Sōlarc®
LIGHT

TECHNICAL OPERATION GUIDE

USHIO

TABLE OF CONTENTS

Today's markets dictate that the products you design must meet your customers' needs as well as stand out from their competition. You're asked to deliver brighter, longer-lasting illumination in a smaller, more portable product. Put another way, your customers want the power of the sun in the palm of their hands.

With USHIO's Sōlarc® lamps, that's precisely what they get. Sōlarc lamps, Light Engines and Light Modules are used worldwide to supply high-quality, white light in a wide variety of optical illumination systems. This is because Sōlarc products give you the design flexibility for use in a wide variety of applications. When properly applied, they will reliably provide hundreds of hours of excellent product performance. And, with their simple packaging, they can be designed into your products with ease.

As with any new technology, it is important that you understand key application techniques. This Sōlarc Technical Operation Guide has been arranged to help you easily find the information you need for your specific application. It summarizes the important information and assembly hints that will help get you started. For more detailed information on specific Sōlarc lamp solutions, please contact your USHIO America representative.

By following the guidelines given in this guide, you (and your customers) will be rewarded with years of dependable, trouble-free service from your new Sōlarc products. Please read these instructions thoroughly before use.

Sōlarc® LAMP OVERVIEW

Each Sōlarc lamp is a metal halide light source in the class of high-pressure, high-intensity-discharge (HID) lights, which differ from halogen, incandescent, fluorescent or light emitting diode (LED) illumination sources. Light is emitted from an arc discharge between two closely spaced electrodes, which are hermetically sealed inside a small quartz glass envelope. During operation, small amounts of metals are heated to a liquid state that provides the needed vapors to create the desired light color.

The light emitted from this arc tube is intense. Appropriate safety precautions relating to exposure protection are required. Metal halide lamps operate at very high temperatures and pressures so proper mounting, cooling and ventilation are required to assure reliable operation. While highly efficient, these metal halide lamps are sensitive to thermal fluctuations and orientation effects. Expect larger variations in color and output than other lower efficiency technologies.

Sōlarc lamps have unique operating and handling characteristics that should be understood to achieve successful and reliable operation:

- Sōlarc quartz glass must be kept clean
- The glass lamps should be handled with care, giving special attention to the quartz arc tube
- Metal halide lamps use high-voltage, short-duration pulses to initiate operation
- Sōlarc is a direct current (DC) lamp, and proper electrical wiring polarity must be observed to prevent damage to the lamp

Sōlarc® LAMP ADVANTAGES

Brilliant Illumination

As a result of USHIO's patented design, the Sōlarc miniature arc lamp provides pure, white illumination with a high color temperature. Sōlarc inherently provides solar-quality brightness, true color rendition and true color balance, ensuring unparalleled results for virtually any lighting product application.

Low Power Draw

Sōlarc lamps operate at 60+ lumens per watt. This allows your product to produce three times the amount of light compared to a halogen lamp running at the same power level. With a standard selection of outputs of 10, 18, 21, 24 and 50W, Sōlarc allows you to design products that are more compact, flexible, reliable and efficient.

Precision Focus

Sōlarc lamps feature a small, typically 1.2 mm, arc gap, and the smallest gap available in a metal halide arc lamp. Combined with elliptical reflectors, this arc gap allows you to focus illumination with laser-like precision into very small areas, such as projection display panels or fiber-optic cables.

Portability

Because they offer low-power arc lamp operation, Sōlarc lamps allow you to design smaller, lightweight and portable products. For example, a 21W Sōlarc lamp with elliptical reflector weighs just 24g. To further facilitate portability, the lamp's ballast, measuring 5.1 x 5.8 x 1.1 cm, weighs just 60g. In addition, Sōlarc's low power draw (10, 18, 21, 24 or 50W) makes battery operation possible, thus enhancing your product's value to your customers.

Shock Resistance

Sōlarc's arc lamp generates its brilliant illumination with precisely aligned electrodes in place of a tungsten filament. This design enhances Sōlarc's durability against shock or vibration, making it an ideal lamp for products that demand superior illumination in rugged operating environments.

Consistent Light Output

Sōlarc superior quality light output will typically maintain at least 75% of its initial value throughout its life. This means that both your reputation and your customers' products will benefit from reliable, consistent performance over longer periods of time.

Easier to Use

High-efficiency operation—combined with its lower gas volume and miniature size—mean that Sōlarc lamps provide solar-quality light output, yet require 1/3 less power than halogen lamps. Additionally, Sōlarc lamps' low wattage generates less heat than halogen lamps. This feature allows you to design products requiring less complex thermal management systems. The net result of these features is that you can design products that deliver optimum performance and safety at a lower manufacturing cost.

USHIO Quality

Every USHIO Sōlarc lamp is designed and manufactured within our strict production standards and tight tolerances to ensure that each operates to its exact specifications. By demanding precise performance from our lamps and our manufacturing processes, we will ensure the value of your products.

Sōlarc® LAMP OPERATING CHARACTERISTICS

Sōlarc lamps contain small amounts of metals. These metals are in both liquid and solid forms when the lamp is cold. When cold, these metals may appear to be dark reddish or reddish-brown in color, can appear as spots or even a film on the inside surface of the arc tube chamber. This appearance is normal and, as the lamp warms up, the metals evaporate and do not interfere with the proper operation of the lamp.

Warm-up

Sōlarc lamps take a brief time to come up to full power after they are turned on (the general rule being about 1 second per watt). For example, a 20W lamp will take about 20 seconds to come to normal brightness. Some amount of instability, i.e., flickering or flashing, is normal during warm-up and will diminish after the lamp reaches its thermal equilibrium.

Restart

If power is interrupted to an operating lamp, the pressure inside the chamber is still very high and the starting pulses will not be strong enough to form an arc between the electrodes. The lamp must cool to a point where an arc can be started. The time required to cool follows our general rule of about 1 second per watt. (A 10W lamp will require about 10 seconds to cool down prior to restarting.)

Operating Orientation

Sōlarc arc is a glowing, heated ball of vapor. Because heat rises relative to the force of gravity, high-intensity discharge lamps are sensitive to orientation. Sōlarc lamps are designed to be operated in one orientation, usually horizontal unless otherwise specified. Orienting the lamp contrary to its original design will cause the thermal environment to change, thus increasing output variability and possibly reducing life.

Ballast Compatibility

A ballast is the electronic control circuit required to operate a discharge lamp. Sōlarc lamps are direct current (DC) metal halide arc lamps. As such, they are to be operated with only approved electronic ballasts. In order to start the lamp, an arc must be struck across the gap formed by the electrodes. To do this, the ballast generates a series of very high voltage (~10 kV) and very short (<1 microsecond) pulses to start the lamp. They can often be heard and sound like a series of clicks. Again, Sōlarc lamps are DC operated and there is a distinct polarity associated with proper electrical connection. Improper wiring can cause either lamp or ballast failure.

Output Ratings

The industry standard for measuring output of light is the lumen. Lumen is a measure of the visible light related to the sensitivity of the human eye. Sōlarc lamps are generally designed, built, and characterized using the lumen as the measure of output and using maintained lumens as the measure of output over time. Because Sōlarc lamps produce full-color light across the entire visible spectrum (UV to IR), they are often chosen for their unique blue (UV curing) or red (IR detection) output. Check specifications carefully to be sure that the lamp is controlled for the light characteristics you are designing in.

Output Stability

Light output fluctuations are a normal characteristic of discharge lights. Generally, fluctuations are not objectionable if they vary no more than 5% at any given time. Sōlarc lamps are controlled to have no more than 5% fluctuations in initial output. Metal halide lamps can also exhibit occasional flaring, or bright flashes of red or pinkish light. Flaring occurs as the liquid metals settle into a stable thermal location within the bulb chamber. Flaring generally occurs during initial warm-up, if the lamp is jarred, or if it changes orientation.

LAMP SAFETY, HANDLING & DISPOSAL

Safety

As with any high-power lighting system, it's important to remember specific safety issues. The Sōlarc lamp system generates a series of high-voltage ignition pulses of approximately 6–10 kV for a short time during each starting cycle. If a lamp fails to start, those starting pulses will stop after 2 seconds. Do not switch the light source from ON to OFF in rapid succession, as this will dramatically shorten lamp life. We also recommend that each application be fused in order to protect the product against any internal failures.

Always allow lamp to cool before replacing. Do not remove the lamp from equipment until it has cooled completely. For optimum performance, avoid handling the bulb or the reflector. Fingerprints or other contaminants on the glass may result in performance degradation.

Photobiological Safety Compliance Standard RP-27.3

As with any Sōlarc product, UV precautions must be taken when directly handling the lamp. Ultraviolet, visible and infrared radiations are emitted from metal halide lamps. Possible skin or eye irritation can result from exposure to the output of a 21W Sōlarc lamp exceeding 15 minutes in one day. Use appropriate personal protective equipment. Do not stare at an exposed lamp in operation. Due to the extremely high brightness of the lamp, proper attenuating glasses must be worn when directly viewing the bulb. During operation, the lamp should be enclosed in a housing to prevent injury in the circumstance of the lamp shattering.

Handling

Ballast products are electrostatic sensitive electronic assemblies and should be handled as such. Proper electrostatic discharge (ESD) handling procedures must be employed.

Protect the quartz arc tube when handling the lamp. The arc tube may be protruding from the end of some reflectorized lamp assemblies. Keep the arc lamp clean. Do not touch the quartz tube, the inside surface of the reflector, or the connecting wires. Contamination can degrade lamp performance or cause premature failures. If necessary, clean the lamp by wiping with a lint-free towel or cotton swab immersed in denatured alcohol.

The high-intensity light at the front of the light source and possibly at the tip of the fiber optic bundle, if used, may give rise to bright light and high temperatures. To minimize the risk of injury, avoid direct viewing or contact.

Disposal

Sōlarc lamps contain a small amount of mercury—usually no more than found in typical fluorescent lighting. Disposal and handling must conform to local regulations and hazardous waste disposal guidelines.

Do not remove lamp from equipment until it has cooled. Never handle the lamp when it is operating!

LAMP LIFE & MAINTENANCE

The industry standard for reporting lamp life is median hours—the point at which 50% of the lamps have stopped operating satisfactorily. Generally, a lamp is considered to have failed if it no longer starts or the lumen output has fallen to half of its initial value. USHIO defines a rated "median life" for all Solarc lamps. This is a statistical determination—based on periodic testing—of the median operating time for randomly selected groups of lamps. One half of the lamps will continue to operate beyond this median life while others will reach their end-of-life earlier.

The predominate symptom of end-of-life is the inability to start the lamp. Once a lamp has started, one can generally count on that lamp continuing to operate throughout a given procedure, however there is a possibility that the lamp could rupture. For that reason, lamps should be installed in an enclosure.

To fully characterize lamp life, one must also define a duty cycle. Duty cycle is how often a lamp is turned on and off. Sōlarc lamps are typically tested in the laboratory with a duty cycle of one or two hours on and 15 or 30 minutes off. More frequent cycling will reduce the lamp life. For instance, turning the lamp off every 10 minutes may reduce rated life as much as 50%. Conversely, operating the lamp in a continuous mode may extend life up to 30%.

Lamp life will also be decreased if the lamp is operated above designed operating temperatures. (Please refer to Lamp Temperature & Cooling on page 6.) It is important that the equipment designer ensures that the maximum operating temperature is not exceeded and that free airflow is available at all times.

Figure 9 (page 10) depicts a graph of lumen maintenance versus life for the 21W lamp. This data was taken with the lamps operating in their standard duty cycles at rated wattage. Performance can vary substantially under different operating conditions. You should always qualify performance for the specific operation that you design.

In Figures 10–13 (starting on page 11), you will find graphs indicating the color stability of the lamp. The first pair of plots indicates X and Y chromaticity deviation versus life, while the second set of plots show a spectral distribution taken from a typical lamp when new and after a period of time. Sōlarc lamps will maintain a high level of both chromaticity and light intensity throughout their lives.

DESIGNING Sōlarc® LAMPS INTO YOUR PRODUCTS

Packaging

When developing mountings and enclosures for Sōlarc lamps and ballasts there are several design aspects to consider. Heat management is critical. In many applications forced-air cooling is used to maintain the recommended temperatures at the critical measurement points. For Sōlarc lamps with no cover glass, drawing the air across the face of the lamp is preferable—blowing air on the lamp is not recommended. Use the natural effect of heat rising as a supplement to drawing the air up from the bottom of the lamp. This is how all devices manufactured by USHIO America are designed. If the system cannot be cooled using forced-air cooling, such as in a flashlight or torch, sufficient thermal conduction methods must be used to assure critical thermal points are within specification. When designing light engine and light module components which incorporate vents and cooling fans, be careful to assure sufficient clearance and pathways so that the airflow is not obstructed.

While Sōlarc lamps have no filament to break, nonetheless, they are made of quartz glass and subject to breakage from shock and vibration. Shock mounting techniques and shock isolation can provide a more robust design. Remember it is up to you, the OEM, to test the end product in its intended use to assure it meets your customer's requirement.

Mounting

Sōlarc arc lamps are specified for operation in a specific orientation, such as horizontal or vertical base down. Verify specified orientation with the appropriate lamp specification sheet. Lamps specified for horizontal operation have a preferred rotational orientation. Refer to the specific lamp data sheet or follow the "THIS SIDE UP" or "UP" designation on the lamp base. To prevent damage during lamp installation, mounting and replacing, care must be taken to avoid mechanical interference with the quartz arc tube.

Mount the printed circuit board version of the ballast as desired by using the four corner through-holes provided on the circuit board assembly or by some other acceptable means. Exercise care when handling and mounting the circuit board assembly to prevent mechanical stressing of the ballast components. It is not recommended to use the ballast heat sink for mounting, as it is electrically floating. Since there is high voltage on the board, spacing of 9.53 mm (0.375 in) on all sides of the ballast is required, or appropriate nonconductive electrical insulating material must be used.

Electromagnetic Interference (EMI)

The Sōlarc product family has been designed to pass industry-standard EMI requirements. The ballast should be located close to the lamp for this very reason. It may be necessary to add an additional metal shield over both the lamp and ballast depending on the specified EMI immunity levels. In addition, it is best to keep the distance from the power source to the ballast as short as possible. When specifying long wire lengths it is best to use twisted pair configuration and/or shielded wire to minimize radiated EMI from that wire.

System Integration Guidelines to Minimize EMI

Ballasts and other power conversion circuitry emit parasitic energy that may affect or interfere with the operation of other equipment. The following guidelines are recommended to minimize ballast emissions and reduce the possibility of radiated or conducted interference with other equipment.

- Overlapping sections of the ballast/electronic enclosure should be clean and free from paint
- Use metal screws to fasten cabinet sections together
- Attempt to keep fasteners approximately two inches apart and avoid any distortion of the clean metal mating surfaces. Use EMI gasketing if distortion is unavoidable
- Avoid dissimilar shielding metals and moisture that will cause galvanic action and thus cause deterioration of the clean metal shielding surfaces
- Maximum shielding occurs with materials that have the highest conductivity
- Principal EMI issues arise due to breaches in shielding
- Cover or subdivide areas inside large electronic enclosures
- Avoid long ground wire connections to reduce loop size
- Route all internal cables as close to the ground plane/surfaces as possible to minimize loop size
- Use an IEC power input filter module
- Mount an IEC power input filter module to a clean, paint-free section of the cabinet wall and as close as possible to the DC power supply. Use the widest and shortest possible strap to ground the input filter module to the ground plane if unable to ground the filter module directly to cabinet wall
- Plastic-coated enclosures provide excellent HF shielding, but considerable care is needed to ensure that all seams are conductively closed
- Do not route cables close to seams or openings and especially not close to small openings or cracks
- Terminate all cable shields to the enclosure
- Use holes and avoid the use of slots for cooling openings
- Use chokes on power leads and or twist power leads to eliminate noise issues
- Make sure all power terminals are clean and tight
- Do not run wires parallel to each other, which could cause crosstalk issues
- Avoid tying or locating signal leads (DC) close to power leads (AC)
- Keep ballast module approximately two feet away from a CRT, computer or other magnetic field-sensitive devices. Use thicker shielding if close proximity is unavoidable
- Ferrite cores can normally be used to eliminate a resonance problem or control interference

System Integration Hints

Physically locate the ballast away from circuitry that is noise sensitive or circuitry that is routed outside of the system housing. This will help control EMI/RFI emissions and help enable the ballast to be compatible with the system. Don't bundle sensitive signal leads with the ballast input and output power leads. Intentional spacing or shielding may be required to enable the ballast to be compatible with adjacent circuitry. A common symptom is interference with adjacent circuits during ignition.

Operating Voltage

Maintaining the proper input voltage is extremely important. Do not exceed the absolute maximum voltage listed for your particular ballast. It may cause a nonrecoverable failure of the lamp, ballast or both. When operating with batteries, it's important to research the batteries' characteristics when fully charged and how they discharge to ensure compatibility with your ballast. If a lamp fails to start, the ballast will shut down and will only draw a low amount of power. The power must be cycled off and back on in order to re-light the lamp.

Input Power Supply Selection

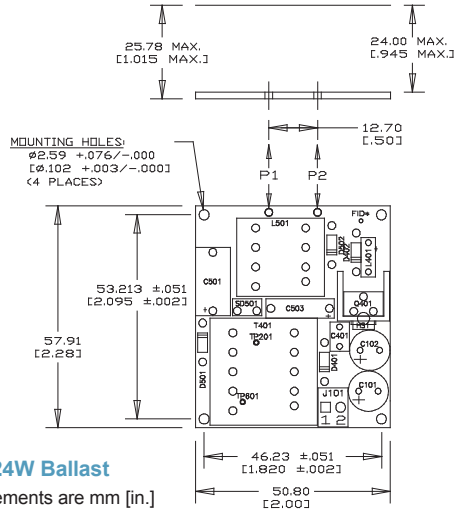
The power ratings of the ballasts refer to the output power to the lamp. The ballast input power will always be greater than its output power because of its efficiency limitations. The ballast has a capacitive input, which will demand a short-duration in rush current from the power supply. This is usually not a cause for concern.

Input Wiring for Printed Circuit Board (PC) Version Ballast

USHIO America recommends complying with IPC-A610D solder process standard or equivalent. Construct an input power connector assembly compatible with the input connector (Molex 41791 connector 2-pin series or equivalent) located on the ballast circuit board assembly. The input connector can be found at the bottom edge of the ballast assembly shown in Figures 1 & 2, location J101. Pin 1 is the positive input voltage and Pin 2 is the negative input voltage. Slide the connector housing portion of the assembly onto the input power connector, location J101, until the mating halves lock in place. Observe the wiring voltage polarity as specified in the pinouts section in the performance specifications table. Failure to observe input power wiring polarity could result in failure of the product.

Wiring for Printed Circuit Board (PC) Version Ballast

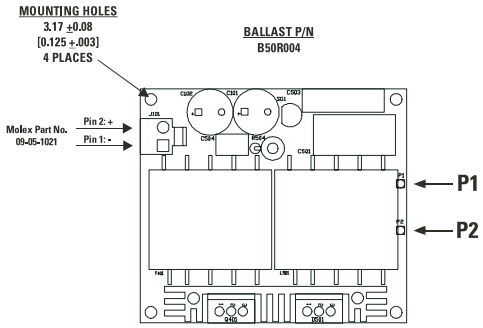
Figure 1: Ballast Assemblies



18, 21 & 24W Ballast

All measurements are mm [in.]

Figure 2: Ballast Assemblies



50W Ballast

All measurements are mm [in.]

USHIO America's Solarc lamps are designed for direct current (DC) operation. It is vital that the lamp be installed and maintained with the correct polarity. The supplied polarized connectors, which electrically couple the arc lamp and ballast, are designed to provide the proper voltage polarity.

The two insulated wires supplied with the connection assemblies are colored-coded: the black wire is connected to the cathode and the white wire is connected to the anode of the arc lamp. Solder the anode lead (white wire) of the lamp connector assembly to P1. Solder the cathode lead (black wire) of the lamp connector assembly to P2. Trim any excess material. The P1 and P2 output terminals can be found at the top middle edge of the ballast assemblies shown in Figures 1 and 2.

- Avoid connecting the P1 and P2 terminals to anything other than the arc lamp. Instrumentation and/or other circuitry connected to either one of these electrical nodes can drastically affect normal ballast operating performance
- High-voltage pulses are present on the P1 terminal during ignition
- Failure to observe input power wiring polarity could result in catastrophic failure of the product

Labeling

Proper labeling is important with any product, and the Sōlarc is no exception. Warnings reminding users that the lamps can be hot and should be allowed to cool down prior to replacement, and not to put anything, including fingers, into the lamp socket, should be clearly marked in the appropriate languages.

LAMP TEMPERATURE & COOLING

Cooling (10W Systems)

Heat removal is important. The main heat transfer occurs through the ballast. The ballast sides also provide the best mechanical surface for heat conduction to occur. Although plastic housings can be designed into your product, it is best to have a solid metal-to-metal contact with the ballast can. An air gap between the ballast and its mounting surface should be avoided. If plastic is preferred, then heat-transferring plastics such as 30% carbon-filled or glass-filled material are best.

The most important measurement of a proper Sōlarc lamp and ballast installation is the temperature on the ballast metal can. With a thermocouple attached half way up the side of the ballast, you can measure the heat conduction of the system. It's important to keep the maximum case temperature no greater than 90°C.

Unusual increases in operating temperature can be caused by a variety of factors:

- Nothing should be mounted directly to the back side of the reflector
- An additional heat shield (commonly found on halogen installations) will cause a significant rise in operating temperatures within the assembly
- Any housing that immediately surrounds the lamp should be black so as not to reflect stray light back into the lamp
- When an additional cover glass is used, make sure it is rated for high transmission; otherwise reflected light energy from the front can overheat the system
- Never use any plastic material as an outside barrier
- The common cause of high temperature is overvoltage to the ballast. Make sure that you have the correct ballast for the particular battery type and configuration

When designing the enclosure, consider the fact that your product may not always be running in an ideal laboratory environment. The 90°C maximum temperature should take into account typical operating temperatures the product will experience in actual use, as well as any extreme conditions it might encounter.

Cooling (18W – 60W Systems)

The maintenance of adequate cooling is another critical consideration in lamp life and arc stability. The lamp must not exceed its operating temperature limits, which in most cases requires that the lamp be forced air-cooled. Cooling must be sufficient to maintain the temperature at the tip of the arc tube generally between 200°C and 285°C.

In a few situations it may be possible to cool the lamp by convection. In general however, the equipment designer must be certain that the flow of air is adequate and cannot be blocked. Conversely, it's also important that the lamp not operate overly cooled or it will experience instability, inconsistent performance, an arc that is bluer in color and may cause possible flickering.

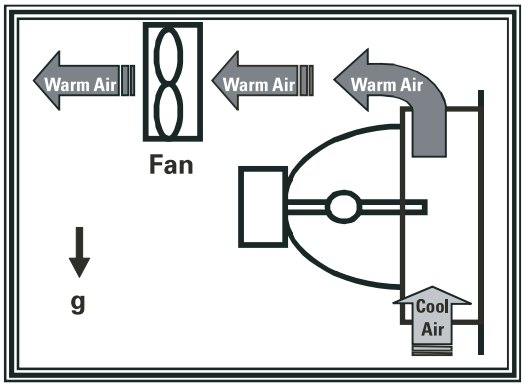
The critical temperatures are at the seals of the arc tube and at the molybdenum foils. If the temperature limits at these points are exceeded, the seal between the foils and the glass envelope may fail and create a leak, thus shortening lamp life and causing erratic performance.

It is equally important not to directly cool the arc chamber (the center of the bulb). This may also cause erratic performance and shortened life.

Figures 14 and 15 (located on page 11) show the critical regions of the lamp and the optimum temperature ranges. To help you design the Sōlarc lamp into your equipment, USHIO America can provide specially prepared lamps with Type K thermocouples attached to the exposed end of the arc tube (anode seal) and embedded at the cathode seal. Using these sensors, thermal management systems and operating temperatures can be monitored and optimized. While the operating temperature at both ends of the tube is important, the thermal characteristics of the lamp construction actually make the exposed end of the arc tube the most vulnerable. The reflector tends to conduct heat away from the near end. For this reason, it is wise to carefully distribute the airflow to the lamp.

Some air must be directed across the reflector in order to prevent adverse effects. The designer must also allocate some airflow across the bulb tip without directly cooling the arc chamber itself. This may require careful design since the reference surface for the lamp is the front face of the reflector. Drawing air across the front of the reflector and directly cooling the tip of the arc tube and anode seal can accomplish this. (Refer to Figure 3.) Sōlarc lamps have been incorporated in USHIO America proprietary products using forced-air cooling at flows ranging from 9 to 20 cfm (ft3/min) (0.25 to 0.57 m3/min), depending on external environment and chassis restrictions.

Figure 3: Lamp Cooling



Many of the same considerations apply to a single-ended lamp, except that the application may be complicated by the user's own optical design.

The ballast should reside in a well ventilated housing. Forced-air cooling is highly recommended, but not a strict requirement. The power field effect transistor (FET) heat sink (largest heat sink on PC board) located adjacent to the input power connections must be maintained below 90°C. See Figures 1 and 2 for the power FET location.

For optimum temperature measurement, position and adhere a thermocouple on the reverse side of the FET heat sink at the same height as the FET. Increase airflow requirements by 1 cfm for every 2°C rise above 25°C. Do not allow the temperature of the heat sink to rise above 125°C. Additional heat sinking is possible by screwing more thermally conducting material to the top of the heat sink. Use a #2 screw and thermal compound to ensure proper conduction.

OPTICAL PERFORMANCE OPTIMIZATION

Sōlarc lamps are typically mounted within dichroic coated reflectors for visible applications. For fiber optic illumination, typical elliptical reflectors are utilized where the arc is positioned at the internal reflector focal point (F1) and light emitted from the lamp is reflected and redirected to the external focal point (F2). The majority of reflected light is focused at the F2 position within a defined solid angle. The angular distribution of the light emitted from the reflector is a function of the ellipse geometry and the radiation emitted from the arc source. For maximum transmission through fiber optics, it is critical to match the reflector angular distribution to the fiber optic acceptance cone angle (otherwise known as numerical aperture—NA). The NA of the lamp must match the NA of the fiber for optimal performance.

The angular distribution of the lamp coupled with larger bundle diameters can impact the optical performance. A light depression is typically observed when the angular distribution propagates through the fiber optics. In most applications, it is desirable to tilt the lamp's optical axis relative to the fiber optic opto-mechanical axis to eliminate this propagated depression for uniform projected illumination as viewed from the fiber optic distal end. USHIO typically sets this angle at about 12 degrees.

This tilting of the lamp can also be used to provide additional thermal optimization. Tilting the lamp's connector downward allows the reflector's top to open slightly, allowing the chimney effect to exhaust more efficiently.

LAMP REPLACEMENT INSTRUCTIONS

(LE, LM, LB MODELS)

1. Turn unit off and unplug the power from the light engine
2. Rotate lamp spring retainer from lamp spring
3. Disconnect the lamp connector and remove the lamp by pulling back and up against the lamp spring
4. Replace with USHIO America replacement lamp only
5. Reconnect the lamp to the connector and insert lamp so that the lamp is seated properly in the lamp block; pay attention to applicable keys or alignment pins
6. Rotate lamp spring retainer back into position over lamp spring

TROUBLESHOOTING

Discharge lamps fail for a variety of causes that all relate to thermal and mechanical stresses imposed by the extreme operating temperatures inside the lamp. Typical failure modes include chamber rupture (sometimes with an audible pop), cracking and leaks of chamber, and cracking and leaks of or near the glass-to-metal seals. These types of failure modes are normal and do not imply a defective lamp.

If the lamp fails to ignite:

- Check input and output wiring polarity and integrity
- Attempt ignition a second time after properly resetting the ballast by disconnecting and reconnecting the input voltage
- Verify proper input power—both voltage and current

If the above steps fail to correct the problem:

- Ensure the anode wire is not routed near any metal or other conductor
- Ensure that no arcing occurs on the ballast assembly in the area near the P1 connector. (A dark room enables visual detection of arcing)
- Ensure that no arcing occurs between the ballast assembly and any adjacent subassembly within the system (components, subassemblies, wire harnesses, etc.). A 9.53 mm (0.375") air spacing (or higher dielectric strength) is recommended in the above mentioned areas

Lamp Stability

Unstable lamp operation accompanied by a markedly bluish cast to the light may indicate an overcooled lamp. Verify proper power input and operation of the thermal control circuit.

Early lamp failure accompanied by a markedly reddish cast to the light may indicate a lamp that is overheated. Verify proper power input and operation of the thermal control circuit. Verify that no obstructions exist in the airflow path.

Maintenance and Repair (LE)

Only qualified personnel should make electrical inspections and repair USHIO America's Sōlarc light engines, light modules and light boxes.

WARRANTY

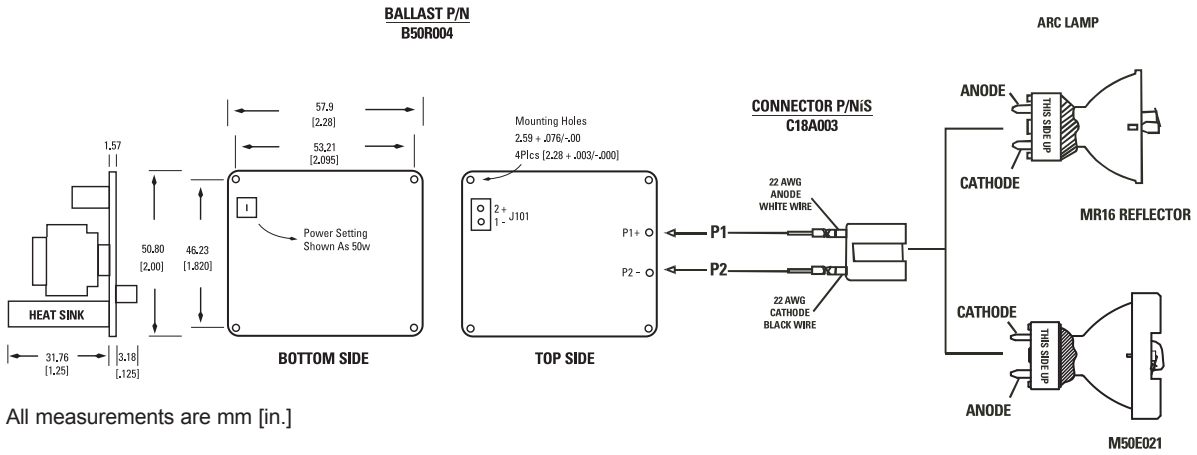
Refer to USHIO America's standard terms and conditions of sale for warranty information.

CONCLUSION

USHIO America's Sōlarc lamps combine all the features you're looking for in a lamp: high-quality illumination, low power consumption, precision focus, safety and multiple wattage configurations. All this—along with USHIO America's assurance that each and every Sōlarc lamp will operate to specifications-combines to deliver lamps that ensure your product's success.

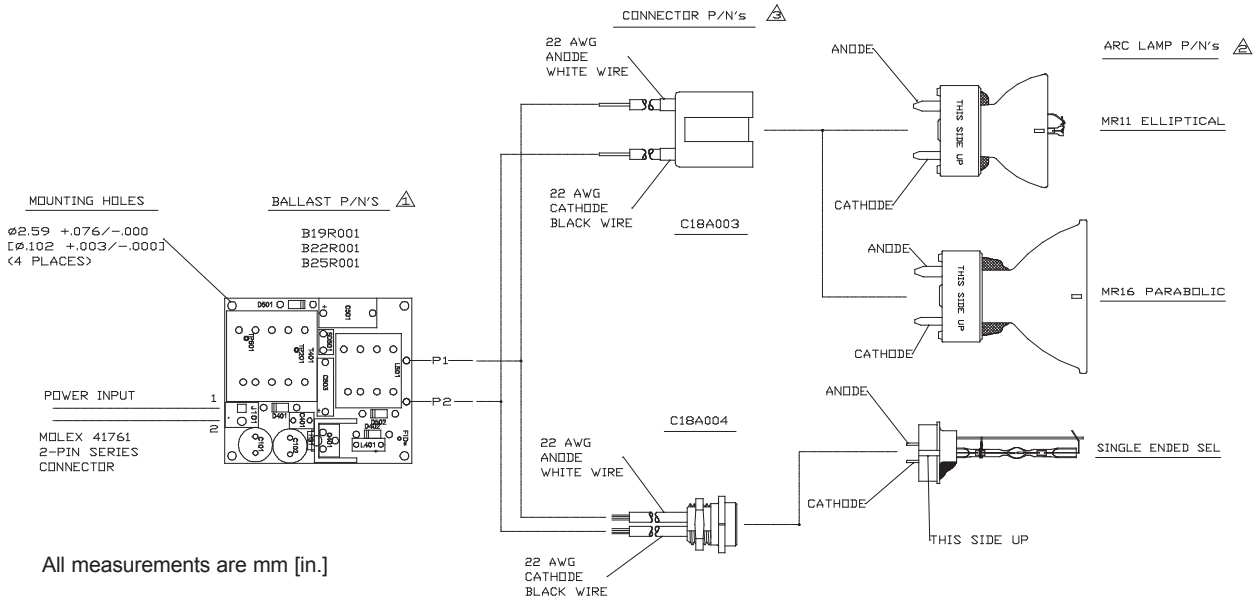
To take full advantage of the design possibilities that Sōlarc can deliver, feel free to draw from our experience in designing products using Sōlarc lamps by contacting us. If you would like further guidance and/or information on any of the design issues found in this manual, contact an USHIO representative today at 800-838-7446.

Figure 4: Ballast / Arc Lamp Configuration



All measurements are mm [in.]

Figure 5: Ballast / Arc Lamp Configuration



All measurements are mm [in.]

Figure 6: Parabolic Reflectorized Lamp Typical Performance Specifications

LAMP P/N	M21P011	M21P021
Output Performance		
Output (CBCP)	14,500	5,000
Beam Divergence (@ 50% Intensity)	12	20
Application Information		
Color Temperature	6,000K	
Chromaticity (x, y)	0.32, 0.32	
Median Life	750 Hours	
Warm-up Time to >90% of Rated Output	20 Seconds	
Restart Time to >90% of Rated Output	25 Seconds	
Ballast	**B22R001**	
Input Voltage	9.8 V–15 V	9.8 V–15 V
Current @ 12 VDC	2.3 A	2.3 A
Lamp Connector	**C18A003**	

Duty cycle for Rated Median Lamp Life: 21W – 1 Hr on / 15 min off. 50 W – 2 Hr on / 15 min off

Figure 7: 19, 22 & 25 Watt Ballasts Performance Specifications

ELECTRICAL		B19R001	B22R001	B25R001
Input Power		Specifications, unless otherwise indicated, are nominal at or near 25˚C.		
Turn-on Voltage[1]		9.8 VDC		
Turn-off Voltage[1]		9.2 VDC		
Maximum Voltage		16.0 VDC		
Steady State Current [2]		2.0 A	2.3 A	2.6 A
ENVIRONMENTAL				
Operating Temperature		0˚ to +70˚C (forced convection cooling recommended)		
Storage Temperature		-40 to +105˚C		
PINOUTS	**CONNECTOR**			
Input Power (Molex 41791 series)	J101 41671 or 26-48-1025	Pin 1 = "+" input power Pin 2 = "-" input power		
Output Power	P1 P2	Anode, white wire on ballast connector Cathode, black wire on ballast connector		

[1] Turn-on and turn-off specifications are a function of input wiring resistance. The voltage at the pins of J101 are regulated using the remote sense leads of a power supply.
[2] Steady state current flow after lamp warm-up @ 12 V.

Figure 8: Sõlarc® MR-11 Elliptical Lamp Performance Specifications

Wattage	19 Watts	22 Watts	25 Watts
Performance @ Rated Power: Luminous Flux			
Lumens Through a 4 mm Aperture	560	620	720
Lumens Through a 2 mm Aperture	200	260	350
Correlated Color Temperature (˚K)	6,900	6,200	5,200
Chromaticity (CIX, CIY)	0.32, 0.31	0.33, 0.32	0.33, 0.34
Lamp Life (Hours)	1,100	750	350
Lamp Maintenance and Spectrum	Refer to charts below		
Warm-Up Time to 90% Output	20 seconds		
Restart Time to 90% Output	30 seconds		
Reflectorized Lamp Application Information	**MR11**		
Numerical Aperture	NA–0.67		
Spot Size @ Focal Plane F2	2 mm @ 50% Intensity		
F2 Distance from Rim	14.7 mm		

Figure 9: 21W Lamp - Typical Light Maintenance

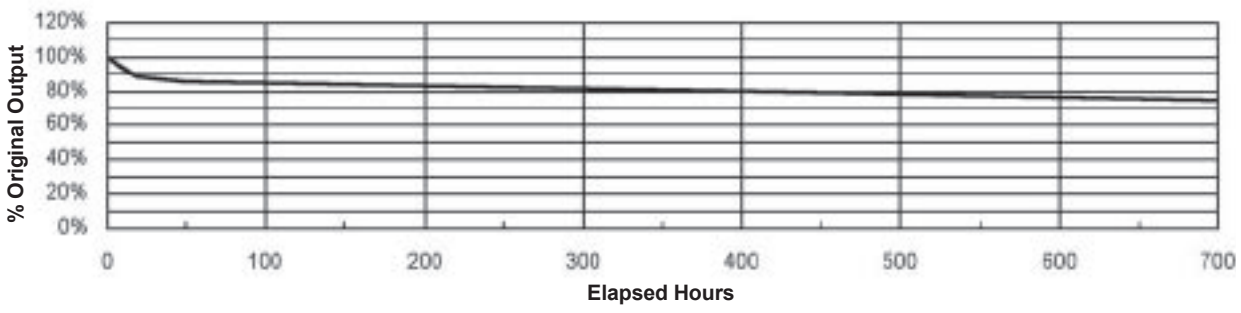


Figure 10: CIX Chromaticity Maintenance

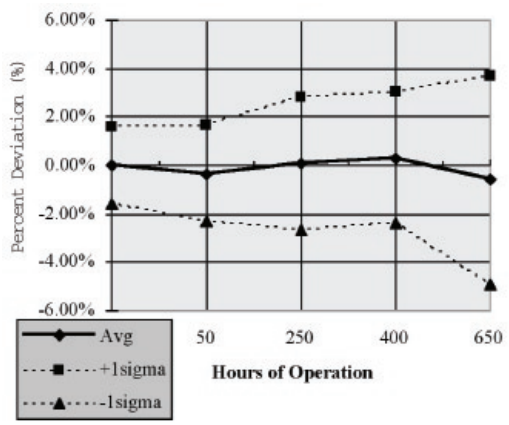


Figure 11: CIY Chromaticity

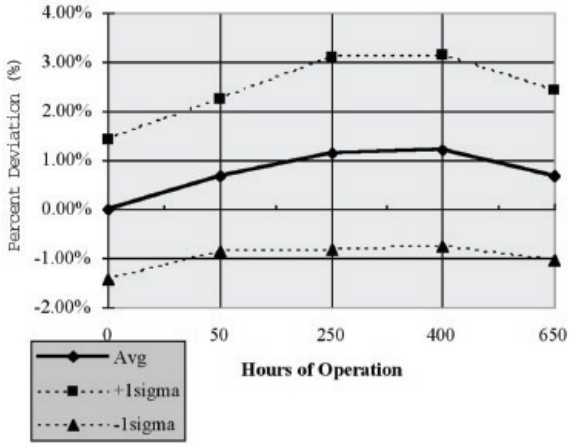


Figure 12: Spectral Output at Zero Hours

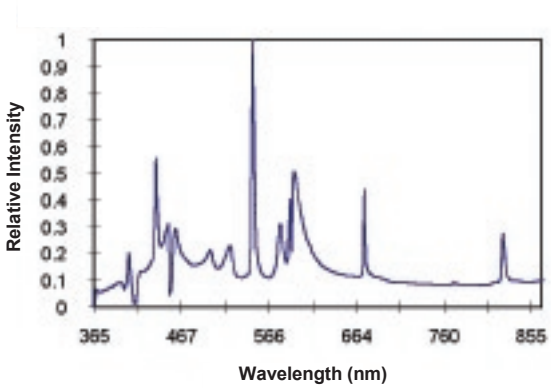
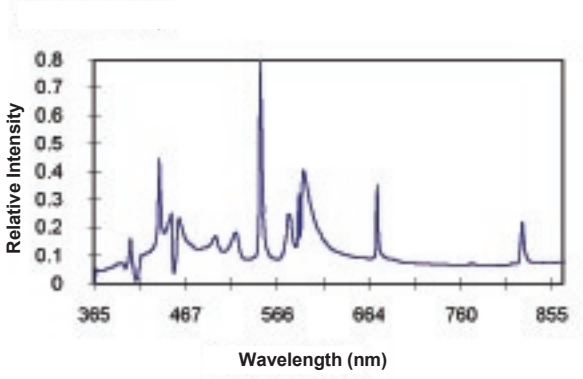


Figure 13: Spectral Output at 650 Hours



Spectral Distribution

The plots above provide an indication of the degree of relative energy changes within the spectral distribution as the lamp ages. The curves describe the performance of a typical 21W lamp in its reflector, operated at rated wattage and standard duty cycle.

Figure 14: 18, 21 & 24W Reflectorized & Sel Lamps

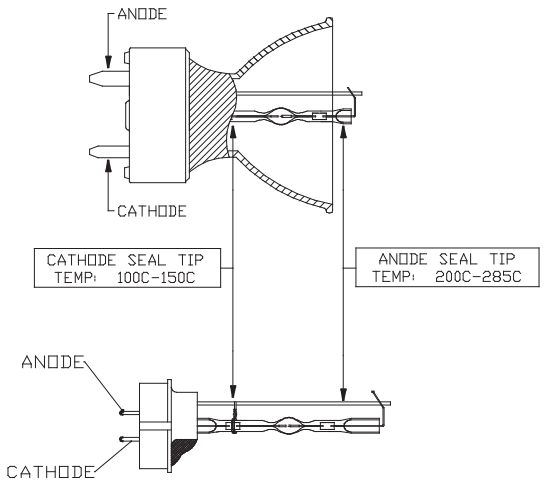


Figure 15: 50W Reflectorized Lamp