NLPIP Lighting Answers

Volume 6 Issue 1 September 2002

MR16 Lamps

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Abstract

This publication answers commonly asked questions about MR16 lamps. Lighting Answers: MR16 Lamps helps lighting professionals understand what MR16 lamps are and their most important performance characteristics. It explains the advantages and disadvantages of using MR16 lamps and the differences between MR16 lamps and other types of reflector lamps. It provides information about issues such as heat and quality differences between different types and grades of MR16 lamps. Finally, this publication provides pointers to lighting professionals on how to choose MR16 lamps for their applications.

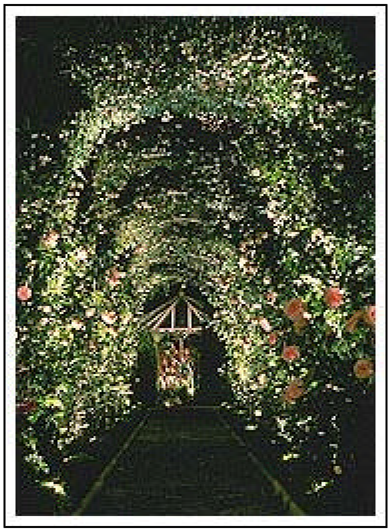
Introduction

MR16 lamps are **halogen incandescent light sources**, and because they are reflector lamps, they provide directional light. Originally used in slide projectors, these lamps are widely used for accent, task, and display lighting in architectural lighting applications such as in museums, art galleries, retail stores, residential settings, entertainment venues, and landscapes, as shown in Figures 1-1, 1-2, and 1-3. MR16 lamps are commonly used for displaying objects because of their higher **color temperature** than standard incandescent lamps, high **color rendering index**, and well-controlled, high-intensity beam. They are usually housed in track, recessed, or pendant **luminaires** for interior applications, and stake, surface-mounted, or below-grade luminaires for outdoor applications.

Figure 1-1. MR16 lamps used in retail applications

Source: Jan Moyer Design

Figure 1-2. MR16 lamps used in landscape



Source: Jan Moyer Design

Figure 1-3. MR16 lamps used in residential settings

Source: Jan Moyer Design

What are MR16 lamps?

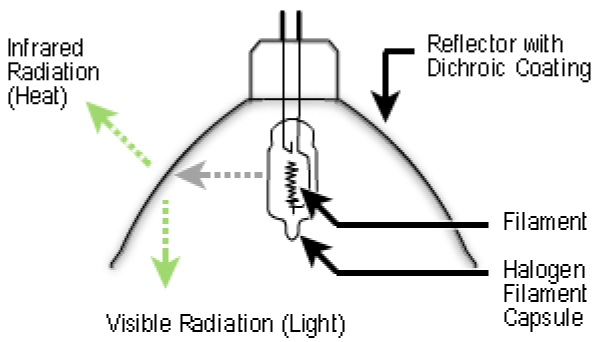
"MR" stands for multifaceted reflector, a pressed glass reflector with the inside (reflecting side) surface composed of facets and covered by a reflective coating. These facets provide optical control by gathering the light from the filament to create a concentrated beam of light. The reflectors of some MR lamps have a smooth inside surface instead of facets, but they are still called MR lamps by convention. Figure 2-1 shows MR16 lamps with different reflector types.

Figure 2-1. MR16 lamps with different reflector designs *

*Incandescent A-lamp on far right shown for size comparison

The light source of MR lamps is a single-ended quartz **halogen** filament capsule. The reflective coating of MR16 lamps can be either dichroic or aluminum. A dichroic coating is a thin, multi-layer dielectric (non-metallic film) that allows infrared radiation (heat) from the filament capsule to pass through the reflector while it reflects visible radiation (light) forward (see Figure 2-2). An aluminum coating is a thin film of aluminum that, unlike the dichroic coating, reflects both infrared and visible radiation. Some MR16 lamps have a cover glass on the front end of the reflector. This cover is a safety measure designed to contain any broken fragments in case the lamp shatters when it fails (see "What are the disadvantages of MR16 lamps?").

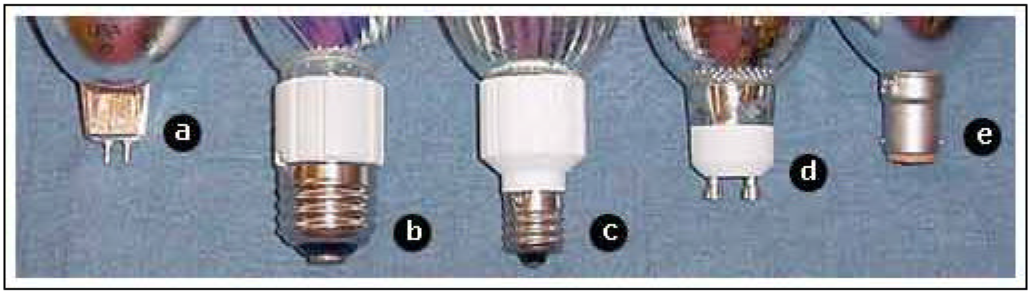
Figure 2-2. Schematic diagram of how a dichroic coating works



MR lamps come in different sizes. The size is determined by the maximum diameter of the lamp in eighth-of-an-inch increments (1 inch equals 2.5 centimeters). The most common MR lamp, the MR16, is 16 eighths of an inch or 2 inches (5 centimeters) in diameter at its largest circumference, hence the name "MR16." Other sizes include MR8 (1 inch, or 2.5 centimeters, diameter) and MR11 (1-3/8 inch, or 3.5 centimeters, diameter). The power ratings of MR16 lamps used in architectural lighting applications range from 10 to 100 watts.

Most MR16 lamps are operated using voltages lower than 120 volts, typically 12 volts. Some MR16 lamps, however, operate using 6 or 24 volts. A **transformer** is needed to reduce the line voltage from 120 or 277 volts to the appropriate level for these lamps. MR16 lamps can be dimmed through commercially available dimmers for low-voltage loads. Most low-voltage lamps have 2-pin bases. Other bases are the bayonet and turn and lock. A new generation of MR16 lamps with an integrated transformer has been developed and marketed in the last few years. These lamps operate on 120 volts and have a screwbase to fit medium-base (Edison) sockets. Figure 2-3 shows samples of commercially available MR16 lamps with different base types.

Figure 2-3. Different MR16 lamp base types



(a) 2-pin
(b) medium screwbase with integral transformer
(c) intermediate screwbase with integral transformer
(d) turn and lock
(e) bayonet

What are the important performance characteristics of MR16 lamps?

There are seven important performance characteristics to consider: lamp life, correlated color temperature (CCT), color rendering index (CRI), lumen maintenance, beam angle and center beam candlepower, lumen output, and luminous efficacy.

Lamp life:

According to manufacturers' catalogs, the **average rated life** of MR16 lamps used in architectural lighting applications ranges between 2000 and 10,000 hours. This lifespan is equivalent to 8 months to 3 years and 4 months, respectively, assuming the lamps are on 8 hours per day. Lowering the supply voltage slightly from its specified operating voltage can extend the life of an MR16 lamp.

Correlated color temperature (CCT):

An MR16 lamp produces light by the incandescence of its tungsten filament. This method of light production, along with the reflector characteristics, determines the lamp's color characteristics. MR16 lamps have a **CCT** of between 2800 K and 3200 K depending on the manufacturer and type of lamp. The CCT of MR16 lamps is higher than that of general incandescent lamps because their filament temperature is higher due to a more compact filament size made for low-voltage use. In addition, the dichroic coatings on the reflectors of MR16 lamps remove some long-**wavelength** light, resulting in higher CCTs. A handful of manufacturers have designed their dichroic reflectors to remove additional long-wavelength light to obtain MR16 lamps with CCTs of up to 4700 K (see "What are MR16 lamps?").

Color rendering index (CRI):

The **CRI** of MR16 lamps ranges between 95 and 100. The color of the light may change as the lamps age. The most common reason for this change is the degradation of the reflector coating over time. Degradation occurs because of the decomposition of the dichroic coating or oxidation of the metallic (aluminum) coating materials. All coating materials undergo this process, but some of them withstand decomposition longer than others. The quality of reflector coatings differs from manufacturer to manufacturer and even between products by the same manufacturer.

Lumen maintenance:

There are two lamp components that determine the **lumen maintenance** of MR16 lamps: the halogen filament capsule within the lamp and the reflector. The lumen maintenance of the filament capsule is excellent because the regenerative **halogen cycle** that occurs within the filament capsule keeps the bulb wall from blackening. The halogen gas removes evaporated tungsten from the bulb wall, preventing bulb wall blackening, and in turn, keeping the **lumen output** relatively constant over time. This process results in higher lumen maintenance than that of non-halogen incandescent lamps. The lumen maintenance of halogen filament capsules varies depending on the quality of components; at 40% of the rated life, it may be as high as 95% (Rea 2000). The reflector, on the other hand, can affect lumen maintenance negatively over time because of degradation of the coating material or dirt accumulation.

Beam angle and center beam candlepower:

Beam angle and **center beam candlepower** (CBCP) are performance parameters that characterize the **beam appearance** and the maximum beam **intensity** of a directional lamp. According to manufacturers' catalogs, the beam angles of MR16 lamps range from 7 to 60 degrees, and their CBCP may range from about 500 up to 15,000 **candelas**, depending on different wattage and beam angle combinations.

Lumen output:

Most lamp manufacturers do not publish lumen output ratings for MR16 lamps or other reflectorized lamps in their catalogs. Instead, they publish beam angle and CBCP, which provide more accurate information about the performance characteristics of the lamp. NLPIP tested several 50-watt MR16 samples of the same type (EXN) to determine their lumen output, which ranged between 560 **lumens** to 710 lumens, and averaged 625 lumens.

Luminous efficacy:

In general, low-voltage halogen lamps have higher **efficacies** than common incandescent lamps because the low-voltage filament is more compact than a 120-volt filament. The low-voltage filament does not need as much electric power to keep it hot. When a low-voltage lamp uses a reflector, its efficacy decreases because of light losses associated with light absorption. NLPIP tested several MR16 samples to determine their efficacy. Efficacies ranged from 12 to 15 lumens per watt. These results account for the light losses from the reflector but not the losses of the **transformer**, which are 10%, as a rule of thumb. MR16 lamps that use an **infrared** (IR) coating on their filament capsules have higher efficacies than non IR-coated lamps. The IR coating used in MR16 lamps is a relatively new technology. It is a multi-layer dielectric film used on the outside surface of the filament capsule to reflect the IR radiation from the filament back to re-heat the filament. This reheating causes the luminous efficacy of the tungsten incandescence radiation to increase because less electrical power is required to heat the filament.

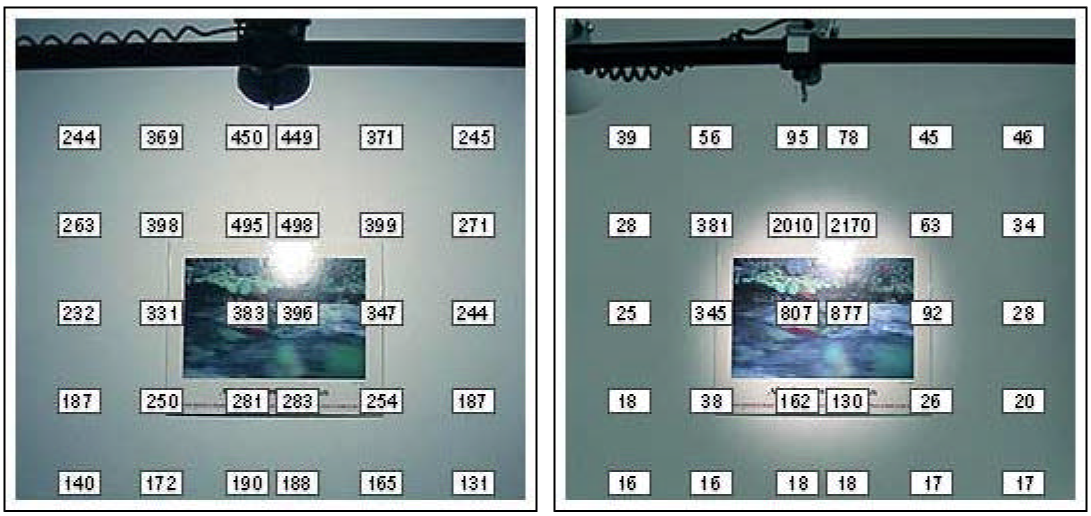
Although reflector lamps, in general, may have lower luminous efficacies than non-directional sources such as compact fluorescent lamps (**CFLs**), their light distribution makes them more effective for directing light in a specific direction without wasting much light elsewhere. Figure 3-1 shows the lighting effects produced on a painting by a 20-watt reflector CFL and a 20-watt MR16 lamp. Figure 3-2 shows how the MR16 lamp provides higher **illuminances** on the painting compared to the reflector CFL. The light from the MR16 lamp is concentrated within its **beam spread** with little light spill outside the painting. MR16 lamps have much better optical control and can produce much narrower beam angles while CFLs, although having higher efficacies (lumens per watt), cannot be easily controlled from an optical point of view because the light source is larger. Figure 3-3 shows a plot of the illuminance measurements across the horizontal centerline of the painting for both lamps. As this graph shows, the illuminances measured at the grid points in the painting area are higher for the MR16 lamp than for the reflector CFL of the same wattage. The average illuminance on the painting is 680 lux (63.2 footcandles) for the 20-watt MR16, versus 375 lux (34.9 footcandles) for the 20-watt reflector CFL. To achieve the same illuminances on the painting using a CFL, one would have to increase the wattage of the CFL lamp by 80%. In this case, the MR16 lamp is more effective in delivering the light where it is needed, which could result in energy savings.

Figure 3-1. Lighting effects of a reflector CFL and an MR16 lamp

20-watt R40 CFL

20-watt 40° MR16 lamp

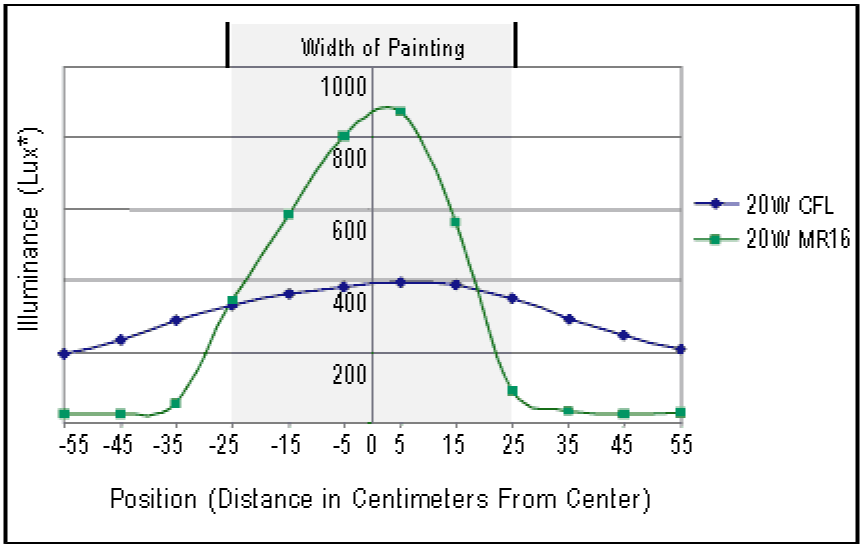
Figure 3-2. Illuminances (lux) on and around the painting from a reflector CFL and an MR16 lamp



20-watt R40 CFL

20-watt 40° MR16 lamp

Figure 3-3. Horizontal centerline illuminance plot of a reflector CFL and an MR16 lamp



*1 lux = 0.0929 footcandles

20-watt R40 CFL vs. 20-watt 40° MR16 lamp

Can a reflectorized lamp be interchanged with an MR16 lamp within a luminaire?

Generally speaking, MR16 lamps cannot be easily interchanged with other reflectorized lamps such as reflector (**R**), parabolic aluminized reflector (**PAR**), or compact fluorescent lamps (**CFLs**) within a **luminaire**. The main challenges are the difference in input voltage, the size of the lamp, and the socket. MR16 lamps need a **transformer** to reduce the voltage from 120 volts to, typically, 12 volts. In addition, the base type for MR16 lamps is, in most cases, different from the medium screwbase of R, PAR, and reflector CFL lamps (see "What are MR16 lamps?"). Medium screwbase MR16 lamps with 120-volt input voltage would make this exchange easier, but it is important to consult with the lamp and luminaire manufacturers to consider safety and performance issues, including:

- the additional heat radiated out of the back of an MR16 lamp and whether the fixture is designed to accommodate this heat
- the aperture size of the luminaires because the size of the lamps most likely will be different
- the size of luminaires themselves because of the location and dimensions of the transformer

On the other hand, luminaires designed for MR16 lamps provide great flexibility because these lamps come in a wide variety of wattages and beam spreads. This interchangeability makes their use worthwhile for many lighting professionals.

What are the advantages of using MR16 lamps?

MR16 lamps have several advantages over other reflectorized lamps such as standard incandescent reflector (**R**) lamps, parabolic aluminized reflector (**PAR**) lamps, and reflector compact fluorescent lamps (**CFLs**). These advantages are their small size, color properties, and beam control.

Size:

MR16 lamps are small. Their 2-inch (5-centimeter) diameter allows for great flexibility, especially where luminaire size is an issue because of space constraints or aesthetic concerns. The ceiling aperture for a downlight luminaire using an MR16 lamp, for example, can be as small as 1¼ inches (3 centimeters) in diameter. These **luminaires** are known as pinhole downlights.

Color properties:

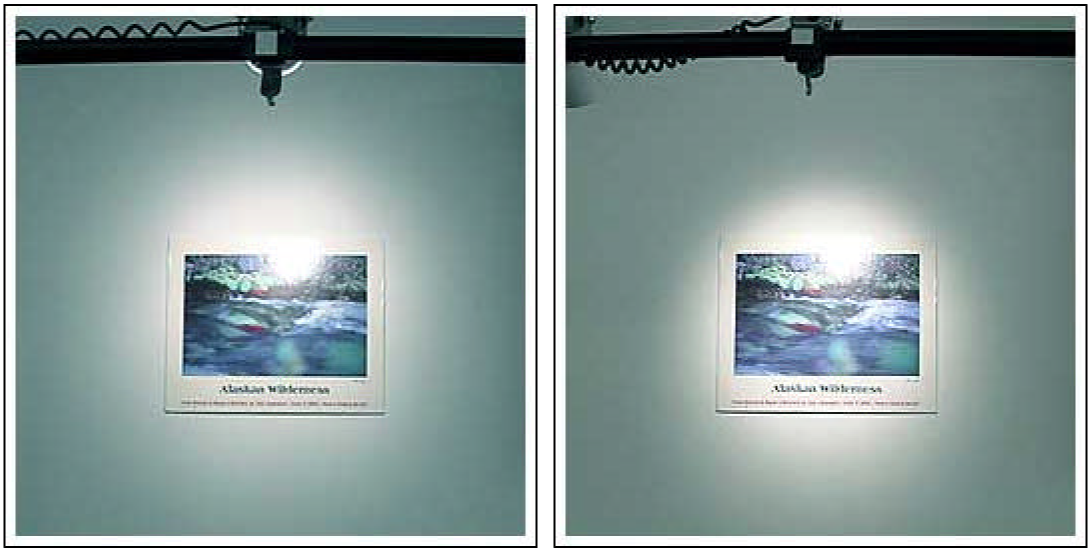
Halogen incandescent lamps such as MR16 lamps provide light that appears whiter (2800 K to 3200 K) compared to the yellowish white light provided by non-halogen incandescent lamps (normally 2700 K). In certain applications such as in retail or museums, whiter light may be more desirable. Halogen incandescent lamps have a higher **color rendering index** (CRI) (CRI of 95 to100) than reflector compact fluorescent lamps (CRI of 82), for example. A higher CRI means that the light source will most likely render the color of objects more naturally and in some cases more vividly.

Beam control:

Low-voltage tungsten filaments in halogen lamps are smaller than those in 120-volt incandescent lamps. The smaller the filament, the better the reflector's optical control for a given size reflector. Manufacturers commonly align the filament coil within the MR16 lamp with an optical system, while R and PAR lamps are aligned mechanically. The MR16's optical alignment gives it more accurate optical control than R and PAR lamps. As a result, MR16 lamps have confined beams, and the light **intensity** drops sharply at the edge of the beam. MR16 lamp beams can be designed to be as small as 7 degrees or as wide as 60 degrees, giving the lighting designer great flexibility.

As an example, it may be useful to compare two specific lamps. In this case, the 50-watt halogen PAR lamp is a flood lamp, while the 50-watt MR16 lamp has a 40-degree beam angle (see "What do I need to know when specifying MR16 lamps?"). Figures 4-1, 4-2, and 4-3 show the lighting effects, **illuminances** on a painting for both lamps, and a graphic plot of the illuminance measurements across the horizontal centerline of the painting for both lamps, respectively. The average illuminance on the painting is 1187 lux (110.3 footcandles) for the 50-watt PAR lamp, versus 1607 lux (149.3 footcandles) for the 50-watt MR16 lamp.

Figure 4-1. Lighting effects of a halogen PAR30 flood lamp and an MR16 lamp

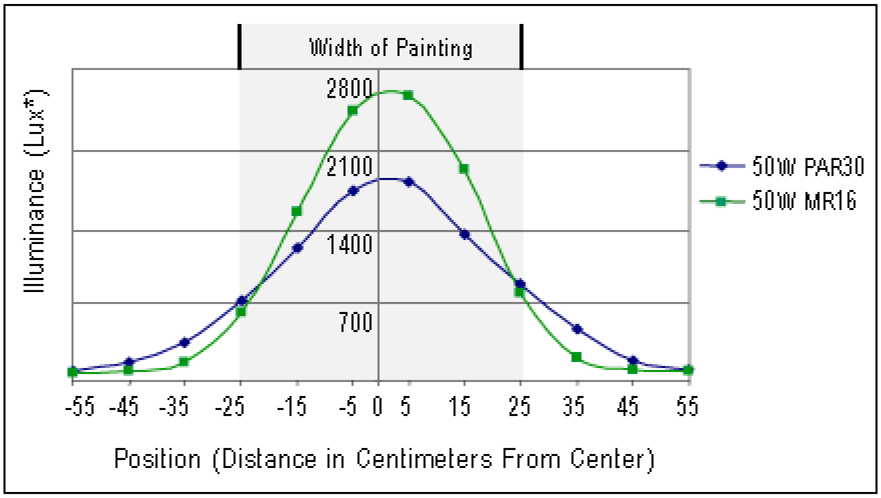


50-watt PAR30 flood lamp | 50-watt 40° MR16 lamp

Figure 4-2. Illuminances (lux) on and around the painting for a halogen PAR30 flood lamp and an MR16 lamp

50-watt PAR30 flood lamp | 50-watt 40° MR16 lamp

Figure 4-3. Horizontal centerline illuminance plot of a halogen PAR30 flood lamp and an MR16 lamp



*1 lux = 0.0929 footcandles

50-watt PAR30 flood lamp vs. 50-watt 40° MR16 lamp

What are the disadvantages of using MR16 lamps?

Improperly used, MR16 lamps can become inefficient or hazardous. They should be handled with caution.

Energy efficiency:

In applications where directional lighting is not necessary, such as in ambient lighting applications, MR16 lamps are not as energy efficient as fluorescent lamps.

Temperature:

The temperature of the filament capsule of MR16 lamps rises to at least 260°C (500°F) to maintain the **halogen regenerative cycle** during operation. Obviously, these temperatures can be dangerous if the capsule comes in contact with skin or flammable materials (Rea 2000). The heat produced by these lamps should be accounted for when considering using them in heat-sensitive applications such as in museums.

Non-passive failure:

The filament capsule of an MR16 lamp is pressurized. The quartz capsule should not be touched with bare hands because the oil and salts from the fingers can corrode the quartz and weaken it. At the end of life, the broken filament coil within the capsule may touch the quartz and melt into it while it is still hot. This event will create defects on the quartz envelope, and defects of this sort can make the capsule shatter. Failure can also occur if the lamp is accidentally struck. MR16 lamps must have a cover glass when used in open **luminaires**. The cover glass contains any broken fragments from the capsule.

What do I need to know when specifying MR16 lamps?

MR16 lamps used in architectural lighting applications come in a variety of wattages and **beam angles**. MR16 lamp manufacturers such as EYE, GE, OSRAM SYLVANIA, Philips, and Ushio offer wattages that range between 10 and 100 watts and beam angles ranging from 7 to 60 degrees. Figure 5-1 shows the lighting effects produced by two lamps with different beam angles.

Figure 5-1. Different beam angles yield different beam spreads

8-degree beam angle (left) vs. 40-degree beam angle (right)

Lighting professionals should understand the language used to identify MR16 lamps. Manufacturers usually have their own lamp codes, but there are standard lamp designations and beam angle nomenclature that make their identification easier.

Lamp designations:

MR16 lamps can be identified by a three-letter code created by the American National Standards Institute (ANSI). The three-letter code represents a specific type of lamp identified by its wattage, bulb shape, and beam angle. For example, "EXN" stands for 50 watts, MR16 lamp, 40 degrees or 50MR16/40°. Lighting professionals can specify MR16 lamps by their ANSI code or by their wattage, bulb shape, and beam angle interchangeably. Table 1-1 shows a partial list of ANSI three-letter designations and their abbreviated descriptive equivalent.

Table 1-1. ANSI designations for some MR16 lamps

ANSI Designation	Lamp Abbreviation* (wattage MR16 / Beam Angle)
BAB	20MR16/40°
ESX	20MR16/10°
EXN	50MR16/40°
EXT	50MR16/15°
EXZ	50MR16/25°
FPA	65MR16/15°
FPB	65MR16/40°
FPC	65MR16/25°
EYC	75MR16/40°
EYF	75MR16/15°
EYJ	75MR16/25°

* Data taken from ANSI C78.379-1994 Annex B

Beam angle nomenclature:

Beam angles are specified in two ways: by the number of degrees (for example, 40 degrees), or by nomenclature that describes the lighting effect produced by the reflector lamp. The National Electrical

Manufacturers Association (NEMA) categorizes MR16 lamps as spot lamps or flood lamps. Some lamp manufacturers have created subcategories to better capture the ranges of beam angles. These subcategories are:

- **VNSP**: Very narrow spot
- **NSP**: Narrow spot
- **SP**: Spot
- **NFL**: Narrow flood
- **FL**: Flood
- **WFL**: Wide flood
- **VWFL**: Very wide flood

Keep in mind that manufacturers may sometimes use these subcategories differently. Table 1-2 shows the differences between some lamp manufacturers. This table does not provide a comprehensive list of all products or manufacturers, but it shows examples of the beam angle nomenclature used by some lamp manufacturers. Lamp manufacturers such as EYE define beam angle as number of degrees only.

Table 1-2. Beam angle nomenclature from different lamp manufacturers

Beam Angle (degrees)	GE	OSRAM SYLVANIA	Philips	Ushio
7	VNSP	*	*	*
8	*	NSP	SP	*
10	*	NSP	SP	*
12	*	*	*	Narrow
13	*	*	*	Narrow
15	NSP	*	*	*
20	SP	*	*	Medium
22	*	*	*	Medium
23	*	*	*	Medium
24	*	*	NFL	Medium
25	NFL	NFL	*	*
28	*	*	*	Medium
30	NFL	*	*	*
35	*	FL	*	*
36	*	*	FL	Wide
38	*	*	FL	Wide
39	*	*	*	Wide
40	FL	FL	*	*
55	WFL	*	*	*
60	*	VWFL	WFL	Super Wide

* Lamp manufacturer does not offer beam angle

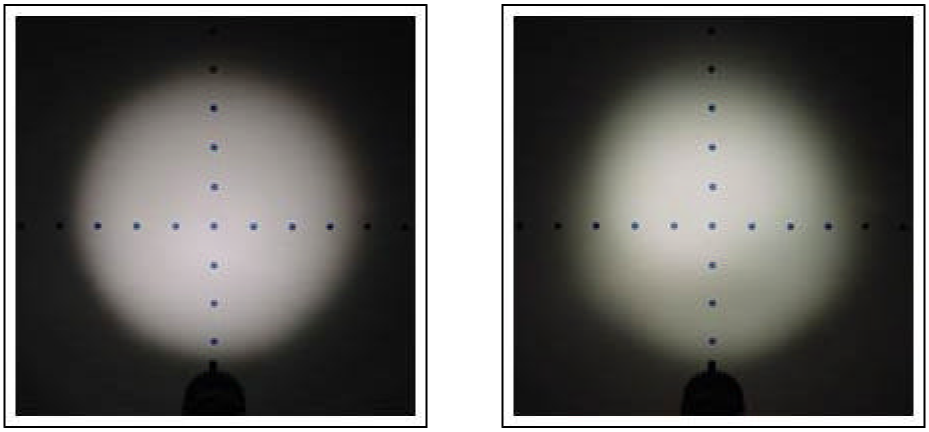
Base type:

Because the most popular base type for MR16 lamps is the 2-pin base (ANSI designation: GU5.3), it is a good idea to specify the base type clearly when a different base is required.

Quality differences:

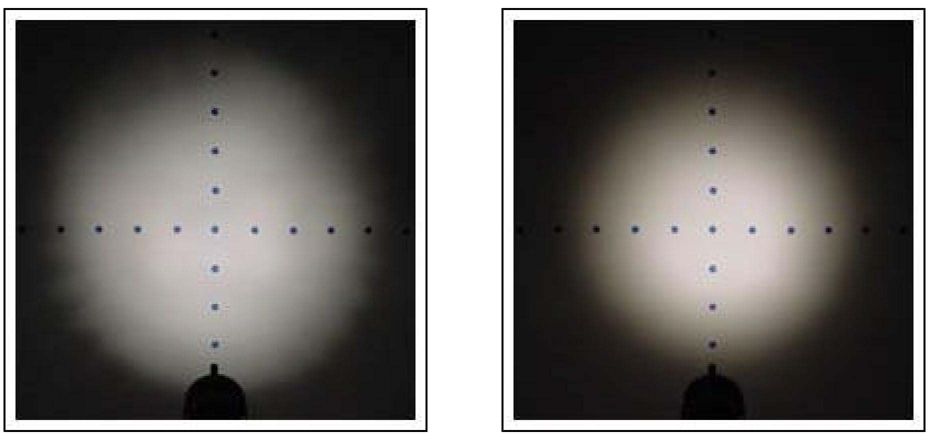
The quality of MR16 lamps can differ between manufacturers and within manufacturers' different product lines. Therefore, MR16 lamps of the same type may produce different results. Figures 5-2 and 5-3 show four MR16 lamps of the same type EXN (50MR16/40°) with obvious differences in the light appearance, light color, **beam appearance**, and actual size of the **beam spread**.

Figure 5-2. Different lighting effects produced by two EXN (50MR16/40°) lamps from different manufacturers



Uniform beam appearance   Non-uniform beam appearance

Figure 5-3. Different beam spreads produced by two EXN (50MR16/40°) lamps from the same manufacturer



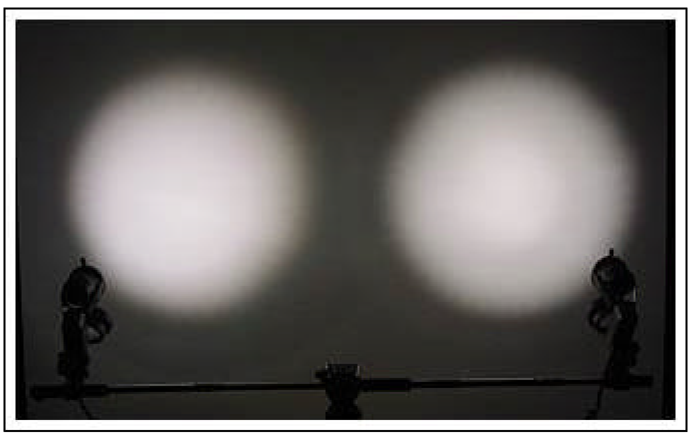
Larger beam spread   Smaller beam spread

Lamp manufacturers offer different quality grades for the same MR16-type lamp. Manufacturers also offer lamps with performance improvements such as color stability over time, better beam quality, a more precise beam angle, or longer life. These improvements are usually recognized from manufacturer to manufacturer through different trade names. Figures 5-4 and 5-5 show examples of different quality grades for the same EXN lamp type.

Figure 5-4. Two grades of EXN (50MR16/40°) lamps from Manufacturer A

The beam appearance on the left has subtle striations (variegated), but the color of the light is whiter and will be more stable over time because of a higher quality reflective coating (see "What are the important performance characteristics of MR16 lamps?")

Figure 5-5. Two grades of EXN (50MR16/40°) lamps from Manufacturer B



The beam appearance on the left is more uniform (smooth), while there is a ring (ripple) shade for the beam on the right

Heat:

MR16 lamps can create heat. Excessive heat from these lamps could potentially damage objects illuminated by these sources. MR16 lamps with aluminum coatings on their reflectors will send more heat forward than MR16 lamps with dichroic coatings. Lamps with dichroic coatings are also called "cool beam" because the coatings allow most of the heat from the filament capsule to pass through the reflector while reflecting only visible radiation to the front (see "What are MR16 lamps?").

NLPIP performed a simple experiment to examine how quickly the heat produced by two MR16 lamps affected a heat-sensitive object. Two EXN (50MR16/40°) lamps from the same manufacturer were used, one with an aluminized reflector and the other with a dichroic reflector. Figures 5-6 and 5-7 show the experimental setup and results. Two pieces of chocolate of the same shape and mass were put on a plate 20 centimeters (8 inches) away from the lamps for 10 minutes. The chocolate under the MR16 lamp with the aluminum reflector melted within that time and began to deform when the plate was tilted. The chocolate under the MR16 lamp with the dichroic reflector held its shape, and only its surface began to melt within the same time.

Figure 5-6. MR16 lamp with aluminum reflector

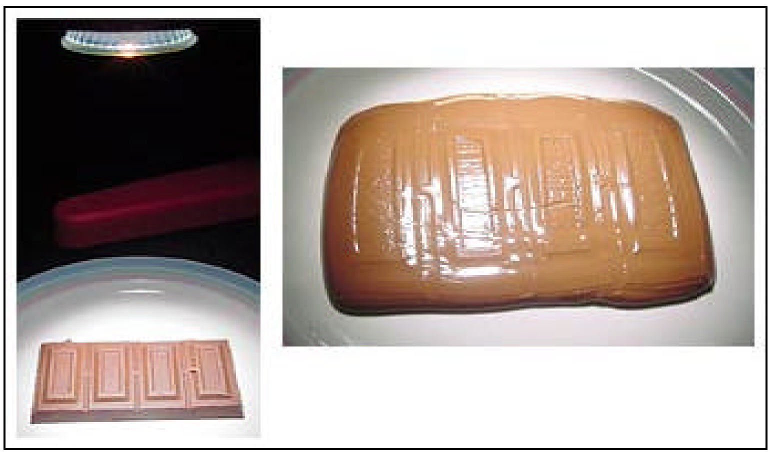


Image on right shows chocolate after 10 minutes

Figure 5-7. MR16 lamp with dichroic reflector

Image on right shows chocolate after 10 minutes

Ultraviolet radiation:

The envelope material of a tungsten filament capsule determines the amount of **ultraviolet** (UV) radiation emitted. The envelope material for MR16 lamps is quartz. Quartz transmits most of the UV radiated by the filament, while regular glass absorbs UV radiation. If an MR16 lamp does not have a cover glass, the luminaire must have a lens or cover glass that, in addition to providing the required safety protection in case of lamp breakage, filters out most of the UV radiation. Some quartz halogen lamps have additives in the quartz designed to significantly reduce the amount of UV radiation transmitted by the quartz bulb (Rea 2000).

How much do MR16 lamps cost?

The MR16 lamps supplied by some lighting manufacturers such as GE, OSRAM SYLVANIA, and Philips can cost from $3 to $27 each. This price varies depending on wattage, **beam angle**, coating technology, and where the lamp is purchased. Retail prices of MR16 lamps vary significantly among vendors. Specialty MR16 lamps such as projection, medical, and airport specialty lamps can cost much more.

There is an additional initial cost when specifying MR16 lamps. Except for the lamps that operate at 120 volts, all MR16 lamps require **transformers**. Typically, however, each transformer operates more than one lamp based on load capacity (wattage). The cost of transformers varies depending on the transformer technology used, operating condition (indoor or outdoor, dry or wet location), input-output voltage, and load capacity. Table 3-1 lists examples of different types of transformers and their approximate prices. According to transformer manufacturers, the average life of a transformer can be up to 28 to 35 years.

Table 3-1. Examples of the cost of different transformers

Operating condition	Input-Output voltage	Capacity (wattage)	Approximate Price (US$ each)
Indoor	120V-12V	60W	$20
Indoor	120V-12V	100W	$30
Indoor	120V-12V	300W	$75
Outdoor	120V-12V	60W	$50
Wet Location	120V-12V	200W	$110

How do I choose the most appropriate MR16 lamps for my application?

Selecting MR16 lamps can be complicated, and the process of selecting these lamps may be different from application to application. The following are general guidelines for selecting MR16 lamps:

- Choose MR16 lamps with the **beam angle** and **center beam candlepower** (CBCP) necessary to obtain the appropriate lighting effect and **illuminances**. Be aware that the beam angle and CBCP of MR16 lamps of the same type may be different between manufacturers and even within the same manufacturer (see "What do I need to know when specifying MR16 lamps").

- Refer to manufacturers' catalogs for the **average rated life** of the MR16 lamps you intend to use to learn how often you will need to replace these lamps.

- Consider the **correlated color temperature** (CCT) of the lamp. Manufacturer catalogs list CCTs. Be aware that although the CCTs of MR16 lamps of the same type may be equal in catalogs, the actual appearance of color may vary from manufacturer to manufacturer or between grades of lamps for the same manufacturer (see "What do I need to know when specifying MR16 lamps?").

- Depending on the application's context, beam quality may be very important. Given that there are different grades of MR16 lamps on the market with drastically different beam qualities, lighting professionals should familiarize themselves with the different lamps' characteristics by examining the manufacturers' catalogs or by actually testing the lamps to learn more about their **beam appearance** and color.

- Pay attention to the heat from MR16 lamps. If the application is heat sensitive, choose MR16 lamps with a dichroic-coated reflector (see "What do I need to know when specifying MR16 lamps?").

Resources

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Acknowledgements

NLPIP thanks Thomas Golz, Bill O'Connell, Victor Roberts, and Tianji Zhao for providing important technical information to this project.

Other Lighting Research Center personnel who contributed include Andrew Bierman, Jean Paul Freyssinier, Russ Leslie, Lenda Lyman, and Jan Moyer.

The people above are listed to acknowledge their contributions to the publication. Their approval or endorsement of this publication is not necessarily implied.

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Lighting Answers - MR16 Lamps
Volume 6 Issue 2 September 2002

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Glossary Terms

Average rated life	The number of hours at which half of a large group of product samples fail under standard test conditions. Rated life is a median value; any lamp or group of lamps may vary from the published rated life.
Beam angle	The angle at which luminous intensity is 50 percent of the maximum intensity.
Beam appearance	The description of the beam's image on a wall as determined by subjective visual evaluations of each lamp. The descriptive categories used are smooth, cloud, two-contour, ripple, and variegated.
Beam spread	The width of a light beam, expressed in degrees. The beam of light from a reflector-type lamp (PAR, R, ER, or MR) can be thought of as a cone. The beam spread is the angular width of the cone. Common beam spreads are known as spot, narrow, narrow flood, and flood.
Candela	The Systeme International d'Unities (SI) of luminous intensity. One candela is one lumen per steradian. Formerly, candle.
Center beam candlepower (CBCP)	Center beam candlepower is the luminous intensity at the center of a beam, expressed in candelas (cd).
Color rendering index (CRI)	A measure of the degree of color shift that objects undergo when illuminated by a lamp, compared with those same objects when illuminated by a reference source of comparable correlated color temperature (CCT). A CRI of 100 represents the maximum value. A lower CRI value indicates that some colors may appear unnatural when illuminated by the lamp. Incandescent lamps have a CRI above 95. The cool white fluorescent lamp has a CRI of 62; fluorescent lamps containing rare-earth phosphors are available with CRI values of 80 and above.
Compact fluorescent lamp (CFL)	A family of single-ended fluorescent-discharge light sources with small-diameter [16-millimeter (5/8-inch) or less] tubes.
Correlated color temperature (CCT)	A specification of the apparent color of a light source relative to the color appearance of an ideal incandescent source held at a particular temperature and measured on the kelvin (K) scale. The CCT rating for a lamp is a general indication of the warmth or coolness of its appearance. As CCT increases, the appearance of the source shifts from reddish white toward bluish white; therefore, the higher the color temperature, the cooler the color appearance. Lamps with a CCT rating below 3200 kelvins are usually considered warm sources, whereas those with a CCT above 4000 kelvins usually considered cool in appearance.
Dichroic coating (dichroic filter)	A multi-layer coating that transmits certain wavelengths and reflects those not transmitted.
Efficacy	The ratio of the light output of a lamp (lumens) to its active power (watts), expressed as lumens per watt.
Halogen cycle	Halogen incandescent lamps are in the same family as standard incandescent lamps. The basic operating principle is the same, except that chemicals called halogens are introduced in the gas fill. When electricity passes through the lamp's filament, it is heated until it glows and emits light. In this process, tungsten from the filament evaporates and, over the life of the lamp, causes the glass bulb wall to slowly blacken and the filament to disintegrate until the lamp fails. Halogens remove evaporated tungsten from the glass wall and redeposit it back onto the filament. As a result, tungsten does not build up on the bulb, so the light output does not degrade as rapidly.

Halogen lamp	An incandescent lamp that uses a halogen fill gas. Halogen lamps have higher rated efficacies and longer lives than standard incandescent A-lamps.
Illuminance	The amount of light (luminous flux) incident on a surface area. Illuminance is measured in footcandles (lumens/square foot) or lux (lumens/square meter). One footcandle equals 10.76 lux, although for convenience 10 lux commonly is used as the equivalent.
Infrared radiation	Any radiant energy within the wavelength range of 770 to 106 nanometers is considered infrared energy. (1 nanometer = 1 billionth of a meter, or 1 X 10^{-9} m).
Intensity (luminous intensity)	Total luminous flux within a given solid angle, in units of candelas, or lumens per steradian.
Lumen (lm)	A unit measurement of the rate at which a lamp produces light. A lamp's light output rating expresses the total amount of light emitted in all directions per unit time. Ratings of initial light output provided by manufacturers express the total light output after 100 hours of operation.
Lumen maintenance	The ability of a lamp to retain its lumen output over time. Greater lumen maintenance means a lamp will remain brighter longer. The opposite of lumen maintenance is lumen depreciation, which represents the reduction of lumen output over time. Lamp lumen depreciation factor (LLD) is commonly used as a multiplier to the initial lumen rating in illuminance calculations to compensate for the lumen depreciation. The LLD factor is a dimensionless value between 0 and 1.
Luminaire	A complete lighting unit consisting of a lamp or lamps and the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamp(s) to the power supply. (Also referred to as fixture.)
PAR lamp	An incandescent or tungsten-halogen incandescent lamp with a hard glass bulb and an interior reflecting surface, a precisely placed filament, and a lens to control beam spread. The lens is hermetically sealed to the reflector. Metal halide PAR-lamps are also now available.
R lamp	A common reflector lamp. An incandescent filament or electric discharge lamp in which the sides of the outer blown-glass bulb are coated with a reflecting material so as to direct the light. The light-transmitting region may be clear, frosted, or patterned.
Transformer	Transformers are electrical devices with no moving parts, which change distribution voltages to higher or lower levels. When used with incandescent or halogen lamps, they typically step 120-V distribution downward to 12V, although 5.5V and 24-V models are also offered.
Ultraviolet	Any radiant energy within the wavelength range 100 to 400 nanometers is considered ultraviolet radiation (1 nanometer = 1 billionth of a meter, or 1 X 10^{-9} m).
Wavelength	The distance between two corresponding points of a given wave. Wavelengths of light are measured in nanometers (1 nanometer = 1 billionth of a meter, or 1 X 10^{-9} m)

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