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Cosmedico technical advisory: ballasting options for UV lamp operation

Presently there are three ballasting systems being used to operate Low Pressure (fluorescent) tanning lamps. All perform the following identical primary functions: (1) Provide proper voltage to heat the cathodes of the lamp, thus, aiding the starting process; (2) Provide the lamp with adequate starting voltage; and (3) Limit the electrical current through the lamp.

Preheat Choke Systems are the most universally used and accepted system and commonly powers lamps from 8 watts to over 200 watts. This method of driving sun lamps is the dominant method employed in North America (choke ballast usage in North America is estimated to be 5 times greater than the other two competing systems combined) and is used exclusively in Europe. The reasons behind this technology's dominance will become clear as we continue.

Rapid Start Magnetic Systems are used by a few U.S. based equipment makers. Use of these ballasts is almost exclusively limited to HO (100w) and VHO (160w) lamp operation.

Rapid Start Electronic Systems have been used for powering HO (100w) lamps only. The use of this ballast is almost exclusive to small home-tanning units. Typically these beds have few lamps, many run at 120V and the actual weight of the finished bed is an important design consideration. Electronic ballasts are ideal for these in-home small bed or canopy applications. However, electronic ballasts are extremely expensive, comparatively speaking, so usage beyond these applications has been negligible. For this reason, Electronic Rapid Start will not be included in this paper.

As a starting point, an overview of the two primary systems will be helpful.

Rapid Start Magnetic Systems

The Rapid Start magnetic ballast was designed with the purpose of quickly and smoothly starting Rapid Start lamps in general lighting applications. This system utilizes a separate winding within the ballast which provides the lamp electrodes with a low voltage that "heats" the electrodes. The lamp electrode, also called a cathode, is similar to the coil of an incandescent lamp. This heating reduces the starting requirement of the rapid start lamp and, under normal conditions, the lamp is easily started in about 1 second. This trait has proven to have much aesthetic value for general lighting systems in offices or classrooms. Once the lamp is started the cathode heat that is essential to the starting of the rapid start lamp becomes non-essential following lamp ignition, yet it remains even when the lamp is operating. "Special" Rapid Start ballasts are available that disconnect the cathode heat after the lamp has been started. These ballasts can save hundreds of dollars in energy use over their life, but their very high cost makes them impractical for operation in tanning equipment. Typically, if a Rapid Start ballast is used in tanning equipment, the ballast will be a conventional Two-Lamp type.

A two-lamp Rapid Start ballast, as the name implies, operates 2 lamps. This ballast will start the lamps in sequence and then operate them in series. When the circuit is closed, this ballast first heats the cathodes of both lamps. An internal ballast capacitor arrangement allows almost all of the ballast output to start the first lamp. Shortly after lamp #1 starts, the total ballast output shifts to lamp #2, and once started, the two lamps run in series. Because we have a series circuit, operation of one lamp is dependent upon operation of the other, i.e., when one lamp fails, the companion lamp also fails.

To assure dependable starting of tanning lamps on Rapid Start ballasts, it is absolutely imperative that the lamps be positioned within 1" of a continuous grounded metal strip that runs the entire length of the lamp. In most cases the equipment maker must satisfy this requirement by placing the lamp within 1" of the body or reflector.

With Rapid Start systems, power factor correction is provided by a second capacitor which is also built into the ballast housing.

Preheat Choke System

Preheat systems are quite different. The term system is used because several separate components are needed to operate Preheat lamps. (Remember, with a Rapid Start ballast the different components are pre-wired into a single enclosure or "can".)

With a Preheat system the ballast itself is usually a simple, inexpensive

"choke" transformer. It serves to provide the proper starting current and to limit (or "choke") the current to the lamp during operation. The choke ballast is used in combination with a separate "starter". This device provides about one second of current flow to the lamp cathodes to "preheat" them which causes the cathodes to emit electrons that aid the starting process. Once the cathodes reach the preheat condition, the starter will automatically open to stop the current flow. When this occurs, full voltage is applied between the two cathodes of the lamp, the arc strikes and the lamp is operational. In addition to the choke ballast and starter, many applications use a third component called a capacitor to provide power factor correction. With Preheat systems this capacitor is a separate component (in Rapid Start systems this part is incorporated into the ballast can). With Preheat systems, the power factor correction capacitor, if used skillfully, can also be used to modify or condition the operation of the lamp.

There are some rules for operating both rapid start lamps and preheat lamps. Generally, a preheat system (ballast + starter + capacitor) can operate both Rapid Start and Preheat lamp types. However, rapid start ballasts (which incorporate a core and coil, cathode winding, starting capacitor, and power factor capacitor) are designed to operate only rapid start lamps. Lamps designed for exclusive operation on preheat circuits will not operate reliably on rapid start ballasts. While these lamps might work under the very best of conditions, under normal conditions starting is doubtful and unreliable. Today, most tanning lamps are actually hybrids and are listed as acceptable for both preheat and rapid start operation.

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Advantages and disadvantages of the two systems

In order for sunbed designers and salon owners to make educated decisions as to which system is more worthy, it is necessary to compare systems at many levels and from many perspectives.

Acceptance: Approximately **96%** of the worldwide installed base of equipment uses the Preheat Choke System. The reasons for this dominance will become clear as we continue.

ADVANTAGE: **Preheat Choke**

Flexibility: Preheat choke systems are commonly used to operate from 8 watt to 200+ watt L/P lamps. R/S magnetics are used almost exclusively w/HO (100w) & VHO (160w) lamps.

ADVANTAGE: **Preheat Choke**

Optical Design of Equipment: The requirement that a continuous grounded strip be positioned within 1" of the entire length of the lamps that are operated by R/S ballasts requires numerous design compromises by equipment manufacturers. This often results in a loss of optical efficiency. This does not apply to preheat operation.

ADVANTAGE: **Preheat Choke**

Continuity of Service: Preheat systems operate with one ballast and starter per lamp. Failure of the lamp, ballast or starter means one lamp is inoperative. An R/S magnetic ballast operates 2 lamps in series. Failure of either lamp or the ballast means two lamps are out.

ADVANTAGE: **Preheat Choke**

Weight/Dimensions: A 2-lamp R/S (100w) ballast weighs 10+ pounds. Two 100w choke ballasts w/starters, starter sockets, and capacitor weigh slightly over 6.5 pounds. In a 40 lamp bed this translates to 140± extra pounds to ship, lift, and move. Also, 2 choke ballasts + capacitor consume approx. 40% of the space needed for a 2-lamp R/S unit.

ADVANTAGE: **Preheat Choke**

Ease of Installation by Manufacturer: The Rapid Start ballast requires less skilled labor and is probably easier. All input and outputs are made via color-coded leads integral to the ballast. When using a choke ballast and components the bed maker usually uses a pre-assembled wire harness.

ADVANTAGE: **R/S Magnetic**

Ease of Installation (Replacement by User): Replacement of a failed R/S magnetic ballast by a service person or salon operator involves the disconnect and reconnect of no fewer than 8 wires; chokes have 2.

ADVANTAGE: **Preheat Choke**

Lamp Starting (functional): Both systems are designed to start a lamp quickly while "minimizing the harm" that occurs to the lamp during starting.

A major proportion of R/S ballasts are used to operate recessed double contact (RDC) based lamps, and *the connection between RDC lamps and an RDC socket are not as positive and reliable as a bi-pin connection.*

R/S operation depends upon an almost perfect connection between lamp and lampholder. Absent quality contact, the cathodes fail to heat properly prior to the ballast initiating ignition which causes "sputtering" of the cathode's emissive coating from the cathode to the glass wall of the lamp.

The lamp will turn "black at the ends" quickly and the lamp often fails early. *Poor RDC connections are probably the greatest single cause of premature lamp failure.*

ADVANTAGE: **Preheat Choke**

System Maintenance (Total Cost): The preheat system consists of two "wear" parts: lamp and starter. The Rapid Start has only the lamp. Starters are often replaced when and if they fail, but some salon owners "group" replace every 2nd, 3rd, or 4th change to assure integrity of operation (+6,000 cycles are typical starter ratings).

The choke ballast itself is almost bullet-proof; if installed and operated properly, +50,000 hours of operation can be expected. Rapid start ballasts perform close to this specification. In reality, failure rates for both are minimal. But when a failure occurs the similarity ends.

In a preheat, 100w system the cost to the salon to replace a failed starter may be somewhere between $1.50 and $1.75. Replacement of a 100w choke ballast may run from $10.00 to $15.00. Any failure of a single internal component of a magnetic R/S ballast (starting coil, starting cap, etc.) dictates the replacement of the entire ballast. No low-cost repairs can be made. Salons will pay in the range of $50.00 to $65.00 to replace a two-lamp 100w magnetic ballast. Similar ratios pertain to the 160w system.

ADVANTAGE: **Preheat Choke**

Troubleshooting: With a R/S system all problems can be traced to either the lamp, lampholder, connection or ballast. With a preheat system, we must add the starter and starter socket. This probably gives a slight edge to the R/S system.

ADVANTAGE: **R/S Magnetic**

Adaptation of Equipment to Utility Provided Service: When rapid start ballasts are used in tanning equipment, the choice is usually for one with an input voltage rating of 120V. This voltage is available on the two most common utility systems in the U.S.: The 120/240V single phase, 3-wire, and the 120/208V, three phase, 4-wire. Under normal conditions a rapid start bed may be hooked directly to utility-provided power without the need for conditioning.

Choke powered equipment is different. While in most cases these beds and booths may be directly connected to a single phase service, the addition of a small "buck/boost" transformer is necessary for 120/208V service connections.

This assures reliable lamp starting and optimal lamp performance. The "size" of this transformer may be anywhere from .25KVA to 1.0KVA (depending upon the KVA requirement of the bed) and cost ranges from $69.00 to $212.00 (source of price data: Grainger catalog).

ADVANTAGE: **R/S Magnetic**

Effects of Humidity and/or Dirt on Lamp Operation: One of the critical elements of R/S operation is that the lamp must be "excited" by means of external voltage which causes ionization of the lamp's internal gases. This external "excitation" is created by the potential that exists between the lamp and a continuous ground that must run the entire length of the lamp.

The rapid start lamp itself must be coated with a clear (nonwetting) silicon material. This is done to counteract the adverse effect that humidity has on R/S lamp starting. Under high humidity conditions, lamps on R/S circuits may start slowly or not at all. This is usually due to dirt on the lamps that is offsetting the desired effect of the silicon coating. Unfortunately, tanning lamps have some very rigorous cooling requirements, and movement or circulation of air is the only practical method to accomplish this. With air circulation comes many forms of airborne contaminants, many of which are deposited on the surface of the lamps. This dirt is particularly unfriendly to R/S systems.

To complicate the matter, many common "cleaners" will also strip the silicon coating from the lamp, making it impossible to start the lamp at all. The preheat system is virtually immune to these problems.

ADVANTAGE: **Preheat Choke**

Total Cost of Equipment: Most equipment manufacturers will quickly admit to moderately higher labor costs when building a piece of equipment using preheat choke ballasts and related components versus rapid start magnetic. These higher labor costs are readily

Advantages and disadvantages of the two systems (cont.)

accepted because of the huge material savings that are realized. The net result is that the preheat choke equipment will always have a total manufacturing cost that is less than its rapid start magnetic counterpart.

The worldwide business for products and services thrives on the fact that consumers are ready and willing to pay premiums for features or enhancements that offer benefits such as: improved performance, lower cost of ownership, ease of use, durability, etc. In the case of preheat choke vs. rapid start magnetics, there are no features and benefits to offset the higher costs of the rapid start system. In simple terms, these higher costs are unnecessary. Higher manufacturing costs inevitably translate directly to higher consumer prices.

Ultimately, it is the lower cost of preheat choke systems, and the better consumer value, that explain the dominant use of this system.

ADVANTAGE: **Preheat Choke**

Lamp Output (using standard components): In today's market, "Lamp Output" is probably the most important factor for those purchasing new equipment. Which of the two competing systems normally, readily, easily and inexpensively optimizes lamp output? In order to make this comparison, we tested commonly available, off-the-shelf components used in the every day production of tanning equipment. In all comparisons, the exact same lamp was used to eliminate error caused by normal lamp-to-lamp variations. In all cases, multiple measurements were taken and averages used so that conclusions are not reached from a single test. Other conditions such as ambient temperature and warm-up time were consistent from test to test. Lamp irradiance was measured using an IL 1700UV meter. Tests were conducted and reported by Szekely Engineering and are available on request.

100w/HO OUTPUT COMPARISON

SYSTEM		100w Preheat Choke	1000MA Rapid Start Magnetic
INPUT VOLTAGE		220V 60HZ (± 1%)	120V 60HZ (± 1%)
Lamp Irradiance (W/cm^2)	UVA	**1.322E-03**	1.211E-03
	UVB	**9.558E-07**	8.690E-07

ADVANTAGE: **Preheat Choke**

160w/VHO OUTPUT COMPARISON

SYSTEM		160w PreHeat Choke	1500MA Rapid Start Magnetic
INPUT VOLTAGE		220V 60HZ (+/- 1%)	120V 60HZ (+/- 1%)
Lamp Irradiance (W/SQ. CM)	UVA	**2.080E-03**	1.880E-03
	UVB	**1.540E-06**	1.380E-06

ADVANTAGE: **Preheat Choke**

Energy Efficiency: Today's energy costs require that we also consider ballast efficiency. Both systems take A/C input and convert it to UV output and heat. The most efficient system will maximize UV and minimize heat. Excess heat is not only wasteful in itself, but must be disposed of by the equipment maker and salon owner via increased cooling capacity. At the same time we conducted output measurements, we monitored and recorded energy consumption. This data follows. As you can see, the choke system is inherently more efficient, due in great part to the wasteful cathode heat energy that remains following lamp ignition on the rapid start system.

100w/HO EFFICIENCY COMPARISON

SYSTEM		100w Preheat Choke	1000MA Rapid Start Magnetic
INPUT VOLTAGE		220V 60HZ (± 1%)	120V 60HZ (± 1%)
Lamp Efficiency (W/SQ. CM)	UVA	**5.848E-06**	5.395E-08
	UVB	**4.267E-09**	3.871E-09

ADVANTAGE: **Preheat Choke**

160w/HO EFFICIENCY COMPARISON

SYSTEM		160w Preheat Choke	1500MA Rapid Start Magnetic
INPUT VOLTAGE		220V 60HZ (± 1%)	120V 60HZ (± 1%)
Lamp Efficiency (W/CM^2)	UVA	**5.097E-06**	4.614E-06
	UVB	**4.375E-09**	3.387E-09

ADVANTAGE: **Preheat Choke**

Modification of Components: The ability to modify or enhance lamp output when using the Preheat Choke System is unsurpassed. Design adjustments to the wattage of a choke ballast are quickly and easily made and carry small (if any) cost premiums. Small, inexpensive buck/boost transformers on the service feed may be used to correct (up or down) input voltage to the very precise value recommended by the equipment manufacturer. Additionally, creative circuitry and use of capacitors may further refine lamp output so that very exact lamp irradiance objectives are met. This degree of flexibility and precision are not practically obtainable with the R/S system.

ADVANTAGE: **Preheat Choke**

Advantages Summary

	Preheat Choke	Rapid Start Magnetic
Acceptance	✔	
Flexibility	✔	
Optical Design of Equipment	✔	
Continuity of Service	✔	
Weight/Dimiensions	✔	
Ease of Installation (OEM)		✔
Ease of Installation (Replacement)	✔	
Lamp Starting (functional)	✔	
System Maintenance (Total Cost)	✔	
Troubleshooting		✔
Adaptation To Utility Service		✔
Effects of Humidity/Dirt	✔	
Total Cost of Equipment	✔	
Lamp Output/ 100w	✔	
Lamp Output/ 160w	✔	
Lamp Efficiency/ 100w	✔	
Lamp Efficienty/ 160w	✔	
Modification of Components	✔	

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