Flourescent Lamps
The fluorescent lamp produces light by the passage of an electric current flowing through a vapor of mercury.

1. Electron emitted from electrode collides with mercury atom.
2. Impact produces ultraviolet rays
3. Phosphor converts ultraviolet to visible light.

This process is known as “fluorescence,” hence the name fluorescent lamp.
THE ELEMENTS OF A FLUORESCENT LAMP

A fluorescent lamp contains the following basic elements:

- Bulb
- Base
- Electrodes
- Phosphors
- Gases
- Mercury
THE ELEMENTS OF A FLUORESCENT LAMP

THE BULB

• Most fluorescent lamps are made in straight tubular bulbs in various diameters.

• Circline lamps are in the form of a circle.

• U-Bent lamps are essentially straight lamps bent to form a U shape.
THE BASE
The base provides the means of holding the lamp firmly in the lamp holders or sockets and providing the electrical connections for the lamp/ballast circuit. The basic types are:

• **Bipin** – Used on preheat and rapid start lamps.

![Diagram of lamp base types]

- **Miniature**
  - T-5
- **Medium**
  - T-8/T-12
THE ELEMENTS OF A FLUORESCENT LAMP

• **Single Pin** – Used on slimline lamps.

![Single Pin](image)

T-8/T-12

• **Recessed Double Contact** – Used on HO and VHO lamps.

![Recessed Double Contact](image)

T-8/T-12
THE ELEMENTS OF A FLUORESCENT LAMP

PHYSICAL DIMENSIONS
The significant dimensions of fluorescent lamps are:
• Bulb diameter
• Nominal overall length

Bulb Diameter – Expressed in eighths of an inch.

Diameter = 12 \( \div 8 = 1 \frac{1}{2} \) inches
THE ELEMENTS OF A FLUORESCENT LAMP

Nominal Length – Unique to fluorescent lamps.

• Straight Lamps – Measured from the back of one socket or lampholder to the back of the other socket. Pin to Pin.
THE ELEMENTS OF A FLUORESCENT LAMP

- **U-Bent Lamps** – Measured from the back of the socket to top of the lamp.

- **Circline Lamps** – Measured from the outside diameter of the lamp.
THE ELEMENTS OF A FLUORESCENT LAMP

THE ELECTRODES

• Coiled tungsten wires coated with an emission material
• When heated, emit electrons
• Electrons bombard mercury atoms producing ultraviolet rays.

THE PHOSPHORS

Phosphors are the coated powders on the inside of the bulb that convert the ultraviolet rays to visible light. There are two basic types:

• Halophosphates
• Trichromatics or Triband Phosphors
Halophosphates

- Single phosphor, or a blend of two or more phosphors
- Produce wide bands of light
Trichromatics or Triband phosphors

- Blend of three, or more, rare earth phosphors.
- Each phosphor produces a narrow band of light – one blue, one green, one red.
- In combination, these phosphors produce a highly efficient white light with excellent color rendition.
- By changing the proportion of the phosphor blend, any color temperature can be obtained.
Color temperature is a characteristic of visible light that has important applications in photography, videography, publishing and other fields. The color temperature of a light source is determined by comparing its chromaticity with a theoretical, heated black-body radiator. The temperature (in kelvin) at which the heated black-body radiator matches the color of the light source is that source's color temperature; for a black body source, it is directly related to Planck's law.
THE ELEMENTS OF A FLUORESCENT LAMP

Special phosphor applications
• Growing plants
• Aquariums
• Diazol printing
• Phototherapy treatment of jaundice in newborn infants
• Black light
THE GASES

In the manufacturing process, all the air in a fluorescent is removed, and the lamp filled with a small amount of gas. The gas affects the lamp’s starting and operating characteristics.

• Argon is most commonly used in the US
• A blend of Krypton and Argon is commonly used in Europe as well as US energy saving fluorescent lamps
• A blend of Xenon, Krypton and Argon is used in European energy saving lamps.
All fluorescent lamps require a ballast for starting and operation. The ballast has two basic functions:

• Limit the lamp’s operating current
• Provide the required voltage to start the lamp

**LIMITING THE CURRENT**

• When a fluorescent lamp is started, its resistance to the current flow decreases dramatically.
• If not controlled, the current would increase rapidly and destroy the lamp virtually instantaneously.
• The ballast limits the current.
BALLASTS

STARTING VOLTAGE

- Each lamp type has a specific voltage required to start it.
- If the supply voltage is not sufficient to start the lamp, the ballast also contains a device to provide the required starting voltage.

BALLAST ARE OF TWO BASIC TYPES:

- Electromagnetic
- Electronic
**Electromagnetic Ballasts**

- The current lighting device is a reactor.

Supply voltage sufficient to start the lamp
- The starting voltage device is an auto transformer.

Supply voltage insufficient to start the lamp
- Operate the lamps at 50/60 Hertz
Electronic Ballasts

- Both starting and current limiting functions are provided by electronic components.
- Operate the lamp at 20kHz or greater.
LAMP TYPES AND THEIR OPERATING CIRCUITS

PREHEAT LAMPS

• Have bi-pin bases
• Utilize a starter circuit that preheats the electrodes before lamp starting
• Starts within 2 – 3 seconds
The Preheating Cycle

Switch Open:
• No current flows through the lamp
• Supply voltage insufficient to strike the arc
LAMP TYPES AND THEIR OPERATING CIRCUITS

Switch Closed:
• Current flows through each electrode
• Ends of lamp glow
Switch Open:
- Arc strikes
- Current flows through the lamp

The switch in the starting circuit can be:
- A manual switch
- An automatic starter
LAMP TYPES AND THEIR OPERATING CIRCUITS

**Manual switch**
- Held down for preheating
- Released to start the lamp
- Used in desk lamps, under-counter fixtures and other applications

**Automatic starter**
- Contains a glow switch
- Closes and opens automatically
RAPID START LAMPS

- Have bi-pin bases
- Cathodes are continually heated by low voltage transformers in the ballast
- Starting voltage between that of preheat and instant start
- Lamps start rapidly in one to two seconds
LAMP TYPES AND OPERATING CIRCUITS

THE SLIMLINE LAMPS

• Have single pin bases

• Lamps start instantly

• Ballasts provides high voltage
LAMP TYPES AND PHOSPHORS

FLUORESCENT LAMP PHOSPHORS
The phosphor powder determines the performance characteristic of the light output of a lamp.

• Lumens
• Lumen maintenance
• Color Temperature (K)
• Color Rendering Index (CRI)

Lumens
A measure of the rated light output of a lamp.

% Lumen Maintenance
A measure of the average lumen output of a lamp over its rated life
LAMP TYPES AND PHOSPHORS

Color Temperature (K)
• Describes the color appearance of the lighted lamp
• Describes the environment that will be created in a room or space
• 3000K – creates a warm, friendly environment similar to that of incandescent
• 3500K – creates a neutral environment
• 4100K – creates a cool, airy environment
• 5000K – creates an environment similar to daylight

Color Rendering Index (CRI)
• Describes how colors appear when lighted by the lamp
• An average measure of the relative ability of a lamp to match the color rendering of a standard illuminant
The significant operating characteristics of fluorescent lamps are:

- Rated life and mortality
- Life vs. burning cycle
- Efficacy vs. frequency
- Lumen maintenance
- Effect of humidity
- Effect of temperature
SYLVANIA-SLI T5 LAMPS

T5 LAMPS

• T5 bulb
• 60% thinner that T-12 bulb
• Trichromatic phosphor blend
• 85 Cri
• Color temperatures: 3000K, 3500K, 4100K, 5000K
• Efficacy up to 104 LPW – Best
• 97% lumen maintenance – Best
• 24,000+ hours life
• Requires ballasts designed to operate T-5 lamps. Pre-programmed or instant start
ECO-LINE LAMP TECHNOLOGY

- Significant reduction in the amount of mercury in the lamp
- Pass EPA test for hazardous waste – TCLP compliant
- Open lamp disposal options
- No change in lamp performance

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<th>700 series</th>
<th>800 series</th>
<th>T8 energy saving</th>
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<td>79</td>
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</table>
RATED LIFE AND MORTALITY

As with incandescent lamps, rated hours life refers to the average life of a large group of lamps operated under specified conditions.

Some lamps will fail before their rated life, others will still be burning beyond their rated life.

In general, 50% of a large group of lamps will fail by the time rated life is reached.
OPERATING CHARACTERISTICS

LIFE vs. BURNING CYCLE

• The life of a fluorescent lamp is affected by the number of times it is started.
• Rated published life values are determined by testing lamps on a burning cycle of 3 hours per start.
• Longer burning cycles increase lamp life and varies with the lamp type.
EFFICACY vs. FREQUENCY

- Efficacy of a fluorescent lamp increases with frequency

- At 20,000 cycles per second, a lamp produces approximately 10% - 20% more light than it does at 60 cycles operating at the same wattage.

- Most electric ballasts operate lamps at approximately 20,000 cycles. They trade the higher lumen output for lower input wattage.
OPERATING CHARACTERISTICS

LUMEN MAINTENANCE

• As fluorescent lamps accumulate burning hours, their light output decreases.
• This depreciation is due chiefly to a gradual deterioration of the phosphor powders.
• Lumen maintenance varies with the phosphor types.
EFFECTS OF HUMIDITY

• In a moist atmosphere, water can cling to the outside of a lamp.
• The moisture forms a conductive path, which results in erratic lamp starting.
• Rapid start and instant start lamps are coated with silicone to prevent the moisture from forming a continuous path.
OPERATING CHARACTERISTICS

EFFECTS OF TEMPERATURE

The starting and light output of fluorescent lamps are affected by the surrounding air temperature.

Starting:

• Most ballasts will start standard lamps down to 50°F and Econ-o-watt lamps down to 60°F.
• Special electromagnetic ballast for standard rapid start lamps will start lamps down to 0°F.
• Lead-lag electromagnetic ballasts will start slimline lamps down to 0°F.
• Special electromagnetic and electronic ballasts will start HO lamps down to -20°F.
Light Output:

- Most fluorescent lamps product their peak output at approximately 77°F.
- VHO-O lamps peak at approximately 20°F.
- VHO-O jacketed lamps peak at approximately -20°F.
MAINTENANCE HINTS

The following will service as a guide in recognizing common operating conditions or problems.

End Discoloration

- **Spotting** is normal and may develop during life. No effect on lamp performance.
- **End banding** is normal and may develop gradually during lamp life. No effect on lamp performance.
- **Blackening** may occur at end of life, or in rapid start lamps operating with no cathode heat.
MAINTENANCE HINTS

Persistent Tendency to Flicker
• Econ-o-watt lamps
• Cold drafts hitting the lamp or low temperature
• Econ-o-watt lamps should be operated in temperatures below 60°F.

Radio Frequency Interference
• Fluorescent lamps generate low power electromagnetic radiation.
• The radiation can cause a buzzing sound in AM radios.
• The radiation can be direct from the lamp, or by feedback into the electric supply circuit.
• The direct radiation can be eliminated by moving the radio out of range of the lamp.
• The feedback radiation is usually eliminated by capacitors in the ballast or starter.
Electromagnetic Interference (EMI)

- Electronic ballasts operate at high frequency and generate EMI.
- The interference may feed back into the power system and affect operation of data processing and communication equipment.
- Electronic ballasts must meet standards set by the Federal Communications Commission (FCC).
QUESTIONNAIRE

Instruction: Answers to the following questions can be found the in the text of this module.

1. In fluorescent lamps, light is produced by the following process: (check all that are correct)
   A. ☐ Electrons emitted from the electrode collide with mercury atoms.
   B. ☐ The collisions produce ultraviolet rays
   C. ☐ The phosphor converts the ultraviolet to visible light
   D. ☐ The phosphor also determines the rated life of the lamp

2. Recessed double contact bases are used on T-12 slimline lamps.
   ☐ True ☐ False
3. The nominal length of a fluorescent indicates the length: (check all that are correct)
   A. ☐ From the end of one pin to the end of the opposite pin for slimline lamps
   B. ☐ From the face of one base to the face of the opposite base for bipin lamps
   C. ☐ From the back of one socket to the back of the other socket.
   D. ☐ All of the above

4. Trichromatic phosphors in fluorescent lamps: (check all that are correct)
   A. ☐ Are a blend of three phosphors
   B. ☐ Produce a highly efficient white light with excellent color rendition
   C. ☐ Can be blended to produce any color temperature
   D. ☐ Produce wide bands of blue, green, and red light
5. A feature of T12 Energy saving lamps is the gas mixture, a blend of Argon and Krypton.
   - [ ] True
   - [ ] False

6. All electromagnetic ballasts contain an autotransformer to provide the required voltage to start the lamp.
   - [ ] True
   - [ ] False

7. Electronic ballasts are different from electromagnetic ballasts in that:
   - [ ] A. They do not need a current limiting circuit
   - [ ] B. The contain a manual starting switch
   - [ ] C. The operate lamps at approximately 20,000 Hertz or higher
   - [ ] D. All of the above
8. **Fluorescent lamps operate on a variety of circuits.** (Check all that are correct):
   - ☐ Preheat lamps require a starter, either manual or automatic
   - ☐ Slimline lamps operate on ballasts that provide voltage for instant starting
   - ☐ HO and VHO lamps are operate on instant start circuits.
   - ☐ Rapid start ballasts contain low voltage transformers to heat the lamp electrodes

9. **Econ-o-watt lamps are interchangeable with standard lamps, operate at 15 to 20% lower wattage with no loss in light output.**
   - ☐ True
   - ☐ False
10. The color temperature of a fluorescent lamp describes the environment that will be created in a room or space. For example: (Check all that are correct):
   A. ☐ 3000K creates a warm, friendly environment similar to incandescent
   B. ☐ 3500K creates a neutral environment
   C. ☐ 4100K creates a cool, airy environment
   D. ☐ 5000K creates an environment similar to daylight

11. Color Rendering Index (CRI) provides a measure of how colors appear when lighted by a lamp.
   ☐ True ☐ False
12. 700 series T8 lamps have the following features: (Check all that are correct):

- ☐ Contain trichromatic/triband phosphors
- ☐ T-8 bulb
- ☐ CRI of 75
- ☐ Are interchangeable with T-12 lamps, operate on the same ballasts

13. ECO-LINE lamp technology provides the following end-user benefits:

- ☐ A significant reduction in the amount of mercury in the lamp
- ☐ Pass EP test for hazardous waste
- ☐ Same performance characteristics as standard lamps
- ☐ All of the above
14. The life of F32T8 rapid start lamps operating at 16 hours per start is approximately:
   A. ☐ 18,000 hours
   B. ☐ 24,000 hours
   C. ☐ 26,000 hours
   D. ☐ 32,000 hours

15. All fluorescent lamps are coated with silicone to prevent moisture from collecting on the bulb, which results in erratic starting.
   ☐ True    ☐ False
16. The light output of fluorescent lamps is affected by the surrounding air temperature. The peak light output for VHO-O lamps occurs at approximately:

16. □ -20°C
17. □ 0°C
18. □ 20°C
19. □ 32,000 hours

The lamp ordering code F32T8/841 should be used in answering questions 18 through 20.

17. The letter “F” stands for:

A. □ Four feet
B. □ Formerly
C. □ Fluorescent
D. □ All of the above
18. The number “32” stands for:
   18. A.  ☐ Nominal length               C.  ☐ Rated wattage
   19.  ☐ Nominal wattage               D.  ☐ None of the above
19. The number “841” indicate the lamp’s color temperature:
   18. True               ☐ False
20. The letters “RS” stand for:
   18. A.  ☐ Rough Service               C.  ☐ Power-saving
   19.  ☐ Rapid start operation only     D.  ☐ None of the above