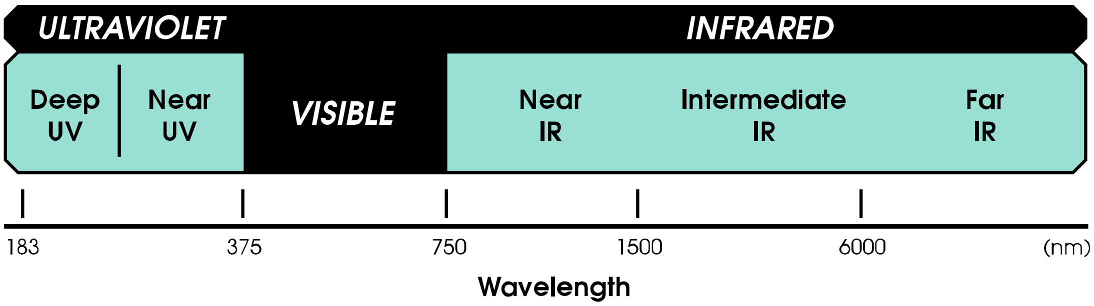
I. QUARTZ INFRARED HEATER - INFRARED RADIATION

1.1 ELECTROMAGNETIC SPECTRUM

Light can be defined as an electromagnetic wave within the range of 100nm-100000nm (1mm). The boundaries for the spectrum for visible light are 380nm-750nm; IR radiation is divided up into Near-Wave, Intermediate-Wave, and Far-Wave Infrared Radiation.

Near-Wave is less than 2000nm, Intermediate-Wave is between 2000 and 4000nm, and Far-Wave IR is above 4000nm.

FIGURE 1 The Electromagnetic Spectrum



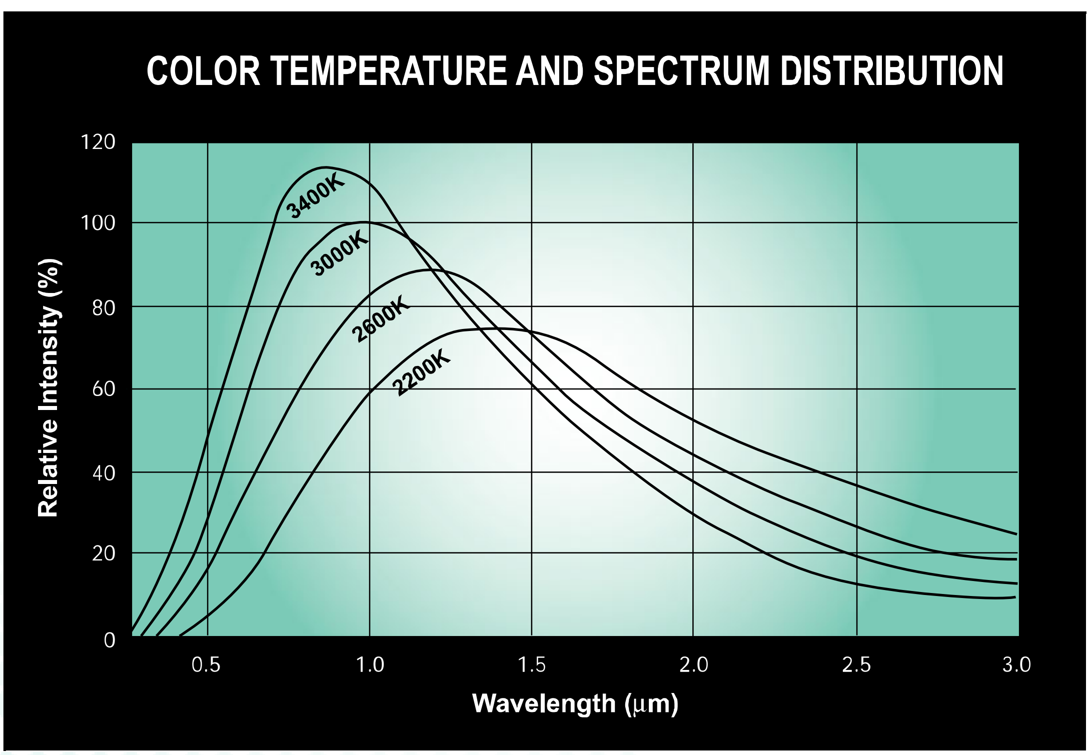
1.2 THE SPECTRUM DISTRIBUTION OF QUARTZ INFRARED HEATER (QIH) LAMPS

Several types of halogen lamps with color temperatures ranging from 2000-3400K are available. QIH lamps have a height intensity in Near-Wave radiation, with a color temperature ranging from 2300K to 2700K. IR-Wave radiation produces more effective heating; QIH lamps are specifically designed to use for heating products.

Figure 1.2 illustrates the color temperature and spectrum distribution of the QIH lamp. The relative energy increases as the temperature rises with the peak, moving toward the shorter range of the wavelength (visible light range).

The wavelength at the point of the peak of the curve can be calculated by dividing 2897 by the color temperature(K).

FIGURE 1.2



II. QUARTZ INFRARED HEATER - HEAT TRANSFER

The transfer of heat is achieved by three different methods: Conduction, Convection, and Radiation.

2.1 CONDUCTION

Occurs when an object is placed in direct contact to a heat source in which the heat is transferred from the source to the object. This can be observed by placing a pan on a hot stove.

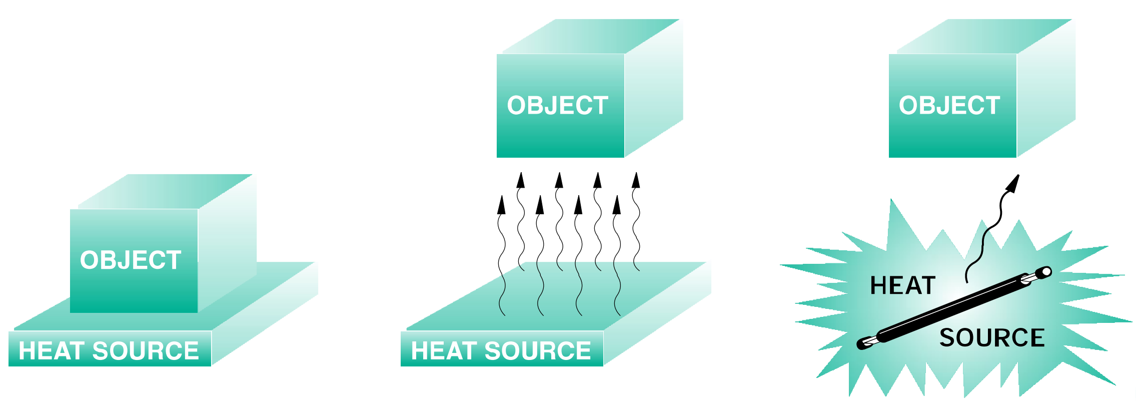
2.2 CONVECTION

Occurs when a heat source transfers heat to the surrounding atmosphere which in turn, transfers heat to the object it comes in contact with. This is how a hair dryer, conventional oven and home heating works.

2.3 RADIATION

Occurs when a heat source emits infrared electromagnetic waves which when striking and absorbed by an object, cause its temperature to rise. This is the way heater lamps and microwave ovens work and also the way the sun heats the earth.

FIGURE 2 Heat Transfer



III. QUARTZ INFRARED HEATER - DESCRIPTION

3.1 HIGH EFFICIENCY

The lamp envelope is of quartz glass. The compact bulb supplies a high luminous output per watt. The “Halogen Cycle” minimizes evaporation of the tungsten filament.

3.2 STABLE COLOR TEMPERATURE

Thanks to the “Halogen Cycle” — a chemical reaction whereby evaporated tungsten particles are returned to the filament —blackening of the bulb wall and thinning of the tungsten filament are kept to a minimum. Light intensity and color temperature remain stable throughout the life of the lamp.

3.3 LONG LIFE

The “Halogen Cycle” guarantees extremely long lamp life. Service life is about twice that of an ordinary incandescent lamp.

3.4 ECONOMY

Compact and lightweight, halogen lamps have made it possible to design very compact lighting or heating fixtures and equipment, allowing for a reduction in the cost of production facilities. Additionally, the long life of halogen lamps permits a further reduction in maintenance and related expenses.

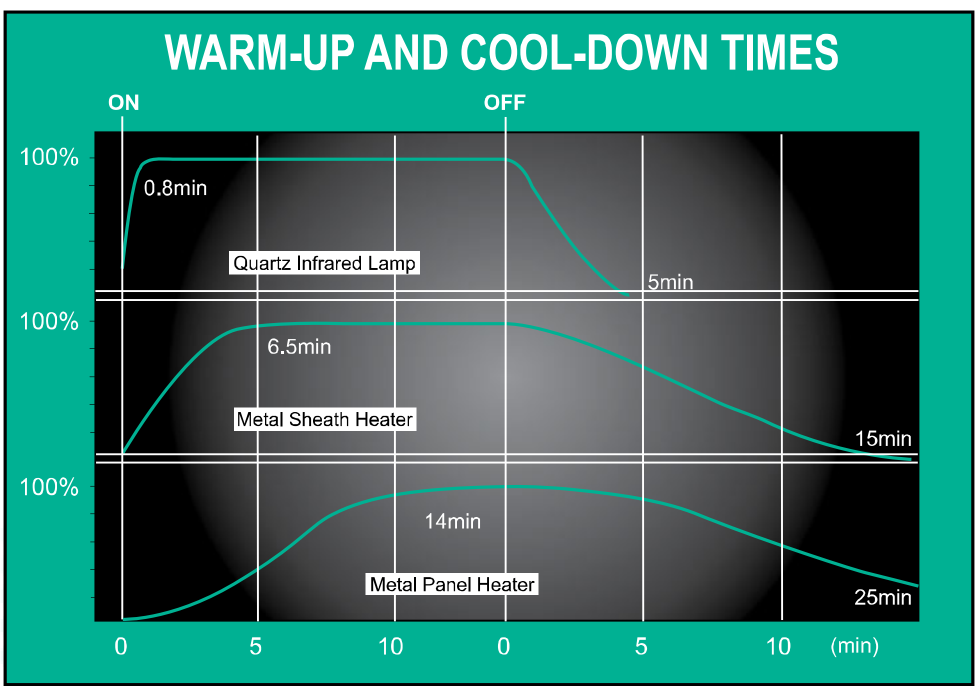
3.5 HEAT IMPACT RESISTANCE

With their quartz glass envelope, halogen lamps are much more resistant to heat impact than ordinary incandescent lamps. It is very unlikely that a halogen lamp will break should it come into contact with cold water.

3.6 WARM UP AND COOL DOWN

When a Quartz Infrared Heater lamp is turned on, it will be able to achieve its maximum radiation (heat energy) in the shortest time when compared with other heaters. The length of time it takes to achieve the maximum radiation output is 40-50 seconds; it also has a rapid cool down when the lamp is switched off.

FIGURE 3



IV. QUARTZ INFRARED HEATER - CHARACTERISTICS

4.1 VOLTAGE VARIATIONS AND VARIATIONS OF OTHER FACTORS

There are several factors (F), as shown in Fig. 4.1, that are inherent to the characteristics of halogen lamps. The change ratio (F/Fo: F is the actual value and Fo is the rated value) for their factors is approximate and expressed as: $F/Fo=(V/Vo)^K$ or $F=Fo\ x(V/Vo)^K$

FIGURE 4.1 Index K

F	CURRENT	WATTAGE	LUMEN	COLOR TEMP.
K	0.54	1.54	3.19	0.37

4.2 VOLTAGE VARIATION AND LIFE VARIATION

Voltage Variation and Life Variation is illustrated in Figure 4.2. 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; however, halogen lamps are made with an amount of halogen gas appropriate to the specific designed filament temperature. If the lamp is operated at a lower voltage, insufficient to raise the temperature of the filament to its optimum value, 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.

4.3 SEAL TEMPERATURE AND SEAL LIFE

Another cause of shortened lamp life involves damages to the seal. Figure 4.3 shows the relationship between seal temperature and seal life. This graph may vary according to the type of lamp. At high temperature ranges, life values are widely scattered. A molybdenum foil is used at the seal; however, the foil is not completely air tight. There is a very small gap between the quartz seal and the outer lead which enters through the quartz. Through this gap, very small quantities of air can be introduced into the seal area. Molybdenum easily oxidizes when temperatures rise above 350 degrees C. Measurement of the temperature at the seal can be made by using a thermocouple.

FIGURE 4.2

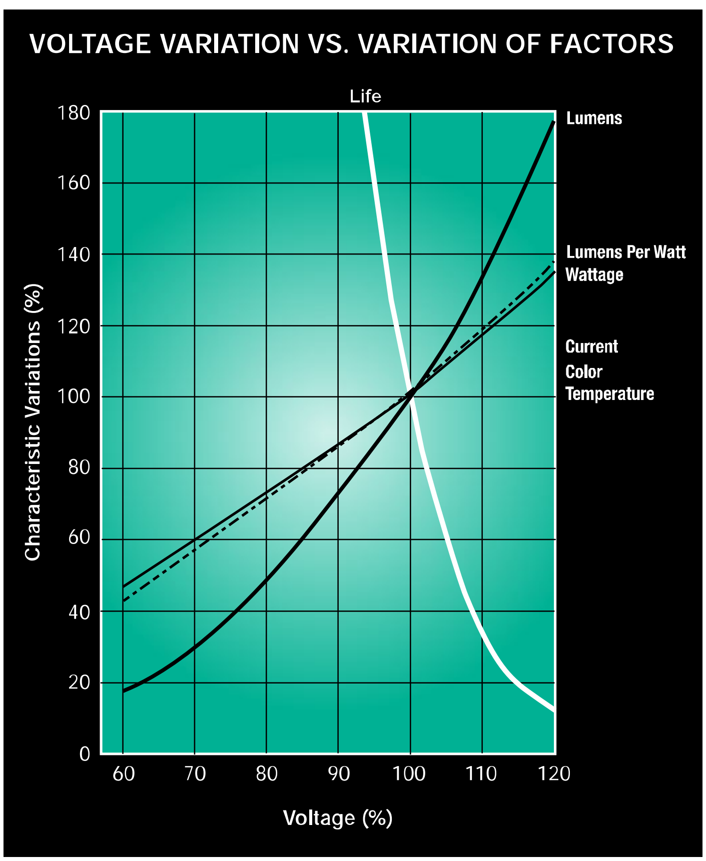
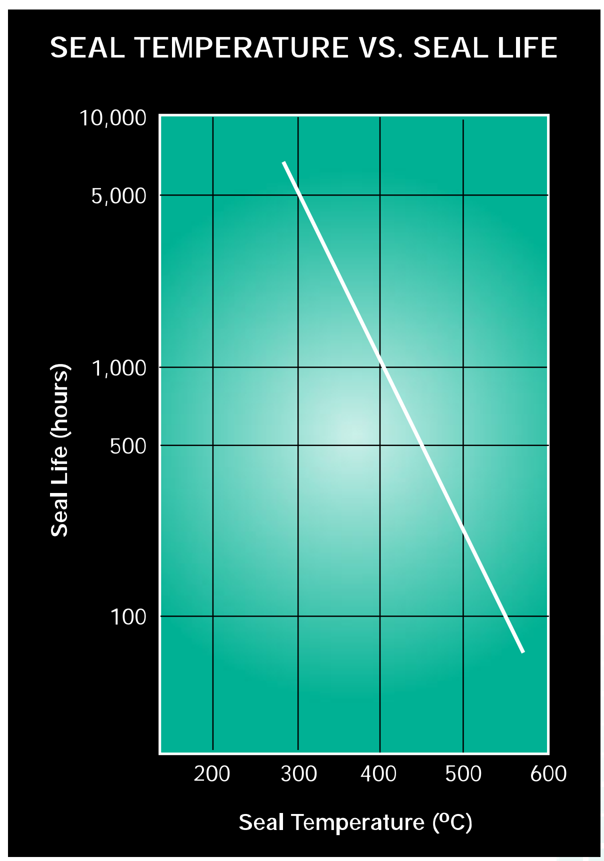
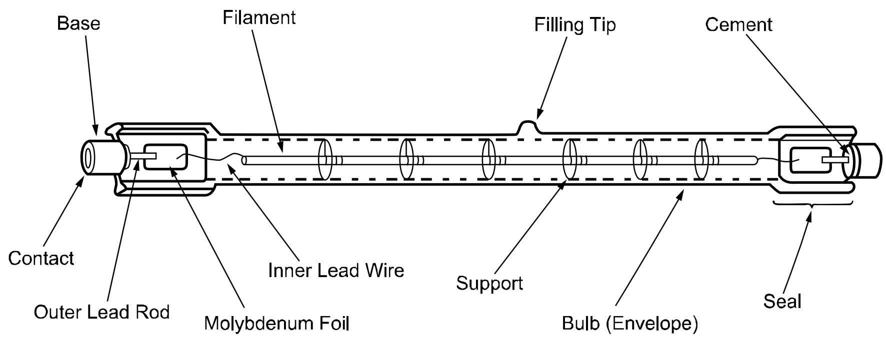


FIGURE 4.3



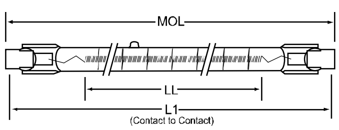
V. QUARTZ INFRARED HEATER - CONSTRUCTION

5.1 GENERAL VIEW OF LAMP

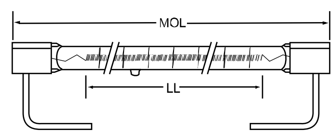


5.2 BASE TYPE OPTIONS

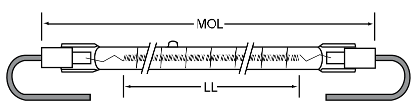
R7S Contact



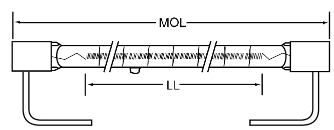
Flat Ceramic with Lead Wire (with Glue)



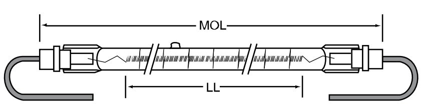
Ceramic with Lead Wire



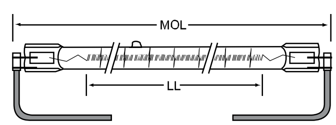
Flat Ceramic with Lead Wire (without Glue)



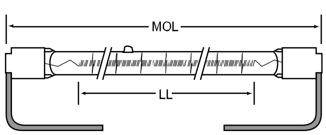
Round Ceramic with Lead Wire



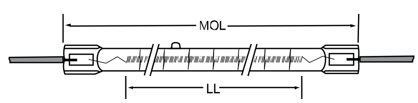
Lead Wire w/o Metal Sleeve



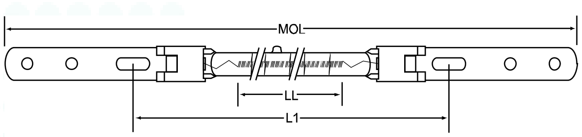
Metal Sleeve with Lead Wire



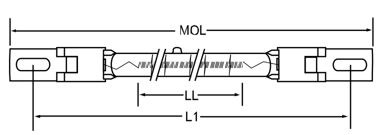
Lead Wire w/o Metal Sleeve



Metal Clip Base



Metal Clip Base



VI. QUARTZ INFRARED HEATER - MATERIALS

6.1 QUARTZ BULB

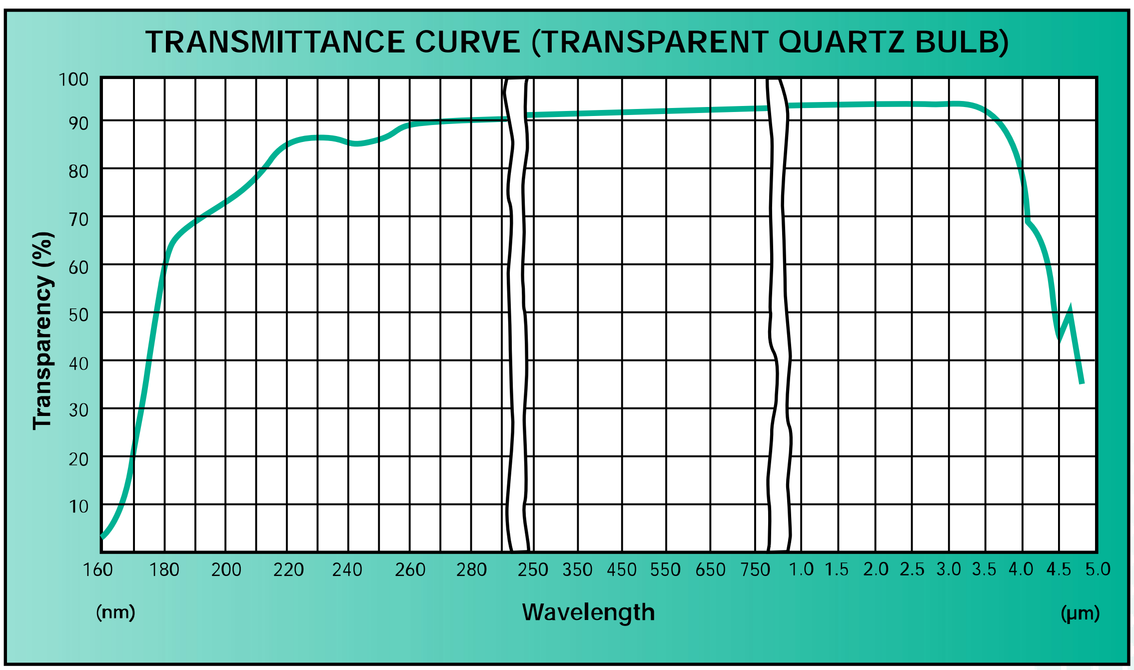
Quartz bulbs are indispensable due to the high temperature tolerance requirement of halogen cycles. There are two kinds of quartz bulbs— transparent and translucent. Translucent quartz bulbs are limited to use in certain heaters. For other types of lamps, frosted transparent quartz bulbs are also popular, as they diffuse the filament image providing a wider distribution of light radiation.

TABLE 1

PHYSICAL PROPERTIES OF THE TRANSPARENT QUARTZ BULBS

ITEM	UNIT	
Density	kg/m^3	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	2086
Annealing Point	K	1486
Distortion Point	K	1380
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 6.1



VI. QUARTZ INFRARED HEATER - MATERIALS

6.2 FILAMENT (TUNGSTEN) AND MOLYBDENUM FOIL

Quartz Infrared Heater 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 that are distortion free (non-sagging) and have long life. Known as doped tungsten, this sag resistant filament is in the K_2O-SiO_2-Al_2O_3 family.

Molybdenum foil is used as a conductor through the seal area of the Quartz Infrared Heater lamp. The foil, which ensures a hermetic sealing of the lamp, has a configuration as shown in Figure 6.2A. Table 2 lists the characteristics of tungsten and molybdenum.

FIGURE 6.2 Interlocked Recrystalized Particles in the Doped Tungsten

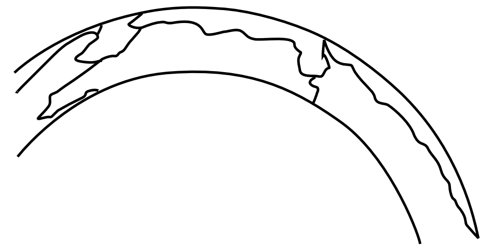


FIGURE 6.2A Cross Section of Molybdenum Foil

TABLE 2

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 (1530°C) 1.05×10^{-6} Pa (2130°C) 8.73×10^{-3} Pa (2730°C) 6.24×10^{-1} Pa (3230°C)	8.53×10^{-7} Pa (1530°C) 1.07×10^{-4} Pa (1730°C) 5.33×10^{-3} Pa (1930°C) 1.33×10^{-2} Pa (2035°C) 1.33×10^{-1} Pa (2295°C) 1.33 Pa (2535°C)
Specific Gravity	19.3	10.2 (Casting)
Volume Resistivity	5.5×10^{-8} Ω·m (27°C) 2.6×10^{-7} Ω·m (750°C) 4.0×10^{-7} Ω·m (1200°C) 8.5×10^{-7} Ω·m (2400°C)	5.78×10^{-8} Ω·m (27°C) 2.39×10^{-7} Ω·m (727°C) 3.52×10^{-7} Ω·m (1127°C) 4.72×10^{-7} Ω·m (1527°C)
Thermal Conductivity	1.67×10^{2} w/(m·k)(0°C)	1.34×10^{2}w/(m·k)(0°C)

6.3 FILLING GAS

Together with Nitrogen (N_2) and Argon (Ar), a small amount of halogen gas is used to fill the lamp. The most widely used halogen gases are compounds of Bromine (Br) and Chlorine (Cl_2). Selection of the halogen gases are based on conditions relative to the lamp application.

6.4 BASE AND LEAD WIRE

The base of Quartz Infrared Heater lamp is usually made of steatite or heat resistant metal. The lead wire may be nickel stranded, silicon covered, glass braided or Teflon covered.