



Property Risk Consulting Guidelines

XL Risk Consulting

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FLUORESCENT LIGHTING

INTRODUCTION

Fluorescent lighting fixtures cause a significant number of fires. Over a 4-year period, an insurance company experienced 34 fire losses attributed to fluorescent lighting fixtures, although in some incidents, fire destroyed all the evidence. Excluding one loss that exceeded \$6 million and 18 losses that were less than the deductibles, the cost to the insurance company averaged \$100,000 per loss. Analyzing ignition sources and applying loss lessons can reduce the frequency and severity of losses.

Manufacturers' recommendations and National Electrical Code® (NEC) requirements provide the minimum level of loss control at AXA XL Risk Consulting locations. This Property Risk Consulting Guideline highlights and supplements those prerequisites for typical fluorescent lighting fixtures. It does not cover high intensity discharge lighting, neon signs, or other gas discharge lighting rated above 480 V.

POSITION

Maintain fluorescent lighting equipment by using a comprehensive preventive maintenance program that includes the features described in NFPA 70B and the detailed guidance presented in this section.

Immediately disconnect, test, clean and repair or replace as necessary, any fluorescent lighting fixture demonstrating any of the following problems:

- Overheated ballast, evidenced by smoke, odor, or discoloration.
- Light output reduction, evidenced by a tube that appears dim when compared to others in the area.
- Unstable light output, evidenced by lamp flickering or blinking.
- Lamp failure to light whether caused by burned out tubes or open circuits.
- Lamp blackening, which usually occurs at one end of the tube.

Keep fluorescent lighting fixtures clean by preventing dust and residue from accumulating on components.

Use only approved fluorescent lighting fixtures in hazardous (classified) areas where a fire or explosion hazard can exist due to gas, vapor, dust, fibers, or flyings.

Prohibit direct contact between fluorescent lighting fixtures and combustible construction. Where a fixture must be mounted to a combustible member, install a heat-resistant barrier between the two to prevent heat conduction. Also, maintain an adequate clear space to dissipate heat emanating from the fixture.

When representative similarly-aged ballasts from a group of fluorescent fixtures show signs of deterioration, replace all ballasts in the group with modern devices having integral thermal protection.

Disconnect power to fluorescent light fixtures whenever the illuminated area is unoccupied.

Ground lighting fixtures and ballasts. Although the NEC permits ungrounded ballasts, grounding provides superior protection.

Follow all local and national legislation concerning the use and disposal of fluorescent lighting fixtures.

To reduce fluorescent light output, use an approved dimming type fluorescent ballast or an approved ballast accessory. Never dim a fixture by removing one lamp.

DISCUSSION

Background

Fluorescent lighting fixtures arc and produce heat. Arcing is normally confined to a tubular lamp. Heating occurs in the lamp, ballast, wiring, and related circuit devices. Equipment design and installation precautions normally provide for safe heat dissipation. This text broadly defines the term fixture to include the ballast, lamp, lamp holder, starter, and other connected lighting components.

The ballast provides the voltage necessary to cause the initial arc to strike. When an arc is struck, the gas in the lamp conducts current and completes the circuit, while the ballast limits and stabilizes current flow. For example, to initiate the arc, a ballast can increase the voltage to 380 V across a lamp, and then limit and stabilize the current by reducing the lamp voltage to 100 V.

Many loss control people believe fluorescent lighting ballasts still cause a significant number of fires. Older, unprotected ballasts did cause many fires. But today's ballasts may be getting unfair blame.

Operating any fixture in an unsuitable environment, or with weakened or aged insulation, or with loose connections, can eventually cause the electrical insulation to break down. Uncontrolled arcing or heating can lead to fire.

Ballasts - General

Typically, a ballast is an assembly of components in a single metal or plastic case. A ballast can be located inside the metal enclosure forming the base of a fluorescent fixture, or in a separate metal cabinet, or away from the fixture without an enclosure. A ballast can be electronic or one of three electromagnetic types; most ballasts can be obtained with a "Class P" designation.

The maximum surface temperature contemplated in the design of a typical ballast is 90°C (194°F). Above that temperature, an overheated ballast emits smoke and odor. Electromagnetic ballasts can also drip asphalt. If a ballast operates at 8°C (14°F) overtemperature, its service life is halved. Higher temperatures reduce ballast life even further, and can lead to breakdown and fire.

A *simple reactance* (reactor) *ballast* is typically found in a preheat starting circuit. This electromagnetic ballast is basically a single coil wrapped around a core to provide inductance to the lighting circuit. The ballast may be open, not separately enclosed or encased, if it is mounted inside an enclosure provided for other devices.

Reactance ballasts used with most ac fluorescent lighting systems are more complex. These electromagnetic ballasts can have several components to provide inductive-only, capacitive-only, or inductive and capacitive, reactances. One component can be a specialty-type transformer to develop proper ac voltages. Another component can be a capacitor to raise the power factor or to provide an impedance for filtering the power supply. Another can be a resistor for bleeding stored charges from an internal capacitor after a ballast is deenergized. A fuse or other thermally actuated element can be another component. Reactance ballasts can be designed for rapid or instant start applications. Reactance ballasts can also be used for dc fluorescent lighting systems.

Resistance ballasts are used for dc fluorescent lighting systems. No reactive (inductive or capacitive) components are designed into these electromagnetic ballasts.

Electronic ballasts perform high frequency switching. They contain transistors or thyristors along with components like those used in reactance ballasts. Electronic ballasts are likely to be more susceptible than electromagnetic ballasts to power quality problems.

Electromagnetic Ballasts

The common electromagnetic ballast usually contains a laminated steel-alloy core, wire, and various electrical insulating systems. The insulation, usually rubber or plastic, is needed between windings, between windings and core, for runs of wire, and for support of live parts. Often, a heavy potting or impregnating compound, sometimes an asphalt and sand mixture, is used as insulation to fill the space between the interior components and the ballast case. Potting compound also minimizes noise caused by case vibration. Minor compound leakage from new units is not a problem, because the material hardens when exposed to oxygen.

Electromagnetic ballasts are also called “core and coil” and “reactor type” ballasts. They operate at normal power system frequency which is 60 Hz in the U.S. Their expected service life is generally from 10 to 15 years, but can approach 30 years.

Insulation in electromagnetic ballasts can deteriorate and cause a short circuit. Power quality problems, aging, or manufacturing defects can break down insulation. Ballast failure can cause overheating and ignite combustibles.

Electronic Ballasts

Electronic ballasts perform high frequency switching. Although the ballast’s input frequency is normally the same as that of the normal power system, e.g., 60 Hz, the ballast’s output frequency is normally in the 20-60 kHz range. At these higher frequencies, lamp phosphors perform more efficiently and arcs are struck more easily with less stress than those produced by 60 Hz. An electronic ballast usually contains an input surge protector, a filter to minimize electromagnetic interference, an ac to dc converter, and an inverter to provide the high frequency ac output.

Product claims for fixtures using electronic ballasts include higher lamp efficiency, lower power consumption, cooler and quieter operation, higher power factor, lighter weight, reduced maintenance costs, and longer life. These ballasts also permit operating features that are not normally available with electromagnetic ballasts. For example, electronic ballasts coupled with external sensors can maintain constant lighting levels.

The use of electronic ballasts is rapidly expanding. However, field experience has yet to demonstrate the consequences of ballast failure.

Class P (Protected) Ballasts

Fluorescent lighting fixtures became common in the 1940s. Early electromagnetic ballasts were not designed with thermal protection and developed a reputation for causing fires. Electronic ballasts appeared in the late 1960s; these early models had a number of “bugs.” Reliability, fire, and service life were major concerns. Class P (thermally protected) ballasts were also developed in the late 1960s, but Class P ballasts were initially available only as electromagnetic ballasts. Today’s Class P electromagnetic and electronic ballasts are reliable and are not as likely to cause fires as the early models. Class P ballasts do not reach temperatures that can initiate fires unless the ballast protection fails.

Typically, a Class P ballast contains an integral thermal device that opens the power supply circuit before the ballast temperature exceeds a specified limit. Some newer Class P ballasts also respond to abnormal voltage and current. A Class P electronic ballast does not require a circuit opening device if the ballast circuitry limits the temperature of the case to an acceptable limit under specified test conditions.

Circuit protective devices used with most Class P ballasts automatically reclose when the ballast is cooled. Because of this feature, a lamp supplied by an overheated ballast can cycle off and on. Such cycling usually indicates that the ballast has deteriorated and should be replaced.

Since 1969, the NEC has required new and replacement indoor fluorescent fixture ballasts to contain integral thermal protection (Class P). Simple reactance ballasts are excluded from this requirement.

Causes of Losses

Housekeeping and overtemperature are important factors in many losses initiated by electrical equipment. Sixteen of the thirty-four losses mentioned in the Introduction describe deficient housekeeping, including accumulated lint and residue. If housekeeping near the fixtures had been improved, these losses might have been avoided entirely or at least limited to replacing a fixture or component.

Typically, fixtures around dusty operations require frequent and thorough cleaning. Where lint or dust accumulates slowly, the need for a cleaning schedule might not be obvious. In a typical warehouse, dust may accumulate slowly on hanging light fixtures that are not easy to inspect. Even though the building appears clean, a fixture can become a fire hazard from an accumulation of dust that blocks cooling and becomes “baked” and overheated.

Also, as a fluorescent lighting fixture is turned on and off each day, the repeated heating and cooling of an internal ballast causes the enclosure to “breathe.” Normal dust in the environment can be drawn into the fixture through joints or seams and can coat the ballast with a thermal blanket that obstructs cooling.

Some loss investigations of overheated ballasts fail to identify root cause of loss. Only when this cause is identified and effective loss prevention actions are taken can similar losses be prevented. Obviously, not all losses can be prevented, but where fixtures have Class P protection and where knowledgeable maintenance practices are followed, many losses are being prevented.

Other causes for fluorescent lighting losses include:

- **High ambient temperatures.** High ambient temperatures can overheat ballasts. Special attention should be given to construction features which affect the ballast ambient temperature as the fixture operates. Confined spaces, obstructed venting, pendant and surface mounting, and recessed fixture cavities can all cause different ambient temperatures.
- **Low ambient temperatures.** Where ambient temperatures are usually low, special low temperature ballasts with higher starting voltages might be needed. These special ballasts can cause higher electrical stresses which lower the projected service life of equipment.
- **Lamp rectification.** Near the end of its useful service life, a lamp may no longer conduct ac current effectively and might convert (rectify) ac current into dc pulses. Blackening at one end of the lamp and flickering can be symptoms of rectification. A rectified current can overheat a ballast designed for ac operation.
- **Lamp burnout.** Ballast overheating can result if a single lamp fails to operate in a multilamp fixture.
- **Ballast deterioration.** A lamp that cycles on and off (or blinks) signals repeated ballast overheating and cooling.
- **Ballast misapplication.** Overheating is only one possible outcome of ballast misapplication. Ballasts should be used as designed and must match the designated lamp method of starting.
- **Fixture misapplication - reducing lighting.** Operating a multilamp fixture with one lamp removed can increase ballast current which overheats the ballast.
- **Fixture misapplication - hazardous (classified) area.** Refer to article 500 of the NEC, and to NFPA 497 and NFPA 499. Using a fixture in an environment for which it was not designed can cause a fire or explosion. Component surface temperatures and contact arcing can ignite gases, vapors, dusts, and fibers in hazardous (classified) areas.

- **Power quality.** Power surges and harmonics can break down insulation. Harmonics can overheat an electromagnetic ballast.
- **Poor connections.** A termination or splice can overheat as current flows through the high resistance contact caused by poor design, sloppy wiring, inadequate maintenance, or mechanical injury.

Investigations

Where a fluorescent fixture or ballast is suspected of causing a fire, the loss investigation should attempt to answer these questions:

- Was the equipment suitable for the environment, such as temperature, humidity, vapors, dust, or fibers?
- Was housekeeping a factor? Did accumulations of dust or residue cause an electrical device to overheat? Did accumulations ignite?
- Were ballasts listed? Were they Class P? Were other NEC requirements followed?
- Did electrical components perform as designed?
- What was the source of the energy that caused ignition?

Answers to these questions will identify any need for fluorescent lighting equipment design changes and code changes. The need for making such changes is of interest to manufacturers, code authorities, and testing labs.

Lamp Starting Methods

Three common methods of “starting” fluorescent lamps are *Preheat*, *Instant* and *Rapid Starting*. Preheat starting is also called hot-cathode starting. Instant starting is cold-cathode starting. Lamps, ballasts, wiring, and all other fixture components and circuit arrangements must be compatible with the chosen starting method.

Figures 1 through 3 show simplified circuit arrangements for starting single-lamp fixtures. They represent the common starting methods and do not show complete systems. Figures for multilamp fixtures are beyond the scope of this guide.

Preheat starting (Figure 1) requires a starter switch which is initially closed, and tungsten-filament cathodes at each end of the fluorescent tube. When the lighting fixture is initially energized, the electrical circuit is completed through the starter. No current flows through the gases in the lamp because the cathodes are cold and the starter switch path provides less resistance. Current flows in a series circuit through a cathode on one side of the lamp and continues through the starter, the other cathode, and the ballast. The cathodes are heated as this current passes through them.

The automatic starter switch, having a delayed response, opens seconds after the fixture is energized to break the circuit and cause a voltage kick across the gas filled tube. The heated filaments and voltage kick emit electrons from one of the cathodes to strike an arc and complete the circuit through the lamp. The direction of current flow continually changes with the ac voltage. Current flowing through the lamp continually heating the filament eliminates further need for the starter. Preheat starting lamps typically give off more light (lumens) per watt but have a shorter service life than instant starting lamps.

Instant starting lamps are also called slimline lamps. Each end or base requires only one pin. Instant starting (Figure 2) lights the lamp without preheating the two cathodes and is therefore cold-cathode starting. A cathode is part filament, and part sheet-metal rolled into a cylinder to provide a large surface area. This surface area may be coated to improve electron emission response.

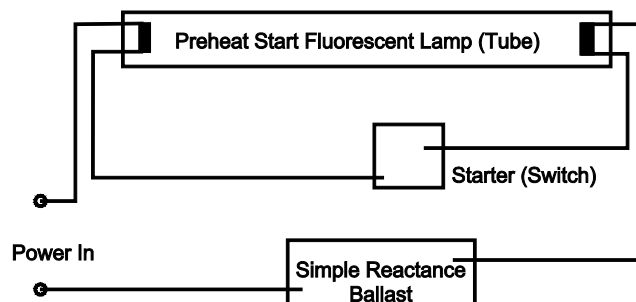


Figure 1. Preheat Starting

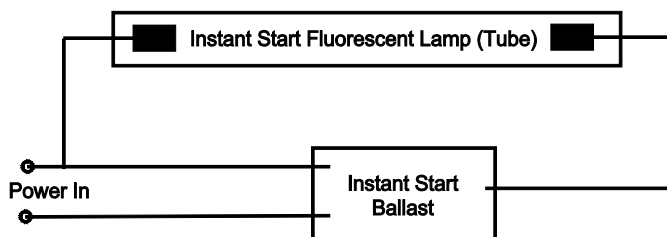


Figure 2. Instant Starting

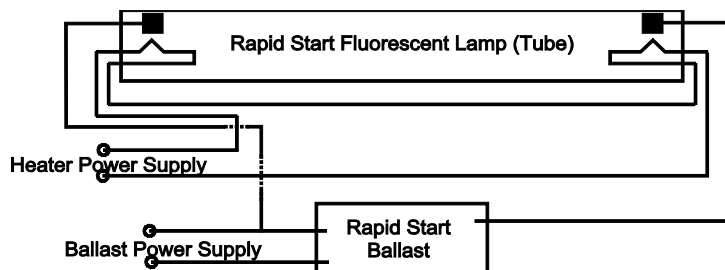


Figure 3. Rapid Starting

When an instant starting fixture is energized, a ballast impresses a high starting voltage across the lamp. Because of its large surface area, the cathode emits electrons and an arc forms through the lamp to complete the circuit. The filaments do not directly assist in starting the lamp, but they become important once the lamp is lit. As is the case with preheat starting, current flowing through the circuit heats the filaments, allowing them to emit electrons. As a result, the lamp continues to operate at a lower voltage than would be needed with only cold-cathode operation. Thus, a ballast must satisfy both the high initial and lower operating voltage requirements.

Rapid-Starting (Figure 3) uses neither a starting switch nor a high starting voltage. Special heaters are powered continuously by a separate circuit. Alternately, not shown in the figure, the heaters can be powered by the ballast. When the heaters bring the cathodes to an arcing temperature that can support emission, then lamp discharge can occur whenever a separately switched ballast lamp circuit is energized.

Installation Considerations

A fluorescent lamp should be used at rated voltage and with a proper starting circuit. Within a range of $\pm 10\%$, a lamp will emit light in proportion to the voltage across it. Too high a voltage and frequent starting shortens lamp life. Too low a voltage makes starting difficult and likewise shortens lamp life. High and low ambient temperatures and drafts also affect light output and lamp life. Lamp failure is usually caused by the filament emission material depleting which prevents the gases from ionizing.

Fluorescent lighting fixtures should be installed by following the manufacturers' guidelines and the NEC requirements. Even with proper installation and approvals, some components of fluorescent lighting fixtures can still get hot. They can expose combustible materials to temperatures of 90°C (194°F). The exposed surface of an approved resistance ballast may reach 150°C (302°F).

Combustible materials can “bake” under those temperatures, driving moisture out, leaving the material readily ignitable. Upon electrical breakdown, even higher temperatures can occur, with or without arcing. Although article 410 of the NEC describes requirements for arranging equipment, the restrictions for combustible construction are minimal. Generally, direct contact between a fluorescent fixture and combustible construction is allowed. But where possible, direct contact should be avoided. Loss experience shows repeated instances where a fluorescent fixture ignited a wooden structural member.

Capacitors may be used with fluorescent lighting systems to correct low power factors (which may be as low as 0.5 lagging) caused by the inductive windings in electromagnetic ballasts. If capacitors are not constructed as part of a ballast, they may be connected across a circuit or system at some other point. Capacitors should be dry type. If fluid-filled capacitors must be used, they should be other than PCB type, and should be arranged with due consideration for the fluid. Article 460 in the NEC describes capacitor installation requirements.

Sometimes external fusing is provided for each fluorescent fixture. External fusing can help satisfy electrical coordination where only one device must be isolated. However, an external fuse is not the same as integral thermal protection. A fuse does not detect the temperature of a ballast, but only excessive current flow. Furthermore, fuses used for these applications must be slow acting and, to prevent nuisance outages, must be rated well above inrush starting currents. Since excess current is only one of the possible causes of component overheating, external fusing has only limited value in fire prevention.

A replacement ballast should match the appropriate voltage, wattage, and type of starting recommended by the manufacturer. It should be used only for the designated dc, 60 Hz, or 50 Hz application. Ballast and fixture selection should assess environmental conditions including temperature, corrosiveness, and humidity. Identical ballasts exposed to the same operating conditions and in the same branch circuit will have similar service lifespans. Replacing entire groups of ballasts or fixtures is one loss control technique.

Environmental Considerations

Identifying specific local and national regulations is beyond the scope of this document. Materials which could be of concern include PCBs, mercury, mercury vapor, and phosphor coatings. Responsibly handling and disposing of these materials requires knowing what the materials consist of and developing and documenting safe procedures.

The following information about usage and disposal may be helpful:

Usage: In the U.S., federal energy legislation enacted in 1992 narrows the options for maintaining existing systems and selecting new systems. Many lamps used today will no longer be manufactured once the 3-year production phase-out is complete. In general, users might have to replace fixtures and ballasts and rewire lighting circuits in response to the requirement to use lamps meeting the new color rendering and lighting efficiency standards. The new premium efficiency ballasts have twice the life expectancy of older types.

Disposal: The Environmental Protection Agency estimates 400 million ballasts are in use in the U.S. Many were manufactured before 1980 and contain polychlorinated biphenyls. Safe disposal may require that an EPA approved hazardous waste disposal company incinerate the materials. Similarly, the lamp or gas tube usually contains a small amount of mercury and mercury vapor. If the tube breaks, mercury can escape into the environment. In many countries, special handling and disposal precautions are necessary for ballasts and lamps.