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A New Light on Metal Halide Fiber Illumination

by Ian Edwards, Welch Allyn Lighting Products Division

The design of medical illumination systems such as endoscopes and physician headlamps has traditionally been a tradeoff between light quality and cost. Halogen lamps and xenon arc lamps have each been used for years, but require compromises by the designer that leave the purchaser conceding on the combination of light quality, cost, maintainability and side effects such as heat and noise. While metal halide lamps have so far failed as an alternative, a new glow has been cast on this technology that is now offering better choices to design engineers.

Fiber optic medical illuminations systems such as endoscopes have revolutionized medical diagnosis. Instruments such as the laparoscope, gastro scope, and sigmoid scope allow unprecedented views inside the body cavity or organ with a flexible or rigid illuminated optic instrument. Endoscopy and the minimally invasive surgery it allows, such as in arthroscopy of the knee, now account for over 25 percent of all surgery in developed countries.

Halogen and xenon arc lamps have dominated the design of fiber optic endoscopes and headlamps. Metal halide lighting has the advantage of being an arc lamp, but it has traditionally not proven useful as a third choice because of its low-color temperature, lack of color constancy and a large arc gap that was unsuited to the small spot size requirements of thin optical fibers.

Since the fiber optic cables that provide illumination for a physician's headlamp are usually no more than 6' long, the lamp box is usually less than 6' away from the doctor's head. The fan within a physician's metal halide headlamp is essentially inaudible.

Recent Solarc lamps offer a three-fold efficiency over halogen and xenon arc lamps — a savings that can be channeled into three times the light output or a battery lifetime three times longer.

The drawbacks of metal halide have now been mostly overcome. Recent metal halide lamps offer a threefold efficiency over either halogen or xenon arc lamps, a savings that can be channeled into three times the light output or a battery lifetime three times longer. They provide 20 times the lifetime of halogen bulbs, and twice the lifetime of xenon arc lamp lighting. Hospitals, which have had to choose between a less-than-ideal halogen system or a xenon arc lamp system costing about six times as much, can now obtain near-white light illumination with a much more palatable increase in expenditure.

Your Father's Lighting

Halogen filament lamps, now about 30 years old and commonly used in commercial lighting, flashlights, automobile headlights and other products, have dominated the fiber illumination market. They are inexpensive, readily available and use simple power supplies. (The power supply must, however, be stepped down from 120 V.)

The drawbacks of halogen lamps as illuminators of endoscopes, though, are many. They do not provide the same color light as daylight, under which doctors are taught to distinguish irregular tissue. Instead, they radiate as a blackbody at 3,200 K. (By contrast the sun, also a blackbody radiator, has a color temperature of 6,500 K, reduced to 5,600 K after its sunlight passes through the atmosphere.) The large filament inside a halogen bulb makes it difficult to obtain a spot size below about eight millimeters, meaning enough light isn't directed into the thin fibers of the medical instruments. After plastic cladding, the endoscopes can become quite thick, and considering the parts of the body they're snaked through, increased diameter is not too desirable.

Smaller filaments generate less light, so they must be subject to higher power. The resulting heat can actually melt the end of the fibers, and in any case a hot lamp box is certainly not a desirable object in a surgical setting. Higher power also causes the filament to burn out in typically approximately 50 hours.

About 15 years ago xenon arc lamps solved many of halogen's technical problems. Its source is only about one or two millimeters across, meaning it can illuminate smaller diameter fibers. Its color is much closer to daylight, and there is no filament to burn out, making its lifetime ten times than that of halogen.

But xenon arc lamps require a more complicated power system than halogen, driving up the illumination system cost, and they are not commonly available. Xenon's "cost of light," — the ratio of bulb cost to bulb lifetime — is actually about six times higher than halogen bulbs, and system costs are also six times higher. For every xenon illumination system that is sold today, five or six halogen systems are sold, despite halogen's shortcomings.

Solarc Brightens the Scene

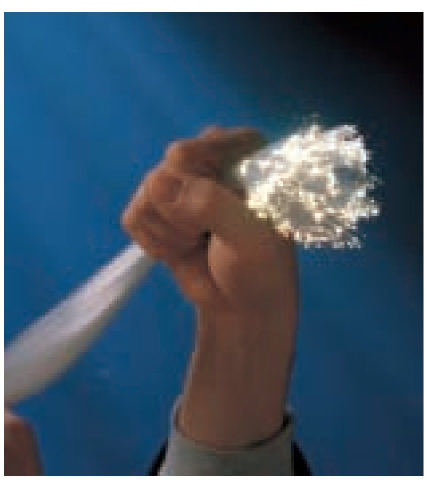
The ideal solution would be a system with the benefits of xenon arc lamp systems at the cost of halogen bulb systems. New metal halide systems are designed to fill this gap.

The latest metal halide lamps, such as the Solarc™ light source family from Welch Allyn, have a much more favorable cost of light ratio than xenon: about twice the light for a quarter of the cost. Their lifetime is 1,000 hours, twice that of xenon arc lamps, requiring much less maintenance (and hence downtime) than halogen lamps and half the maintenance of xenon lamps. Being arc lamps, metal halide lamps have no filament to break.

Today's metal halide lamps have the same short arc gap of a xenon lamp, offering use of the same small scopes there were developed for xenon. Lamps such as Solarc are three times more efficient than both halogen and xenon lamps, so they require only one-third the power for the same brightness, generating significantly less heat. A 50 W metal halide lamp will emit the same luminous flux as a 150 W halogen lamp.

With heat reduction comes smaller cooling fans, and with those come less noise. Fans for these metal halide lamps are essentially inaudible, an important consideration to workers in a surgical room. The fiber optic cables that provide illumination for a physician's headlamp are usually no more than 6' long, so (allowing for cable draping) the lamp box is usually less than 6 feet away from the doctor's head.

Metal halide's drawback has been color. Unlike the pinkish-yellow color of the generic metal halide bulbs seen in parking lots, Solarc is daylight color. But while it starts at about the color temperature of sunlight, it changes over its 1,000-hour lifetime, from 5,600 K to about 6,500 K, a slight blue. While that's always significantly better than halogen, it drifts away from xenon arc lamps over time.



Fiber optic-based medical illumination systems such as the laparoscope, gastro scope and sigmoid scope have revolutionized medical diagnosis by allowing unprecedented views inside the body cavity or organ with a flexible or rigid illuminated optic instrument.

The Solarc fiber optic illuminator consists of a metal casing that houses a 50 W Solarc bulb and all necessary control electronics and cooling components. A plug-and-play solution for light source integrators, the illuminator can also be customized to support any fiber or connector.

The lumen degradation of generic metal halide lamps and xenon lamps is infamously about 50 percent, but metal halide lamps such as Solarc retain approximately 70 percent of their initial lumens at the end of their lifetimes. (By contrast, halogen bulbs are typically 80 to 90 percent.) Moreover, halogen lights applied in endoscopy were originally designed for use in eight- and 16-millimeter film projectors, and their reflectors were not optimally designed for fiber optic illumination. Today's Solarc lamps have reflectors designed specifically for illuminating the small fibers used in medical applications, so they lead to brighter, crisper images.

FDA-Approved

As medical equipment, endoscopic and headlamp systems require approval of the US Food and Drug Administration. Heat is one issue, but the main issue is electromagnetic interference given off by xenon arc and metal halide lamps — pulses from the lamp can cause digital electronics to be reset. Both are overcome by enclosure of the lamp, electronics, and wiring in a metallic (Faraday) cage.

The new metal halide lamps can provide more light in a smaller size, and can be battery powered. They can also be used in remote and portable lighting products, camera lights, and bicycle lights. Their ability to provide whiter and brighter light at a lower wattage leads to their potential use in a host of applications, just as they are finding their way into operating and examination rooms in hospitals today.

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