WHAT COLOR IS WHITE LIGHT?

NEMA Conference 2016

Steven Rosen, Available Light

Dave Seibert, Peabody Essex Museum

Handout Packet
The Functions & Qualities of Light

Without some common vocabulary, discussions about such an ethereal subject as light are difficult. A return to the basics, defining the Functions and Qualities of light, can lead us to an excellent departure point for our discussion.

Like their colleagues, Lighting Designers oftentimes trap themselves in the limits of budgets, time schedules and energy management—rather than first developing an organic design and then subjecting the concept to real world parameters. The nature of theatre forces the theatrical lighting designer to deal with color & movement, mood & motivation of light—even when subjected to the same design traps as their architectural colleagues.

Functions of Light

Visibility - Seeing an intended object (and, conversely, not seeing that which is undesirable) is the most important function of light. Issues of glare and contrast are important considerations when considering visibility.

Motivation - Is the light from a candle? from the sun? from within a diamond ring? What would the designer have us believe?

Composition - Does aesthetic balance exist within the field of view? Are there visual clues, subtle or outrageous, that lead the eye from object to object in a way that makes the sum greater than its parts? Is there a suggestion of depth when actually there is none?

Mood - Does the visible field suggest either an emotional state or activity level? The lighting for a Music store will probably be different than lighting for a tea shop.

Qualities of Light

Intensity - Literally, how bright is the light? All we see is perceived by contrast; in the proper setting a candle can be as revealing as intensely bright sunshine—sometimes more so. Having adjacent areas within an environment illuminated to different intensities is the start of compositional development.

Angle/Direction - An enormous amount of visual clues are fed to the brain by the angle of light striking an object—perhaps this explains why many photographers prefer using black and white film stock. The angle or direction of
a particular light goes a long way in revealing (or denying) the form of any three-dimensional object. Mood is intimately entwined with angle; how one feels at sunset is usually quite different than at high noon.

**Color** - Whether used to extreme effect (i.e. a Rock concert) or with a delicate touch (as in employing a mixed light source scheme such as Metal Halide & High Pressure Sodium) color can add drama and suggest mood. Color is perceived by contrast—blue light looks more intensely blue when contrasted with amber light—this physiological attribute must be heeded when choosing a color palette for a particular project. Finishes specified by architects and/or interior designers will weigh in when the lighting color palette is chosen.

**Movement** - One aspect of movement in light is a change in intensity—as in the dimming of a lamp. Movement is also exemplified by the shifting of shadows, created by sunlight penetrating an interior, as the size of the shadow and angle of the sun changes over time. Dynamic movement is the ability to explore and manipulate the juxtaposition of highlight and shadow.

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A Glossary of Lighting Terms

**Absorption**: Refers to a measure of the amount of light absorbed, rather than reflected by an object. Dark colored and matte surfaces are least likely to reflect light.

**Accent Lighting**: Lighting directed at a particular object in order to focus attention upon it.

**Ambient Lighting**: The soft indirect light that fills the volume of a room with illumination. It reduces contrast, softens shadows on people’s faces, and creates an inviting glow in the room.

**Amperage**: The amount of electrical current consumed by conductive source such as a lamp.

**Angle of Reflectance**: The angle at which a light source hits a specular reflective surface equals the angle at which the resulting glare is reflected back. The angle of incidence equals the angle of reflectance.

**ANSI**: American National Standards Institute. A five digit numbering system in national use for designing lamp types.

**Ballast**: Device, each specific to a lamp type, that transforms and regulates electrical energy to operate fluorescent and high & low intensity discharge lamps.

**Beam Angle**: Used to measure the diameter (in degrees) of a beam of light produced by a specific lamp or luminaire. The beam angle is the area where the candle power is equal to 50% of the CBCP.

**Beam Spread**: The diameter of the pattern of light produced by a lamp or lamp and luminaire together.

**Below Grade**: Recessed below ground level.

**Black Hole**: Refers to an opening or window in a room that appears to be empty darkness, especially at night, because there is insufficient illumination at the other side to light up the objects or features framed by the opening.

**Bridge System**: Two wire, low-voltage cable system.
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**Candle Power or Candela:** A measure of intensity of light related to lumens.

**CBCP:** Center Beam Candle Power. The brightness in the center (or brightest part) of a beam of light produced by a particular luminaire.

**Cold Cathode:** A neon-like electric-discharge light source primarily used for illumination (neon is often used for signage or as an art form). Cold cathode can sometimes be used where fluorescent tubes would be too large or too hard to re-lamp.

**Color Rendering Index (CRI):** A scale used to measure how well a light source reveals the color tone of an object compared with the near perfect color rendering capability of either incandescent light or natural daylight. See also **TM30-15**.

**Cross Baffle:** A metal or plastic accessory used on a luminaire to help prevent glare.

**Decorative Luminaire:** Luminaire designed to please the eye and provide focal illumination.

**De-rating:** The reduction of the amount of wattage used to prevent overheating within a total electrical system.

**Diffusion Filters:** Glass or high temp polymer lenses used to widen and/or soften light output. Available in a variety of densities.

**Dichroic Filter:** Color filters utilizing the selective reflective properties of multi-layered coatings to produce a single saturated color. This process works by removing heat from a beam of light by transmitting one color and reflecting its complement.

**Dimmer:** An electrical device that regulates light levels; usually operated in tandem with some sort of control device.

**Driver, LED:** An **LED driver** is a self-contained power supply/transformer which has outputs that are matched to the electrical characteristics of a particular **LED**. **LED** drivers may offer dimming by means of pulse width modulation circuits, 0-10v or other protocol. More than one channel for
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separate control of different LEDs or LED arrays is not unusual especially if color changing (RGB+W &/or A) is present.

**Efficacy**: Measurement of the efficiency of a light source; usually represented by the ratio of in lumens produced per watt

**ETL**: An independent testing facility, similar to UL.

**Fade Rate**: Rate at which light levels decrease.

**Fiber Optics**: A illuminating system composed of a lamp source/illuminator, fiber/tether, and output optics/luminaires used to remotely light an area or object. Often used where access to the object being illuminated is limited or non-existent and/or where eliminating heat, UV or IR from the light beam is desirable.

**Field Angle**: Used to measure the diameter (in degrees) of a beam of light produced by a specific lamp or luminaire. The field angle is the area where the candle power is equal to 10% of the CBCP.

**Filters**: Glass or metal accessory used to alter beam patterns (I.E. color or intensity)

**Fish Tape**: Mechanical device used to pull wires in tight spaces or conduit.

**Fluorescent Lamp**: A very energy-efficient type of lamp that produces light through the activation of the phosphor coating on the inside surface of a glass envelope. These lamps come in many shapes, sizes, wattages, and colors rendering capabilities.

**Footcandle**: A measurement of the total light reaching a surface. One lumen falling on one square foot of surface produces the illumination of one foot candle.

**Footcandle Hour**: A measurement used by conservators to determine light exposure on a sensitive object/artifact. Expressed as a ratio of footcandles striking an object to the number of hours the light is present. Limitations are usually expressed as allowable footcandle hours per year.

**Ganging**: Grouping two or more controls in one enclosure.
**Glare/Glare Factor**: A source of uncomfortably bright light (either direct or reflected) that becomes the focus of attention rather than what it was meant to illuminate.

**Halogen**: An incandescent lamp containing halogen gas which recycles the tungsten filament. Typically brighter, “whiter,” hotter, and longer-lasting than standard incandescent lamp sources.

**Hard Wire**: Method of permanent luminaire installation using a junction box with no plug.

**High Pressure Sodium**: An H.I.D. lamp that uses sodium vapor as the light-producing element. It produces a yellow-orange light.

**High Intensity Discharge (H.I.D) Lamp**: A category of lamp that emits light through electricity activating pressurized gas in a bulb. Mercury vapor, metal halide, and high pressure sodium lamps are all H.I.D. sources. They are bright, energy-efficient, and long lasting light sources.

**Housing**: Enclosure for recessed sockets and trim above the ceiling.

**Illuminance**: Calculated as the amount of lumens per unit area. Two common units used to measure illuminance are footcandles (lumens/square feet) and lux (lumens/square meter). For conversion purposes, 1 footcandle is equal to 10.76 lux.

**Incandescent Lamp**: The traditional type of light bulb that produces light through electricity causing a filament to glow. It is a very inefficient source of illumination.

**Junction Box**: Enclosure for joining wires behind walls or ceilings.

**Kelvin (K)**: A measure of color temperature. An incandescent lamp is rated at about 2800K, halogen at about 3200K, and daylight is rated at about 5600K. The higher the Kelvin rating the “bluer” the source.

**Kilowatt**: A measurement of electrical consumption. A thousand watts equals one kilowatt.

**Kilowatt Hour**: Used to determine electrical usage; the number of Kilowatts burning per hour.
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Lamp: What the lighting industry technically calls a light bulb. A glass envelope with gas, coating, or filament that glows when electricity is applied.

LED: Light Emitting Diode. An solid state semiconductor that, by exciting current, emits light in a very narrow spectrum in a specifiable color from infrared through visible spectrum to ultraviolet. The produced color may be a direct result of the chemical recipe integral to LED (such as blue, amber, red or green) or a combination of UV produced light that causes a layer(s) of phosphor to glow (such as white or purple.)

Line-Voltage: 110/120 volt household current, generally standard in North America.

LM-79
Electrical and Photometric Measurements of SSL Products. Documents lumen maintenance. Applies to LED-based products incorporating control electronics and heat sinks. It does not cover retrofit lamps or luminaires sold without a light source.

LM-80
Applies to LED-based light sources (i.e. retrofits, modules, etc.) Documents lumen maintenance. Does not cover measurement of luminaires. Does not provide for estimation of life. TM-21 will do that.

Louver: A metal or plastic accessory used on a luminaire to help prevent glare.

Low-Pressure Sodium: A discharge lamp that uses sodium vapor as the light-producing element. It produces an orange-gray light.

Low-Voltage Lighting: System that uses less than 50-volt current (commonly 12 or 24 volt), instead of 110-120-volt, the standard household current. A transformer is used to convert the electrical power to the appropriate voltage.

Lumen: A unit of luminous flux. A measure of light output emitted from a light source. One lumen falling on one square foot of surface produces the illumination of one footcandle.
Luminaire: The complete lighting fixture—with all parts and lamps (bulbs) necessary for positioning and obtaining a power supply.

Luminance: The luminous intensity of a surface of a given projected area. Luminance is closely related to the brightness of an object and is measured in units known as candela.

Mercury Lamp: An H.I.D. lamp where the light emission is radiated mainly from mercury. It can be clear, phosphor-coated, or self-ballasted. It produces a bluish light.

Metal Halide Lamp: An H.I.D. lamp where the light comes from radiation from metal halide. It produces the best CRI light of the H.I.D. sources; a subset of this family is Ceramic Metal Halide lamp where CRI approaches an excellent 95. Limitations of wattage, bulb type, expense and availability can add to the challenges of employing this technology.

MR16/MR11/MR8, Multi-Mirror Reflector Lamp: Low voltage miniature tungsten halogen lamps with a variety of beam spreads and wattages. The light is controlled by mirrored facets positioned in the reflector.

Motion Sensor: An energy savings device which activates luminaires when movement occurs. Conversely, when no motion is detected, this control device switches the luminaire off.

Neon: A glass vacuum tube filled with a variety of neon gas and phosphors formed into signs, letters or shapes of varying colors.

Panic Switch: An on/off switch to activate security lighting, usually located by the bed for emergencies.

PAR Lamps: Lamps (bulbs) with Parabolic Aluminized Reflectors that give exacting beam control. There are a number of beam patterns and wattages to choose from, ranging from wide flood to very narrow spot. PAR lamps can be used outdoors due to their thick glass, which holds up in severe weather conditions.

Photo-Pigment Bleaching: Mirror like reflection of the sun on a surface causing glare.
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Photosensor: A control device that responds to ambient light levels which consequently activates, deactivates or dims luminaires depending on surrounding light levels.

Planetarium Effect: Too many holes in the ceiling from an over abundance of recessed fixtures.

R Lamp: An incandescent source with a built in reflecting surface.

Reflectance: The ratio of light reflected by a surface or medium to the light incident upon it.

Reflected Ceiling Plan (RCP): A lighting plan drawn from the floor looking at the ceiling above.

RLM Reflectors: A luminaire designed to reflect light down and prevent upward light transmission.

Spectrum: The visual spectrum is comprised of all colors of lights—measured in nanometers—that are perceptible to the human eye from deep purple (400N) through to magenta. (700N) “White” light is a combination mix of all of these colors. Just below 400N is ultraviolet and just above 700N is infrared.

Spread Lens: A glass lenses accessory used to diffuse and widen beam patterns.

Stake Lights: Luminaires mounted on a stake to stab into the ground or a planter.

Swiss Cheese Effect: Too many holes in the ceiling from an overabundance of recessed fixtures.

T2, T5, T8, T12: Linear fluorescent lamp designation/profile. ‘T’ means tubular, the number refers to the tube diameter in 1/8’s of an inch; lamp length is determined by wattage I.E. an F32/T8 fluorescent lamp is 32 watts, 1” in diameter and 48” long.

Task Lighting: Illumination designed for a work surface so good light, free of shadows and glare, is present.

Timers: Control devices to activate luminaires at set timed intervals.
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**TM-21:** Lumen Degradation Lifetime Estimation Method for LED Light Sources. Extends the usefulness of LM-80. TM-21 has become the standard method for estimating useful LED lighting product life at operating temperatures for typical applications.

**TM-30-15:** A method for evaluating light source color rendition that goes significantly beyond CRI. Developed especially to better predict, communicate, and realize color performance in the age of SSL the system employs multiple metrics (Color Rendition, Color Fidelity & Color Discrimination) to evaluate color perception.

**Transformer:** A device which can raise or lower electrical voltage, generally used for low-voltage lights.

**Tungsten-Halogen:** See Halogen.

**UL:** Underwriters Laboratory, an independent testing company.

**UV:** Ultra-violet radiant energy not perceptible to the human eye. UV light speeds the deterioration of organic elements such as paper, leather, wood, etc.

**Veiling Reflection:** A mirror like reflection of a bright source on a shiny surface.

**Voltage:** A measurement of the pressure of electricity going through a wire.

**Voltage Drop:** The decrease of voltage (and consequent light output in fixtures) based on the distance of a luminaire from the power source.

**White Light:** Usually refers to light with a color temp. between 5000-6250 degrees Kelvin and composed of the whole visible light spectrum. This light allows all colors in the spectrum on an object’s surface to be reflected, providing good color-rendering qualities.

**Xenon:** An inert gas used as a component in certain lamps to produce a cooler (higher) color temperature than standard incandescent. It is often used in applications where halogen may otherwise be specified, because of xenon’s longer lamp life.
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**Automated Lighting and Control**
High End Systems, Inc.
www.highend.com

Martin
www.martin.dk

Vari-Lite, Inc.
www.vari-lite.com

Clay Paky, Inc.
www.claypaky.com

Coemar
www.coemar.it

Color Kinetics
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Electronic Theatre Controls, Inc.
www.etcconnect.com

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www.strandlight.com

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Altman Stage Lighting Company, Inc.
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Apollo Custom
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www.gerriets.com/us

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www.rosebrand.com

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