

Lighting

The Easy Solutions

Direct light where it's needed

Very bad Bad Better Best

Non cutoff Semi cutoff Cut off Full cutoff

https://soa.utexas.edu/sites/default/disk/urban_ecosystems/urban_ecosystems/09_03_fa_kwallek_riosvelasco_ml.pdf

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Lighting

- The Hawthorn Study
 - Professor Elton Mayo, conducted a study at the Hawthorne Works of the Western Electric Company.
- Productivity increased in both treatment groups

Management and the Worker. By F. J. ROETHLISBERGER and WILLIAM J. DICKSON. (Cambridge, Mass: Harvard University Press (Oxford University Press). 1939. Pp. xxiv +615. 26s. 6d.)

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Hawthorn Studies

- Results had nothing to do with workplace lighting
- Psychological factors are more important than physiological, and
- That sociological and anthropological factors are more important than economic

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Hawthorn Studies

- The Hawthorne Effect
 - Also referred to as the "observer effect"
 - A type of reactivity in which individuals modify an aspect of their behavior in response to their awareness of being observed

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Hawthorne Effect



https://www.youtube.com/watch?v=040090lqT6E&feature=emb_rel_end

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Lighting

- Wide variety of visual demands



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Basic characteristics of visual demands

- Size and a three-dimensional shape of the object being viewed
- Contrast between the object and the background
- Viewing distance
- Motion of the object
- Field of view around the task
- Sensitivity of the visual task to error
- Frequency of task
- Time available to perform task

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Lighting

- Illuminance
 - The amount of light falling on a work of service or task
 - Measured with an illuminance meter in Lux

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Lighting

- Luminance
 - Measure of light reflected off the surface
 - Measured with a photometer candela/m2

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Lighting

- The Illuminating Engineering Society of North America (IESNA)
 - Comprehensive lighting design guide
 - Lighting level should not vary more than 30% from these recommended levels for quality purposes.
 - The measured illuminances should be within 10%

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Recommended Range of Illuminance for Various Areas and Tasks Typical in Work Settings

| Type of Activity or Area (TABLE 8.1) | Illuminance (lux) | |
|---|-------------------|-----------------------------|
| | Horizontal | Vertical |
| Public/Service areas | | |
| Exit from building | 10 | 10 |
| Walkways (minimum) | 10 | 22 (at 1.8 m above path) |
| Parking lots (uniformity ratio 15:1) | 2 | 1 |
| For security | 5 | 2.5 |
| Lobbies | 100 | 30 |
| Copy rooms | 100 | 30 |
| Mail-sorting rooms | 500 | 30 |
| Rest rooms | 100 | 30 |
| Stairways | 50 | — |
| Elevators | 50 | 30 |
| Conference rooms | | |
| Meetings | 300 | 50 |
| Video conferences | 500 | 300 |

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Recommended Range of Illuminance for Various Areas and Tasks Typical in Work Settings

| Type of Activity or Area (TABLE 8.1) - (Continued) | Illuminance (lux) | |
|---|-------------------|----------|
| | Horizontal | Vertical |
| Office areas | | |
| Open-plan office, intensive VDT use | 300 | 50 |
| Open-plan office, intermittent VDT use | 500 | 50 |
| Private office | 500 | 50 |
| Control panels, VDT observation | 100 | 30 |
| Drafting/graphic-art work | | |
| Computer workstations only | 100 | 30 |
| Mix of computer and paper-based tasks | 300 | 30 |
| High-contrast media | 500 | 100 |
| Low-contrast media | 1000 | 300 |
| Reading tasks | | |
| VDT screens (data processing) | 30 | 30 |
| Keyboard | 300 | — |
| 6-point type, maps, telephone books | 500 | — |
| Inkjet/laser printer, typewriter output (at 8 points or larger) | 500 | — |

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Recommended Range of Illuminance for Various Areas and Tasks Typical in Work Settings

| Type of Activity or Area (TABLE 8.1) - (Continued) | Illuminance on Task Plane |
|---|------------------------------|
| Basic industrial tasks | |
| Visual demands are not high: Coarse processing of raw material, ¹ warehousing and storage of bulky items with large labels, loading inside trucks and freight. | 100 |
| Performance of visual tasks—high-contrast items or large size: Medium processing of raw materials, wrapping, packing, labeling, shipping and receiving, picking stock and classifying, warehousing and storage of small items with small labels, manufacture of large components, simple assembly or inspection, rough bench or machine work, coarse manual crafts ² | 300 |
| Performance of visual tasks—medium-contrast items or small size: Fine processing of raw materials, manufacture of medium-size components, rough grinding, medium buffing and polishing, ordinary automatic machines, maintenance work, medium craft work | 500 |
| Performance of visual tasks—low-contrast items or very small size: Very fine processing of raw materials, fine component manufacturing, difficult assembly and inspection, fine automatic machines, medium grinding, fine buffing and polishing, fine manual crafts | 1000 |
| Performance of exacting visual tasks: Extra-fine bench or machine work (fine grinding); exacting assembly and inspection, precision manual arc welding, exacting manual crafts | 3000 |

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Lighting and quality issues

- Glare
 - Exceptionally brilliant and distracting or uncomfortable amount of light

Direct Glare Zone

Indirect Glare Zone

Offending Zone

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Lighting and quality issues

- Shadows
 - The opposite of glare.

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Lighting and quality issues

- Room appearance
 - Balance the brightness of room walls and ceilings



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Lighting and quality issues

- Natural sunlight



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Lighting and quality issues


- Age of the user



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Lighting design

- Lighting best provided by combination of ambient room lighting and specific task lighting
- Design must balance illumination levels with implementation and operation cost
- Selection should consider “color rendering”

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Lamp types


Incandescent



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Lamp types


Fluorescent



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Lamp types


High intensity discharge (mercury vapor, metal halide, high pressure sodium)






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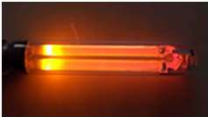
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Lamp types


Low pressure sodium





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Direct and indirect luminaries

- Luminary
 - A fixture that produces, controls, and distributes light face down word or face upward
- Desk lamps
 - Avoid using as task lighting whenever possible



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Computer workplace lighting


- Minimize glare
- Anti-reflection coding on screens
- Antiglare filters
- Lower ambient lighting
- Paint walls



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Computer workplace lighting

- Avoid use of items with reflective surfaces in the room
- Last resort, tilt the screen downward
- Install screens at right angles to windows



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Computer workplace lighting



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Computer workplace lighting



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Dark room lighting


Biggest challenge is with means of egress related to exit light signage and a minimum illumination requirement



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Inspection workplace lighting


- Product and material inspection is one of the most demanding visual tasks
- Minimize illumination reflectance
- Paint walls and ceilings
- Darker floor tile and carpeting
- Eliminate ambient overhead lighting



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Questions for Lighting Surveys and Focus Groups

| TABLE 10.7 Questions for Lighting Surveys and Focus Groups |
|--|
| How is the light in your workstation? |
| How satisfied are you with the lighting in your work environment? |
| How satisfied are you with the lighting in your workstation? |
| Does the lighting affect your work performance? |
| Does the light disturb your work performance? |
| Does the lighting level cause slips, trips, and falls? |
| Does the lighting cause tiredness in the eyes? |
| Do you need to change posture for better viewing because of the lighting? |
| Additional artificial light would improve my work environment |
| More windows, natural light would improve my work environment |
| Better maintenance of lighting would improve my work environment |
| A better mix of natural and artificial light would improve my work environment |
| Better use of color would improve my work environment |
| Any other suggestions? |

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Items from the Eye Complaint Questionnaire


| TABLE 10.8 Items from the Eye Complaint Questionnaire |
|---|
| 1. I have difficulty seeing |
| 2. My eyelids feel heavy |
| 3. My eyes hurt |
| 4. My eyes water |
| 5. My eyes burn |
| 6. My eyes are tired |
| 7. I have a strange feeling around my eyes |
| 8. My eyes itch |
| 9. My eyes are red |
| 10. My eyes are dry |

Note: Scored on a seven-point Likert scale, where 1 = "not at all" and 7 = "very much."

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Summary

- The furniture and materials determine the balance of luminance seen by workers.
- Large targets - higher and far way
- Small targets – lower down and closer
- Natural light, a view out of the window, and control over light.
- Administrative controls.

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Environmental Stressors

Color



Figure 3: Nine monochromatic colored offices




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Light and Color


How Lighting Affects Productivity

One of the most striking factors influencing how we work is the color temperature — measured in Kelvin (K) — of the light sources we're exposed to on a regular basis.

| | | | |
|--|--|---|---------------------|
| 2,000 K | 4,000 K | 5,000 K | 7,000 K |
| FIRE | SUNSET | DAYLIGHT | OVERCAST WINTER DAY |
|  W A R M |  M I D |  C O L D | |
| Use in: Intimate settings, break rooms Creates a sense of comfort and relaxation. | Use in: Conference rooms Welcoming but still cool enough to promote alertness. | Use in: Brainstorming rooms Improves alertness, mood and productivity. Lowers melatonin, which reduces fatigue. | |


Sources:
<http://www.westinghouselighting.com/color-temperature.aspx>
<https://www.jocidailyrhythms.com/articles/10186/740-3391-6-2/>


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Color

- Purpose isn't to inspire workers but to **reduce eyestrain improve visibility and increase efficiency.**
- Influence of color has not been thoroughly examine

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Light Reflective Values (LVR) of the path colors

| Color or Surface Texture | Light Reflectance Value (LRV) % | Color or Surface Texture | Light Reflectance Value (LRV) % |
|--------------------------|---------------------------------|--------------------------|---------------------------------|
| White | 85 | Dark Grey | 30 |
| Light cream | 75 | Dark Red | 13 |
| Light Grey | 75 | Dark Brown | 10 |
| Light Yellow | 75 | Dark Blue | 8 |
| Light Green | 65 | Dark Green | 7 |
| Light Blue | 65 | Wood | 63 |
| Medium Yellow | 65 | Satin Wood | 34 |
| Medium Grey | 55 | Concrete | 55 |
| Medium Green | 52 | Cardboard / Paperboard | 30 |
| Medium Blue | 35 | Black | 5 |

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Color

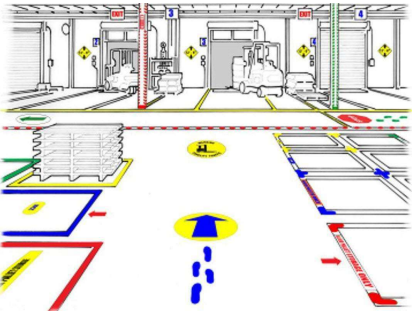
- Workplace guidelines
 - Ensure uniform reflectivity avoid primary colors
 - Pastel colors are generally preferred for walls and work services
 - Use warm colors on walls with windows
 - Green and blue-green wall colors are good for tasks that require high concentration
 - Provide contrast between the work surface and the components being assembled
 - Provide screens to block out distracting items
 - Use bright colors to highlight critical parts of the machine
 - Selection of color scheme should be coordinated with the decisions about illumination type

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A Workplace That Shines




A 5S Factory

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5's Factory

- Sort
- Set in Order
- Shine
- Standardize
- Sustain

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Noise's Definition

Noise is unwanted sound considered unpleasant, loud or disruptive to hearing.

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Noise's Definition


From a physics standpoint, noise is indistinguishable from sound, as both are vibrations through a medium, such as air or water.

The difference arises when the brain receives and perceives a sound.

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Noise


Sound level meter (dB)


Dosimeter Decibel (dB)



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Noise

- Contributes to hearing loss
 - Noise induced hearing loss covered in FPST 2343
- Annoys and distracts people
- Interferes with communications
- Alters performance

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Contributes to hearing loss


- 85 dBA – 8 hours/day, +dBA – time.
- Duration of exposition, level, and susceptibility.
- Hearing conservation programs:
 - OSHA 1983
 - NIOSH 1972,1998


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Distraction


- The higher the demand for concentration the lower the noise levels should be
- General rule for office or production equipment
Noise should be kept below 50 dBA
- Must consider the needs for both
communication and speech privacy


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ANSI 12.2-1995

- Criteria for evaluating room noise
suggests using NCB (noise-criteria-
balanced) curves to evaluate
acceptable noise levels in spaces

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Recommended NCB Curves and Sound Pressure Levels for Several Categories of Activity (Beranek 1989a)

| TABLE 8.5 - Acoustical Requirements | NCB Curve | Approximate L _A (dBA) |
|---|------------------|----------------------------------|
| Listening to faint musical sounds or distant microphone pickup used (concert halls, opera houses, recital halls) | 10 to 15 | 18 to 23 |
| Excellent listening conditions (large auditoriums, large drama theaters, large churches) | Not to exceed 20 | 28 |
| Close microphone pickup only (broadcast, television, and recording studios) | Not to exceed 25 | 33 |
| Good listening conditions (small auditoriums, small theaters, small churches, music rehearsal rooms, large meeting and conference rooms or executive offices, conference rooms for 50 people with no amplification) | Not to exceed 30 | 38 |
| Sleeping resting or relaxing (Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, etc.) | 25 to 40 | 38 to 48 |
| For good listening conditions (private or semiprivate offices, small conference rooms, classrooms, libraries, etc.) | 30 to 40 | 38 to 48 |
| Conversing or listening to the radio and TV (living rooms in dwellings) | 30 to 40 | 38 to 48 |

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Recommended NCB Curves and Sound Pressure Levels for Several Categories of Activity (Beranek 1989a)

| TABLE 8.5 - Acoustical Requirements - (Continued) | NCB Curve | Approximate L _A (dBA) |
|---|-----------|----------------------------------|
| Moderately good listening conditions (large offices, reception areas, retail shops and stores, cafeterias, restaurants, etc.) | 35 to 45 | 43 to 53 |
| Fair listening conditions (lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas) | 40 to 50 | 48 to 58 |
| Moderately fair listening conditions (light maintenance shops, industrial-plant control rooms, office and computer equipment rooms, kitchens and laundries) | 45 to 55 | 53 to 63 |
| Just acceptable speech and telephone communication (shops, garages, etc.) | 50 to 60 | 58 to 68 |
| Speech not required but no risk of hearing damage | 60 to 75 | 63 to 78 |

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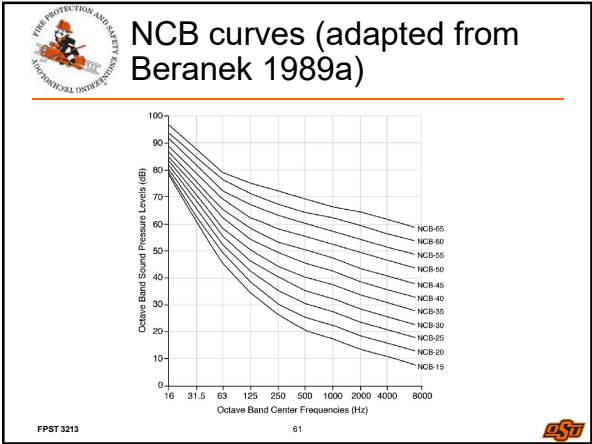
Noise levels


| Noise Criterion | Octave Band Center Frequency (Hz) | | | | | | | |
|-----------------|-----------------------------------|-----|-----|-----|------|------|------|------|
| | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| | Sound Pressure Levels (dB) | | | | | | | |
| NC-15 | 47 | 36 | 29 | 22 | 17 | 14 | 12 | 11 |
| NC-20 | 51 | 40 | 33 | 26 | 22 | 19 | 17 | 16 |
| NC-25 | 54 | 44 | 37 | 31 | 27 | 24 | 22 | 21 |
| NC-30 | 57 | 48 | 41 | 35 | 31 | 29 | 28 | 27 |
| NC-35 | 60 | 52 | 45 | 40 | 36 | 34 | 33 | 32 |
| NC-40 | 64 | 56 | 50 | 45 | 41 | 39 | 38 | 37 |
| NC-45 | 67 | 60 | 54 | 49 | 46 | 44 | 43 | 42 |
| NC-50 | 71 | 64 | 58 | 54 | 51 | 49 | 48 | 47 |
| NC-55 | 74 | 67 | 62 | 58 | 56 | 54 | 53 | 52 |
| NC-60 | 77 | 71 | 67 | 63 | 61 | 59 | 58 | 57 |
| NC-65 | 80 | 75 | 71 | 68 | 66 | 64 | 63 | 62 |
| NC-70 | 83 | 79 | 75 | 72 | 71 | 70 | 69 | 68 |

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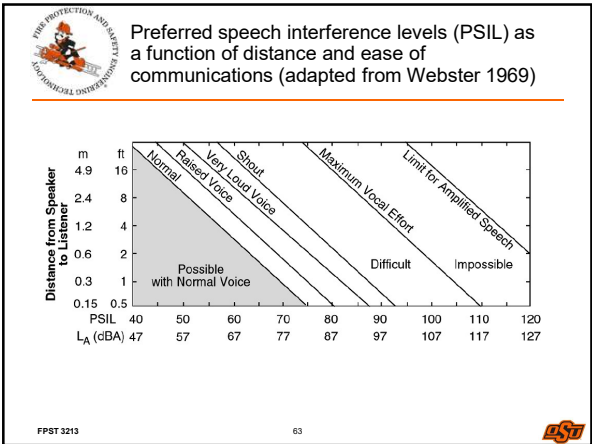



Interference with communication

- Method for rating speech interference affects of noise is called “preferred speech interference level” (PSIL)
- PSIL used to indicate whether or not there will be a communications problem.

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Approaches to reducing noise in the workplace


- Reduce the level or altering the noise generated
- Use barriers
- Absorbing reflected noise



- PPE

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Approaches to reducing noise in the workplace

- Background music
 - No conclusive proof music increases productivity
 - Most if not all workers enjoy listening to music
 - However those who do not enjoy the music will probably complain




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Questions?

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