All electric discharge lamps are characterized as negative resistance light sources. Therefore, they require support devices that limit the current when voltage is applied, to prevent the lamp from being destroyed. The ballast is the device limiting the current capability.

Additionally, the ballast provides the lamp with proper voltage to reliably start and operate the lamp throughout its rated service life. A transformer integral to the ballast circuit matches voltage required for the lamp to the available supply voltage.

Fluorescent and HID lamps exhibit several electrical characteristics that have important effects on ballasts. The following definitions will help explain those characteristics.

**Starting Voltage**
Fluorescent Rapid Start lamps contain cathodes which are preheated by the ballast. A variety of fluorescent rapid start ballasts are available to produce reliable starting for specific ambient temperatures. Mercury Vapor and most Metal Halide lamps incorporate integral starting electrodes which allow the lamps to start at relatively low voltages in ambient temperatures ranging above -20°F (-30°C). High Pressure Sodium and low wattage (less than 100 watts) Metal Halide lamps require separate electronic starting devices (called “ignitors”) which deliver a high voltage pulse to establish the arc. HPS will start reliably above -40°F (-40°C) ambient temperatures. The pulse repeats each cycle with a maximum pulse width of 15 microseconds. Once the lamp arc is established, the ignitor drops out of the circuit.

**Starting Current**
This is the initial current available to the lamp during warm-up. If the current is incorrect, the lamp may not start or reach its rated operating performance. Rated lamp life may be affected.

**Operating Current**
This is the rated current flow under nominal operating conditions once the lamp arc has been established and is performing at rated levels. The starting current may differ from the operating current. Care should be taken to load circuits to the highest load conditions (amperes). Normal power factor ballasts have higher starting currents than operating. Low wattage (100 watts or less) Metal Halide and HPS lamps have the highest current demand during restrike (hot start).

Fluorescent lamp operating voltage remains relatively constant throughout rated life. Lamp life, ballast life, and light output may be affected if the operating voltage varies significantly from the voltage specified for the ballast. In general, fluorescent ballasts should be operated within ±7½% of their rated voltage. Mercury Vapor and Metal Halide lamp operating voltage remains relatively constant throughout rated life, although lamp manufacturing tolerances can allow for as much as ±10% variance from nominal. As a result, depending on the type of ballast being used, HID lamp wattage may vary considerably. High Pressure Sodium lamp operating voltage rises continually from initial installation until end of life. HPS ballasts are designed to provide increased voltage requirement to the lamp through rated life. For example, a 400W HPS lamp normally starts at 100 volts and increases to 140 volts at end of life.

**Operating Wattage**
Fluorescent lamps operate at rated wattage if the supply voltage is nominal and the lamp is operating at an ambient temperature of 77°F (25°C). HID lamps operate at rated wattage only if the lamp voltage and supply voltage is nominal. Lamp wattage, light output, and lamp life may be affected if any conditions vary from nominal.

**Crest Factor**
This is the ratio of peak to RMS (root mean square) current. For example, the crest factor of a true sine wave form is 1.41. Lamp manufacturers' published data is based on lamps operated on a standard reactor ballast with a 1.41 crest factor. Input voltage to a commercial ballast is a sine wave, but the secondary voltage wave shape in the inductive and capacitive type ballast is distorted, and their crest factors are higher than 1.41. Tests indicate that ballasts with higher crest factors may result in depreciation of lumen output or reduced lamp life. In general, a maximum lamp current crest factor of 1.7 for fluorescent ballasts is recommended. HID constant-wattage and constant-wattage autotransformer ballasts have a crest factor of about 1.8. Metal Halide and HPS ballasts approach 1.65. HID lamp recommendations suggest a maximum crest factor of 2.0 for Mercury Vapor and 1.8 for Metal Halide and HPS.

**Power Factor**
Power factor (phase between voltage and current) is the ratio of line watts to line volts x line amps, expressed in a percentage. A high power factor (HPF) ballast must have a power factor of at least 90% at nominal line voltage and lamp voltage. In most cases, as the lamp and capacitors age, the power factor will drop below 90%. A normal power factor (NPF) ballast has a power factor below 90%, usually around 50%. NPF compact fluorescent ballasts can be as low as 28%. A normal power factor ballast has almost twice the line current as a high power factor ballast, thereby requiring larger wire sizes, breakers, switches, etc. for the equivalent connected load. Some power utilities may assess a penalty charge for inefficient use of power due to low power factor equipment.

**Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI)**
Electronic fluorescent ballasts generally operate at a frequency in excess of 20,000 hz to optimize lamp efficacy. Electronic ballasts may feed back interference into the power system resulting in interference with sensitive electronic equipment such as communications or data processing equipment. High quality electronic ballasts use filters and enclosures to reduce conducted and
radiated EMI to acceptable limits as specified by the Federal Communications Commission (FCC).

Ballast Sound Ratings
Core and coil ballasts may produce a slight hum due to the magnetic action within the ballast. Fluorescent ballasts are sound rated by a letter code, A through D. An A sound rating is the quietest ballast and is typically recommended for commercial applications. Because solid state electronic ballasts do not contain a core and coil, they will generally operate quieter than magnetic ballasts.

Ballast Case Temperature
The ballast case temperature is affected by changes in ambient temperature and voltage increase. Fluorescent ballasts contain a Class P thermal switch which will disconnect the ballast if it exceeds 105°C. Excessive ambient temperature or voltage supply may significantly reduce the life of the ballast.

Harmonic Distortion
All ballasts generate harmonic currents of some magnitude in the electrical distribution system. The ratio of RMS (root mean square) harmonic current to the RMS fundamental current is the Total Harmonic Distortion or THD. THD is often used to assess the ability of a fluorescent electronic ballast to control harmonic currents. The proposed ANSI standard for electronic ballasts specifies a maximum THD of 32%. Conventional magnetic ballasts are generally in the range of 10% to 20%. Most hybrid electronic ballasts (containing both electronic and electromagnetic components) fall into the area of 20% to 30% THD. Solid-state electronic ballasts (containing virtually all electronic components) are usually less than 10%.

Ballast Regulation
This is the ability of a ballast to control lamp wattage when subjected to line voltage variation. Consideration should be given to line voltage variations expected on a given electrical system where HID lamps are used. Most new power distribution systems are designed to provide ±3% of nominal voltage. However, some systems, especially older ones, may have variances up to ±10% from nominal. Regulation characteristics for various ballast types are listed in the ballast data tables. Typically, the cost of a ballast rises with the degree of regulation available. The better the regulation, the higher the cost.

Primary Dropout Voltage
All power distribution systems experience dips and peaks in line voltage as well as other transient conditions. Well regulated systems seldom see voltage fluctuations of 20% or more. Be sure to check the primary dropout voltage rating on HID ballasts if voltage variations are of concern. Voltage dips in excess of this rating may cause the lamps to extinguish and recycle.