Mercury-Free Lighting: The Pros and Cons

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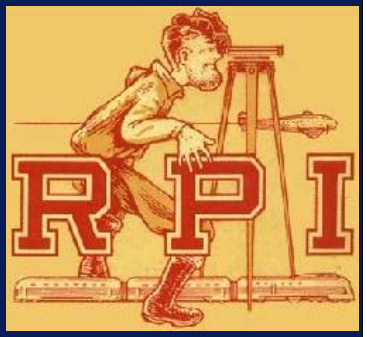
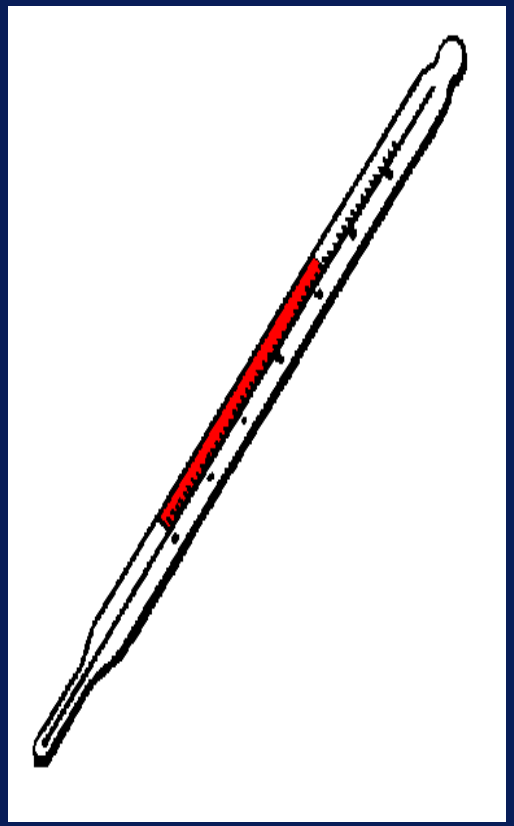


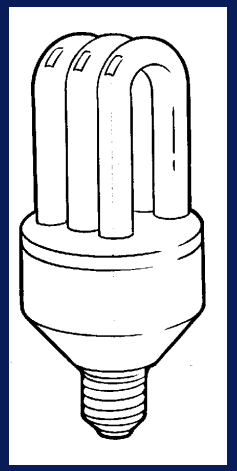
Mercury in Light Sources

- Many light sources contain mercury (Hg) as a primary component of light generation
- Pessimism among many in the lighting industry about whether mercury in discharge lamps is replaceable
- Distinction between mercury in lamp and mercury contributed to environment by generation of electricity

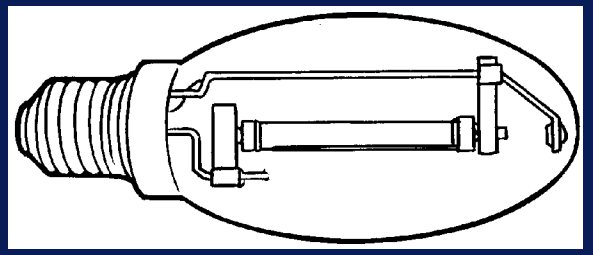


General Lighting Sources Containing Mercury

- **Fluorescent lamps**



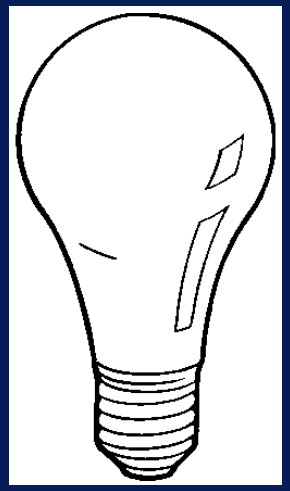
- **High intensity discharge lamps**
  - mercury vapor
  - high pressure sodium
  - metal halide



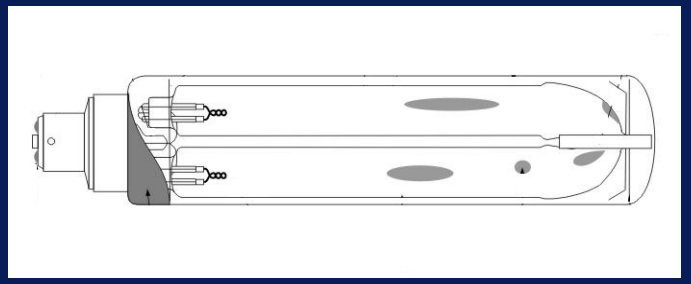
- Alternatives include existing and "in-development" technologies

Alternatives to Hg-Containing Lamps: General Lighting

- **Incandescent**
  - Pros: Inexpensive, widely available
  - Cons: Low efficacy, short life

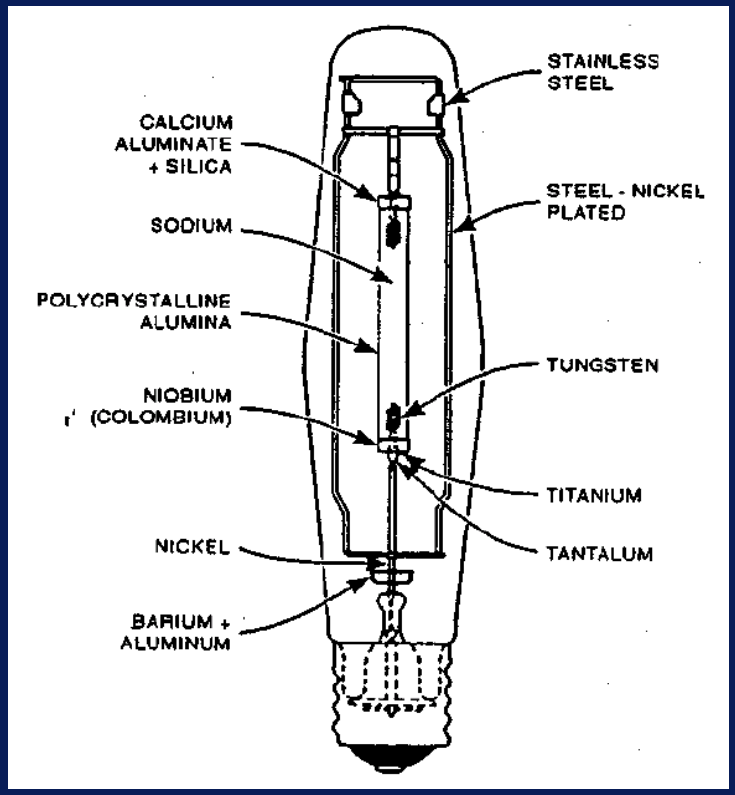


- **Low pressure sodium**
  - Pros: High efficacy
  - Cons: Poor (nonexistent) color rendering



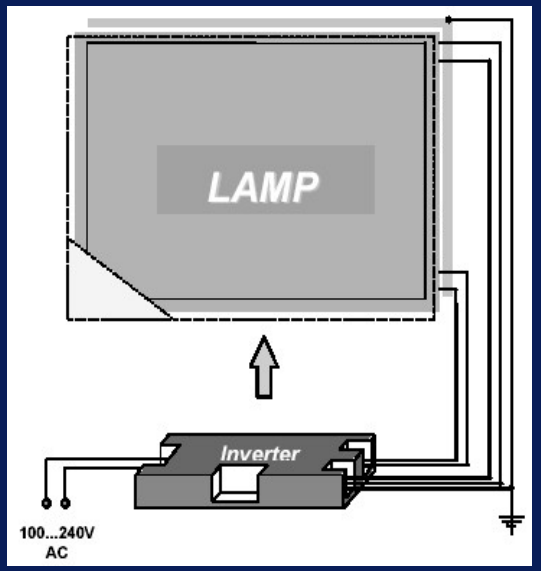
Alternatives to Hg-Containing Lamps: General Lighting (cont'd.)

- **Hg-free high pressure sodium** (<= 150 W)
  - Pros: High efficacy
  - Cons: Higher wattages unavailable, slightly lower efficacy than conventional HPS



Hg-Free Alternatives: Not Yet Used for General Lighting

- **Xenon barrier discharge** used for display backlighting
  - Pros: uniform luminous appearance, long life
  - Cons: planar shape* (rather than tubular), low efficacy



**tubular discharge lamps are becoming available for architectural applications*

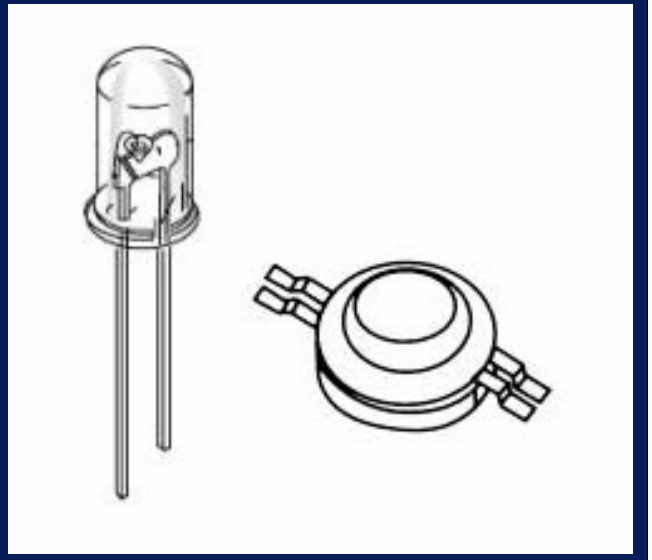
Hg-Free Alternatives: Not Yet Used for General Lighting (cont'd.)

- **Field emission display** devices used for displays
  - Pros: uniform luminous appearance, large color gamut
  - Cons: very high voltage required, planar shape

Hg-Free Alternatives: Not Yet Used for General Lighting (cont'd.)

- **Light emitting diodes** (LEDs)
  - Pros: "long" operating life, many colors available
  - Cons: small lumen packages* available (120 lm max. for 5-W device), relatively low efficacy

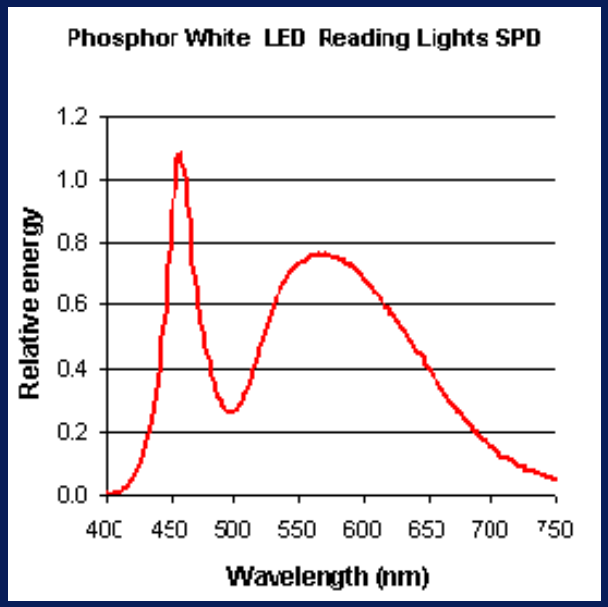
**32-W T8 fluorescent lamp, approx. 3000 lm*

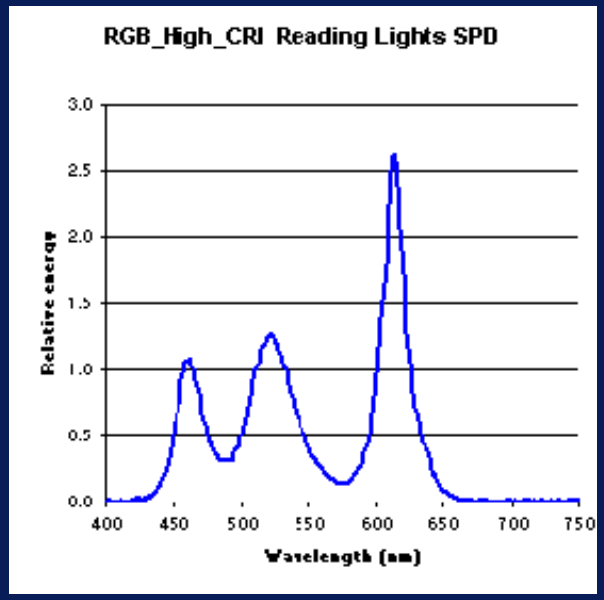


left: 5-mm indicator
right: high-flux LED

White Light LEDs

- Two approaches: blue+phosphor and red/green/blue (RGB) mixture

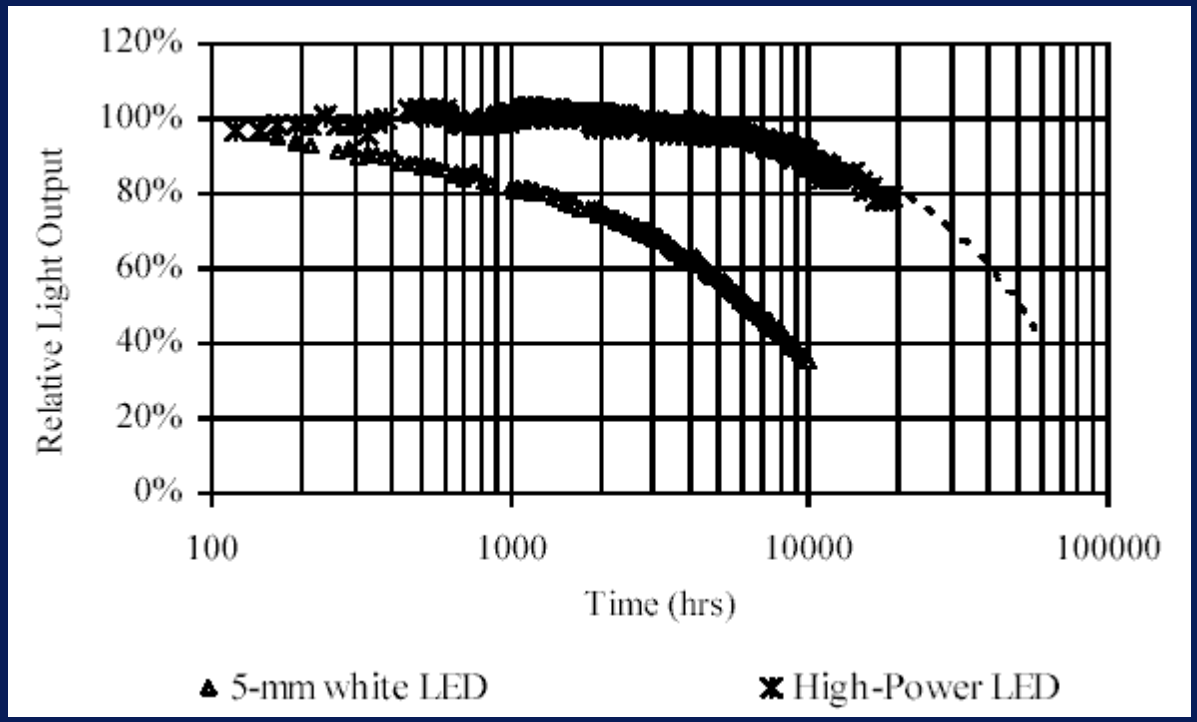




- Phosphor: single package, lower efficacy
- RGB mixed: higher efficacy, mixed array needed

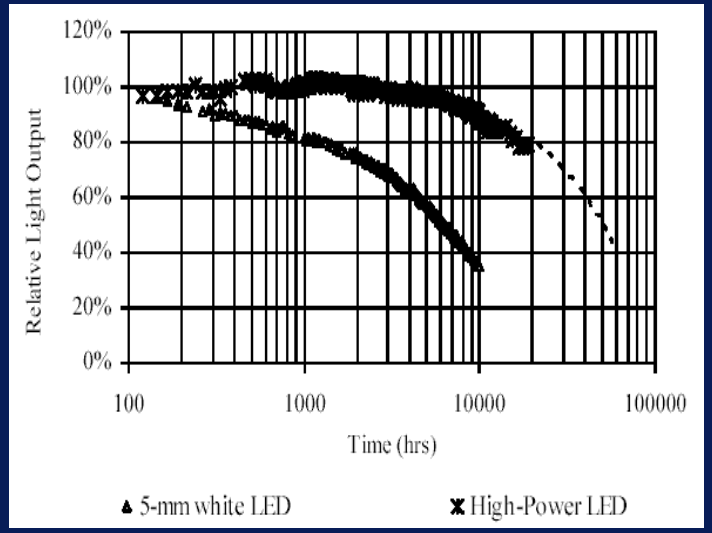
What is "useful" life?

- Component life can be 100,000+ hours (20,000-30,000 for linear fluorescent) but all LEDs experience lumen depreciation, depending on package

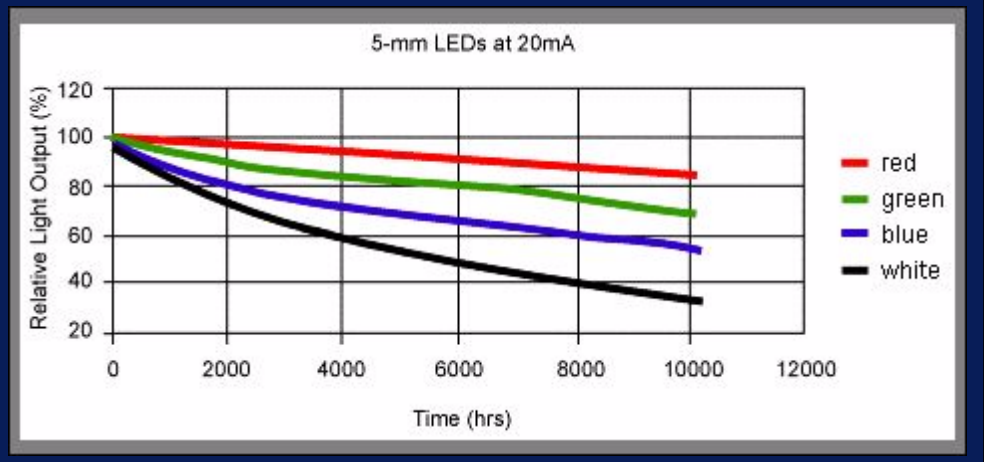


Barriers to LED Lighting

- Temperature dependence (different for each color) - heat sinking very important



- Different long-term degradation characteristics for each color



Forthcoming LED Lighting Applications

- Task lighting
- Outdoor low-level path lighting
- Indicator/wayfinding
- General lighting?
  Maybe in 10+ years...

www.lrc.rpi.edu/programs/solidstate
www.lrc.rpi.edu/ltgtrans/led
www.lrc.rpi.edu/programs/nlpip/lightinganswers/led

Alternatives to Hg-Containing Lamps: Not (Yet) Available

- **Sulfur discharge lamp**
  - Pros: broad spectral power distribution, relatively long life
  - Cons: not presently available, magnetron needed to operate, excessive lumen package is impractical, requires air cooling, "minty green"

Alternatives to Hg-Containing Lamps: Not (Yet) Available (cont'd.)

- **Zinc-based metal halides** in development for automobiles
  - Pros: efficacy and color parameters near those of conventional metal halide (MH)
  - Cons: zinc-quartz reactions dramatically shorten life
- Other MH lamp materials are under investigation

Luminous Efficacy/Life

Fluorescent	90-100 lm/W	20-30,000 hr
MH	90-100 lm/W	15-20,000 hr
HPS	100-120 lm/W	24,000+ hr
Incandescent	15-20 lm/W	1,000 hr
LPS	180 lm/W	16-20,000 hr
Hg-free HPS	90-110 lm/W	24,000 hr
Xe barrier/Field emiss.	30 lm/W	50,000+ hr?
LED	20-40 lm/W	20,000 hr?*
Sulfur	70-80 lm/W	15-20,000 hr**
Zn, other Hg-free MH	70-80 lm/W	too short (so far)

*"useful" life - to 80% light output

**magnetron life

Prospects for Hg-Free Lighting

- Currently available general lighting technologies are less than ideal
  - possible exception: low-wattage HPS?
- Closest to Hg-free seem to be HID family (HPS and MH)
- Nothing on the horizon approaches output, efficiency of linear fluorescent