Energy Focus, Inc. Uses LEDs to Light Navy Ships

Roger Buelow, Chief Technology Officer, Energy Focus, Inc.

Energy Focus, Inc. (formerly Fiberstars) has developed a line of LED fixtures that could save the US Navy tens of millions of kilowatt hours, millions of gallons of fuel and hundreds of person-years currently spent changing light bulbs.

"The entire EFOI team has worked tirelessly to make sure we're delivering a high quality, high efficiency product to our warfighters," said Roger Buelow, VP and GM for Military Sales.

The fixtures are direct replacements for linear fluorescent and incandescent fixtures that are used on every ship in the Fleet. The fixtures include two sizes of incandescent fixtures for general lighting and a berth detail light used in each sailors bunk. EFOI fixtures use 30 to 90 percent less power than those currently installed.

EFOI's Director of Advanced Engineering, Dave Bina said, "EFOI is always committed to energy saving fixtures but in this case we couldn't have used more watts even if we wanted to. All the breakers are optimized for the current load. Adding even one watt could cause big problems."

On diesel burning ships, electricity is produced onboard using large generators that burn the same kind of fuel used to propel the ship. To generate a kWh, the ships must carry the fuel with them out to sea and turn it into electricity in less than ideal conditions, resulting in electricity much more expensive than power generated on land. The energy savings from EFOI's lights means less fuel burned for electricity, so the ship can travel farther between fill-ups.

Emails from Sea

EFOI staff has made friends with the crew during ship installs and has gotten positive feedback on their lights. "These sailors are some our most sophisticated customers. They run the numbers on energy, maintenance and fuel savings. They calculate payback times and understand how many hours of electrician time can be used for something other than changing lightbulbs. They do all of this while keeping their ship running full steam ahead," said Buelow. "We've heard how a bunch of Japanese officers toured the ship and were jealous of the lights"

Sailors also appreciate the improvements in their personal berth (bunk). The fluorescent tubes in the bunk lights used to frequently go missing and took awhile to come on. With the EFOI lights, the lights come on instantly.

Ships will also free up a tremendous amount of space by reducing the number of spare bulbs they have to take to sea as well as space to hold the burned out bulbs.

A Rough Environment

Any lighting fixture the Navy bolts to the exterior of their ships will experience extreme temperatures, continual salt spray exposure and violent physical shocks. The Navy has a set of mil-spec standards that detail the tests required in order for them to have confidence that a lighting fixture will stand up to this environment. EFOI designed the fixtures to work from -40°C to 93°C (200°F), to maintain their seal after 30 years of sea spray exposure and to pass a test where a 400 lb. hammer is repeatedly dropped on the fixture from 5 feet. Bina, who led the engineering team in meeting the requirements, said, "The challenge for these fixtures was to meet rigorous mil-spec requirements while maintaining very high delivered efficiency."

Some of the fixtures needed to withstand a 500°F diesel fuel blast. The intense heat drove material and electronic component selections. The EFOI team built a diesel exhaust test chamber to help them test for the long term effects of these caustic fumes.

An important advantage of the EFOI lights are that they don't require the brass shock mounts that incandescent fixtures rely on to survive. The solid state light sources can handle the vibration and shock. A major failmode for the existing lights is corrosion of the shock mounts.

Thermal Management for Extreme Ambients

Meeting the 93°C specification required careful source selection and advanced thermal engineering. Finite Element Analysis models were used to maximize the heat pulled from the sources while keeping to the legacy fixture footprint. IR cameras were used to confirm the thermal performance using cast prototypes. The LEDs were mounted on metal core boards by Heatron in Erie, Pa.

Greg Frankiewicz, EFOI's LED System Specialist, said, "When you are starting at 93°C, there's not much working room between ambient and the maximum junction temperature. The thermal management must be robust; traditional heat sinks don't make the grade."

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Maximizing Optical Efficiency at 40 Knots

Since some of these fixtures were being used to replace linear fluorescent fixtures, the optical efficiency was paramount. EFOI used patented optical designs and proprietary production means to build optical elements that collect, direct and focus the light. The Navy standards include very specific beam pattern requirements so EFOI used Optical Research Associate's Lighttools program to optimize the optics one degree at a time. Frankiewicz explained, "When we first looked at the beam distribution specifications, the complexity made us a little cross-eyed. After we lighted our first prototype, we could see that the specification was exactly what the sailors need - and we delivered it."

Buelow said, "The Navy is understandably sensitive to stray light leaving the ships. Our strategy to put light exactly where it was needed (and nowhere else) matches their philosophy."

Additionally, both colored and white lights are in the fixture line. The colored lights were optimized for night vision goggle (NVG) compatibility.

Run Silent, Run Deep

EFOI developed the electronics to drive the LEDs to match the mil-spec requirements for electronic noise and electronic pulse vulnerability. These specs are far more stringent than for commercial lights. The Navy requires that all fixtures' electronic signature meet this tight limit so that the ship as a whole is very hard to detect and so that our own sensors aren't confused.

When is the US Navy like Old Navy?

EFOI is selling commercial versions of these fixtures, but has also used the expertise and tools from this project to develop an entire LED fixture line for retail, commercial and residential use. Low CCT and high CRI LED sources are opening up new markets for their fixtures.

"Of course, we aren't going to sell an 80°C fixture for use in a 30°C mall - but we have used the tricks, tools and economies of scale from the Navy fixture development to make high performance retail LED fixtures, our new Silver Bullet fixture is a great example," said Buelow.

Support from DARPA, NAVSEA

EFOI was the system integrator for Defense Advance Research Projects Agency's(DARPA) High Efficiency Distributed Lighting (HEDL) project. The goal of HEDL was to develop fixtures that deliver full spectrum white light at over 70 lpw. LED, optics and electronic advancements from HEDL set the stage for developing these new products.

EFOI received substantial support from DARPA, Program Executive Office Ships (PEOSHIPS), Commander - Naval Surface Forces (COMMSURFOR) and NAVSEA to bring these products to the ships. Buelow explained the benefits, "DARPA set aggressive goals for efficiency and performance. Their vision, encouragement and leadership has been a tremendous asset. The team at NAVSEA has helped us work through the finest of details of mil-spec qualification."

What's Next for EFOI?

During their ship audits and installations, EFOI identified several other applications that could be replaced by LED fixtures. Their engineering team is starting to develop the next wave of military products in parallel with meeting the increased demand for high performance retail fixtures. They have set their sites on wall washers, downlights and accent lights for their next family of LED fixtures.

Roger Buelow has more than 12 years of R&D and engineering experience at companies such as General Electric, where he spent four years developing metal halide and halogen lamps and the equipment to build them.

While at Energy Focus, Buelow has developed novel designs, applications, processes and equipment to support the company¹s growing fiber optic lighting businesses. He has led the Energy Focus engineering and R&D departments in developing EFO technology since its inception and has been the principal investigator on five federal research contracts spanning military and civilian technologies.

He holds 10 patents and earned BS and MS degrees in Applied Mathematics and Systems Engineering from Case Western Reserve University in Cleveland, Ohio.

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