Session 15 – Lighting Fundamentals

SOURCE IEx

Illumination Levels - Example

Location	fouling factor
Plant areas (both indoor and outdoor):	0.80
Non-plant areas (outdoor):	0.80
Non-plant areas (indoors):	0.85

REQUIRED ILLUMINATION LEVELS

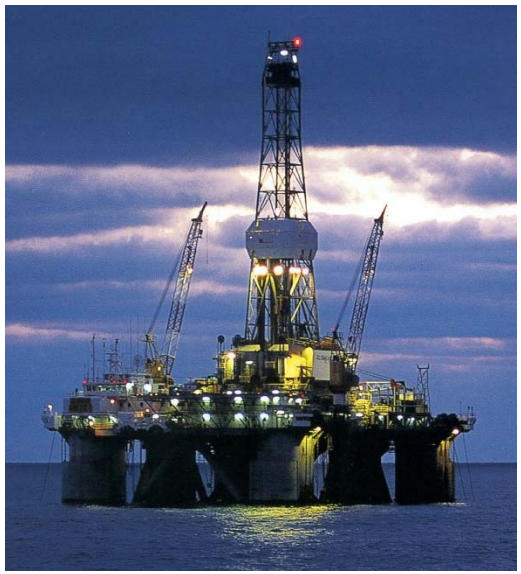
Location		Lux	Notes
CONTROL ROOMS			
General, including front of panel		300/500	1, 7
Rear of panels		150	
Auxiliary rooms		150/300	2
Outside, near entrances		150	
PLANT AREAS			
Operating areas requiring regular operator intervention	pumps, compressors, generators, drivers, valves, manifolds, loading arms, etc.	150	3
Local control and monitoring points	indicating instruments, gauges and control devices	75	
Level gauges (see-through) to be lit from behind by single tube fluorescent luminaires			
Access ways:	walkways, platforms, stairways, ladders, module roofs (offshore)	25	
Plant and jetty approaches and road intersections		5	
Non-operational areas with limited attendance, e.g. tank farms without equipment requiring regular operator intervention.		0.5	
Loading gantries:	top loading, walkways and top of tankers	150	
	bottom loading (coupling handling area)	150	
Road tanker parking area		25	

SOURCE IEx

Illumination Levels – (Cont.)

Location		Lux	Notes
NON-PLANT AREAS			
Switchrooms, including relay and auxiliary rooms		150	
Workshops and garages	indoor general	250	3
	local on workbenches and machine tools	400	4
	outdoor storage and handling areas	50	
Warehouses and stores	indoor between storage racks	150	
	bulk storage	50	
	outdoor storage areas	5	
Laboratories and analyser rooms		400	
Street lighting and fence lighting	Lit by twin 40 W fluorescent or single 70 W HP sodium (SON) luminaires on standard 8 m poles at, typically, 50 m centres		5, 6
NON-INDUSTRIAL AREAS			
Canteens (dining areas)		100	
Car parks		1	
Catering areas (food preparation and serving)		300	
Communications rooms		400	
Computer rooms		400	7
Conference rooms		400	
Corridors and stairways		100	
Drawing offices		400	7, 8
First aid rooms		400	
Libraries and reading rooms		400	
Lifts		100	
Offices		400	
Plant rooms		150	
Print rooms		250	
Reception areas		150-400	
Recreation rooms and lounges		300	
Store rooms		150	
Toilets and locker rooms		100	

Lighting Sources in the International World



- **Incandescent:** -40° C (-40° F)
- **Fluorescent:** -20° C (-4° F) minimum starting temp.
  - Luminous intensity less than 10% @ -20° C
  - Low temperature Lamps provide -40° C (-40° F)
- **Inductive Lamp:** -80° C
  - instant light with 100,000 hr. lamp life
  - Available in 55, 85 and 125 watt units
- **High Pressure Sodium:** -50° C (-58° F)
  - Full luminous intensity over temperature range
  - **Dual Arc Tube versions**

    instant light when power is reapplied

    extremely long rated life up to 55,000 hours
- **LED** - -40°C
  - Very energy efficient and long life up to 70,000 hours. Typical LED provides a seven time efficiency vs. Fluorscent lamps

Why so much use of Fluorescent lighting in the International world…

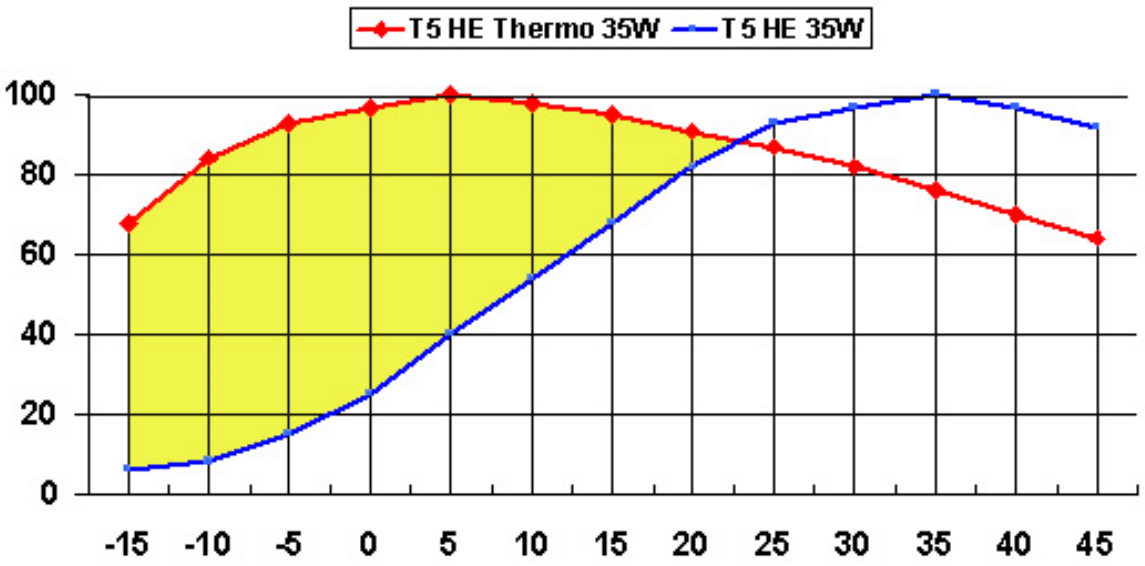
HID Lamp technology much better in US than Europe

- Lower mounting heights due to space restrictions & limitations in Europe vs. US
- Intermediate T rating issue
- Enclosed and Casketed not approved protection
- Zone 2 only recently expanded and products approved
- Ex ‘nR’ recently introduced
- Lamp standardization
- Quality of light issues
- Lower overall Lux requirements
- Better technology with Fluorescents (-30^{o} C ratings)

… It all adds up to more fluorescents

Lumen output of Traditional Fluorescent vs. cold temperature versions

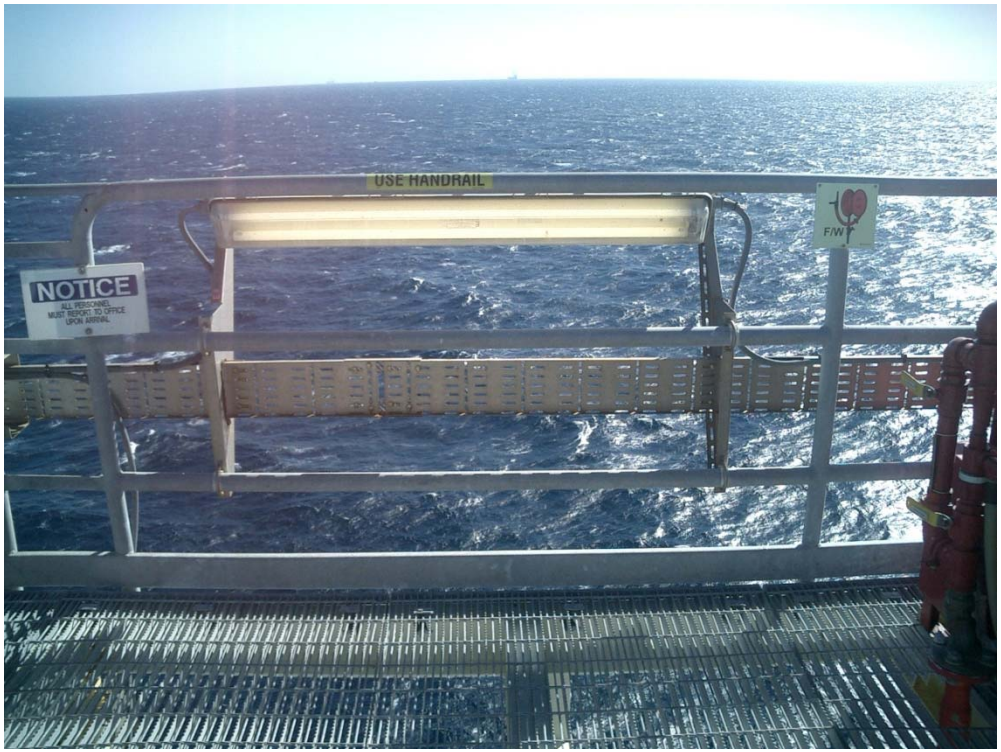
Traditional fluorescents provide little or no light at ambients below 15˚C where specialized lamps can provide better illumination at colder temperatures.



Typical lighting installations

The use of fluorescent lamp technology even for high mounting requirements is fairly common in the European market. Long life fluorescent lamps with lamp life up to 80,000 hours is typically used in areas where quality of light and accessibility is important…

Support Systems Installation
Lighting Examples

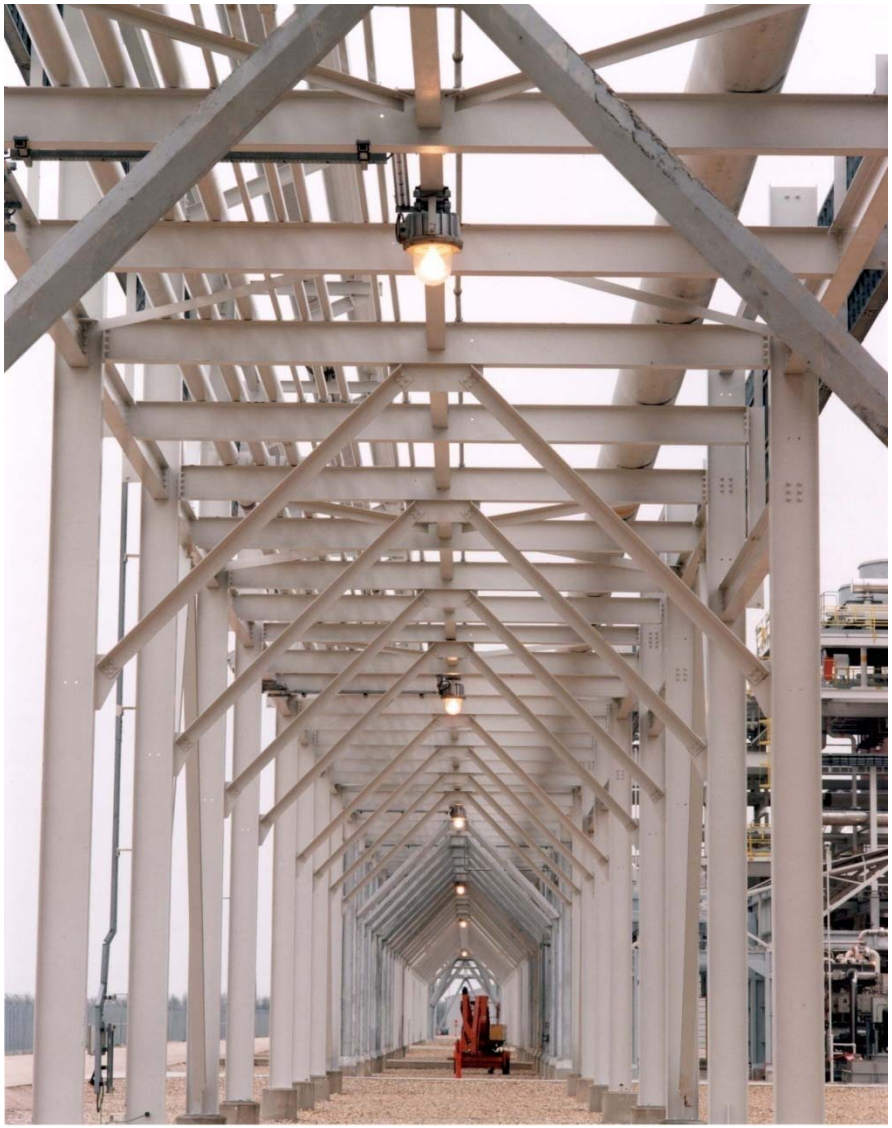


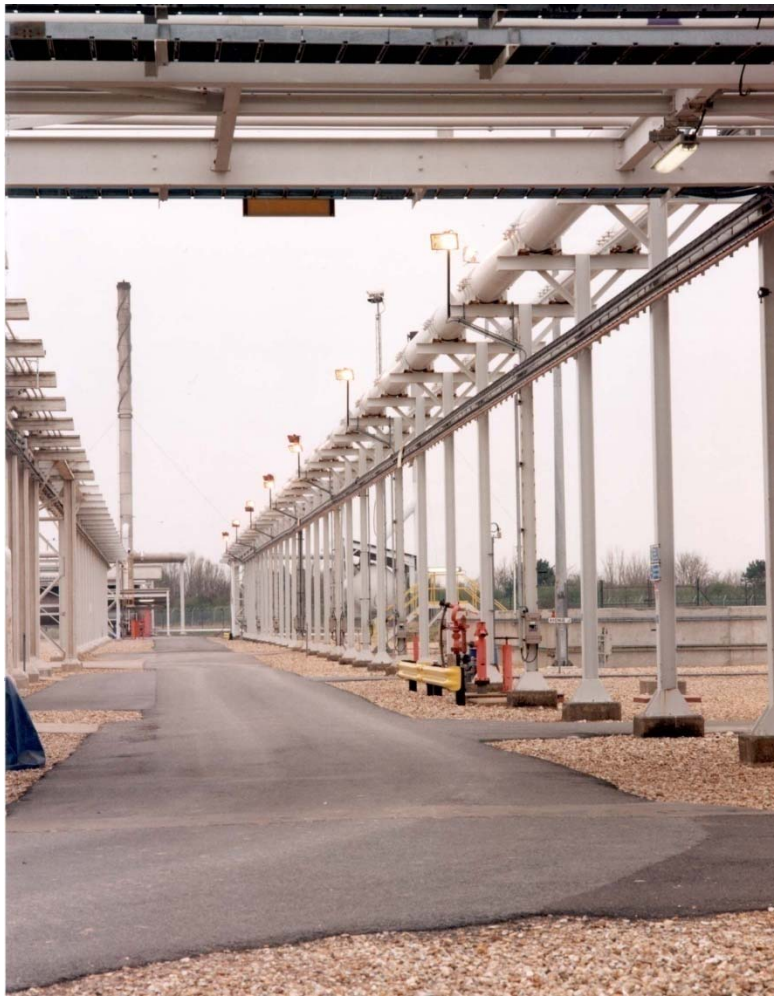
Typical lighting installations

Fluorescent lamps used on long linear spans for even distribution of lighting and reduction of glare with HID light sources

Typical lighting installations

Common use of HID lighting is to use a reflector lamp for high mounting applications



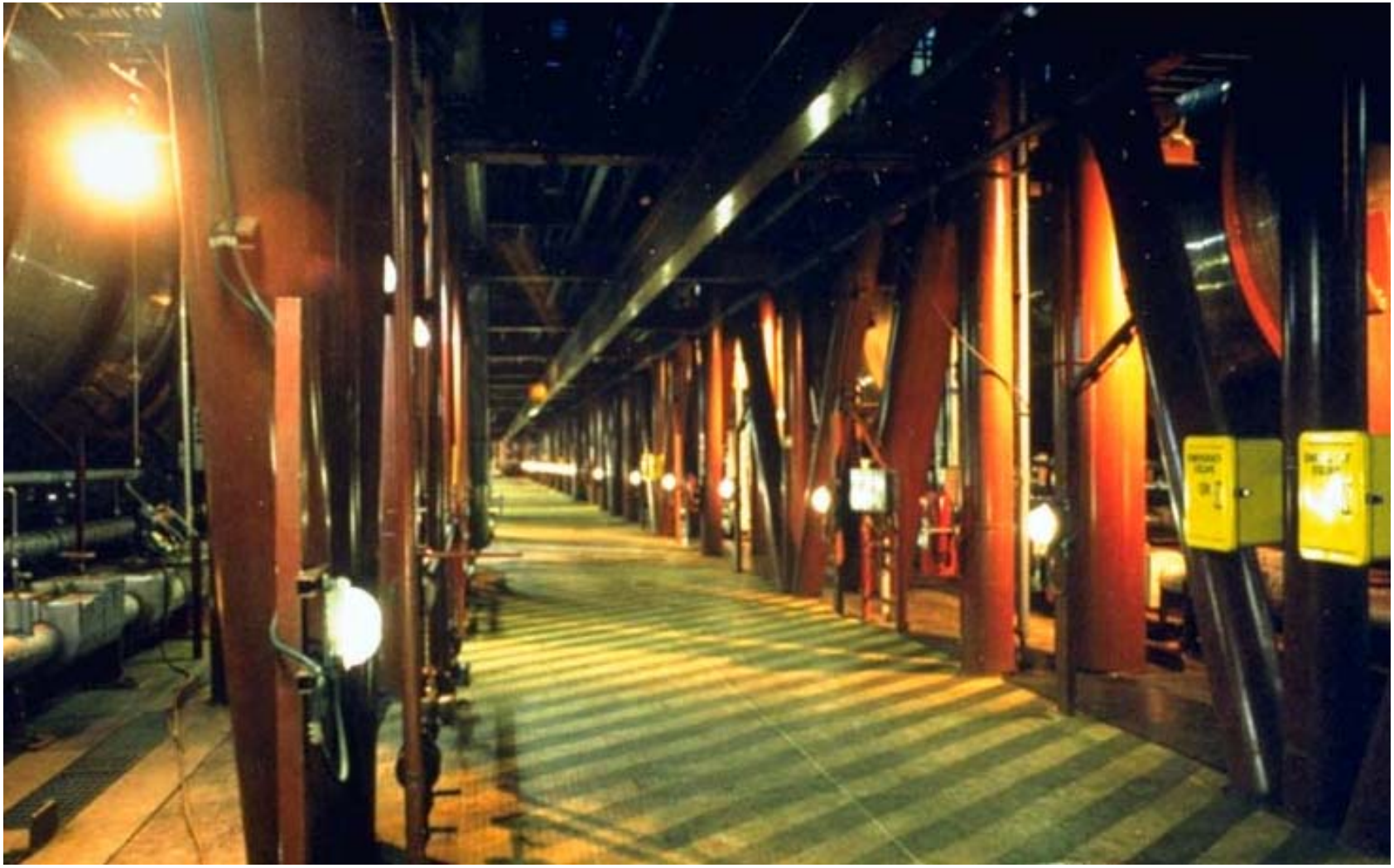


Typical lighting installations

Although not as frequently used today, still some offshore designs with high wattage HID light fixtures use remote ballasts for ease of maintenance and to prolong the ballast life.

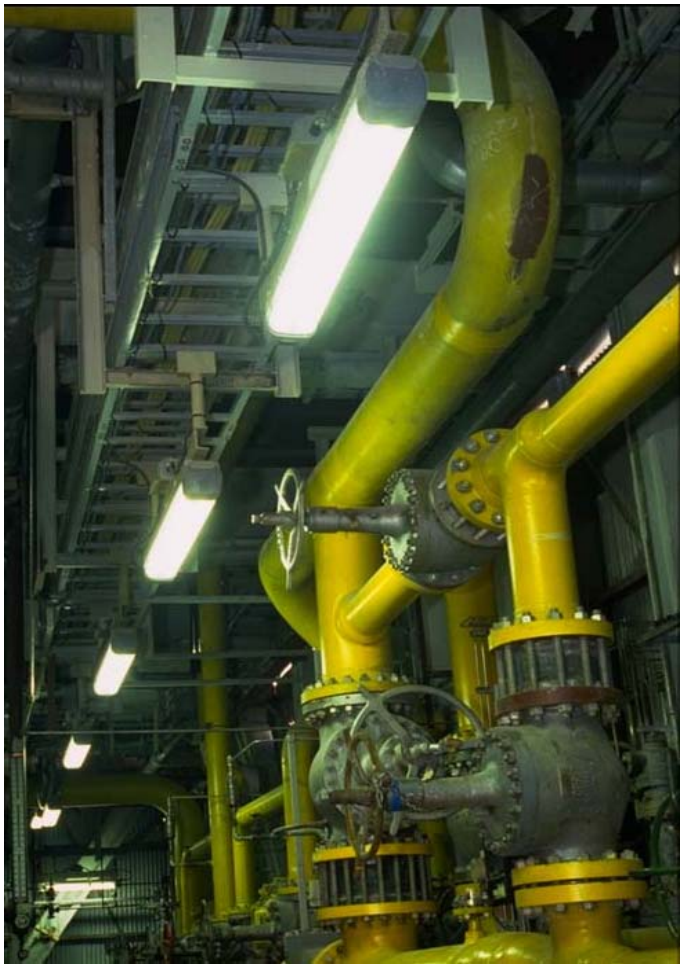
Typical lighting installations

Combining the use of HID and fluorescents for normal lighting is and has been a common installation practice. The HID lighting shown in the picture is rated Zone 2 while the fluorescent bulkhead fixtures below are rated Zone 1.



Typical lighting installations

The use of HID or Fluorescents is a decision usually based upon previous engineering installations. Both products are suitable but each have advantages and disadvantages….



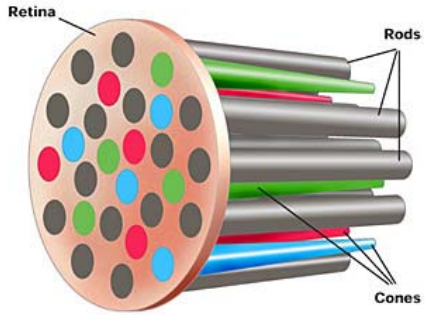
LED Technology – Understanding Scotopic vs. Photopic Lumen Output

54W LED bulb on the left vs. 250W HPS bulb on the right….

Why do we ‘feel’ that we have the same amount of usable light on the left using LED technology vs. higher wattage HID lamp sources?

LED Technology – Understanding Scotopic vs. Photopic Lumen Output

- Our eyes have two types of photoreceptors, cones and rods
- **Cone** light receptors control **photopic vision**, the scientific term for color detection in high light – Sensitive to red, blue and green in high light
- Rods control **scotopic vision**, the scientific term for visual perception in dim light – Sensitive to blue and responsible for opening/closing the puple.
- These descriptions over-simplify how cones and rods create our vision. Rods, specifically, are widely thought to only be important for night vision, when in actuality they contribute largely to vision behavior at various light levels. There are a range of light levels called the **mesopic region**, where both rods and cones affect the human visual system.



LED Technology – Understanding Scotopic vs. Photopic Lumen Output

- The rods control of pupil size significantly influences vision; smaller pupils improve your depth of view, provide better acuity, and allow a higher quality in vision at certain light levels and color temperatures (Kelvin) illuminating the eyes.
- Unfortunately, most lighting practitioners crank up the light levels to reduce pupil size, which only wastes energy, adds glare and creates headaches for the onlooker.
- Instead, the best way to reduce pupil size is to increase the color temperature, not increase the light level. **The higher the color temperature, the more the lighting is scotopically elevated**, or contributing to more rod activation. This is proven by studies that show subjects choose the scotopically enhanced light as brighter than a photopically enhanced light, even though the light level is measured 30% lower by the light meter.

LED Technology – Understanding Scotopic vs. Photopic Lumen Output

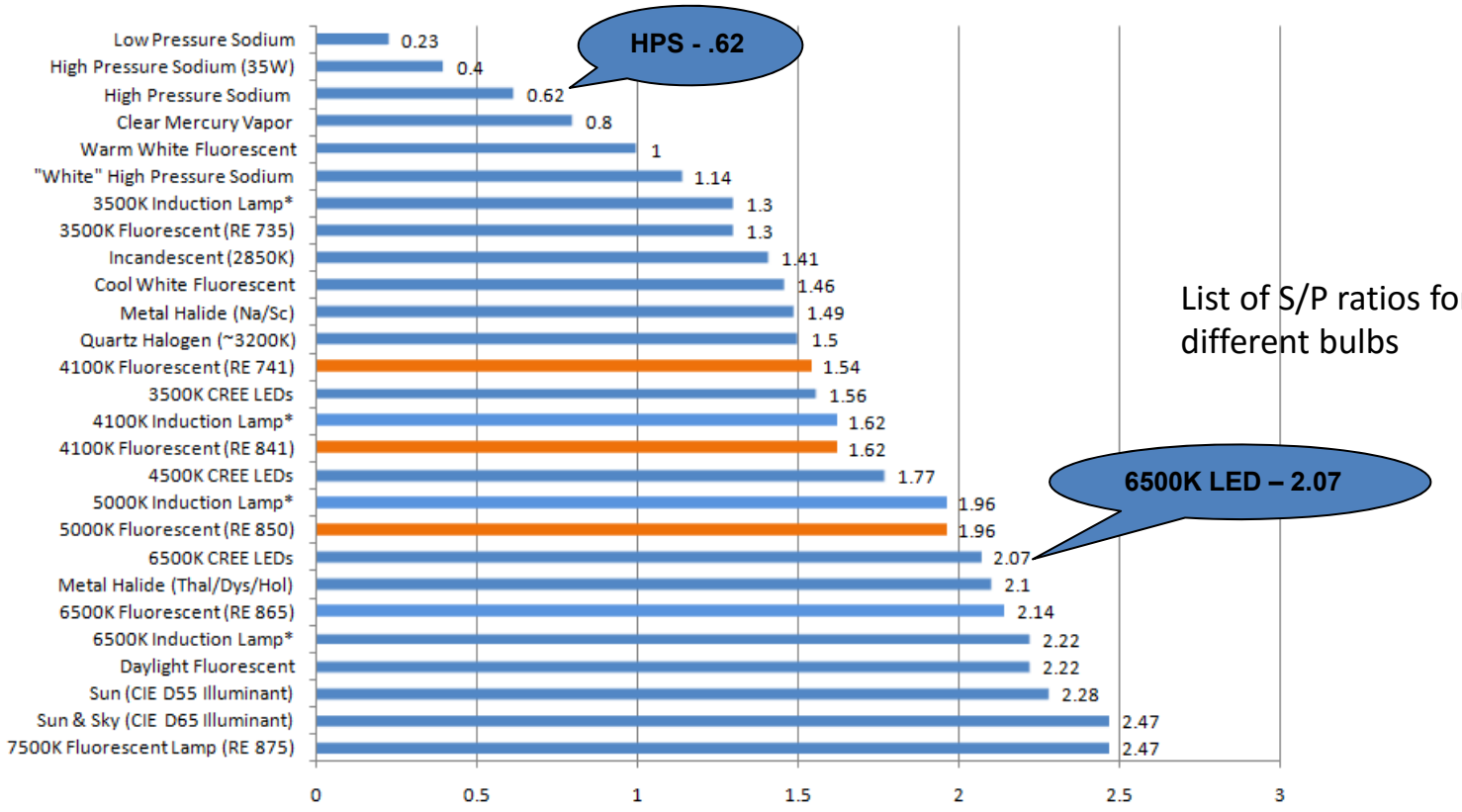
Generally, lighting companies only rely on photopic lumen measurements to describe a lamp's brightness. Photopic lumens are the only lumens measured in general tests and other current light simulation tests, which lamps are put through in order to determine the brightness (luminous flux), light distribution angles, and efficacy.

- Typical 100 watt High Pressure Sodium Lamp Characteristics

Color Rendering Index	21 Ra8
Color Temperature	2100 K
Color Temperature technical	2050 K
Chromaticity Coordinate X	523 -
Chromaticity Coordinate Y	417 -
Initial Lumens	9300 Lm
Luminous Efficacy Lamp	93 Lm/W
Design Mean Lumens	7750 Lm

LED Technology – Understanding Scotopic vs. Photopic Lumen Output

Different types of bulbs have different measures of photopic and scotopic light levels. For instance, depending on the temperature color, LEDs range from a high of 1.56 to 2.07. To determine the total of visually effective lumens (also called “pupil lumens”), we can multiply photopic lumens by (S/P)0.78. S/P is a ratio that describes scotopic to photopic quantities.



List of S/P ratios for different bulbs

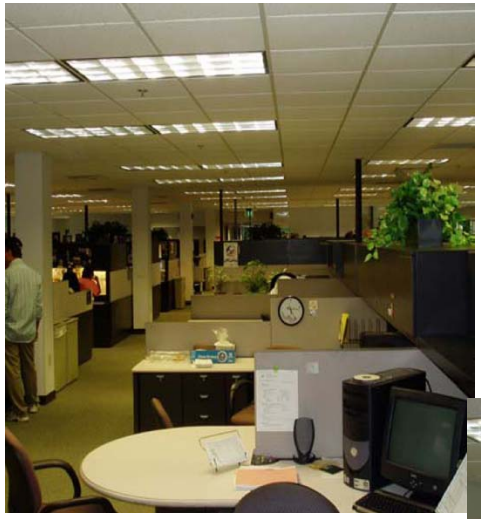
LED Technology – Understanding Scotopic vs. Photopic Lumen Output

- White light that is "cool" in appearance, with more energy in the short-wavelength (blue-violet) part of the spectrum, appears to be brighter than white light that is "warm" in appearance
- In general, the higher the Correlated Color Temperature (CCT) of a light source, the "cooler" it appears. Sometimes this kind of light source is called "scotopically enriched," meaning there is greater stimulation of the rods. An example of this effect is that, given equal illuminance, a **space lighted with a "cooler" appearing light source will appear brighter to human eyes than the same space lighted with a "warmer" appearing light source**.
- Research has also shown that at medium-to-high (photopic) light levels it is easier to discern small details under a light source that has more blue in the spectrum (cooler in appearance). This effect may be helpful for people doing inspection, surgery, sewing, and other detail-oriented visual tasks.

LED Technology – Understanding Scotopic vs. Photopic Lumen Output

- However, that these effects aren't due to the rods after all, but to a different kind of light-sensitive cell on the retina, called intrinsically photosensitive retinal ganglion cells (ipRGCs), which have a peak sensitivity in the blue part of the spectrum, not far from the rods' peak sensitivity.
- Researchers have compared foveal (line of sight) vision and peripheral vision under HPS and MH luminaires at mesopic levels. They found that the color of the light source didn't affect direct vision, the ability to see details when looking directly at the object. However, in a simulated roadway application where they tested peripheral vision, they found that the subjects had faster reaction times under MH/LED's than under HPS, all other conditions being equal. Unlike the effects found at medium and high light levels, this *is* a rod effect; the rods, most responsible for our peripheral vision, are more sensitive to the "cooler" wavelengths of the MH/LED light source.

LED Technology – Using Scotopically enhanced lighting sources



Benefits of spectral enhanced lighting

Specifications

	Pre-Retrofit	**Post-Retrofit**
Lamp	F032/741/ECO	F030/850XP SS/ECO
Nominal lamp wattage	32	30
Temperature (Kelvin)	4100	5000
CRI	75	85
Lamp color	741	850
Rated photoptic lumens (P)	**2800**	2800
Ballast factor (BF)	0.88	0.71
Lumen output (PxBF)	2464	1988
S/P ratio	1.56	1.85
Visually effective lumens	3486	3212
Measured connected load	27.11 W/lamp	21.56 W/lamp

Resulted in a 20.5% energy savings with payback in 3.49 years

Importance of LED output vs. HID Lamp sources

Issues in comparing the lumen output of LEDs to a typical HID lamps

- HID lamp lumens are measured spherically, counting all the lumens being produced over 360 degrees. The discharge arc tube is NOT a point source and is difficult to optimize optically, making for poor light collection efficiency and utilization. Many light fixtures have to redirect most of the lumens produced by a bulb, losing as much as 50% of the output.

- LEDs on the other hand are directional and have practically no wasted lumens. Virtually every LED lumen is directed and placed to maximize efficiency. A more accurate evaluation is to measure actual foot-candles or LUX on the ground. In addition, HPS and MH lamps have a considerable initial light output loss within the first 6 months. LEDs have no such drop and deliver useful light [with only 30% depreciation] for 12 to 15 years before needing replacement.