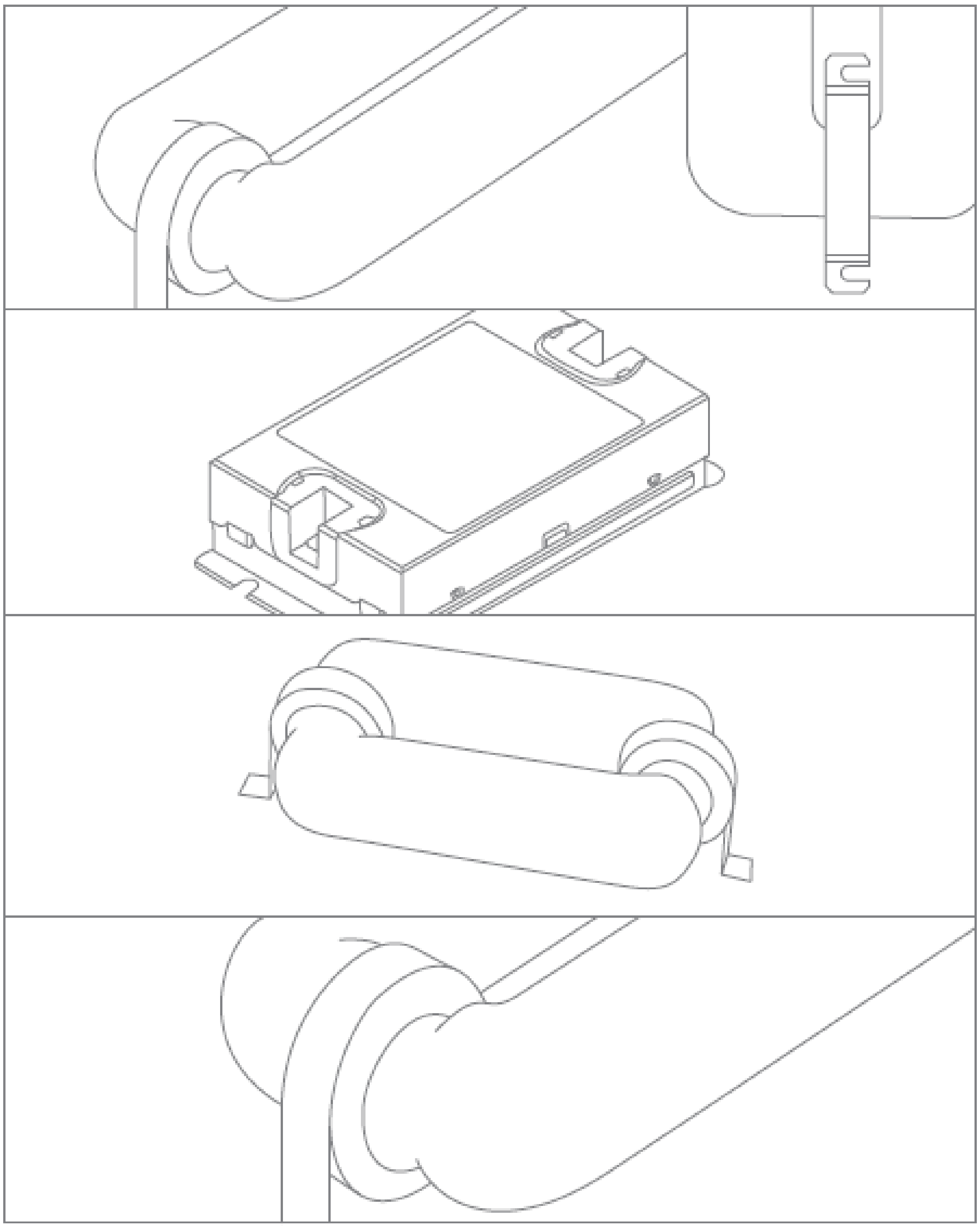
SYLVANIA ICETRON® QUICKTRONIC® Design Guide

Inductively Coupled Electrodeless Lighting System



FL022R4

Table of Contents

Introduction

List of Tables

List of Figures

Introduction

1.1 PRODUCT DESCRIPTION

The SYLVANIA ICETRON® QUICKTRONIC® system consists of an inductively coupled fluorescent lamp and a high frequency ballast. These systems use magnetic-induction technology instead of an electrode at each end of the fluorescent tube to power the discharge. Removal of the electrodes eliminates one of the major life-limiting components of a fluorescent lamp. The system design is optimized for high efficacy, high lumen output and maximum reliability.

SYLVANIA ICETRON lamp and ballast systems can reduce maintenance costs due to an average rated life of 100,000 hours. This is five to eight times the typical service life of conventional fluorescent and metal halide lamps. The ICETRON system is especially well suited for application where relamping is difficult or expensive. The high output ICETRON lamp is constructed of 2-1/8" (54 mm) diameter tubing with a closed loop discharge path. The lamp is driven with a high frequency (250 kHz) electronic ballast. Power is coupled to the lamp inductively through two ferrite core transformers located on the ends of the lamp. With no electrode to break or emissive coating to evaporate, lamp life is limited only by lumen maintenance. Further, lumen maintenance is improved over that of conventional fluorescent or HID systems due to the electrodeless design.

Figure 1: ICETRON System

1.1.1 System Features

- High lumen output
- High system efficacy – up to 89 LPW
- 100,000 hour life
- Instant on/instant restrike
- Fast warm-up time
- White light – minimal color shift over life
- 3500K, 4100K and 5000K color temperatures
- Excellent color rendering – 80 CRI
- Starting temperatures as low as -40°F
- Amalgam technology for wide operating temperature range
- 80% lumen maintenance at 60,000 hours of life (70W, 100W & 150W ICE lamps)
- 70% lumen maintenance at 60,000 hours of life (200W ICE lamps)
- Low EMI – Complies with FCC non-consumer limits

1.1.2 System Offering

Table 1: System Availability

Ballast**	Lamp	Input Power 120/277V (Watts)	Initial System Lumens* (5000K)
QT1x100 ICE/UNV-T	ICETRON 70	79/77	6815 (6655)
QT1x100 ICE/UNV-T	ICETRON 100	106/103	8600 (8300)
QT1x150 ICE/UNV-T	ICETRON 100	154/149	11,900 (11,500)
QT1x150 ICE/UNV-T	ICETRON 150	161/156	13,000 (12,700)
QT1x200 ICE/UNV-T	ICETRON 200	220/214	16,400 (15,800)
QT1x100 ICE UNV/DIM	ICETRON 100	112/108	8600 (8300)

*values for 3500K & 4100K (values in parenthesis is for 5000K)

**QT1x100 ICE/UNV & QT1x150 ICE/UNV also available in Type 2 (-W) design.

1.2 LAMP SYSTEM TECHNOLOGY AND OPERATION

1.2.1 Operating Principle

The ICETRON QUICKTRONIC lighting system incorporates an electrodeless fluorescent lamp which is excited by a radio frequency (RF) magnetic field. As a fluorescent lamp, ICETRON utilizes the same mechanism for light generation as found in conventional fluorescent lamps with internal electrodes. That is, the ultraviolet (UV) radiation generated by the internal discharge is converted to visible light by the phosphor coating on the inner wall of the lamp envelope. In contrast with conventional discharge lamps of fluorescent type, ICETRON does not require electrodes. Furthermore, the discharge current path forms a closed loop as shown in Figure 2 below. The electric field that initiates and maintains the plasma inside the discharge vessel is created not by electrodes but by an RF magnetic field concentrated within ferromagnetic ring cores. In essence, the ICETRON lamp is an electrical transformer with the closed loop discharge plasma serving as a one-turn secondary winding coupled to ferromagnetic cores whose multi-turn primary windings are excited by an electronic RF power converter (the ballast).

The ICETRON lamp utilizes an inductively coupled plasma that is driven in a closed loop discharge tube. Within that tube, RF power is evenly distributed along the discharge path. This allows a low profile geometry that avoids excessive thermal stress near the excitation area (typical of RF lamps with internal RF drive).
ICETRON operates at a frequency of 250 kHz (relatively low when compared to other RF lamps which function at 2.65 and 13.56 MHz). This frequency minimizes electromagnetic interference problems and ballast complexity. Together with the decentralized power injection, the low frequency operation results in a long-life electrodeless fluorescent lamp with unprecedented light output and system efficiency.

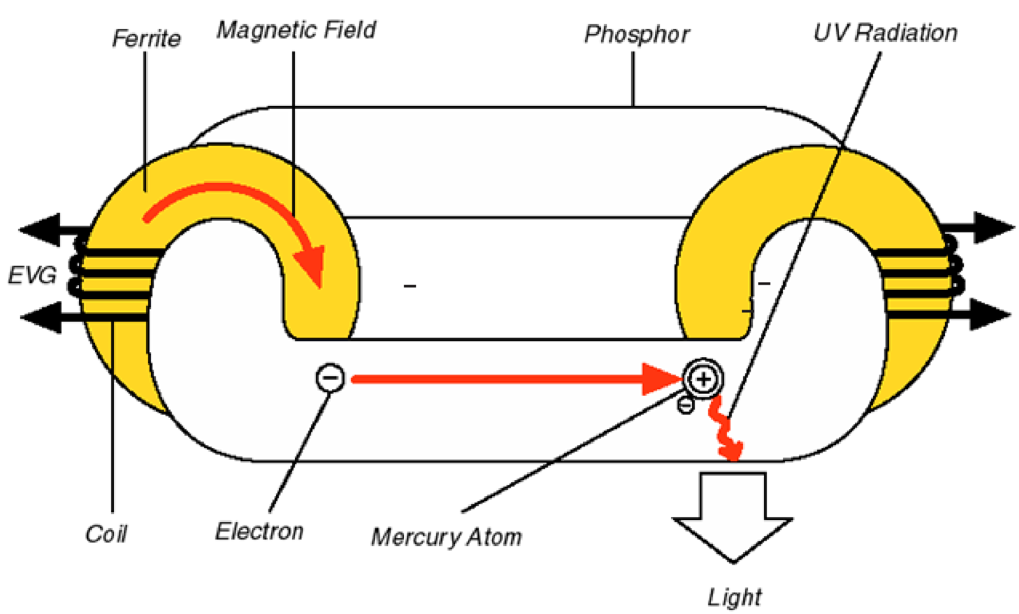


Figure 2: How does the ICETRON lamp work?

1.3 ICETRON SYSTEM OVERVIEW

1.3.1 Ordering and Specification Information

Table 2: Ordering and Specification Information

SYSTEMS

System Description	Lamp Wattage	Input Power 120/277V (Watts)	Initial System Lumens* (5000K)	Mean System Lumens* (5000K)	System Efficacy (lm/W)	Average Rated Life	Burning Position
ICETRON 70/QT100	70	79/77	6815 (6655)	5645 (5515)	86/89	100,000	Universal
ICETRON 100/QT100	100	106/103	8600 (8300)	7125 (6880)	81/83	100,000	Universal
ICETRON 100/QT150	100	154/149	11,900 (11,500)	9860 (9530)	77/80	100,000	Universal
ICETRON 150/QT150	150	161/156	13,000 (12,700)	10,775 (10,525)	81/83	100,000	Universal
ICETRON 200/QT200	200	220/214	16,400 (15,800)	12,185 (11,740)	75/77	100,000	Universal
ICETRON 100/QT100DIM	100	112/108	8600 (8300)	7125 (6880)	79/81	100,000	Universal

*Values for 3500K & 4100K (values in parenthesis is for 5000K)

** Mean lumens at 40,000 hours

LAMPS

Item Number	Ordering Description	Initial Lamp Lumens	Mean Lamp Lumens[1]	Color Temp (K)	CRI
26087	ICE70/850/2P/ECO	6500	5385	3500K	80
26088	ICE70/841/2P/ECO	6500	5385	4100K	80
26089	ICE70/850/2P/ECO	6350	5260	5000K	80
26102	ICE100/835/2P/ECO	8600	7125	3500K	80
26103	ICE100/841/2P/ECO	8600	7125	4100K	80
26105	ICE100/850/2P/ECO	8300	6880	5000K	80
26152	ICE150/835/2P/ECO	13,000	10,775	3500K	80
26153	ICE150/841/2P/ECO	13,000	10,775	4100K	80
26155	ICE150/850/2P/ECO	12,700	10,525	5000K	80
26893	ICE200/835/RCT/2P/ECO	16,400	12,185	3500K	80
26895	ICE200/841/RCT/2P/ECO	16,400	12,185	4100K	80
26897	ICE200/850/RCT/2P/ECO	15,800	11,740	5000K	80
26894	ICE200/835/CIR/2P/ECO	16,400	12,185	3500K	80
26896	ICE200/841/CIR/2P/ECO	16,400	12,185	4100K	80
26898	ICE200/850/CIR/2P/ECO	15,800	11,740	5000K	80
22093*	AMALGAM TIP COVER (2pk)				
22352*	AMALGAM TIP COVER (100pk)				

[1] Mean lumens at 40,000 hours.

[2] Lumens, wattage, Color Temp and CRI measured at an amalgam tip temperature of 149°F (65°C) for ICETRON® 100 and 158°F (70°C) for ICETRON 70, ICETRON 150 & ICETRON 200.

* When used in cold temperature applications, it is recommended that amalgam tip covers be used to insulate the amalgam tips and improve lumen output.

Ballast Factor for the ICETRON 70/QUICKTRONIC QT100W is 1.05

Ballast Factor for ICETRON 100/QUICKTRONIC QT150W is 1.38

BALLASTS

Item Number	Ordering Description	Input Voltage (VAC)	Input Current (AMPS)	Compatible Lamps
49753	QT1X100ICE/UNV-T	120/277	0.66/0.29 0.88/0.37	ICE70/2P ICE100/2P
46756	QT1X100ICE/UNV-W	120/277	0.66/0.29 0.88/0.37	ICE70/2P ICE100/2P
49772	QT1X150ICE/UNV-T	120/277	1.28/0.54 1.34/0.58	ICE100/2P ICE150/2P
49773	QT1X150ICE/UNV-W	120/277	1.28/0.54 1.34/0.58	ICE100/2P ICE150/2P
49789	QT1X200ICE/UNV-T	120/277	1.84/0.78 1.84/0.75	ICE200/RCT/2P ICE200/CIR/2P
49759	QT1x100ICE/UNV DIM	120/277	0.94/0.39	ICE100/2P

Per UL file E258264 Vol. 3.

Type 1, electric discharge ballasts QT1x100ICE/UNV-T or QT1x150ICE/UNV-T shall be mounted inside an electrical enclosure or raceway.

Type 2, outdoor electric discharge ballasts QT1x100ICE/UNV-W or QT1x150ICE/UNV-W may be mounted outside an electrical enclosure, but the input and outputs terminals, leads, and connections need to be suitably enclosed in conduit, raceway, or electrical enclosure.

Specifications: UL Listed Class P, Type 1, OR Type 2, Outdoor, CSA Certified
Temp Test Point (Tc) on ballast label for Type 1: 65°C Max (100W); 70°C Max (150W); 75°C Max (200W)
For Type 2: 71°C Max (100W & 150W)
FCC 47CFR Part 18 Non-Consumer
Sound Rated A
ANSI C62.41 Cat. A Transient Protection
RoHS Compliant
Complies with NEMA 410
Remote Mounting: Contact OSRAM SYLVANIA

1.3.2 Ordering Guide

Table 3: Ordering Guide

QT1X200ICE/UNV-T

QT	1	X	100	ICE	/ UNV	-	T
QUICKTRONIC®	No. Lamps (1)		Lamp Wattage	ICETRON® Inductively Coupled Electrodeless	Line Voltage (120 to 277V)		T = Type 1 W = Type 2

ICE200/835/RCT/2P/ECO

ICE	200	/8	35	/RC T	/2P	/ ECO
ICETRON® Inductively Coupled Electrodeless	Lamp Wattage 70 watt 100 watt 150 watt 200 watt	8=80 CRI	35=3500K 41=4100K 50=5000K	Bulb Type RCT=Rectangular CIR=Circular	2P = 2 prong connector blank = 3 prong connector	ECOLOGIC® TCLP Compliant

1.3.3 System Comparison

Table 4: System Comparison

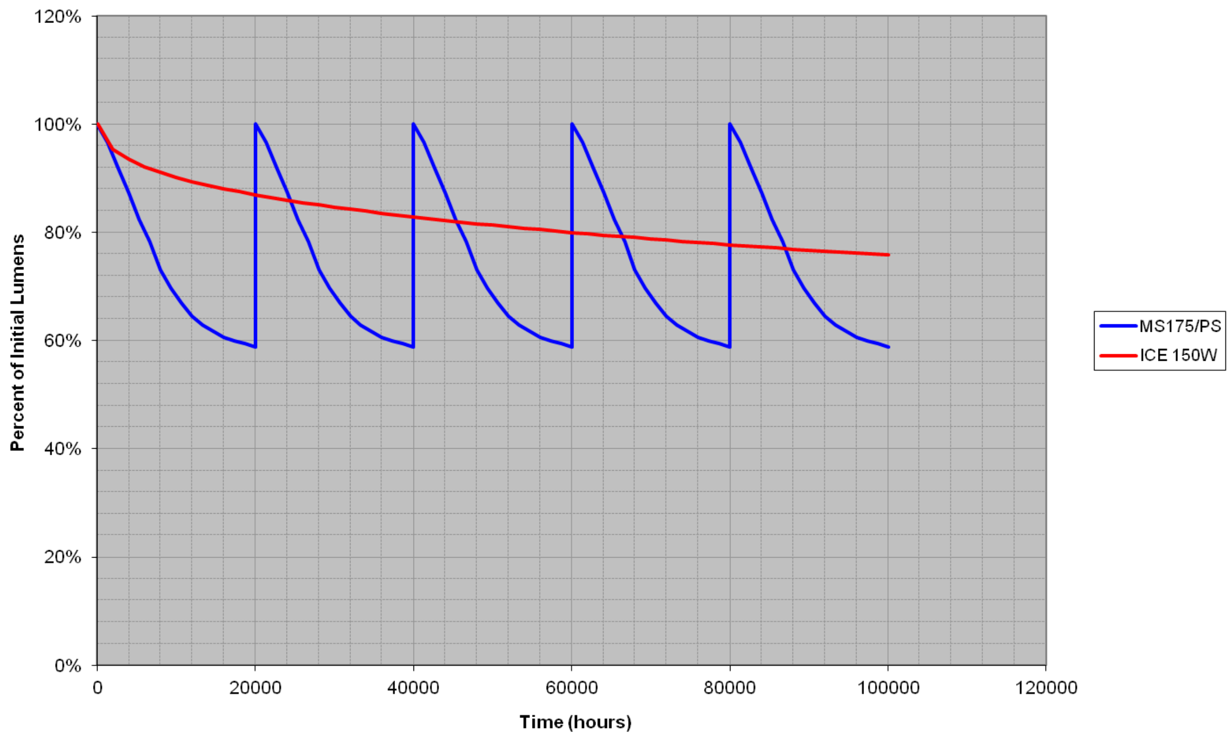
System Description	System Wattage[1]	System Lumens[2]	System LPW[1]	System Lumens @ 10,000 hours	Average Rated Life[3]	CRI
ICETRON 70/QT100	79/77	6815	86/89	6145	100,000	80
70W Metal Halide	90	5200	58	3400	15,000	75
ICETRON 100/QT100	106/103	8600	81/83	7755	100,000	80
100W Metal Halide	129	8500	62	5500	15,000	75
ICETRON 150/QT150	161/156	13,000	81/83	11,725	100,000	80
150W Metal Halide	185	12,900	70	8400	15,000	75
ICETRON 200/QT200	220/214	16,400	75/77	13,990	100,000	80
250W Metal Halide	285	20,000	70	13,000	7500	65
400W Metal Halide	460	32,000	70	20,500	15,000	65

[1] For ICETRON only, values given for 120V and 277V input voltage to ballast.

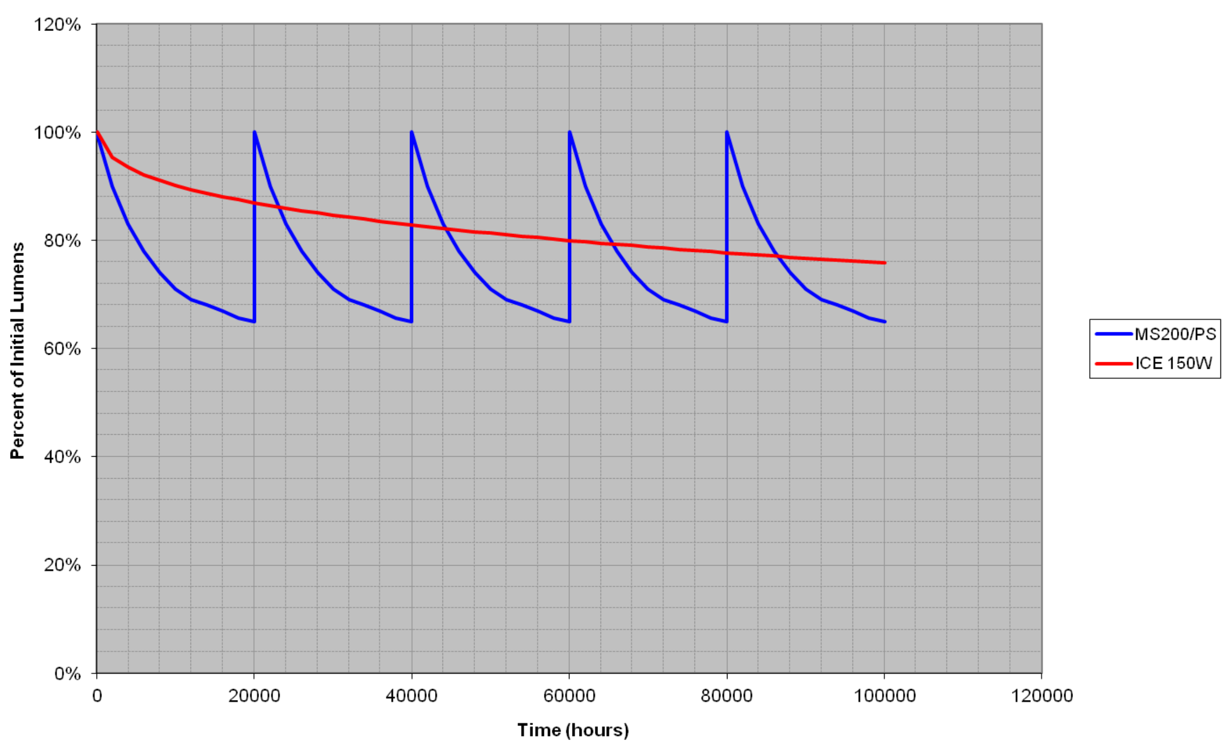
[2] Lumens based on 4100K CCT Systems. Lumens for 5000K systems will be slightly lower.

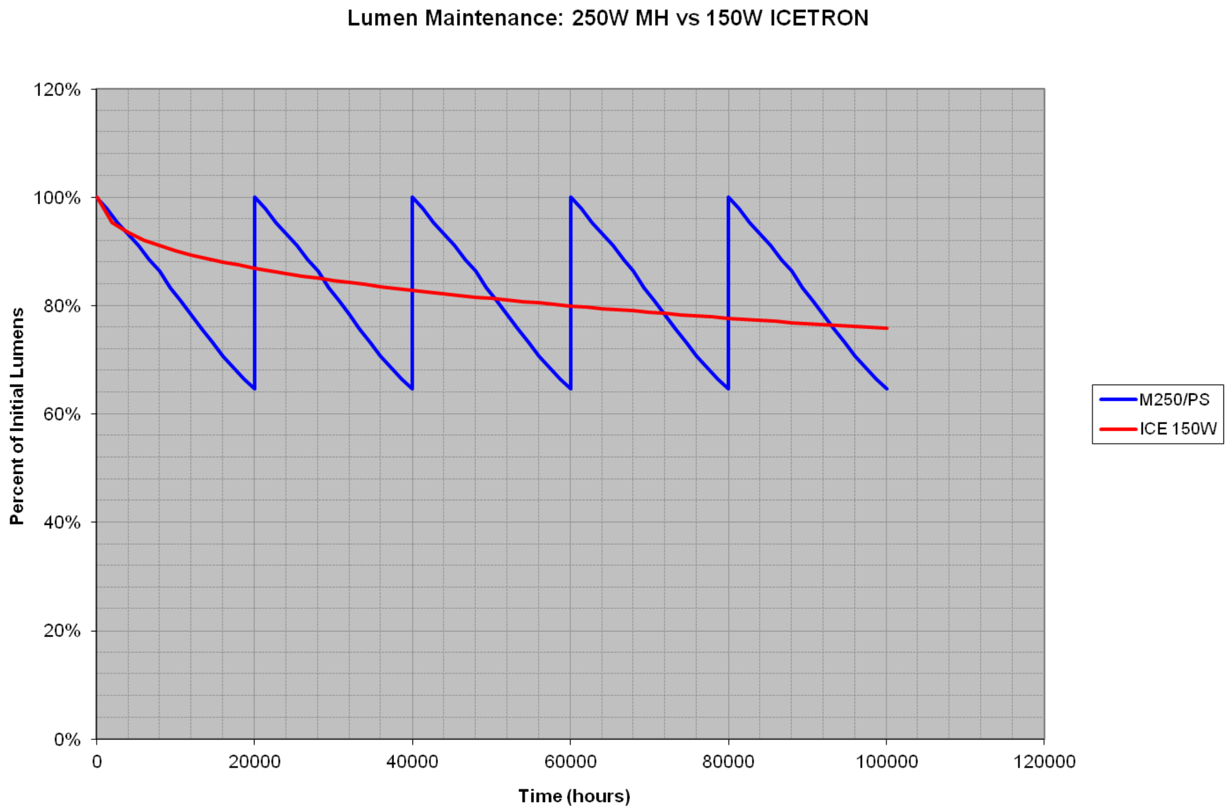
[3] Average rated life for HID systems based on 10 hours/ start .

Lumen Maintenance: 175W MH vs 150W ICETRON



Lumen Maintenance: 200W MH vs 150W ICETRON





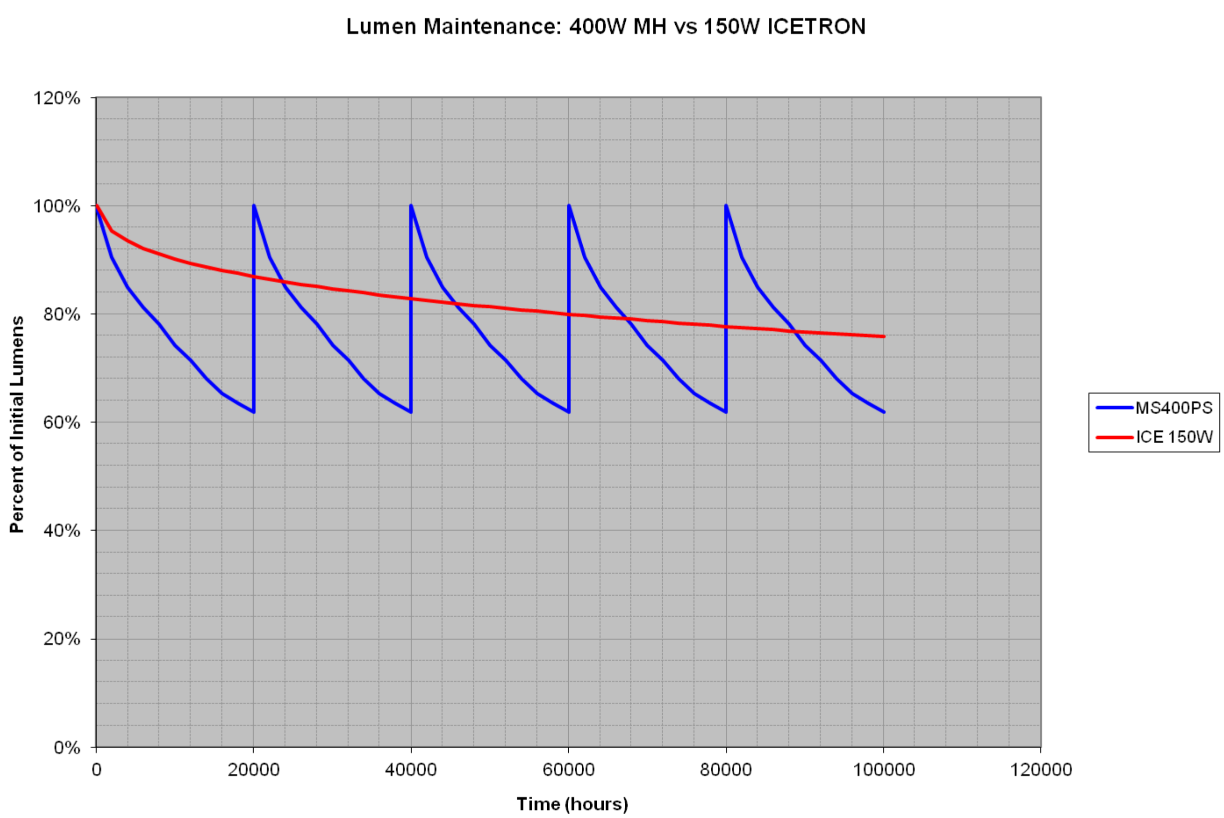


Figure 3: Lamp life and lumen maintenance comparison to HID

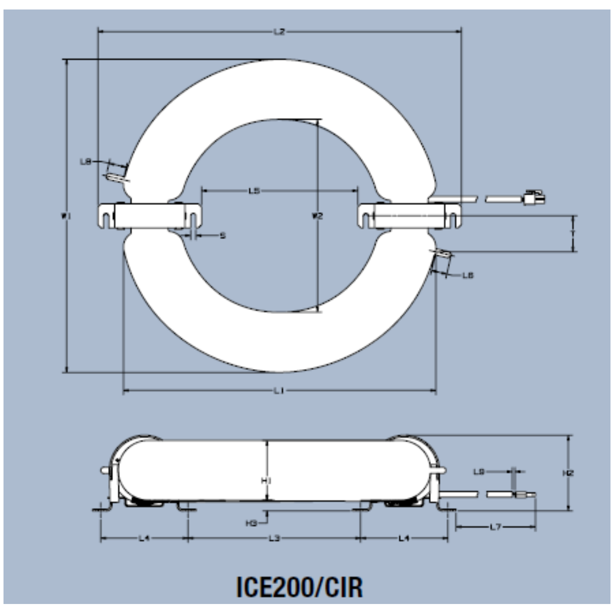
Physical System Characteristics

2.1 LAMP DIMENSIONS

Table 5: Lamp Dimensions

		ICE70 & ICE100		ICE150 & ICE200/RCT		ICE200/CIR	
	Dims.	in.	mm	in.	mm	in.	mm
Height of glass	H1	2.13	54	2.13	54	2.28	58
Overall height	H2	2.87	73	2.87	73	2.83	72
Tube to mount height	H3	0.39	10	0.39	10	0.31	8
Length of main body	L1	9.84	250	13.78	350	11.93	303
Overall length	L2	12.40	315	16.34	415	14.17	360
Mount hole spacing (between cores)	L3	5.10	130	9.04	230	6.46	164
Mount hole spacing (each core)	L4	3.23	82	3.23	82	3.27	83
Bracket spacing	L5	4.13	105	8.07	205	5.79	147
Amalgam tip length	L6	0.59	15	0.59	15	0.59	15
Lead wire length	L7	24.00	610	24.00	610	24.00	610
Slot width	S	0.20	5	0.20	5	0.20	5
Tip to centerline	T	0.98	25	0.98	25	1.38	35
Width	W	5.41	138	5.41	138	12.20	310
Lamp weight	-	1.8 lb	0.84 kg	2.1 lb	0.96 kg	1.9 lb	0.87 kg

Note: Dimensions are subject to change.



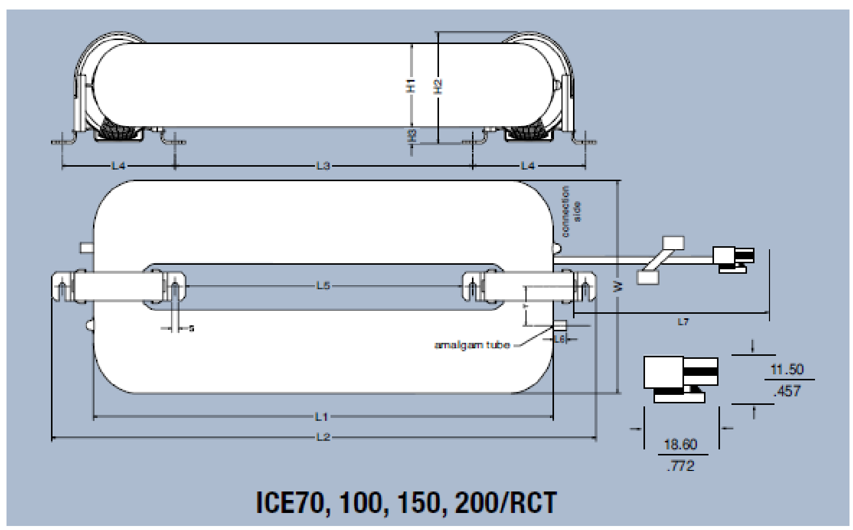


Figure 4: ICETRON® Lamp

2.2 BALLAST DIMENSIONS

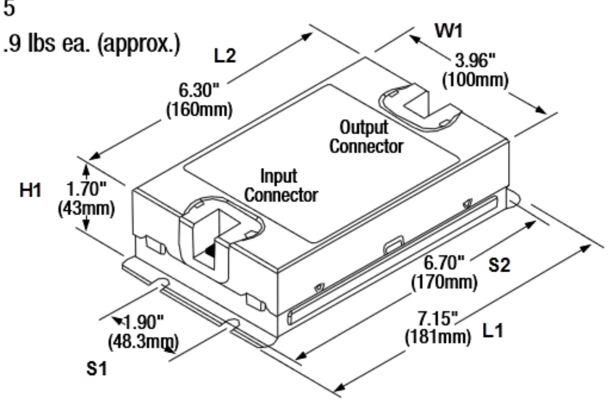
Table 6: Ballast Dimensions

		Type 1		Type 2		ICE/DIM	
	Dims.	in.	mm	in.	mm	in.	mm
Case width	W1	3.96	100	4.30	109	4.50	114
Case length	L2	6.30	160	6.20	158	6.00	152
Overall length	L1	7.15	181	7.10	180	6.50	164
Case height	H1	1.70	43	1.70	43	1.80	45
Mount slot (center to center)	S1	1.90	48	1.90	48	-	-
Mount slot (center to center)	S2	6.70	170	6.70	170	5.50	140
Slot width	W2	0.31	8	0.31	8	0.30	9
Mount slot (center to edge)	S3	0.97	25	0.97	25	2.00	51
Ballast weight	-	1.9 lb (approx.)	0.86 kg (approx.)	2.5 lb (approx.)	1.13 kg (approx.)	lb (approx.)	kg (approx.)

Note: Dimensions are subject to change.

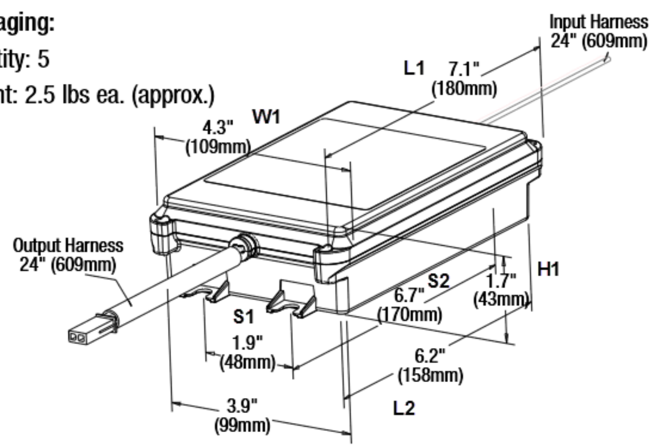
Type 1 Dimensions:
Overall: 7.15" L x 3.96" W x 1.70" H
Mounting: 6.70" L x 1.90" W

Packaging:
Quantity: 5
Weight: 1.9 lbs ea. (approx.)



Type 2 Dimensions:
Overall: 7.10" L x 4.30" W x 1.70" H
Mounting: 6.70" L x 1.90" W

Packaging:
Quantity: 5
Weight: 2.5 lbs ea. (approx.)



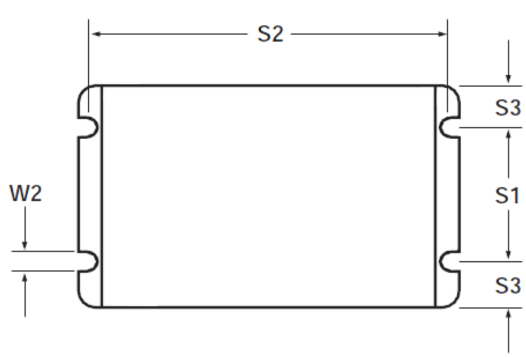


Figure 5a: ICETRON® Type 1 & 2 Ballast

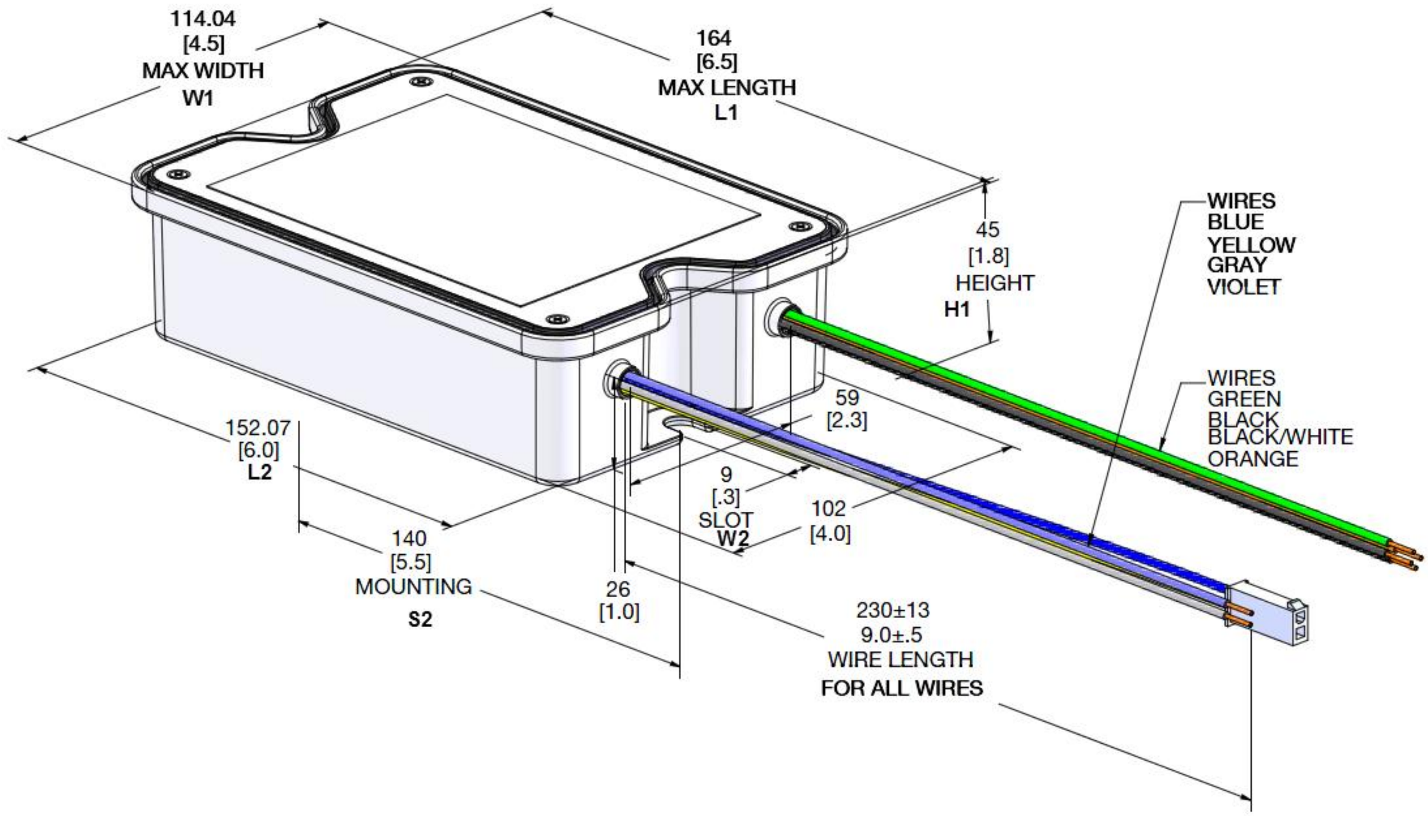


Figure 5b: ICETRON® Dimming Ballast

2.3 LAMP ADAPTER AND WIRE HARNESS

Figure 6 : The old-lamp-to-new-ballast adapter, NAED 26240, allows the use of the original ICETRON® lamp with 3-Prong connectors with the ICETRON QUICKTRONIC ballast with 2-Prong connectors on ballast (no leads).

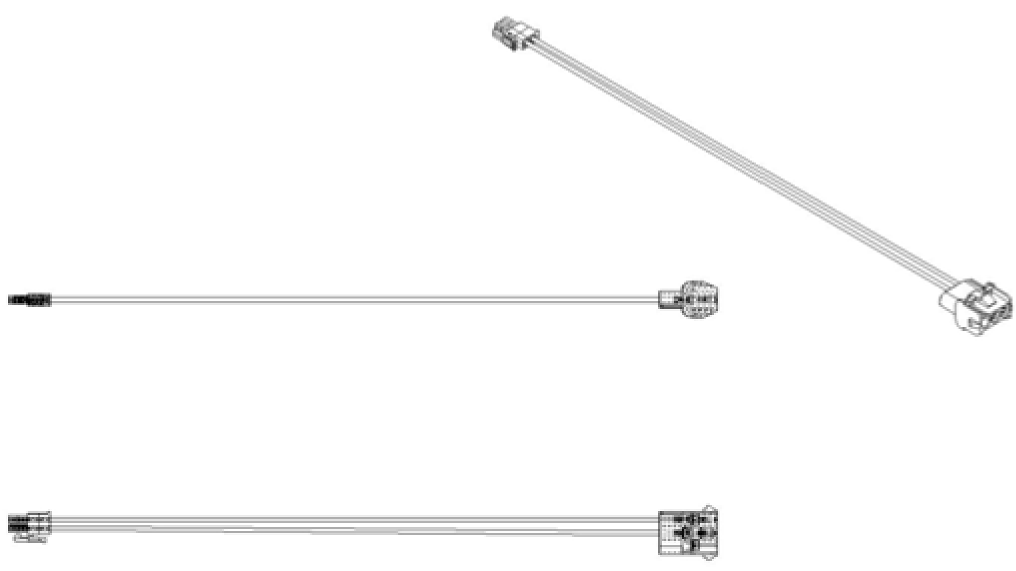


Figure 7: The 24" wiring extension/harness with silicon tubing (NAED 49755). Note: Cannot use more than one 24” wiring extension. If a longer extension is required, please refer to section 4.3.3 Remote Operation.

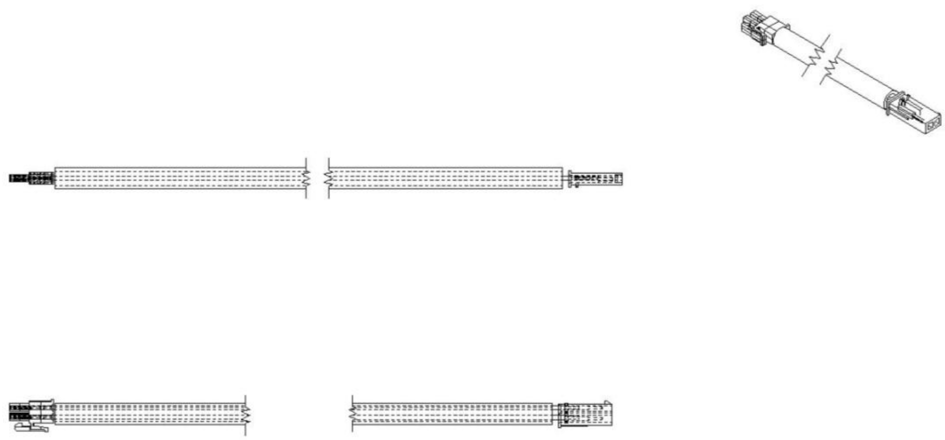
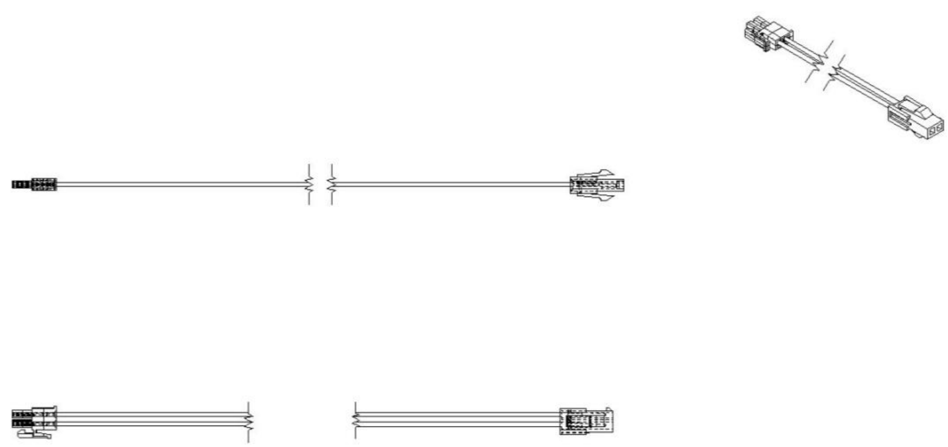


Figure 8: The 24" panel-mount extension/harness without silicon tubing (NAED 49757). Note: Cannot use more than one 24” wiring extension. If a longer extension is required, please refer to section 4.3.3 Remote Operation.



System Performance

3.1 ELECTRICAL AND PHOTOMETRIC CHARACTERISTICS

The ICETRON QUICKTRONIC ballast is designed to operate at line voltages of 120 to 277± 10% VAC. Electrical and photometric characteristics listed in Table 7 below apply to operation on 120 VAC line voltage. System efficacy increases slightly when operated at 277 VAC.

The table below applies to the following *test conditions*:

- 120V, 60Hz input
- Lamps aged 100 hours
- 4-hour warm-up time
- Amalgam tip temperature of 149°F (65°C) for ICE 100 lamp[1]
- Amalgam tip temperature of 158°F (70°C) for ICE 70W, 150W, 200W lamp[1]

[1]For more details see section 3.7.2

Table 7: Electrical and Photometric Characteristics

	Unit Measure	QT1x100ICE* ICE70	QT1x100ICE* ICE100	QT1x150ICE* ICE100	QT1x150ICE* ICE150	QT1x2000ICE ICE200
Ballast input voltage	V	120/277	120/277	120/277	120/277	120/277
System power	W	79/77	106/103	154/149	161/156	220/214
System lumens (5000K)	Lm	6815 (6655)	8600 (8300)	11,900 (11,500)	13,000 (12,700)	16,400 (15,800)
System efficacy (5000K)	LPW	86/89 (84/86)	81/83 (78/81)	77/80 (75/77)	81/83 (79/81)	75/77 (72/74)
Ballast input current	A	0.66/0.29	0.88/0.37	1.28/0.54	1.34/0.58	1.84/0.78 RCT 1.84/0.75 CIR
Ballast input frequency	Hz	50/60	50/60	50/60	50/60	50/60
Ballast power factor	PF	0.95	0.95	0.95	0.95	0.95
Ballast THD max.	%	10	10	10	10	10
Lamp operating frequency	kHz	250	250	250	250	250
Starting voltage max.	Vrms	1200	1200	1400	1400	1600

Nominal values unless otherwise noted.

*Values shown are for Type 1 & Type 2 ballasts.

3.2 LAMP SPECTRAL CHARACTERISTICS

3.2.1 Color Characteristics

The x and y chromaticity coordinates determine the correlated color temperature (CCT) of the lamp. For many applications, the color rendering properties are also important. The color rendering index (CRI) provides an indication of how colors appear when illuminated by the lamp. An ideal source is given an index value of 100.

The color data in Table 8 applies to lamps aged 100 hours and with an amalgam tip temperature of 158°F (70°C) for ICTRON 70W, 15 0W and 200W lamps and 149°F (65°C) for ICETRON 100W lamp.

Table 8: Color Characteristics

		Chromaticity Coordinates			
System Lamp/Ballast	Color	x	y	CCT K	CRI Ra
ICE70/QT100	/835	0.411	0.393	3400	80
	/841	0.380	0.380	4050	80
	/850	0.346	0.359	5000	80
ICE100/QT100	/835	0.411	0.393	3400	80
	/841	0.380	0.380	4050	80
	/850	0.346	0.359	5000	80
ICE100/QT150	/835	0.407	0.393	3500	80
	/841	0.376	0.380	4150	80
	/850	0.344	0.359	5050	80
ICE150/QT150	/835	0.411	0.393	3400	80
	/841	0.380	0.380	4050	80
	/850	0.346	0.359	5000	80
ICE200/QT200	/835	0.411	0.393	3400	80
	/841	0.380	0.380	4050	80
	/850	0.346	0.359	5000	80

3.2.2 Color Tolerance Chart

Chromaticity coordinate tolerance ovals represent the maximum allowable variation of lamp color. The ovals in Figure 9 are 5-step for 3500K, 4100K and 5000K. One step represents the minimum perceivable difference in color between two lamps. The tolerance ovals are plotted relative to the black body locus in the figure below.

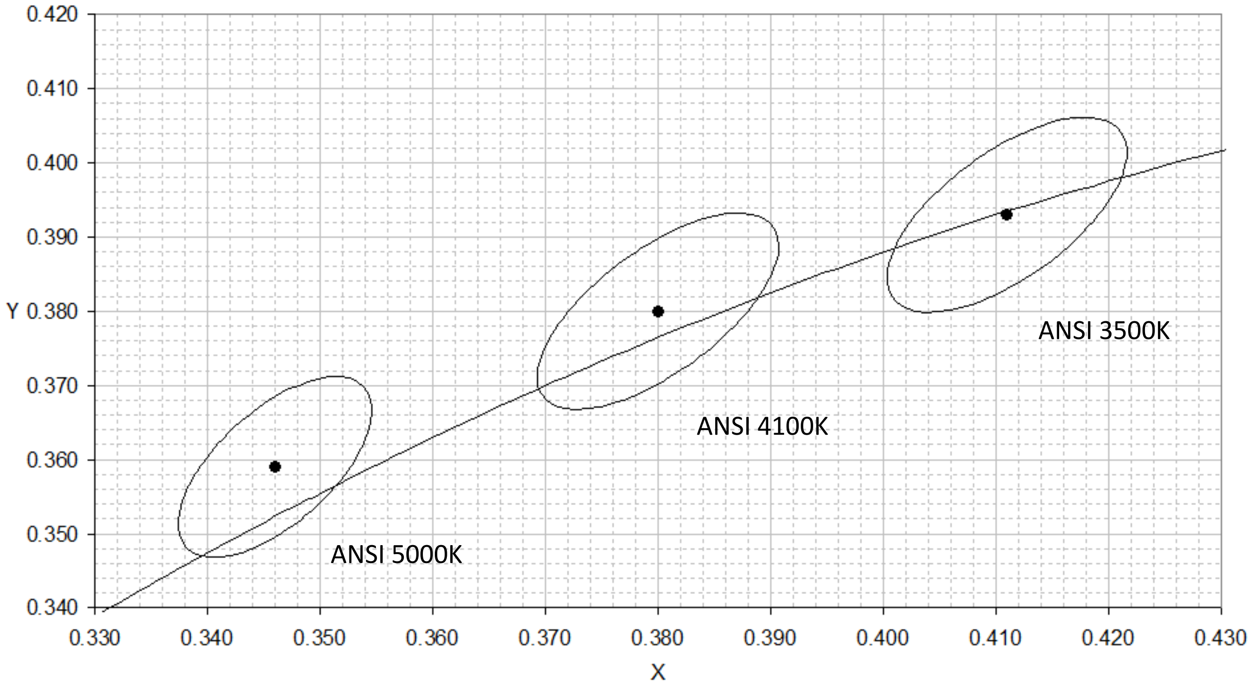


Figure 9: Color Tolerance Ovals for Nominal Amalgam Tip Temperature

3.2.2.1 Effect of Temperature on Color

The color temperature, chromaticity coordinates, and color rendering index of these lamps are influenced by the mercury vapor pressure, which in turn is determined by the amalgam tip temperature.

The amalgam tip temperatures for optimum performance are:

149°F (65°C) and 229°F (108°C) for ICETRON 100W lamps.

158°F (70°C) and 229°F (108°C) for ICETRON 70W, 150W and 200W lamps.

At tip temperatures below the lower optimal values listed above, color temperature decreases. Conversely, amalgam tip temperatures above the higher optimal values result in higher color temperatures. At temperatures between the two nominal operating points, the color temperature increases. For more details see section 3.7.2.

3.2.3 Spectral Power Distributions

A Spectral Power Distribution curve (SPD) shows the distribution of the spectral components of a given light source by plotting the level of power associated with each wavelength within the visible portion of the electromagnetic spectrum. This spectral information is a basic characteristic from which several simple descriptors may be calculated, for example, correlated color temperature (CCT), color rendering index (CRI), and chromaticity coordinates. These terms are often used in place of the SPD because of their simplicity and the relative ease with which distinct light sources may be compared on a quantitative basis. The spectral power from a fluorescent lamp is produced by two separate mechanisms. First, the mercury discharge generates narrow bands of radiation in the UV and blue regions. Second, the triphosphor coating is excited by ultraviolet radiation from the mercury discharge, which produces the radiated visible power at specific frequency bands centered at red, green, and blue, the primary colors of white light.

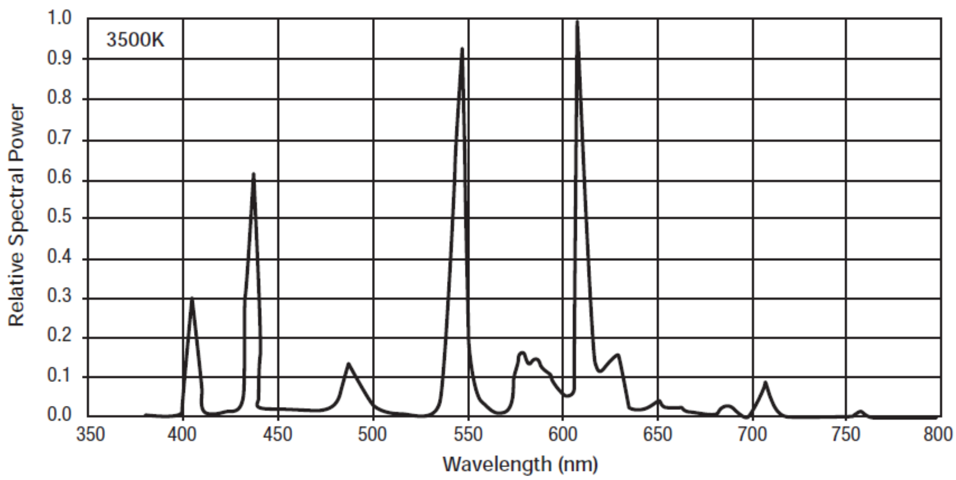


Figure 10 : Spectral Power Distribution – 3500K

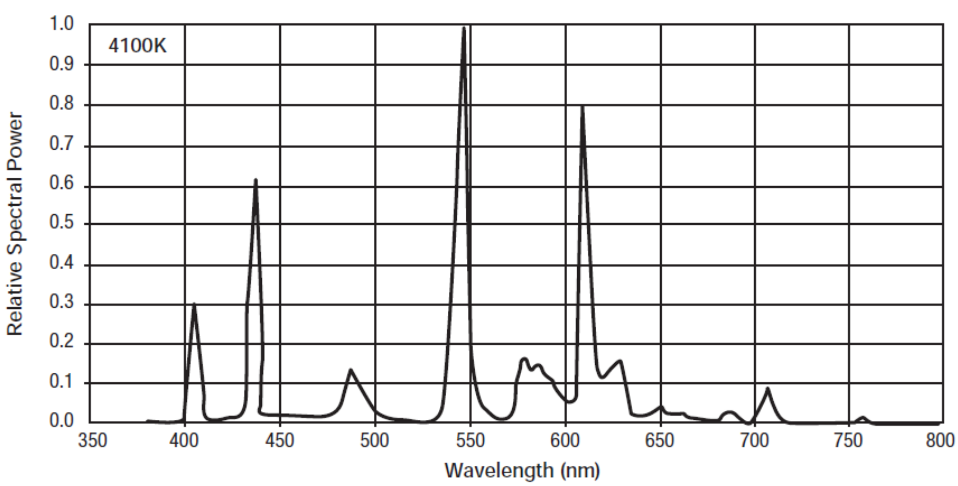


Figure 11 : Spectral Power Distribution – 4100K

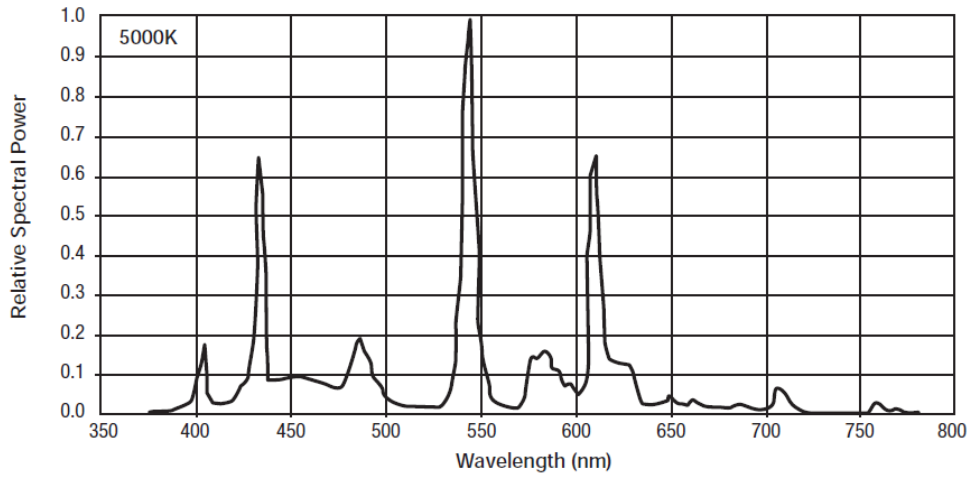


Figure 12 : Spectral Power Distribution – 5000K

3.2.4 UV Emission

There are several metrics that characterize the UV emission from a lamp. Many materials, such as paints, dyes, cloth, paper, leather, etc. will discolor and/or weaken when exposed to radiant energy. UV has the greatest potential for such damage. In many lighting situations the total UV (λ < 400nm) is taken as a simple benchmark of potential damage.

Because UV below about 320nm has a high probability of interaction with many materials, this is possibly a better indicator of UV damage, especially to plastics.

There are also some health hazards associated with exposure to radiation below 400nm where the biological action spectrum varies over several orders of magnitude. Exposure is evaluated in terms of the ACGIH S(λ) weighted power which gives higher weighting to the more damaging UV below 300nm.

The UV exposure under common lighting systems is below the accepted safe exposure limits.

The UV metrics of the ICETRON 150 lamp are shown in Table 9 on the following page. The values are normalized to a per unit light basis expressed in microwatts per lumen. Some other representative light sources are listed in the table for comparison.

Table 9: Comparison of UV Metrics

Lamp Type	λ < 320nm	λ < 400nm	S(λ) Weighted
ICETRON 150	9	75	0.15
Incandescent (2850K)	2	75	0.2
OCTRON Fluorescent	25-45	90-150	0.4-1.2
Standard Metal Halide	8-16	~500	0.2-0.6

3.3 LUMINOUS INTENSITY DISTRIBUTION

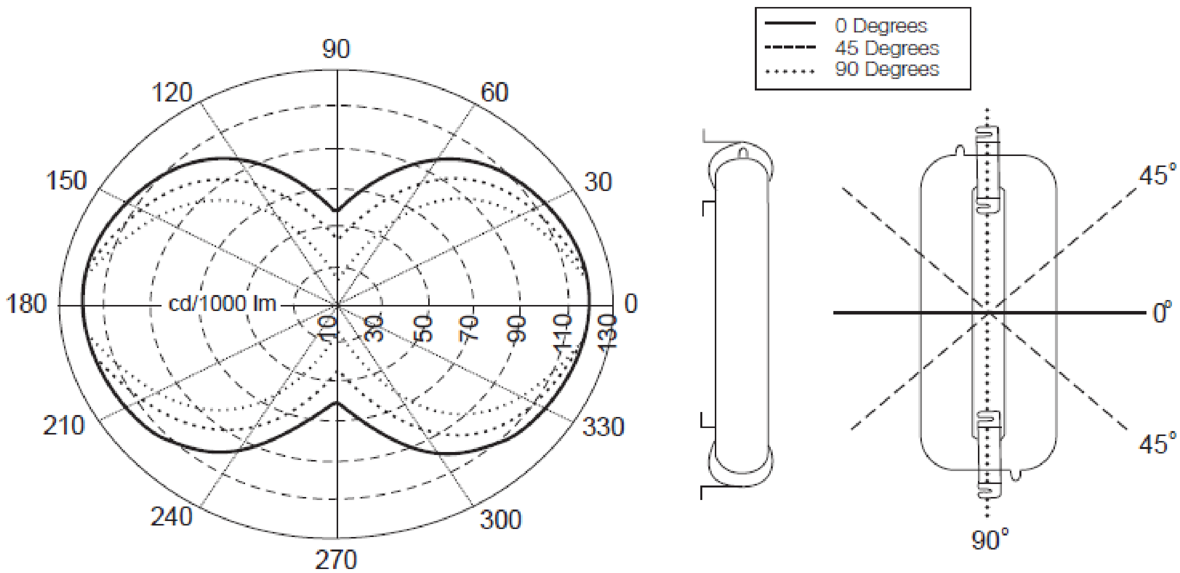


Figure 13: Typical Luminous Intensity Distribution, IES files can be found on the OSRAM SYLVANIA website

3.4 STARTING

3.4.1 Run-Up Time

The lumen output of ICETRON QUICKTRONIC systems is dependant on the mercury vapor pressure in the lamp which in turn is determined by the ambient temperature. These lamps use an amalgam system which results in low mercury vapor pressure before starting. However, an auxiliary amalgam is located in the discharge to ensure fast lumen run-up. After switch-on, this auxiliary amalgam heats rapidly, releasing mercury into the discharge. Light output quickly peaks and then dips slightly as mercury vapor pressure increases above optimum. After a few minutes, the mercury begins diffusing back to the main amalgam. The time required for thermal equilibrium depends on ambient temperature, fixture design, and off time; but typically requires about four hours.

A typical run-up curve for an ICETRON lamp after 16 hours of off time at 77°F (25°C) ambient temperature is shown in Figure 14. Under these conditions, lumen output is more than 90% of peak after about 10 seconds. Subsequent lumen variations are measurable but not noticeable to the eye. For off periods of less than 1 minute, the light output returns almost immediately to the equilibrium value.

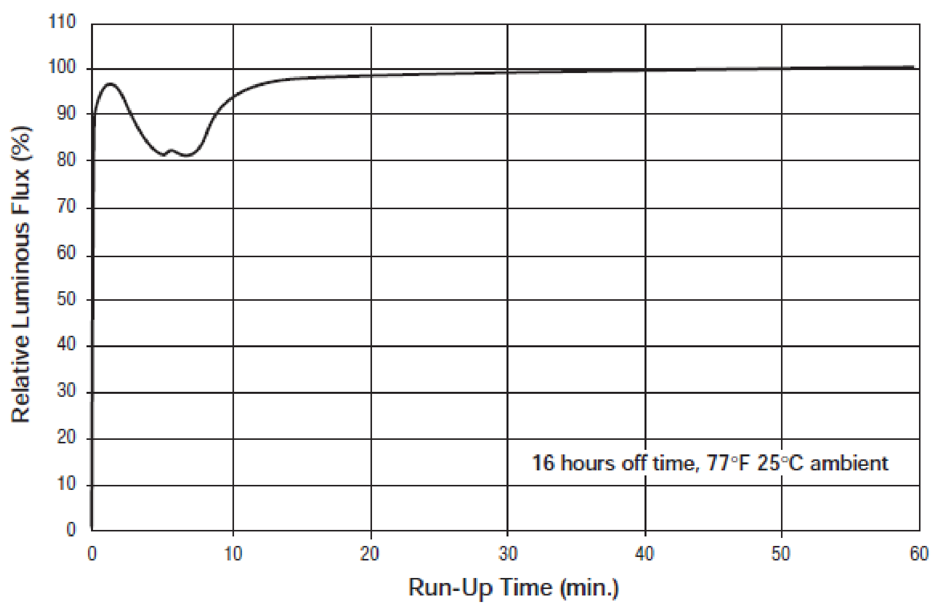


Figure 14: Run-up of lamp in open air at 77°F (25°C) after 16 hours off time

3.4.2 Low/High Temperature Starting

The 100W, 150W and 200W ICETRON QUICKTRONIC systems provide fast, flicker-free starting at ambient temperatures down to -40°F (-40°C). The 100W dimming system provides reliable, flicker free starting down to +5°F (-15°C) ambient temperatures. The 70W system provides reliable, flicker-free starting down to -13°F (-25°C) ambient temperatures. In most applications, including hot strike, the start time will be less than 50 msec.

3.5 LIFE EXPECTANCY

3.5.1 Typical Lumen Maintenance

When a fluorescent lamp is new, its light output reaches the maximum value for which the plasma discharge and phosphor coating have been designed. As the lamp operates, various processes (plasma, chemical, and thermal) within the lamp envelope cause a gradual reduction of its light generating capability.

The degree to which the actual light output decreases with operating time is referred to as lumen maintenance. A typical lumen maintenance curve for the ICETRON lamp is shown in Figure 15 & 16 on the following page. Light output (normalized to 100% of the 100 hour value) is displayed as a function of time (operating hours).

3.5.2 System Mortality

The ICETRON QUICKTRONIC systems are designed to have an average rated life of 100,000 hours at a maximum ballast case temperature of 149°F (65°C) for the 100W ballasts, 158°F (70°C) for the 150W ballast and 167°F (75°C) for the 200W ballast. After 100,000 hours 50% of the ballasts will be surviving. (At 60,000 hours, 10% failures are expected.)

However, the luminous flux of the ICETRON lamp is expected to have depreciated after 60,000 hours to no less than 80% for the 70W, 100W and 150W lamps and 70% for the 200W lamp of the initial rated lumens. See Figures 15 & 16 for lumen maintenance curves and Figure 3 for lamp life and lumen maintenance comparison to HID lamps.

3.6 LAMP ORIENTATION

The ICETRON lamp may be operated in any position. If the lamp is operated in the vertical or an angled position, the lamp should be mounted with the amalgam tip in the downward position. The amalgam tip is on the lamp connector side. Operating position has a slight effect on the amalgam tip temperature and this should be considered in fixture design to ensure optimum performance. (See section 3.7 for detailed information on performance versus temperature). The lamp should be attached to the fixture only by the mounting feet. There should be no other direct contact between the fixture and the lamp. Any thermally conductive contact with the lamp glass can result in a relatively cool spot where mercury can condense, creating a competing mercury vapor pressure control point which will adversely affect the lamp performance.

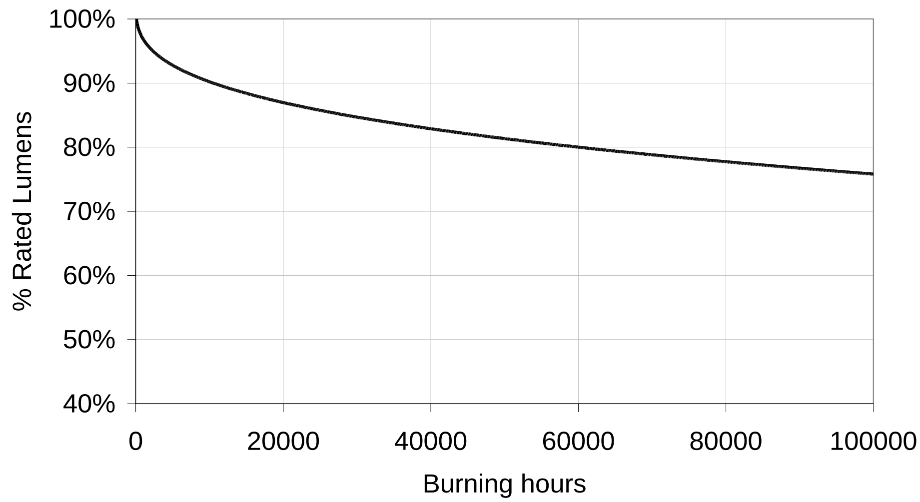


Figure 15: ICETRON 70,100 and 150W Lumen Maintenance Curve

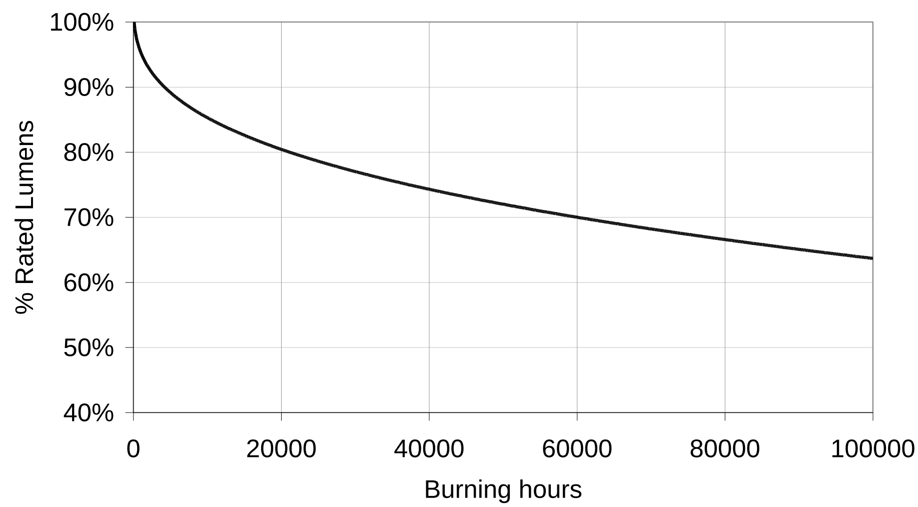


Figure 16: ICETRON 200W Lumen Maintenance Curve

3.7 TEMPERATURE CONSIDERATIONS

3.7.1 System Temperature Limits

The 150W ICETRON QUICKTRONIC system has a maximum allowable ballast case temperature of 158°F (70°C), the 100W system have a maximum allowable ballast case temperature of 149°F (65°C) and the 200W system has a maximum allowable ballast case temperature of 167°F (75°C). To maximize system life, ambient temperature of the ballast should be kept as low as possible. It is also important to maintain effective dissipation of heat using the lighting fixture as a heat-sink for the ballast enclosure and the lamp induction cores. For more detail, see section 4.4.

The temperature of the lamp should also be controlled. The maximum recommended temperature at the mounting base of the lamp induction core is 212°F (100°C) and the maximum allowable temperature for the ferite core is 302°F (150°C). To exceed 90% light output, the amalgam tip temperature must be within the range of:

- 70W, 150W and 200W Lamps: 131 to 257°F (55 to 125°C)
- 100W Lamp: 122 to 257°F (50 to 125°C)

Minimum system starting temperatures are:

- 70W System: -13°F (-25°C)
- 100W, 150W and 200W Systems: -40°F (-40°C)
- 100W Dimming System: +5°F (-15°C)

3.7.2 Effect of Amalgam Tip Temperature on System Performance

The light output and system wattage of ICETRON QUICKTRONIC systems depend on the amalgam temperature during operation. Figure 17 shows this relationship for a nominal ICTERON 70 lamp operated on QT100 ballast. Light output is at least 90% of peak over the temperature range of 131°F to 257°F (55°C to 125°C). Figure 18 shows this relationship for a nominal ICETRON 100 lamp operated on QT100 or QT150 ballast. Light output is at least 90% of peak over the temperature range of 122°F to 257°F (50°C to 125°C). The effect of amalgam temperature on relative luminous flux and system power for the ICETRON QUICKTRONIC 150 system is illustrated in Figure 19. A nominal ICETRON QUICKTRONIC 150 system produces at least 90% of peak output over amalgam temperature range of 131°F to 257°F (55°C to 125°C). The effect of amalgam temperature on relative luminous flux and system power for the ICETRON QUICKTRONIC 200 system is illustrated in Figure 20. A nominal ICETRON QUICKTRONIC 200 system produces at least 90% of peak output over amalgam temperature range of 131°F to 257°F (55°C to 125°C).

The amalgam temperature during operation is determined by the ambient temperature, the ICETRON QUICKTRONIC system used, and the lighting fixture construction.

- In general, a one degree increase in ambient temperature will result in a corresponding one degree increase in amalgam temperature. However, the actual temperature difference between ambient and amalgam tip temperature depends on the system used and fixture construction. A fixture that reflects light back onto the lamp or that concentrates heat near the amalgam tip will result in a higher ΔT.
- The ICETRON 100 lamp operated on our QT150 ballast runs substantially hotter than either the ICETRON QUICKTRONIC 150 system or standard ICETRON QUICKTRONIC 100 system due to the higher power dissipation per unit area of lamp surface. This results in a higher amalgam temperature at a given ambient temperature. Therefore, this system is better suited for lower temperature applications.
- The ICETRON 200 system runs hotter than the other ICETRON systems and is therefore well suited for low temperature applications. This should be taken into consideration when designing a fixture.
- The ICETRON 70 lamp operated on the QT100 ballast will run cooler than both the 100W and the 150W; its amalgam tip temperature will also be lower. This should be taken into consideration when designing a fixture.
- The amalgam tip temperature can be increased by insulating the tips with amalgam tip covers available from OSRAM SYLVANIA. Use of the amalgam tip covers is recommended for cold temperature applications.
- The range of high lumen output can also be shifted to lower ambient temperatures by increasing the heat retaining characteristics of the lighting fixture. Small fixture volume, low fixture surface area, use of low thermal conductivity materials or multiple wall construction, etc. will increase the temperature difference between amalgam and ambient temperatures, shifting the lumen vs. ambient temperature curve to lower temperatures. Conversely, open, increased fixture volume, high surface area fixtures shift the curve to higher ambient temperatures. Orienting the lamp with amalgam tip down and avoiding reflection of light back onto the lamp also allows operation in higher ambient temperatures.

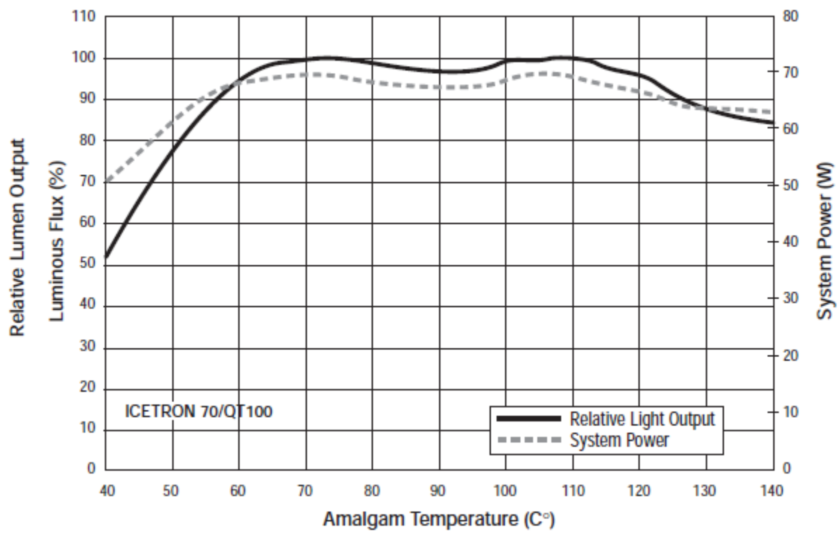


Figure 17: System Power and Relative Lumen Output vs. Amalgam Temperature for ICETRON 70

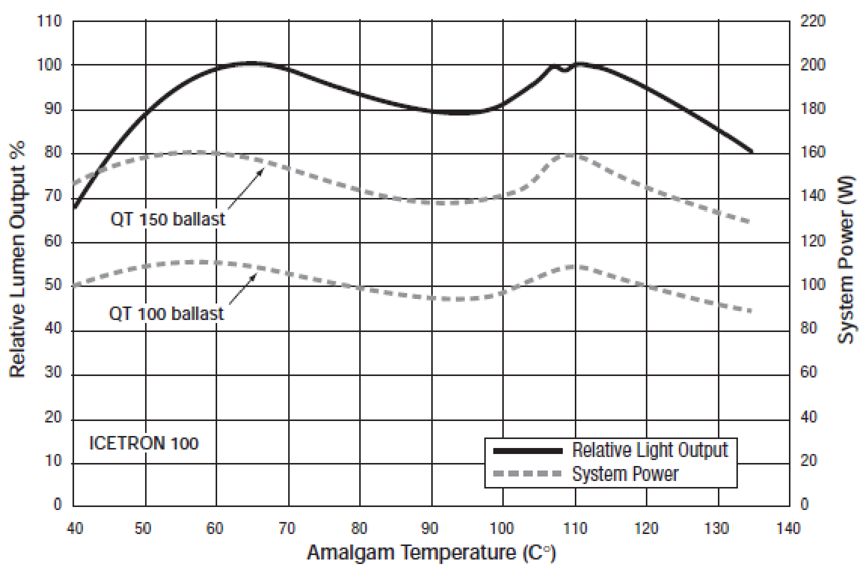


Figure 18: System power and relative lumen output versus amalgam temperature for ICETRON 100

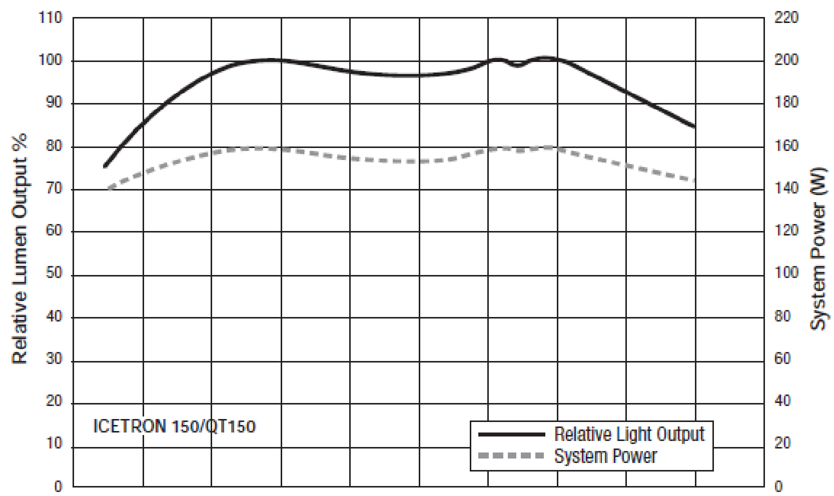


Figure 19: System power and relative lumen output versus amalgam temperature for ICETRON 150

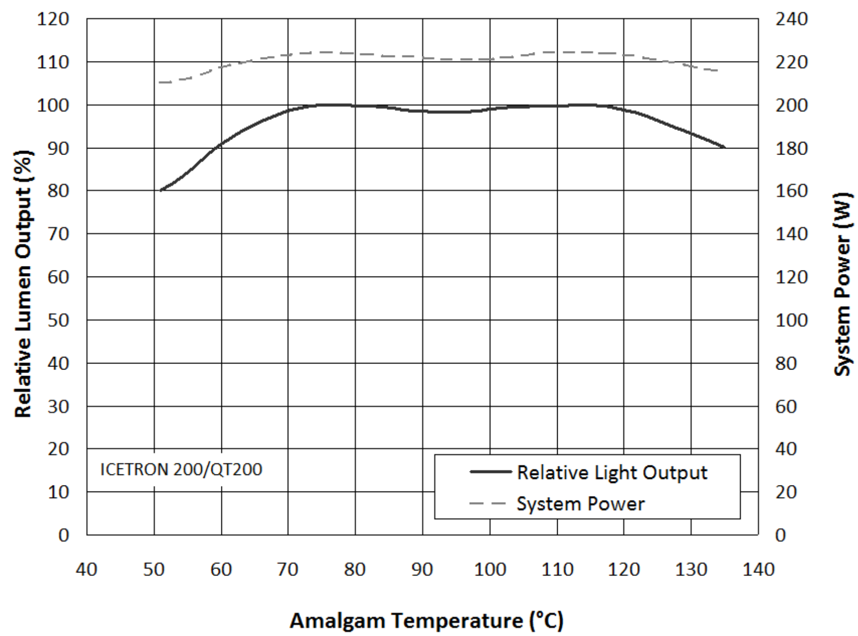


Figure 20: System power and relative lumen output versus amalgam temperature for ICETRON 200

3.7.3 Effect Of Ambient Temperature On System Performance

For a given system and fixture, the ambient temperature will determine the system's temperatures: amalgam tip, ballast, bulb wall, and magnetic toroid will affect system performance and/or system life.

In general, a one degree increase in ambient temperature will result in a one degree increase in the system components' temperatures. It is imortant to design the fixture for the system used, in order to satisfy the different thermal requirements of the ICETRON QUICKTRONIC systems. Refer to section 4.4 for more details.

The following charts show the system temperatures versus the ambient temperature with the corresponding system power and relative light out put. The actual temperatures recorded will depend on the fixture design: housing dimension, heat sinking efficiency, reflector geometry and size, use of passive or active amalgam heating etc. However, the relationship between ambient and system temperatures variations will remain roughly one to one.

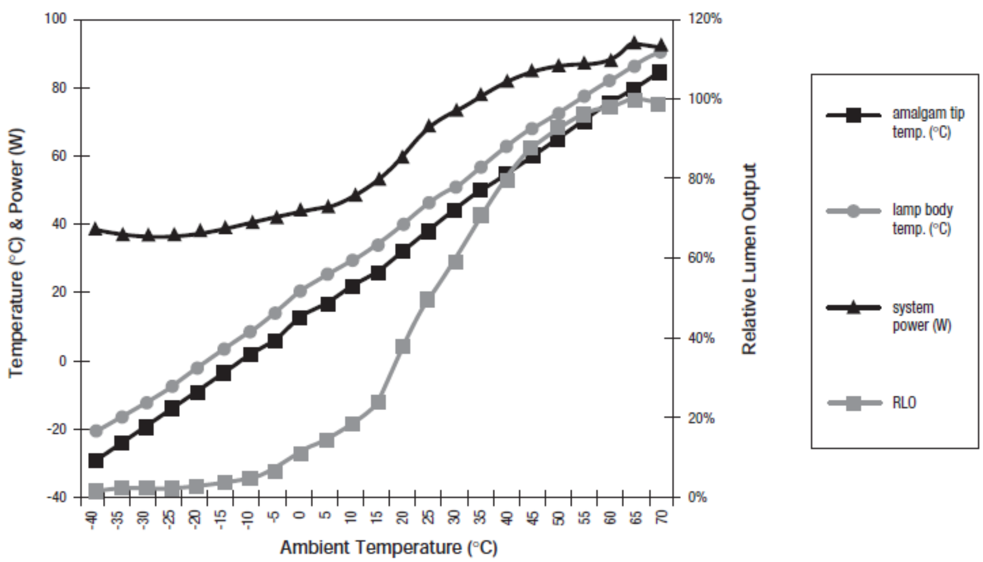


Figure 21: 70W ICETRON lamp/100W QUICKTRONIC ballast

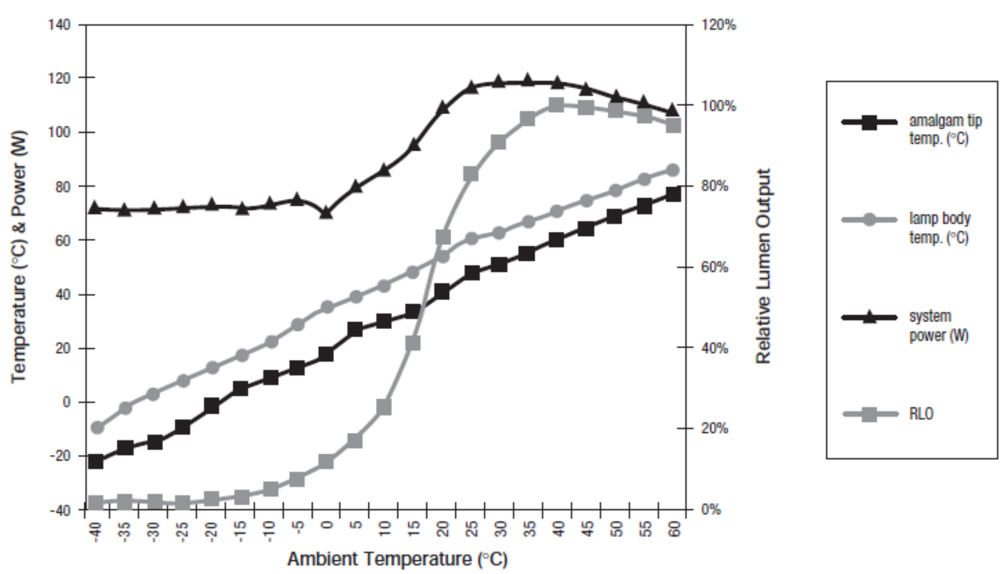


Figure 22: 100W ICETRON lamp/100W QUICKTRONIC ballast

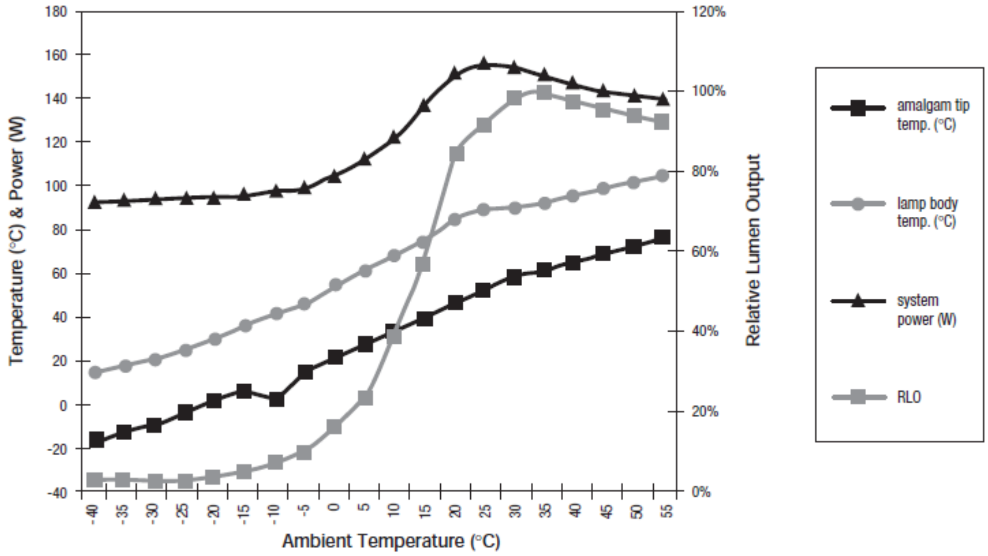


Figure 23: 100W ICETRON lamp/150W QUICKTRONIC ballast

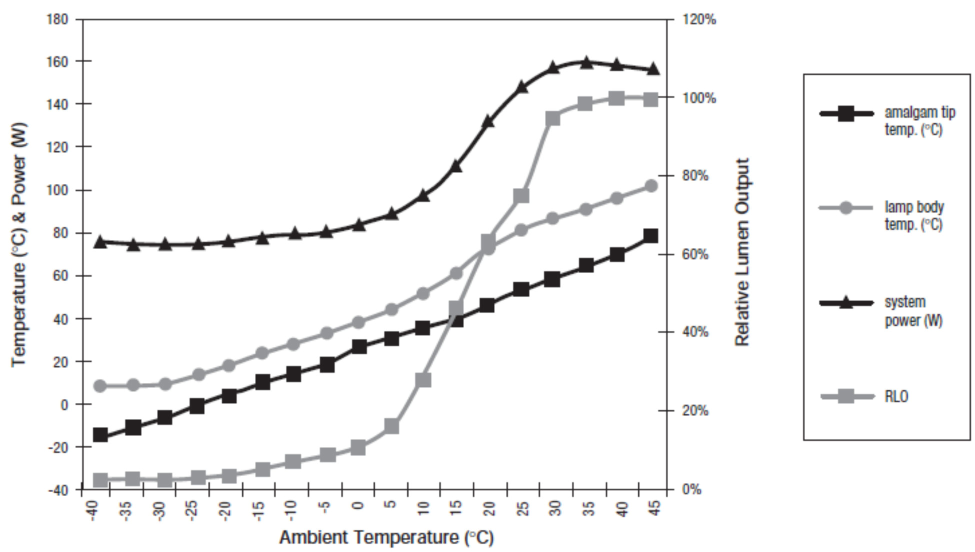


Figure 24: 150W ICETRON lamp/150W QUICKTRONIC ballast

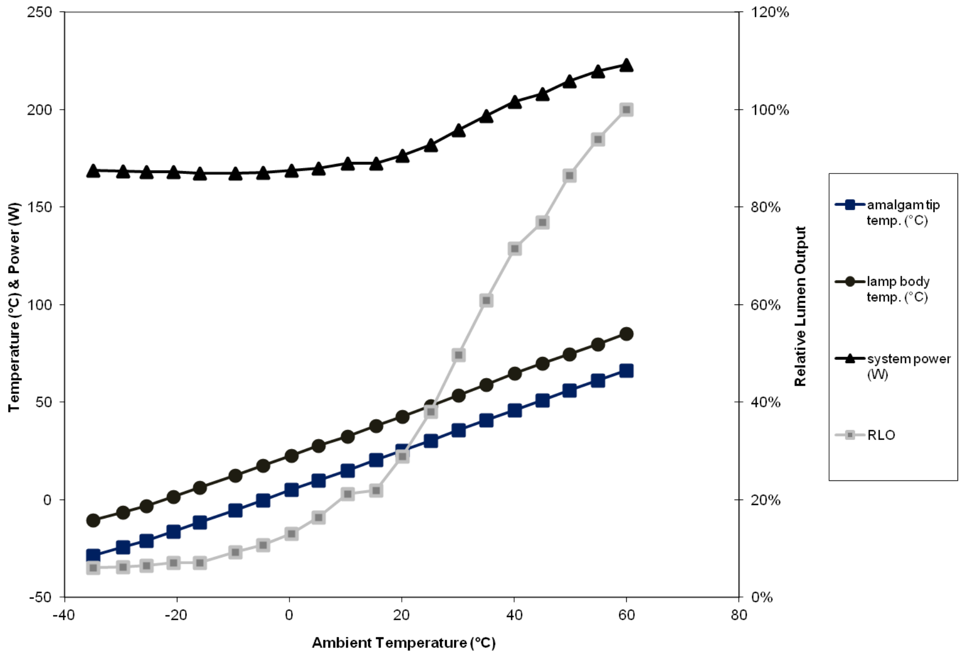


Figure 25: 200W ICETRON lamp/150W QUICKTRONIC ballast

3.8 EMI CHARACTERISTICS

3.8.1 EMI/RFI Characteristics

Electronic devices often contain power supplies that can generate electromagnetic interference (EMI/RFI). The interference may either be conducted through the power supply wiring or radiated through air. The ICETRON QUICKTRONIC system contains filter circuitry within the ballast that limits the amount of electromagnetic interference to comply with Federal Communications Commission's (FCC) limits for commercial lighting products (FCC CFR 47, Part 18, non-consumer rating).

3.8.2 EMI/RFI Performance

Figure 26 shows the conducted electromagnetic interference for the ICETRON QUICKTRONIC systems. ICETRON QUICKTRONIC systems comply with the FCC limits which are: 1) conducted: maximum 1000 microvolt in the 0.45 MHz to 1.6 MHz range, and maximum 3000 microvolts in the 1.6 MHz to 30 MHz range 2) radiated field strength limit at 30 meters: maximum 30 microvolts per meter in the 30 MHz to 88 MHz range, maximum of 50 microvolts per meter in the 88 MHz to 216 MHz range, and maximum 70 microvolts per meter in the 216 MHz to 1000 MHz range.

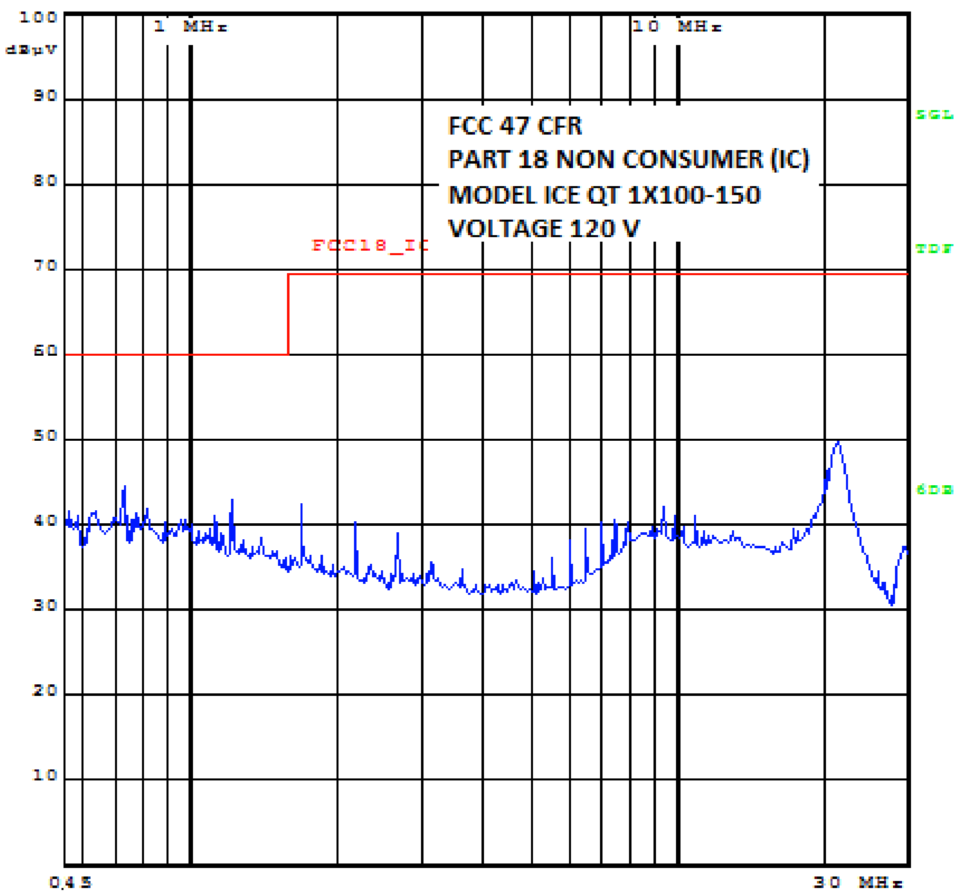


Figure 26: EMI QT1x150ICE/UNV-T with 20 meter remote cable in conduit

3.9 SHOCK AND VIBRATION

The ICETRON® lamp is designed to tolerate shock and vibration that would be expected in typical applications such as post top, bridge, roadway underpass or tunnel lighting. ICETRON lamps have been tested under the following conditions with no damage:

Shock – Lamps subjected to three (3) one-half sine wave shocks of 10 ms duration at 20 g.

Table 10: Vibration Parameters

The vibration parameters were adapted from ANSI C136.31-2001, American National Standard for Roadway Lighting Equipment – Luminaire Vibration, Section 5, luminaire vibration test.

Start Freq.	Amplitude	End Freq.	Amplitude
5 Hz	1.5 G	7.07107 Hz	3.5 G
10 Hz	3.5 G	30 Hz	3.5 G

Sweep between 5 Hz and 30 Hz at 0.861654 Min/sweep (linear)

Duration: 100,000 cycles at 100%
Total test time: 1:36:30

Care should be taken when mounting the ballast to minimize vibration.

3.10 SYSTEM PROTECTION

3.10.1 Lamp Fails to Light

If the ICETRON lamp should fail to light within 10 seconds the ballast will shut down (providing protection for the system components). To reset the ballast, the input voltage to the ballast must be turned off for a minimum of 10 seconds, then reapply input voltage.

ICETRON 200W ballasts are equipped with a "multistrike" feature that allows reignition of the lamp without cycling the input voltage.

3.10.2 Replacing a Failed Lamp

Before replacing a lamp, power to the ballast must be turned off. If a user mistakenly unplugs a lamp from an energized ballast, the ballast will automatically shut down. If an operational lamp is re-connected to the ballast, the ballast will automatically reset and provide power to the lamp.

3.11 ELECTRICAL FUSING

All ICETRON QUICKTRONIC systems contain inherent electrical protection. Although there is no need to externally fuse the ballast, should code or regulation require it, a 4 amperes slow blow fuse is recommended.

3.12 SOUND RATING

ICETRON QUICKTRONIC ballasts are sound rated A (up to 75% quieter than magnetic types) and are acceptable for most applications.

Fixture Design Guidelines

4.1 THERMAL ISSUES

The following thermal issues need to be addressed when designing a fixture for ICETRON® QUICKTRONIC® systems.

1. The ballast is a complex piece of electronic equipment that is sensitive to temperature. Elevated temperatures above its maximum design temperature rating will reduce the life expectancy of the electronic components inside the ballast. See Table 11.

Ballast Model	Ballast Temperature	
	TC Max °C	TC Max °F
QT 1x100ICE	65°	149°
QT 1x150ICE	70°	158°
QT 1x200ICE	75°	167°
QT 1x100ICE Type 2 QT 1x150ICE Type 2	71°	160°

Amalgam Tip Temperature for 90% RLO		
Lamp type	°C	°F
70W	55 – 125°	131 – 257°
100W	50 – 125°	122 – 257°
150W	55 – 125°	131 – 257°
200W	55 – 125°	131 – 257°

Table 11: Temperature charts

2. Light output from the ICETRON QUICKTRONIC system is strongly influenced by the amalgam tip temperature. Follow the suggested guidelines in section 4 to ensure that the lamp will provide the optimum amount of light for your application.
3. The connector used to join the lamp to the ballast has a maximum temperature rating of 221°F (105°C). Keep connector away from lamp.
4. Although the lamp is not as sensitive to heat as the ballast, proper heat sinking can improve the performance of the lamp.

See section 4.4 for thermal testing and analysis guidelines.

4.2 EMI ISSUES

The ICETRON system operates at radio frequencies (250 kHz). Therefore it is important to suppress electromagnetic interference (EMI) to acceptable levels. Steps may be taken to ensure that EMI radiated from the system and EMI conducted into the power lines is minimal. See sections 3.8 and 4.3.3 for details.

4.3 LAMP/BALLAST MOUNTING

Due to their long life, ICETRON QUICKTRONIC system components are intended to be permanently attached to the lighting fixture. Several precautions should be taken when considering the system mounting configuration.

4.3.1 Ballast

The fixture must be configured such that the temperature at the test point on the ballast label (T_C Max) does not Exceed temperatures in table 11 when the fixture is operated at the expected maximimum ambient temperature. Applications in which the ballast case temperature exceeds this maximum void all warranties. The following are guidelines to help the designer achieve maximum cooling of the ballast. Note: Type 1 ballast must also be protected from exposure to rain and other elements.

- If possible, mount the ballast in its own compartment, thermally isolated from the compartment that houses the lamp. This will prevent the lamp from heating the ballast and this also helps prevent the lamp from communicating electrical noise to the ballast input wires.
- Mount the ballast below the lamp so that heat rising from the lamp is not directed toward the ballast.
- Mount the ballast on metal surfaces that will be cooled by the outside air.
- If the ballast must be mounted in the same compartment as the lamp itself, then consider the following guidelines:
    - Mount the ballast behind the lamp reflector. The lamp reflector will reflect much of the infrared energy away from the ballast.
    - Do not mount the ballast on the same metal substrate used to heat sink the lamp.
    - If the ballast is to be mounted to a surface, make sure the bottom of the ballast and the mounting surface are in intimate contact for good heat transfer. The mounting surface must be flat. Do not mount the ballast on a warped surface.
    - Four (4) mounting screws are required for proper grounding and heat sinking to a manufacturer's fixture. A serrated head or captive star washer screw is required for proper grounding. For example; a Serrated Hex Washer Head Slotted Sheet Metal Screw No. 10. McMaster p/n 900063A242 or equivalent is acceptable
    - Fixture volume including ballast compartment should be no smaller than about 50 liters.
    - If no appropriate cool metal surfaces are available, consider mounting the ballast away from all hot metal surfaces and attach a black, aluminum heat sink with cooling fins to the bottom of the ballast.
    - Ballast and lamp induction core weight (several pounds) should be considered when designing the method of fixture attachment to ceiling grid, etc. These components should be mounted so that vibration is reduced as much as possible.

4.3.1.1 Fixture/Outdoor Requirements

Input: Input line power should be disconnected from the ballast when the fixture is being serviced.

Fixtures: Fixture manufacturers need to design the fixture to prevent exposure to rain. A properly designed fixture needs to have adequate sealing and may consider mounting the type 1 ballast upside down to avoid exposure to water accumulation inside the fixture.

Per UL file E258264 Vol. 3

Type 1, electric discharge ballasts QT1x40ICE/UNV-T , QT1x100ICE/UNV-T, QT1x150ICE/UNV-T or QT1x200ICE/UNV-T shall be mounted inside an electrical enclosure or raceway.

Type 2, outdoor electric discharge ballasts QT1x100ICE/UNV-W or QT1x150ICE/UNV-W may be mounted outside an electrical enclosure, but the input and outputs terminals, leads, and connections need to be suitably enclosed in conduit, raceway, or electrical enclosure.

4.3.2 Lamp

The following lamp considerations should be taken into account when designing a fixture:

1. The luminous output of the lamp depends strongly on the amalgam tip temperature. To obtain at least 90% of maximum light output, the amalgam temperature must be between ranges listed in table 11
   Depending on the size and openness of the lamp compartment, the amalgam tip may need additional thermal coupling to make sure that its temperature range corresponds to the ambient temperature range to which the fixture will be exposed. The following factors can influence amalgam tip temperature:
   - Lamp orientation. If the lamp is operated vertically (with amalgam tip down as specified) the tip will tend to run cooler because of internal gaseous convection currents, and hence the allowable fixture ambient temperature range will be slightly higher. If the lamp is operated horizontally, the tip will run a little warmer and the allowable fixture ambient temperature range will be slightly lower.
   - Fixture openness. If the lamp is mounted in a sealed fixture, the amalgam tip temperature will be higher than if it is mounted in an open fixture.
   - Close proximity to other sources of heat, e.g., other lamps and/or ballasts in a multi-lamp fixture. These sources of heat may cause amalgam tip temperature to be higher.
   - Reflector design. Amalgam tip temperature will be higher in fixtures that direct radiation back onto the lamp.

   The fixture designer may need to take measures to heat or cool the amalgam tip. Suggestions for doing so may be found in section 4.4 "Thermal Testing Procedure."
2. The lamp connector should not be positioned close to the lamp or in any location where its temperature will exceed 221°F (105°C) at maximum ambient temperature.
3. The lamp should be mounted firmly to a heat sinking structure. The temperature at the feet should not exceed 212°F (100°C) at the maximum fixture ambient temperature. The temperature of the ferrite cores must not exceed 302°F (150°C) at the maximum fxcture ambient temperature.
4. Position the lamp so as to achieve the optimum lumen output considering amalgam tip positioning, temperature and ambient heating (see section 3.7.2).
5. The lamp is attached to the ballast via mating plug-in connectors. The total wire length after mating is approximately two feet for the type 1 ballast and four feet for the type 2 ballast. Caution: the wire and the mating connectors should not be altered.
   These wires should be routed within the fixture so as to comply with regulatory agency approvals (UL, NEC, etc.).
6. Any input lead or the output connector must be kept a minimum of 4 inches away from the ICETRON lamp or must be Teflon® coated (or other similarly approved material that is able to withstand UV radiation of 1 microwatt per square centimeter for the life of the fixture).

4.3.3 Remote Operation

The ICETRON lamp (1) and ballast (2) can be remote mounted from each other using the specified remote mounting cabling (see Figure 27). The ICETRON QUICKTRONIC ballast will operate a lamp with a special high voltage cable (3) in conduit up to 66 feet (20 meters)* long as specified below. Only this cable is approved for operation with the ICETRON QUICKTRONIC system. Use of an unapproved cable voids the warranty.

* For the 100W dimming system the maximum cable length is: 10ft (3m) for +5°F (-15°C) to +50°F (+10°C) 66ft (20m) above +50°F (+10°C).

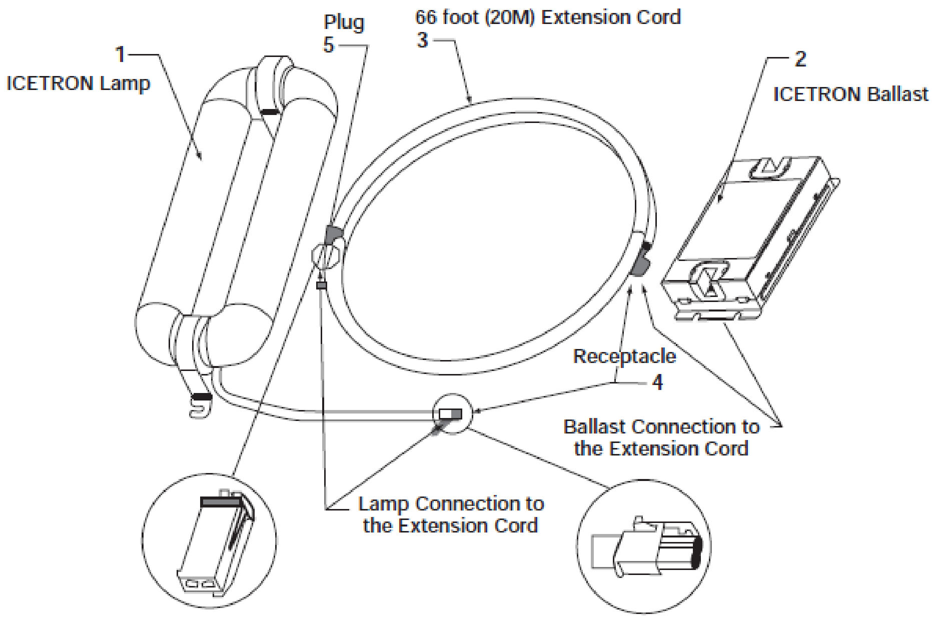


Figure 27: Remote Mounting

The following materials are approved for the remote cable up to 66 feet (20 meters):

a. Wire: 18 AWG wire (19/30) MIL-W-16878E (type EE), UL1180, 200°C, 1000 Volt, stranded silver-plated copper, extruded TFE TEFLON, wire must be twisted pair, manufacturer: Anixter. Note. See the Sylvania procedure "Icetron Cable Extension Procedure" for instructions on building the extension

b. Conduit: 3/8" flexible steel conduit UG380; manufacturer: Liquatite. (note: Conduit must be electrically connected to earth ground.) See note below for alternatives

c. Receptacle (4): Mini-fit, jr., Molex part number 39-01-2025 to be used with crimp, female molex part number 39-00-0059 or 39-00-0060.

d. Plug (5): Mini-fit, jr., Molex part number 39-00-0061 or 39-00-0062.

The ICETRON® QUICKTRONIC® system complies with Federal Communications Commission (FCC) limits.
An improperly installed extension cable can cause increased EMI/RFI. The OEM is solely responsible for ensuring that the ICETRON system with remote mounting properly suppresses both conducted and radiated emissions and meets the FCC limits.

For further information please contact your OSRAM SYLVANIA Sales Specification Engineer.

Note: Conduit Alternative:

Using this conduit, and following the directives above, will ensure that the ICETRON system will work as specified. Using other conduits is possible. Any conduit used with the ICETRON system must meet the following requirements:

1. Metal conduit so it can be grounded (to surpress EMI)
2. Internal diameter of conduit (including manufactuer's tolerance) must be at least 0.433" wide. When choosing a conduit, make sure that the smalled diameter of conduit (nominal minus tolerance) is greater than or equal to 0.443"
3. Water must not penetrate the conduit. Choose proper conduit for the application.

Note: The requirements brought forth by SYLVANIA only pertains to the performance of the ICETRON system and does not imply or suggest compliance with any regulatory bodies such as UL.

Note: For remote operation, only one cable can be run per conduit. This is to avoid cross-conduction between the wires which could affect starting and/or operation.

4.3.4 Other Considerations

The following considerations are important in achieving optimal fixture performance:

1. To keep EMI conducted in the power lines to a minimum, keep the ballast input wires (power supply lines to the ballast) as far away as possible from the ballast output wires (supply to the lamp) and any part of the lamp.
2. To assure maximum safety and to further suppress EMI, make sure that the ballast case and the lamp mounting brackets are electrically grounded. Four serrated head mounting screws or captive star washers or equivalent are required to ensure proper ground connection of the ballast. The serrated head screw or equivalent must cut through the paint on the ballast and fixture surface for good metal to metal contact to earth ground. All four mounting screws must be used for the proper heat transfer from the ballast to the fixture. See Section 4.3.1 for details.
3. Painting the fixture with a high emissive paint will permit the fixture to dissipate heat more effectively through thermal radiation.
4. Heat is transferred better through spot welds than through surface to surface contact. Use as many spot welds as possible.

4.4 THERMAL TESTING AND ANALYSIS

4.4.1 Temperature Measurement Points

Ballast measurement point:

The ballast measurement point, called the T_C Max, is located on the ballast label. This point must not exceed temperatures listed on table 11 under any conditions or the warranty will be voided. This is the location where all temperature measurements must be taken.

The maximum ballast case temperature should be measured using a fine wire thermocouple and temperature meter. The thermocouple should be attached (using a high temperature resistant glue) to the test point, T_C Max on the ballast label. Critical lamp and ballast temperatures can be measured by attaching thermocouples using suitable tape or thermally conductive cement. If the thermocouple is attached by means other than cement, a thermally conductive paste should be applied to ensure that thermocouple and measurement point are at an equal temperature. Allow at least four hours (for a typical fixture) for temperatures to stabilize before recording data. The temperature measurement points on the lamp and ballast are shown below.

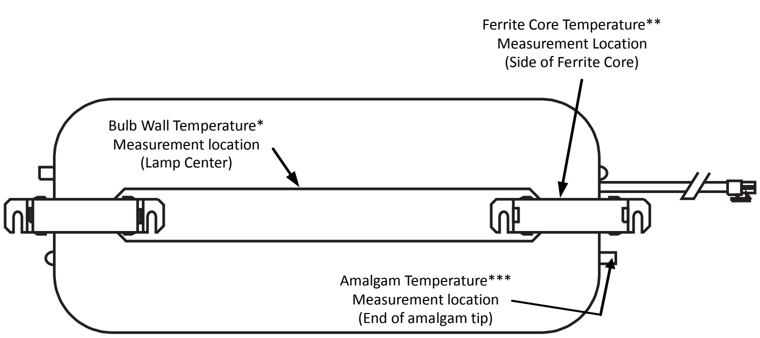


Figure 28: Measurement Points on ICETRON® Lamp

* Maximum Bulb Wall Temperature is 302°F (150°C).

** Maximum Ferrite Core Temperature is 302°F (150°C)

***See table 11

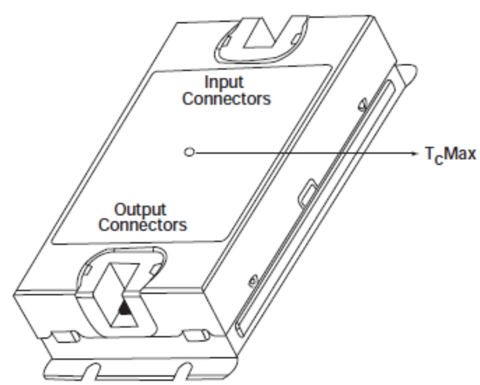


Figure 29: Measurement Point on ICETRON QUICKTRONIC ballast

4.4.2 Thermal Testing Procedure

The procedure for measuring critical temperature points for the ICETRON QUICKTRONIC® system is as follows:

1. Connect thermocouples to the lamp test points and the ballast test point (see figures 28 and 29). Allow enough slack in the thermocouple wires to permit measurements when the fixture is mounted as it would be in the field. Refer to section 4.4.1 for further instructions on mounting thermocouples.
2. Mount the ICETRON QUICKTRONIC system into the fixture.
3. Assemble the fixture into its complete form, i.e., the way the fixture will be used in the field. Orient and mount the fixture as in a typical application.
4. Apply power to the system and allow the fixture to thermally equilibrate (approximately four hours).
5. Measure the temperature at the ballast test point "T_c Max" which is located on the ballast label ($T_{ballast}$).
6. Measure the amalgam tip temperature (T_{amal}).
7. Measure the room temperature (T_{room}).
8. Measure the ferrite core temperature (T_{core})
9. Measure the temperature at the mounting foot of the lamp (T_{foot}).
10. Measure the temperature at the bulb wall (T_{bulb}).

4.4.3 Thermal Analysis

There are two primary factors that place limits on the range of operating ambient temperature. These factors are the amalgam temperature range and the maximum ballast case temperature (T_c Max).

1. First, calculate the lower and upper limits of operating ambient temperature based on the measured amalgam temperature. The formulas are:

   $T_a = T_{room} – T_{amal} + 55$ For the ICETRON 70, 150 and 200

   $T_b = T_{room} – T_{amal} +125$

   $T_a = T_{room} – T_{amal} + 50$ For the ICETRON 100

   $T_b = T_{room} – T_{amal} +125$

   where all temperatures are in degrees °C.

   T_a is the minimum ambient temperature under which the fixture may be operated to obtain at least 90% of maximum light output. T_b is the maximum ambient temperature under which the fixture may be operated to obtain at least 90% of maximum light output.

2. Next, calculate the maximum ambient temperatures allowed for various parts of the system.

   Tmax/ballast = Troom - Tballast + 75 (for 200W type 1 ballast)

   $T_{max/ballast} = T_{room} – T_{ballast} + 70$ (for 150W type 1 ballast)

   $T_{max/ballast} = T_{room} – T_{ballast} + 65$ (for 100W type 1 ballast)

   Tmax/ballast = Troom - Tballast + 71 (for 100W and 150W type 2 ballast)

   (All temperatures in degrees °C)

   $T_{max/core} = T_{room} – T_{core} + 150$

   $T_{max/bulb} = T_{room} – T_{bulb} + 150$

   Set T_{max} = (lowest of $T_{max/ballast}$, $T_{max/core}$ and $T_{max/bulb}$)

3. Determining the operating ambient temperatures.
   - The lowest temperature in which the fixture will operate properly is T_a. This is the ambient temperature that corresponds to the lower limit of the amalgam temperature range for 90% of peak light output. The fixture may be operated in lower ambient temperatures, down to -40°F (-40°C) for the 100W, 150W and 200W, -13°F (-25°C) for the 70W and +5°F (-15°C) for the 100W DIM). (see Section 3.7.1 for details), with no adverse affect on the life of the system, but the light output will be reduced and lamp color may shift.
   - The highest allowable temperature in which the fixture may be operated is T_{max}. This will correspond to one of the maximum temperatures allowed at the various test points. **Operating the fixture with ambient temperatures higher than T_{max} will result in shortened life of the system and possibly damage the ballast.**
   - T_b is the ambient temperature that corresponds to the higher limit of the amalgam temperature range for 90% of peak light output. T_b may be higher than T_{max}, but again, the system must not be operated above T_{max}.

4a. Correcting thermal problems—Two problems may occur:

- The maximum allowable temperature, T_{max}, is too low for the fixture's particular application. To correct this problem, follow the guidelines for proper lamp and ballast mounting. If all the guidelines have been followed and the maximum allowable temperature is still too low, then more aggressive cooling options may need to be investigated.
- The temperature limits, T_a and T_b, corresponding to the ambient temperature limits for at least 90% peak light output are too high, or too low. For example, T_b could be much higher than T_{max}, thus preventing the fixture from taking advantage of the amalgam's full temperature range. This means that the amalgam tip is too cold for any given fixture ambient temperature. Whether or not action must be taken to adjust the amalgam temperature range is a judgment call of the designer. Figure 30 shows the amalgam temperature as a function of fixture ambient temperature. Figure 30 also shows the effect of heating or cooling the amalgam tip on operating ambient temperature range. Cooling shifts the range up and heating shifts the range down (see Figure 30). For every degree the ambient temperature changes, the temperatures internal to the fixture change by one degree. So, according to the graph, to shift the entire range by ΔT degrees, you must apply heating (or cooling) to the amalgam tip so that at any given fixture ambient temperature, the amalgam temperature changes by an amount $-\Delta T$.

4b. Techniques to passively heat the amalgam tip are:

1. Insulate the lamp compartment so that the local lamp environment runs hotter. However, to prevent the ferrites from overheating you should make sure you have good heat sinking at the lamp's mounting feet.
2. Reduce the dimensions of the lamp compartment or seal the lamp compartment to eliminate cooling from outside air.
3. Install amalgam tip covers (foam plug) on both amalgam tip and exhaust tip. Installation of an amalgam tip cover on the exhaust tip is also required in order not to create a competing cold spot for mercury vapor pressure. Amalgam tip covers can be ordered from OSRAM SYLVANIA; the part number is 22093.
4. Parts of the lamp that generate heat are the glass bulb and the ferrite coupling cores. Take advantage of these heat sources by conducting heat from them to the amalgam tip. Some examples are:
   - Install a thin aluminum tube about the length of the amalgam tube itself over the amalgam tip so that the end of the tube is located close to the heat producing glass bulb. You can increase or decrease heating by moving the aluminum tube closer or farther away from the bulb respectively. If the use of an adhesive is necessary, use a transparent silicone adhesive.
   - Place a wire mesh over the tip and extend the mesh onto the surface of the bulb. Use a transparent silicone adhesive if necessary.
   - Install some kind of thermal connection: e.g., aluminum strip etc., between the amalgam tube and the ferrite, which generates heat. Use a transparent silicone adhesive if necessary.*

     *** CAUTION — vibration may induce tip breakage!**

4c. Techniques to passively cool the amalgam tip are:

1. Give the lamp compartment a more open design.
2. Increase the dimensions of the lamp compartment.
3. Provide a heat sink, such as an aluminum tube between the amalgam tip and a much cooler, heat-dissipating structure

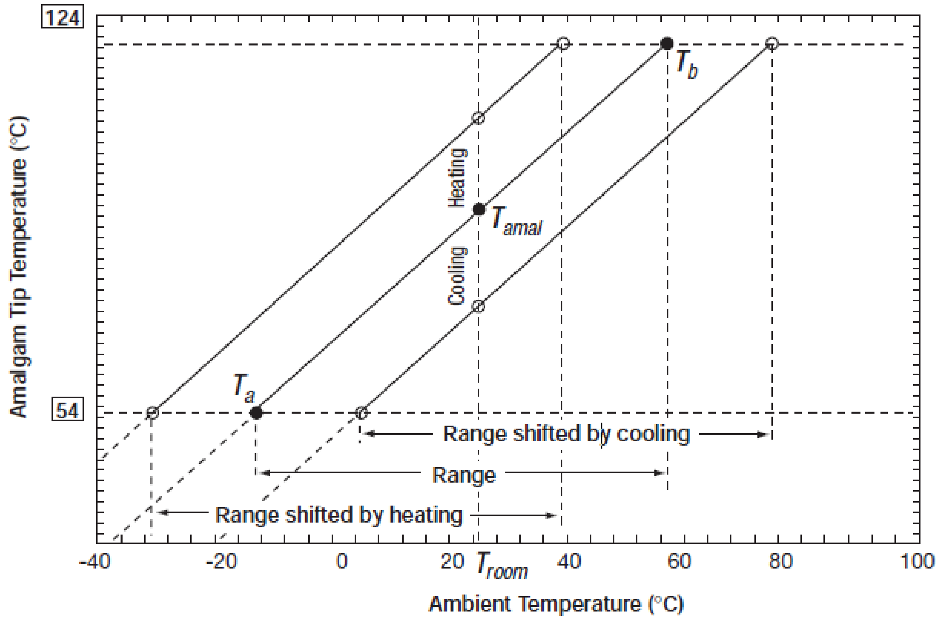


Figure 30: Amalgam temperature as a function of fixture ambient temperature

4.5 FIXTURE EFFICIENCY CONSIDERATIONS

4.5.1 Calculating Fixture Efficiency

Fixture efficiency is calculated by measuring the total luminous flux from the fixture and dividing by the total flux from the lamp alone. The measurements are (normally) made on seasoned lamps at an ambient temperature of 77°F (25°C). However, the light output of ICETRON® lamps varies somewhat with the temperature of the amalgam.
To get a valid measurement of fixture efficiency, one of the following methods must be used:

1. The amalgam tip temperature can be controlled at a constant temperature for both bare lamp and fixture readings. This will ensure that the actual lumen output of the lamp is constant regardless of ambient temperature.

Or:

2. A correction factor can be applied to both bare lamp and fixture measurements to normalize the output to the estimated peak value. In this case, there is no need to control the amalgam tip temperature.

4.5.1.1 Controlled Amalgam Tip Temperature

If extensive measurements are planned, an amalgam tip heater and temperature controller can be constructed. The heater can consist of a section of heating tape applied around the tube with a thermocouple cemented to the tube adjacent to the amalgam to monitor tip temperature.

Alternately, an aluminum rod can be drilled to fit over the amalgam tip. This rod can be heated by heat tape or by a small cartridge heater. The thermocouple can be attached directly to the aluminum in this case. Thermally conductive paste must be used between heater and the amalgam tip. A temperature controller should set power level to the heater. The recommended set-point temperature is 65°C for the 100W and 70°C for 70W, 150W and 200W which should result in near peak light output. The system should be powered on and allowed to reach a stable operating condition. This typically requires about 4 hours from a cold state.

4.5.1.2 Peak Output Correction Factor

The light output of an ICETRON® lamp operating at thermal equilibrium is determined by the mercury vapor pressure. The mercury vapor pressure, in turn, is determined by the temperature of the main amalgam. The total light output will typically be within 10% of maximum for tip temperatures in the range in table 11.
However, when a cold lamp is first turned on, the lumen output will rapidly increase to an intermediate peak which is about 3% lower than maximum.
The peak light intensity (L_p) of a bare lamp can be measured from any reference point.

The system must reach thermal equilibrium before photometric measurements are made. This typically requires about four hours. The system has reached thermal equilibrium when there is no further change in system power or light output. Stabilized light intensity (L_S) of the lamp is measured from the same reference point used for measuring (L_p). The ratio L_p/L_S then provides a correction factor to normalize output to the peak reading. The total luminous flux of the bare lamp (Φ_L) must be measured on a thermally stabilized system. The corrected total luminous flux of the bare ICETRON lamp is therefore:

$$\Phi_{Lc} = \Phi_L * (L_p/L_S)$$

The same procedure can be used when an ICETRON QUICKTRONIC® system is mounted in a fixture where F_p is the peak light intensity and F_S is stabilized light intensity measured from the same reference point. The total luminous flux of the fixture (FF) must also be measured on a thermally stabilized system and corrected as with the bare lamp.

$\Phi_{Fc} = \Phi_F * (F_p/F_S)$ so Fixture Efficiency is Φ_{Fc} / Φ_{Lc}

4.5.2 Reflector Design Suggestions

In contrast with the current general tendency to reduce the tube diameter of conventional fluorescent lamps (T12 → T8 → T5), the ICETRON lamp requires a larger diameter discharge tube. For the 70W, 100W and 150W ICETRON lamps, a tube diameter of 54 mm (T17) is optimal; for higher lamp power ratings even greater diameters will be needed. Because smaller diameters elevate the lamp voltage (V_L), and the empirically determined ferrite core loss relationship, $P_{core} \sim V_L^{2.5}$, losses in the coupler cores of the ICETRON lamp would increase unacceptably with diminishing tube diameter.

In a fixture intended for high-bay or street lighting, it is important to direct as much light as possible downwards. Therefore a reflector is incorporated within the fixture to redirect light that is emitted from the upper surface of the lamp so that it travels in a downward direction. Several fixture designs incorporate reflectors to direct light where it is needed and reduce stray light. If the lamp has a large diameter, and if a small fixture or small reflector is used, a considerable fraction of the light incident upon the reflector is generally reflected (“redirected”) back toward the lamp. The light is then scattered and/or partially absorbed. This decreases fixture efficiency. However, it is possible to avoid this difficulty by following the principles described in section 4.5.3.

4.5.3 The Reflection Principle

Consider a light ray emanating tangentially from a point E on the lamp surface (tube radius R) and striking the reflector at point D. If that ray is not reflected back upon itself and this condition can be satisfied for all other points of the reflector contour (r/R), then it is possible to suppress the light loss due to scattering and absorption. This can be realized because all other rays (originating from any lamp surface point between E and E') bypass the lamp to the right after reflection from point D. This is illustrated in figure 31 between the solid and dashed lines. Some rays may be reflected a second time (D'). These conditions are fulfilled when all parts of the reflector curve are perpendicular to the respective tangent lines exemplified here by ED in the figure. This leads to the following mathematical definition (in differential form) of the reflector contour:

$$d\varphi = (1/R^2 - 1/r^2)^{1/2} \times dr \quad (1)$$

The reflector curve can be determined by mathematical integration of Equation (1). The result is

$$\varphi = \varphi 0 \pm \{[(r/R)^2 - 1]^{1/2} + \text{across } (R/r)\} \quad (2)$$

The reflector curve (r/R) shown in Figure 31 is calculated from = 0 and the positive bracketed factor, +{...}. It is a spiral contour that issues radially from the lamp surface and unfolds clockwise. A counterclockwise opening spiral with the negative bracketed factor, -{...}, is equivalent, and the curves may start at any angle φ0.

Because all parts of this special reflector fulfill the non-redirected condition, any part (or parts) of the reflector can be utilized as a reflector surface, depending on the requirements of the lighting application. This reflector also suppresses temperature rise of the lamp surface.

4.5.4 Application to the ICETRON System

For the rectangular version, instead of a single tube the ICETRON® lamp incorporates two tubes parallel to each other (see Figure 32). Illumination losses in this implementation can result from the light of one tube being scattered and partly absorbed by the other, as well as from light being retro reflected onto the lamps by the reflector.

The reflector (see Figure 32) shows an integrated reflector system needed to satisfy the non-redirected conditions. It displays the basic reflector parts **1 and 2** that are identical with φ (r/R) of reflector design 1 (Figure 31). Part **3** is the mirror image of part **2** about the x-axis. Parts **4, 5, and 6** are the mirror about the y-axis. The reflector parts **2, 3, 5, 6** are only needed to avoid the absorption of light that the light that two tubes emit towards each other.

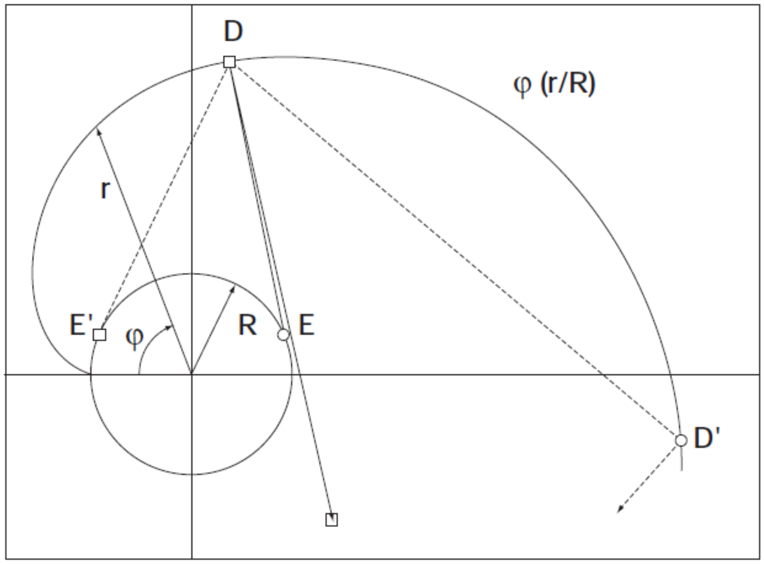


Figure 31: Reflector Design 1

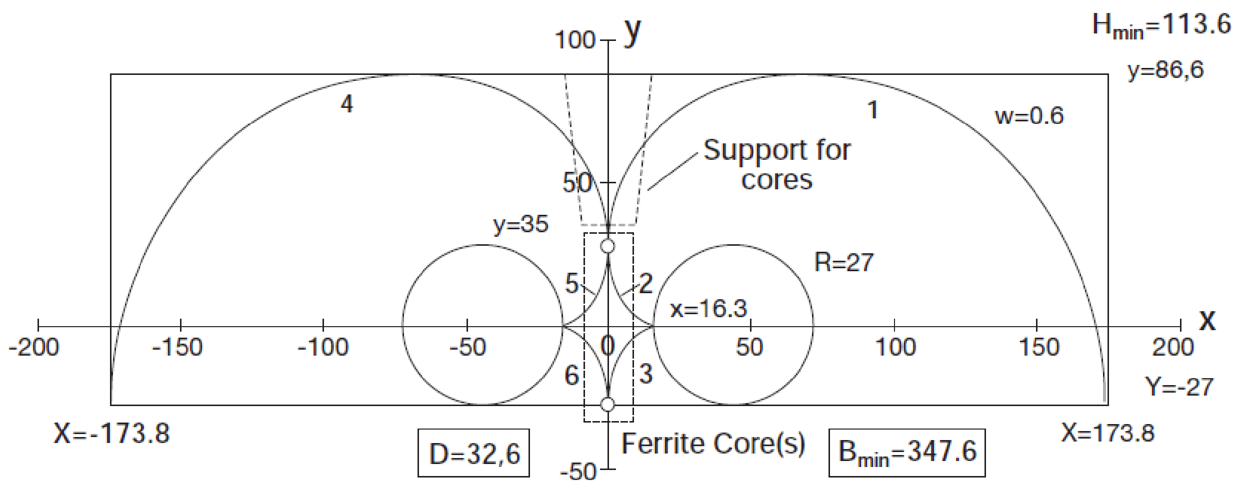


Figure 32: Reflector Design 2

4.6 MULTIPLE LAMPS

Although it may be advantageous to design ICETRON® system fixtures with multiple lamps/ballasts, the following guidelines should be followed. Ballast should be positioned such that this case temperature maximum is not exceeded.
The maximum allowable ballast case temperature, T_C Max is given in table 11

Thermal characteristics of the lamp such as proper amalgam tip temperature, bulb wall temperature, and thermal coupling of induction cores with fixture are important in maintaining sufficient light output and reliability. Routing the input leads to the ballasts away from the ballast/lamp output leads (as well as limiting the length of the ballast/lamp output leads) provides the lowest possible level of EMI/RFI.

Note: A case temperature reference point is specified on the housing of all ICETRON ballasts. This specific reference point (Tc) is the exact position on which the maximal case temperature should be measured in order ot ensure the proper thermal operation of the ballasts in the Fixture.

4.7 TROUBLESHOOTING

ICETRON systems should be installed and operated in compliance with the National Electric Code (NEC), Underwriters Laboratories Inc. (UL) requirements, and all applicable codes and regulations. As it is possible to come in contact with potentially hazardous voltages, only qualified personnel should perform system installation or troubleshooting. The ballast can become electrically unsafe and fail to meet FCC compliance if the cover is removed. All installation, inspection, and maintenance of lighting fixtures should be done with the power to the fixture turned off.

The following should be used to guide qualified personnel in the troubleshooting and correcting of the most commonly encountered problems in typical lighting systems:

Lamp does not light.

Check to see if there is power to the ballast. If so, is the ballast or lamp at fault? Swap known good components to determine if the lamp or ballast has reached its end of life. Other possible causes: Has input voltage to the ballast been switched off for more than 10 seconds, resetting the ballast, after lamp was replaced? Are the lamp and ballast wire connectors properly mated? Is the input line voltage within specified limits? Are in-line fuses or other devices at fault?

See section 3.7.2 Effects of ambient temperature on system performance

Lamp starts slowly, flickers, or fails prematurely.

Is the lamp at fault? Swap with a known good lamp to determine if the lamp has reached its end of life. Other possible causes: Are ambient conditions within specified limits? Is the input line voltage within specified limits? Are fixture and system components properly grounded? Are the lamp and ballast wire connectors properly mated? Is the lamp the correct type to be compatible with the ballast? (Compatible lamp types should be listed on the ballast label.) Is the ballast at fault? (Swap with a known good ballast to determine if the ballast is defective.) Is fixture rated for TYPE 1 (if type 1 ballast used)?

Lamp lights and operates for a while, then shuts off.

Is the ambient temperature of the ballast too hot? Ballast case temperature should be below ranges listed in table 11.

Other possible causes: Is the lamp the correct type to be compatible with the ballast? (Compatible lamp types should be listed on the ballast label.) Is the ballast at fault? (Swap with a known good ballast to determine if the ballast is defective.)

Excessive noise.

Are any of the lighting fixture components loose? Are ballast case and lamp secured tightly to fixture? Other possible causes: Is the ballast at fault? (Swap with a known good ballast to determine if the ballast is defective.)

Interference.

Is a radio or antenna close to lamps? Move the radio or antenna away as much as practically possible from lamps. If problem persists, separate branch circuits may be required for the radio equipment and lighting fixtures.

Other possible causes: Are fixture and system components properly electrically grounded? Are the ballast input and output leads separated as much as practically possible? Is the ballast at fault? (Swap with a known good ballast to determine if the ballast is defective.) Is the TYPE 1 outdoor rated ballast protected from exposure to moisture and water?

4.8 ICETRON FIXTURE DESIGN CHECKLIST

The following items must be strictly adhered to in order to achieve an acceptable ICETRON® system fixture design. Applications that do not meet these criteria will not be covered by warranty.

4.8.1 Lamp

Lamp is firmly attached to fixture via the four mounting holes.

Lamp is attached to fixture by mounting feet only.

Amalgam tip temperature for 90% of maximum light output is within the specified range. For more details see section 4.4.

For vertical (non-horizontal) lamp operation, the amalgam tip is positioned downward.

Bulb wall temperature does not exceed 302°F (150°C). For more details, see section 4.4.

Temperature of ferrite core does not exceed 302°F (150°C)

Lamp induction cores have good thermal coupling to the fixture.

Wire and mating plug-in connectors between lamp and ballast have not been altered in any way.

Wire and mating plug-in connectors must be kept at least 4 inches away from any lamp surface.

The lamp connector should not be positioned close to the lamp or in any location where its temperature will exceed 219°F (104°C) at maximum ambient temperature.

4.8.2 Ballast

Ambient temperature of the ballast is kept as low as possible.

Dissipation of heat is enhanced by using the metallic lighting fixture as a heat-sink for the ballast enclosure and the lamp induction cores.

The bottom of the ballast (largest surface area possible) is mounted flat against a large metallic surface of the fixture.

Test point temperature of the ballast (T_C Max) does not exceed the specified values (see table 11).

For more details, see section 4.4.

Type 1 ballast is protected from exposure to rain and other elements that could damage the ballast.

Grounding through four (4) serrated head or captive star washer mounting screws, or equivalent, are required for proper grounding. The serrated head screws must cut through the paint on the ballast flange and fixture surface for good metal to metal contact.

Ballast input leads and ballast/lamp output leads are separated as much as physically possible to minimize EMI.

Per UL file: E258264 Vol 3.

Type 1, electric discharge ballasts QT1x100ICE/UNV-T or QT001x150ICE/UNV-T shall be mounted inside an electrical enclosure or raceway.

Type 2, outdoor electric discharge ballast QT1x100ICE/UNV-W or QT1x150ICE/UNV-W may be mounted outside an electrical enclosure, but the input output terminals, leads, and connections need to be suitably enclosed in conduit, raceway, or electrical enclosure.

4.8.3 Fixture

Wire and mating plug-in connectors are routed within the fixture so as to comply with regulatory agency approvals.

Fixture is grounded.

High emissive surfaces for heat transfer (recommended).

Suitably sealed for outdoor application.

Provides proper ballast protection from exposure to water according to ballast type (type 1 or type 2)

General Information

5.1 GLOSSARY

ACGIH: The American Conference of Governmental Industrial Hygienists. They have established Threshold Limit Values (TLVs) for chemical substances and physical agents that are generally used in the U.S. and are widely accepted overseas.

Amperes (Amps): The unit of measure for electrical current flow.

Ambient Temperature: The air temperature in a general environment (room temperature).

ANSI (American National Standards Institute): The regulatory body charged with developing standards for performance, safety, etc. for various products.

Audible Noise (Sound): All fluorescent ICETRONIC QUICKTRONIC ballasts are lamp ballasts produce some acoustic noise and are sound rated.

Average Rated Life (system): ICETRON QUICKTRONIC ballasts designed to have an average rated life of 100,000 hours when operated at the rated Tcmax see table 11.
Because the lamp has no electrodes to wear out, the system life is essentially determined by the life of the ballast. Note: the 70, 100 and 150W lamp have 76% and the 200W has 64% maintenance at 100,000 hours.
To maximize system life, the ballast case temperature should be kept as low as possible. It is also important to maintain effective dissipation of heat using the metallic lighting fixture as a heat sink for the ballast enclosure.

Ballast: A current or power regulating device used to control discharge lamps.

Ballast Basics: Ballasts have three primary functions: 1) start the lamp, 2) control operation of the lamp once it has started, 3) control the shape of the line current waveform. These high frequency electronic ballasts operate lamps more efficiently and eliminate the hum and visible flicker normally associated with magnetic ballasts.

Ballast Factor (BF): Relative light output of a commercial ballast as compared to a reference ballast (e.g., BF of 0.90 would yield 90% of a lamp's rated lumens).

Candela (cd): The unit of measure quantifying the luminous intensity (candlepower) of a light source in a specific direction; any given light source may exhibit different luminous intensities, depending upon the direction considered.

Color Temperature: The absolute temperature in degrees Kelvin at which a black body emits radiant energy most closely matching the color perceived from a given light source.

Color Rendering Index (CRI): Measure of the degree of color shift that objects undergo when illuminated by a light source as compared with the color of those same objects when illuminated by a reference source, e.g., a tungsten filament of comparable color temperature. A CRI of 100 corresponds to negligible color shift.

ECG: Electronic Control Gear (ballast).

Electromagnetic Interference / Radio Frequency Interference (EMI/RFI): ICETRON QUICKTRONIC ballasts contain circuitry that limits the electrical noise conducted onto the power line or radiated through the air, otherwise referred to as EMI/RFI. ICETRON QUICKTRONIC ballasts comply with FCC 47 CFR Part 18, non-consumer limits for commercial applications. Ballasts for residential applications must meet consumer limits.

Fixture Efficiency: Ratio of luminous output emitted by a fixture compared to the total luminous output emitted by the lamp or lamps used in a specific fixture.

Fixture Watts: The input power (watts) cited in the ballast specifications is measured according to ANSI specification (ballast and lamps are measured while placed on benchtop at room temperature). Actual operation in an enclosed fixture, due to the ambient heating of the lamps, may differ from the ANSI rating.

Fluorescent lamp: A phosphor-coated, gas-filled glass tube, which emits light by ultraviolet excitation of the phosphor. UV energy is provided by a low-pressure mercury discharge.

Footcandle (fc): A unit of illuminance equal to 1 lumen per square foot.

Frequency (Hz): The number of times per second that an alternating current system reverses from positive to negative and back to positive, expressed in cycles per second or Hz.

Fusing: ICETRON QUICKTRONIC ballasts contain an internal electrical fuse. Although there is no need to externally fuse the ballast, should code or regulation require one, 4-amp slow blow fuses are recommended.

Grounding: The ICETRON QUICKTRONIC ballast case and metallic fixture must always be grounded. The grounding helps assure safety, proper lamp starting, and acceptable EMI/RFI performance.

Hertz (Hz): Measure of frequency; 60 cycles per second = 60 Hz.

Illuminating Engineering Society of North America (IESNA): Professional society that advances knowledge and disseminates information in the lighting industry.

Institute Of Electrical and Electronic Engineers (IEEE): Organization of engineers that establishes standards for safety and performance for the electrical and electronics industries.

Integrating Sphere: A spherical photometer that enables total luminous flux to be determined by a single measurement. Measures indirect luminance of the inner sphere surface.

International Electrotechnical Commission (IEC): The international standards setting organization. The equivalent in the United States is ANSI.

K-Factor: A parameter that quantifies the effect of non linear equipment, such as lighting ballasts, on an electrical system. Lighting systems should be designed so that the transformer rating is sufficient for the ballasts used (typically K-Factor < 4). ICETRON® QUICKTRONIC® ballasts meet this specification.

Light Level: Light output from a system is a function of rated lamp lumens, ballast factor, fixture efficiency, and ambient temperature. All of these factors must be considered when designing or retrofitting a lighting system.

Low Temperature Starting: The ICETRON QUICKTRONIC system has the capability to start the lamp at temperatures as low as -40°F (-40°C) for the 200W, 150W and 100W lamp, -13°F (-25°C) for the 70W and +5°F(-15°C) for nthe 100W DIM. Enclosed fixtures are recommended because the lamp has reduced light output at cooler ambient temperatures.

Lumen Maintenance: Light output at a particular point in lamp life. Expressed as a percent of initial lumen (100 hour lumen) output.

Luminous Efficacy (lm/W): Total luminous flux emitted by lamps divided by the total lamp or system power input, expressed in lumens per watt.

Luminous Intensity: Luminous flux per unit solid angle in a certain direction from the light source. Expressed in candelas.

Maximum Case Temperature: ICETRON QUICKTRONIC ballasts have a maximum allowable case temperature (see table 11) Applications in which the case temperature is allowed to exceed this maximum void the manufacturer's warranty.

Mortality: Lamp life rated as the average life of a group of lamps operated under ballast-controlled laboratory conditions. Average rated system life is defined when about 50% of the systems in a large test group have failed while 50% remain lighted.

Phosphor: Material used to coat the inside surface of fluorescent lamps; this controls color and the amount of visible light produced.

Polychlorinated Biphenyls (PCBs): A material formerly used in ballast capacitors but now considered hazardous and disposal is regulated. ICETRON QUICKTRONIC ballasts do not contain PCBs.

Power Factor (PF): The ratio of real power (watts) consumed to apparent power (Volts X Amps). The higher the power factor, the less current required to produce a given amount of usable power.

Radio Frequency Interference (RFI): Electrical noise that is generated by various types of equipment and may be radiated through the air.

Safety: ICETRON QUICKTRONIC ballasts should be installed and operated in compliance with the National Electric Code (NEC), Underwriters Laboratories Inc. (UL) requirements, and all applicable codes and regulations. Because it is possible to come in contact with potentially hazardous voltages, only qualified personnel should perform ballast installation. The lamp should not be taken apart. All installation, inspection, and maintenance of lighting fixtures should be done with the power to the fixture turned off.

Spectral Power Distribution (SPD): Graph of continuous and/or banded power density given off by fluorescent lamps, display from ultraviolet to infrared wavelengths. The area under the curve represents lamp total power output.

System Warranty: The ICETRON QUICKTRONIC system is covered by a comprehensive system warranty (consult QUICK 60+® warranty bulletin for additional details).

Total Harmonic Distortion (THD): The presence and extent of a current or voltage waveform at multiples of the fundamental frequency. Excessive THD (defined by ANSI as greater than 32%) may cause adverse effects to the electrical system. ICETRON QUICKTRONIC ballasts operate at less than 10% THD.

Transformer Rating: K-factor rating quantifies how much harmonic distortion a transformer can safely handle. The higher the transformer K-factor rating, the more harmonic distortion a transformer can safely handle.

Transient Protection: ICETRON QUICKTRONIC ballasts meet ANSI 62.41 Category A. This helps to ensure isolation from electrical disturbances such as power line transients, and temporary line voltage dropouts, surges and sags.

Type (ballast type):

UL935
Per UL file E258264 Vol 3.

Type 1, electric discharge ballasts QT1x100ICE/UNV-T or QT1x150ICE/UNV-T shall be mounted inside an electrical enclosure or raceway.

Type 2, outdoor electric discharge ballasts QT1x100ICE/UNV-W or QT1x150ICE/UNV-W may be mounted outside an electrical enclosure, but the input and outputs terminals, leads, and connections need to be suitably enclosed in conduit, raceway, or electrical enclosure.

Volt (V): Unit of measurement for the electrical potential between two points.

Watt (W): Unit of measurement for actual power consumed.

OSRAM
Americas Headquarters

OSRAM SYLVANIA Inc.
100 Endicott Street
Danvers, MA 01923 USA
Phone 1-800-LIGHTBULB (1-800-544-4828)
www.sylvania.com