M/MS 175, 250, 400

MetalArc Lamps

Technical Manual

SYLVANIA

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Introduction

METALARC metal halide lamps as produced by GTE are among the highest efficacy and best colour performing lamps available today. Pioneered in the mid 1960's by SYLVANIA with a unique sodium-scandium arc tube chemistry, METALARC lamps became a considerable success for indoor and outdoor lighting. Constant performance progress was achieved by using the results of most advanced research and development technology, including laboratory tests in the Challenger space shuttle.

Super METALARC (MS) lamps are the latest generation, with operating position dedicated and optimised arc tubes, for outstanding performance regarding their luminous efficacy, colour stability and lamp life.

Metalarc lamp positioning and economics

METALARC lamps are economical lighting solutions for indoor and outdoor applications where a combination of the quality of light (colour temperature and colour rendering index) and the luminous efficacy (lumen/Watt) are important.

In comparison with mercury and high pressure sodium lamps we can observe the following performance.

Lamp	Type	Wattage	Lumen	lm/W	Tc (K)	CRI (Ra)
Mercury	SC	400	24.000	60	3400	55
SHP	STD	400	48.000	120	2050	24
SHP	HCRI	400	34.000	85	2200	65
METALARC	3200 K	400	40.000	100	3200	70
METALARC	4000 K	400	40.000	100	3700	70
METALARC	CLEAR	400	40.000	100	4200	65

METALARC lamps versus SHP lamps provide much better light at lower but still excellent luminous efficacy.

METALARC lamps versus mercury lamps provide better light quality and much higher luminous efficacy.

A key factor in lighting economy is the luminous efficacy (lumen/Watt) of the light source. The above comparison shows that METALARC lamps are very well placed.

Applications

METALARC lamps are available in two generalised groups, 3000 K warm white and 4000 K neutral white light colour. This provides an ideal choice for most applications. Clear lamps are the choice for best luminaire efficiency and optical control.

The following table gives some guidance on possible applications.

Application Guide (Proposals)

Lamp Type	Clear	4000 K	3000 K
	Car Parks	High/low bay industrial	Entrance halls
	Security	Warehouses	Banks
	Bridges	Sports halls	Hotels
	Sports outdoor	Exhibition halls	Supermarkets
	Flood lighting	Train stations	Retail stores
	Monuments	Airport halls	Horticultural
	Airports	Petrol stations	Petrol stations

Product Range

METALARC lamps are part of a larger family of metal halide lamps manufactured and sold by GTE SYLVANIA.

Other types include:

HSI/T 35W, 70W and 150W G12 base Single Ended Display Types
HSI/TD 70W, 150W and 250W RX7s or Fc2 base Double Ended Display Types
HSI/T 250W, 400W, 1000W and 2000W E40 base Floodlighting Types
MP75, MP100, M150 E27 base Indoor General lighting and Mini Floodlighting Types.

Product Range Overview

The SMA range is organised around a matrix concept of lamps which are:

- Specified for best operation according to burning position e.g.

  U = universal or no restriction
  BU = vertical base up +/- 15 degrees
  BD = vertical base down +/- 15 degrees
  HOR = horizontal, position orientated arc tube and with +/- 15 degrees out of the principal lamp axis.

- Specified for alternative correlated colour temperatures e.g.

  3200 Kelvin Phosphor coated (Warm)
  3500-4200 Kelvin Phosphor coated bulbs (Neutral White)
  3500-4200 Kelvin Clear bulbs (Neutral White)

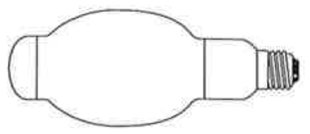
- Specified by lamp power and lumen output

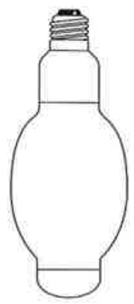
  175 Watt - 14000 to 15000 lumens
  250 Watt - 20500 to 23000 lumens
  400 Watt - 34000 to 40000 lumens

For further information please consult the data section.

175 WATT A popular lamp size for vertical and horizontal fixtures. Includes clear lamps (colour temperature: 4400K), coated lamps (colour temperature: 4000K) and warm-colour 3K coated lamps with a CRI of 70 ideally suited for apparel shops, grocery stores, and a wide range of merchandising applications.

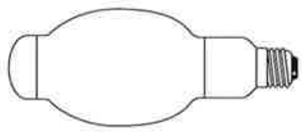
250 WATT Available in a choice of warm, cool or balanced colour temperatures to suit specific colour environments - universal or horizontal operation.





	175 Watt		250 WATT	
	SUPER METALARC		METALARC	
	Coated	Coated 3K	Coated	Coated 3K
Sylvania Item Number	20604	20600	20694	20621
ANSI Spec. Number	M57		M58	
Ordering Abbreviation	MS175/C/HOR	MS175/3K/HOR	M250/C/U	M250/3K/BU
PHYSICAL CHARACTERISTICS				
Burning Position	Horizontal (± 15°)		Universal	Base Up Only
Bulb Designation	BT-28		BT-28	
Nominal Bulb Diameter mm.	90 (3.5")		90 (3.5")	
Base Type	Position Oriented E40		E40	
Nominal Light Center Length mm.	127 (5")		127 (5")	
Maximum Overall Length mm.	211 (8.3")		211 (8.3")	
Nominal Arc Length mm.	26 (1")		35 (1.37")	
Maximum Bulb Temp. °C (F)	350° (662°F)		350° (662°F)	
Maximum Base Temp. °C (F)	210° (410°F)		210° (410°F)	
ELECTRICAL CHARACTERISTICS				
Nominal Lamp Watts	175		250	
Nominal Lamp Volts	130		133	
Nominal Lamp Amps.	1.55		2.1	
Min. RMS for Lamp Stability	250		250	
Min. start volt., lead peaked	RMS	Peak	RMS	Peak
ballast at -30° C (Crest Factor 1.8).	280	560	270	486
PHOTOMETRIC CHARACTERISTICS				
Initial Lumens	15000	14000	20500	19000
Mean Lumens (40% Rated Life)	11300	10500	16000	15000
Avg. Rated Life (10 Hrs./St.)	7500		10000	
CIE Correlated Color Temp.	4200K	3200K	3900K	3200K
Colour Rendering Index (CRI)	70		70	
Warm up Time (minutes)	2-4		2-4	
Hot Restart Time (minutes)	7-12		7-12	
CIE Chromaticity X-	.373	.425	.385	.425
Coordinates Y-	.380	.410	.380	.410
Lumen Maintenance/	1		2	
Mortality Curve	4		5	

250 Watt

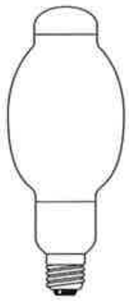
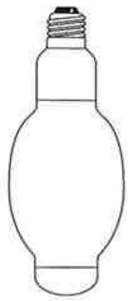


		SUPER METALARC	
		Coated	Coated 3K
Sylvania Item Number		20605	20601
ANSI Spec. Number		M58	
Ordering Abbreviation		MS250/C/HOR	MS250/3K/HOR
PHYSICAL CHARACTERISTICS			
Burning Position		Horizontal (±15°)	
Bulb Designation		BT-28	
Nominal Bulb Diameter mm.		90 (3.5")	
Base Type		Position Oriented E40	
Nominal Light Center Length mm.		127 (5")	
Maximum Overall Length mm.		211 (8.3")	
Nominal Arc Length mm.		33 (1.29")	
Maximum Bulb Temp. °C (F)		350° (662°F)	
Maximum Base Temp. °C (F)		210° (410°F)	
ELECTRICAL CHARACTERISTICS			
Nominal Lamp Watts		250	
Nominal Lamp Volts		130	
Nominal Lamp Amps.		2.1	
Min. RMS for Lamp Stability		250	
Min. start volt., lead peaked ballast at -30° C (Crest Factor 1.8).		RMS 270	Peak 486
PHOTOMETRIC CHARACTERISTICS			
Initial Lumens		23000	21500
Mean Lumens (40% Rated Life)		1700	16500
Avg. Rated Life (10 Hrs./St.)		10000	
CIE Correlated Color Temp.		3700K	3200K
Colour Rendering Index (CRI)		70	
Warm up Time (minutes)		2-4	
Hot Restart Time (minutes)		7-12	
CIE Chromaticity X-		.380	.425
Coordinates Y-		.380	.410
Lumen Maintenance/		2	
Mortality Curves		5	

400 WATT The most complete family of metal halide lamps available for all of your applications, including "MS" and "MP" series. Ideal for shallow light fixtures in stores, offices, public buildings, lobbies, production areas, warehouses, and other locations where high light output is desirable.

The Exclusive Metalarc "MP"-Series is specifically designed for use in open-bottom vertical fixtures.

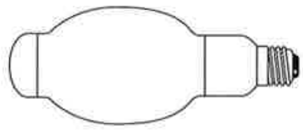
400 Watt


	SUPER METALARC			METALARC	
	Coated	Coated	Coated 3K	Clear "MP"	Coated "MP"
Sylvania Item Number	20608	20607	20603	20330	20331
ANSI Spec. Number		M59		M59	
Ordering Abbreviation	MS400/C/BD	MS400/C/BU	MS400/3K/BU	MP400/BU	MP400/C/BU
PHYSICAL CHARACTERISTICS					
Burning Position	Base Down Only	Base Up Only (± 15°)		Base Up Only (± 15°)	
Bulb Designation		BT-37		BT-37	
Nominal Bulb Diameter mm.		117.5 (4.62")		117.5 (4.62")	
Base Type		E40		E40	
Nominal Light Center Length mm.		178 (7")		178 (7")	
Maximum Overall Length mm.		292 (11.5")		292 (11.5")	
Nominal Arc Length mm.		38 (1.5")		38 (1.5")	
Maximum Bulb Temp. °C (F)		400° (752°F)		400° (752°F)	
Maximum Base Temp. °C (F)		210° (410°F)		210° (410°F)	
ELECTRICAL CHARACTERISTICS					
Nominal Lamp Watts		400		400	
Nominal Lamp Volts		133		133	
Nominal Lamp Amps.		3.2		3.2	
Min. RMS for Lamp Stability		250		250	
Min. start volt, lead peaked ballast	RMS	Peak		RMS	Peak
at -30° C (Crest Factor 1.8).	295	530		295	530
PHOTOMETRIC CHARACTERISTICS					
Initial Lumens	40000	37000	40000	38000	
Mean Lumens (40% Rated Life)	31000	31000	28000	30500	28500
Avg. Rated Life (10 Hrs./St.)		20000		20000	
CIE Correlated Color Temp.	3500K	3500K	3200K	3800K	3600K
Colour Rendering Index (CRI)	70	70		65	70
Warm up Time (minutes)		2-4		2-4	
Hot Restart Time (minutes)		7-12		10	
CIE Chromaticity X-	.410	.410	.425	.390	.400
Coordinates Y-	.380	.380	.410	.385	.390
Lumen Maintenance/		3		3	
Mortality Curves		6		6	

Metalarc Safeline "MPT" lamps are self-extinguishing should the envelope be damaged. These lamps are ideal for auditoriums, stadiums, gyms and similar installations.

400 Watt



	METALARC	SUPER METALARC	
	Coated 3K "MP"	Coated	Coated 3K
Sylvania Item Number	20332	20606	20602
ANSI Spec. Number	M59	M59	
Ordering Abbreviation	MP400/3K/BU	MS400/C/HOR	MS400/3K/HOR
PHYSICAL CHARACTERISTICS			
Burning Position	Base Up Only(± 15°)	Horizontal (± 15°)	
Bulb Designation	BT-37	BT-37	
Nominal Bulb Diameter mm.	117.5 (4.62")	117.5 (4.62")	
Base Type	E40	Position Oriented E40	
Nominal Light Center Length mm.	178 (7")	178 (7")	
Maximum Overall Length mm.	292 (11.5")	292 (11.5")	
Nominal Arc Length mm.	38 (1.5")	38 (1.5")	
Maximum Bulb Temp. °C (F)	400° (752°F)	400° (752°F)	
Maximum Base Temp. °C (F)	210° (410°F)	210° (410°F)	
ELECTRICAL CHARACTERISTICS			
Nominal Lamp Watts	400	400	
Nominal Lamp Volts	133	130	
Nominal Lamp Amps.	3.2	3.4	
Min. RMS for Lamp Stability	250	250	
Min. start volt., lead peaked ballast	RMS	RMS	Peak
at -30° C (Crest Factor 1.8).	295	295	530
PHOTOMETRIC CHARACTERISTICS			
Initial Lumens	35000	40000	36000
Mean Lumens (40% Rated Life)	26500	31000	27000
Avg. Rated Life (10 Hrs./St.)	20000	20000	
CIE Correlated Color Temp.	3200K	3800K	3200K
Colour Rendering Index (CRI)	70	70	
Warm up Time (minutes)	2-4	2-4	
Hot Restart Time (minutes)	10	7-12	
CIE Chromaticity X-	.425	.385	.425
Coordinates Y-	.410	.368	.410
Lumen Maintenance/	3	3	
Mortality Curves	6	6	

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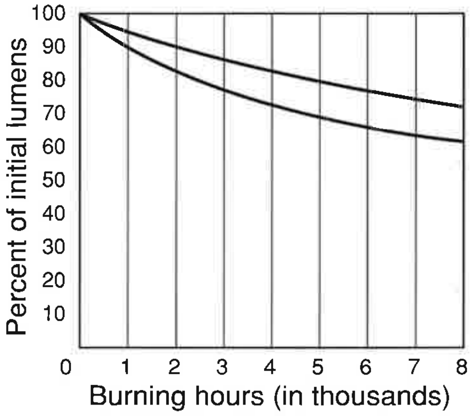
Typical Lumen Maintenance

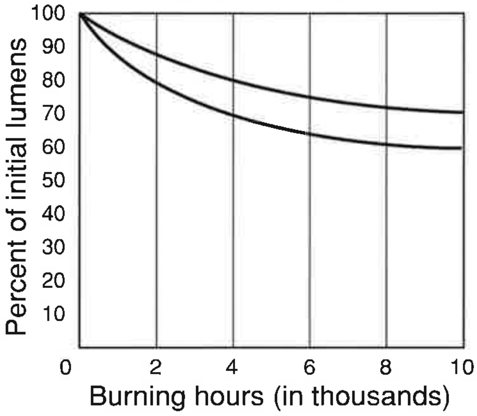
7,500 hour lamps

NR 1



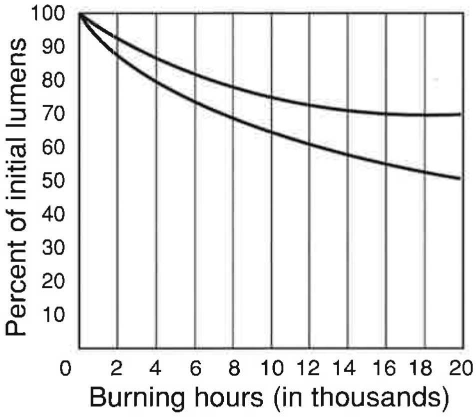
10,000 hour lamps

NR 2



20,000 hour lamps

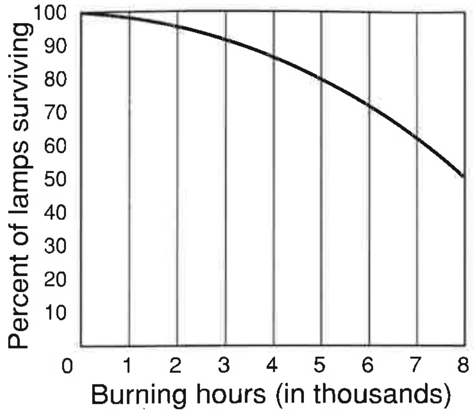
NR 3



Typical Lamp Survival Curves

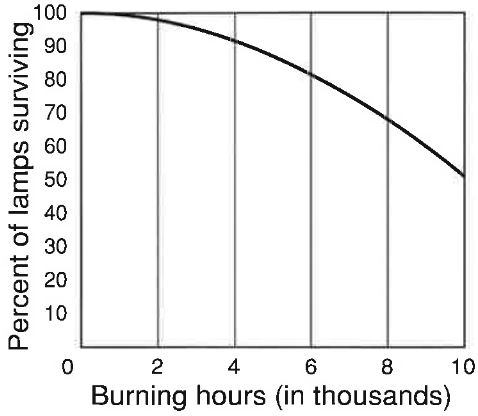
7,500 hour lamps

NR 4



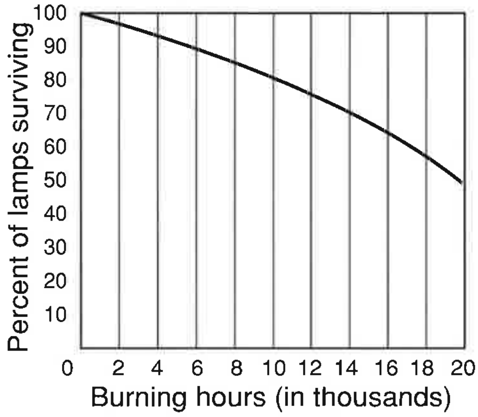
10,000 hour lamps

NR 5



20,000 hour lamps

NR 6



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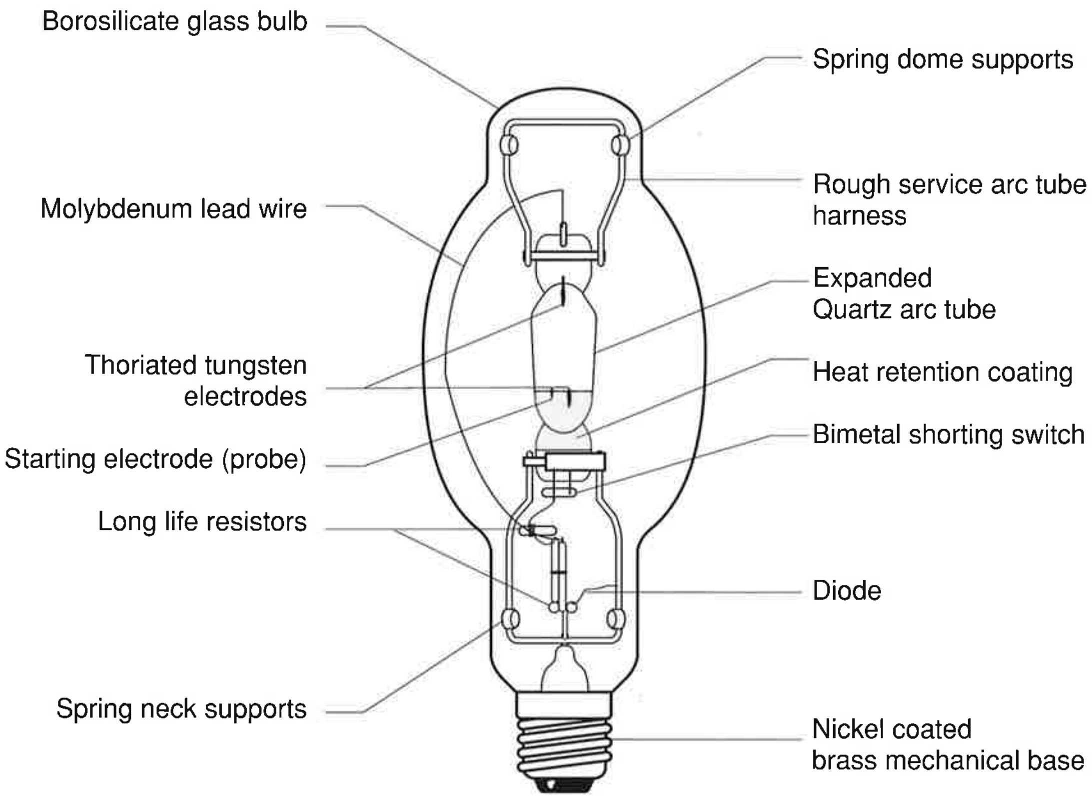
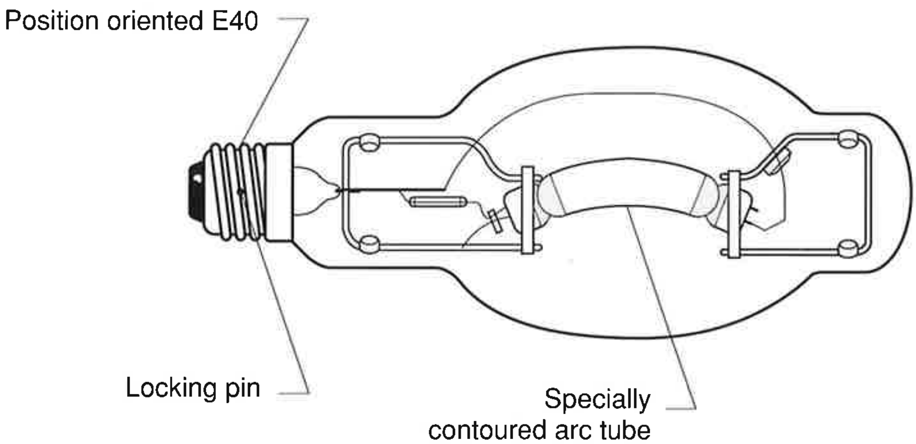
Lamp Construction

METALARC Lamp for Vertical Operation



METALARC Lamp for Horizontal Operation



General Construction, Features and Benefits

All METALARC lamps are made with hard glass outer jackets to resist against thermal shock and with corrosion resistant nickel plated E40 bases to enable easy removal from the socket at the end of life. METALARC lamps feature auxiliary arc tube electrodes which enable the lamps to soft start without the need of a high voltage ignitor. The lamp is designed for operation on a particular form of control gear known as a constant wattage autotransformer circuit. This circuit is later described in detail but the main point to retain at this stage is that this circuit regulates the lamp much more closely than a conventional choke and so provides a close control of the lamp wattage and colour during operation.

Arc Tube Technology

METALARC lamps are equipped with arc tubes which comply with 3 important criteria in arc tube design to obtain a high performance light source:

a. Uniform temperature distribution on the arc tube. This is important for obtaining an excellent control on the partial pressures of the halides in the arc tube atmosphere, and consequently colour stability. Special arc tube shapes, particularly for horizontal and vertical burning positions achieve this, as shown on page ...

b. Controlled convection currents in the arc tube. This is important to avoid halide segregation and colour structures in the discharge, which in conjunction with the luminaire reflector would create disturbing colour patterns on the illuminated area. The special arc tube shapes of METALARC lamps avoid such effects.

c. Optimised discharge form for high light output and arc stability.
In horizontal operating mode the discharge will trend to bow upwards due to the convection currents and uneven temperature distribution in a linear arc tube. - The specially bowed arc tubes of METALARC lamps are adapted to the natural discharge shape, resulting in higher light output and a better electrode load (axial with the discharge) for long lamp life.

In vertical operating mode the shape of the arc tube should assure a wall stabilisation of the discharge, controlled convection currents and uniform temperature distribution, all for stable discharge and light colour conditions. The specially expanded arc tube shape of METALARC lamps provide these.

Arc Tube Chemistry

METALARC lamps are manufactured using Sodium Scandium (Na-Sc) chemistry.
In comparison with other multicomponent systems the Na-Sc is, as a two component system, more reliably reproducible in manufacturing and consequently gives reliable performance in the installation in terms of colour when combined with CWA ballasting. The Na-Sc material is dispensed into the arc tube in the form of iodide salts which are "friendly" towards the metals used in the electrodes so ensuring long life.

Lamp Technology

There are two factors which will influence the lamp performance.

a. METALARC lamps feature a frameless mount construction to minimise sodium loss from the arc tube due to sodium ions diffusion through the quartz glass.
This assures light colour stability over long operating hours.

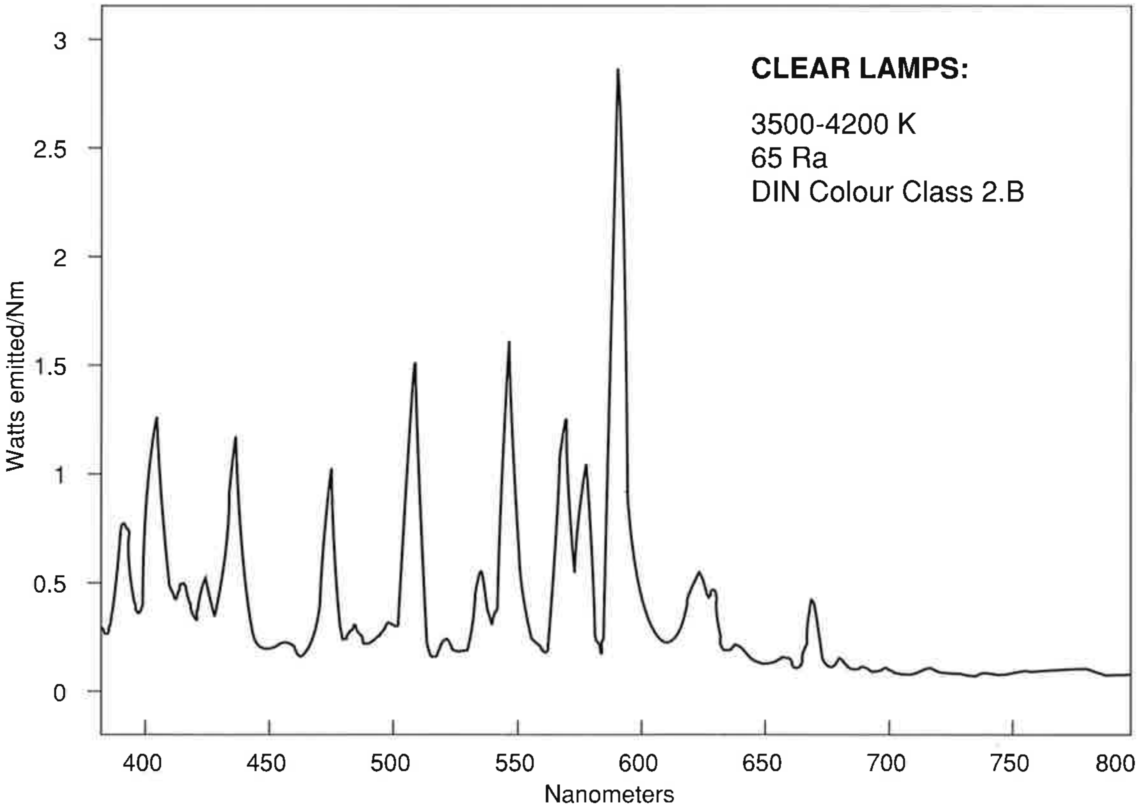
b. METALARC lamps are equipped with powerful hydrogen getters to avoid hydrogen diffusion into the arc tube.
This assures that the starting properties of the lamps are maintained over lamp life.

The BT shaped bulb of METALARC lamps helps in both cases to create ideal solutions.

METALARC Light Colours, and Efficiency

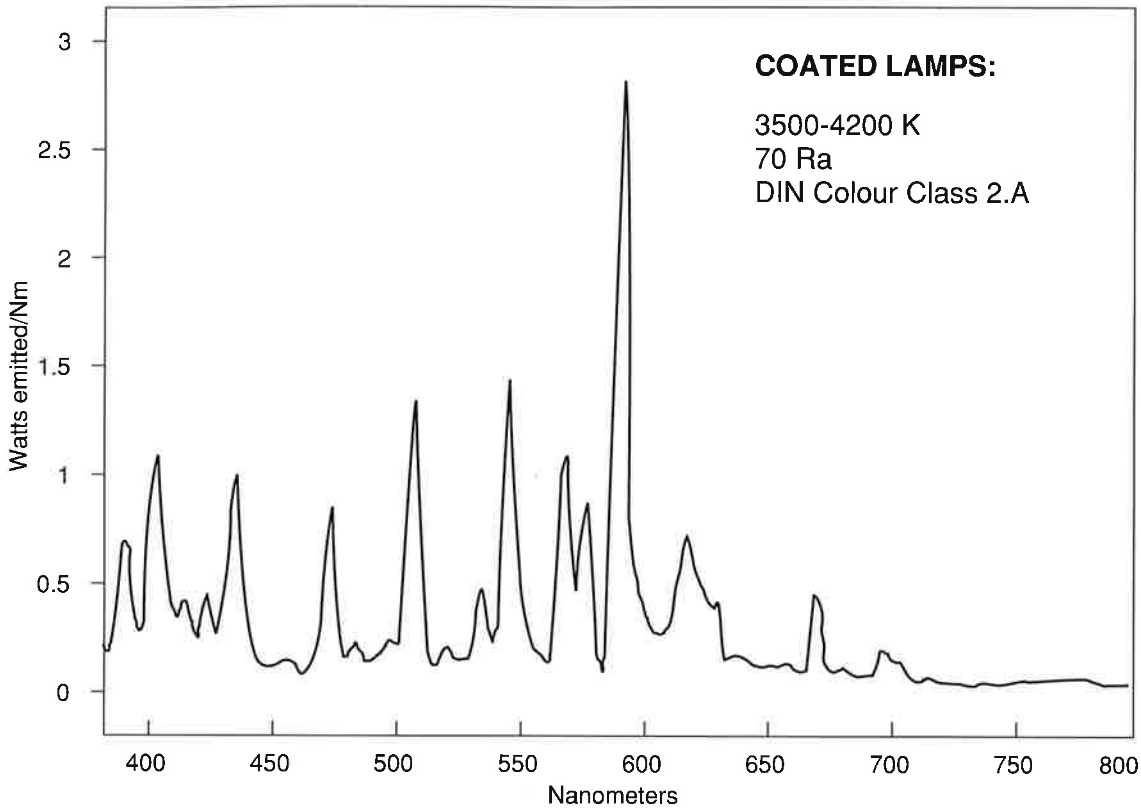
As indicated in the data section, METALARC lamps are available in three executions regarding the bulb finish. Typical spectral power distribution curves are presented in the following.

While the choice of the light colour may be imposed by the application, it should be considered that clear lamps with an adequate reflector are optically more efficient and lead to higher luminous efficiency of the luminaire.

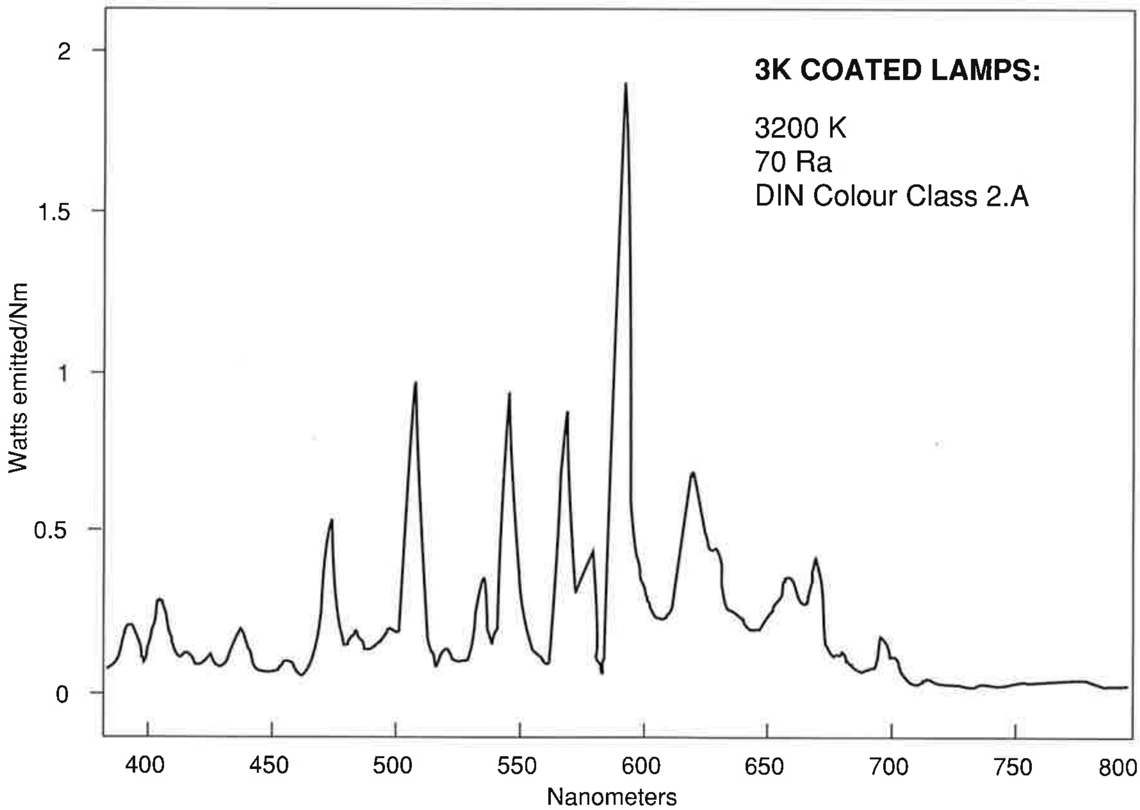


MS400/Clear

SYLVANIA



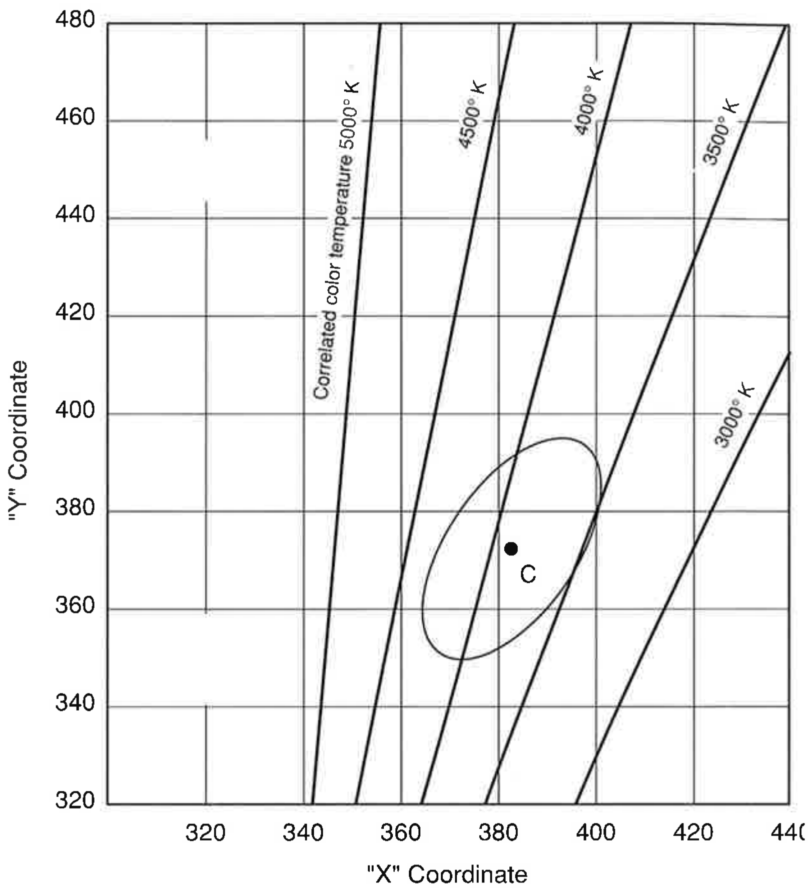
MS400/Coated



MS400/3K

Colour Uniformity

Typical Chromaticity Diagram



The specification of light colour appearance for each type of METALARC lamps is given in the data section by X-Y coordinates which are related to the CIE chromaticity diagram (page 13). An example of such a specification is given in this diagram.

Each lamp type carries a set of coordinates plus a tolerance area surrounding it. The size of this oval is set under reference conditions to define the limits at which colour difference is visually detectable for lamps which are in diametrically opposed on the oval boundary. These are known as 10 mpcd (mean perceptible colour difference) ovals. Sylvania aims for plus/minus 5 mpcd ovals.

It is important to note that variation from reference conditions, almost unavoidable in a practical installation, can still lead to lamp to lamp differences which users may find objectionable. There are a number of steps to be taken should an installation give rise to complaint. It is worth noting that lamps take 100 hours to stabilise initially. Do not make any critical evaluation before this lapse of time. They are:

1. Check the line voltage is within prescribed limits compared with the rated input voltage and that the correct tapping is in use.

2. Check that the capacitor is within 5% of its rated value.

3. Check the bulb wall temperature to ensure that return thermal radiation from fixture reflector is not overheating the lamp.

4. Ensure that the lamps are switched off at least once per week for at least 15 minutes.

5. Ensure that the lamp used is burning within the specified position limits.
   Should these checks not improve the situation then consider tuning the installation by switching lamps around so that similar colour aspect lamps become "neighbours".

Note particularly that lamps of widely differing production dates will rarely be closely similar in colour and that only lamps of the same date code should be installed together. Furthermore, spot replacing lamps in an installation approaching the end of the lamps' service life will usually lead to colour-matching problems. Replace lamps as a batch at the end of their economic life.

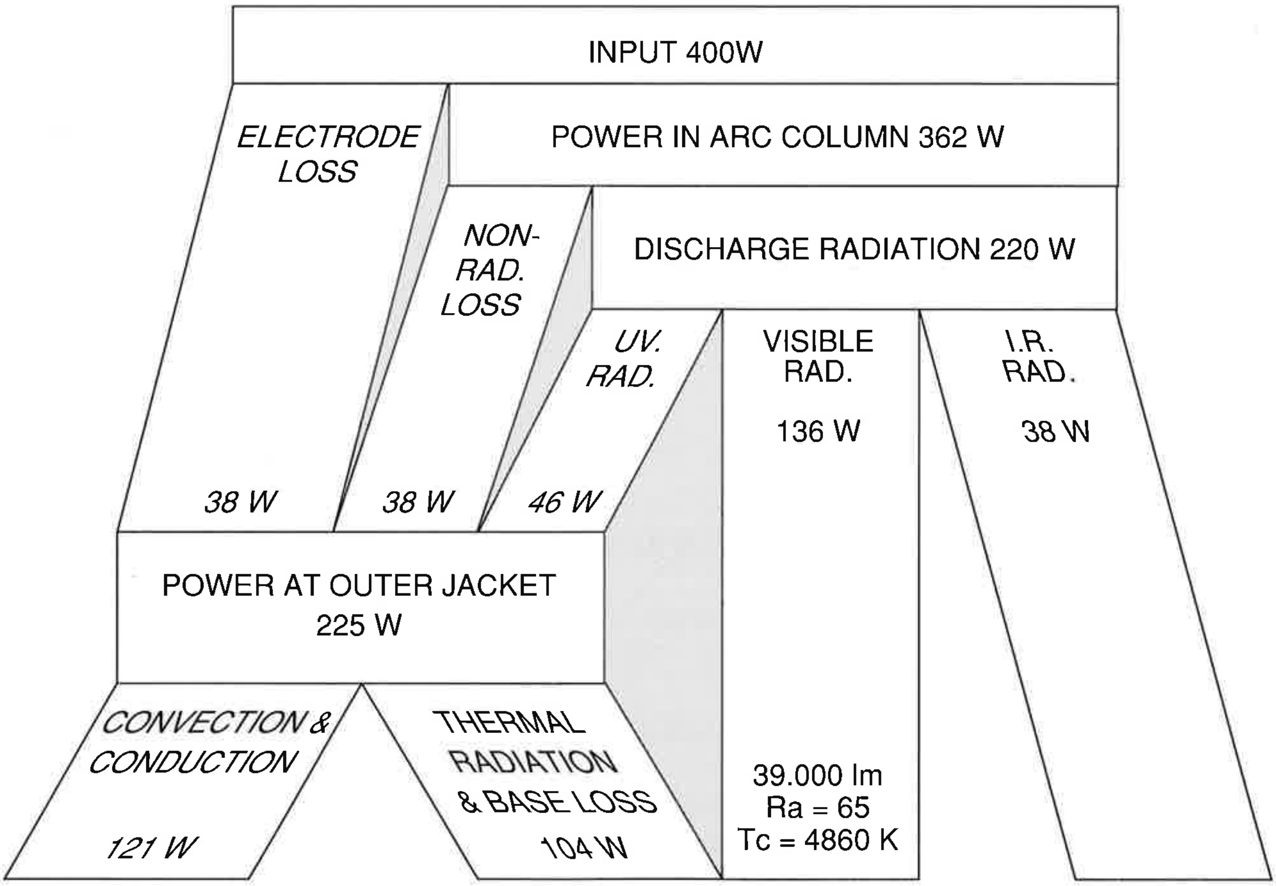
Power Household of METALARC Lamps

The following diagram shows how the input power is converted by a 400W METALARC lamp, data which may be considered for luminaire design. There are two additional considerations:

a. Coated lamps will convert most part of the UV radiation into visible radiation.

b. For the thermal household of the luminaire it must be considered that part of the visible radiation (power) will be absorbed in the luminaire and converted into heat.

MS 400W/Clear



Radiation Analysis

The radiation from the bulb of a 400W METALARC lamp (convection and conduction excluded) can be analysed as follows: (typical values)

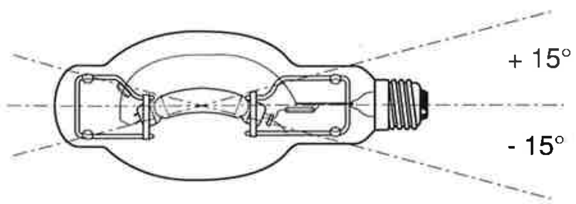
Wavelength (nm)	**Clear Lamp**	**Coated Lamp**
	Percent of Lamp Wattage	
250-315*	0.11	0.02
315-400	4.8	3.6
400-700	34	35
700-	30	30
Total Radiation	**68.9**	**68.6**

* almost exclusively UVB radiation of 280-315 nm.

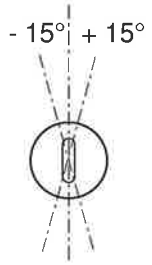
Operating Positions

METALARC Lamps for Horizontal Operation (HOR)

Due to their particular arc tube design two limitations must be respected to obtain the full performance benefits.



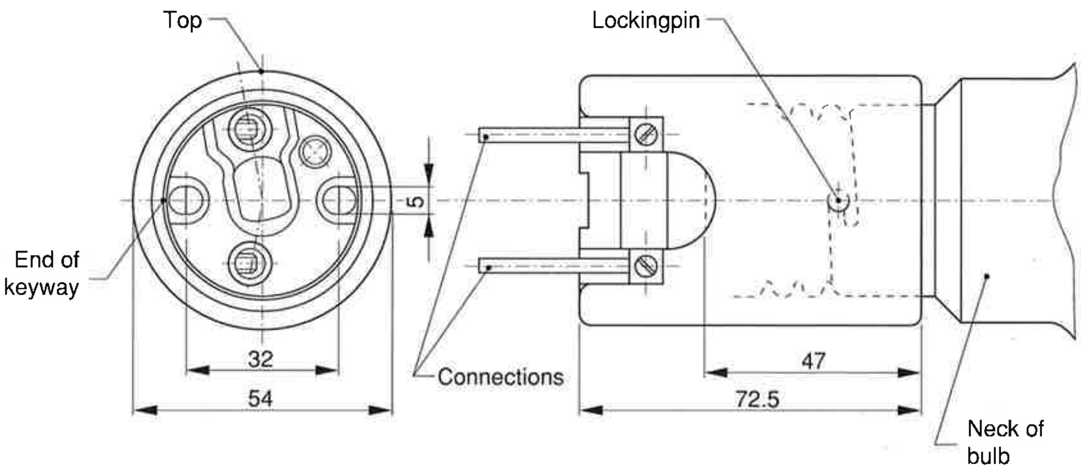
Lamp Axis



Lamp Rotation

These METALARC lamps are equipped with a position oriented base, E40 POS. A pin on the side of the base and a cut-out on the lamp holder bring the lamp automatically into the right position when inserted into the luminaire.

The correct socket-lampholder is manufactured by Metalluk GmbH Bamberg, Germany, under the reference 10.991.40003 and can also be obtained from Sylvania.



METALARC Lamps for Vertical Operation (BU, BD)

The tolerance is ± 15° from the vertical BU ... Base Up or BD ... Base Down position, to obtain the nominal lamp performance.

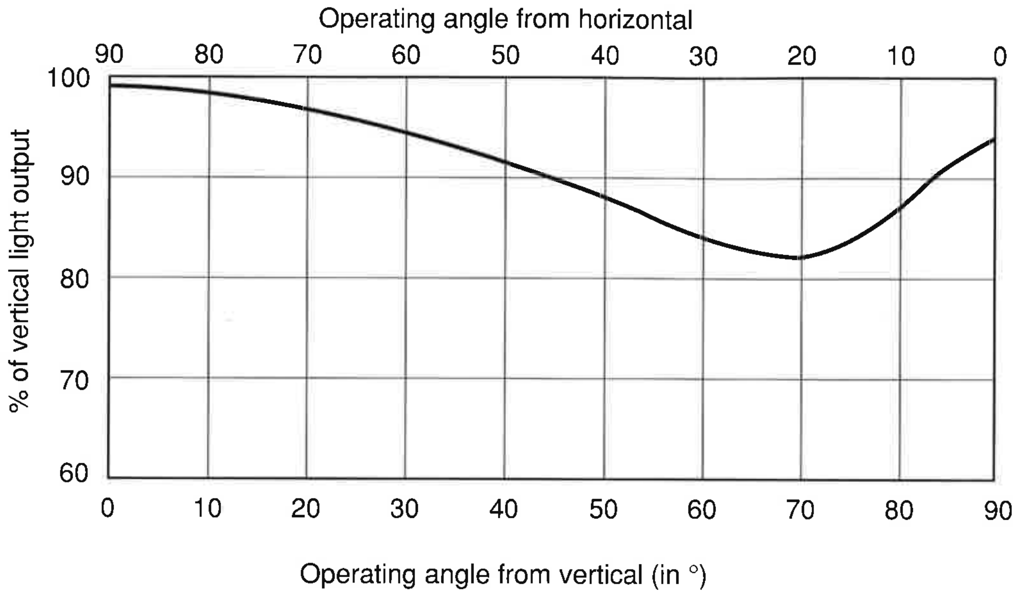
METALARC Lamps for Universal Operation Mode (U)

There are several types permitted for universal operating position. In general, these lamps perform best in vertical operating mode, with reduced light output and lamp life in horizontal mode.

For best performance, lamps for a dedicated operating position should be given preference.

Influence of Operating Position on Light Output (Tilt Factor)

The following diagram shows the relative light output of a nominal vertically operating or horizontally operating lamp.



METALARC Lamps- Typical Lumen Output Characteristics.

Symptoms for Lamps Operating Out-of Tolerance

Several symptoms can be observed.

a) Reduced light output
b) Wrong colour temperature
c) Unstable discharge
d) Non or slow starting
e) Long run-up time
f) Short life
g) In extreme cases, violent end-of life arc tube rupture

Operation

Lamp Starting

The open circuit voltage (OCV) from the CWA will cause a glow discharge at one end of the arc tube between the starting electrode and main working electrode. The resulting local ionisation will then be sufficient, together with the OCV to establish the initial discharge between the working electrodes in the argon and low pressure mercury atmosphere.

Run-Up Conditions

More mercury will evaporate because of the raising arc tube temperature and beyond 400°C the metal halides will start evaporating. Stable conditions are reached in 3-4 minutes, with an arc tube temperature of about 800°C.

All mercury is then evaporated with its main function in the discharge to determine the electrical properties of the arc tube (lamp voltage, current and power).

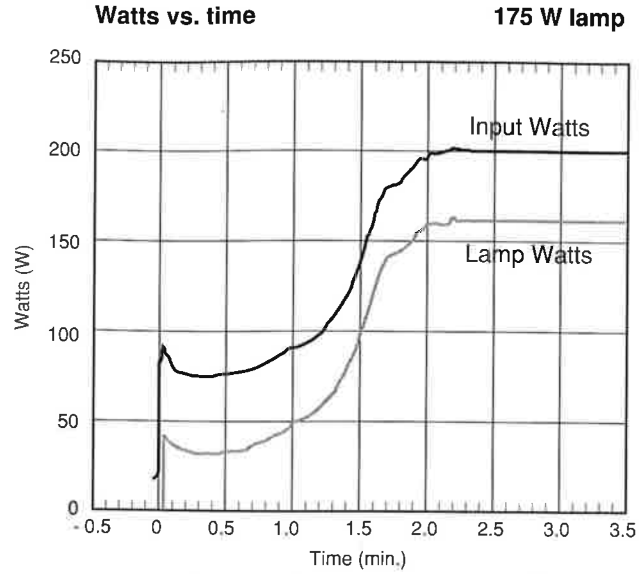
The metal halides (sodium iodide and scandium iodide) have reached their partial pressures according to the temperature and pressure conditions in the arc tube.

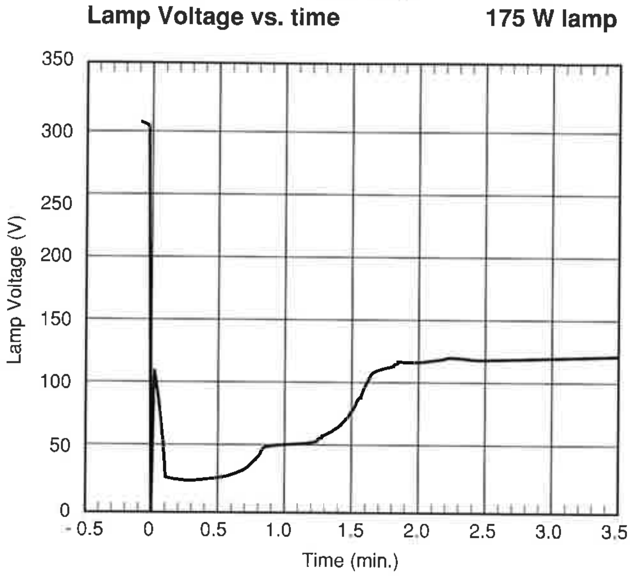
Starting Electrode Deactivation

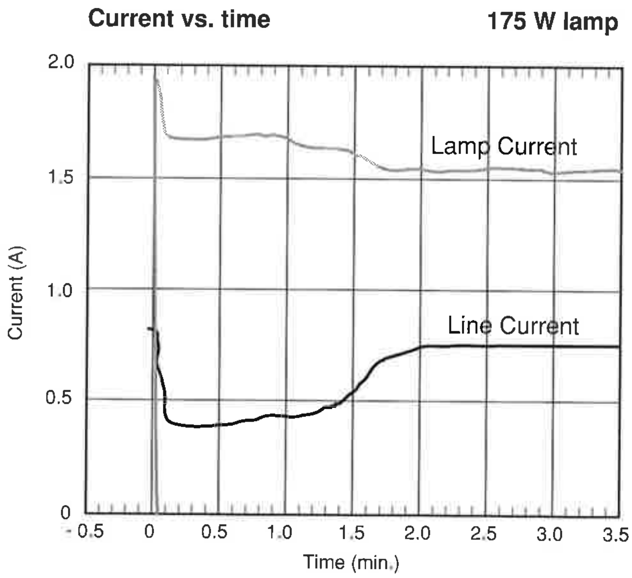
A bimetal will short-circuit the electrical potential between the starting and main working electrode once the arc tube has reached its stable working temperature.

Electrical Run-Up Conditions

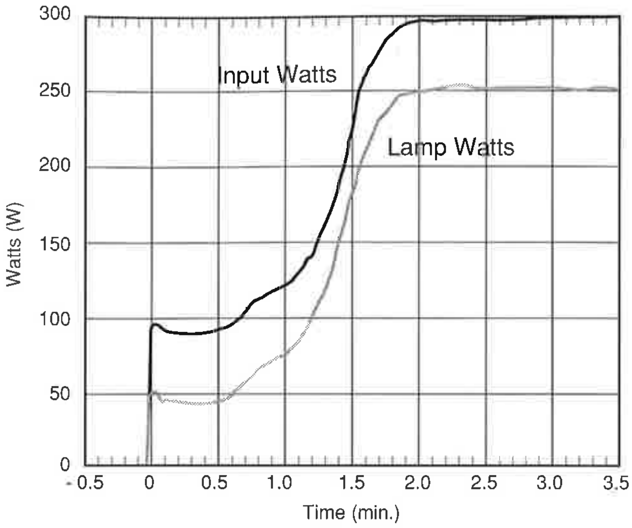
The following diagrams reflect typical electrical data during the run-up period on a commercial control gear (CWA) and at rated input voltage.



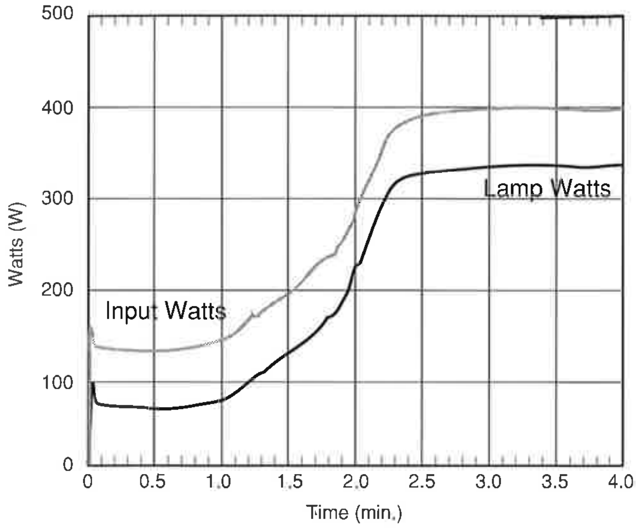




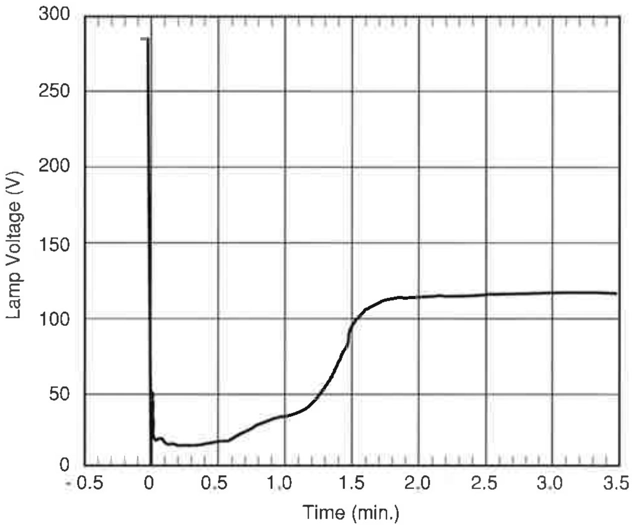
Watts vs. time **250 W lamp**



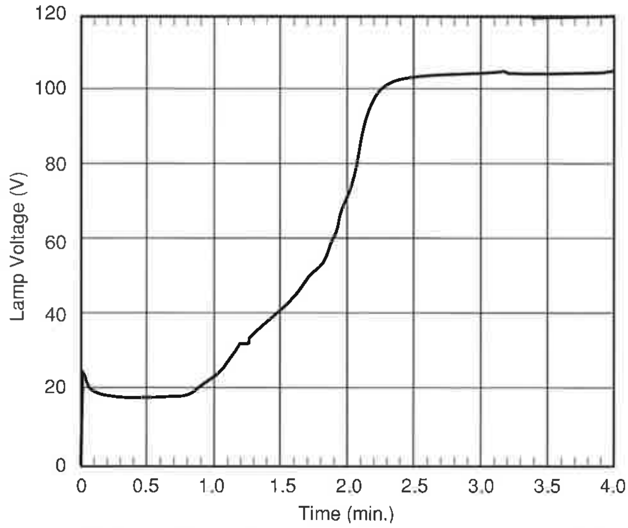
Watts vs. time **400 W lamp**



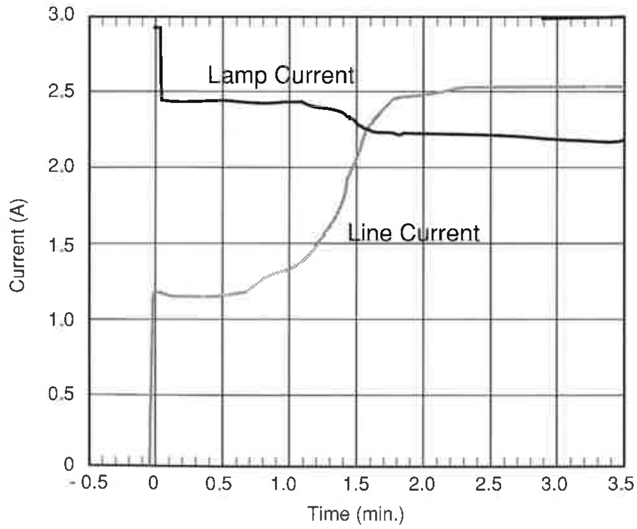
Lamp Voltage vs. time **250 W lamp**



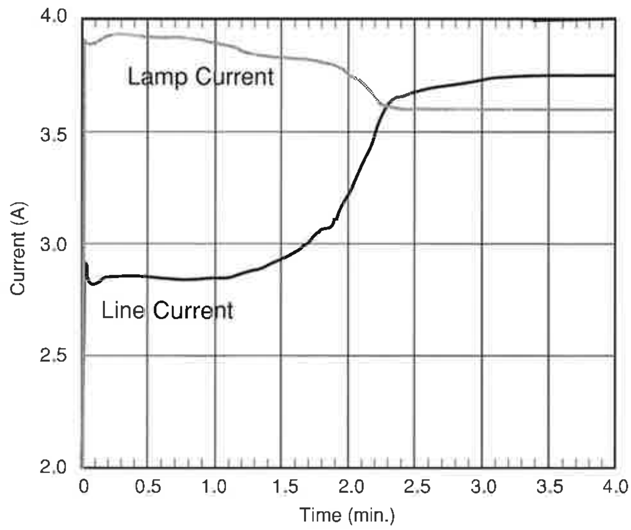
Lamp Voltage vs. time **400 W lamp**



Current vs. time **250 W lamp**



Current vs. time **400 W lamp**



Circuit Fusing

Compared to other circuits for discharge lamps we can take from the diagrams that the start-up line currents are rather low.

A general recommendation for slow acting fuses is as follows:

METALARC Lamp	175W ...	4A
	250W ...	10A
	400W ...	15A

Dimming

The lamps can be dimmed using specialised electronic equipment. Present experience shows, however, that the colour performance of the lamp will be substantially changed. As a general rule therefore dimming is not advised.

Lamp Circuit Testing (see also Trouble shooting)

Any investigation of electrical parameters must be performed by a qualified person aware of the hazards of electrocution.
Only a limited number of tests can be performed in situ in the installation such as checking the input line voltage. Also ballast output can be checked using the 1000 volt AC voltage setting of a multi-meter to see if the starting voltage available at the lamp socket is sufficient. Otherwise for safety and efficiency reasons the fixture and lamp should be removed to a bench test area.

A Multi meter of the True RMS type suitable for voltages up to 1000V and 10 amperes (with current clamp) plus an Ohmmeter-Continuity Tester will be found most useful. Gas Discharge lamps cannot be fault diagnosed by continuity testing by using an ohmmeter but can be checked for outer jacket vacuum integrity and internal weld failure using a high tension spark coil (Tesla coil).
Since static voltages of up to 55kV are used, this is best left to a specialist. In the case of a lamp that will not start or run satisfactorily preferably change it and consult the local Sylvania office.

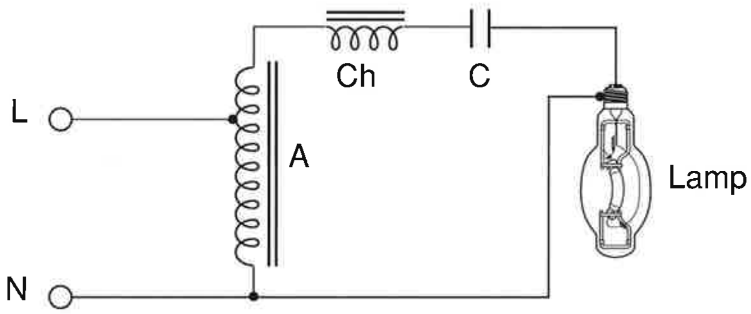
Generally speaking the ballast can be tested for electrical continuity of both the primary and secondary (but not connected to the mains). An Open Circuit Voltage (OCV) test can be performed by connecting the Voltage probe of the 1000V AC test connection to the lamp socket with the mains live. Note that the instrument will show only the RMS value which should not be less than 295V. Peak values can best be read with an oscilloscope. During the same test the lampholder should be checked for a short circuit particularly if no OCV is observed and the ballast surface temperature exceeds 90 degrees celsius.

The current flow in the lamp leads can be measured and should be within plus/minus 10% of the nominal value. If there is a substantial difference then the line voltage compatibility and the capacitor should be checked.

Only a limited amount of capacitor testing can be done with a multimeter. To establish the exact capacitance value either a bridge test will be required or better, use a commercial capacitance tester. The multimeter should be set on the highest ohm scale and connected to the capacitor which has been isolated from the circuit. A low resistance rising steadily indicates the capacitor is functional. If there is no increase in resistance the capacitor is in short circuit. If a high resistance is immediately observed, the capacitor is open circuit and in both these latter cases must be replaced.

Description of The Constant Wattage Auto Transformer (CWA)

METALARC lamps are operated on lead-peaked constant wattage autotransformers (CWA), which consist of following components:



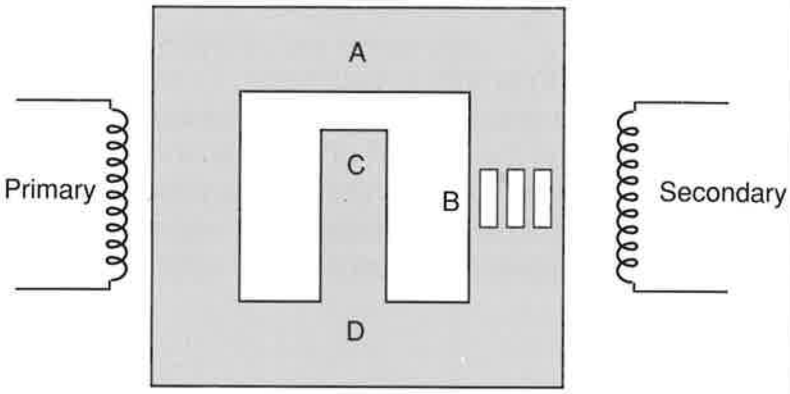
- A Autotransformer, provides the required open circuit voltage. Usually combined in one unit with
- Ch Choke, regulates the lamp current
- Ca Capacitor, provides the reignition voltage after each half cycle

The CWA is a final design stage resulting from the line voltage (and frequency) conditions in the USA and the lamp development with self starting feature, without external high voltage ignitors.

Originally lag type autotransformers were used, but such units were large in size to produce the required high peak OCV with a sinusoidal wave shape.

The use of a series capacitor between the inductive part and the lamp, combined with a splined secondary iron core on the autotransformer permitted to make the inductive part considerably smaller, lighter and less costly.

The Autotransformer

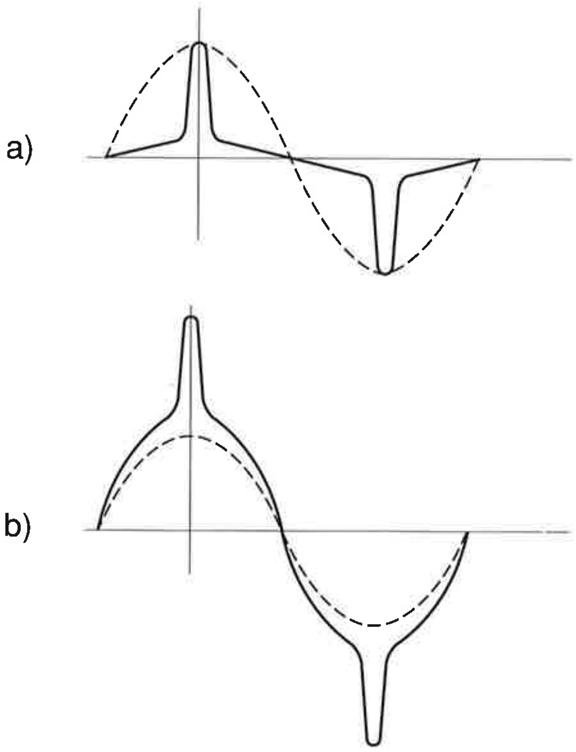


A-C Air Gap
B Splines
C Shunt
D Core

Keeping in mind the objectives to design a unit of small size and low losses, the major consideration is to provide to the circuit the required OCV by

- peak voltage
- RMS voltage
- crest factor

See lamp data section.



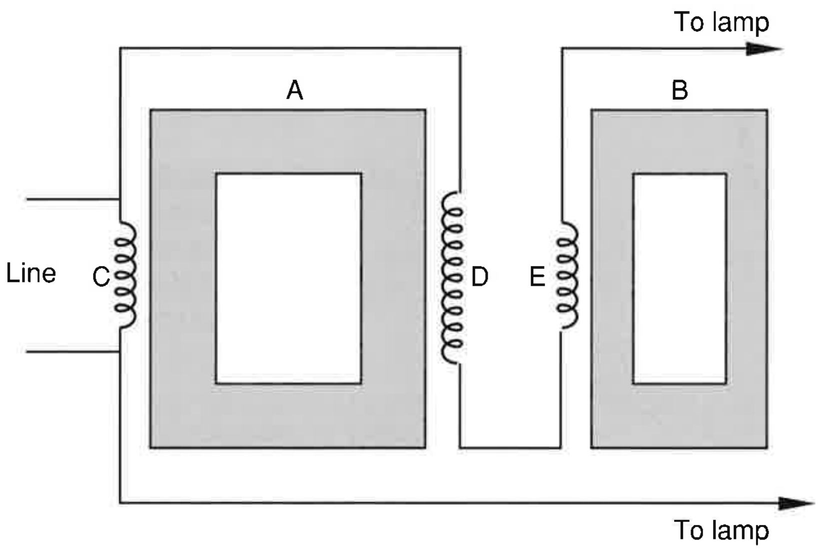
a) Waveform of secondary voltage (solid line). Dotted line shows wave form that would have been obtained if core cross section had been uniform all the way around the magnetic circuit.
b) Sum of primary and secondary voltages (autotransformer output voltage). Dotted line is same as in a)

The voltage peak is obtained by producing the secondary side of the autotransformer with a splined gap as shown in the upper diagram. This permits to obtain the OCV peak voltage which is required for safe starting of the lamp also at low temperatures without the requirement to provide such a voltage in sinusoidal form, as shown in the lower diagrams (a) and (b).

The Choke

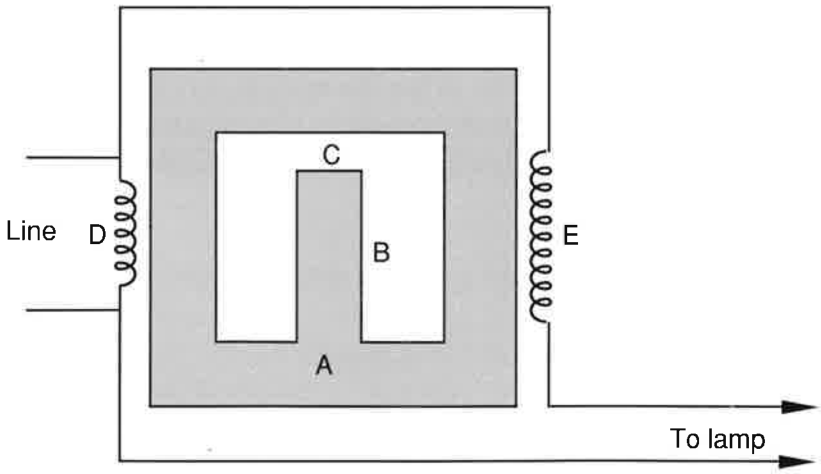
The inductance is chosen to provide the lamp with the specified lamp current and is usually integrated with the autotransformer part. The following diagrams show two solutions for this purpose.

a) "Stiff" autotransformer plus external inductance



A Transformer core
B Inductor core
C Transformer primary
D Transformer secondary
E Inductor winding

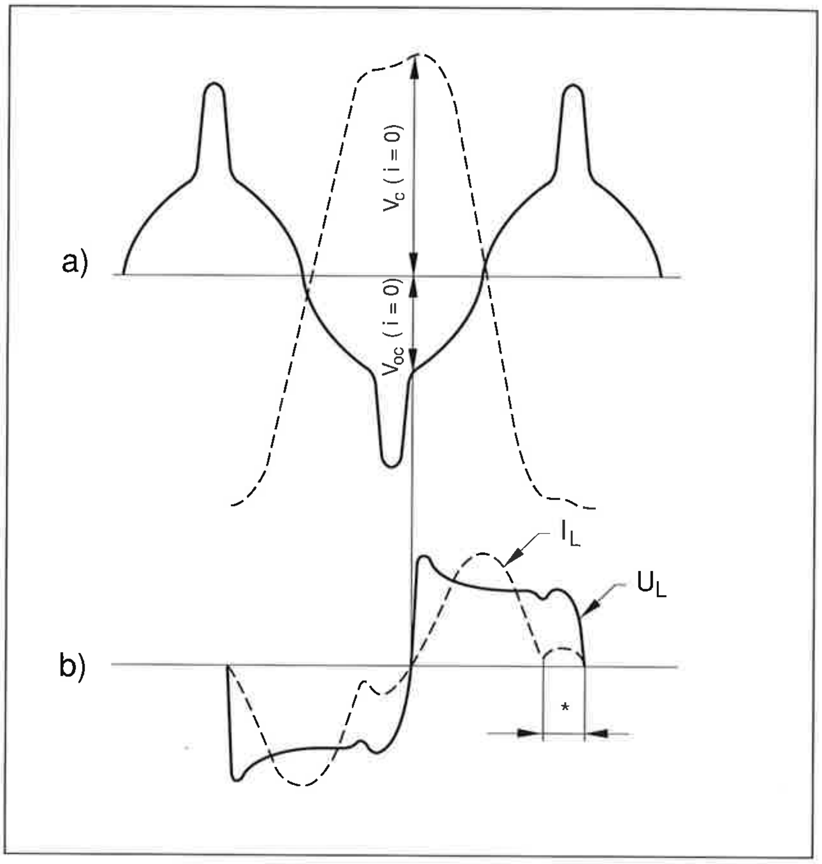
b) Leakage reactance autotransformer having the same characteristics as the combination in a) except substantially smaller total weight and cost



A Core
B Shunt
C Air gap
D Transformer primary
E Transformer secondary

The Capacitor

The series capacitor between the choke and the lamp plays an important role for providing the reignition voltage after each half cycle, as shown in the following diagrams. Diagram (a) shows the OCV and capacitor voltage, diagram (b) the lamp current and lamp voltage.



A careful match of the capacitance, OCV and inductance is important for two reasons:

- availability of a sufficient reignition voltage
- to achieve a current wave form with a definite current reversal to the next half wave and a short low current (off-time) period (*) between half cycles.

It is for these reasons that we recommend that complete control gear with matched capacitors are utilised, supplied and specified by the control gear manufacturer.

Capacitors for CWA Operation

Due to the before mentioned criteria, the importance of the stability and tolerance of capacitance, but also because of particular circuit conditions during lamp starting and stabilisation, only selected types of capacitors are suitable for operation in a CWA circuit. See capacitor listing.

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Lamp Operation on CWA Control Gear

For a complete understanding of the interaction of METALARC lamps and their control gear we refer to the literature ELECTRIC DISCHARGE LAMPS by John F. Waymouth, The M.i.T. Press, Cambridge, Mass., USA

Lamp Starting, Glow to Arc Transition

When line voltage is applied to the circuit the OCV will cause the initial break-down of the low pressure argon and mercury vapour atmosphere in the arc tube. We can now observe a glow stage which is characterised by a high voltage drop in the immediate surrounding of the electrode (high cathode fall). In this situation

- the current is mainly carried by positive ions
- the energy of the ions which return to the electrodes is converted into heat, which brings the electrodes to operating temperature and thermionic electron emission (low cathode fall)
- the high energy ion bombardment of the electrodes knocks away tungsten atoms (sputtering) which erodes the electrodes.

The design of the control gear should provide sufficient voltage to the lamp (the RMS value is more important than the peak value for this purpose) at sufficiently high current to obtain a fast transition from the glow stage to stable arc conditions - Lamp (electrode) life depends on this performance.

Control Gear to Lamp Distance

Since the starting system of METALARC lamps does not involve high frequency pulses of several thousand volts it is possible to operate lamps at considerable distances from the ballast. The cross section of the cable connecting lamp and ballast should not only be chosen for its current carrying capacity but also for least voltage drop at the lampholder. Generally the lamp may be operated AT 20 METRES distance from the ballast.

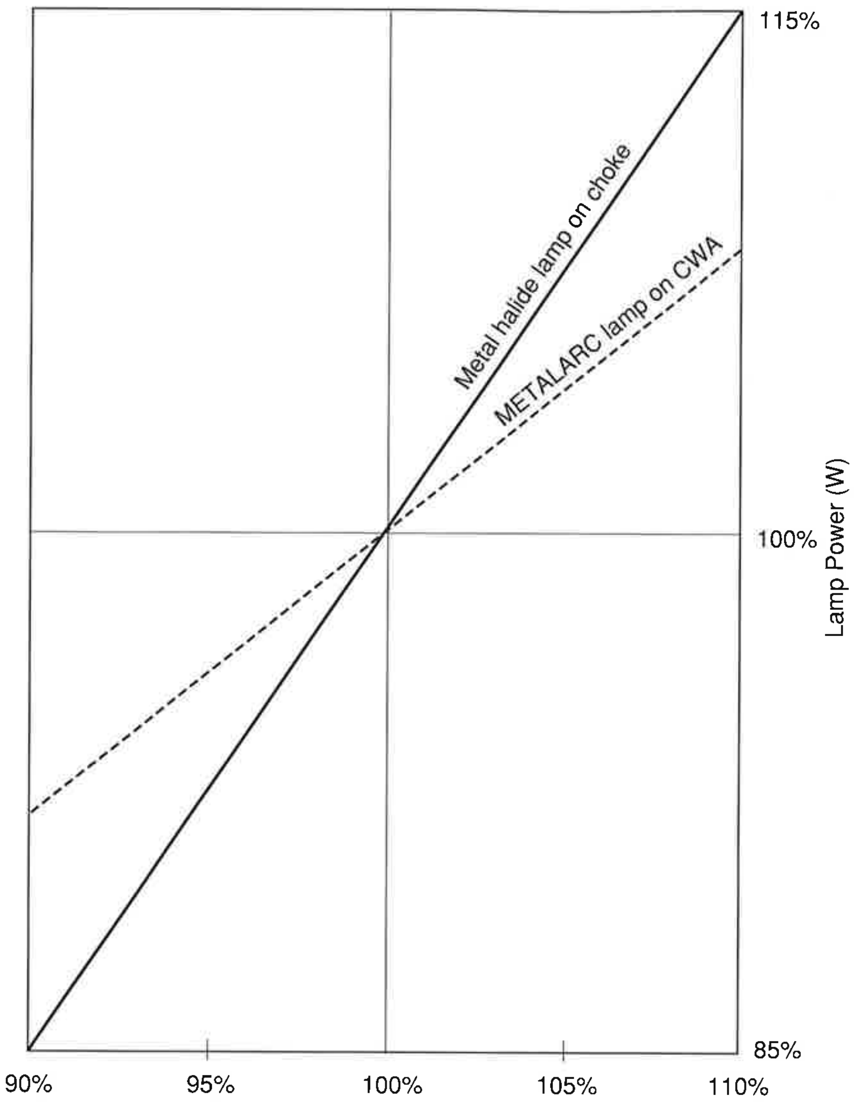
Performance Variation with Varying Line Voltage

CWA control gear should be designed to operate the lamp stably between ± 10% of rated line voltage.

One advantage of the CWA is a linear and low change of lamp current (wattage) with line voltage variation. Typical values are 8-10% lamp data change with 10% line change. See diagram.

The design of the magnetic part of the CWA will influence this in the way that higher RMS values of the OCV result in lower changes for the lamp.

A CWA system also provides better conditions for the lamp in case of sudden line voltage dips.



Performance variation with varying line voltage

Possible Problems on Phase to Phase Systems

CWA ballasts are for phase to neutral connection. Line harmonics, resulting from the higher current crest factor and principally the third, can be generated and will pass in to the neutral conductor. For this reason the neutral conductor in a balanced three phase system, must be of equal size to the phase conductor. Cross phase connection at 380/440 Volts RMS will possibly provide near correct OCV peak and sustaining voltages but the inductor-series capacitor network is likely to generate resonances leading to instability and lamp extinction.

General Advantages - Disadvantages Of The CWA System

Advantages

- Power factor correction
  Better than Cos $\varphi = 0.9$
- Lamp current/wattage regulation
- Lower line current regulation
- Long distances CWA to lamp
- Lamp stability for line voltage dips
- Longer lamp life
- Stable lamp colour

Disadvantages

- Size, weight (cost)
- Higher losses than a choke

Fixture Design Aspects

METALARC lamps require very careful consideration regarding the thermal and mechanical design aspects of the fixture.

There are several key points:

1. Observing the lamp base and bulb wall temperature
2. Separating the lamp compartment from the ballast compartment
3. Observing capacitor and ballast surface temperature limits bearing in mind the expected local ambient temperature of the installation
4. Designing the reflector to minimise infrared back radiation to the arc tube and lamp incremental voltage rise
5. The requirement for lamp enclosure (except MP types)

Energy Household, Lamps and Control Gear

The example of the power household is given on page17 for a clear 400W METALARC lamp. For the total thermal household of the luminaire, the losses of the control gear have to be added. Depending on the supplier of the gear following values may be considered.

Lamp Wattage	175W	250W	400W
Control Gear Losses	30-35W	35-40W	50-65W

For a safe assumption the entire lamp power plus 10% should be taken into consideration to design for heat dissipation.

Lamp Wall and Base Temperature.

The lamp must not exceed 210 celsius measured at the principal solder button of the E40 base. The lamp holder mounting must offer sufficient heat sinking capability to assure that this limit temperature is not exceeded at line voltage plus 10% and 25 degrees ambient temperature.

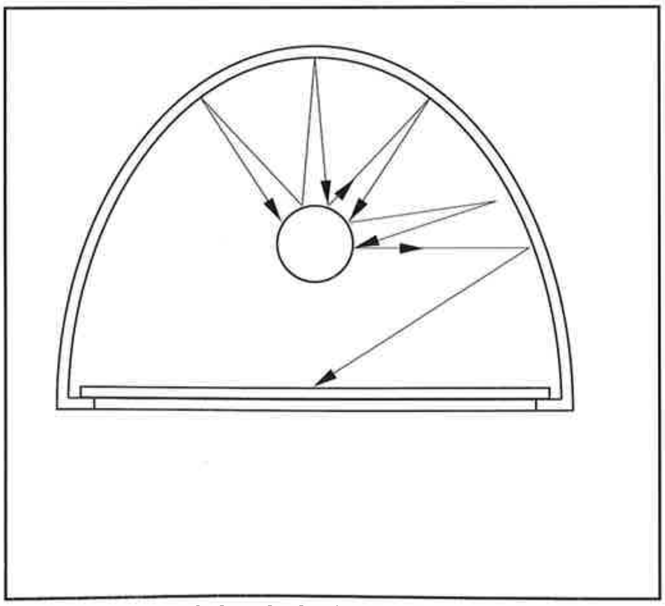
The lamp wall temperature must not exceed 350 degrees celsius.
Otherwise the lamp voltage will rise and colour shift, cycling and short life will occur.

Ballast Compartment Design

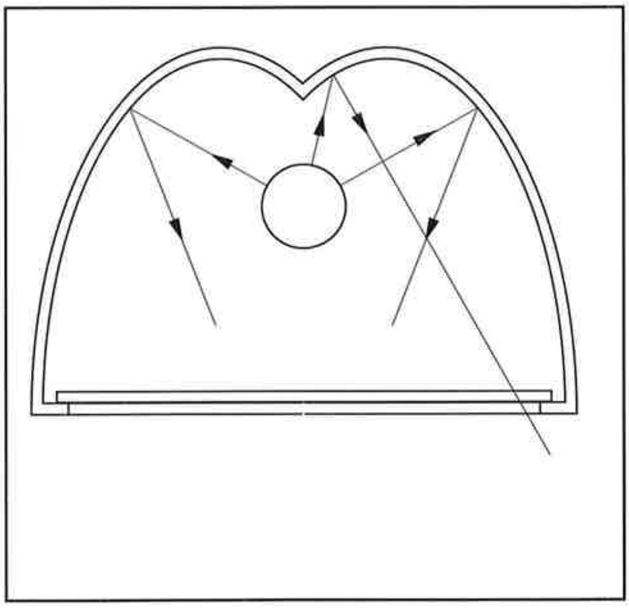
The ballast compartment design must afford adequate external or internal ventilation to allow heat dissipation by convection. The ballast must be mounted in such a way as to allow heat to be conducted to the outside wall of the ballast compartment if external convection is the principal means of cooling. The surface temperature of the capacitor should be kept below 65 degrees celsius which may involve screening the capacitor from the ballast or spacing it away sufficiently. It is generally preferable to separate the lamp and ballast compartment to ensure that the ballast does not thermally radiate towards the lamp and cause voltage rise with all the undesirable consequences mentioned before.

Reflector Design and Effect on Lamp Voltage

A phenomenon to be avoided is that the reflector design inadvertently focuses some of the lamp radiant flux on the cold spot of the arc tube within the lamp. With all saturated vapour systems operating at high temperature it is the coldest spot on the arc tube surface which sets the vapour pressure, the resultant lamp voltage, power, lumen output and colour performance. A useful guide to whether the reflector is creating problems or not is to observe the difference in arc voltage between a test lamp burning in free air and the same lamp burning in the same orientation in the fixture. The lamp voltage should not increase by more than 10 Volts.



Reflector with inadmissible infared reflection to the quartz glass tube



Reflector with reduced infared reflection to the quartz glass tube

Enclosure

METALARC lamps should be enclosed as a general rule with a few only exceptions. The risks of non enclosure for certain types lie in the domain of hot glass particles being ejected following a violent lamp failure or of UV burns to the eyes and skin if the lamp outer jacket detaches.

The following statement summarises the present position of Sylvania for all lamps except the 400 watt Base-Up types when burned within 15 degrees of the vertical.

"A suitably enclosed fixture uses lens/diffuser material able to contain fragments of hot quartz or glass up to 1000 degrees celsius. Enclosed fixtures which comply with UL standard 1572 rev. 26/12/1988 should withstand an arc tube rupture."

In practise this means either tempered glass or minimum 5mm thickness polycarbonate.

Trouble Shooting

The following information concerns safety during procedures designed to determine faults in the lamp or circuit. Extreme care is required in order to avoid any live contact during investigation. It is preferable to work with the fixture off.

1. Lamp flashes brightly on switch on is destroyed or will not relight

This type of phenomenon indicates that the circuit condition is dangerous and may lead to violent failure.

- No Ballast
- Internal Ballast Short Circuit
- Ballast wrongly connected
- Capacitor wrongly connected

2. Lamp does not ignite

- Lamp is at end of useful life
- Loose connection in the circuit
- Poor lampholder contact
- Low Ballast open Circuit Voltage
- Low Mains Voltage
- Lamp is hot and should cool down

3. Lamp glows but the arc does not strike

- Ballast OCV RMS value low
- Lamp damaged due to overload (1)

4. Lamp ignites but fails to stabilise and cycles or extinguishes

- Lamp is at the end of useful life
- Lamp in incorrect burning position
- Too high mains voltage
- Wrong or defective choke
- Over temperature in lamp reflector housing
- Transients in the electrical supply caused by nearby heavy electrical equipment.

5. Strong blackening of the arc tube with light output reduction

- Lamp has been overloaded (1)
- Wrong or defective ballast
- Capacitor misconnected

6. Fuse tripping after switch on

- Fuse of incorrect rating see page 24

7. Lamp extinguishes arc tube expanded

- Severe prolonged overload
- Stray magnetic field has deformed discharge
- Horizontal Burning lamp burned in incorrect position

8. Abnormal colour

- Incorrect burning position
- Wrong ballast
- Capacitor has lost value. Check and replace if necessary
- New lamps replaced beside older lamps. Group change only

9. Safety instructions

SWITCH OFF THE ELECTRICAL SUPPLY BEFORE ATTEMPTING ANY LAMP CHANGE OR CIRCUIT CHECK

FOR LAMP CHANGE MAKE SURE THAT THE RIGHT LAMP TYPE IS INSERTED FOR ITS WATTAGE AND OPERATING POSITION

MAINTENANCE SHOULD BE PERFORMED ONLY BY QUALIFIED PERSONS WHO ARE AWARE OF ELECTROCUTION HAZARDS AND ARE EQUIPPED WITH ADEQUATE EYE AND SKIN PROTECTION

NEVER OPERATE A LAMP WITHOUT ITS OUTER JACKET OTHERWISE SERIOUS AND PERMANENT INJURY TO LIVING TISSUES AND EYES WILL OCCUR

METALARC LAMPS CONTAIN MERCURY. THEY MUST BE DISPOSED OF IN ACCORDANCE WITH LOCAL AUTHORITY REGULATIONS WHICH YOU SHOULD CONSULT. DO NOT BREAK THE ARC TUBES OTHERWISE MERCURY WILL BE RELEASED.

Capacitors for CWA Operation

As a general rule the capacitor should be obtained from the CWA ballast manufacturer. In the case that this is not possible then GTE recommends suitable capacitor manufacturers as follows:

Condensadores NK, Granollers, Barcelona, Spain
Magnatek, Huntington USA
Advance, Chicago USA

NB. This list is correct at the time of writing and is not exhaustive.

Manufacturers of Complete CWA Control Gear

W.J. Parry & Co.
Victoria Mills, Draycott
Derby DE7 3PW, United Kingdom

Tel. (03317) 2321
Telex 37374

ADVANCE Transformer Co.
10275 West Higgins Road
Rosemont
Illinois 60018, USA

Tel. (708) 3905091
Fax. (708) 3905109
Telex 25-4305

ELT
Especialidades Luminotécnicas S.A.
Malpica Industrial Estate
Calle E, Nr. 11
50016 Zaragoza, Spain

Tel. (976) 57 36 60
Fax. (976) 57 49 60

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