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White Paper

Specifying Gaskets for Outdoor LED Lighting Fixtures

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Executive Summary

LED Lighting technology has potential to lower energy consumption and reduce maintenance costs on outdoor installations such as area lighting and parking lights, street lights and other “difficult to reach” outdoor locations. When operating in controlled temperatures and weather-proof environments, solid state LED lights are designed to operate for 5 to 10 years. Outdoor LED housings and lighting enclosures are constructed from powder coated aluminum to resist the effects of direct sun and weather for many years. However, if the full payback on the investment in outdoor LED lighting is to be realized, the gaskets required to protect the solid state electronics must function for the 5 to 10 year life of the product.



Outdoor LED Lighting
Fixture

This brief on **Specifying Gaskets for Outdoor LED Lighting Fixtures** discusses options for gasket materials and gasket types that will last and perform for the anticipated life of the outdoor LED lighting unit. The best material for long-term performance is silicone rubber. This paper provides the designer a comparison between the performance properties of traditional gasketing materials and readily available silicone gasketing materials and adhesive backings. Silicone withstands the broad temperatures, weather and long term exposures of outdoor lighting.

LED Lighting Enclosure Gaskets / Housing Gaskets

LED Lighting Enclosure Gaskets or Housing Gaskets are specified to seal exterior aluminum housings. Housing gaskets must seal out rain and moisture for years and function over broad temperature ranges and daily temperature excursions. LED lighting enclosures typically have the International Protection or Ingress Protection rating of IP66 - defined as protected against high pressure jets of water from all directions - with limited ingress permitted. For reference, an IP66 rating is equivalent to a NEMA 4 or 4X rating by the National Electrical Manufacturers Association.



LED Streetlight

Traditional Gasket Materials Will Deteriorate on Long Term Outdoor Lighting Installations

Cost has been a major consideration when designing gaskets for the lighting fixture industry. The materials specified have generally been closed cell EPDM (ethylene propylene di-monomer) and

Specifying Gaskets for Outdoor LED Lighting Fixtures

closed cell neoprene sponge. These traditional gasket materials are provided in extruded profiles, die cut gaskets and slit-to-width rolls with or without adhesive backing.

EPDM sponge has been used on incandescent lighting fixtures for many years, and generally provided good value as a gasket material on fixtures where some moisture incursion was not critical to the performance of the lighting fixture.

Closed Cell EPDM (ethylene propylene di-monomer) sponge is molded into buns and skived or split into sheets from .062” through .500” thick. Closed cell EPDM sponge is available in soft, medium and firm densities. Although EPDM is good for UV resistance and aging, the compression set and sealing properties of closed cell EPDM are not considered adequate for long term sealing of enclosures rated for IP66.

Closed Cell Neoprene sponge is molded into buns and skived or split into sheets like EPDM sponge. Closed cell neoprene is frequently blended with other elastomers such as styrene-butadiene rubber (SBR) and EPDM. Blended neoprene sponge is prone to hardening due to aging and may take a permanent compression set, rendering it unreliable for long term outdoor LED lighting installations.

PORON® Microcellular Urethane Foam is cast into continuous rolls from .032” to .500” thick. PORON has excellent compression set resistance. Despite its open cell structure, if deflected approximately 35 to 50%, PORON gaskets may permit an enclosure to pass a NEMA 4 wash down if the edge of the gasket is not directly exposed to pressurized water. However, intermittent moisture contact and freezing may cause PORON gasketing to deteriorate over time if exposed to long term outdoor conditions.

The following chart shows four gasket materials that function very well in many gasket applications. However, the long-term performance requirements of the outdoor LED lighting industry may disqualify these materials on applications where the long-term compression set performance is critical to the sealing integrity of the enclosure. The outdoor temperature excursions in direct sunlight will continue to degrade long-term sealing performance in these traditional gasket materials.



Table 1 - Traditional Gasket Materials that will Deteriorate in Long Term Outdoor Installations

Product	Description	Standard Color(s)	C - Set at 158°F *	C - Set at 212°F **	Density, lbs/cu ft.	CFD, tested 73°F	Max Rec. Temp °F	Relative Cost \$ (.125" thk)	Comments on Outdoor Gasket Effectiveness
R497-T	Closed Cell EPDM Sponge	Black	25	NR	23	12	200	1.50	Good sun and UV resistance, however it will take a set and fail
R431-N	Closed Cell Neoprene Sponge	Black	25	NR	23	11	185	2.80	Long term weather and sun will age this material
SCE43B	Blended Closed Cell Sponge	Black	35	NR	9	11	200	1.00	Long term weather and sun will age this material
4701-40	PORON Microcellular Urethane Foam	Black	10	NR	20	11	180	1.75	May eventually wick and / or absorb water and fail

* Compression Set %, after 50% deflection for 22 hours @ 158° F (70°C)
 ** Compression Set %, after 50% deflection for 22 hours @ 212°F (100°C)
 CFD, or Compression Force Deflection is the amount of force (psi) required to deflect by 25%
 Values can be referenced in ASTM D1056-07 (now referenced in D6576-00)
 NR - these materials will not perform in long term exposures to these temperatures

Silicone Rubber Materials are Designed to Resist Aging in Outdoor Conditions

The major producers in the silicone rubber industry, such as Momentive (formerly GE Silicones), Dow and Wacker Silicones to name a few, have enhanced the performance properties of this versatile elastomer. As a percentage, the material costs of silicones have not increased as much as some of the traditional gasket materials since the recent energy cost increases.



Silicone LED Lighting Gaskets

Silicone Rubber has the combined properties of resilience, high temperature stability and general inertness that are unavailable in any other elastomer. Silicones are generally unaffected by extended exposure to temperatures from -100°F to 500°F, and are also resistant to aging and degradation from sunlight and ozone. Silicone rubber is a versatile elastomer, as it can be processed into silicone foam, closed cell silicone sponge and solid silicone rubber from either a traditional gum base or two part liquid silicone base.

Silicone Foam is cast into continuous rolls from liquid silicone rubber. Silicone foam can be cast .032" thick through .500" thick with a smooth surface finish on both sides. Lightweight silicone foam materials with density of approximately 12 pounds per cubic foot are generally open cell. Medium and firm density silicone foam materials with approximately 20 and 23 pounds per cubic foot of density contain more closed cells. Since silicone rubber resists aging due to UV exposure and oxidation, silicone foam retains its elasticity and sealing properties for many years. IP66

sealing can typically be achieved with a medium density silicone foam gasket deflection of approximately 50%.

Silicone foam has compression set resistance of <5% over temperatures ranges that would be typical for outdoor LED lighting installations. Further, silicone foam resists stress relaxation which along with excellent compression set properties enables long term performance against ingress of dust and water over time. One particular advantage of silicone foam over other gasketing materials is its inherent flame retardant properties. Thicknesses over .093" thick generally pass UL 94V-0 and thinner gauges pass UL 94HF-1.

Silicone Sponge is molded into sheets from .062" to .500" thick and rotocured into continuous rolls from .032" to .250" thick. Silicone sponge is derived from a gum silicone rubber base which is calendered to a thin gauge and cured on a Teflon® coated fiberglass bleeder cloth which imparts a fine textured finish on both sides of the finished sheet or roll. Silicone sponge is a closed cell gasketing material. It has a compression set resistance of <10% over anticipated outdoor temperatures and resists hardening and aging due to ozone, UV and weather. IP66 sealing can be achieved with medium density closed cell silicone sponge gasket deflection from 25% to 50%.

Liquid Silicone Rubber, or LSR, can be cast into continuous rolls of solid silicone rubber from .010" to .125" thick and generally in low durometers of 20 to 40 Shore A. Solid silicone rubber is rather expensive and solid rubber requires flat sealing surfaces and adequate closure force to maintain a consistent seal over time. Liquid silicone rubber is more often designed into molded gaskets with sealing beads and features that can be injection molded into custom sealing gaskets. LSR is available in a 2 part system that is mixed and metered into the press just prior to the injection molding cycle.

Injection Molded Silicone Gaskets provide a cost-effective long term sealing solution where the designer has standardized on an enclosure design that will be used on a number of outdoor lighting products. The typical injection mold for a gasket with sealing beads may cost \$3000 to \$4000 and require 6 weeks prior to first article approval.

Molded liquid silicone gaskets can be designed with sealing beads and configured to seal out water in immersion (IP67 ingress rating) for applications such as architectural lighting near waterways that might flood.



Table 2 - Comparative Materials Properties - Silicone Gasket Materials for Long Term Performance in Outdoor Lighting and Enclosures

Product	Description	Standard Color(s)	C - Set at 158°F *	C - Set at 212°F **	Density, lbs/cu ft.	CFD, tested 73°F	Max Rec. Temp °F	Relative Cost \$ (.125" thk)	Comments on Outdoor Gasket Effectiveness
R10470	Closed Cell Silicone Sponge	Orange, Gray, Black	10	15	29	10	450	6.50	Good for wind driven rain at 20 to 30% deflection
F-12	Open Cell Silicone Foam	Gray	5	10	12	3	400	9.00	Open cell structure requires > 50% deflection
BF-1000	Open Cell Silicone Foam	White, Gray	5	10	12	3	400	6.25	Open cell structure requires > 50% deflection
HT-870	Open Cell Silicone Foam	Black	5	5	15	4	400	6.75	Modified closed cell structure seals out rain at 50% deflection
HT-800	Closed Cell Silicone Foam	Gray, Black	5	5	22	9	400	5.50	Closed cell structure seals out rain at 30% deflection
HT-820	Closed Cell Silicone Foam	Gray	5	5	23	16	400	7.00	Closed cell structure seals at 30% deflection
HT-6220	Cast Liquid Silicone, 20 durometer A	Black	N/A***	N/A ***	90	65	400	37.75	Cost prohibitive in sheet form, better for injection molded gaskets

* Compression Set %, after 50% deflection for 22 hours @ 158° F (70°C)
 ** Compression Set %, after 50% deflection for 22 hours @ 212°F (100°C)
 *** Solid Silicone has a different test parameter for Compression Set
 CFD, or Compression Force Deflection is the amount of force (psi) required to deflect by 25%
 Values can be referenced in ASTM D1056-07 (now referenced in D6576-00)

Chemically, silicones are different from most other gasketing materials. All organic polymers, such as EPDM, Neoprene and Urethane, are made up of a backbone of carbon to carbon atoms. Silicones differ in that their molecular structure is made up of silicon and oxygen molecules. This silicon-oxygen linkage is the same bond that is found in other high temperature and age resistant materials such as quartz, glass and sand, hence the outstanding thermal stability of silicones and their general inertness.

Silicone rubber materials can withstand the long-term weather exposure and temperature cycles anticipated on outdoor LED lighting fixtures. The designer has access to a broad range of silicone gasketing materials, such as silicone foam, closed cell silicone sponge and solid silicone rubber. The fabrication options include die cutting, water jet cut cutting, slit-to-width gasketing with adhesive in roll form (gasket tape), custom molded gaskets and extruded and spliced gaskets. This is why silicone is considered the versatile elastomer!

LED Enclosure Gasket Configurations

Large Die Cut Gaskets for enclosures made from silicone foam or closed cell silicone sponge can be expensive relative to traditional gasket materials such as EPDM sponge or neoprene sponge. The use of mitered and dovetail joint gaskets reduces material cost and adds only a small amount of additional assembly time for the manufacturer of the housing assembly. It is recommended the width of the dovetail gasket be at least .750" wide for a dovetail key feature of .250" wide.

A gasket fabricator should be able to accept electronic files and provide prototype samples for evaluation and testing. Water jet cutting often works best for fabricating silicone foam and silicone sponge rubber gaskets with dovetail features for prototyping and production. The fine corners of the dovetail gasket can be water jet cut without the distortion or edge concavity that is typically evident when die cutting gaskets with fine corner details. Laser cutting is not compatible with silicone foam and silicone sponge as the laser cutting process chars the edges of these inherently flame retardant gasket materials.



Adhesive Backings on LED Lighting Enclosure Gaskets

Selecting the correct **Pressure Sensitive Adhesive** on the outdoor LED lighting enclosure gasket requires an understanding of the enclosure surface the gasket is to be bonded to.

One option is to have the surface area for the gasket masked prior to painting or powder coat. If the bond location is unpainted aluminum, a high performance pressure sensitive acrylic adhesive such as 3M #9485 should provide sufficient long term holding strength.

If the entire housing is to be powder coat finished, a special low surface energy pressure sensitive adhesive such as 3M #9490LE may be required to provide sufficient bond strength.

If the housing and mating gasket have many mounting holes, the adhesive backing only has to serve as a temporary assembly aid. In this case, a film supported acrylic adhesive such as Adchem 256M will provide the dimensional stability to allow the assembler to match up the hole patterns without stretching the thin, soft gasket. Since acrylic adhesives have relatively low initial tack – repositioning is possible if gasket placement needs adjustment.

If the housing can be effectively sealed with a slit-to-width roll or strip of adhesive backed gasketing, silicone sponge with an unsupported transfer film adhesive is often used as the adhesive film construction permits turns and making radius corners during assembly and installation.

Table 3 - Pressure Sensitive Adhesives Most Frequently Specified on Outdoor Gaskets

Product	Description	Bond Strength (oz/in)*	Total Thickness	Comments and Characteristics
9485	Unsupported Transfer Film Adhesive	150	0.005"	Medium Initial Tack / High Bond Strength acrylic adhesive is the best choice when a strong transfer film adhesive is required. 9485 works on some powder coat surfaces
9490LE	PET Film Supported Acrylic Adhesive for low surface energy surfaces	124	0.006"	Low Surface Energy Acrylic Adhesive is designed for tough-to-stick surfaces such as most powder coat surfaces and polypropylene
256M	PET Film Supported Acrylic Adhesive	70	0.0045"	High Tack Acrylic Adhesive - its total thickness includes a .0005" thick PET carrier for dimensional support. Used for HT-800 Gasket Tape Series

* Based on 180° peel on stainless steel after 24 hour dwell time

LED Lighting Bezel Gaskets

Cobra head lighting fixtures and similar LED lighting fixtures will require sealing to withstand long term outdoor conditions. Since high powered LED light sources generate heat, a gasket material with excellent thermal stability is required.

LED Lighting Bezel Gaskets are specified to seal the optical assembly or array of luminaires from dust and rain. Even though the luminaire is facing down and may appear to be shielded from direct rain and weather, long term functionality often requires meeting IP65 low pressure water and dust ingress design standards.

LED bezel gaskets need to be configured with many holes to match the luminaire array, and will typically be designed using .032" or .062" thick cellular silicone capable of being deflected over 50% without taking a permanent compression set after long term use.

Silicone Foam can be cast to $.032 \pm .016$ " and $.062 \pm .020$ " thick in medium and firm densities with a smooth surface on both sides. The excellent compression set resistance of silicone foam over temperature ranges that would be typical for outdoor LED lighting installations enables long term performance against ingress of dust and water over time. Silicone foam is typically provided in light gray or black which allows the gasket to be hidden from view.



LED Bezel Gaskets



LED Pylon Light

Specifying Gaskets for Outdoor LED Lighting Fixtures

Closed Cell Silicone Sponge can be roto-cured .032±.010” and .062±.015” thick in medium density with a fine textured finish on both sides. Thinner gauges of closed cell silicone sponge may be more difficult to handle during assembly than silicone foam due to the relative elasticity of the two families of materials. For this reason, testing the silicone foam products first is recommended.

Due to the need for potential field replacement due to upgrades and maintenance, bezels gaskets typically do not have pressure sensitive adhesive backing.

As with LED enclosure gaskets, the gasket fabricator should be able to accept electronic files and provide prototype samples for evaluation and testing.

The plastics industry has developed polycarbonate resins that resist the effects of long term UV exposure and heat generated in close proximity of the LED light source. Silicone foam bezel gaskets also resist the effects of UV and Heat aging.

Conclusion

The advances in silicone rubber gasket materials over recent years provide the outdoor enclosure designer more options for long term sealing reliability.

Silicone foam and closed cell silicone sponge have been specified and installed in remote or difficult-to-service installations such as telecommunication base stations and repeaters. Telecom engineers continue to specify both silicone foam and closed cell silicone sponge for access panel gaskets that must last for many years in harsh environments.

Similar to the telecom industry, outdoor LED lighting will require gaskets that effectively seal for the life of the product. Silicone foam and closed cell silicone sponge are commercially available in thickness and density ranges that provide a number of options for the LED Lighting designer.



Outdoor LED Lighting Array

About Stockwell Elastomerics, Inc.

Stockwell Elastomerics, Inc. is a leading manufacturer of custom silicone rubber and elastomeric gaskets, pads and components for demanding technical design requirements. Stockwell Elastomerics' core competence is the fabrication and molding of silicone rubber and similar high performance elastomers. On-site production capabilities include adhesive lamination, slitting, die cutting, water jet cutting and custom molding. Stockwell Elastomerics is ISO 9001:2008 registered.

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