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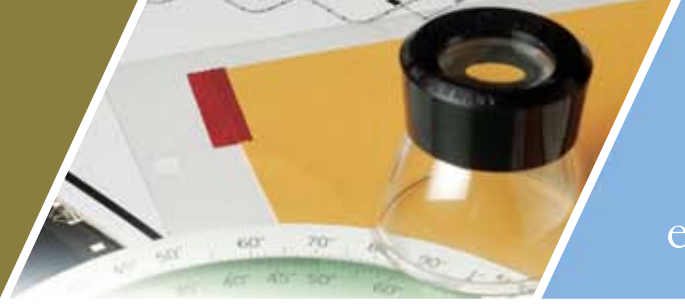

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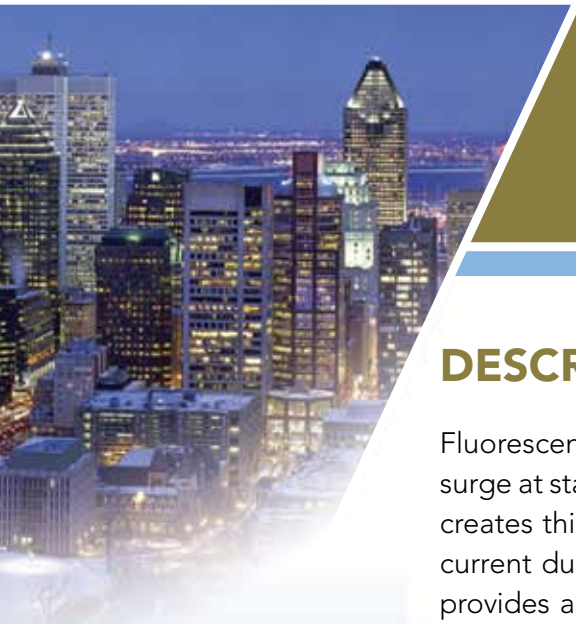

FLUORESCENT LAMP AND BALLAST OPTIONS

DESCRIPTION

Fluorescent lamps require a high-voltage surge at start-up. A device called a ballast creates this surge, then limits the flow of current during operation. This fact sheet provides a review of some of the current technologies for lamps and ballasts, along with a brief review of their advantages and disadvantages. The focus is on the 122-cm (4-ft.) length x two-lamp ballast combination, as it is the most common configuration in Canada.

There are two types of ballasts available on the market today: electromagnetic and electronic. The first is not energy efficient and is currently being phased out of the Canadian market. The electronic ballast is used with the more efficient T-8 lamps and offers a more efficient lighting system.

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TECHNICAL SPECIFICATIONS

Fluorescent Lamps

T-8 lamps can be grouped into three basic categories: standard, low-wattage and premium efficiency.

FIGURE 1 - T-8 LAMPS

The **STANDARD** T-8 lamp (Figure 1) has become the fluorescent lamp of choice for many reasons.

Although this lamp type has only been actively used in Canada since the 1990s, manufacturers continue to improve this product. Newer designs of T-8 lamps include longer life, higher colour rendering index (CRI), lower wattage and higher lumen output.

The benefits of these lamps over the older design T-12 lamps include:

- Higher CRI – a typical "cool white" F40T12/ES (Energy Saving) lamp has a CRI of approximately 62, whereas the CRI of a typical 800 series F32T8 lamp ranges from 82 to 86 (100 is considered optimal). This high index is achieved cost-effectively by using more expensive tri-phosphor coatings.

Technical Fact Sheet

Canada

- Smaller-diameter lamp – allows for greater optical control, thereby increasing luminous efficiency.
- Longer-rated lamp life – 24 000 to 30 000 hours versus 20 000 hours (based on three hours per start).
- Better lumen maintenance – 94 percent versus 86 percent for T-12 lamps.
- Lamp choices – including CRI ratings of 70+, 80+ and 90+.
- Colour choices – colours typically used include 3000°Kelvin (K) (similar to warm white), 4100°K (similar to cool white) and 3500°K, which is the most popular choice.

Light output for T-8 lamps typically range from 2800 to 3100 lumens (F40T12/ES) lamps are rated at 2650 lumens). **STANDARD** T-8 lamps are rated at 32 watts. **LOW WATTAGE** lamps are available at 30, 28, 27 and 25 watts. These **low-wattage** lamps also have a relative drop in lumen output. These lamps can be used to achieve energy savings in applications that are slightly over-illuminated. There are, however, some disadvantages to these lower-wattage lamps:

- They are more sensitive to cold temperatures.
- They do not offer any dimming capabilities.
- They are not recommended for use with occupancy sensors.
- They are limited in the type of ballasts they can use.
- In some cases, they offer a shorter lamp life.

FIGURE 2 - ELECTRONIC BALLAST

PREMIUM EFFICIENCY (PE) T-8 lamps have recently been introduced by the major lamp manufacturers. These lamps have rated light output levels as high as 3100 lumens, have a lamp life of up to 30 000 hours and are available in the popular colour temperatures.

Another newly introduced fluorescent lamp type, the T-5, has grown in popularity for special applications. Its primary benefit is based on its smaller diameter, which allows increased optical control even over T-8 lamps. It is mostly used for indirect lighting applications. A luminaire designed specifically for the T-5 lamp can provide a greater spread of light on the ceiling.

The T-5 lamp is well suited for highbay applications. With its higher efficiency, optical control ability, instant on and good lumen maintenance, the T-5 and T-5 high output (HO) lighting systems have many advantages over metal halide lighting systems.

Retrofitting existing fluorescent systems has proven to be a cost-effective way of reducing energy use. Although the T-5, T-5 HO and T-8 have similar efficiencies, the T-5 and T-5 HO lamps are shorter and cannot be directly installed for a retrofit in existing T-12 or T-8 luminaires. Another design consideration is that T-5 and T-5 HO lamps are designed to provide their maximum light output at 35°C versus 25°C for T-8 lamps.

BALLASTS

There are two main types of fluorescent lamp ballasts in use today: electromagnetic and electronic. Electromagnetic ballasts perform the essential functions required to start and operate a lamp, but are not as efficient as electronic ballasts (Figure 2).

In addition to lower efficiency, electromagnetic ballasts have a number of disadvantages compared with electronic ballasts, including lamp flicker, tar leakage and a shorter life expectancy. Electronic ballasts virtually eliminate lamp flicker, do not leak and have a 20-year life expectancy (Table 1).

Federal legislation introduced in 2005 regulates the ballast performance for 1- and 2-lamp ballasts, essentially eliminating the use of most electromagnetic ballasts for new applications; in 2010, the "replacement" ballasts will also be regulated. The only applications

that are exempt from this regulation are the ballasts requiring low-temperature operation, such as exterior signs or ballasts with integrated dimming capabilities of 50 percent or more. For more information on these new regulations, visit Natural Resources Canada's Web site at oee.nrcan.gc.ca/regulations/amendment9_part1.cfm?text=Y&printview=N. For general information about lighting, see the *Lighting Reference Guide* at oee.nrcan.gc.ca/publications/equipment/lighting/.

Electronic ballasts are available in four basic types: instant start (IS), rapid start (RS), program start (PS) and dimmable. Dimmable ballasts for fluorescent lamps are more expensive than non-dimmable systems, and are therefore typically used for special applications, such as boardrooms and perimeter areas with daylight control systems. The primary difference between IS, RS and PS ballasts is the way they start lamps. IS ballasts apply a high voltage across the lamp without preheating the cathodes, whereas PS and RS ballasts apply a lower voltage to the cathodes to preheat them before starting the lamp. PS ballasts maintain the lamp operation at a lower wattage than the RS design and are expected to replace the RS design in the future.

A recent introduction to the IS ballasts design is the "Premium Efficiency" IS ballast.

As a result of this difference in starting, IS and PS ballasts are more energy efficient than RS ballasts, typically using 1.5 to 2 watts less per lamp, with Premium Efficiency IS ballasts achieving up to 4 watts less per lamp. However, on shorter duty cycles (e.g. 3 hours per start or less), IS ballasts reduce lamp life. As the duty cycle increases to 8 hours and more, the effect on lamp life is similar. RS ballasts are therefore recommended where lights are cycled on and off frequently, such as in an environment where lights are operated by occupancy sensors.

TABLE 1 - BALLAST TYPES

Electronic	Electromagnetic
No lamp flicker (20 000+ Hz)	Visible lamp flicker (60 Hz)
No tar	Can leak tar
20-year life expectancy	10-year life expectancy
1-, 2-, 3- or 4-lamp models	1- or 2-lamp models

ENERGY INFORMATION

Ballasts are available with various ballast factors. Ballast factor is defined as the relative light output compared with a reference ballast. For example, a ballast factor of 0.85 would yield 85 percent of a lamp's rated lumens or light output. Refer to Table 2 for energy usage for various types. Electronic ballasts are typically available in three groups of ballast factors:

- Low ballast factor (LBF) = 70 to 80 percent of rated lamp light output
- Normal ballast factor (NBF) = 85 to 95 percent light output
- High ballast factor (HBF) = 105 to 115 percent light output

Table 2 illustrates the differences in operating costs for a common two-lamp system. The analysis reveals that T-8 lamps combined with an electronic ballast produce approximately 89 lumens of light per watt, whereas T-12 lamps using a standard electromagnetic ballast produce only 54 lumens per watt. The maximum energy efficiency can be achieved by using both premium lamps in combination with premium ballasts. This combination produces close to 100 lumens of light per watt.

COMPARISON

The combination of lamp and ballast determines the type of light produced. Selecting the right combination starts with knowing the location and purpose of the lighting. After determining the required lighting levels and selecting the appropriate luminaire, the proper lamp and ballast must be chosen. Refer to Table 2 for light output comparison. It should be noted that light outputs are based on initial levels. The lamp lumen depreciation (LLD), at 40 percent of rated lamp life, is 85 percent of initial lumens for a T-12 lamp, whereas the T-8, T-5 and T-5 HO lamps are much better at 95 percent.

In areas with fixed ceiling grid patterns or for a retrofit project, the available options allow you to select the right combination of lamps and ballasts to meet the lighting requirements for the space in the most cost-effective and energy-efficient manner.

TABLE 2 - ENERGY USE FOR A TWO-LAMP SYSTEM

System	Watts	Lumens Per Watt	Light Output (initial lumens)	Operating Cost/yr ($5/kW; $0.05/kWh @ 4000 h/yr)	kWh/m²*	Operating Cost/m² *
T-12 ES (Energy-Saving) and standard electromagnetic ballast	81	54	4370	$25.92	66.17	$5.29
T-12 ES and ES electromagnetic ballast	74	59	4370	$23.68	60.45	$4.84
T-8 lamp and LBF ballast	51	89	4543	$16.32	40.07	$3.21
T-8 lamp and NBF ballast	59	90	5310	$18.88	39.66	$3.17
T-8 lamp and HBF ballast	78	91	7080	$24.96	39.33	$3.15
T-8 PE LBF ballast	48	96	4602	$15.36	37.24	$2.98
T-8 PE NBF ballast	55	96	5280	$17.60	37.19	$2.98
T-8 PE HBF ballast	72	98	7125	$23.04	36.08	$2.89
T-5 NBF ballast	62	94	5800	$19.84	38.16	$3.05
T-5 HO NBF ballast	120	83	10 000	$38.40	42.84	$3.43

*Values have been normalized to be relative to matching light outputs.

Case Study

FIGURE 3 - OFFICE BUILDING

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As an example of an upgrade to an existing lighting system, consider the case of a 25-storey building with 6500 luminaires (Figure 3). The existing lighting used recessed lensed luminaires with three F40T12/ES lamps and standard electromagnetic ballasts. To optimize this type of lighting system, the existing three-lamp luminaires were converted to three F32T8/841 lamps with an LBF ballast. This combination allows the tenants to select three different lighting levels with one, two or three lamps operating. With the three-lamp arrangement, de-lamping could be achieved while maintaining an even illumination over the lens surface.

As Figure 4 illustrates, the energy savings for an office building project of this size would be $100,000 per year, at a rate of $5 per kilowatt (kW) and $0.05 per kilowatt hour (kWh), with a resulting 5-year payback period.

FIGURE 4 - ESTIMATED SAVINGS

Aussi disponible en français sous le titre :
Options de lampes fluorescentes et de ballasts

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