

## **Metal Halide Hits the Trail with Bright Light, Low Wattage**

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Designing a portable light source once meant sacrificing the quality of illumination. Historically, the superior light rendered by high-intensity discharge lamps came at a cost to weight, size and battery-life, relegating most portable sources to filament-based technology.

Emerging metal halide sources, however, have literally started to blaze new trails for high-intensity portable lamps. Emitting only 10 W, these compact, efficient, highly focused point sources have already found application as mountain bike lamps, dive lights and illumination for security and emergency applications. Their high lumens per Watt (lpw) translate into extended battery life, while their small arcs enable more compact, light-weight reflectors.

Originally developed for medically oriented fiber illumination, metal halide sources now offer a flexible new tool for illumination engineers and lighting experts. To understand the potential application of these new lamps, it may help to understand how their unique design translates into end-user benefits, namely high intensity light at a low wattage.

### **Design and benefits**

Prior to 10-W metal halide sources, the notion of portable discharge lamps would have forced a difficult choice upon designers. A 100-W halogen lamp, for example, provides a comparable amount of light, but it necessitated either a very large battery or a very short lamp-life. By comparison, a 10-W metal halide lamp can provide four hours of light using an 8 C-cell sized battery.

Building a portable arc lamp naturally required a smaller arc – smaller, that is, in size, not power. The 1.2-mm arc now available is about a tenth the size of conventional short arc lamps. Coupled into an M10P001 parabolic reflector lamp, it generates power of 13,000 candles along the central beam.

These small arcs have an impact on reflector design. Larger sources require larger reflectors to fit the focal point of the light within the parabola. Because this technology enables 10-W point sources, however, it allows lamp designs using smaller and lighter reflectors.

The sources nearest in capability are 21-W metal halide lamps designed for fiber endoscopes and related instruments. These devices also sport an arc gap small enough for compact and potentially portable sources. The 10-W lamps, however, extend these advantages to a higher level of performance in terms of battery life and power.

The proximity of the cathode and anode in a 10-W lamp enables stabilization of its arc by the electrode temperature, rather than the wall temperature. Mounted horizontally, the arc moves to the highest point of the electrode and stays there. In practical terms, this electrode-stabilized design focuses light better and reduces flicker and flare to less than 2 percent, peak to peak.

Alongside these benefits, however, most engineers will recognize that miniaturization presents challenges: Producing such a small arc introduces the problem of arranging it precisely within the reflector. Without a certain degree of precision, the benefits of the short arc gap are lost.

The gap, for example, must be maintained at 1 mm when heating and melting the glass envelope. Afterwards, these compact sources must be exactly placed within the focal point of the reflector. To hold an image to 0.004-in, the arc tube must be positioned to 0.001-in. Fortunately, machine vision techniques have evolved enough to optically position a 1.2-mm arc gap in a base or a reflector to within thousands of an inch. The upshot for illumination engineers is that, despite its size, this technology can accurately deliver light where they need to direct it.

The evolution of material handling methods also has advanced, enabling the measurement of metal halide salts down to microgram doses. This is especially remarkable considering these oxygen-sensitive materials must be introduced in precise ratios through the second seal under oxygen-free control. In terms of illumination applications, this capability is vital to achieving the life, luminous efficacy, color balance and minimal flicker of 10-W sources.

One final but important feature of these portable devices is that the arc source operates within a sealed outer bulb, which distinguishes it from higher-wattage sources used in stage and studio applications. The heat these bulbs generate requires an extra degree of safety from users.

### **Putting it to work**

The unique design of 10-W metal halide lamps provides illumination experts and end-users with a new low wattage source specifically designed for applications under battery power. It also delivers a highly focusable arc gap, daylight color temperature and compact size. But the true test of any design is what solutions it has actually provided to real world applications.

It is appropriate somehow that the earliest adopters of this leading edge technology were extreme sports enthusiasts and divers. Its solar quality illumination and compact housing has provided a nighttime edge to competitors in 24-hour mountain bike marathons. It delivers similar characteristics in lamps carried by professional divers, who also benefit from the thallium-enhanced spectral characteristics added to 10-W lamps. This particular salt emits greenish wavelengths that cut through seawater better than the yellowish illumination from halogen or alternate sources.

Portable metal halide lamps have also appeared in high brightness flashlights used for border patrol, at crime scenes and in forensic detection. It also expands upon past uses in fiber endoscopes to render portable video boroscopes for inspecting car engines and other hard-to-reach areas.

Thus far, the focus has been on portable applications where, until recently, the only alternative was more powerful halogen sources that emitted an overabundance of light for the job. Watt per watt, metal halide sources are three times more efficient than halogen lamps both in terms of lpw and focusing ability. They deliver outputs of about 45 to 60 lumens for every watt of input power. Compare this to halogen lamps, which typically emit between 15 and 20 lpw.

Also, the 10-W metal halide design does not require OEMs to locate the ballast in the battery housing, separate from the emitter. With minor modifications, these sources adapt neatly into a flashlight structure, which represents something of a conceptual breakthrough for arc discharge lamps.

However it is applied, current and future users can expect to address similar issues with the technology. One is meeting the electrical requirements of the ballasts in battery-powered sources. Fully charged battery packs often temporarily exceed the maximum allowable voltage that the ballast can withstand. One solution some OEMs have applied is conditioning circuits that cap the maximum voltage delivered to the ballast. The ballast also requires heat sinks to prevent it from exceeding its 90 C maximum case temperature.

Early adopters have also developed shock reduction techniques, but this is generally a value-added feature rather than a requirement: While metal halide lamps are as durable as conventional halogen sources, they are more expensive to replace. Controlling shock requires little more than mounts or vibration isolation techniques designed for the task. Clearly, however, the early adoption of 10-W metal halide sources for 24-hour mountain bike races testifies to its durability. Lamp tests with a one-hour-on cycle followed by a 15-minute-off cycle have consistently shown a median life in excess of 1000 hours for 10-W lamps.

### **Looking ahead**

Little speculation is required to foretell that the intrinsic versatility of 10-W metal halide will uncover new applications. The technology's higher wattage cousins already provide focused, but divergent light for stage and studio. Low-powered, portable sources could provide interesting alternatives.

Architects may find the 6,000- to 7,000-K color temperature high, and the color rendering index of 70 low for most display illumination. But the ability of 10-W metal halide sources to run on sealed lead acid batteries, offers a brighter more penetrating beam for emergency lamps.

Although developed for visible emissions, adapting the chemical make-up and the reflector of metal halide sources offers possible new sources for ultraviolet curing applications.

Wherever the technology finds application, its significance to illumination designers and engineers lies in its bright, highly focused and efficient short arc. OEMs requiring high intensity from a compact, lightweight source have little to lose by exploring how miniature 10-W metal halide sources could benefit their application.