamp in a fiber optic system, if it can be used in focus. That translates into more photons as useable footcandles. In turn that means less hardware to install and maintain.

Photons out of the lamp make it into the fiber and out the other end. This focus is invaluable. Other lamp choices can mean 3 times to 10 times the fiber optic hardware to produce the same footcandle levels.

There is a constant push to convert all lamps into energy saving lamps. But for fiber optic lighting, a halogen lamp is more energy efficient than an LED lamp if the goal is to get beams of light out of the fiber and not just effect lighting. Filament lamps offer focus. Focus translates into efficiency.

The Challenge for Fiber Optics

The challenge is that, as mentioned before, the lamp produces most of its photons as heat. Photons with big spin diameters are more easily absorbed. For fiber, the 94% of infrared



produced by the lamp will melt and burn plastic fibers and will degrade the binding of glass fibers.

Acrylic is opaque to IR. It will absorb IR up to its melting point. That is how they form aircraft canopies from acrylic. This is the reason it is not used as a communication fiber.

(Communications applications use IR band lasers as signal sources. Glass fiber was originally designed for communications use and has its optimum transmission at 1400 nanometers, right in the middle of the IR band.)

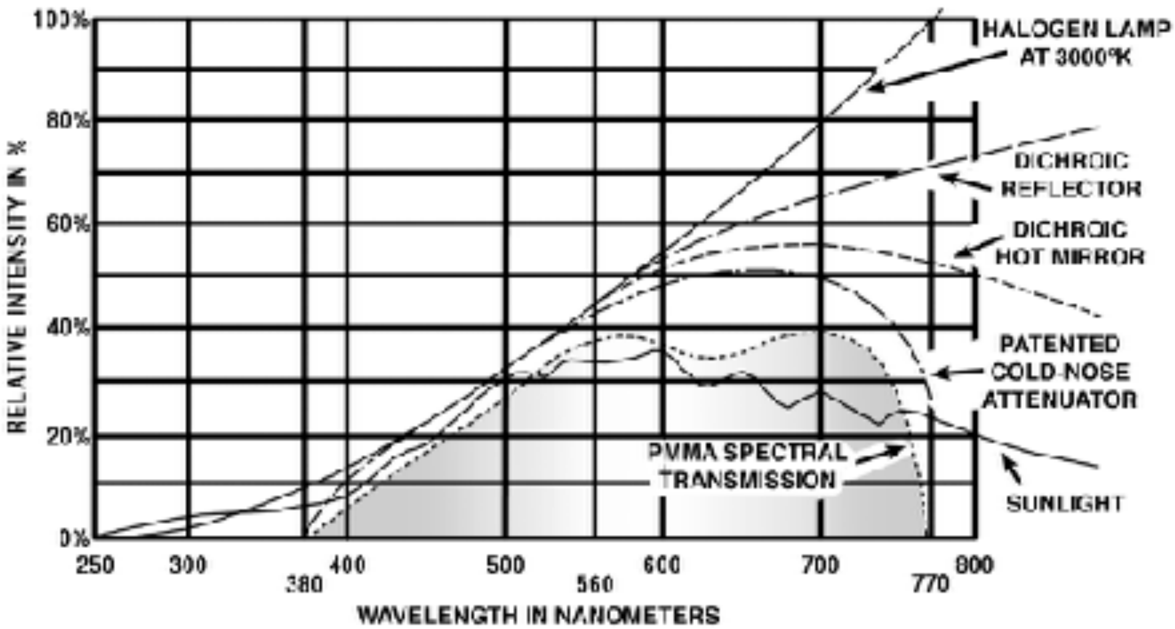
Because acrylic absorbs IR, it is very susceptible to heat damage.

Therefore, great care needs to be used.

The IR must be removed from the light source *BEFORE* it is focused into the fiber.

Failure to do this will result in yellowing, loss of transmission and fiber failure. Fiber melts easily. So the best lamp can also be a curse.

NoUVIR trims out the IR. Fiber optic projectors available through NoUVIR Lighting operate fiber ends at the projector in the bushing at roughly 45°C.



NoUVIR is so certain that the acrylic crystalline molecules are not shuffled by IR photons that the company offers a ten-year warranty against yellowing or any loss of transmission for their aerospace-grade acrylic fiber.

The heat in a halogen lamp at full voltage is filtered by a high-quality dichroic reflector and an aerospace-grade dichroic hot mirror (filter #2). Then COLD-NOSE technology tunes the photons depending upon their spin diameter. The spectral transmission of what goes through the fiber is shaded.

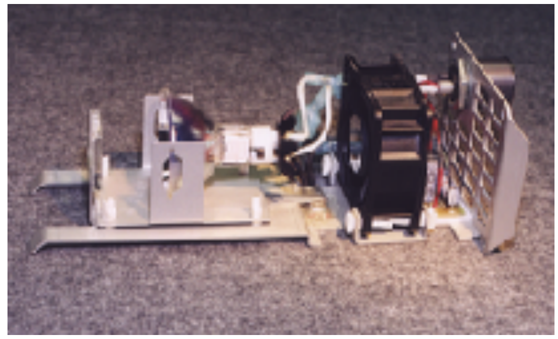
Any acrylic fiber should not exceed a temperature of 70°C.

And for safety, no fiber optic projector should exceed 90°C which is the U.L. limit for a light fixture. Some fiber optic projectors can exceed this limit. Be cautious of projectors listed as stage lighting which can exceed 90°.

Again, NoUVIR's fibers are lit and run at around 45°C or 110°F. It is in the summer sun warm. Not only does the acrylic material need to be protected, but the goal is to keep the crystals flat, straight and ideal for the entrance of visible photons. This is one of the reasons NoUVIR recommends the polishing of all acrylic fiber.

Even if you are using a commercial or hobby grade fiber instead of aerospace grade fiber, acrylic fiber has better transmission if it is polished. Polishing is easy. It can be done by hand in a few minutes.

(If you have a problem with a failed fiber optic system that has burned fiber at the bushing, take photographs and contact NoUVIR by e-mail. We have replaced several systems and gotten people back up and running when a competitor's system has melted fibers. If you are comparing fiber optic lighting systems, carefully read the warranty. Warranties are a good indication of actual performance)



What Lamp Does NoUVIR Use?

NoUVIR fiber optic projectors use the projection lamp designated EKE. This is a reflector lamp MR16 150W 21V GX5 with a bi-pin base. Use the three letter code. It will automatically specify the lamp.
An EKEX is available, but this will output less light as the lamp manufacturer has simply derated the watts input to the lamp. Use the projector on low-setting instead. There will be a slight color shift for the longer lamp life. Look. See if it matters. In some cases it is undetectable. In other case, it is. NoUVIR recommends using projectors on high.

Do not substitute an LED version for the lamp. The fiber will be dim. The color will be marginal.

The manufacturer of an EKE lamp is important. We have tested many brands and picked the one with the best performance. Unknown brands tend to have much shorter lamp life. One major manufacturer makes an EKE with shorter pins than normal. If you buy this manufacturer's lamp, be cautious to make sure you get good contact with the lamp socket.

In Summary

The best lamp for a museum quality fiber optic lighting system is a halogen tungsten lamp. However, they are rarely used in focus. The reason is that the high IR content damages most fiber.

NoUVIR is very unique. It has technology that allows acrylic fiber to be very brightly illuminated in the lamp's focus, but has removed the heat before the light gets to the fiber. NoUVIR can light the best in fiber for transmitting visible light. But can do it without melting or harming the fiber.