USHIO HALOGEN LAMPS TECHNICAL SPECIFICATIONS

[1] Light and the Halogen Lamp

Light can be defined as an electromagnetic wave within the range of 100nm (100 × 10 $^{-9}$ m) ~ 3,000 nm. Anything which radiates radioactive waves within these wavelengths can be called a light source. Visible light takes up only a relatively small part of this spectrum — in the 400 ~ 750 nm range. Ultraviolet light has an even shorter wavelength of 100 ~ 400 nm. The longest waveform is infrared with a wavelength of 750 ~ 3,000 nm.

Traditionally, light sources have been divided into three categories — natural (e.g., solar, lunar, etc.), flame (e.g., torch, gas, oil, etc.), and electrically energized (e.g., bulb filament, light emitting diode, etc.).

Within this final category of electrically energized light sources, there are three sub-groups:

(1) Incandescent Light Sources (Heat Radiated)

Electric energy is transformed into heat energy which raises the temperatures of solid bodies. The heated body radiates varying qualities of light in accordance with the degree to which it has been heated. Incandescent light sources include electric bulbs with filaments. Both incandescent and halogen lamps fall into this category.

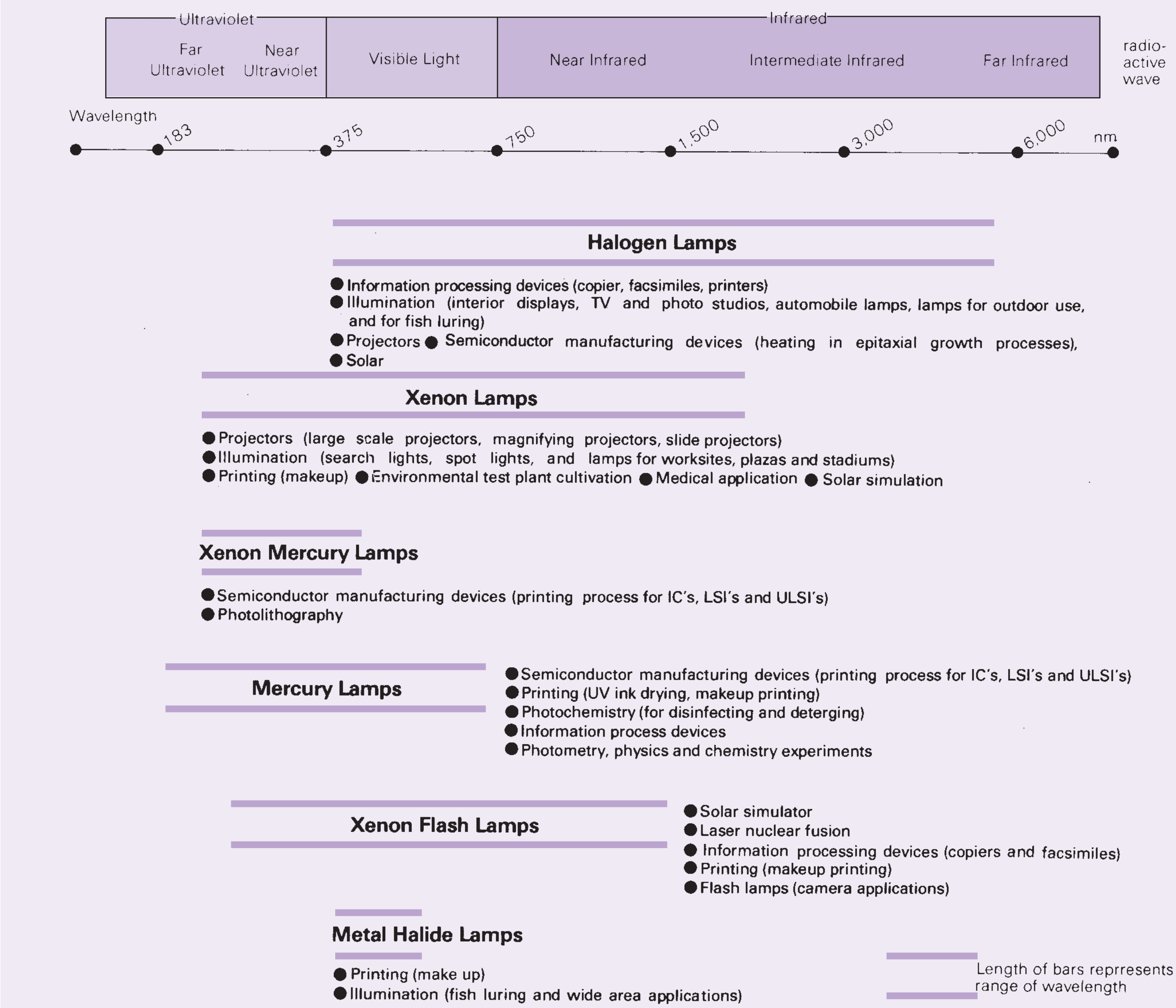
(2) Gaseous Light Sources

Atoms or molecules of gas can radiate light at controlled wavelengths by charging them with electricity to produce an excited state and then allowing them to return to a ground state. Both mercury and xenon lamps are gaseous light sources.

(3) Solid state light sources

Atoms or molecules, or electrons in the solid body energy band, also produce light after they have been energized by electricity and brought back to a ground state. Light thus radiated is at a wavelength proper to the solid body. Sold state light sources include electroluminescence lamps, light emitting diodes (LED), and semiconductor lasers.

Figure 1 The Solar Spectrum and Ushio's Lamps



[2] The Halogen Lamp

Halogen lamps are incandescent lamps in which small quantities of halogen gas has been filled. Halogen is a group name for iodine (I), bromine (Br), chlorine (Cl) and fluorine (F). Invented by Zubler and Mosby of General Electric, they were first called quartz-iodine lamps.

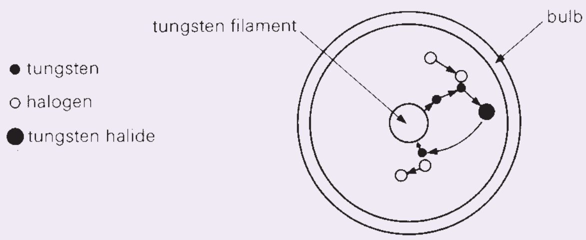
Incandescent lamps include a heating element which is heated to the incandescent state and emits incandescent light. Tungsten, because of its high melting point (about 3400°C), is often used as a filament. Nevertheless, the tungsten filament gradually evaporates. In the slow process of evaporation, gaseous tungsten moves to the walls of the bulb, reducing brightness by as much as 20%. Halogen prevents this evaporation and thus maintains brightness and lengthens lamp life.

How Halogen Gas Works

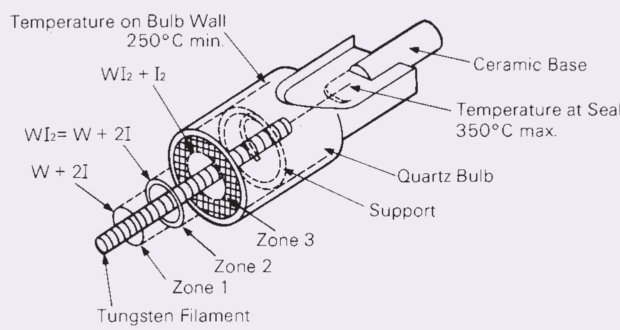
As tungsten evaporates from the filament (zone 1), it combines with halogen gas (zone 2) and becomes tungsten halide. This tungsten halide state is maintained at temperatures between 250 and 1400°C (zone 3). The temperature of the bulb is kept above 250°C in order to maintain this state and prevent the tungsten from sticking to the bulb wall and darkening it. When the tungsten halide nears the filament, the heat of the filament separates the tungsten from the halogen gas, redepositing the tungsten on the filament. The freed halogen gas then repeats the same process again. These cycles of tungsten halide composition, tungsten -halogen gas decomposition is called a halogen cycle.

Thus the halogen cycle greatly increases the life and brightness of the lamps. Nevertheless, halogen lamps do eventually wear out. This occurs because the temperature of the filament is not uniform. At those points along the filament with higher temperatures, evaporation of tungsten is greater. And at those parts with lower temperatures, evaporation is slower. This results in very gradual thinning of that portion of the filament at the higher temperatures.

Figure 2 Halogen Cycle Outline



How the Halogen Lamp Works



[3] Highlights of the Halogen Lamp

(1) Constant Light Output (Total Light Flux)	The halogen cycle effectively prevents blackening of the bulb wall so that there is no reduction of light output or color temperature.
(2) Long Life	The halogen cycle gives longer lamp-life than that of ordinary incandescent lamps. Higher color temperature is attained when the same life is required.
(3) Compact Size	In order to maintain the temperature at 250°C, the bulb wall has to be closer to the filament. This requires a very narrow bulb construction — about 1/200 the size of conventional incandescent lamps.
(4) Heat Impact Resistance	Quartz is used for high temperature bulbs. This also ensures against heat shock.

[4] Ushio's Line of Halogen Lamps

Table 1 Types and Applications of Halogen Lamps

Type	Features	Wattage	Color Temperature	Life in Hours	Application
QR	Partial Illumination ON-OFF Use	200-1500	3000	200,000 (cycles)	Exposure Light for Copy Machines
QIR	Near Infrared High Radiation Effect	200-6000	2500	4,000	Developer heat for Copy Machines Infrared Heater
J	Line Light Source Long Life	300-1500	3000	2,000	General Purpose Illumination
JP	Line Light Source High Color Temperature	500-1000	3200	200	Studio Lights
JPD	Short Light Source	300-3000	3200	150	Studio Lights Overhead Projectors Projectors
JCD	Short Light Source Single End	300-2000	3200	150	Overhead Projectors Projectors Photography
JCV	Single Socket (Screw Type) Long Life	60-5000	2900	2,000	Interior Illumination Exterior Illumination Display Fish-Luring
JA	High Vibration Resistance (Twin Filaments)	35-100	3100	150	Automobile
JCR	Cold Mirror Attached High Color Temperature	50-250	3400	50	8mm Projectors Photo Enlarger (Color)
JC	Square Type Filament	30-300	3400	50	Overhead Projectors Projectors

[5] Halogen Lamp Construction

Figure 3 Double End Type

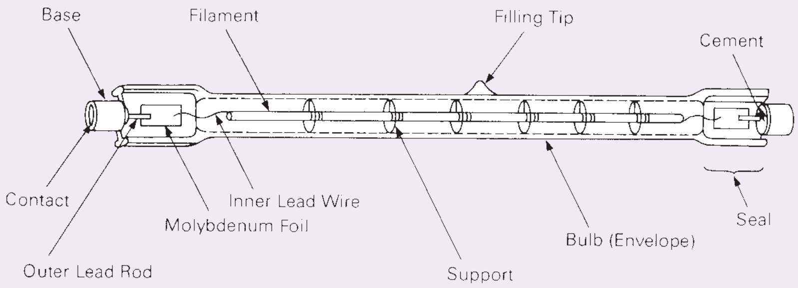


Figure 4 Single End Type

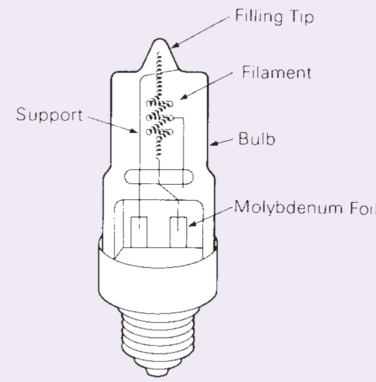


Figure 5 Filament Types

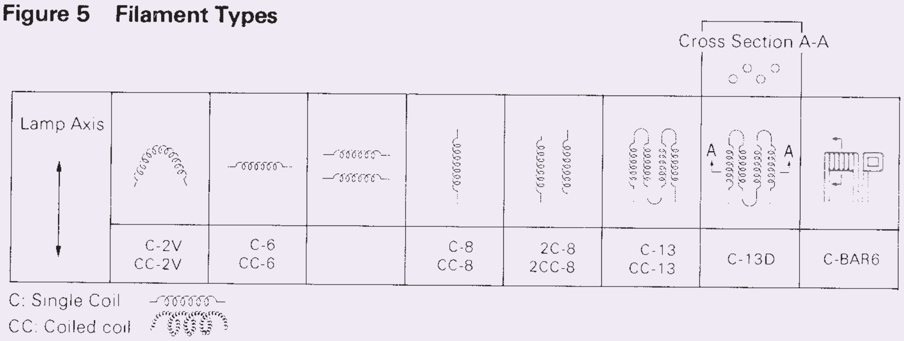


Figure 6 Base Types for Double Ends

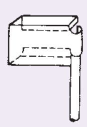


Figure 6-1
Metal Base

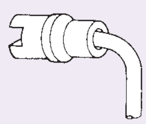


Figure 6-2
Lead Wire Base

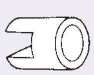


Figure 6-3
RSC Base

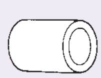


Figure 6-4
RSC Base
(Cylinder Type)

Figure 7 Base Type for Single End

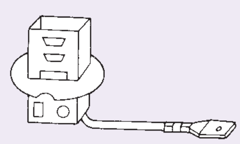


Figure 7-1
Prefocus Type Base

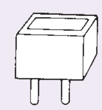


Figure 7-2
2 Pin Base

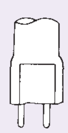


Figure 7-3
2 Pin Base

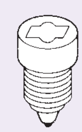


Figure 7-4
Screw-Type Base

Figure 8 R7S and Lead Wire Type Base

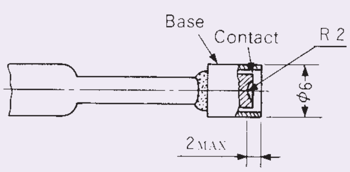


Figure 8-1

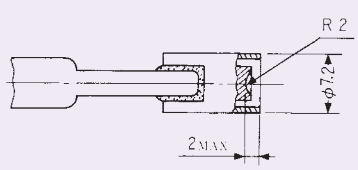


Figure 8-2

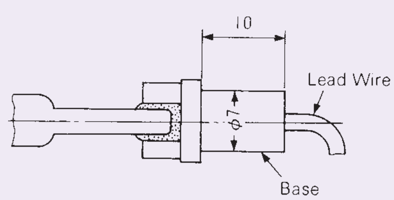


Figure 8-3

[6] Materials Used in Halogen Lamps

(1) Bulb (Quartz)

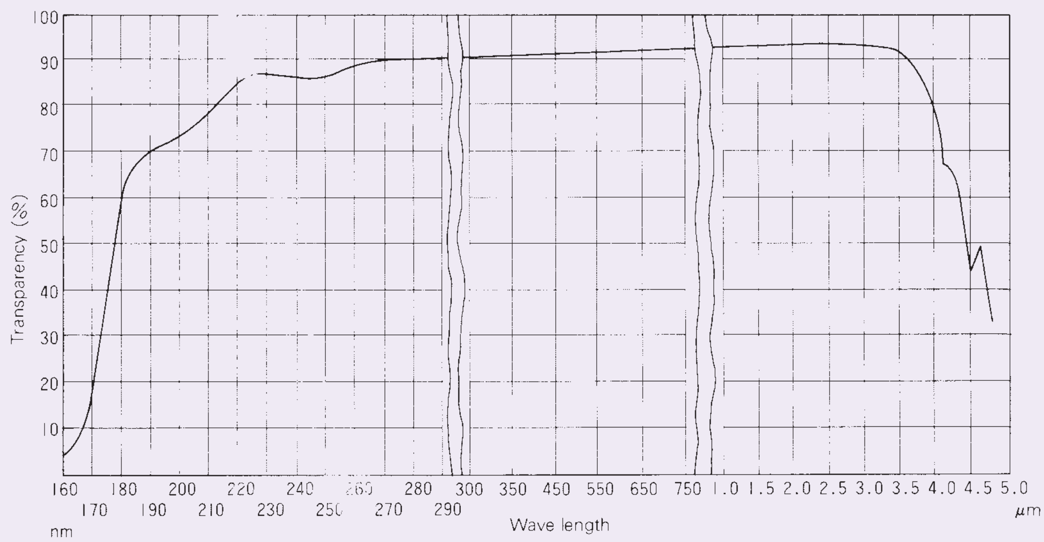
Quartz bulbs are indispensable because of the high temperature, tolerance requirement of halogen cycles. There are two kinds of quartz bulbs — transparent and translucent.

Translucent quartz bulbs are limited to use in certain heaters. For other types of lamps, transparent quartz is used. Frosted transparent quartz bulbs are also popular because they diffuse the filament image and obtain a wider distribution of light radiation. In addition, halogen lamps for automobile headlights are now made with a hard glass from the aluminosilicates family.

Table 2 Physical Properties of the Transparent Quartz Bulb

Item	Unit	
Density	kg/m³	2.20×10^{3}
Young's Modulus	Pa	7.2×10^{10}
Rigidy Modulus	Pa	3.1×10^{10}
Poisson's Ratio		0.16
Compressive Resistance	Pa	1.1×10^{9}
Bending Resistance	Pa	6.2×10^{5}
Tension	Pa	4.8×10^{7}
Softening Point	K	2,086
Annealing Point	K	1,486
Distortion Point	K	1,380
Coefficient of Thermal Expansion	m/m · K	5.5×10^{-7} (293 ~ 593K)
Rate of Resistance	Ω·m	7×10^{7}
Dielectric Constant		3.75 (293K, 1MHz)
Dielectric Resistance		$<4 \times 10^{-4}$ (293K, 1MHz)

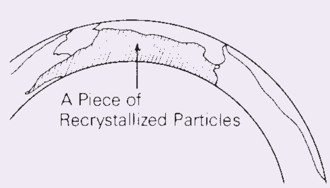
Figure 9 Transmittance Curve (Transparent Quartz Bulbs)



(2) Filament (Tungsten)

Halogen lamps use tungsten filaments because of their high flexibility and low rate of evaporation at high temperatures. Tungsten wire used in the filament is composed of recrystallized particles which are extended along the length of the wire and are interlocked. This specially made tungsten wire makes it possible to produce filaments which are distortion free (non-sagging), and have long life. Known as doped tungsten, this non-sag filament is in the K_2O-SiO_2-Al_2O_3 family.

Figure 10
Interlocked Recrystallized Particles in the Doped Tungsten



(3) Sealing (Molybdenum)

Molybdenum foil is used as a conductor through the seal part of the halogen lamp. The foil, which insures hermetic sealing of the lamp, has a configuration as shown in Figure 11. Table 3 lists the characteristics of molybdenum.

Figure 11
Cross section of Molybdenum Foil

Table 3 Properties of Tungsten and Molybdenum Elements

	Tungsten	Molybdenum
Atomic Number	74	42
Atomic Weight	183.92	95.95
Specific Heat	1.4×10^{-4}J/(kg·k) 1.5×10^{-4}J/(kg·k)	2.5×10^{-4}J/(kg·k) 3.3×10^{-4}J/(kg·k)
Melting Point	3395 ± 15°C	2620 ± 10°C
Boiling Point	5530°C	4800°C
Vapor Pressure	2.57×10^{-13}Pa (1,530°C) 1.05×10^{-6}Pa (2,130°C) 8.73×10^{-3}Pa (2,730°C) 6.24×10^{-1}Pa (3,230°C)	8.53×10^{-7} Pa (1,530°C) 1.07×10^{-4} Pa (1,730°C) 5.33×10^{-3} Pa (1,930°C) 1.33×10^{-2} Pa (2,035°C) 1.33×10^{-1} Pa (2,295°C) 1.33 Pa (2,535°C)
Specific Gravity	19.3	10.2 (Casting)
Volume Resistivity	5.5×10^{-8}Ω·m (20°C) 2.6×10^{-7}Ω·m (750°C) 4.0×10^{-7}Ω·m (1,200°C) 8.5×10^{-7}Ω·m (2,400°C)	5.78×10^{-8} Ω·m (27°C) 2.39×10^{-7} Ω·m (727°C) 3.52×10^{-7} Ω·m (1,127°C) 4.72×10^{-7} Ω·m (1,527°C)
Thermal Conductivity	1.67×10^{2}w/(m·k) (0°C)	1.34×10^{2}w/(m·k) (0°C)

(4) Filling Gas

Together with Nitrogen (N_2), Argon (Ar) and Kripton (Kr), a small amount of halogen gas is filled in the lamp. Today, most widely used halogen gases are chemical compounds of Iodine (I_2), Bromine (Br_2) and Chlorine (Cl_2).

	Nitrogen — Argon — Kripton
Gas Price	Low ⟶ High
Arcing Voltage	High ⟵ Low
Thermal Loss	Large ⟵ Small
Molecular Mass	Small ⟶ Large

	Iodine — Bromine — Chlorine
Activeness	Small ⟶ Large (for High Temperatures) — (for Low Temperatures)

Selection of the halogen gases should be based on conditions where the lamp is actually used. When long life is required, the lamp is pressurized. Gas pressure one to three atmospheres filled in the lamp suppresses evaporation of the tungsten and ensures long life.

(5) Base

The base of the halogen lamp is usually made of steatite or heat-resistant metal. For double-ended type halogen lamps an RSC base was once popular because of its handy plug-in and out feature. Recently, however, a lead wire type has become more popular for use in heaters, because of its socket design and connection reliability.

Based on application, lead wires may be nickel stranded, silicon covered, silicon covered glass braided or teflon covered.

[7] Characteristics of the Halogen Lamp

(1) Color Temperature and spectrum Distribution

A lamp converts 75%～95% of electric energy into heat and light emitted from the lamp. Visible light accounts for only 6%～12% of the converted energy. The remainder is emitted in the form of infrared radiation (see Figure 12).

Halogen lamps have color temperature and spectrum distribution as shown in Figure 13. The relative energy increases as the temperature rises with the peak moving toward the shorter range of the wavelength (visible light range).

The wavelength of the point where the peak of the curve is located can be calculated at 2897 divided by the color temperature (K). The spectrum distribution of the visible light to be radiated is calculated by using Plank's law of radiation.

Figure 14 shows spectrum distribution of a halogen lamp when different voltages are supplied to the lamps.

Figure 12 Typical Ratio of Radiated Energy and Heat Loss

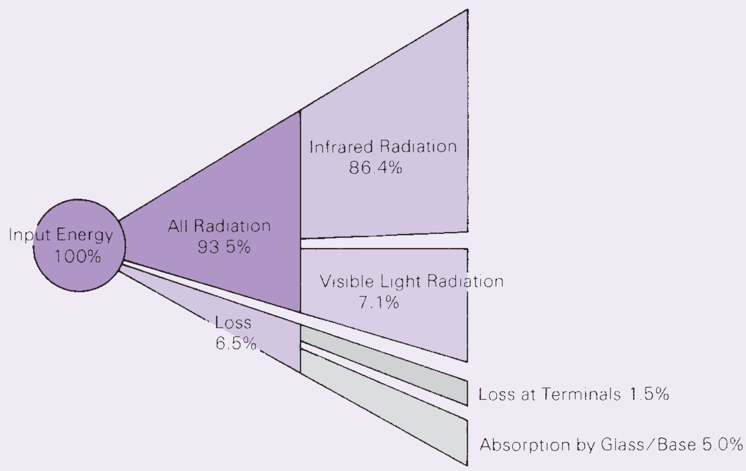


Figure 13 Spectrum Distribution with Fixed Input of Electrical Energy

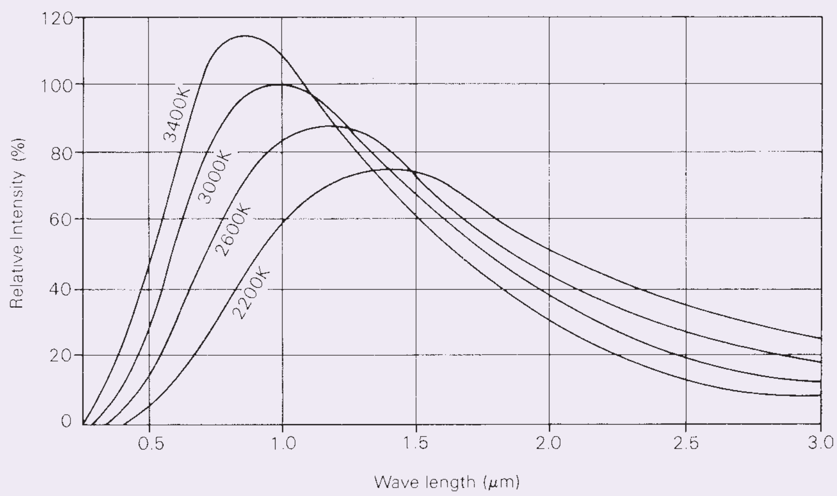
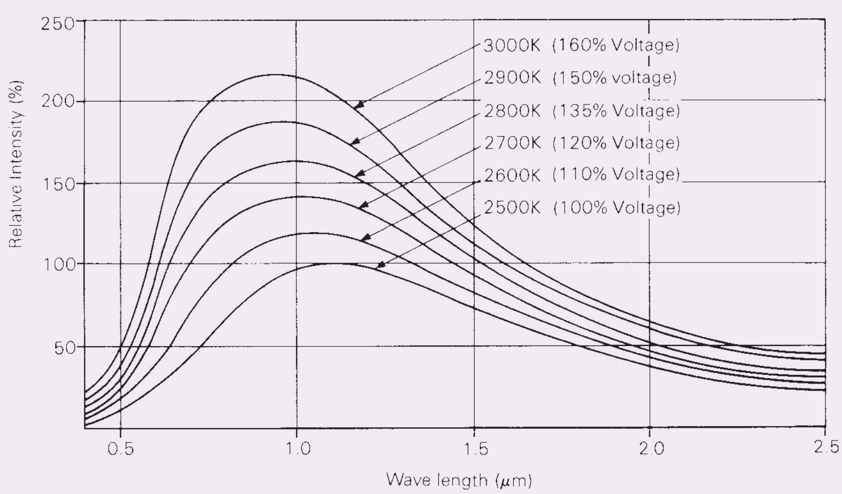


Figure 14 Spectrum Distribution with Different Input Voltage



(2) Lumen Per Watt and Color Temperature

The relation between lumen per watt and color temperature is shown in Figure 15. Segmented filament type lamps used as light sources in copiers show a slightly higher color temperature than halogen lamps for general purpose use. Because, segmented filament types have both lighted and non-lighted parts, the non-lighted parts cause lower efficiency.

(3) Voltage Variations and Variations of Other Factors

There are several factors (F), as shown in Table 4, which are inherent to the characteristics of halogen lamps. The change ratio (F/F_0: F is the actual value and F_0 is the rated value), for these factors is approximate and expressed as:

$F/F_0 = (V/V_0)^K$ where V is the actual voltage value and V_0 is the rated voltage value.

Table 4 also shows the values of K for each of the factors (values for K may vary slightly according to the configuration of each lamp).

Figure 16 shows the graphs for each factor.

(4) Voltage Variation and Life Variation

Life of a halogen lamp is expressed with the supply voltage as:

$L/L_0 = (V/V_0)^{-10 \sim -14}$ where L is the actual life, L_0 the nominal life, V the actual voltage and V_0 the rated voltage.

If 90% of the rated voltage is supplied, the lamp life will be extended by 3.5 times. If 110% of the rated voltage is supplied, the life will be 1/3 (see Fig. 16). However, halogen lamps are made with a certain amount of halogen gas appropriate to the specific filament temperature. If the lamp is operated at a lower voltage which does not raise the temperature of the filament to the optimum value, the excess halogen gas will damage the filament. This process works to shorten lamp life. On the other hand, if the lamp is operated at a higher voltage, the bulb wall will darken with excess tungsten vapor. Thus, when a halogen lamp is operated under variable supply voltages, optimum ranges should always be considered. When the actual supply voltage differs widely, a new lamp design may be necessary.

Figure 15 Lumen Per Watt Versus Color Temperature

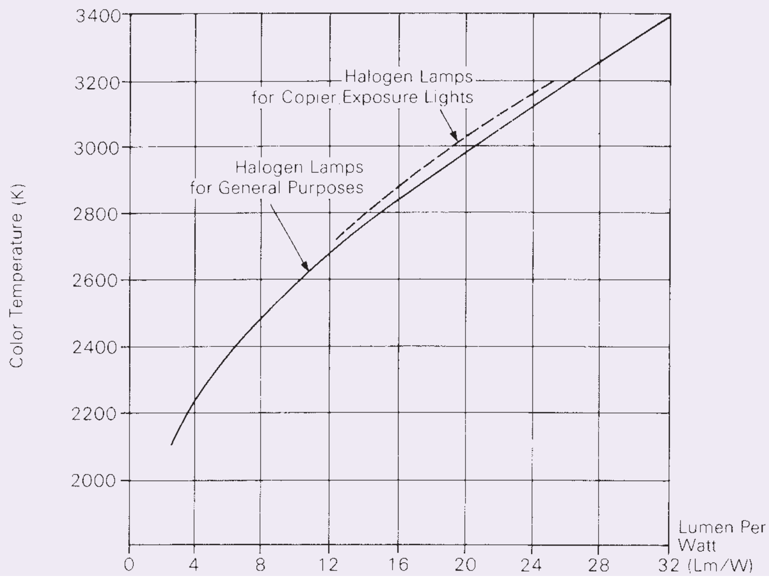


Table 4 Index K

	F	Current	Wattage	Lumen Per Watt	Lumens	Color Temperature
K	Halogen Lamps	0.54	1.54	1.65	3.19	0.37

Figure 16 Voltage Variation Versus Variation of Factors

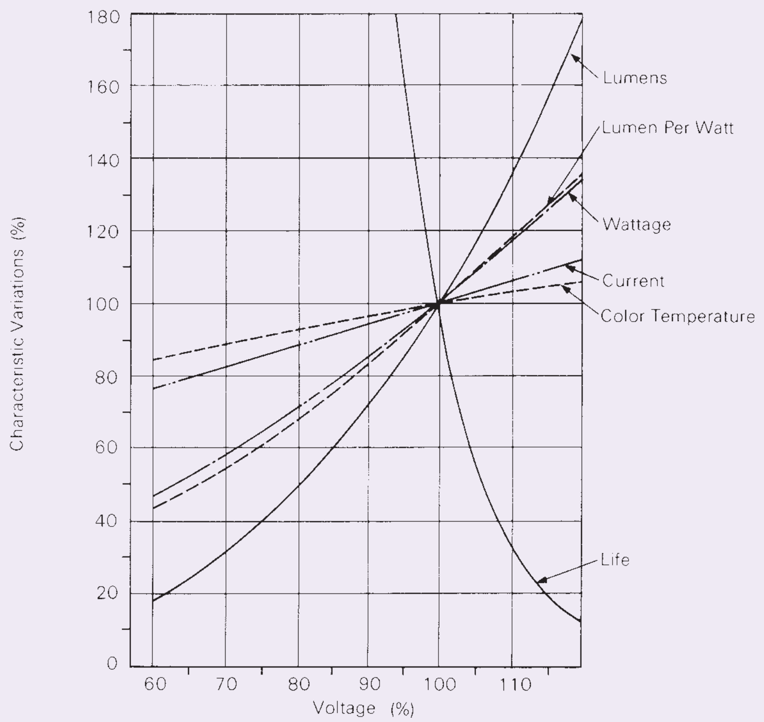


Figure 17 Lumen Per Watt Versus Life of Halogen Lamps for General Purposes (continuous filament)

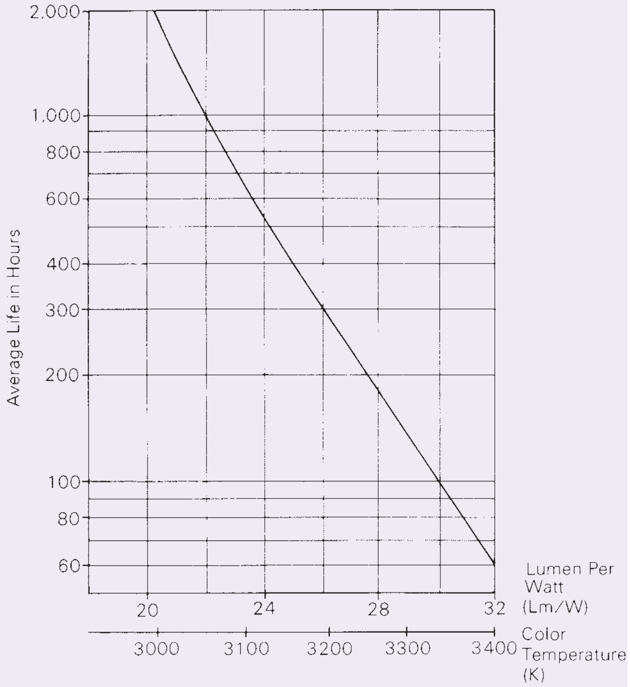


Figure 18 Lumen Per Watt Versus Life of 80V 250W Halogen Lamps for Copy Machine Exposure Lights (Segmented Filament)

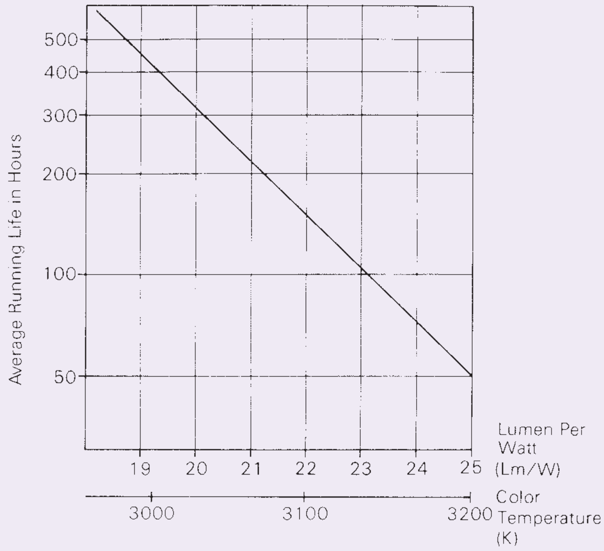


Figure 19 Lumen Per Watt Versus Life of 170V 350W Halogen Lamps for Copier Exposure Lights (Segmented Filament)

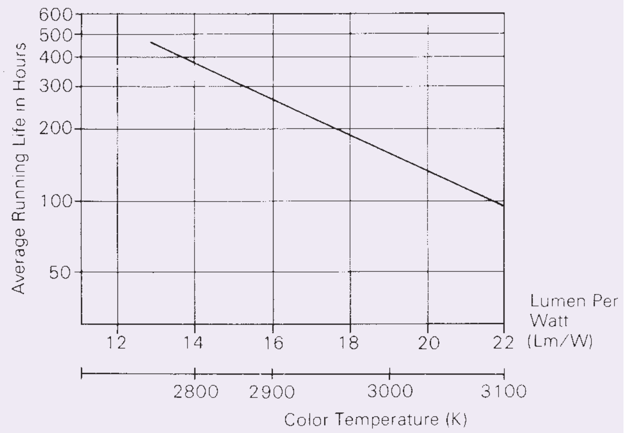
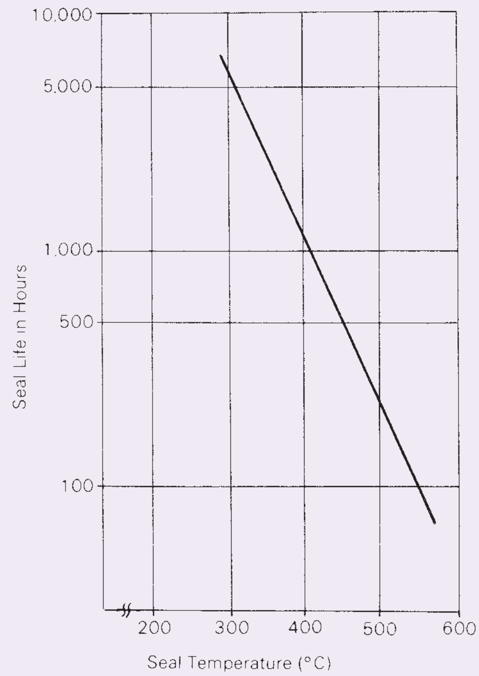


Figure 20 Seal Temperature Versus Seal Life



(5) Lumen Per Watt and Life

The life of a lamp (filament life) depends on the evaporation rate of the tungsten. This rate is proportional to the filament temperature which is equal to the lumen per watt of the lamp. Relations between lumen per watt and life of halogen lamps for general purpose use and copier exposure lights are shown in Figures 17～19. As is shown in these figures, halogen lamps for general purpose have a much longer life than lamps for copiers. This is because the segmented filament type lamps used in the copiers have greater heat loss. Even when rated at the higher voltage to equalize lumen per watt, these lamps have a shorter life. This is because high voltage lamps use filaments which are smaller in diameter and which wear out sooner.

(6) Seal Temperature and Life

Another cause of shortened lamp life involves damage to the seal. Figure 20 shows the relations between seal temperature and seal life. This graph may vary according to type of lamp. Also, at higher temperature ranges, life values are widely scattered. A molybdenum foil is used at the seal as described in [6]-(3). The foil is not completely air tight. There is a very small gap between the quartz and the outer lead which enters through the quartz. Through this gap, very small quantities of air can enter.

Molybdenum easily oxidizes when the temperature rises above 350°C. It expands as a result and causes shattering of the quartz and lacerations in the molybdenum foil. This makes it desirable to limit the temperature to below 350°C. Measurement of the temperature at the seal is usually made by using a thermocouple. For detailed information, please refer to the technical references [13]-(2). In order to allow customers to measure the temperature of the seal, Ushio provides sample lamps with a thermocouple.

(7) Bulb Temperature and Life

Life of a halogen lamp also depends on the bulb temperature (see Fig. 21). The curve in Figure 21 shows a typical pattern. Actually the curve varies according to the construction of each lamp.

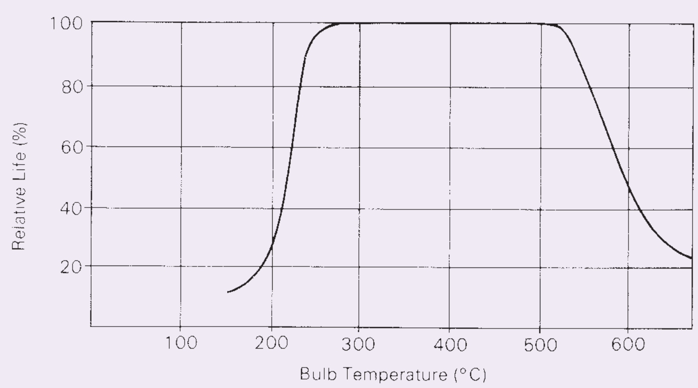
The minimum temperature of the bulb must be 250°C. Below this temperature, the halogen cycle does not operate properly and the bulb will darken. The maximum temperature is approximately 550°C (800°C for heaters). Above this temperature, foreign matter in the bulb wall will start emitting gases and accelerate the darkening of the bulb and fusion of the filament. When high temperatures cannot be avoided, a cooling system or a larger diameter bulb should be used.

When the halogen lamp operates at extremely low voltages, the bulb temperature may not reach 250°C. This will also reduce tungsten evaporation and will not result in the bulb darkening.

Sometimes, materials in the lamp combine with the filled gas and stain the bulb at that point of the bulb where the temperature is the lowest. This stain, however, never reaches the filament area so that the performance of the lamp is not degraded.

Keeping ahead of the world, Ushio has developed a very thin halogen lamp with a diameter of 6mm and put it in mass production. This lamp is intended for use in compact low wattage copiers. The small diameter is one solution to maintaining proper temperature of the bulb wall with little electric energy.

Figure 21 Bulb Temperature Versus Relative Life



(8) Light Distribution Profiles

Various halogen lamps are used in illumination devices which are designed to put the light distribution profiles of the lamp into use. Figure 22 shows the light distribution profiles of various halogen lamps.

Figure 22-1
Light Distribution Profile of the J Type Lamp

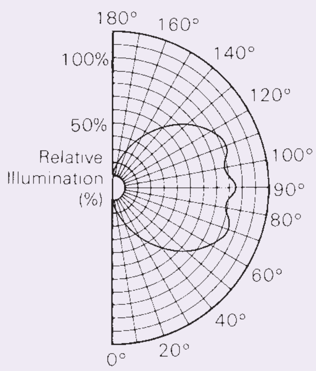


Figure 22-2
Light Distribution Profile of the JP Type Lamp

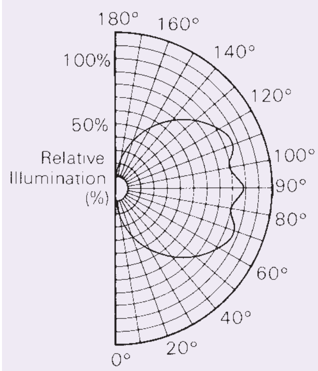


Figure 22-3
Light Distribution Profile of the JPD Type Lamp

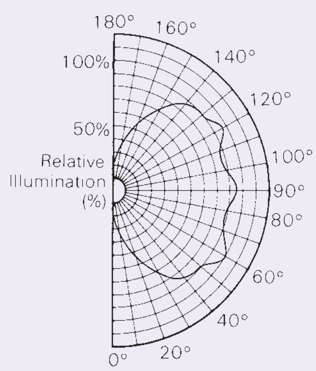


Figure 22-4
Light Distribution Profile of the JCD Type Lamp

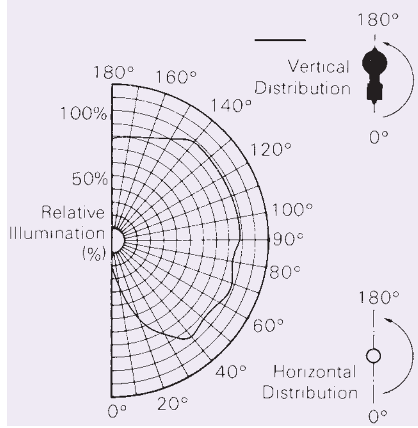


Figure 22-5
Relative Distribution of the JCV Type Lamp

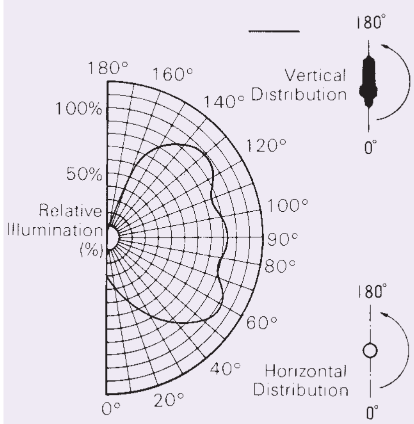
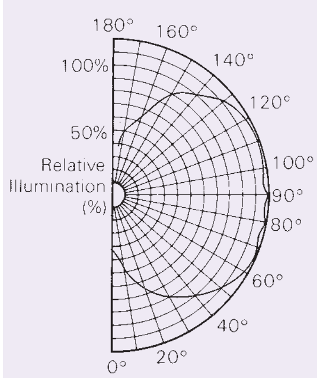


Figure 22-6
Light Distribution of the JA Type Lamp



[8] Characteristics of the Halogen Lamps for Copier Exposure

(1) Rise Time

Light radiation of an incandescent lamp is derived from a incandesced white heated tungsten filament. This means that light output cannot reach its nominal value immediately after the switch is turned on. Rise time is defined as the time required to reach 90% of the nominal value after the switch is turned on. Rise time depends much on the heat capacity of the filament. Low current, high color temperature filaments will achieve quick rise time, while filaments for high current and low color temperatures will have a slow rise time.

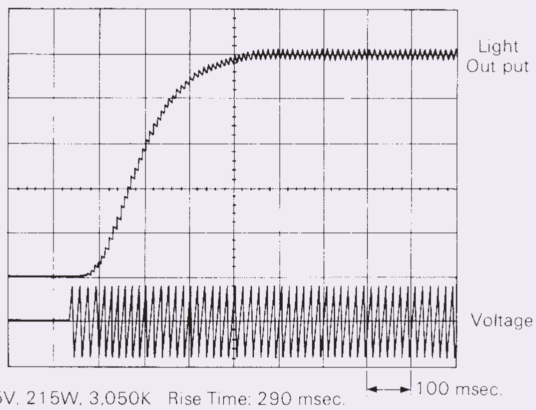
Figure 23 diagrams the rise times of two types of 215W halogen lamps for use in copier exposure. With the same wattage and similar color temperature, the 85V halogen lamp shows a rise time of 290m sec. The 170V halogen lamp, which needs little electric current and runs on a small filament, has a rise time of 190msec.

Rise time is almost always decided after the lamp characteristics (voltage, wattage and color temperature) are fixed. In order to meet varying rise time requirements based on specific applications, it is possible to change rise time through a variety of alternate methods. One involves preheating the lamp with 10%~20% of the nominal voltage. Another is to start the lamp with excessive voltage (although this method may reduce lamp life). A third method is to avoid the first flash by the use of repetitive flash lights.

Figure 23 shows the change of rise time when the applied voltage is varied.

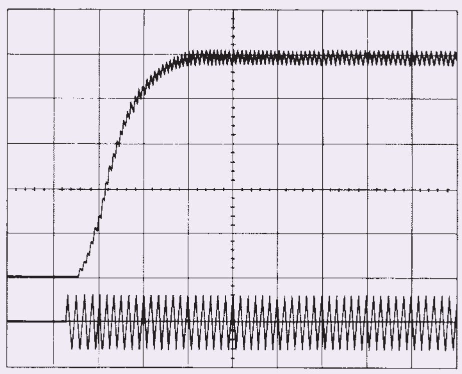
With certain types of heaters, it can be made of multi-wire filament. The rise time of the multi-wire filament is approximately 50 percent faster than that of single-wire filaments where both have the same characteristics.

Figure 23-1 Rise Time Measurement



Lamp: 85V, 215W, 3,050K Rise Time: 290 msec.

Figure 23-2 Rise Time Measurement



Lamp: 170V 215W 2,980K Rise Time: 190 msec.

Figure 24 Supply Voltage Versus Rise Time

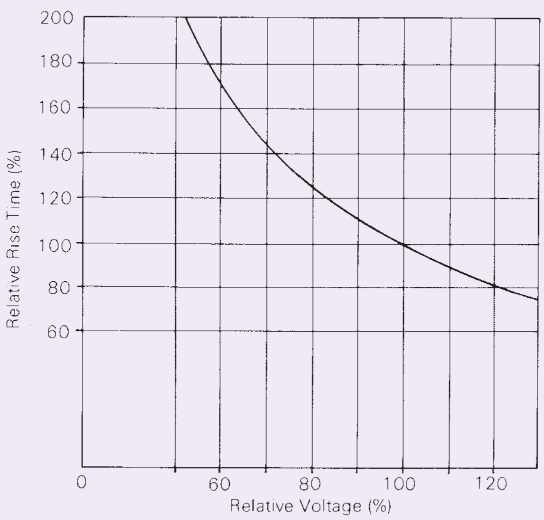
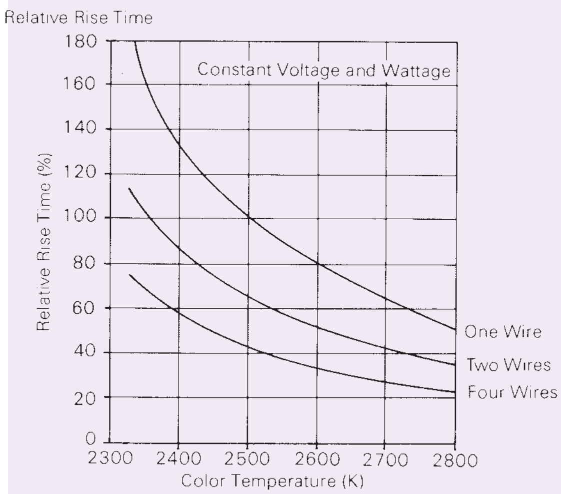


Figure 25 Rise Time Dependence to Number of Coil Filaments



(2) Inrush Current

Resistivity of tungsten varies according to temperature. It is very low at room temperature, but very high at high temperatures (See Fig. 26). Accordingly, there are large current flows when the power is first supplied to the lamps. This initial current flow is called inrush current. Figure 27 shows a typical sample of the inrush current. Theoretically, the amount of the inrush current reaches 13～16 times that of the nominal value. In actual use, however, it is reduced to 7～10 times by the impedance of the circuitry.

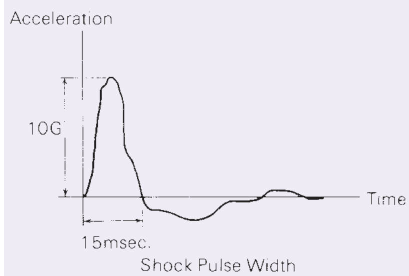
The inrush current, when required, can be reduced by preheating the lamp with a smaller power voltage, or by utilizing a soft start technique.

(3) Shock Resistance

Shock resistance is one of the important requirements for halogen lamps used in copiers. Excessive shock may cause the filament to be distorted or even break. Halogen lamps for use in copier exposure are designed to withstand shock of 10G (shock duration of approximately 15 msec.), when the shock is applied in a direction perpendicular to the axis of the lamp bulb. Because of the construction of the lamp, however, any shock in the direction of the axis of the lamp itself should be avoided.

The application design of the halogen lamps, therefore, needs to take into consideration this requirement to avoid all shock in the direction of the axis of the lamp. It must also take into consideration the fact that maximum shock in a direction perpendicular to the axis of the bulb must be less than 10G. When either greater or peculiarly directioned shocks are anticipated, they must be measured and analyzed so that a special lamp construction can be designed. Figure 28 shows a pulse waveform of the shock which is applied to the lamp with Ushio's shock test equipment.

Figure 28 Typical Test Shock Pattern



Bulb resonance will occur when exceptionally long halogen lamps are used in copiers. When it occurs, there will also be filament resonance causing an irregular light diffusion and an unusual sound may be heard. Figure 29 shows the relation between the length of the bulb and the resonance.

Figure 27 Inrush Current

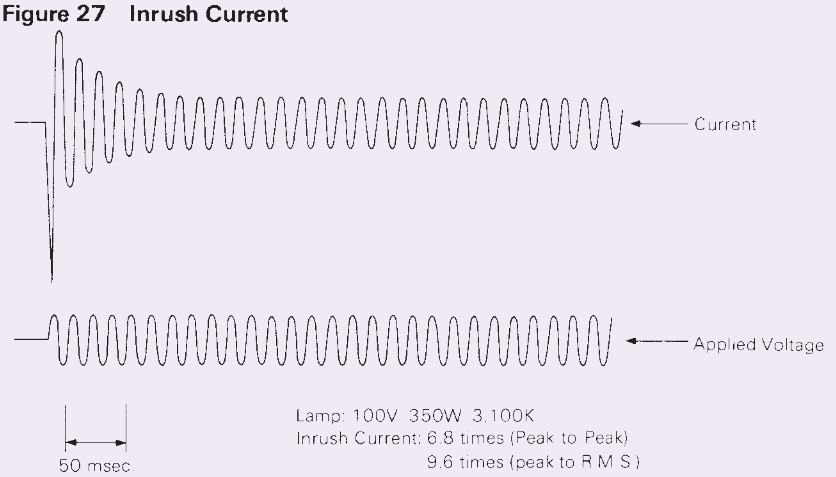


Figure 26 Resistance Change of the Tungsten Wire (Ro = Resistance at 293K)

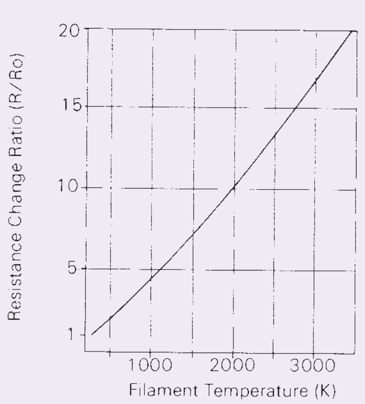
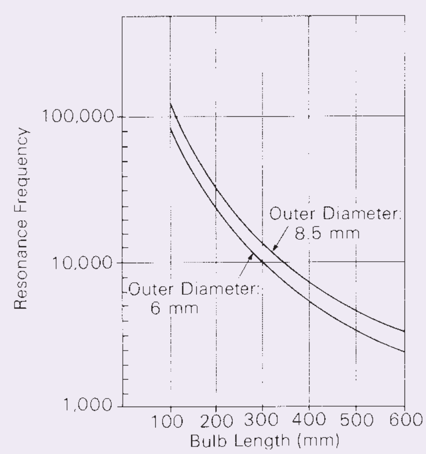


Figure 29 Bulb Length Versus Resonance Frequency



(5) Light Distribution Profiles

Halogen lamps for copier exposure need to project light on the original paper being copied. For this, adequate light distribution profiles are necessary.

Segmented filament type lamps are widely used where several short filaments are lined up at an appropriate distance from eachother. This type of lamp can meet all the requirements for wide light distribution profiles everywhere except at the ends of the lamp.

Figure 30 shows the light distribution profile of a filament with an effective lighted length of 300mm. The actual profile drop at either end are peak values and appear at places a little bit inside. The location of the peaks shift as the distance from the lamp changes (See Fig. 31).

When a clear quartz bulb is used, the light distribution profile shows a ripple. This is mainly caused by the pitch of the filament coil. The small ripple can be eliminated by using a frosted bulb (See Fig. 32).

Frosted bulbs reduce light output by 2%～4%. They have a wide light source area which may prevent intensive and sharp light from converging on the original. On the other hand, by using a properly designed reflector, a dull light projection results which enables easier adjustment of the light distribution profile on the original.

The light distribution profile changes as the distance from the lamp changes (see Fig. 33). This means that distance is one of the vital factors in obtaining optimum light distribution profiles. Supply voltage affects the distribution profile also. Variations in supply voltage have only little effect on flat distribution profiles, (see Fig. 34), but are greater for those with sagging curves (see Fig. 35).

Figure 30 Light Distribution Profile

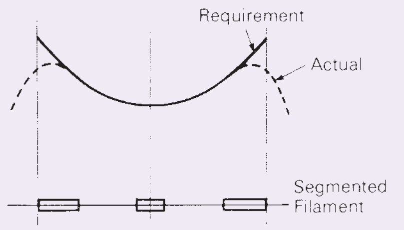


Figure 31 Light Distribution Profile

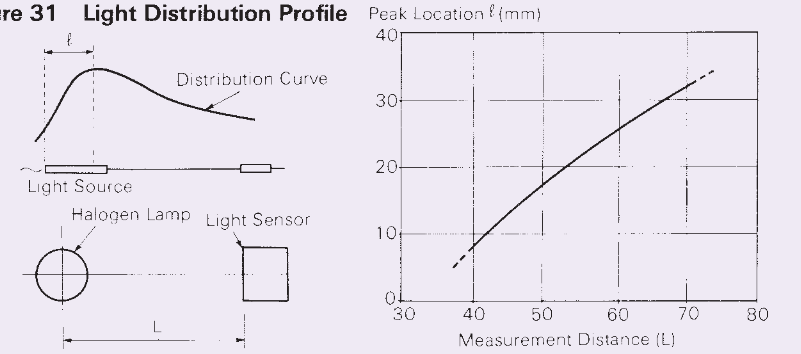


Figure 32 Frosted Bulb Eliminates Ripples

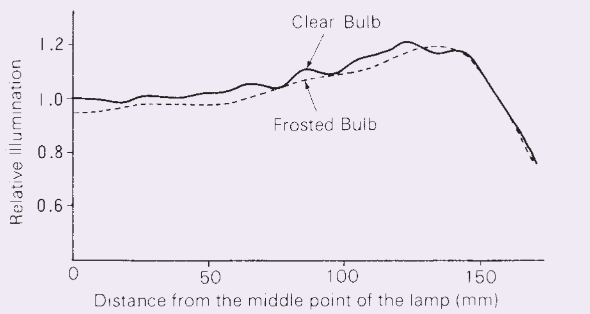


Figure 34 Light Distribution Profile Fluctuation at Reduced Voltage (Flat-Type Lamp)

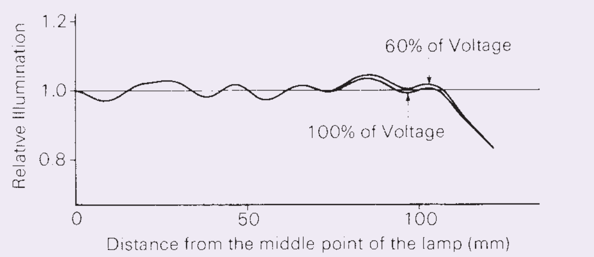


Figure 33 Light Distribution Profile Change at Different Measurement Distance

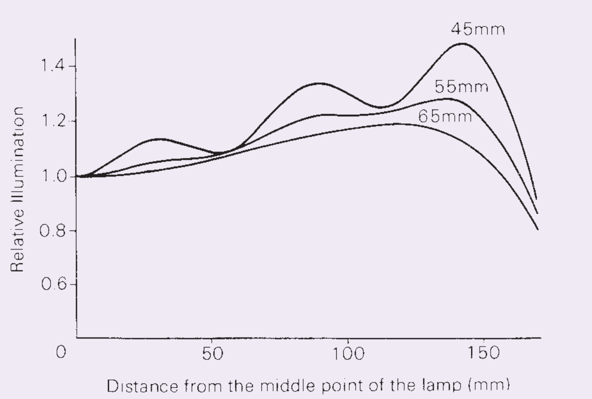
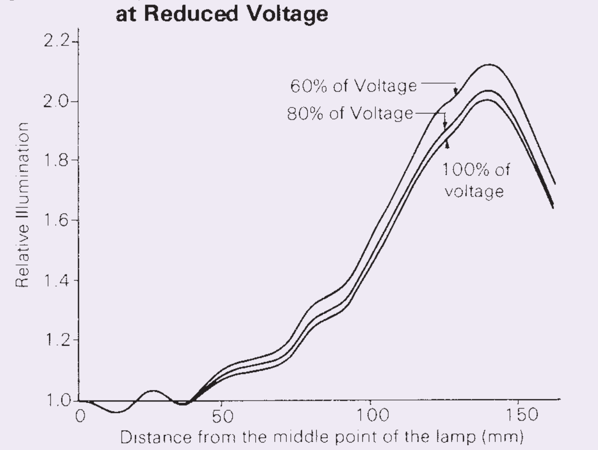


Figure 35 Light Distribution Profile Fluctuation at Reduced Voltage



[9] Copier Exposure Units

(1) Applications

Another major application of our halogen lamps is for use in copier exposure units. We produce and sell these units for use in plain paper copiers (PPC's). Combining the core halogen lamp with lenses, sockets and other small parts, they can be easily installed in copiers as a sub-assembly unit.

Features

1 — High optical characteristics needed in the final stage of photocopying.

2 — Elimination of time consuming PPC assembly site adjustments for variations of the luminance level and light profile.

3 — Separate from other parts of the copier, the exposure unit can be designed and prototype developed for professionals. Thus the total time and cost of copier development will be reduced.

4 — Savings in procurement and inventory costs. With fewer parts required for assembly, it is easier to order only the number of units required for the production line. This reduces warehousing space and cuts costs to management.

(2) Component List

Component	Type	Use	Construction
(1) Halogen Lamp	A	Light source for illuminating originals	QR, JC for use in high speed copiers
(2) Contact Clip	A	Support for halogen lamp and supply voltage	Phosphor bronze
(3) Contact Supporter	A	Insulator to secure contacts	Ceramic (steatite) or heat resistant plastic
(4) Main Reflector	A	Collects light at the original copy	High gloss aluminum with extrusions or sheets treated by polishing and anodization
(5) Sub Reflector	B	Eliminates paper edge shadow and illuminates area in back of lamp	Polished and aluminum (extruded mold or sheets)
(6) Side Reflector	B	Compensates for reduced brightness at either end of lamp	Aluminum sheets or foil
(7) Base	B	Supports the complete unit	Steel sheets (May not be necessary when extruded mold main reflector is used)
(8) Side Bracket	B	Supports clips, etc. and is installed to the frame of the copy machine	Steel plate, aluminum, plastic
(9) Lens	B	Projects original image on photoconductor	Fiber lens array or conventional lens
(10) Overheat Protector	B	Shuts down voltage supply in case of overheating	Non-resettable thermal fuse or resettable thermostat
(11) Wire Harness	B	Supplies electric power	Cable, connector, terminal
(12) Light Shield	B	Shields stray light from the photoconductor	Plastic foam or sheets
(13) Filter	B	Compensates spectral sensativity of photoconductor and reduces infrared light	Colored glass, colored plastic film
(14) Dust Shield glass	B	Keeps toner from lens	Clear glass sheet
(15) Mirror	C	Image reflected in reverse on lens (conventional lenses only)	Glass substrate aluminum evaporated mirror
(16) Eraser	C	Eliminates residual charge on photoconductor after transfer of image	Incandescent and neon lamp array
(17) Charger	C	Charges photoconductor prior to exposure	Tungsten wire
(18) Cooling Fan	C	Cools lamp and unit	Cross flow fan, axial fan or sirocco fan
(19) AVR	C	Supplies stabilized voltage to halogen lamp and adjusts light emission	Phase controlled circuit

Type: A — Basic configuration B — Optional configuration C — Special configuration

(3) Conventional and Fiber Lenses

Exposure units generally use either conventional or fiber lenses. Fiber lenses incorporate graded index fiber lens arrays (Selfoc lens arrays), and are most popular in small, lightweight copy machines for general purpose and home consumer use. Because of their compact size, they are designed with sliding screens where the original copy moves over a stationary lamp. Although these PPC's generally do not include photo enlargement or reduction features, their use of fiber lenses ensures the highest quality imaging process.

Conventional lens exposure units incorporate standard round disk lenses. PPC's utilizing these units are generally larger in scale and include enlargement and reduction features. Because of their size, a longer optical path is required in which the lens is separate from the illumination unit. In many cases, the light source moves across a still original, making a light weight illumination unit an important design objective. Another design objective of the illumination unit involves controlling the brightness reaching the photoconductive drum. At Ushio, our units are designed to render the best optical characteristics on the drum. From prototype design, through testing to production, light distribution and luminance levels are strictly controlled.

Figure 36 Fiber Lens Unit

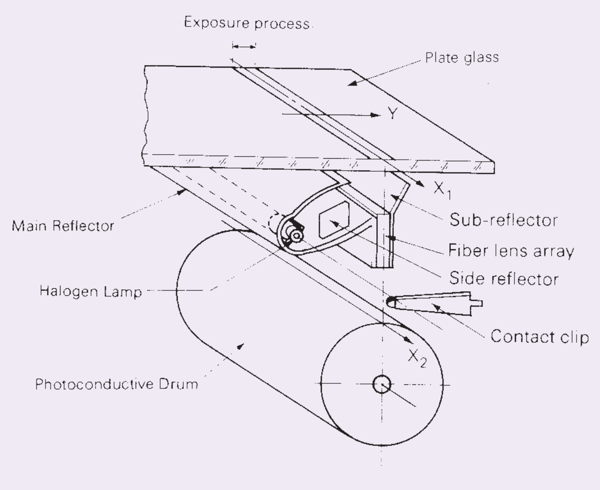
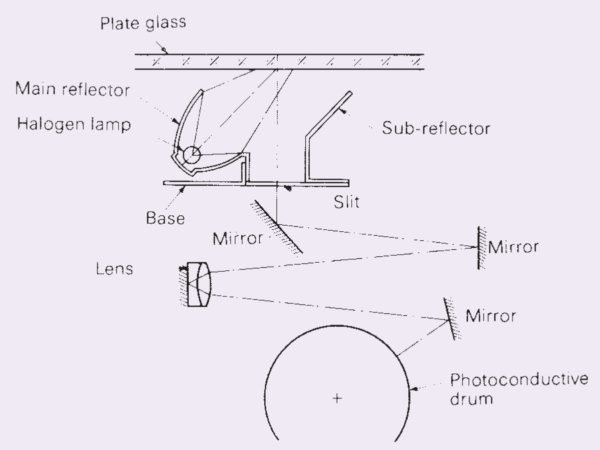
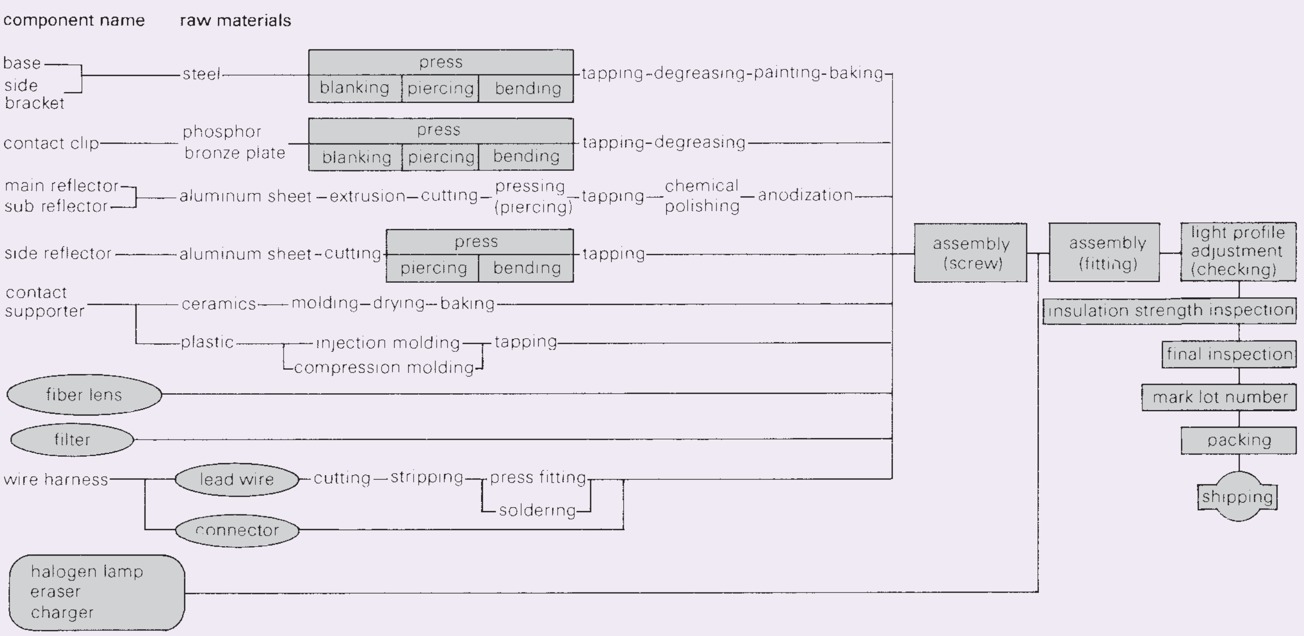


Figure 37 Conventional Lens



(4) The Manufacturing Process

Figure 38 The Manufacturing Process



(5) Light Profile Measurement

Figure 39 Schematic of Photoconductor Light Profile Measuring Instrument

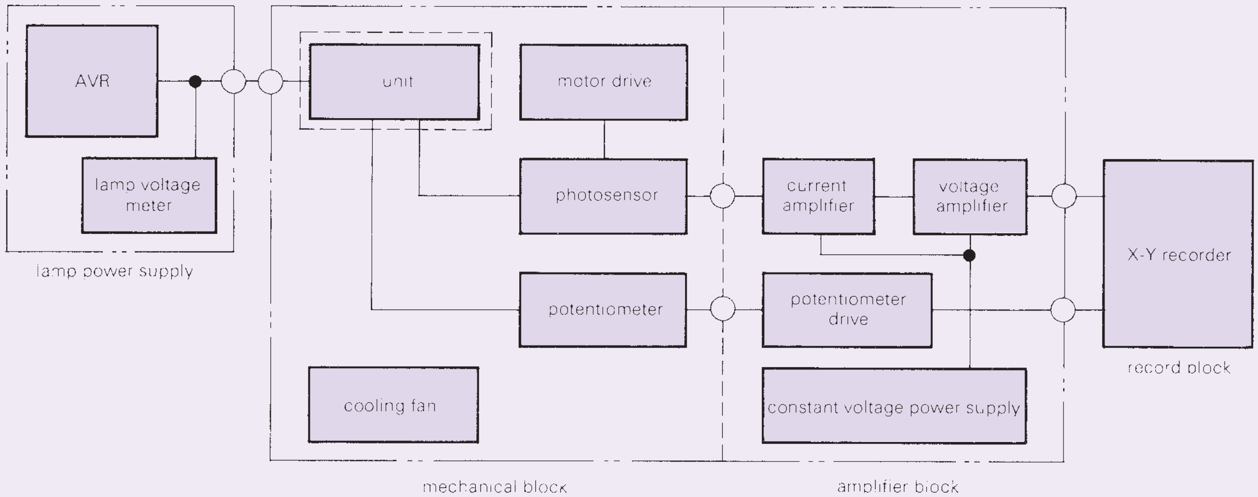
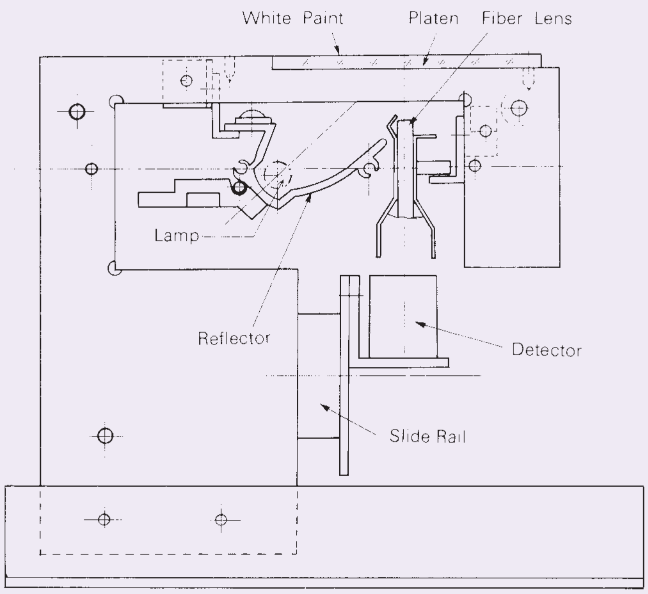


Figure 40 Section Plan



(6) Luminescence Levels of Original Copy and Photo Conductor for Fiber Lens Units

Unit type	Ratings			Operating voltage	Luminescence level of original copy ($\times 10^4$ lx)	Luminescence level of original photoconductor (lx)
	V	W	lm			
A	85	400	6600	80	38	315
	170	350	6900	160	40	330
B	85	400	9300	85	29	160 ~ 170
	190	400		190		
C	80	300	5550	80	34	200
D	65	240	3700	65	24	160 ~ 170
E	80	300	6000	80	36	

※ Frosted lamp
※ Lamp diameter A, B: 8mm C, D, E: 6mm
※ Fiber lens array TC = 64
※ Photosensor: Hamamatsu Photonics S1133-01

※ Luminance level of original copy was measured with 4 × 10mm slit.
※ Luminance level of photoconductor was measured with 1 × 10mm slit.
※ In case of conventional lens, the illuminance levels are near to those in the table.

(7) Characteristics

Figure 41 Luminescence Level Profile of Changes in Photoconductor Magnification of a Single Optical System

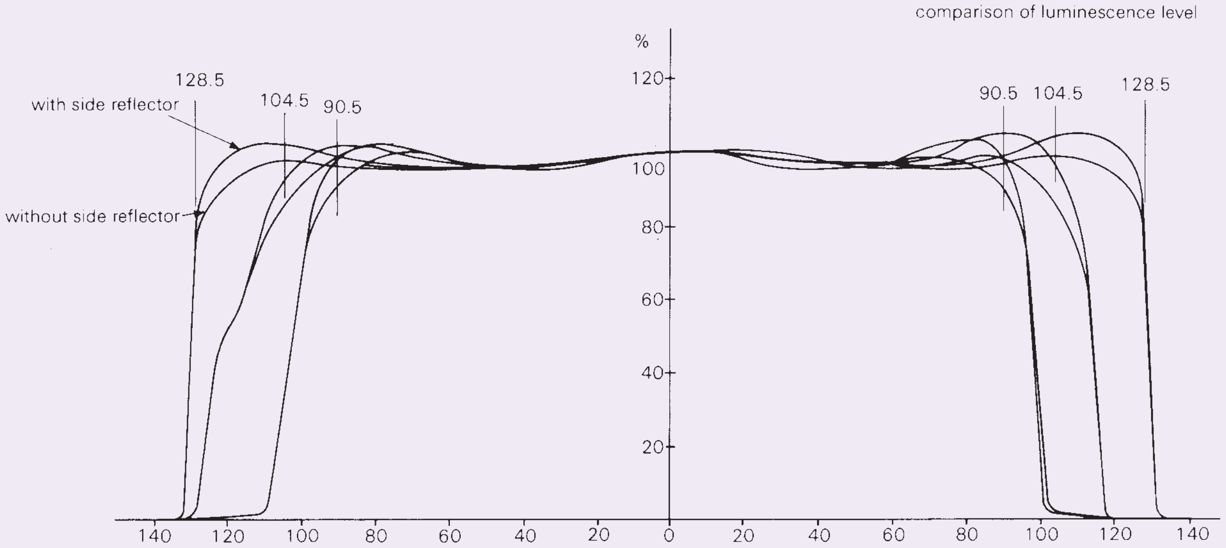


Figure 42 Luminescence Level Profile of the Original Copy Surface

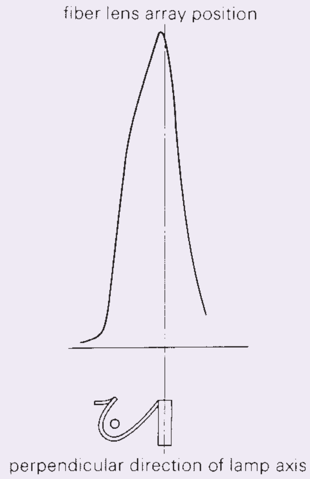
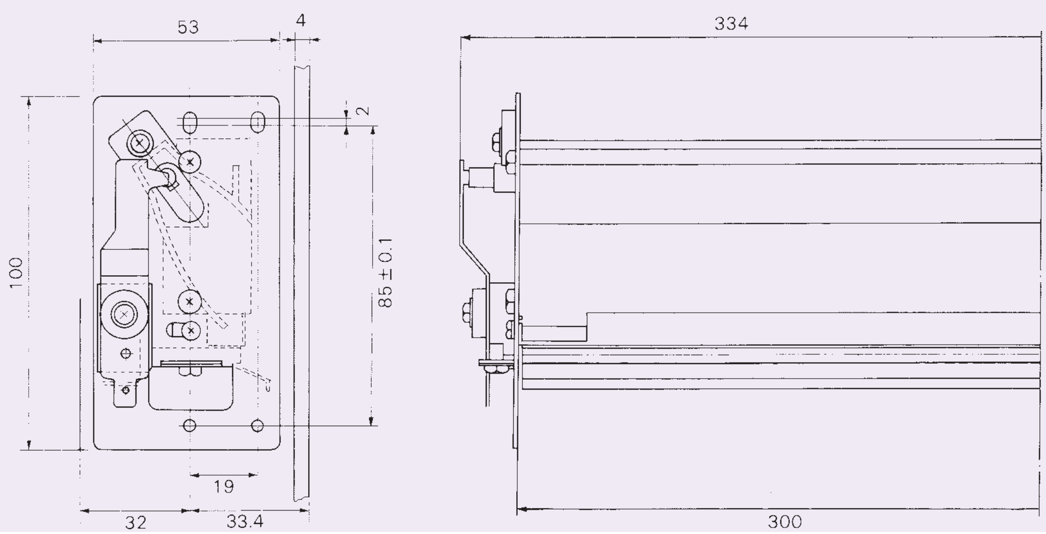


Figure 43 Fiber Lens Configuration



[10] Exposure Lamp AC Voltage Regulator (AVR)

AVR's are ideally suited for use with halogen lamps (QR's) in PPC's. Details of their features, circuitry, specifications and power-on transients are:

(1) Features

1 — Stabilized voltage and constant light output of the lamp. The AVR absorbs input voltage variations caused by PPC line voltage and load variations. This results in constant copy contrast.

2 — Proper contrast. Contrast is maintained by adjusting the lamp supply voltage to compensate the original darkness and reduced light output caused by contamination of the optical path.

3 — Extended lamp life. The AVR prevents inrush current, thus protecting the lamp from damage and extending its life.

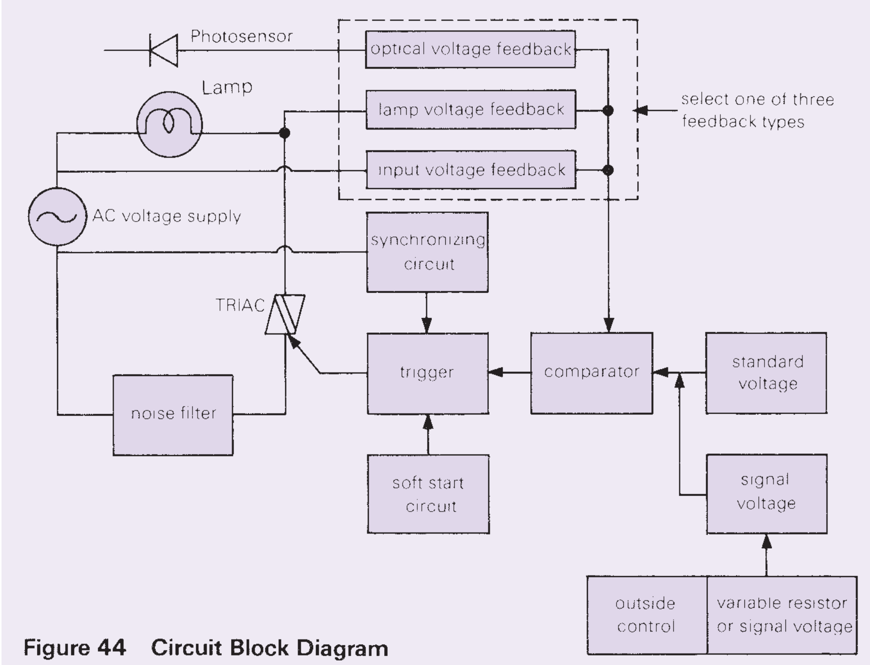


Figure 44 Circuit Block Diagram

(2) AVR Circuitry

Unless otherwise specified, AVR circuits are controlled by a bi-directional SCR (TRIAC) type phase controlled circuit. This circuitry stabilizes light emissions according to the following three methods:

1 — input voltage feedback
2 — lamp voltage feedback
3 — optical feedback

A schematic of the circuit appears in Diagram 44.

(3) Specifications

Typical AVR specifications are shown in Table 5.

(4) Power-on Transients

Figure 45 and 46 show power-on for the AVR.

Table 5 AC Voltage Regulator Specifications for Halogen Lamp Exposure Unit

Item	Specifications	Remarks
(1) Model		
(2) Standards to Apply	UL, CSA	
(3) Environment	0 ~ 60°C, 10 ~ 90% RH	
(4) Operating Conditions	4.5 sec. ON, 1.5 sec. OFF	
(5) Input Voltage	115V AC±10% 50/60Hz/12V DC (Regulated)	
(6) Rated Output Voltage	85V AC	
(7) Rated Output Wattage	300W	
(8) Regulation of Output Voltage	±1%	Input voltage variation ±10%
(9) Set Value Stability	±2%	Rated Voltage (60 Hz)
	±2.5%	Frequency (50/60Hz)
(10) Output Range	35 ~ 85V	
(11) Means of Varying Output	Variable resistor 10KΩB	
(12) Soft Start	None	
(13) Inrush Current	Within 7 times of normal peak value	
(14) Insulation Strength	AC line to ground/AC line AC 1,500V 1 min.	
(15) Insulating Resistance	AC line to ground/AC line DC 500V 100 MΩ	
(16) On-Off Control	Lamp on at 0V of remote terminal / Lamp off at 5V DC	
(17) Vibration	X, Y, Z direction for 2 hours each, 10 ~ 55Hz, amplitude 1.5 mm, Sweep cycle 1 min.	
(18) Shock	X, Y, Z direction three times each 40G	
(19) Leak Current	AC line to ground with 1KΩ resistor less than 0.75mA	
(20) Size	Under 90 × 90 × 30mm	
(21) Connection		

Figure 45 Power-on Transient Wave Forms for Current and Input Voltage

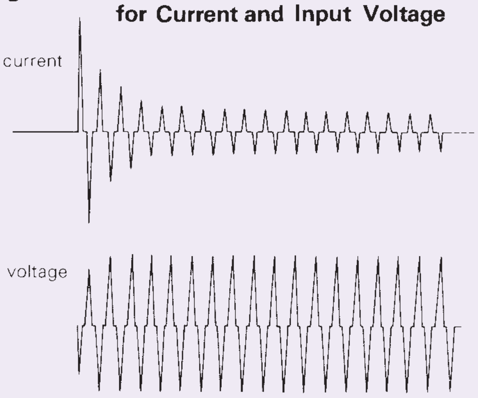
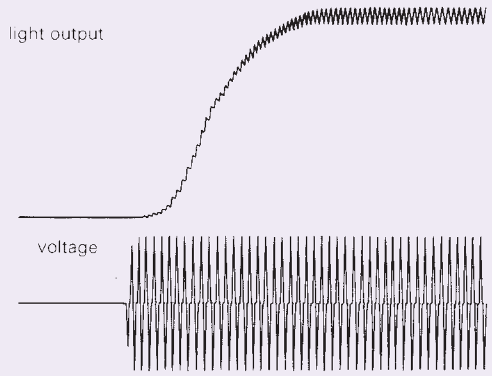


Figure 46 Power-on Transient Wave Forms for Light Output and Input Voltage



[11] Sample Order

Ushio prototypes of lamps and exposure units meet the exacting requirements of our customers at all stages of development. From product planning and research to development and delivery, we work closely with our customers to assure them of the most exact standards and highest quality. Figure 47 shows the form used to place a sample order for the PPC halogen lamps.

Figure 47 Prototype Specifications for PPC Halogen Lamps

Electrical characteristics

rated voltage______VAC operating voltage range______V ~ ______V AC
rated wattage______W ± ______%
total lumens______Lm ± ______%

Life ☐ average life ☐ minimum life
☐ on-off use______ seconds ON______seconds OFF______times
☐ continuous use______hours

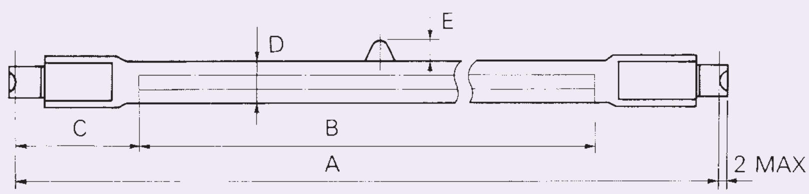
Light ditribution

distance from filament to original______mm

distance from the lamp center	relative illumination	tolerance

Dimension

A contact to contact_____ ± _____
B lighted length_____ ± _____
C contact to filament end__________
D bulb diameter______($\phi 6 \pm 1 / \phi 8 \pm 1$), bulb ☐ clear ☐ frosted
E filling tip height______ MAX. (standard 5 MAX.)



[12] Safety Precautions

(1) Keep the temperature of the seal below 350°C ([7]-(6))

(2) Keep the temperature of the bulb above 250°C ([7]-(7))

(3) Do not hold the bulb in bare hands. Use alcohol solvent to clean the bulb

(4) Avoid shock when the lamp is on. 10G shock is maximum for the lamp used for copier exposure units ([8]-(3))

(5) Use an external fuse when required (labeled on the package of some types of JPD and JCD lamps.)

(6) Fragile. Do not drop, crush, bend or scrub.

(7) The lamp is extremely hot. Do not touch lamp either when it is on or soon after it has been turned off.

[13] Technical References

(1) Filament Temperature

There are four ways to describe the filament temperature: true temperature, brightness temperature, color temperature and distribution temperature.

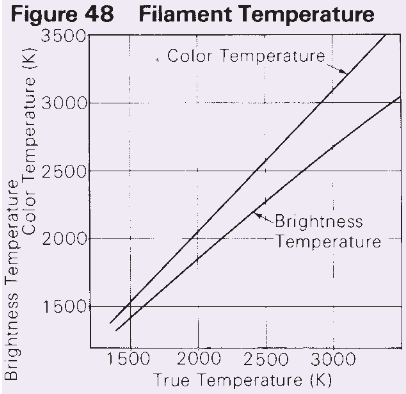
True temperature is the temperature of the radiating body itself.

Brightness temperature is the temperature of a black body which emits the same brightness of light with the same wavelength as a certain radiating body. Brightness temperature is measured by an optical pyrometer using the wavelength of 655nm. Brightness temperature is lower than true temperature.

Color temperature is the temperature at which a black body emits radiant energy competent to evoke a color of the same hue and saturation as that evoked by radiant energy from a given source. Color temperature is higher than true temperature and is measured by a color meter, through calculation from brightness temperature and spectral distribution. Color meters can read color temperature directly. Optical pyrometers give the brightness temperature reading, following which color temperature can be calculated. A small fraction of the filament (e.g., one turn of the coil), is all that needs to be measured. Spectral distribution is determined on chromaticity coordinates by using the measured intensity of spectral radiant intensity of visible light from the radiating body.

Distribution temperature is the temperature of the black body which has the same or approximately the same spectral distribution as the relative spectral distribution of a certain radiating body in the visible light range. Instead of distribution temperature which is used in JIS C7527, color temperature is used throughout this brochure. This is because they both have the same value where halogen lamps are concerned.

Figure 48 Filament Temperature



(2) Measurement of the Seal

(1) Thermocouple

The thermocouples recommended for the temperature measurement are nickel/nickel-chromium, or iron/copper-nickel (Type J). Each wire forming the couple shall have a maximum diameter of 0.3mm.

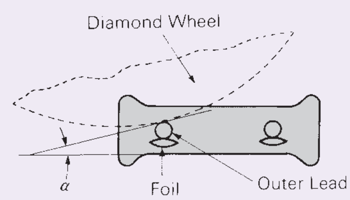
The wires should meet at an angle of 150°, and after the ends have been welded together, the wires are then brought into an approximate straight line with the weld projecting slightly to one side.

(2) Method (I)

Work on the Lamp

Using a diamond wheel which has a maximum width of 0.5mm, and a diameter of approximately 100mm, a notch is made perpendicular to the lamp axis so that the outer lead is exposed. The notch is made on the part where the outer lead and the molybdenum foil are welded. The cutting angle "α" should be determined with consideration given to preventing damage to the molybdenum foil (see Fig. 49).

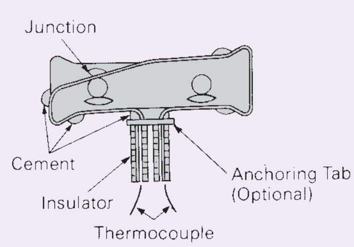
Figure 49 Preparation of Thermocouple Attachment



Attachment of the Thermocouple

The thermocouple is placed in the notch, screwed to contact the exposed part of the outer lead and fixed with cement. In addition, the thermocouple lead wires are tensed both ways in the notch, which is finally filled with cement (see Fig. 50).

Figure 50 Thermocouple Attachment

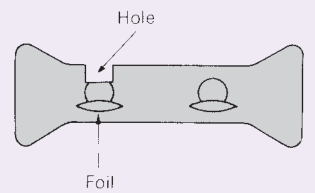


(3) Method (II)

Work on the Lamp

By using an ultrasonic drill, a hole about 1mm in diameter is pierced at the point where the outer lead is welded to the molybdenum foil. The hole is made from the side that the outer lead first touches the drill (see Fig. 51).

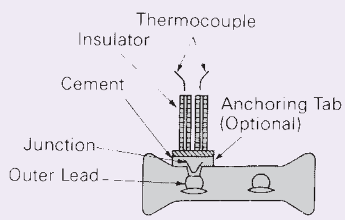
Figure 51 Preparation of Thermocouple Attachment



Attachment

The thermocouple is secured to contact the outer lead and fixed with cement (see Fig. 52).

Figure 52 Thermocouple Attachment



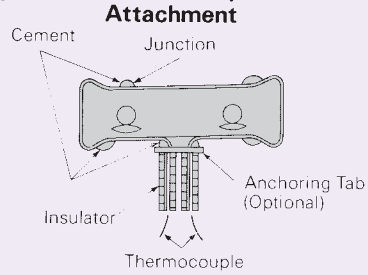
Note

Contact between the thermocouple and the outer lead can be confirmed by checking electrical conductivity. The contact of the two is best achieved by soldering or welding.

(4) Method (III)

The thermocouple is placed on the lamp seal and fixed by cement. The (see Fig. 53).

Figure 53 Thermocouple Attachment



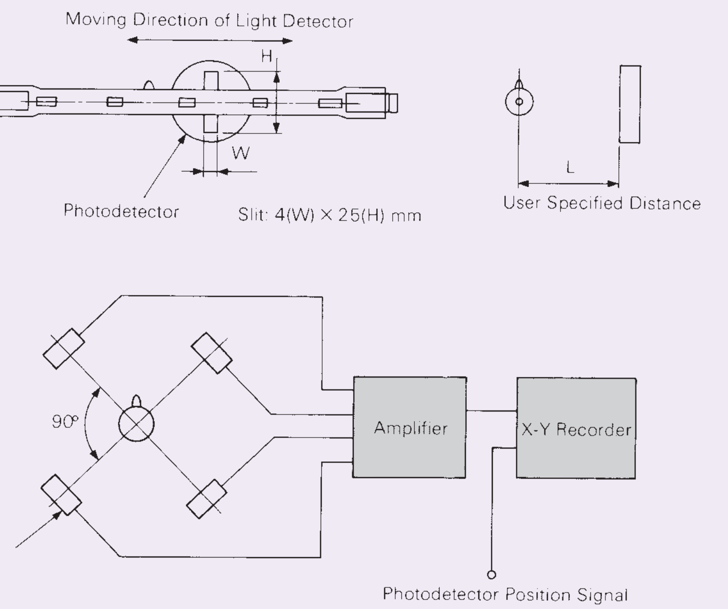
(5) Measurement

Measurement data should be taken 0.5 ~ 1 hours after power-on when the lamp reaches its saturated temperature.

(3) Measurement of Light Profiles

Measurement is taken by using the photodetector developed by Ushio for such purposes. This detector has angular characteristics approximated to cos θ. The device has four photodetectors located 90 degrees apart from each other. It adds their output and plots it on an X-Y recorder.

Figure 54 Light Profile Measurement



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