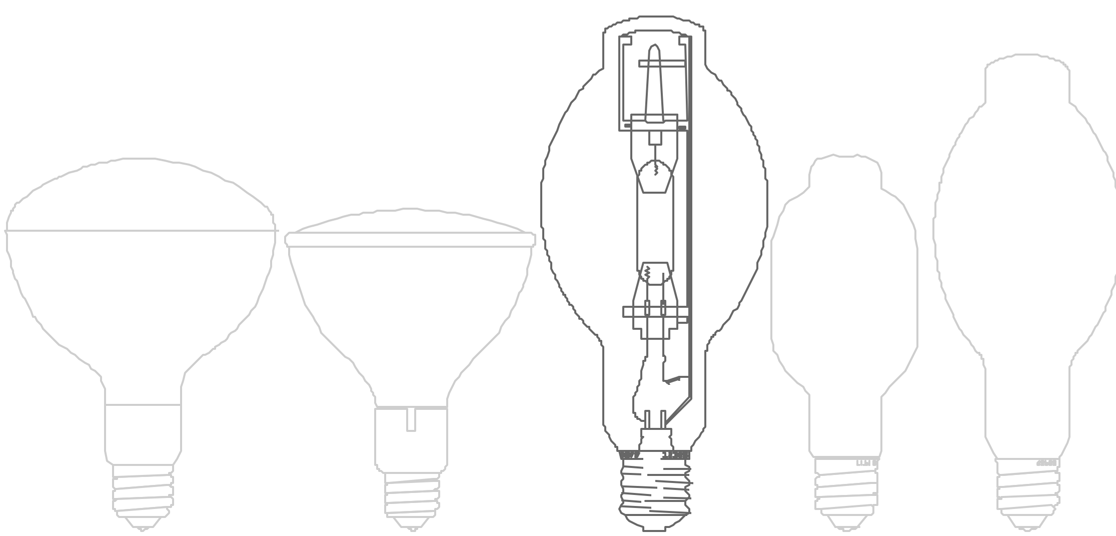
Engineering Bulletin

High Intensity Discharge Mercury Lamps



SFA-HID-MEREB-0696

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The two families of OSRAM SYLVANIA INC. mercury lamps are designed primarily for use in general lighting applications where good efficiency, long life are desired and color rendering requirements are moderate. Applications include streetlighting, industrial hi-bay, parking lot lighting, and general floodlighting.

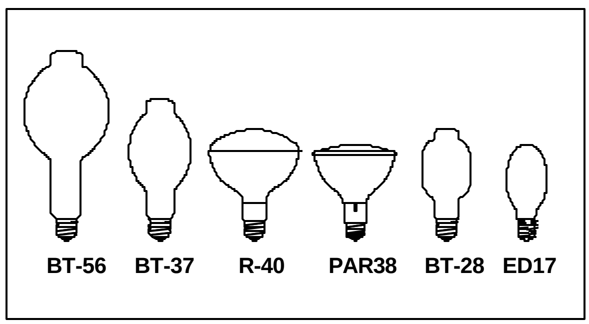
STANDARD MERCURY

Available in a wide range of lamps from 40/50-1000 watts in clear and one type of phosphor coating to improve color rendering capabilities. PAR lamps offer floodlighting and UV for special lighting applications.

MERCURY SAFELINE®

Lamps of 100-1000 watts designed to self extinguish when the outer bulb is broken. Recommended for use in OPEN FIXTURES installed in sports facilities and other places of public assembly where lamps may be subject to breakage by external objects.

OSRAM SYLVANIA MERCURY LAMPS
Bulb Shapes and Sizes



LAMP CONSTRUCTION

The basic parts of a typical mercury lamp are shown in Figure 1. Although there are many sizes and several shapes of mercury lamps, the most commonly used types are of two bulb construction with an outer bulb “jacket” and an inner bulb “arc tube”. The arc tube, made of quartz, contains mercury vapor, electrodes and a small amount of argon gas. The outer bulb, usually filled with nitrogen, protects the arc tube from damage and atmospheric corrosion. It also regulates the arc tube operating temperature and acts as a filter to absorb ultraviolet radiation.

OSRAM SYLVANIA mercury lamps have a rough service one-piece arc tube mount frame construction. The arc tube is firmly supported and correctly positioned by spring spacer supports. The operating electrodes are of trimetallic oxide construction which insures high electron emission and maximum lumen maintenance. A formed tungsten rod supports a spaced tungsten coil with trimetallic oxide emissive compound embedded firmly within the spaced coils and protected by a threaded tungsten coil. The outer bulb is made of Borosilicate (hard) glass, and the mechanical brass base has a date recording feature for marking the month and year the lamp was installed. In some mercury lamps, the inner surface of the outer bulb is coated with a white phosphor which improves the color by converting a large part of the ultraviolet energy radiated by the arc into visible light, predominantly in the red region of the spectrum.

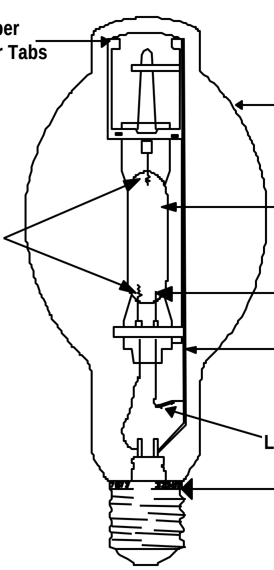


Figure 1.

THEORY OF OPERATION

In the mercury lamp, light is produced by the passage of an electric current through a gas or vapor under pressure instead of through a tungsten wire as in the incandescent lamp. The first practical mercury lamp was the Cooper-Hewitt lamp developed by Peter Cooper Hewitt in 1901. This was a tubular source about 4 feet long which produced light that was distinctly bluish-green in color at a high efficacy compared with the incandescent lamps of those days. The first high-pressure mercury lamp, similar to the ones used today, was introduced in 1934 in the 400-watt size. Lamps now available range in size from 40 watts to 1000 watts.

Ballasts of the correct size and type are required to operate mercury lamps on any standard electrical circuit to convert the distribution voltage of the lighting circuit to the required starting voltage for the lamp and to control the current during operation of the lamp. This current control is necessary because the mercury lamp, like all discharge light sources, has a “negative resistance” characteristic. Once started, the arc will “runaway” with itself and draw an excessive current that will destroy the lamp if not controlled by a ballasting device. Various types of ballasts for mercury lamps are described on pages 11 and 12.

When the line switch is turned on, the starting voltage of the ballast is impressed across the gap between the operating electrodes at opposite ends of the arc tube and also across the small gap between the operating electrode and the starting electrode. This ionizes the argon-mercury in the arc tube by means of a Penning effect. The starting current between the electrode and the probe is limited to a small value by the starting resistor. When there is sufficient ionized argon and mercury vapor distributed throughout the arc tube, an arc strikes between the operating electrodes. This vaporizes more mercury, and the lamp quickly warms up to a stable condition. After the main arc strikes, the starting resistor causes the potential across the starting gap to be too low to maintain that discharge, and the lamp current flows between the operating electrodes.

The ions and electrons which comprise the current flow, or “arc discharge,” are set in motion at tremendous speeds on the path between the two operating electrodes at opposite ends of the arc tube. The impact of the speeding electrons and ions on the surrounding gas or vapor briefly changes their atomic structure. Light is produced from the energy given off by the affected atoms as they change back to their normal state.

ANSI LAMP DESIGNATIONS

Mercury lamps have identifying designations of their own. This system is authorized and administered by the American National Standards Institute (ANSI). All designations start with the letter "H" from the Greek word "Hydrargyrum", meaning mercury. Following this is an arbitrary number or numbers which indicate the electrical characteristics of the lamp and ballast. If there are two numbers, it indicates that the lamp will operate from either type of ballast. The two following letters identify the bulb size, shape, finish and other physical characteristics, excluding color. Following this is a dash and the lamp wattage. Where the outer bulb is phosphor-coated, a slant line and one or more letters are added to specify the color. For example, the H33GL-400/DX designation for the 400-watt Brite-White Deluxe mercury lamp breaks down as follows:

ANSI Designation:

H	-	Indicates mercury lamp
33	-	Number for 400-watt ballasts
GL	-	Two arbitrary letters which describe the physical characteristics of the lamp, such as bulb size, shape and finish.
400	-	400 lamp watts
DX	-	Indicates Brite-White Deluxe color. This part of the designation does not appear on clear lamps.

LAMP TYPES

Mercury lamps for general applications range in size from 40/50 to 1000 watts. The most widely used mercury lamps are the 175, 250, and 400 - watt sizes. Although the various sizes cannot be separated exactly by applications, the following groupings may be made by wattages and common applications.

40/50 - 100 Watt (ED-17, PAR38, R40)
These compact mercury lamps are approximately the same size as the ordinary 150-watt incandescent lamp and provide up to 2-1/2 times the light output of the corresponding wattage incandescent lamps. They can be used for post lanterns, patios, motor courts, parking areas, building entrances and residential applications.

100, 175 and 250-Watt (BT-28, R40 Bulbs)
Applications for these low-wattage lamps include general lighting in low bay areas, residential and secondary street lighting and floodlighting. For blacklight applications in the theater, nightclubs and other entertainment areas, the clear lamps are used with a filter. They are available in clear and several phosphor-coated types.

400-Watt (Mogul Base, BT-37 Bulb)
This is the most popular lamp in the mercury line. Applications include street and roadway lighting, industrial lighting in medium and high bay areas and for floodlighting parking lots. Clear and phosphor-coated types are available.

1000-Watt (Mogul Base, BT-46 and BT-56 Bulbs)
Included in the 1000-watt mercury lamps applications are roadway lighting in heavily traveled areas, high bay industrial lighting and floodlighting for parking lots. These lamps are made in clear and several phosphor-coated types.

CAUTION: The 1000-watt lamp is available in two types- the H34 High Current and the H36 Low Current. The former has a nominal operating current of 8 amperes and a rated average life of 16,000 hours, as compared with 4 amperes and 24,000 hours respectively, for the latter. They are not interchangeable and must be operated on ballasts designed for that lamp type. Lamps and ballasts could be destroyed if H34, H36 lamps are interchanged. Consult warning label.

PERFORMANCE DATA

Table 2 on page 6 lists nominal values for physical, electrical and photometric characteristics of OSRAM SYLVANIA Mercury lamps. Dimensional and electrical values shown are equal to or exceed ANSI standards wherever applicable.

PERFORMANCE DATA FOR OSRAM SYLVANIA MERCURY REFLECTOR LAMPS

Performance data for all mercury reflector lamps are listed in Table 1. Electrical parameters are the same as those given for standard types of comparable wattage in Table 2 on page 6.

OSRAM SYLVANIA Mercury Reflector lamps provide optical directionality with the high output feature of mercury sources. In common with other reflector lamps, they offer built-in reflectors that virtually eliminate the need for labor to clean fixtures. They have long life, which further reduces the need for labor, and have good lumen maintenance. Reflector lamp sources simulate actual fixtures in themselves because of the built-in reflector and several other characteristics which produce various beam distributions from spot to very wide flood. Although they can be used without luminaires, it is recommended that they be installed in a metal housing to protect the bulb from impact or other harm.

Reflector Descriptions

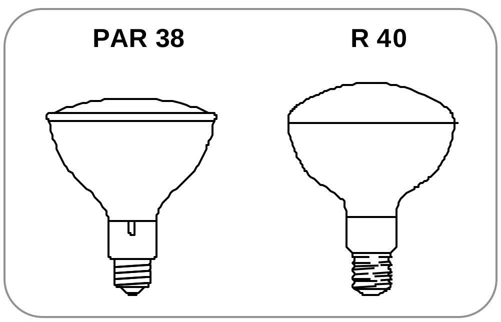


Figure 2.

Color Designations

Mercury lamps are available in color designations including "Brite White Deluxe" and "Clear and Blacklight". Nominal spectral distributions for comparison can be found on page 13.

Candlepower Distribution

Table 1 lists the nominal center beam candlepowers. The 100 Watt PAR 38 reflector lamps are available in a spot and narrow flood design. Nominal candlepower distribution curves are shown on page 8.

TYPES AND APPLICATIONS

100 Watt PAR-38
Available in spot distribution (see Figure), these lamps can be used for general floodlighting. The distinctive blue-green color is well suited to brightlighting shrubs and trees. However, they are most often used with a filter for blacklight applications, such as the locating of cracks and other defects in metal parts and decorative blacklighting.

100 and 175-Watt R-40
These lamps, with Brite White Deluxe color and medium base, can be applied in areas where reflector indcandescent are presently being used. The many applications for these lamps include private security lighting, low-bay warehouse lighting and landscape floodlighting. They are also recommended for lighting walkways, driveways, yards and patios.

TABLE 1. PERFORMANCE DATA FOR OSRAM SYLVANIA MERCURY REFLECTOR LAMPS

NOMINAL LAMP WATTS(1)	ANSI DESIGNATION	OSRAM SYLVANIA ITEM NO.	BULB(2)	BASE	MAX. OVERALL LENGTH (inches)	COLOR DESIGNATION	INITIAL(3) (100 HR) LUMENS	MEAN(4) LUMENS	MAXIMUM BEAM CANDLEPOWER	BEAM SPREAD & DISTRIBUTION	RATED AVERAGE LIFE (Hours)
100	H44GS-100	68843	PAR 38	Medium	5 7/16	Clear, blacklight	2500	1950	16,000	Spot	16,000
100	H44GS-100/MDSK	68846	PAR-38	Med. Skt.	5 7/16	Clear, Blacklight	2500	1950	16,000	Spot	16,000
100	H44JM-100	68844	PAR38	Admed	5 7/16	Clear, Blacklight	2500	1950	4,300	Narrow Flood	24,000+
100	H38BP-100/DX	69405	R-40	Medium	7 1/2	Brite White Deluxe	2500	2000	507	Flood	24,000+
175	H39BP-175/DX	69406	R-40	Medium	7 1/2	Brite White Deluxe	5100	4100	1,300	Flood	24,000+

TABLE 2. PERFORMANCE DATA FOR OSRAM SYLVANIA MERCURY SAFELINE LAMPS

NOMINAL LAMP WATTS(1)	ANSI DESIGNATION	OSRAM SYLVANIA ITEM NO.	BULB(2)	BASE	MAX. OVERALL LENGTH (inches)	COLOR DESIGNATION	INITIAL(3) (100 HR) LUMENS	MEAN(4) LUMENS	RATED AVERAGE LIFE (Hours)
100	H38JA-T100/DX	69410	ET 23 1/2	Mogul	7 1/2	Brite White Deluxe	3600	3000	24,000+
175	H39KC-T175/DX	69414	BT-28	Mogul	8 5/16	Brite White Deluxe	7700	6750	24,000+
250	H37KC-T250/DX	69418	BT-28	Mogul	8 5/16	Brite White Deluxe	11000	9050	24,000+
400	H33GL-T400/DX	69422	BT-37	Mogul	11 1/2	Brite White Deluxe	19800	16000	24,000+
1000	H36GW-T1000/DX	69305	BT-56	Mogul	15 3/8	Brite White Deluxe	55450	44900	24,000+

REFERENCE NOTES

(1) Lamps measured on ANSI reference circuit at rated wattage.
(2) Maximum bulb diameter in eighths of an inch. Dimension given is nominal.
(3) Approximate initial lumen output values after 100 hours with lamp operated at rated wattage on ANSI circuit.
(4) Approximate mean lumens at 40% rated life with lamp operated at rated wattage on ANSI circuit.

TABLE 3. PERFORMANCE DATA FOR OSRAM SYLVANIA MERCURY LAMPS

ITEM NO.	NOMINAL LAMP WATTS(A)	ANSI DESIGNATION	BULB SHAPE & SIZE	BASE TYPE (ALL SCREW TYPE) NICKEL-PLATED BRASS	MAX. OVERALL LENGTH (inches)	LIGHT CENTER LENGTH (inches)	ARC LENGTH (inches)	COLOR DESIGNATION	INITIAL (100 HR) LUMENS(C)	MEAN (40% AVE RATED LIFE) LUMENS	MINIMUM STARTING VOLTS			LAMP OPERATION VOLTS (NOMINAL)		LAMP OPERATING CURRENT (AMPS, NOM.)		RATED AVG LIFE (Hours)(E)
											98% (D) +50°F	90% (D) 5°F	90% (D) -22°	Vert.	Horiz	Vert.	Horiz	
69400	40/50	H45/46DL-40/50/DX	ED-17	Medium	5 1/8	3 1/8	0.7	Brite White Deluxe	1650	1480	180/200	180/200	180/200	90/95	93/95	.53/.60	.535/.60	24,000+
69402	75	H43AV-75/DX	ED-17	Medium	5 7/16	3 3/4	1.1	Brite White Deluxe	2700	1800	220	220	225	130	133	0.66	0.66	24,000+
69403	100	H38AV-100/DX	ED-17	Medium	5 7/16	3 3/4	1.2	Brite White Deluxe	4200	3560	220	220	225	130	130	0.85	0.88	24,000+
69407	100	H38HT-100	ET-23 1/2	Mogul	7 1/2	5	1.2	Clear and Blacklight	4000	3380	220	220	225	130	130	0.85	0.88	24,000+
69408	100	H38JA-100/DX	ET-23 1/2	Mogul	7 1/2	5	1.2	Brite White Deluxe	4100	3300	220	220	225	130	130	0.85	0.88	24,000+
69411	175	H39KD-175	BT-28	Mogul	8 5/16	5	1.8	Clear and Blacklight	7700	7150	210	210	225	130	128	1.5	1.55	24,000+
69412	175	H39KC-175/DX	BT-28	Mogul	8 5/26	5	1.8	Brite White Deluxe	8400	7700	210	210	235	130	128	1.5	1.55	24,000+
69415	250	H37KB-250	BT-28	Mogul	8 5/16	5	2.2	Clear & Blacklight	11600	10800	198	210	225	130	129	2.1	2.15	24,000+
69416	250	H37KC0250/DX	BT-28	Mogul	8 5/16	5	2.2	Brite White Deluxe	12500	11000	198	210	225	130	129	2.1	2.15	24,000+
69419	400	H33CD-400	BT-37	Mogul	11 1/2	7	2.8	Clear & Blacklight	20500	18700	198	210	225	135	130	3.2	3.4	24,000+
69420	400	H33GL-400/DX	BT-37	Mogul	11 1/2	7	2.8	Brite White Deluxe	22000	18800	198	210	225	135	130	3.2	3.4	24,000+
68893	400	H33AR-400	T-16	Mogul	11	7	2.8	Clear	19500	16500	198	210	235	135	130	3.2	3.4	12,000
69332	1000	H34GW-1000/DX	BT-56	Mogul	15 3/8	9 1/2	5.9	Brite White Deluxe	55000	44000	200	325	390	135	134	8.0	8.1	16,000+
69307	1000	H36GV-1000	BT-56	Mogul	15 3/8	9 1/2	6.1	Clear and Blacklight	55200	50000	375	375	390	265	252	4.0	4.3	24,000+
69331	1000	H36GW-1000/DX	BT-56	Mogul	15 3/8	9 1/2	6.1	Brite White Deluxe	60500	48500	375	375	390	265	252	4.0	4.3	24,000+

(A) Nominal lamp watts do not include ballast wattage. Ballast wattage is approximately 10-15% of lamp watts. Consult individual ballast manufacturers data.
Warm-up time 4-5 mins. Re-start time 4-6 mins.

(B) Bulb diameter given in eights of an inch. Dimension given is nominal dimension. Example: BT-56 is 56 eights or 7 inches diam.

(C) Approximate initial lumen values given after 100 hours of operation with lamp operated at rated watts. Initial footcandle reading should not be taken before 100 hours of operation.

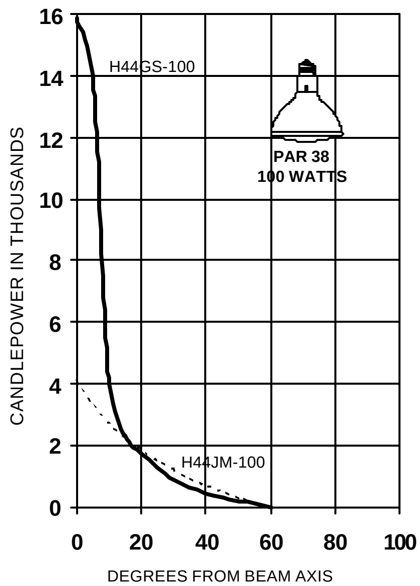
(D) Minimum starting volts required to assure given starting reliability at indicated temperature denotes, for example, that at 5°F with 210 volts open circuit voltage available that 90% of the 400-watt lamps will ignite and stabilize to 95% of their minimum rated voltage within 15 minutes based on 1.414 open circuit voltage crest factor. Although a lower open circuit voltage may ignite the lamp, a higher open circuit voltage than this minimum may be required for proper warm-up, stabilization and reliability of starting throughout the life of the lamp. If a higher ratio of peak to rms is provided, up to a value of 1.8, the rms voltage may be decreased below that specified in the data sheets, provided that the peak voltage is increased 1% for each 2% decrease in the rms voltage and that the rms voltage is not reduced below the voltage necessary for stable lamp operation.

(E) Rated life and mean lumens based on 10 hours operating time per start. Mean lumens based on ballast crest factors of 1.4 to 1.5 mean lumens decrease with higher crest factors.

(F) For 50 watt operation , an H46 ballast is required.

(G) Consult appropriate ANSI Standard for more additional ballast information.

CANDLEPOWER DISTRIBUTIONS



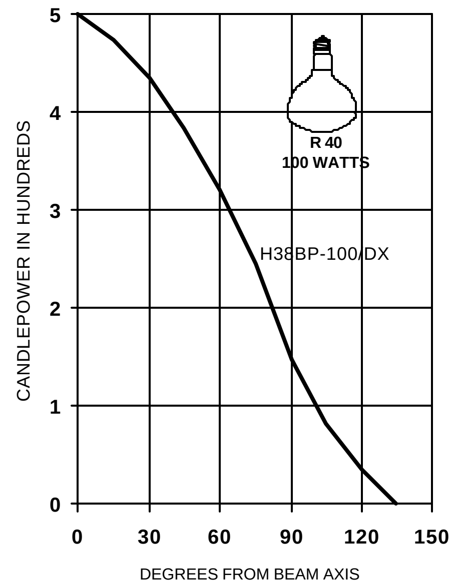


Figure 3.

The above candlepower distributions are nominal. Actual performance will vary with lamps.

OPERATING CHARACTERISTICS OF MERCURY LAMPS

Lamp Life

Long average life is one of the outstanding characteristics of mercury lamps. Nearly all general lighting mercury lamps, 100 watts to 1000 watts have a rated average life of 24,000+ hours. The 100-watt medium base PAR-38 lamps have a life rating of 16,000 hours. The H33AR-400 and H34GW-1000/DX (high current) have an average rated life of 12,000 and 16,000+ hours respectively. The typical survival curve for 24,000+ hour mercury lamps based on 10 hours per start and operation on an ANSI approved circuit is shown in Figure 4. The actual lamp life in applications depends to a large extent upon operating conditions operating cycle, ambient temperature, line voltage and ballast design.

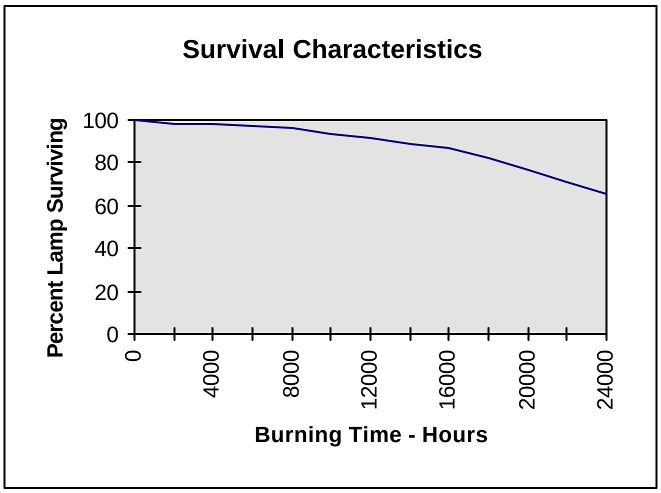


Figure 4.

Lumen Maintenance

In common with other discharge light sources, the light output of mercury lamps gradually declines throughout life, principally the result of the deposit of emission materials (including tungsten) from the electrodes on the walls of the quartz arc tube. The initial rating point of all mercury lamps is at 100 hours of operation because much of the “clean up” of impurities takes place during the first 100 hours of operation. After this period, lamps of the same basic design stabilize in their operating characteristics and the decline in light output then becomes much more gradual.

Figure 5 illustrates the declining trend in lumens of OSRAM SYLVANIA mercury lamps from the 100 hour rating point to the burning time selected on the charts. The graph illustrates a range of lumen depreciation. From mean lumen values, it should be noted that the lumen maintenance is better for clear lamps than for corresponding sizes in color types and is somewhat better for vertical operation than for horizontal. The approximate mean lumens for the various types, determined by integrating the lumen maintenance curves at 16,000 and 24,000 hours, are listed in Table 2. Lumen maintenance range shown below are based on operation on ballasts with current crest factors of 1.4 to 1.5; ballasts with higher crest factors will produce lower lumen maintenance and mean lumens.

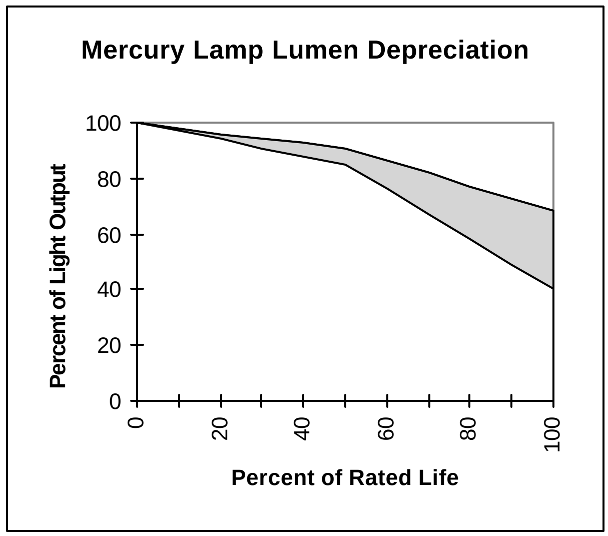


Figure 5.

Starting and Warm-Up

During the starting and warm-up period of a mercury lamp (described on page 3 of this bulletin) there are variations in lamp volts, lamp current, lamp watts and light output. The amplitude and time of these variations are controlled by several conditions including lamp type, ballast type, line voltage, open or enclosed fixture, ambient temperature and wind speed. Normal operating values are generally reached after a warm-up period of four to five minutes. With a typical 400-watt mercury lamp operated on a reactor or autotransformer ballast, the current drops and the voltage rises during the warm-up period until a point of stabilization is reached.

Effect of Line Voltage Variation

If the mercury ballast is tapped, it is very important to match the tap connection to the line voltage measured at the ballast for best lamp performance. Some ballasts are tapped to accommodate more than one line voltage, such as 120/240, and some have taps for line voltages that are different from nominal values, such as 110/120. Variations in the line voltage of the ballast will increase or decrease the lamp watts in various amounts, depending on the ballast type, as shown in Figure 6.

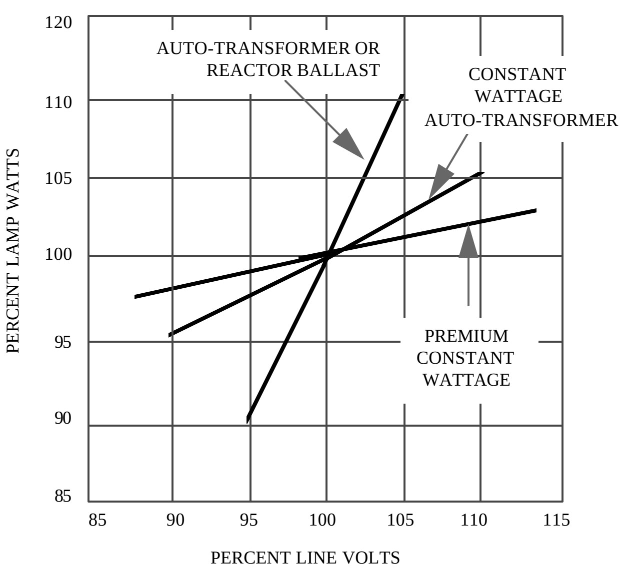


FIGURE 6. Effect of line voltage variation on lamp watts with various ballast types.

Lamp Operating Position

The published light output ratings of mercury lamps are for operating in a vertical position. When the lamps are operated horizontally, the wattage, light output and lamp efficacy decrease slightly. The reason for this is that the arc in the horizontal position tends to bow upward and comes closer to the cooler quartz arc tube wall which slightly reduces the vapor pressure in the arc.

Effect of Temperature

Unlike fluorescent lamps, the lumen output of mercury lamps is not significantly affected by changes in ambient temperature because the outer bulb acts as an insulator for the arc tube. However, to assure satisfactory starting at low temperatures, ballasts that supply higher starting voltages are required. The minimum starting volts to assure given starting reliability at 50°F, 0°F and -20°F are listed in Table 3. For extreme low temperature starting, a Metalarc ballast can be used. Excessive base and bulb temperatures (above 210°C on the base of mogul screw lamps or above 400°C on the bulb walls) may cause lamp failure or unsatisfactory performance due to damage to the arc tube, outer bulb, or other lamp parts. Luminaires with reflectors that concentrate the heat and light rays on either the outer bulb or the inner arc tube can cause overheating and short life.

Stroboscopic Effect

The arc in a mercury lamp operated on a 60 hertz alternating current is completely extinguished 120 times per second. The light from the clear lamp also goes out completely, but with the phosphor-coated lamps, there is some phosphorescent or “carry-over” action. That is, the coating continues to glow for a short period of time after the radiation from the arc is cut off. However, there is still a rapid variation in light output which, under certain circumstances, may produce what is called stroboscopic effect. Because of the stroboscopic effect, an object that is moving at a uniform speed may appear to move in jerks. Under the most extreme conditions, a rotating object, such as a fly wheel, may seem to be standing still or even rotating in a reverse direction. Stroboscopic effect is often unnoticed, and in most installations, it is not a problem. It may be reduced by operating pairs of lamps on lead-lag type ballasts or three lamps on separate phases of a three-phase circuit. Many installations of mercury lamps are performing satisfactorily in areas where very fast motion occurs, such as machine shops, gymnasiums, tennis courts and other sports areas.

Direct Current Operation

Although mercury lamps are designed for operation on alternating current, they can be operated successfully on direct current if the proper ballasting circuit is used. The d-c voltage must be high enough to start the lamp, and a resistor of the correct size should be connected in series with the lamp to limit the lamp current. Published light output, lumen maintenance and life ratings do not apply to mercury lamps when operated on d-c circuits. The polarity of the D.C. supply should be reversed each time the lamp is used to avoid excessive bombardment of one cathode with attendant lower maintenance and life.

Radio Interference

Mercury lamps that are operating normally will not interfere with radio or television reception, except possible for a brief period during starting. If RF noise seems to be caused by a lamp, it can generally be traced to a defective ballast or circuit.

BALLASTING MERCURY LAMPS

Mercury lamps, in common with all high intensity discharge lamps, must be operated with an auxiliary device called a ballast. The principle functions of the ballast are the provision of sufficient voltage to start the lamp and the limiting of operating current to the lamp. If the current in an HID lamp were not limited, it would quickly increase until the lamp burned out. All mercury lamps require a ballast that is designed to meet ANSI specifications for proper lamp operation.

Low Power Factor Reactor Ballast

The low power factor reactor is the simplest type of ballast. It consists of a wire coil wound on an iron core placed in series with the lamp, and its only purpose is to limit the current in the lamp. Reactors can only be used when the line voltage is greater than the lamp starting voltage. Inherently, the power factor of the circuit is about 50% lagging.

Since the reactor only performs the function of current control, it is the most economical, smallest and most efficient ballast. However, it provides very little regulation or fluctuations in line voltage and is not recommended where line fluctuations exceed 5%. The connection schematic is shown in Figure 7.

High Power Factor Reactor Ballast

The reactor ballast can be corrected to high power factor by the addition of a capacitor across the line as shown in Figure 8. Both lamp current and regulations are essentially the same as with the low power factor reactor. The capacitor connected across the lines does not affect the lamp circuit but increases the power factor of the system to better than 90%. In addition, it reduces the value of the input current under starting and operating conditions almost 50% over the low power factor system, which permits the use of a larger number of ballasts and lamps on a line of a given wire size.

Low Power Factor Autotransformer Ballast

When the line voltage is below the minimum lamp starting voltage, a transformer is used in conjunction with the reactor to raise the line voltage. Normally this type of operation is performed by a combination of a secondary winding in series with a primary winding forming a single piece autotransformer, also called a high reactance ballast. This circuit has a power factor of approximately 50%, and the same advantages and disadvantages as the low power factor reactor circuit. A schematic drawing of this type of ballast is shown in Figure 9.

High Power Factor Autotransformer Ballast

The autotransformer ballast can be provided with high power factor by the addition of a capacitor to the primary circuit, as depicted in Figure 10. In order to provide a more economical system, the high power factor autotransformer is generally designed with an extra capacitor winding. This combination of extended windings and capacitor increases the system power factor to approximately 90%. The effect on input current is the same as in the high power factor reactor. Lamp performance and regulation also remain the same.

Constant Wattage Autotransformer Ballast

For applications where a stabilized light output is required with varying line voltages, the constant wattage or regulated type of ballast should be used. A ballast which supplies a reasonable degree of regulation and also has a small economical size is the constant wattage autotransformer (CWA). Other benefits accrued from the use of the CWA ballast are high power factor, low line extinguishing voltage and line starting currents that are lower than operating currents.

The basic electrical difference between the CWA ballast and the high power factor autotransformer ballast is that the capacitor is used in series with the lamp, as shown in Figure 11, rather than as a parallel component. This arrangement allows the lamp to operate with better wattage stability when the voltage on the branch circuit fluctuates. When the capacitor performs an important ballasting function, as it does in the CWA ballast, the circuit is called a lead circuit. In lag circuits inductance serves as the ballasting impedance, such as in the reactor and the high reactance autotransformer ballast. The capacitor used in the lag circuit is purely a power factor correction component and has no ballasting property.

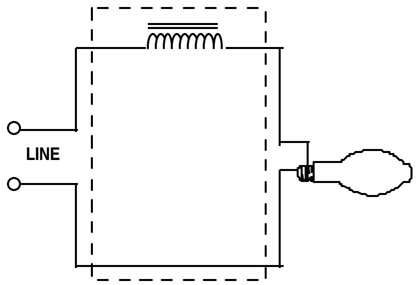


FIGURE 7. Low power factor reactor ballast.

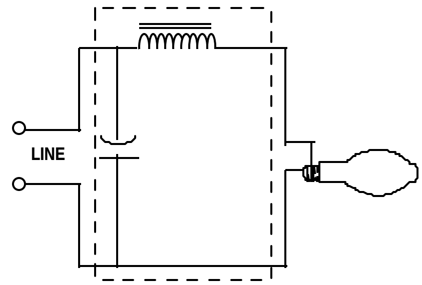


FIGURE 8. High power factor reactor ballast.

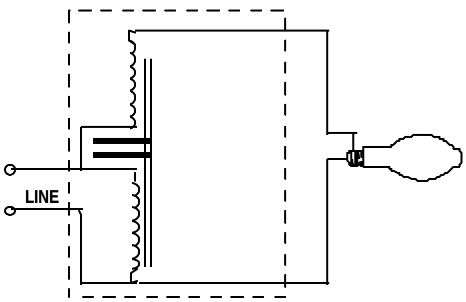


FIGURE 9. Low power factor autotransformer ballast.

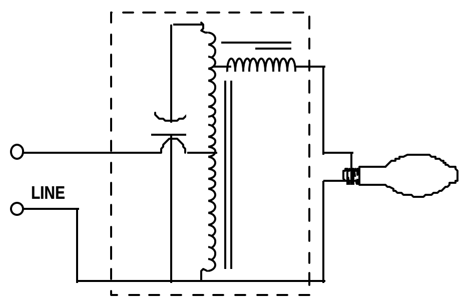


FIGURE 10. High power factor autotransformer ballast.

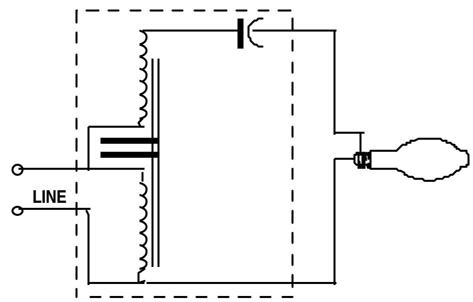


FIGURE 11. Constant wattage autrotransformer ballast.

Premium Constant Wattage Ballast
For applications requiring more stable light output with varying input voltages, the constant wattage (CW) ballast is recommended. This ballast, like the CWA ballast, uses a lead circuit; but unlike the constant wattage autotransformer, the conventional constant wattage ballast is built like an isolation transformer. The CW ballast has the benefits of improved light output regulation and isolated load circuit over the CWA ballast. It also has the same advantages of the CWA ballast, such as high power factor, low line extinguishing voltage and low line starting currents.

Two Lamp Lead-Lag Reactor Ballast
It is common practice to operate 2 400-watt or 2 1000-watt mercury lamps with a two lamp lead-lag reactor ballast which consists of two independent circuits. One lamp is operated with a reactor and the other with a reactor and capacitor connected in series. Each lamp operates independently and continues to operate even when the other lamp fails. The two lamp lead-lag reactor ballast provides high power factor and reduces stroboscopic effect .

Two Lamp Series Constant Wattage Ballast
Indoor applications of 400-watt mercury lamps frequently use two lamp series constant wattage ballasts. This circuit is basically the same as the single lamp conventional constant wattage circuit except that it operates two lamps in series on an isolated secondary winding. The electrical characteristics are similar to the single lamp conventional constant wattage ballast except for regulation which is equal to the constant wattage autotransformer type.

Mercury ballast wattage losses average about 10% of the lamp watts, depending on the ballast and lamp types.

Lamp starting currents are considerably higher for inductive (autotransformer or reactor) ballasts than for CWA or CW ballasts. In selecting the proper wire size for feeder and branch circuit lines, it is very important that consideration be given to starting currents. Ballast manufacturers' technical data should be consulted for specific values.

ILLUMINATION CHARACTERISTICS

Efficacy

High light output is one of the important advantages of mercury lamps. The initial efficacy (at 100 hours operation) ranges from 30 to 60 lumens per watt, depending on the wattage and color of the lamp. This does not include the ballast losses which should be a added to the lamp watts when comparison are made with other light sources.

Spectral Energy Distribution

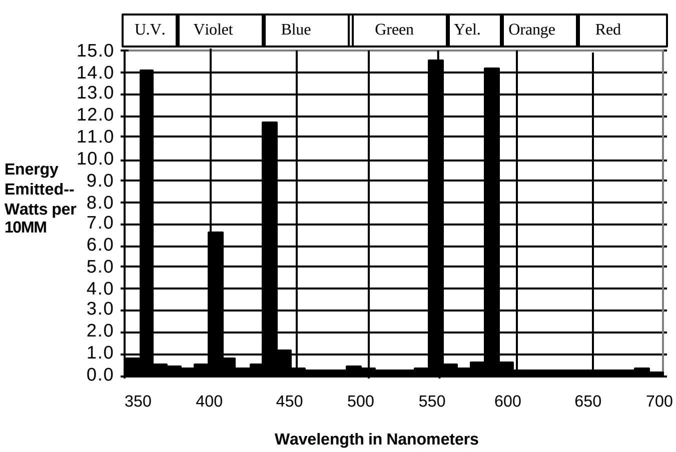
The spectrum of a mercury lamp contains strong lines in the ultraviolet and visible regions. The pressure in the quartz arc tube is responsible to a large degree for the mercury lamp's characteristic spectral energy distribution. The exact spectral distribution varies greatly with the pressure at which the arc tube operates. Standard HID mercury lamps operate at vapor pressures within the range of one to five atmospheres. At these pressures, the mercury spectrum consists of four principal wavelengths in the visible spectrum, 404.7, 435.8, 546.1, and 578.0 nanometers, and two in the ultraviolet at 334.2 and 365.0 nanometers. The quartz arc tube transmits all wavelengths, but the glass outer bulb cuts off practically all wavelengths below 300 nanometers and passes only the near ultraviolet and the visible light.

The clear mercury lamp produces a bluish-white light in which there is virtually no red radiation. Because of the strong blue, green and yellow lines, these colors on objects are enhanced; but the lack of red makes orange and red appear brownish.

A phosphor coating on the inside of the outer bulb greatly improves the color of the light by converting some of the ultraviolet energy into visible light in the same way as in fluorescent lamps. (See Engineering Bulletin 0-341.) These phosphors not only improve the color rendering but also increase the initial light output for some types. The OSRAM SYLVANIA Brite-White Deluxe mercury lamp, for example, has a europium-activated phosphor coating that peaks in the red region of the spectrum and also increase the initial efficacy. This improves the color rendition, as compared with clear mercury lamps. The color rendering capability of the Warm Deluxe mercury is superior to that of the Brite-White Deluxe mercury lamp. Spectral energy distribution curves for 400-watt mercury lamps of several types are shown in Figures 3, 4, 5 and 6.

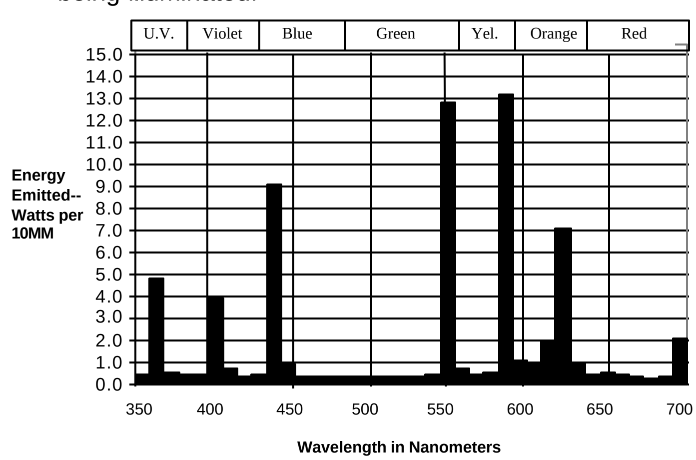
Blacklight

OSRAM SYLVANIA clear mercury lamps are designated as "clear & blacklight". The term blacklight is generally referred to as an ultra-violet light source. In general, the wavelengths of concern are 320 nm to 400 nm. Hence, the clear Mercury lamps are in fact, effective to this purpose. It should be remembered that blacklight effects are extremely dependent upon the objects which are being illuminated.



Correlated Color Temperature -- 5900°K
Color Rendering Index -- 22
CIE Chromaticity -- x = .320 y = .379

400-Watt Clear Mercury Lamp (H33CD-400)



Correlated Color Temperature -- 4000°K
Color Rendering Index -- 43
CIE Chromaticity -- x = .382 y = .385

400-Watt Brite-White Deluxe Mercury Lamp (H33GL-400/DX)

TROUBLESHOOTING

For complete information on troubleshooting procedures, refer to Engineering Bulletin 0-345, Troubleshooting Mercury-Metal Halide Lighting.

WARNINGS

STANDARD MERCURY

This product conforms to USA Federal Standard 21 CFR 1040.30 and Canada Standard SOR/80-301.

This lamp can cause serious skin burn and eye inflammation from shortwave ultra-violet radiation if outer envelope (glass bulb) is broken or punctured. Do not use where people will remain for more than a few minutes unless adequate shielding or other safety precautions are used. Lamps that will automatically extinguish when the outer envelope is broken or punctured are commercially available from OSRAM SYLVANIA INC.

Mercury lamps operate under high pressure (up to 50 p.s.i.) and at very high temperatures and can unexpectedly rupture due to internal causes or external factors such as ballast failure or misapplication. An arc tube rupture can burst and shatter the outer bulb resulting in the discharge of glass fragments and extremely hot quartz particles (as high as 1832°F-1000°C). In the event of such rupture, **there is a risk of personal injury, property damage, burns and fire. To reduce these risks, fixture less/diffuser material must be able to contain hot lamp fragments *up to 1000°C) and the instructions below must be followed.**

Fixtures which comply UL1572 (revised 12/26/88) or later and/or CBA Electrical Certification Notice (dated 6/27/88) should withstand an arc-tube rupture. If you do not know whether your fixture can safely withstand an arc-tube rupture, contact your fixture manufacturer.

Operating and installation instructions:

1. These lamps must be operated in a fixture with a ballast which has an ANSI designation identical to that found on the lamp outer glass bulb.
2. Do not remove the lamp when power is on. If outer glass bulb is broken, shut off power immediately and remove lamp after it has been cooled.
3. Do not expose operating lamp to moisture.
4. Replace the lamp if outer glass bulb has been scratched, cracked or damaged in any way.
5. Electrically insulate any metal in contact with the outer glass bulb to avoid glass decomposition.
6. To ensure electrical contact, screw lamp firmly but not forcibly into the socket. Excessive force may cause the outer envelope to break.
7. Replace lamp at or before end of rated life.

MERCURY SAFELINE®

This product conforms to USA Federal Standard 21 CFR 1040.30 and Canada Standard SOR/80-301.

This lamp should self extinguish within 15 minutes after the outer envelope is broken or punctured. If such damage occurs, TURN LAMP POWER OFF AND REMOVE LAMP to avoid possible injury from hazardous shortwave ultra-violet radiation.

All instructions for standard mercury lamps listed above also apply to the Safeline® lamps.