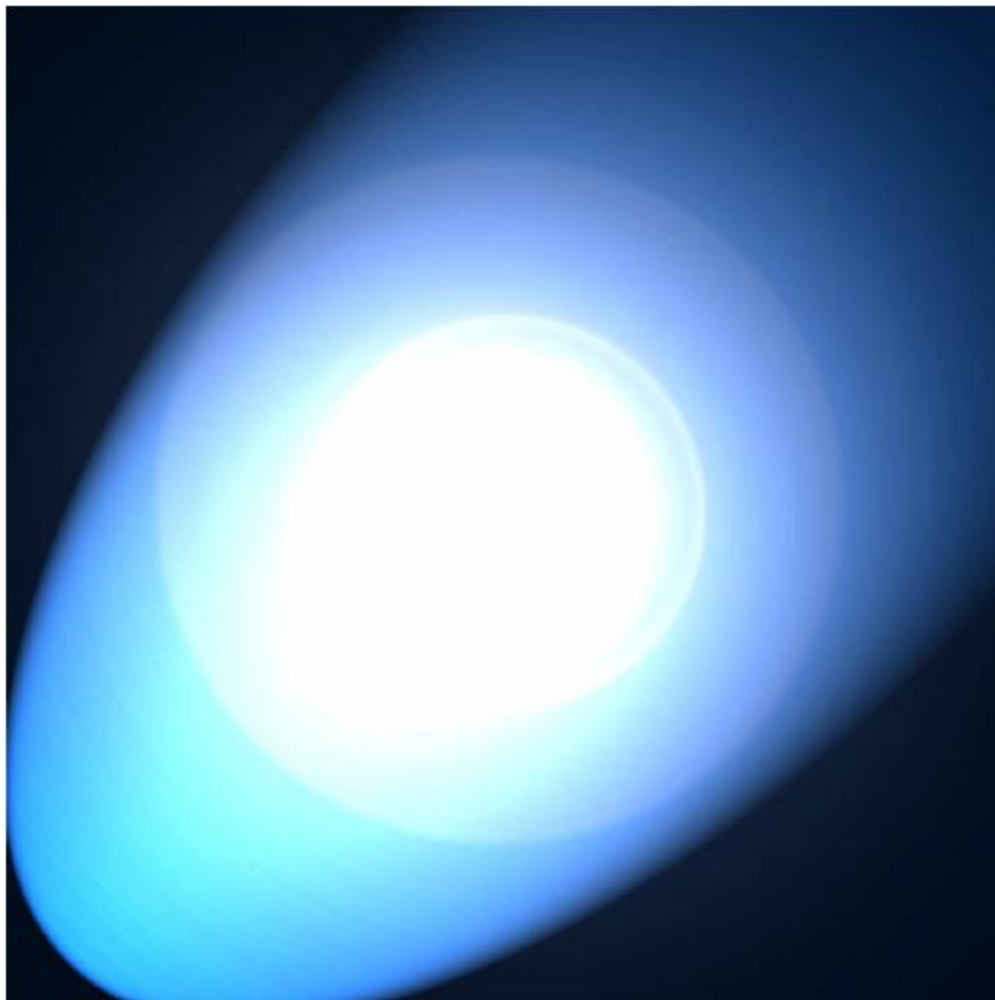


The objective source of lighting product information

Parking Lot and Area Luminaires

Functional Luminaires using HPS and MH Lamps
Volume 9 Number 1, July 2004





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Parking Lot and Area Luminaires

Functional Luminaires using HPS and MH Lamps

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Specifier Reports: Parking Lot and Area Luminaires 3

Introduction

A well-lighted parking lot or outdoor area is an important feature of a shopping center, urban park, apartment building, industrial park, or factory. Well-designed parking lot or area lighting can attract customers, facilitate traffic and pedestrian safety, increase economic development, deter crime and vandalism, and create a sense of personal security. Conversely, lighting that is poorly planned may waste energy, decrease vehicle and pedestrian safety, and may result in light pollution. As with any lighting design, specifying the appropriate luminaires in a parking lot or outdoor area is essential.

In January 1993, the National Lighting Product Information Program (NLPPI) published *Specifier Reports: Parking Lot and Area Luminaires*, which provided information about parking lot luminaires, summarized product information provided by manufacturers, and presented results of application analyses conducted by NLPPI. Since then, parking lot and area lighting luminaires have been examined in new ways. For example, the lighting industry currently is examining the optical efficiency and cutoff properties of these luminaires to determine if high-quality lighting can be achieved while reducing energy consumption, light pollution, and light trespass.

This issue of *Specifier Reports: Parking Lot and Area Luminaires* replaces the previous NLPPI publication by updating information on the critical performance and application issues for parking lot and area lighting luminaires, and identifying the information that a lighting specifier may request from a manufacturer when evaluating different products. This report focuses only on functional luminaires typically used in applications such as parking lots and area lighting, including: the cobra head luminaire, commonly used in roadway lighting but also used for lighting parking lots; the arm mount luminaire, currently the most common type used for parking lot lighting; and the post-top functional luminaire.

This report does not include decorative parking lot or area luminaires such as “teardrop”, “pendant”, or “lantern” style luminaires. It does not discuss high mast lighting systems with luminaires mounted at heights of 60 feet (18.3 meters) or higher because those systems have unique application criteria. This report also excludes wall-mounted or pole mounted “flood” type luminaires as well as ceiling-mounted luminaires used for covered parking. Finally, this report does not discuss indirect, landscape, or façade lighting luminaires.

This issue of *Specifier Reports* is not intended as a tutorial on parking lot or area lighting design. The Illuminating Engineering Society of North America (referred to as IESNA throughout this report), and parking lot and area lighting luminaire manufacturers offer reference materials that address lighting design considerations in detail. Resources are listed on [page 44](#) of this publication.

NLPPI collected data from a variety of commercially available parking lot and area lighting luminaires. A summary of the products from 34 manufacturers, and their characteristics is found in [Table 11](#). NLPPI also purchased 23 luminaires, independently evaluated and analyzed them and compared their performance in terms of luminaire efficiency, glare, light trespass, and sky glow. The selection of these luminaires was limited to luminaires that utilize 250-watt metal halide lamps and the same IES classification. Evaluation results and luminaire analyses are shown in the “Performance Evaluations” section beginning on [page 21](#) and in [Table 13a](#).

Background

Manufacturers of parking lot and area lighting luminaires offer a wide variety of options and accessories for their products aimed to address such issues as light distribution, energy consumption, light pollution, and light trespass, and often customize them for a specific project. Manufacturers can provide luminaires with a wide range of performance characteristics for use in parking lot and area lighting applications as well as other applications such as roadway lighting. The specifier often chooses a luminaire based upon the manufacturer's reputation for service and quality rather than upon the luminaire's individual performance characteristics. The information provided in this issue of *Specifier Reports* will aid in the process of decision-making beyond the manufacturer's reputation and clarify the issues related to the application of parking lot and area lighting luminaires.

Luminaire Types

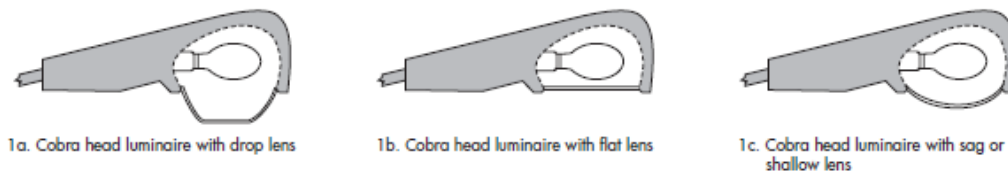
The selection of an appropriate luminaire for a particular application, and the ability to convey the reasons for this selection, require a working knowledge of the relevant luminaire types. This section describes the luminaire types commonly used for parking lot and area lighting applications.

Cobra Head Luminaires

The cobra head luminaire, most commonly used in roadway lighting, is also used for parking lot lighting. This luminaire's optical system typically consists of a horizontally mounted lamp, a reflector, and a lens (Figure 1). This luminaire is available for a wide variety of lamp wattages. Lamps of 250 watts or greater often are used in parking facilities at mounting heights of 20 feet or higher. These units can be mounted in single, twin, or quad configurations (see the sidebar "Mounting Configurations" on p. 6).

The cobra head luminaire is available in IESNA lateral light distribution classification Types I, II, III, and IV (see "Light Distribution" on p. 14). Manufacturers have adapted the optical system of these luminaires in order to limit the light intensity above 80° from nadir (straight down). As a result, the cobra head luminaire is also offered with a flat lens as well as a clear shallow lens to replace the refractor lens as shown in Figure 1. Cobra head luminaires with flat lenses typically cause less glare.

Figure 1. Cobra Head Luminaires



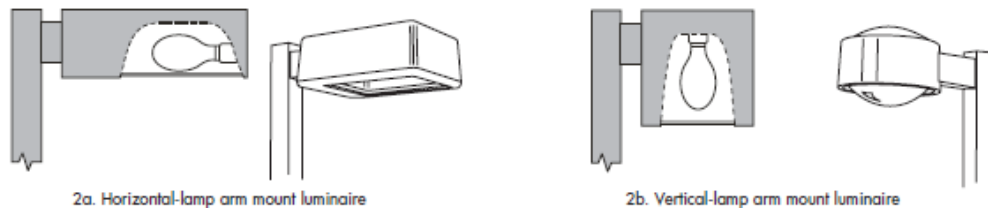
Arm Mount Luminaires

The arm mount luminaire is currently the most commonly used parking lot luminaire. This luminaire type has an optical system that usually consists of either a horizontally or vertically mounted lamp, a reflector, and a lens (Figure 2). Arm mount luminaires are available with various wattage lamps in different-sized housings. Smaller, low-wattage units (150 watts or less) can be mounted as low as 10 feet (3.0 meters); larger units (250 watts or greater) are mounted at typical parking lot pole heights of 20 to 40 feet (6.1 to 12.2 meters). An arm mount luminaire has a short, horizontal mounting arm, and these luminaires can be arranged in single, twin, or quad configurations. Originally designed

with square or rectangular housings, arm mount luminaires are also available in round and domed shapes in a variety of colors and finishes.

Although the outward appearance of the horizontal-lamp luminaire and the vertical-lamp luminaire can be very similar, as shown in Figure 2, their primary functional difference is the light distribution they achieve.

Figure 2. Arm Mount Luminaires



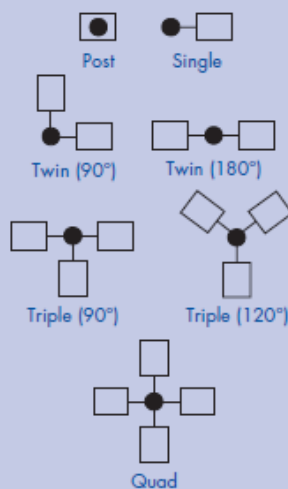
2a. Horizontal-lamp arm mount luminaire

2b. Vertical-lamp arm mount luminaire

Mounting Configurations

Parking lot and area luminaires are pole-mounted in seven different configurations as shown in Figure 4: post, single, twin (90°), twin (180°), triple (90°), triple (120°), and quad. Post-mounting and single-mounting refer to a single luminaire. A post-mounted luminaire is centered over the pole (such as a post-top luminaire); A single-mounted luminaire is positioned on an arm located to the side of the pole (such as an arm mount luminaire).

Figure 4. Luminaire Mounting Configurations



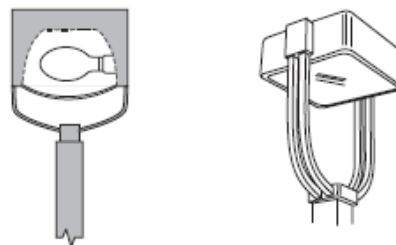
Arm mount luminaires may have full cutoff, semi-cutoff, or cutoff IESNA distributions depending on the lamp orientation, the optics of the reflector, and the optics of the lens. The horizontal-lamp arm mount luminaire, commonly referred to as a "shoebox" or "sharp cutoff" luminaire, provides light distribution Types I, II, III, IV, or V. The vertical lamp arm mount luminaire produces light distribution Types III, IV, or V and minimizes light directly below the unit, compared to luminaires with a horizontally mounted lamp. The vertical-lamp luminaire is usually available with a convex glass lens, although some manufacturers offer flat lens or prismatic refractor options.

Post-top Luminaires

The post-top luminaire is also used for parking lot lighting. This luminaire type has an optical system that usually consists of either a horizontally or vertically mounted lamp, a reflector, and a lens (Figure 3). Post-top luminaires are available with various wattage lamps in different-sized housings. Smaller, low-wattage units (150 watts or less) can be mounted as low as 10 feet (3.0 meters); larger units (250 watts or greater) are mounted at typical parking lot pole heights of 20 to 40 feet (6.1 to 12.2 meters). Because they are mounted on a yoke configuration at the top of a pole, these luminaires are most often used in single configurations.

Similar to the arm mount, the horizontal-lamp post-top luminaire provides light distribution Types I, II, III, IV, or V. The vertical lamp post-top luminaire produces light distribution Types III, IV, or V and minimizes light directly below the unit. The vertical lamp luminaire is usually available with a convex glass lens, although some manufacturers offer flat lens or prismatic refractor options.

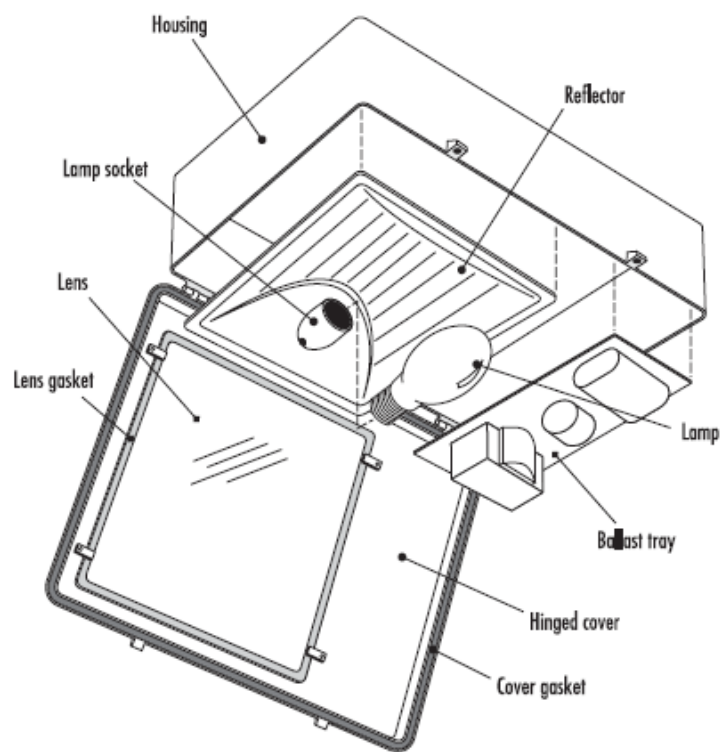
Figure 3. Post-top Luminaire



Luminaire Components

Although luminaire components can be analyzed individually, the overall construction and quality of a luminaire must be evaluated. For example, two luminaires may both be constructed with stainless steel housings, but one of the luminaires may allow water to infiltrate. Similarly, two luminaires may both utilize silicone gasketing, but the design of one of the gasketing systems may provide a better seal. Visual inspection of a product sample is one way to assess the overall quality of a luminaire. Samples usually are available through manufacturers' local representatives. Luminaire components are separated into three sections: optical system, mechanical system, and electrical system. An exploded view of typical luminaire components is given in Figure 5.

Figure 5. Exploded View of Typical Luminaire Components



Optical System

The purpose of an optical system is to produce visible light and redirect that light. A lamp serves as the light source. A reflector uses an opaque material that redirects the light by reflecting it. A refractor uses a transmissive material that redirects the incident light as it passes through it.

Lamps

The most commonly used lamps in parking lot and area lighting applications are high-intensity discharge (HID) lamps. These include high pressure sodium (HPS), metal halide (MH), and mercury vapor (MV). However MV lamps are not recommended by energy efficiency groups, because they are inefficient and their luminous flux output decreases over time to the point that they emit little useful light but still appear to be lighted. Although phosphor coated MH lamps are sometimes used for their improved color properties, the performance of a luminaire's optical system will suffer if a coated lamp is used because the larger, coated outer jacket (bulb) alters the optical size of the lamp.

Low pressure sodium (LPS) lamps are sometimes used for parking lot lighting. A few manufacturers offer parking lot and area lighting luminaires that use incandescent or fluorescent lamps. Among the fluorescent types of lamps is the induction lamp, a type of fluorescent technology that operates without the use of electrodes. This electrodeless lamp may become an important light source for parking lot and area lighting applications in the future because of its ruggedness, good color properties, and long life. With advancements in LED (light-emitting diode) technology, low wattage LED streetlights are also becoming available. As the efficacy of LEDs improve, it may also become an important light source for parking lot and area lighting.

Generally, MH and HPS lamps have greater efficacies and equivalent or longer life ratings than most incandescent and MV sources. The values shown in Table 1 for efficacy and life are for a 250-watt HPS lamp, a probe-start 250-watt MH lamp in vertical, horizontal, and universal mounting positions, a 250-watt MV lamp, and 180-watt and 135-watt LPS lamps. Table 1 provides both

Table 1. Performance Characteristics of Lamps Used in Parking Lot and Area Luminaires^a

Standard Lamp		Lamp Efficacy (LPW) ^b	Lamp Wattage	Life (hours) ^c	Luminous Flux (lumens)		Correlated Color Temperature (K)	Color Rendering Index (CRI)
					Initial	Mean		
HPS		104–116	250	24,000+	26,000–29,000	23,400–27,000	2,000–2,100	21–22
MH (probe-start)	Vertical pos.	70–92	250	10,000	17,500–23,000	11,300–17,000	3,200–4,000	65–70
	Horizontal pos.	69–92	250	10,000–15,000	17,200–23,000	9,400–15,000	3,200–4,300	65–70
	Universal pos.	66–88	250	6,000–10,000	16,600–22,000	10,600–17,500	3,000–5,000	65–75
MV		44–52	250	24,000+	11,000–13,000	8,250–10,800	3,700–6,700	15–50
LPS		167–178	180	16,000–18,000	30,000–32,000	32,000 ^d	1,700–1,800	0
		163–167	135	16,000–18,000	22,000–22,600	19,140–22,600	1,700–1,800	0

^a Philips, GE Lighting, OSRAM SYLVANIA, and Venture Lighting lamp catalogs

^b Efficacy values are for lamps only; ballasts also require power and reduce the efficacy of the lamp/ballast combination. Efficacy is calculated by dividing the initial lamp luminous flux by the lamp wattage.

^c Life ratings are for 250-watt standard lamps, except where noted. These values may be higher for higher wattages or improved lamps.

^d Data only available from one manufacturer

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Lamp Efficacy

LPS lamps have the highest efficacy, which is desirable, but their large size limits the variety of available luminaire designs. This, together with poor color properties, limits the applications appropriate for these lamps. HPS and MH are greatly superior lamp choices. When choosing between HPS and MH lamps for parking lot and area lighting, consider efficacy, lamp life, and color quality. HPS lamps are higher in efficacy and have longer rated lives than MH lamps, but MH lamps have better color properties and may offer an advantage to off-axis vision.

initial and mean luminous flux. Mean luminous flux for HPS, MV, and LPS lamps is at 50% of rated life, while mean luminous flux for MH lamps is at 40% of rated life. MH lamps have lower initial luminous flux as well as mean luminous flux when compared to HPS lamps. Efficacy and life ratings vary for other wattages, with lower-wattage lamps generally providing lower efficacy. These values also vary with improved lamps such as pulse-start MH lamps or non-cycling HPS lamps, among others, which manufacturers offer in addition to the standard types of lamps. Lower wattage (<150 watts) mercury-free HPS lamps are also available. Choosing the “best” lamp requires careful consideration of energy, economic, design, operating, and aesthetic factors. This report is focused on HPS and MH lamp types. In this table, MV and LPS characteristics are provided for comparison.

The position in which metal halide (MH) lamps are installed makes a difference in the color variation and color shift of the lamps. It can also affect a lamp's life, as shown in Table 1. Installing MH lamps in a base-up position generally gives the best results both in terms of color stability and lamp life. Some lamps do equally well when installed base down, while other lamps should only be installed horizontally. The manufacturer's literature should always be consulted to determine the best installation position for a MH lamp. Most manufacturers' catalogs give the luminous flux output for lamps installed in specific burning positions. For more information on mid-range or mid-wattage MH lamps, refer to NLRIP publication, *Lighting Answers: Mid-wattage Metal Halide Lamps*, available online at www.lrc.rpi.edu/programs/nlrp/lightingAnswers/mwml/abstract.asp.

The choice of lamp wattage should be made on the basis of the illumination required, the lighting distribution from the luminaire, and the pole height and spacing. A common mistake in parking lot lighting is to install lamps that are too powerful for the mounting height. These lamps emit too much light for the mounting height used, resulting in glare and uneven light distribution.

Reflectors

The construction of the luminaire's reflector is a major distinguishing factor in its performance and cost. A reflector's optics should avoid redirecting the light back into the lamp, which would reduce the luminaire's efficiency. The goal is to maximize the amount of light coming out of the luminaire. Interchangeable optical systems allow luminaires with the same external housing to have very different optical systems. In some cases the same optical system can be used with lamps of different wattages. However, the position of the lamp's socket must be adjusted to ensure that the position of the lamp's arc tube is optimized with the reflector. Optical systems that can be rotated within the luminaire allow field adjustments to the optical system's orientation after installation.

Most reflectors used in parking lot luminaires are made from aluminum, although some luminaires use glass or plastic prismatic material for the reflector. Common outdoor luminaire reflectors are made of hydroformed aluminum. In this construction method the metal is formed around a male punch. Once the tooling for a particular optical system is complete, these one-piece reflectors can be manufactured economically, and they perform consistently. If a specular finish is required, these reflectors must be mechanically polished. Some manufacturers brighten their reflectors electrochemically in a process known as Alzak®. This results in a specular or semi-specular finish. Diffuse aluminum finishes are available for reflectors as well.

Spun reflectors are the least expensive type to produce. The spinning process shapes a sheet of metal into a reflector on a lathe while pressing it against a form. The finishes available for spun reflectors are the same as those available for hydroformed reflectors.

Segmented reflectors are fabricated from specially designed specular aluminum strips that are shaped and oriented specifically to provide the desired light distribution. Manufacturing costs for segmented reflectors are higher than costs for hydroformed or spun reflectors. Producing segmented reflectors with consistent photometric performance is more difficult than producing one-piece reflectors, but segmented reflectors offer more light distribution options, making it easier to control glare and to create uniform illuminance on the ground.

Lenses

Most luminaires have a glass or plastic lens mounted in the opening to allow light out of the fixture and to seal the luminaire housing to protect the luminaire components. This lens may be a refractor, flat lens, sag lens, or drop lens. A refractor is a type of lens and is often referred to as a prismatic lens. Prisms are designed to refract or spread the emitted light in a specific direction. Refractors are most often used in cobra head luminaires. Other types of lenses, such as clear lenses, can also redirect light, but their main function is to protect the lamp, contain debris when the lamp shatters, and in some cases block ultraviolet radiation. Lens materials used in parking lot and area lighting luminaires include tempered glass, clear glass, borosilicate glass, polycarbonate, and acrylic. Tempered glass lenses are extremely durable and do not deteriorate during their long life. Borosilicate glass is less durable but is able to survive thermal shocks. Polycarbonate is good for applications where vandalism is a problem, because it has extremely high impact resistance. It does become yellow and brittle over time when used in parking lot luminaires, but special ultraviolet inhibitors can slow this process. Acrylic and high-impact acrylic lenses have excellent resistance to ultraviolet radiation, but special, high-temperature acrylic must be used in many of the higher-wattage HID luminaires, which produce higher temperatures.

Mechanical System

The mechanical system provides the structure for a luminaire, including the housing, gasketing, and mounting brackets.

Housing

Luminaires used for parking lot and area lighting must be able to withstand adverse conditions such as solar radiation, saltwater spray, temperature extremes, wind-driven sand and debris, vehicle exhaust, rain and snow, vibration, rocks, and even bullets. Typical luminaire housings are constructed of aluminum, steel, or stainless steel, and non-metallic housings are also available. Aluminum housings endure most outdoor situations, including corrosive saltwater environments. Steel sheet housings are common in lower-cost equipment, but are susceptible to corrosion. Although a protective coating is often applied to the housing, some exposed edges may remain uncoated, or the coating may be scratched during installation and maintenance. More expensive luminaires use extruded aluminum or stainless steel housings. Stainless steel provides superior corrosion protection for extreme environmental conditions. Extruded aluminum housings are almost seamless and are durable in all environments.

A number of finishes are used for parking lot luminaire housings. Anodized aluminum, one of the most permanent finishes available, is only available in natural, bronze, or black, which are referred to as integral color class (ICC) colors. A less permanent and less expensive finish is the dye-anodized finish. An organic dye is used to produce the desired colors, but because the dyes used are organic, they will fade over time with exposure to solar radiation. Painted finishes, such as the polyester powder coat or baked-enamel finish, are available in

Additional System Components

Optical System Accessories

Internal and external louvers and shields are sometimes offered by manufacturers to minimize unwanted light. House-side shields are often used to minimize the light trespass from a luminaire onto a nearby building. Manufacturers also offer caps to stop direct uplight (see the section "Energy and Environmental Issues" on page 19). Retrofitting caps to existing luminaires is becoming a more common practice because it provides a convenient and inexpensive way to reduce unwanted uplight.

Mechanical System Accessories

Mechanical accessories include mounting hardware and various types and lengths of poles.

Electrical System Accessories

Some manufacturers offer photoelectric cells and photoelectric cell receptacles, which are discussed in the section on controls (page 16). Other accessories include quartz restrike and single and double fuses. A quartz restrike system uses quartz incandescent lamps to provide instantaneous light in the event of a power outage because HID sources may require several minutes to restart.

many colors. Painted finishes will also fade over time, and are more easily scratched than the anodized finishes. Some manufacturers offer a warranty on the housing finish.

Gasketing

A well-designed gasket system is essential to keep the luminaire's optical system clean. Poor gasketing can allow dirt or water to penetrate and result in reduced illuminances and increased maintenance or operating costs. When water leaks into a luminaire, the heat from the lamp and ballast causes the moisture to evaporate. The evaporated water may leave a stain on the lens, which reduces the luminaire's light output. Excessive moisture within the luminaire may corrode metal components and cause electrical malfunctions.

Commonly used gasketing materials include rubber (sponge neoprene, ethylene propylene rubber [EPDM, EPT, and Poron®]), polyester fabric such as Dacron® or felt, and silicone. Foam rubber gasketing is used occasionally, but is not as durable. Silicone gaskets are more expensive, but because silicone does not permanently deform with use these gaskets tend to maintain their effectiveness. With use, felt and neoprene materials can become deformed, creating gaps that allow water, insects, or dirt to penetrate. Stiff or non-compliant gasketing may make it difficult to close and clamp the lens frame to the luminaire housing.

Gasketing should be continuous and permanently attached to one surface so it will not fall off during luminaire maintenance. In some cases the optical system of a luminaire is attached to the housing with a molded silicone gasket to create an optical chamber that shelters the optical components from debris and sustains luminaire performance for extended periods of time. Since air will move in and out of the luminaire as it heats and cools during normal operation, some manufacturers allow the luminaire to "breathe" by providing a filter and gasketing system. This reduces substantially any dirt build-up on the lamp surface, interior reflectors, and lenses.

Electrical System

The electrical system includes lamp ballasts, supply wires, and connectors. Although lamps are part of the electrical system, they provide the light source and are included in the optical system section above.

Ballasts

Ballasts for HID lamps are classified by circuit type. Commonly used probe-start metal halide (MH) ballast systems for mid-wattage (175–400 watts) MH lamps include high-reactance autotransformer (HX-HPF), constant-wattage autotransformer (CWA), constant-wattage isolated transformer (CWI), and regulated lag (magnetically regulated) ballasts. CWA ballasts limit variations in wattage, and thus in light output, as voltage varies. CWA ballasts are high power factor ballasts, with power factors greater than 0.90. Another ballast type, HX-HPF, can be used in a wide variety of applications. Ballasts with high power factors draw less current than those with normal power factors, which allows the use of smaller conductors in the electrical distribution system. For more information on ballasts for mid-wattage MH lamps, refer to NLPiP publication, *Lighting Answers: Mid-wattage Metal Halide Lamps*, available online at www.lrc.rpi.edu/programs/nlpip/lightingAnswers/mwmhl/abstract.asp. For more information on HPS ballast systems refer to specific ballast manufacturer catalogs.

Pulse-start MH lamps require a different type of ballast than those described

above. Pulse-start MH ballast systems include super constant-wattage autotransformer (SCWA), linear reactor, and regulated-lag ballasts. The latter is the most sophisticated of all three types and provides the highest power regulation to the lamp.

Most HID lamp ballasts are electromagnetic, but electronic ballasts are becoming available, especially for lower wattage lamp types. Electronic ballasts are only slightly more efficient but may offer features such as dimming, switching, and monitoring functions along with improved lamp performance.

Luminaire Classifications

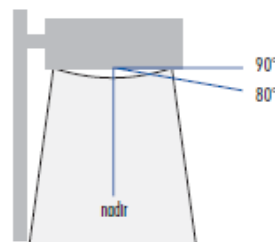
The IESNA classifies luminaires according to different types of cutoff and light distribution. Other classifications, although unofficial, such as by lamp type, lamp position, optical characteristics, or style are also prevalent in the industry. For aesthetic reasons, parking lot and area lighting luminaires can also be classified by their most obvious characteristics—shape and appearance. Unfortunately, decisions based solely on luminaire shape and appearance will tend to overlook issues such as light distribution, luminaire efficiency, energy efficiency, and light pollution.

Cutoff Classifications

Cutoff classifications were adopted by the IESNA as a means to describe and control glare from outdoor luminaires, especially for street lighting. Most planners try to use the fewest luminaires and poles for street lighting. To maximize spacing between luminaires without unacceptable nonuniformity, their luminous intensity at large angles above the nadir should be much higher than their luminous intensity near the nadir. However, such high luminous intensities could potentially cause glare to individuals when the luminaires are viewed from a distance. The cutoff classifications set limits on the luminous intensity permitted at large angles from nadir (such as 80°) and above. Limitations on the luminous intensity in the upward directions (above 90° from nadir) were later incorporated into cutoff classifications to control the amount of direct light going up into the sky.

The IESNA defines four outdoor luminaire cutoff classifications, each with different photometric criteria. For these classifications, two relevant zones are defined with respect to the nadir of a luminaire (Figure 6). One zone applies to angles at or above 80° from nadir; the other covers all angles at or above 90° from nadir. Light emitted in the 80° to 90° zone is more likely to contribute to glare, and light emitted above 90° is uplight.

Figure 6. Angles Referenced by the IESNA Cutoff Classifications



The definitions below are given in terms of *luminous intensity* (in candelas), but the values are made in reference to *luminous flux* (in lumens) of the light source. These values don't necessarily relate to the total amount of light in each zone.

- **Full cutoff**—The luminous intensity (in candelas) at or above an angle of 90° above nadir is zero, and the luminous intensity (in candelas) at or above a vertical angle of 80° above nadir does not exceed 10% of the luminous flux (in lumens) of the luminaire's lamp or lamps.
- **Cutoff**—The luminous intensity at or above an angle of 90° above nadir does not exceed 2.5% of the luminous flux of the lamp or lamps in the luminaire, and the luminous intensity at or above a vertical angle of 80° above nadir does not exceed 10% of the luminous flux of the luminaire's lamp or lamps.
- **Semicutoff**—The luminous intensity at or above an angle 90° above nadir does not exceed 5% of the luminous flux of the lamp or lamps in the luminaire, and the luminous intensity at or above a vertical angle of 80° above nadir does not exceed 20% of the luminous flux of the luminaire's lamp or lamps.
- **Noncutoff**—There is no luminous intensity limitation in the zone above maximum luminous intensity.

Casually skimming these definitions could lead to the assumption that for a cutoff luminaire, no more than 10% of the lamp luminous flux is emitted between 80° and 90° from nadir, or that no more than 2.5% of the lamp luminous flux is emitted above 90° from nadir. In fact, neither of these assumptions is correct.

Careful attention should be paid to the definitions of the various cutoff classifications (Bullough 2002). It is especially important to recognize that the definitions provide limits on *luminous intensity* from a luminaire. This value is expressed as a percentage of the *luminous flux* emitted by the lamp(s) inside the luminaire. For example, the semicutoff classification has an upward (90° and above) luminous intensity limit (in cd) equal to 5% of the lamp luminous flux (in lm). If the luminaire contains a 1000-lm lamp, the luminous intensity from the luminaire in any direction above 90° cannot exceed 50 cd. This differs from a common misinterpretation of the cutoff classifications, which might lead one to assume that the luminous flux from a semicutoff luminaire cannot exceed 5% of the lamp luminous flux. In fact, a semicutoff luminaire with a luminous intensity of 50 cd in every direction above 90° would emit 31% of the lamp luminous flux in the upward direction.

On the other hand, a luminaire (containing the same 1000-lm lamp) emitting no light above 90° would still be considered a semicutoff luminaire if its luminous intensity between 80° and 90° from nadir exceeded 100 cd in at least one direction but did not exceed 200 cd in any direction between 80° and 90°. Thus, a semicutoff luminaire could produce as much as 31% of the lamp luminous flux upward, or as little as 0%.

A luminaire that produces no direct light above 90° cannot automatically be classified as a full cutoff luminaire. To be considered full cutoff, the luminaire must also meet the required luminous intensity limitations between 80° and 90°. For this reason, many specifiers refer to luminaires with no upward luminous flux as *fully shielded* rather than full cutoff. Fully shielded luminaires can be classified as full cutoff, cutoff, semicutoff or even noncutoff luminaires, depending upon their luminous intensity characteristics between 80° and 90° from nadir.

Vertical Illuminance

Cutoff classifications are not useful for comparing the uplight from luminaires (as might be done to address sky glow), because the amount of uplight is not apparent from the cutoff classifications. Cutoff classifications may be useful for comparing the potential for glare, however, because it is possible to calculate the vertical illuminance at an individual's eyes as the individual moves toward a luminaire when the individual's eyes are at or beyond 80° from the nadir of a luminaire. Vertical illuminance at the eye is a useful metric for quantifying disability and discomfort glare (Rea 2000; Boyce 2003). Similarly, for comparing the potential for light trespass, cutoff classifications may be useful if adjacent property lines are located at or beyond 80° from the nadir of a luminaire, for a particular mounting height.

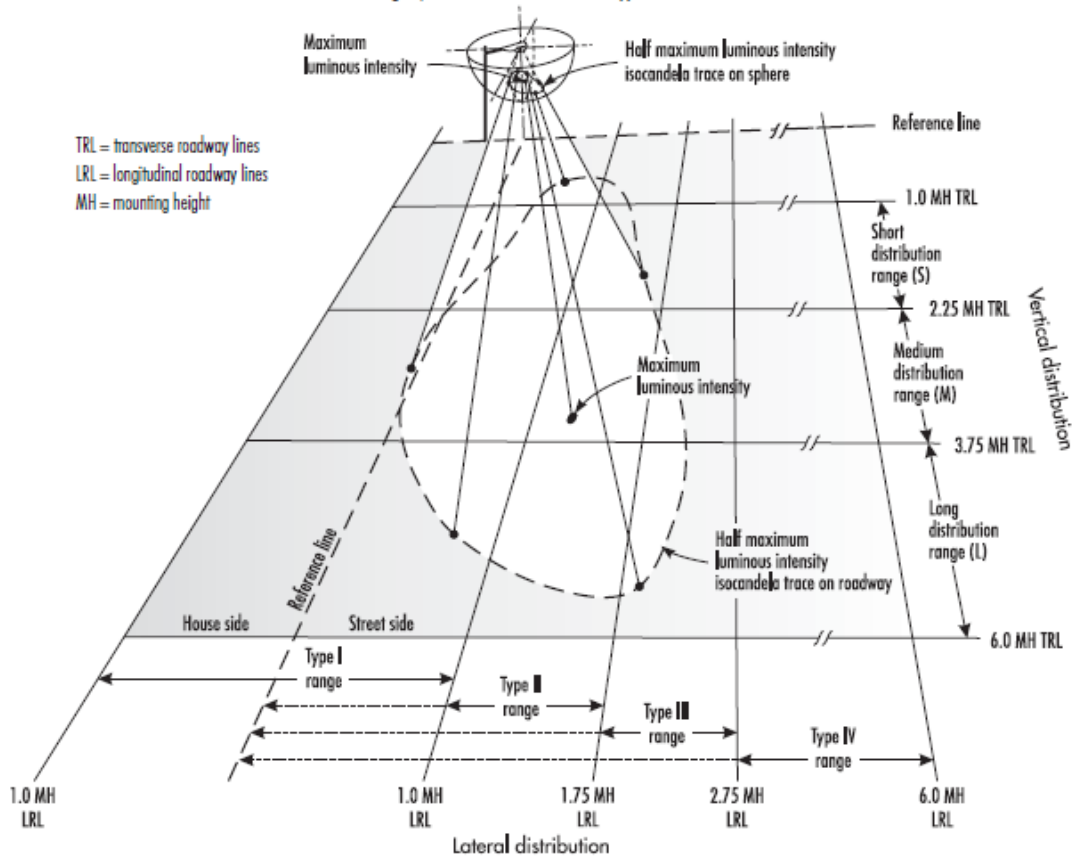
Light Distribution

Luminaire light distribution is defined in terms of vertical light distribution and lateral light distribution. Vertical light distributions are short, medium or long. Lateral light distributions include Types I, II, III, IV and V. Vertical light distributions fall between transverse roadway lines (TRL) and lateral light distributions fall between longitudinal roadway lines (LRL) as shown in Figure 7, based on the luminaire mounting height.

The vertical light distribution is determined based on the location of the maximum luminous intensity value in relation to the TRLs. In Figure 7, the maximum luminous intensity value falls in the medium distribution range from 2.25 to 3.75 mounting height TRL.

Figure 7. Diagram Showing Vertical and Lateral IESNA Distribution

In this figure, the luminaire has a medium Type III distribution.



Adapted from Rea 2000, Fig. 22-7.

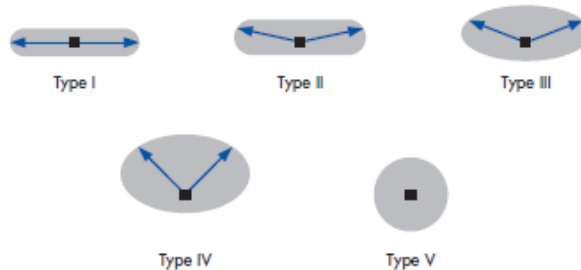
Non-Standard Classifications

While not part of the IESNA lateral light distribution classification, some manufacturers use terms such as *forward throw* to refer to the Type IV distribution, or *asymmetric* to refer to the Type III distribution. They also offer other light distribution patterns such as *square* or *rectangular*. These are identified as Type V-square and Type V-rectangular. While not part of the IESNA vertical light distribution classification, the lighting industry sometimes uses another category known as *very short*. Type III, IV, and V distributions are often used for parking lot and area lighting, while Type I, II, and III distributions are often used for roadway lighting.

Referring again to Figure 7, bounded by the TRLs of the vertical distribution, the lateral light distribution is then determined based on the highest LRL that the half maximum luminous intensity isocandela trace reaches. In this case, within the medium distribution range, the half maximum luminous intensity isocandela trace reaches the Type III range. Therefore, for this figure, the luminaire has a medium Type III distribution. The vertical distribution determines how far down the road the beam extends. The lateral distribution determines the width of the distribution.

The diagrams in Figure 8 further illustrate the lateral distributions of light cast by different types of luminaires. The luminaire is represented by a black square. Arrows show the direction of maximum intensity.

Figure 8. IESNA Lateral Light Distribution Classification Types



Luminaire Considerations

Luminaire Downward Efficiency

The total downward efficiency of a luminaire is expressed by the percentage of the lamp luminous flux that leaves the luminaire in a downward direction. A new luminaire's efficiency is governed by its optical performance. Luminaire efficiency changes over time due to deterioration of luminaire components. For most outdoor luminaires, initial downward efficiencies range from 60% to 90%. Overall performance of parking lot and area lighting systems depends on light distribution, pole layout and heights, and glare characteristics, so the luminaire efficiency value should not be used as the sole selection criteria.

Standards for Luminaires

ANSI (American National Standards Institute) standards exist that define quality levels for electrical materials. Different types of luminaires have multiple ANSI standards that apply. ANSI standards require a level of quality and interchangeability among manufacturers. NEC (National Electric Code) defines a standard for wiring installations performed by licensed electricians.

Maintenance

Maintenance costs for parking lot and area lighting systems can be high, because the mounting heights often require special equipment to access the luminaires. Easily replaced lamps, ballasts, and optical components help to minimize labor costs. Ease of maintenance, however, is also important for the safety of those maintaining the outdoor lighting systems. The less time a person spends replacing failed lamps, repairing faulty electrical components, or dealing with loose fasteners, the less risk there is for accidents to occur. Group relamping, rather than spot relamping, may also help to control maintenance costs (IESNA 2003, DG-4-03).

Dirt depreciation is an important maintenance issue. A clean luminaire is essential for best performance. Poor gasketing that allows dirt or water to penetrate can result in reduced illuminances and may increase maintenance or operating costs over the life of the system (refer to "Gasketing" on page 11).

Simplifying Service

Increasingly more manufacturers are offering products that are easier to service. The ballast and associated electrical parts can be mounted on a separate tray or compartment for easy removal and replacement. Tool-free access trays that hold the electrical components can be easily interchanged with minimum downtime. Electrical plug-in modules, also referred to as "quick disconnects," can minimize the potential for incorrectly reconnecting electrical circuits. Easy access to the lamp compartment eliminates the need for special tools or partial disassembly of the luminaire. Lens replacement should be simplified, because these components can be cracked or broken by extreme weather conditions, handling, or vandalism. Easy-to-find and operate latches, as well as sturdy hinge pins and hanger hooks that do not require tools, will make this process more convenient. Marking the luminaire with the wattage of the lamp required will help to prevent installing the wrong replacement lamp, which can result in short lamp life or other problems.

ANSI C136.15 outlines how a luminaire is to be marked for easy identification of the lamp type and wattage. Compliance with this specification will help prevent installation of the wrong replacement lamp, which could result in short lamp life or other problems.

Controls

Parking lot lighting systems are usually operated by a centralized control system that switches all of the luminaires in an installation as a group. This central system may be operated manually, by a photocell, or a time clock. Astronomical time clocks track the length of daytime throughout the year.

Alternatively, each luminaire can have a photoelectric receptacle for a plug-in photocell unit. The photocell controls the electrical power to the luminaire, so it operates only when the ambient light falls below a certain threshold. The luminaire operates from dusk to dawn and during low-light conditions such as a storm. Photoelectric receptacles are common in roadway, parking lot, and area lighting applications where the electric utility provides the lighting system.

Dusk-to-dawn lighting controls, commonly incorporating a photocell or time clock, ensure that the lighting system is shut off during daylight hours. When luminaires are used in a twin or quad mounting configuration, some of the luminaires may be switched off with a time clock during hours when the parking lot is not expected to be used. This strategy saves energy while maintaining a minimal illuminance for security purposes. A similar control strategy uses a bi-level dimming system, which reduces the power to the lamps by 50% during non-usage hours.

Some manufacturers offer instruments to diagnose the causes of control malfunctioning from the ground, eliminating the need to go up the pole to check the control. In addition, new technology allows wireless communication between poles for maintenance issues to determine which luminaire components require replacement and to monitor lamp life for group relamping.

Safety

Underwriters Laboratories, Inc. (UL) and the Canadian Standards Association (CSA) publish standards for luminaires that address safety issues. Manufacturers that elect to have their products listed by these organizations submit sample products for testing. Electrical or building codes usually require a UL- or CSA-listed luminaire. Luminaires may be listed either as a complete assembly or as being constructed of listed components; the assembly listing is the most comprehensive for the intended use. UL- or CSA-listed luminaires must meet mechanical, electrical, and temperature specifications under stated laboratory test conditions. The listing ensures that a product meets a published operating performance standard. A luminaire that contains listed components, but is not listed as a complete unit, does not necessarily offer this same assurance.

Luminaire Photometry

A photometric report describes the light distribution characteristics of a luminaire. Photometric data are used in computer predictions of illuminances and potential glare. The photometric report should be based on tests performed in accordance with IESNA testing procedures (relevant IESNA publications are listed at the end of this report.) A complete photometric report includes tabulated luminous intensity and luminaire efficiency data, an isointensity or isocandela plot, and a horizontal isoilluminance plot. These data usually are available in an IESNA-approved electronic format known as photometric files or IES files for use in computer calculation programs. Current industry practice is to photometer only the lower hemisphere of roadway, parking lot, and area luminaires, so data on light emissions above 90° from nadir may be difficult to find. These data are becoming more important for light trespass and light pollution calculations, however, so a full photometric report should be requested from the luminaire manufacturer.