

White Paper: Aluminum Extrusion Use in LED Lighting Fixtures



Image reflects the tracing of a restroom wall and ceiling using AIT's IL-XTRU-4023 aluminum profile with embedded RGB LED. © AIT Technologies Design.

It's no secret that the use of LED (light-emitting diode) lighting is growing rapidly, in a wide range of applications, due to dramatic savings in energy use and maintenance costs. A recent U.S. Department of Energy (DOE) report¹ estimated that nearly 50 million LEDs installed in nine applications (indoor A-type, directional, MR-16, decorative, downlight, troffer and high-bay, and outdoor streetlight and parking lot/garage) saved about \$675 million in energy costs in 2012. The DOE further estimates that if these nine markets switched exclusively to LEDs, annual energy **savings could approach 3.9 quadrillion BTUs and \$37 Billion in annual energy costs.**

Yet for all the energy and maintenance saving advantages, conversion to LEDs poses challenges to fixture manufacturers. The LEDs and related electronics generate heat, which must be dissipated to preserve their life. With relamping not required for years, fixtures must be equally maintenance free. LEDs are well suited for demanding environments, raising the performance requirements for the fixtures. And, the small size and design flexibility of LED's, while a boon to the creative designer, can lead to an unwieldy proliferation of parts and SKUs (and substantial ramp-up costs) for the lighting manufacturer.

Custom aluminum extrusions are facilitating the rapid evolution of LED lighting applications by meeting these challenges while providing great design versatility. Extruded aluminum fixture housings serve a dual purpose as heat sinks and reflectors, provide a corrosion-free material ideal for challenging environments, and incorporate interfaces for lenses, circuit boards, and end-caps, while allowing the lighting designer to create the shape they desire and "put the metal where it is needed." And, given that aluminum extrusions are infinitely recyclable with no degradation in properties, and can be specified with significant recycled content, extruded aluminum fixtures enhance – rather than detract from – the sustainability of LED lighting solutions.



Custom extrusions give the designer freedom to create the shape desired and put the metal only where needed. Photo courtesy of Almag Aluminum Inc.

¹ "Adoption of Light-Emitting Diodes in Common Lighting Applications: DOE

Designed for Performance

Extruded aluminum LED lighting fixtures incorporate a number of value-added features that increase the multi-functionality of LED lighting systems. The extrusions themselves may be designed with whatever degree of complexity desired with varying wall thickness. Extrusion dies are relatively inexpensive and extrusions' ability to be easily cut, formed, bent, machined, and finished with anodizing or painting make them ideal for high-efficiency lighting.

Typically, aluminum extrusion alloy 6063 is used for LED fixtures but other alloys may be suitable. Working with extruders can optimize extrudability of the aluminum housing, further reducing costs of the design. Aluminum extrusions are non-magnetic, and have excellent electrical and thermal conductivity, making them ideal housings for LEDs.

Integrated Heat Sink Function

Aluminum extrusions incorporate cooling fins that act as an integrated heat sink to dissipate heat from the LED light. As examined by Steve Jackson, Business Development Manager of Thermal Management at Sapa Extrusions North America, LED lighting technology is significantly hotter than incandescent or fluorescent light bulbs. He notes that aluminum extrusions play a key role in thermal management of LEDs, to preserve the long life and light quality of the diodes [see *"The Advantages of Aluminum Extrusions for the LED Industry"* www.aec.org]. Extrusion engineers utilize Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) software to simulate thermal conductivity and examine the structural integrity of the component. Engineers use aluminum's thermal conductivity to design an extruded LED light fixture that transfers and dissipates heat for optimal thermal efficiency. Aluminum extrusions are typically better thermal conductors than other materials, such as steel, and do not exhibit surface porosity that can affect heat retention in castings.

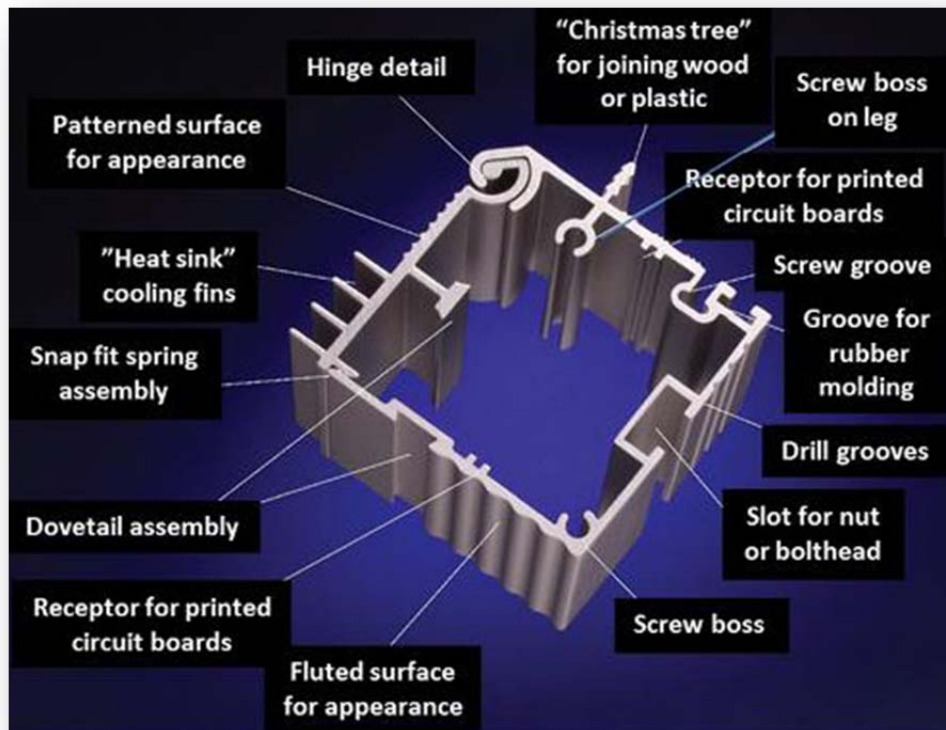
"Extrusion dies are relatively inexpensive and extrusions' ability to be easily cut, formed, bent, machined, and finished with anodizing or painting make them ideal for high-efficiency lighting."

Jackson highlights how fins of an extruded LED housing can be designed without draft (as with castings), allowing for longer fins to provide additional surface area. He notes, "The greater the surface area, the greater the natural convection of the heat into the surrounding atmosphere...the increase in thermal conductivity of extrusions versus castings allows the lighting manufacturer to use less material to obtain the same thermal efficiency. Less material plus a smaller footprint equates to lower total costs."

Morten Sunde, Marketing Director for SPI Lighting, Inc., affirms that the aluminum extrusions are designed to be an effective heat sink to maximize the lumens output and longevity of the LEDs used in their products: "The "wings" of the extrusion dissipate the heat away from the LED diodes, thereby increasing lumen output. The added benefit is that the cooler the LEDs run, the longer their life, helping LEDs to significantly outperform incandescent and fluorescent lampings."

Customized LED Housing Design

Extrusions offer endless design possibilities that include built-in hinges, screw bosses, receptors, and grooves, and can incorporate assembly options such as built-in dovetail, snap fit spring and slots. Extrusions have the added benefit of integrating other materials into the fixture itself, such as the reflectors and mountings, and allowing dual-purpose lighting designs that are compact, easy to install and offer a streamlined appearance.



The design flexibility of the extrusion process allows a great deal of functionality to be designed into extruded components, improving performance, saving secondary operations and speeding subsequent assembly. The extrusion shown above illustrates some of the functions that are commonly incorporated. © Aluminum Extruders Council

Jackson’s article notes the variety of extruded aluminum heat sinks that can be used in LED lighting, with great size flexibility up to 21-inches wide and fin ratios of 19:1. Designers can create wider products with a snap-fit design for enclosures or boxes, and join extrusions together without filler material using Friction Stir Welding technology, which is also used to hermetically seal a cover onto lighting extrusions.

Sunde adds, “The extrusions are designed to allow a variety of lenses to be attached to it to change the distribution of the light output. Internally, we can add several different LED circuit boards to help control light output, color and distribution. In addition, there are several end caps that can be attached to change an interior fixture to an IP66-rated exterior fixture – this all helps to keep inventory and costs down.



SPI Lighting's TRYG Exterior Linear LED (left) features a low-profile housing while its creative design acts as an efficient heat sink, maximizing output and life by allowing the LEDs to operate at an optimal temperature. The STYK Linear LED lighting fixture offers a sleek design in a small efficient package while optimizing life. © Photos courtesy of SPI Lighting, Inc.

A premier AEC extruder member asserts that LED extrusions are moving beyond the typical heat sink design to highly customized shapes, depending on the end use. He notes that although the LED industry has standard configurations with fairly standard component requirements, his company pursues and helps develop specialty components for a diverse LED marketplace--from simple desk lighting to wide broadcast parking lot lighting. He sees LED markets as a major opportunity for aluminum extrusions.

LED Markets for Aluminum Extrusions

Uses for aluminum extrusions in LED lighting fixtures are growing at an unprecedented pace. Extrusion marries form to function for indoor and outdoor applications ranging from industrial and commercial to residential, architectural and transportation.

Industrial applications include extruded housings for LED lighting in warehouses and manufacturing and distribution centers. Commercial outdoor applications include roadway and bridge lighting, streetscapes, sidewalks, bike lanes, exterior lots and security lights, roadway signs, digital display boards, advertising billboards and scoreboards, landscape lighting, including commercial exterior building lighting. Commercial indoor LED extruded fixture applications include parking garages and canopies, retail stores and displays, banks, offices, trade shows/exhibit halls, classrooms, libraries, healthcare facilities/hospitals, restaurants, hotels, and entertainment and sports venues.

Building façade and exteriors use extruded LED lighting fixtures for both decorative and security functions in architectural applications, especially in LEED-certified building and retrofit projects. Transportation increasingly uses extruded aluminum housings for LED lighting in automotive-related applications including emergency vehicles, planes, trains, buses, subway cars, stations, and airports. Consumer residential LED lighting products use aluminum extrusions for outdoor landscape lighting, interior home lighting and portable lighting. The following examples represent just a few of the far-reaching possibilities for extrusion use in LED lighting.

Commercial Applications

Walmart has used LED freezer case lights in its stores since 2005 to reduce electricity use and lower maintenance costs [*January 2011, www.treehugger.com/sustainable-product-design/lighting*]. LED fixtures are now the industry norm in freezer case lighting. Additionally, Walmart began specifying LED lighting in U.S. store parking lots in 2011 for energy and maintenance savings, finding that LED fixtures provide better focused directional light and limited nighttime glare for improved safety and security. Overhead interior LED lighting was tested in Walmart's China stores, with plans to expand globally as the technology improves. The company estimates a 70-percent overall energy savings.

Parking garages are frequently built and retrofitted with LED lighting systems, many housed in aluminum extrusions. Interior parking garage spaces benefit from LED's diffuse uniform high-output lighting that minimizes glare and improves safety and security for drivers and pedestrians. Cree Lighting company's LED parking structure fixtures improve comfort, safety and appearance while cutting energy and maintenance costs. The Cree Edge™ parking garage low-profile modular LED luminaire is housed in rugged extruded aluminum that meets stringent performance standards. The LED fixture is UL Wet listed and offers an integrated bi-level sensor option. The photocell option allows each fixture to turn off if there is enough natural ambient light. The fixture reliably provides instant startup to enhance safety and security and reduce energy consumption in parking garages.



Parking structure at California State University-Fullerton and low-profile modular LED light fixture. © Photos courtesy of Cree, Inc.

Home and Office Applications

AIT's LED lighting systems achieve a sleek, modern look that optimizes versatility by designing and manufacturing extruded channel housings with LED ribbon lighting that offers a stable mounting surface for walls, shelves and indoor or outdoor areas to maximize LED strip lighting applications. The extrusion-housed LEDs help create a safe environment indoors with strip lighting built into stair steps, railings, under kitchen cabinets, in flooring, or exit doorways. The LED extrusions can be made waterproof, enabling use as exterior residential security lighting, to

illuminate garage doors, for emergency signs, and for decorative uses in gardens, water features, pools, spas, or patios. AIT offers a multitude of standard and custom design possibilities, and because the extrusions are compact, they can be cut-to-length and easily installed anywhere.

AIT Technologies' Eran Benghiat states that when aluminum extrusions are matched with LED light strips, their versatility is the key to endless design choices. "The LED extrusions provide stable mounting almost anywhere, as they are compact and can be cut to fit any desired space indoors or outdoors. Aluminum profiles can be used as down lights in a room or embedded



© Photo courtesy of AIT Technologies Design.

into a floor to create a unique architectural experience. Using LED extrusion takes advantage of all of the features of LED strip lights."

AIT's X-LUME and IL-XTRU LED fixtures and profiles serve both residential and commercial applications--from

kitchens, bathrooms and driveways to office work stations, and can be integrated into stair steps, railings, furniture, and flooring.

Unlimited Potential

The potential for growth in extruded aluminum use for LED light fixtures/housings in all market areas is virtually limitless, with energy and maintenance cost savings of 70 to 80 percent setting the bar ever higher. Whether for new or retrofit uses, a multitude of extruded housing designs are rapidly expanding as LED technology evolves and becomes even more cost effective, taking less and less time to pay for itself after initial investment.

The Aluminum Extruders Council (AEC) is committed to bringing comprehensive information about extrusion's characteristics, applications, environmental benefits, design and technology to users, product designers, engineers and the academic community. For more information and resources to assist in discovering the advantages of and practical considerations for designing with aluminum extrusions, visit our website at www.aec.org.
