Energy-Efficient Lighting

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Lithonia Lighting

LITHONIA LIGHTING
An AcuityBrands Company

Why Energy Efficiency?

- Lower costs
- Minimize environmental impacts
- Improve indoor environment
  - lighting for human needs
    - Increased productivity
    - Lower turnover

On A Broader Palette

- Minimize pollution & global warming
- Slow down the rapid depletion of natural resources
- Respond to real threats on our ability to sustain a robust quality of life

Some Specific Impetus

- The Predicted Energy Crisis of 2005
  - Energy costs will rise, permanently, 50-100%
  - Will directly affect fossil fuel energy: gasoline, natural gas, coal and electricity from these sources
  - Will indirectly affect nuclear, hydro, wind and geothermal due to supply and demand issues

Additional Problems of Electricity

- Generating and transmitting capacity is too close to peak demand
- Time of Use pricing will be needed to encourage peak management
- The potential for extremes of pricing and blackouts are constant. The solution is to build rapid response generating capacity using fossil fuels.

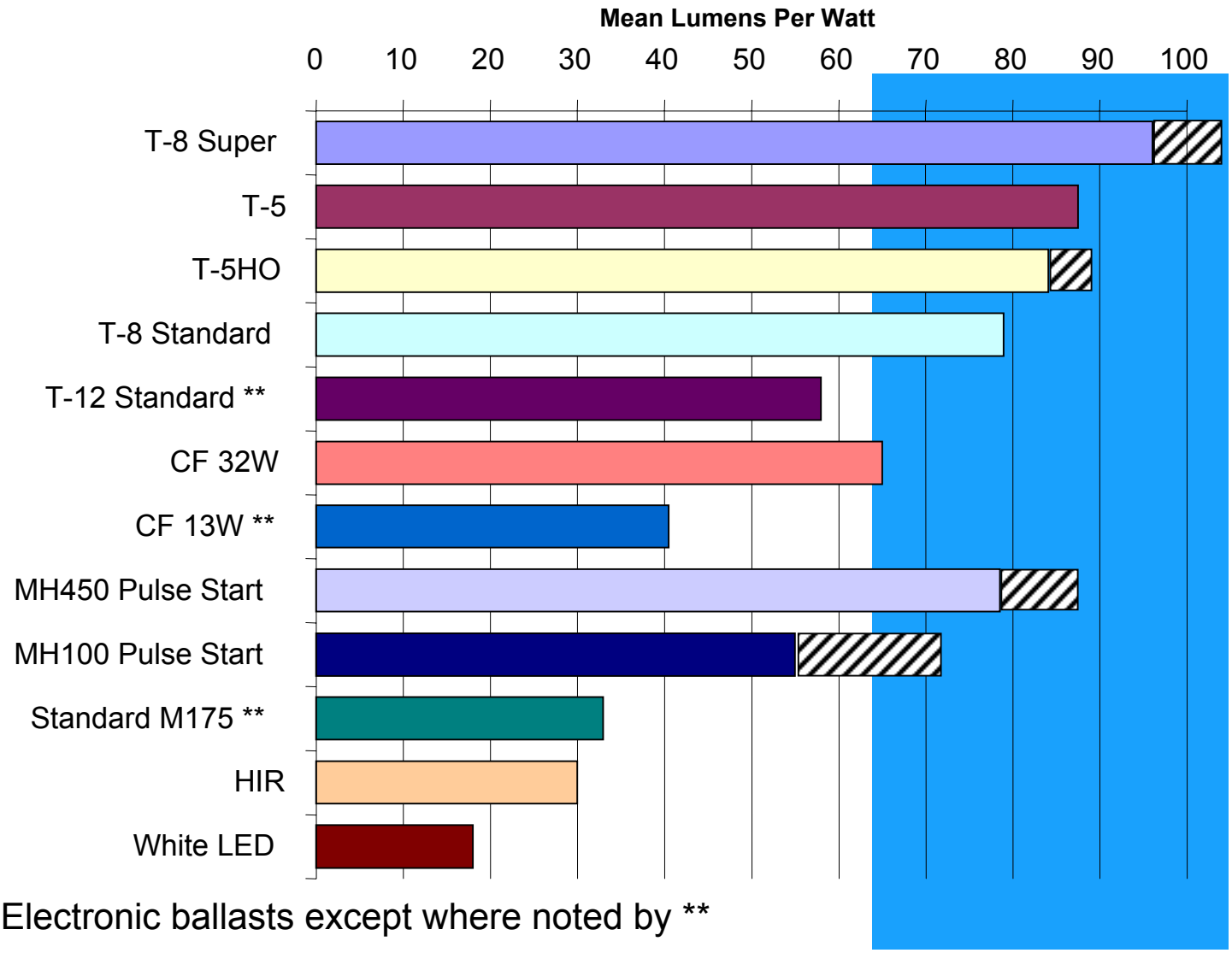
Energy-Efficient Lighting Design

- Daylighting
- Source & Luminaire Selection ✓
- Lighting Controls
- Design Issues
  - Designing for the Human Environment

Select Proper Electric Light Sources

- Efficacy (mean lumens per watt)
  - The higher the efficacy the better.
- Color Temperature
  - Choose “white” light sources between 3000K (“warm”) and 4100K (“cool”). Consider 5000K (cold) for studios.
- Color Rendering Index
  - A measure of light source quality.
  - Where color is important choose light sources with CRI > 80.
  - Under 70 noticeably distorted, under 60 usually unacceptable
- Lamp Life
  - Choose lamps with the maximum life possible to minimize maintenance.
- System Costs
  - Choose systems that employ efficient lamps and ballasts.

Comparison of Lamp Efficacy



Electronic ballasts except where noted by **

Hot Lamps

- T8 Super Lamps & Ballasts
  - 92-100 MLPW
  - 85+ CRI
  - 30,000 hr lamp life on PS electronic ballast
- T5 Standard
  - 92+ MLPW
  - 83+ CRI
  - 20,000+ hr lamp life
- T5 HO
  - 81-90+ MLPW
  - 83+ CRI
  - 20,000+ hr lamp life

What are Super T8 Lamps?

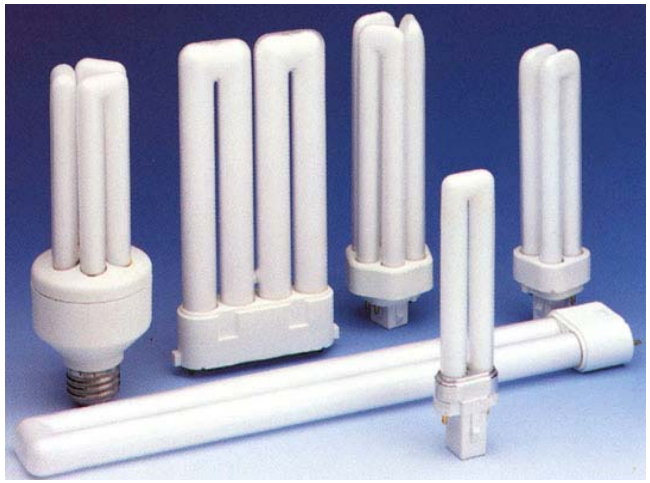
- RE the 32W, 4' F32T8:
  - 3,100+ initial lumens
  - 2915+ mean lumens & 95%+ lumen maintenance at 8,000 hours
  - CRI of 82+
  - Rated for 24,000+ hours (3 hr/start)
  - Will start at 0°F on an instant start ballast rated for 0°F starting.
  - Will operate in RS, PRS, IS or dimming modes, and
  - Enables compliance with low-mercury/TCLP requirements
- Super Ballasts
  - Super 2-lamp T8 ballast – 53 watts (standard = 59 watts)
  - IS can give 100+ MLPW and should be used where lights are left on
  - PS will give 92+ MLPW and can provide extended lamp life when frequently switched

Some Specific Super T8 Lamps

- GE – F32T8/XL/SPXxx/HL/ECO
- Philips – F32T8/ADV/8xx/ALTO
- Sylvania – F032/8xx/XPS/ECO

Secondary and Special Lighting Systems

- Compact fluorescent lamps
  - 10,000 hour lamp life.
  - 50-65 MLPW varies with wattage.
  - High CRI >80.
  - Color temperature 3000K, 3500K, 4100K, and others.
  - NOW – consider 57 watt and 70 watt compact fluorescent INSTEAD of low wattage metal halide!
- Pulse start metal halide lamps
  - 50-79 MLPW varies with wattage.
  - 7,500 to 20,000 hour lamp life.
  - Standard lamps CRI 65-70.
  - Ceramic high color lamps CRI>80.
  - Long warm up and restrike times.
  - PREFER THE CERAMIC METAL HALIDE LAMPS FOR SUPERIOR COLOR



Light Sources for Limited Use

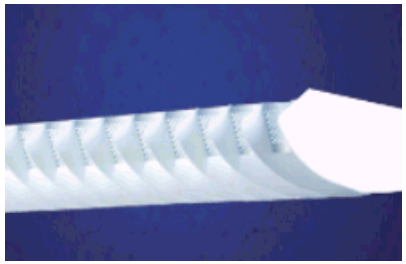
- Halogen IR lamps
  - Excellent CRI ~100.
  - Color temperature warm 2850-3000K.
  - Highly directional.
  - Inexpensively dimmable.
  - Life 3000-4000 hours.
  - Efficacy 20-30 MLPW.

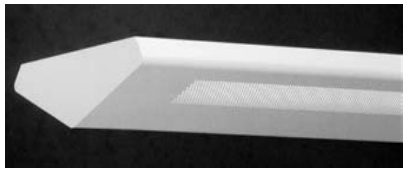
Know Your Ballasts

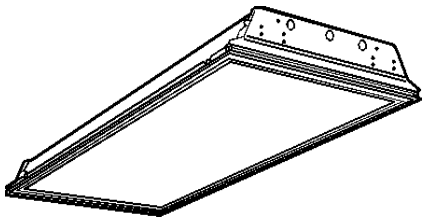
- Use electronic ballasts exclusively for fluorescent and compact fluorescent lamps.
  - For T-8 lamps, investigate “low light output” and “high light output” ballasts to fine tune fixture watts to the minimum needed for a space.
  - Dimming ballast prices are still high – carefully evaluate the need for dimming.
  - Low temperature ballasts permit compact fluorescent lamp starting and operation at < 0ºF.
- Use electronic ballasts for metal halide lamps up to 150 watts (and maybe higher).

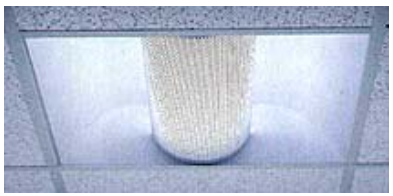
Choose High Efficiency Luminaires

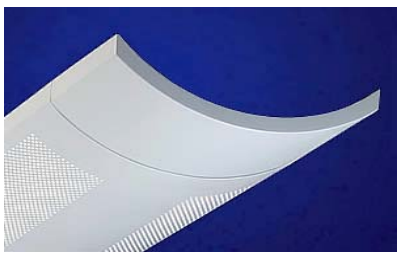
- Carefully compare Super T8 and T5/T5HO versions

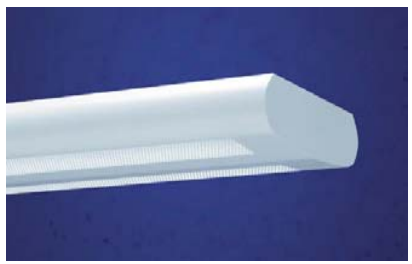










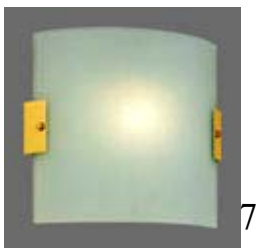


Occasional Luminaires

- Use recessed downlights both in t-bar grid ceilings and hard lid ceilings.
  - Compact fluorescent downlights for most interior and many exterior applications.
  - Metal halide downlights in high bay applications and outdoors.
  - Halogen downlights and accent lights in special “social” spaces and A/V environments.
- Compact fluorescent and HID wallwashers
- Durable wall sconces
  - Incandescent in theaters and AV spaces
  - Compact fluorescent in corridors, offices, other low abuse settings
  - HID in pools and some large spaces

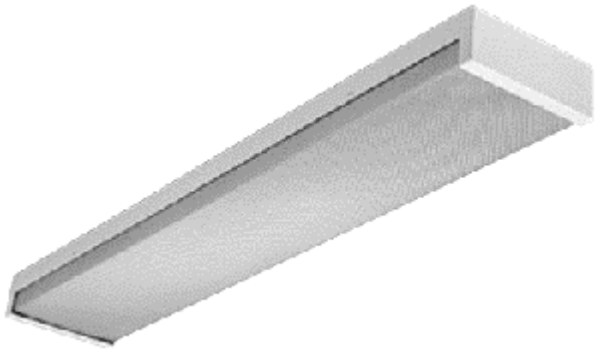
Decorative and Stylish Luminaires

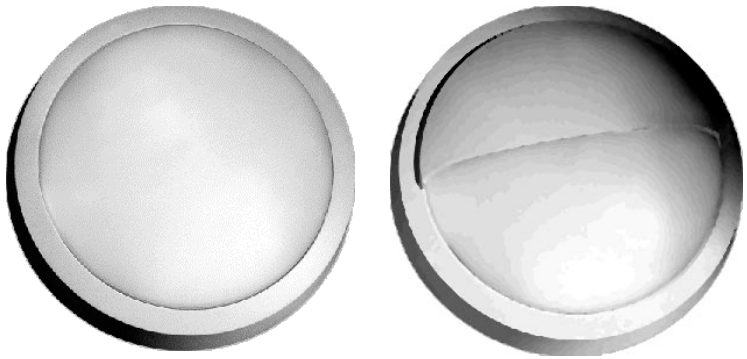
- Add a touch of style
- Use in low abuse and special locations
  - Major entries and lobbies
  - Commons areas
  - Cafeterias
  - Libraries
- All of these are compact fluorescent or skinny tubes

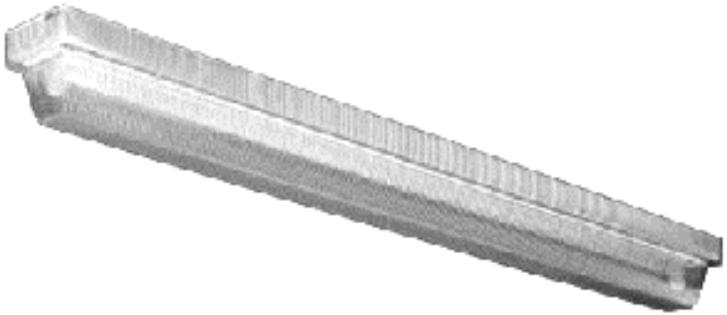


Surface-mounted High Abuse Luminaires

- Choose T-8, T-5, HID or compact fluorescent luminaires for a number of occasional and utility applications such as:
  - Stairwells.
  - Exterior doors.
  - Locker and toilet rooms.







Specialty Luminaires for Gyms and other Big Spaces

High bay fluorescent is the probably the most energy efficient choice for large spaces like gyms. The 6-lamp T5HO fixture at 360 watts exceeds the maintained performance of a 400 watt metal halide operating at 458 watts. Optional uses include 1/3, 2/3 and 3/3 light level operation for energy savings.

High performance metal halide downlights are still a good choice for large gyms and field houses when lights must be left on for many hours a day and mounting heights are very high (>40').

Outdoor Luminaires

- Typically you will use a combination of:
  - Parking lot lights, preferably “shoe box” pole lights to control light trespass and light pollution.
  - Architectural pole lights for drives and entries.
  - Bollards for near buildings and plazas.
  - Special sports lighting for high schools and above.

Exit Signs

- Unless otherwise required by code use LED exit signs.
- Red or green depending on local authorities.
- Use very low power, making them especially easy to equip with their own backup battery.
- Remember, LED exit signs don't have a downlight egress light - you will need to provide that.

Energy-Efficient Lighting Design

- Daylighting
- Source & Luminaire Selection
- Lighting Controls ✓
- Design Issues
  - Designing for the Human Environment

Lighting Controls Basic Principles

- Turn off lights when spaces are not in use.
- Turn off lights when there is adequate daylight.
- Dim lights if daylight levels vary.
  - Stepped dimming
  - Full range dimming
- Dim lights according to need.
  - Stepped dimming is fine in many spaces
  - Full range dimming is costly but works better.

Daylighting Rules-of-Thumb

- Design control circuits PARALLEL to the daylight contours.
- Provide a minimum of two levels of illumination
  - Dimming is nice but costly.
- Allow user override of automatic controls.

Integration with Daylight

- Ensure harvesting of available daylighting.
  - Use daylighting controls.
  - Study spaces to determine appropriate daylight amounts.
- Provide daylight glare management.
  - Determine direct solar glare situations.
  - Design manual or automatic blinds or other means of reducing the direct solar exposure glare and excessive light levels and heat gain.

Simple Classroom Controls

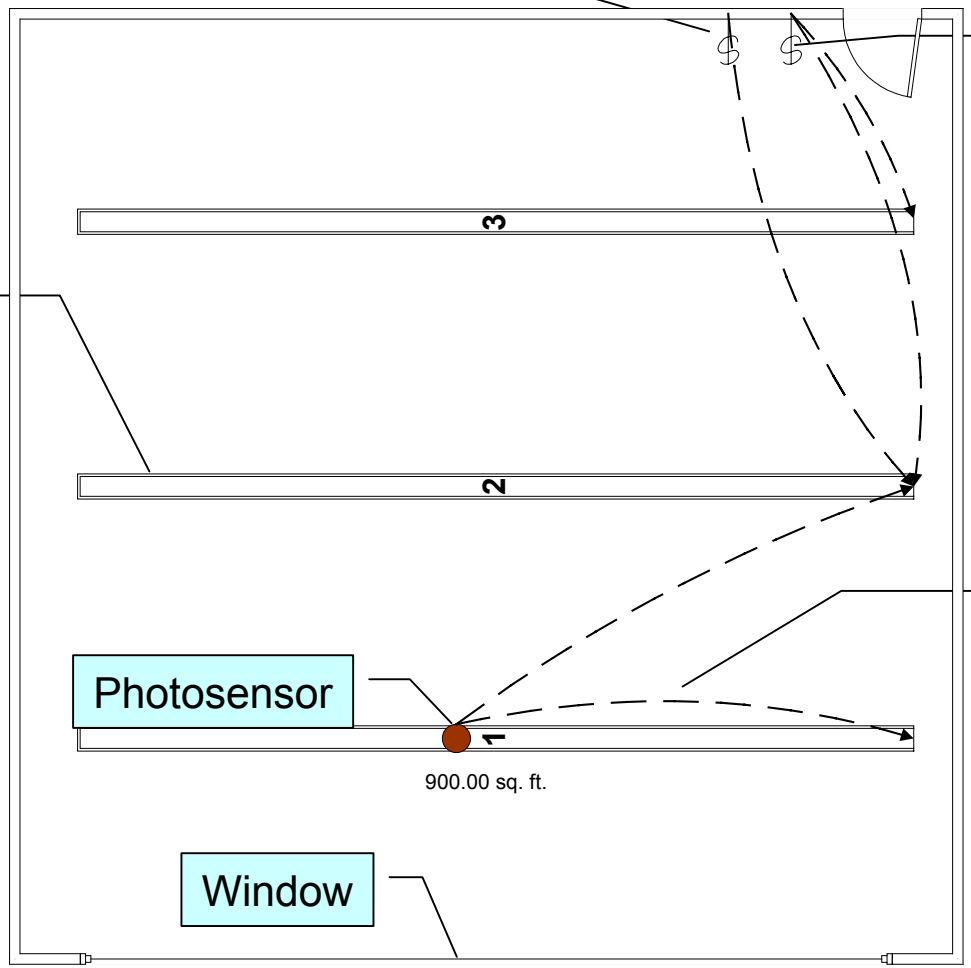
Override switch for Row 2 if it is under photosensor control.

Switch controls Row 3 (and Row 2 if 2 is not under photosensor control)

The photosensor dims Row 2 if the row is within 2 X the window height from the window

E.g. For a window height of 8', the photosensor should dim all luminaires within 16' of the window.

Photosensor controls Row 1

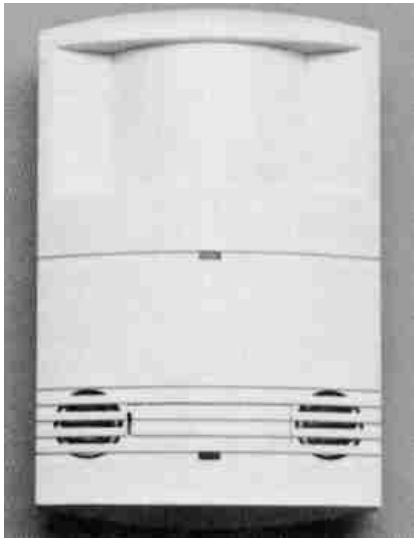


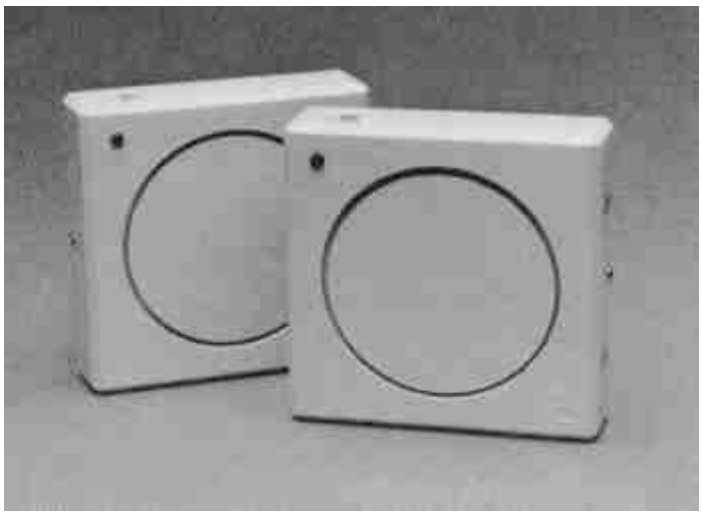
Dimmers for When You Really Need Them

- Manual Dimmers
  - For single rooms and single circuits.
- Preset Dimmers
  - For A/V spaces and social spaces.
- Dimming Systems
  - For managing large facilities and integrated systems.

Occupancy (Motion) Sensors

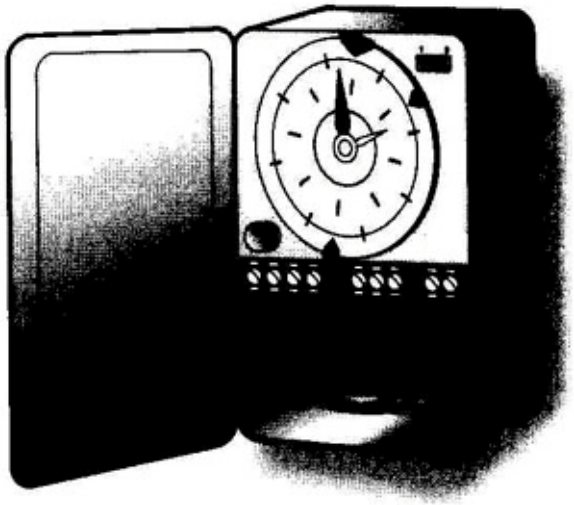
- Types
  - Passive Infrared (PIR.)
  - Active Ultrasound.
  - Dual Technology (PIR+Ultrasound or PIR+Audible Sound).
- Applications
  - Private offices.
  - Classrooms.
  - Conference Rooms.
  - Toilet and Locker Rooms.
  - Storage areas (on-off and high-low).
  - Halls and Lobbies (off-hour override).



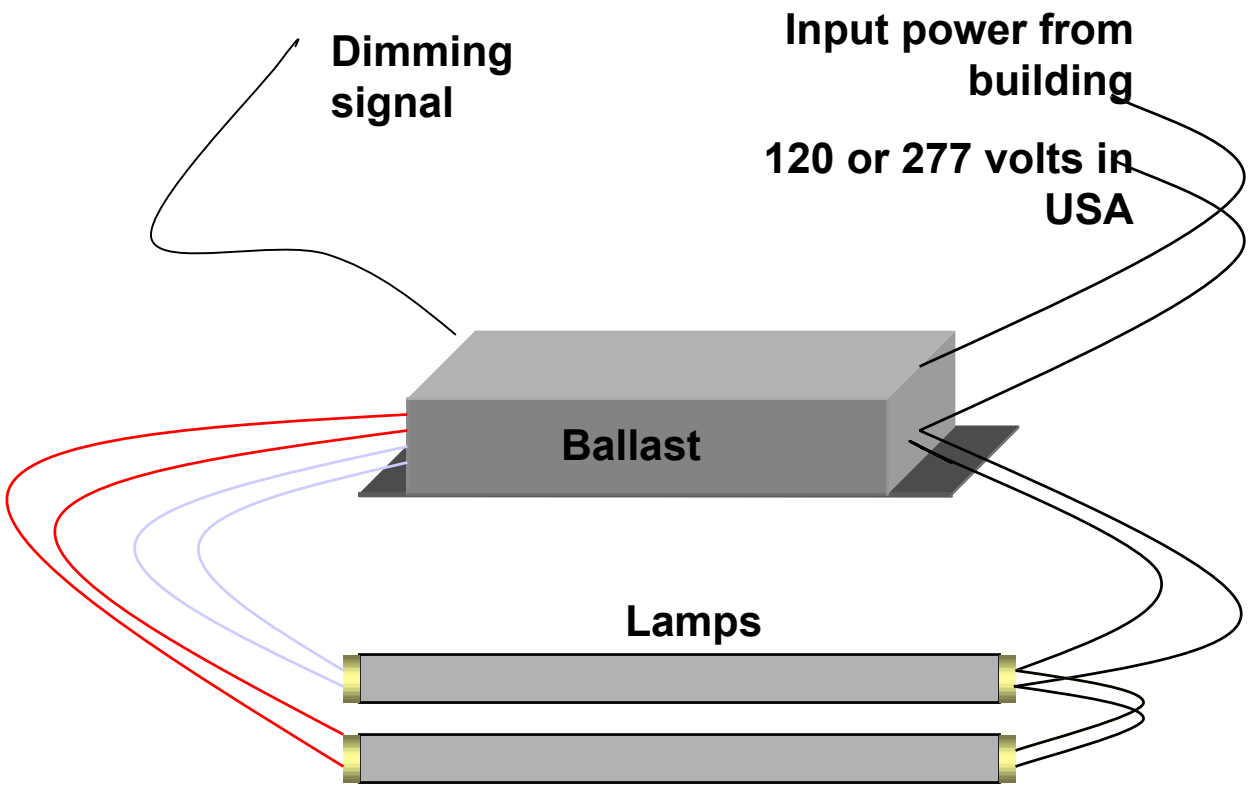


Time Controls

- Timer Switches
  - Mechanical or Electronic Time Out.
- Time Clocks
  - Mechanical or Electronic Time Trips.
- Lighting Relay Panels
  - For automatic time controls of large and/or complex facilities, especially schools.
- Building Energy Management Systems and Building Automation Systems
  - Integrate lighting relay panel operation with HVAC and other building systems.



Dimming Ballasts for Fluorescent Lamps



There are 4 INCOMPATIBLE types of electronic dimming ballasts:

- 3 wire forward phase cut (Lutron, Lightolier)
- 2 wire forward phase cut (Advance, Lutron)
- 0-10 volt analog (Lutron, Advance, Universal, Sylvania, others)
- Digital DALI (Sylvania/Siemens, Tridonic, Lutron, others)

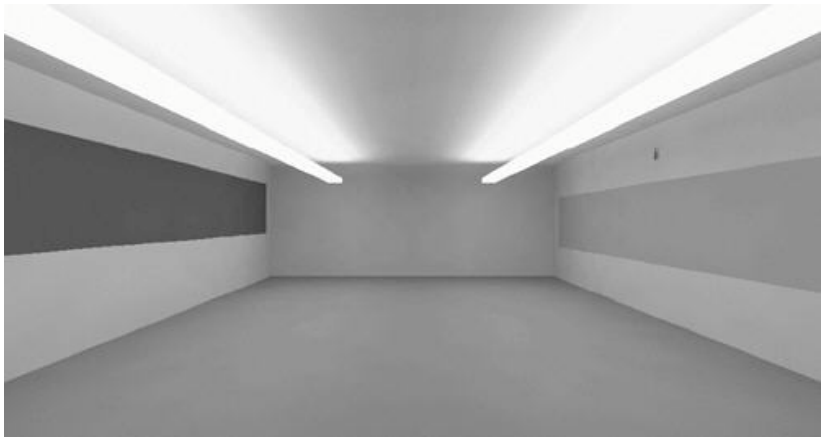
In modern electronic ballasts, dimming occurs INSIDE the ballast. There is presently a 20% dimming ballast penalty.

Analysis Tools

- Lighting Calculation and Illustration Programs.
- Tools to enable better lighting design results.
- Permit exacting calculations.
- Help execute challenging designs.
- Understand natural lighting effects.
- Understand electric/natural lighting interaction.
- Help visualize results.

Lighting program types

- Radiosity
  - Acceptably accurate.
  - Fast execution.
  - Simple renderings.
- Ray-tracing
  - Can be very accurate.
  - Slow input and slow execution.
  - Potential for photorealistic renderings.



Physical Models

- Build models
  - Daylight scales perfectly !
- Observe good and bad daylighting
  - Figure out how balanced light was achieved
- Take advantage of help:
  - Utility technical assistance.
  - Add a daylighting expert to your design team.

Other Software

- Photometric Viewer (free)
  - View and print photometric data
  - View side-by-side comparisons of data
  - Product iso-illuminance diagrams for single luminaires or complete pole configurations
- Economic Viewer (free)
  - Perform LCA for lighting scenarios including:
    - Lighting costs
    - Lighting related A/C and heating costs
    - Initial and annual costs
    - Simple & discounted payback and IRR

Energy-Efficient Lighting Design

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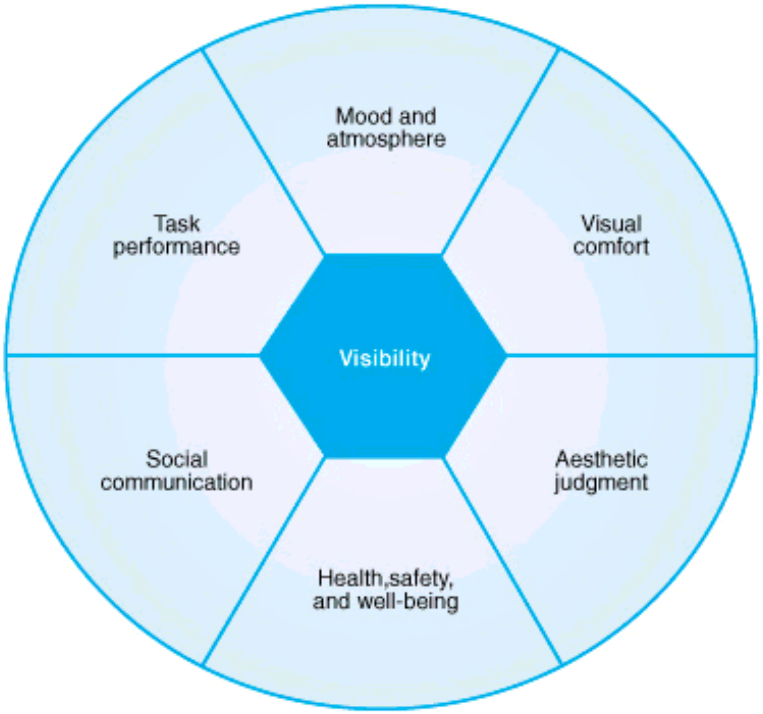
Human Needs

- Visibility
- Task Performance
- Visual Comfort
- Social Communication
- Mood & Atmosphere
- Health, Safety & Well-being
- Aesthetic Judgement



Design Issues

- Appearance of Space & Luminaires
- Color Appearance
- Daylight Integration/Control
- Direct Glare
- Flicker
- Illuminance (horizontal)
- Illuminance (vertical)
- Intrinsic Material Characteristics
- Light Distribution on Surfaces
- Light Distribution on the Task Plane
- Light Pollution/Trespass
- Luminaire Noise
- Room Surface Luminances
- Modeling of faces/Objects
- Peripheral Detection
- Point(s) of Interest
- Reflected Glare
- Shadows
- Source/Task/Eye Geometry
- Sparkle
- Surface Characteristics
- System Control/Flexibility
- Special Considerations
- Transient Adaptation

Color Appearance (and Color Contrast)

- Factors
  - spectral power distribution of the source
  - color perception abilities of the occupant
  - reflective characteristics of surfaces and objects
- CRI
  - 90+ where color matching/selection is occurring
  - 80+ for pleasant appearance of people, food and merchandise
  - 70+ in offices, educational, health care and institutional settings
  - 50+ for most industrial tasks

Direct Glare

- Can cause discomfort and disability
- daylight can be a source (but is tolerated more)
- glare criteria for luminaires for 0-40 degrees below the horizon have been established (RP-1)
- luminaire luminances should never be more than 100 times that of the surrounding surfaces

RP-1 / Direct Glare

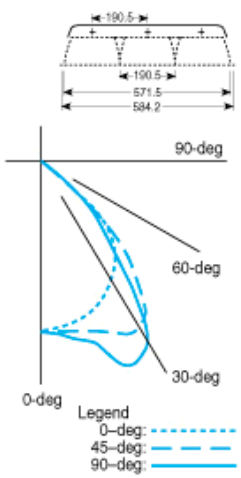
Angle from Vertical (deg.)	Average Luminance (cd/m²)*	
	Preferred	Maximum
55	850	—
65	350	850
75	175	350
≥85	175	175

* Luminance is measured along the lengthwise, cross-wise, and 45° horizontal planes.

Report no.: ABC Company: 00001
Prepared for ABC Company
Catalog no.: ABC00000
Luminaire: Fabricated metal housing, white painted reflector, specular parabolic louver
Lamps: Three F40T12/CW, each rated 3150 lumens
Ballasts: One X000, one CDE X003Z
Mounting: Recessed
Lumen to candela ratio used = 9.17
Total input watts = 131.1 at 120.0 volts
The 0-degree plane is parallel with the lamps

Candela Distribution

	0.0	22.5	45.0	67.5	90.0	Flux
0	2876	2876	2876	2876	2876	
5	2875	2887	2899	2919	2915	278
15	2739	2831	2982	3102	3122	844
25	2485	2700	3197	3703	3767	1462
35	2150	2532	3074	2939	2835	1706
45	1545	1987	1688	1302	1290	1208
55	24	108	295	159	120	214
65	0	0	0	0	0	0
75	0	0	0	0	0	0
85	0	0	0	0	0	0
90	0	0	0	0	0	



Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixt
0– 30	2584	27.3	45.2
0– 40	4290	45.4	75.1
0– 60	5711	60.4	100.0
0– 90	5711	60.4	100.0
90–180	0	0.0	0.0
0–180	5711	60.4	100.0

Total luminaire efficiency = 60.4%
Total reflectance of paint = 91.3%
CIE type – direct
Plane : 0–deg 90–deg
Spacing criteria : 1.2 1.4

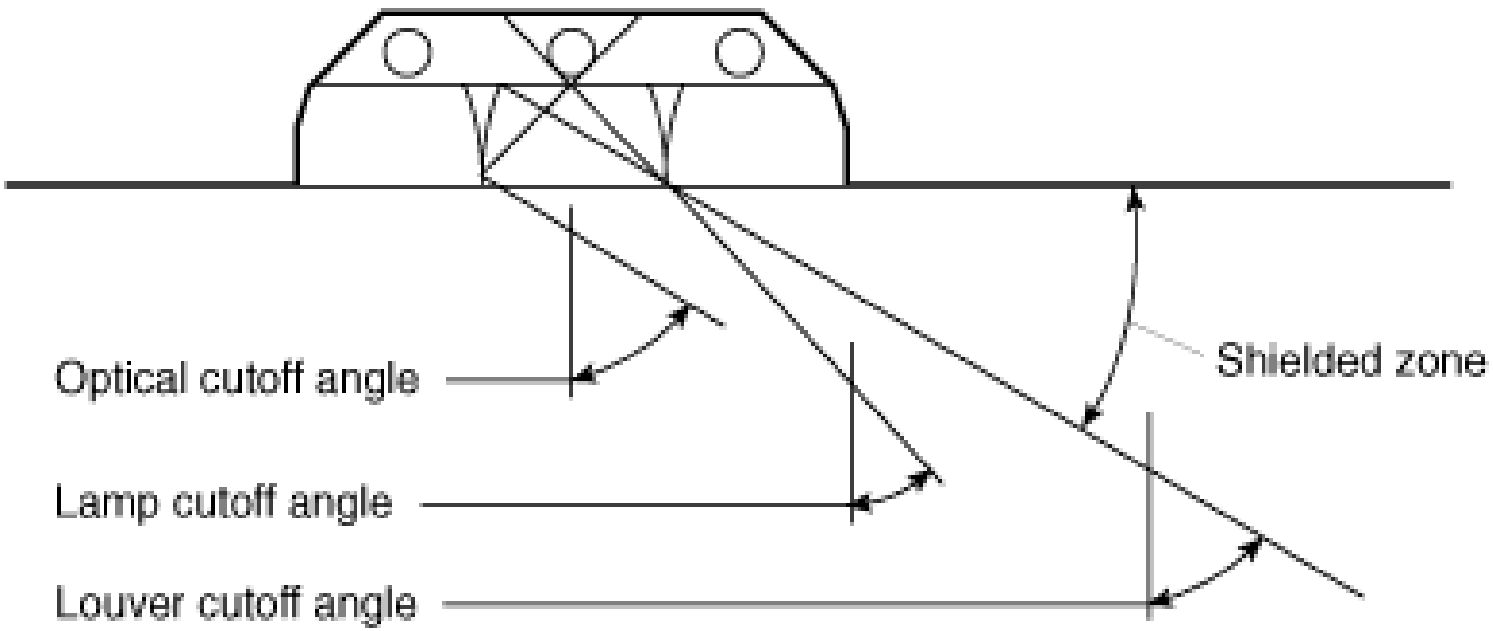
Luminance data in candelas per square meter

Angle	Average	Average	Average
	0-deg		
	2700		
	310		
	0		
	0		
	0		

Luminance data in candelas per square meter

Angle in deg	Average 0-deg	Average 45-deg	Average 90-deg
45	3240	3535	2700
55	60	760	310
65	0	0	0
75	0	0	0
85	0	0	0

Shielding Angle



Flicker (and Strobe)

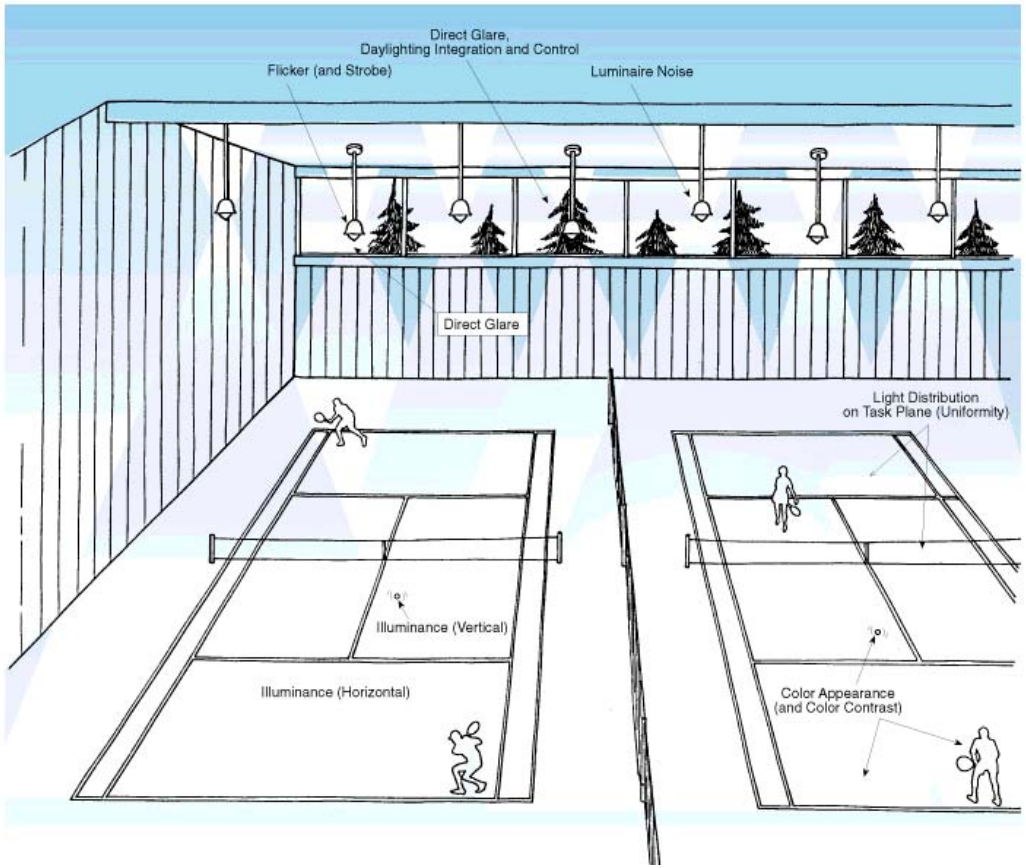
- Biggest concern is with moving objects (machinery, sports)
- response varies by individual
- most noticeable in peripheral vision
- can make moving machinery look still or moving at a different rate
- Can be mitigated using a three-phase system wiring adjacent luminaires to alternate phases
- high frequency electronic ballasts effectively eliminate flicker

Horizontal Illuminance

- Typical workplane heights
  - Interior 30”
  - Recreational 36”
  - Outdoor grade
- E_h is not what we see
- IESNA Guidelines

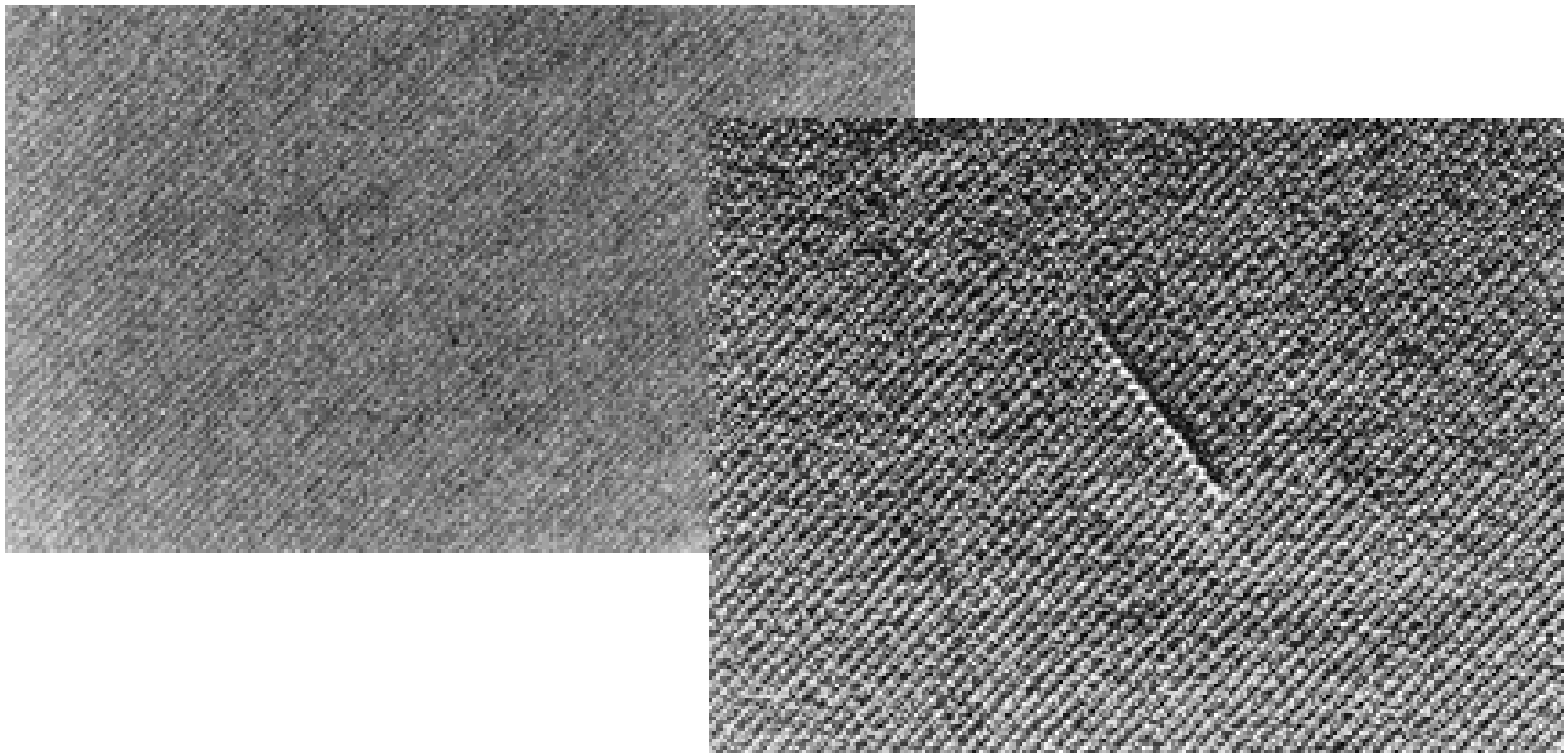
Vertical Illuminance

- IESNA Guidelines



Intrinsic Material Characteristics

- Visual cues such as texture, transparency, nap and grain can be revealed by the lighting



Light Distribution on Surfaces

- harsh striations and heavy shadows are typically avoided
- want to integrate with architectural patterns
- watch luminance ratios; too much contrast can be distracting while totally uniform brightness can lack visual interest

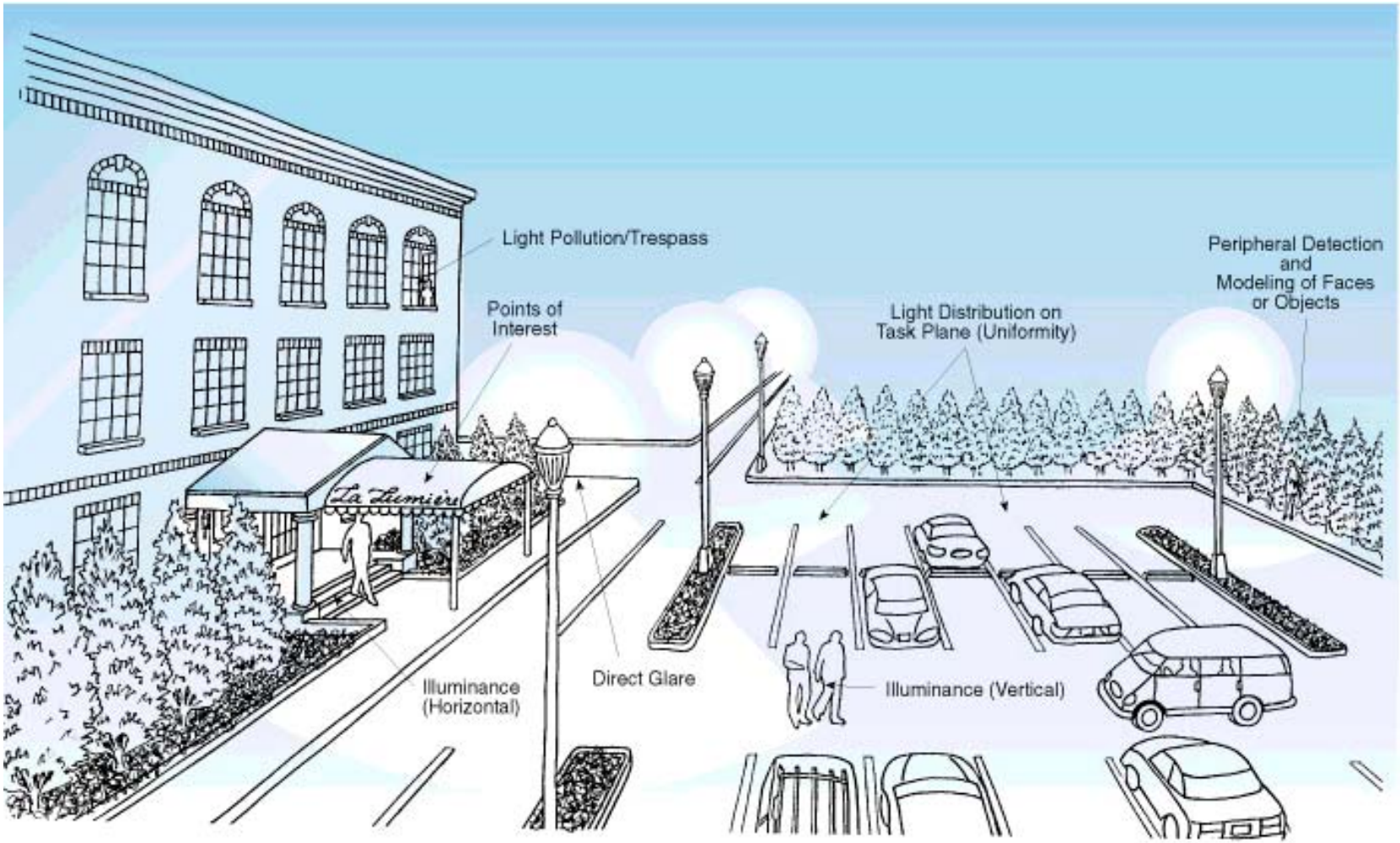
Light Distribution on a Task Plane

- non-uniformities can be distracting
- typically task luminance should be higher than the surround (1.5x to 3x); directs attention
- too great a differential can cause visual fatigue
- uniformity is a function of task

Light Pollution/Trespass

- Pollution - unnecessary sky glow
- Trespass - lighting on adjacent properties
- energy and ‘good neighbor’ considerations
- growing legislation

Light Trespass/Pollution



Luminaire Noise

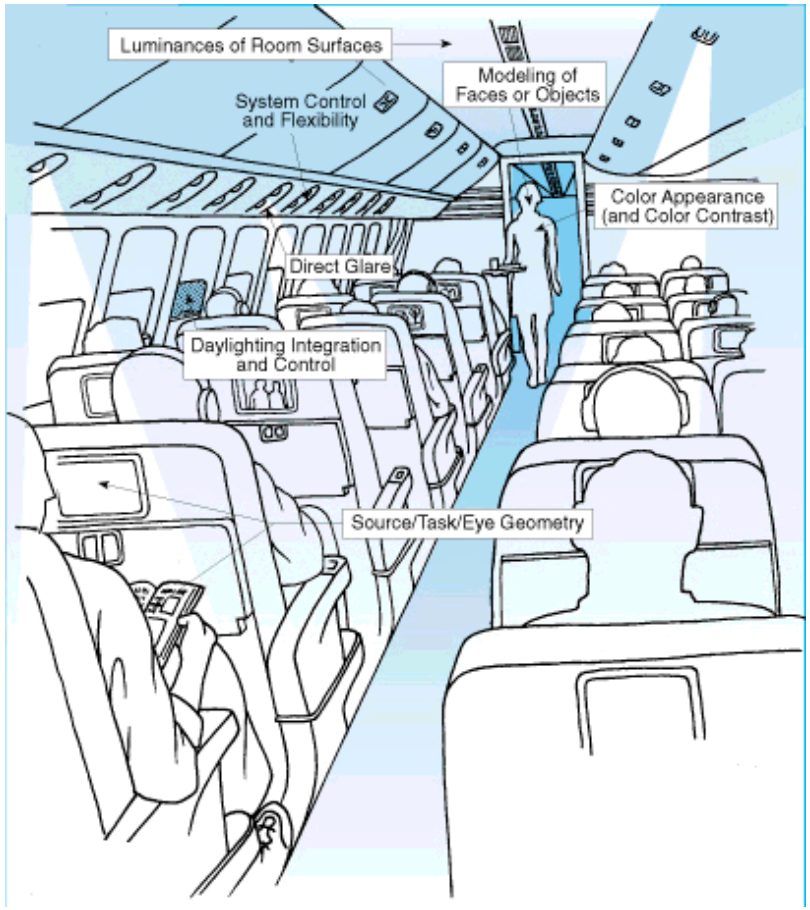
- electromagnetic ballasts
- incandescent lamps on some dimmers
- air-handling luminaires

Luminances of Room Surfaces

- function of illuminance and reflectance
- 30-100 cd/m2 wall luminance in typical offices
- minimize dark strips at top of walls

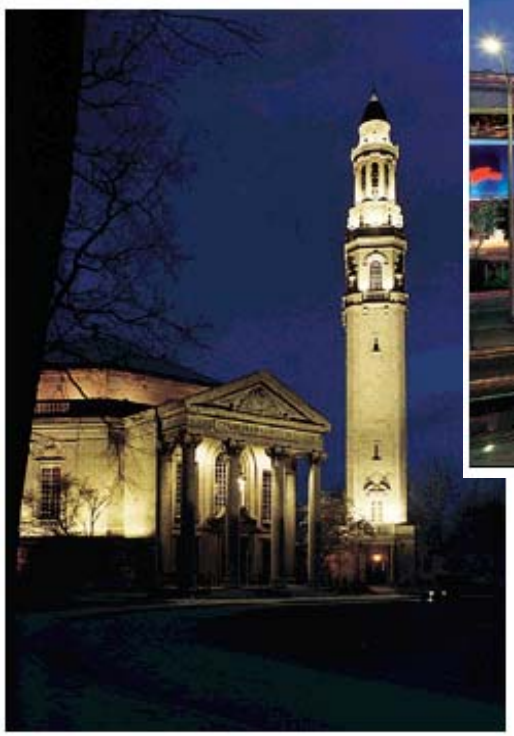
Modeling of Faces or Objects

- lighting can reveal depth, shape and texture
- typical direct and diffuse light is combined
- critical in industrial (key for detection, fill for production) and retail situations (generally a combination of diffuse and directional light)
- aides in non-verbal communication



Point(s) of Interest ...

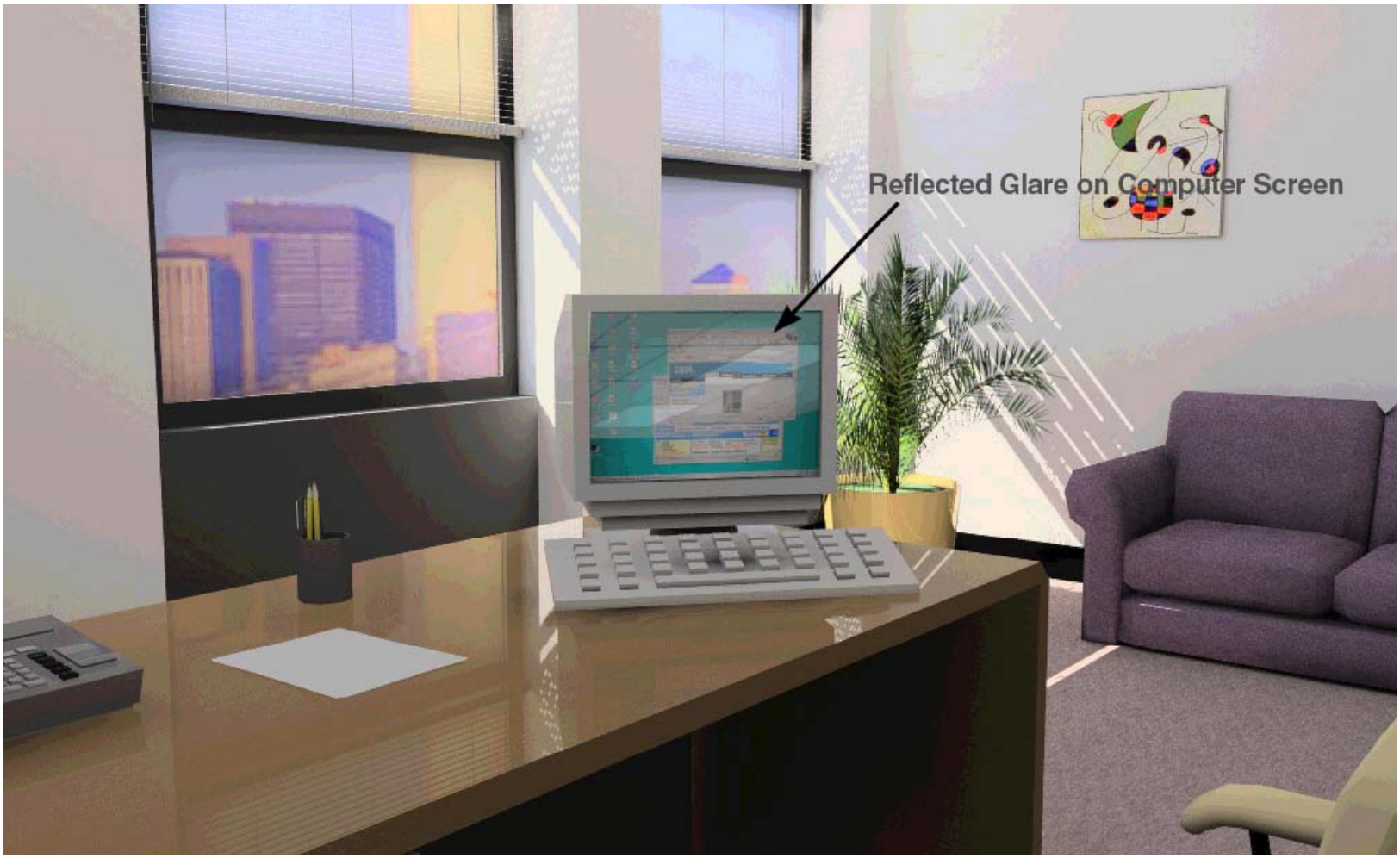
- attention can be directed with movement, luminance contrast and color contrast



Reflected Glare

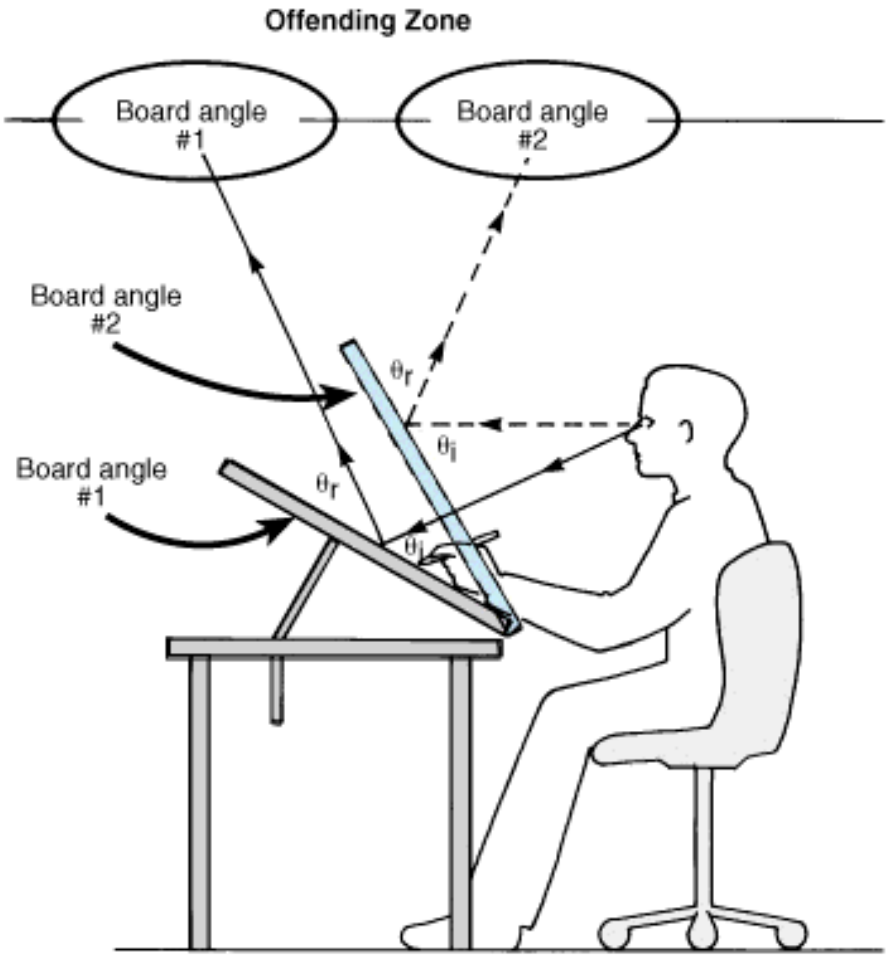
- Polished or glossy surfaces
- Veiling reflections
- Light from the side
- VDT monitors

Reflected Glare



Source/Task/Eye Geometry

- Can be critical to task visibility
- This geometry can both enhance or reduce contrast



Sparkle

- Small points of high luminance can enhance visual interest

Surface Characteristics

- High surface reflectances save energy and minimize contrast between luminaires and their surround
- interior workspaces should have reflectances (walls - 50/70%, ceilings - 75/90%)
- surfaces should be matte or stained to avoid reflected glare
- dark surfaces & the use of saturated colors and glossy finishes can create visual interest but should be used to a limited degree

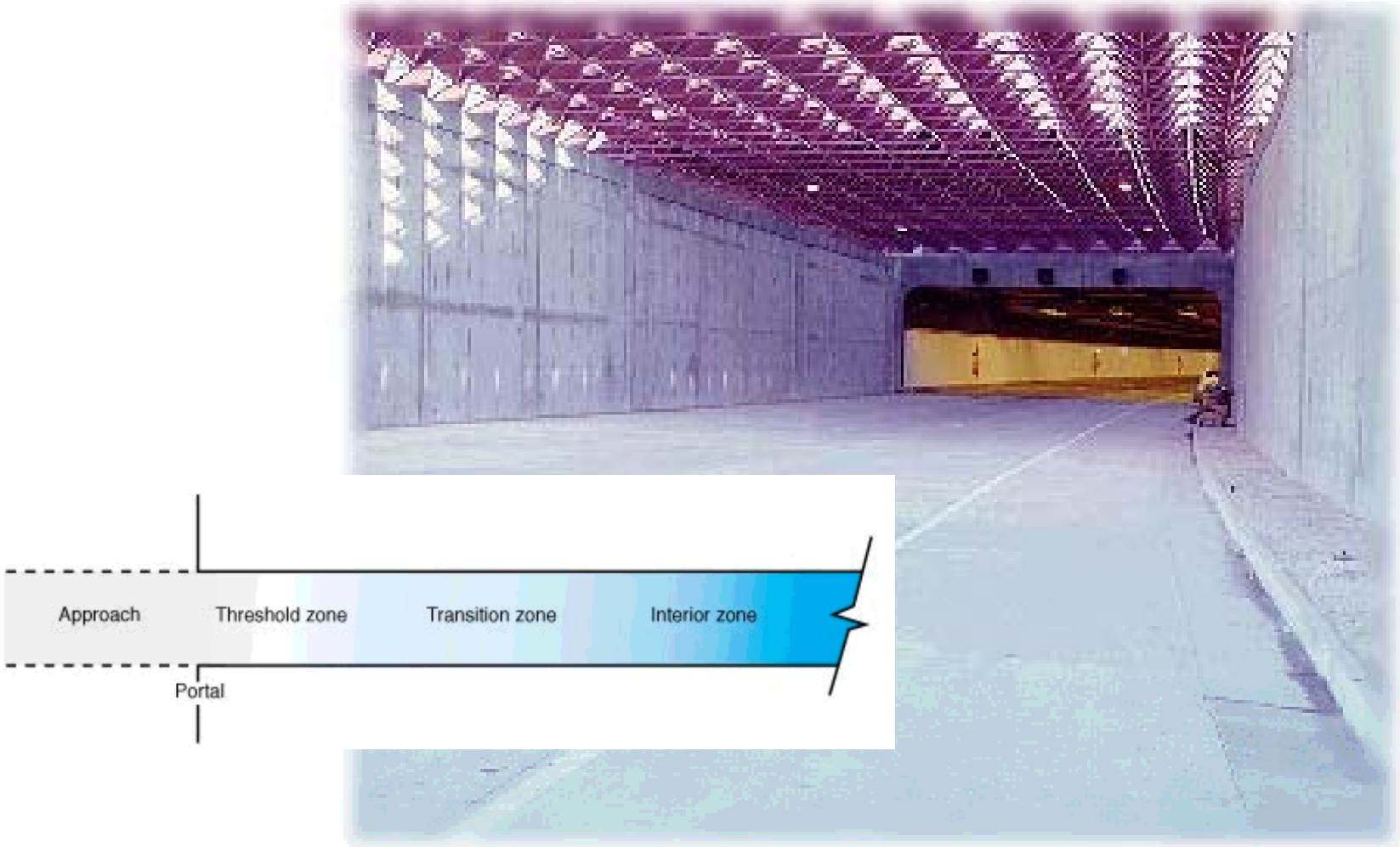
System Control & Flexibility

- Different light levels in the same location
- Different light levels in adjacent locations
- Use of controls and individual task lights can save energy and increase occupant satisfaction.

Transient Adaptation

- Allowing the eyes to adapt as the occupant moves between areas of different luminances.

Transient Adaptation



Any Questions?

- Thank you for your attention!