Technical and Design Considerations

CONTENTS

Lighting Terminology

Definitions

Luminaire – A complete lighting unit consisting of lamp or lamps, the parts designed to distribute the light, the fixture housing and any necessary starting components (ballasts).

Photometrics – A photometric test measures the quantity and direction of light emitted from a luminaire. Photometrics refers to the measured values.

Luminous Intensity – Measured in a photometric test to describe the intensity of light in a particular direction. Measured in *candelas*.

Luminous Flux – The flow of light from a lamp or luminaire. Measured in *lumens*.

Illuminance – The flow of light onto a surface. Expressed in *footcandles* (English units) or *lux* (metric units).

Luminous Efficacy – Quantifies lumens produced per unit of power (watts) consumed. Can be used to evaluate the energy efficiency of a lamp or a luminaire. Measured in *lumens per watt*.

Luminaire Efficacy Rating (LER) – A metric used to describe the energy efficiency of lighting products. This value, listed on many product specification sheets, consists of a prefix indicating the product category and a number indicating lumens per watt or LER.

Luminous Efficiency – Total lumen output of a luminaire expressed as a percent of rated bare-lamp lumens (as determined by photometric tests). Luminous efficiency quantifies only the amount of light emitted from a luminaire. It does not describe the quality of the light from the luminaire.

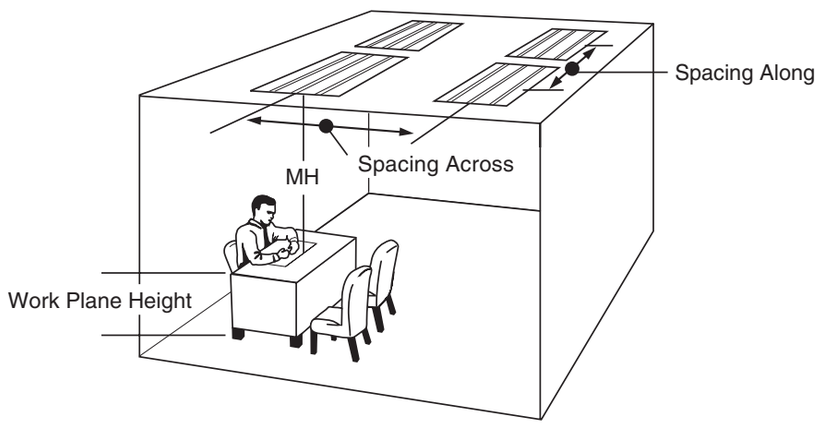
Work Plane – A horizontal surface where visual tasks are performed. The work plane is typically *ground level* for outdoor applications and *2.5 feet* for office applications (corresponding with desk height). In some cases, a work plane may be vertical, such as a library stack or warehouse rack.

Coefficient of Utilization (CU) – The percent of rated bare-lamp lumens that exit the fixture and reach the work plane. The CU accounts for light directly from the luminaire as well as light reflected off the room surfaces. The CU value is used in lighting calculations to estimate light levels or the quantity of luminaires needed. The CU is determined from a photometric test and is typically published on product catalog sheets in a tabular form.

Spacing to Mounting Height Ratio (S/MH) – A value, calculated from photometric data, that is used to estimate how far apart luminaires mounted in a row can be spaced to maintain uniform illuminance on the work plane. The spacing criterion value is multiplied by the luminaire mounting height above the work plane to estimate acceptable spacing. For luminaires mounted in a rectangular array, the spacing criterion provides a better indicator of the spacing required to achieve uniform illuminance.

Spacing Criterion (SC)

A value, calculated from photometric data, that is used to estimate how far apart luminaires can be spaced to maintain uniform illuminance on the work plane. The spacing criterion value is multiplied by the luminaire mounting height above the work plane to estimate an acceptable center-to-center luminaire spacing.



Luminaire Spacing = Spacing Criterion x mounting height above work plane (MH)

Luminaire Classifications for Controlling Glare

The Illuminating Engineering Society of North America (IESNA, or IES) provides classifications for luminaires according to their glare control and high-angle brightness. These classifications include full cutoff, cutoff, semi-cutoff and non-cutoff.

Acuity Brands Lighting uses Nighttime Friendly to identify products that reduce negative impacts on the nighttime environment. Products designated with the Nighttime Friendly logo have no uplight, meet the IESNA definition for full cutoff optics and reduce high-angle brightness. These measures of luminaire performance are consistent with sustainability standards for light pollution reduction.

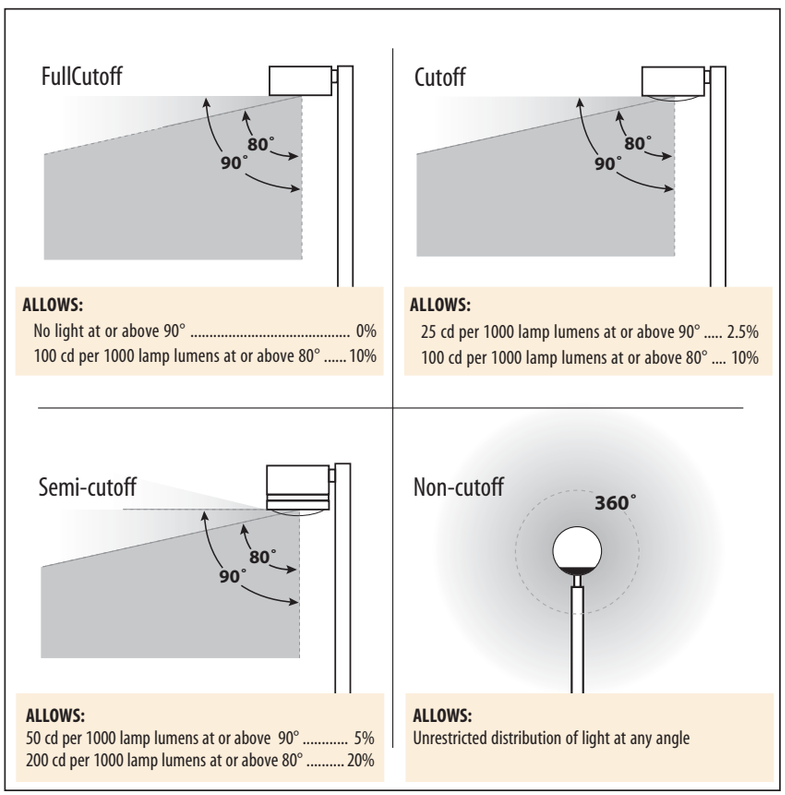
For applications where there is a concern with light trespass on neighboring properties, consider products that limit light behind the pole such as the Type 4 sharp cutoff optical system or house side shielding.

NIGHTTIME FRIENDLY™

Nighttime Friendly designates products with superior optical control that are consistent with the goals of USGBC LEED® and meet Green Globes™ product criteria for light pollution reduction. These products are full cutoff and no more than 10% of the lumens from the luminaire are emitted above 80 degrees from nadir.

Classification	Definition	Benefits	Limitations
Full Cutoff	Zero intensity at or above horizontal (90° above nadir) and limited to a value not exceeding 10% of lamp lumens at or above 80°.	Limits spill light onto adjacent property, reduces glare. No light is emitted directly from the luminaire into the sky.	May reduce pole spacing to maintain uniformity and increase pole and luminaire quantities.
Cutoff	Intensity at or above 90° (horizontal) no more than 2.5% of lamp lumens, and no more than 10% of lamp lumens at or above 80°.	Small increase in high-angle light allows increased pole spacing.	May allow some uplight from luminaire. Typically a small overall impact on sky glow.
Semi-cutoff	Intensity at or above 90° (horizontal) no more than 5% of lamp lumens and no more than 20% at or above 80°.	High-angle light accents taller vertical surfaces such as buildings. Most light is still directed downward.	Little control of light at property line. Potential for increased glare when using high wattage luminaires. Typically directs more light into the sky than cutoff.
Non-cutoff	No limitations on light distribution at any angle.	Uniform luminous surfaces such as internally illuminated signs or globes. Wattage should be limited. Suitable for sports lighting, facade, landscape or other applications where luminaires are tilted due to limitations in pole or fixture locations.	Location and aiming are critical. Most likely of all categories to produce offensive brightness and sky glow.

NOTE:
The Illuminating Engineering Society of North America plans to adopt a new luminaire classification system in 2006 that will supercede the current cutoff classifications.



LEED with Lighting – A LEED Overview

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System® is a voluntary, consensus-based national standard developed by the US Green Building Council (USGBC). LEED standards define the criteria for developing high-performance, environmentally sustainable buildings. For full details, go to www.AcuityBrandsLighting.com/sustainability.

Category	Prerequisite or Credit	NC v2.2 New Construction	EB v2 Existing Buildings	CI v2 Commercial Interiors
Site Selection	Light pollution reduction (½ to 1 credit)	Interior Lighting • The angle of max candela from each interior luminaire shall not exit out through the windows OR All non-emergency interior lighting shall be automatically controlled to turn off during non-business hours. Exterior Lighting • Do not exceed 80% of the LPDs for exterior areas and 50% for building facades and landscape features as defined in ASHRAE/IESNA Standards 90.1-2004 without amendments. • Limits have been set (by IESNA Lighting Zone) on illuminance outside of site boundaries, fall off of illuminance outside of site boundaries and total uplight.	• Have no luminaire 50 watts or greater with uplight or show that less than 5% of light emitted by all exterior luminaires reaches the night sky on an annual basis. • The direction of max intensity for all interior luminaires must fall within the building (not striking a window). • The direction of max intensity for all exterior luminaires must fall within the property.	• Meet or be lower than light levels in IESNA RP-33-99. • Shield all exterior luminaires with initial lamp lumens over 1000 lumens. • All exterior luminaires with initial lamp lumens over 3,5000 must be IESNA full cutoff. • The direction of max intensity for all interior luminaires must fall within the building (not striking a window). • All exterior lighting within 2.5 mounting heights of the property boundary cannot emit light off of the property.
Energy & Atmosphere	Fundamental commissioning (prerequisite)	Lighting controls (including for daylighting) must be commissioned.	Lighting controls (including for daylighting) must be commissioned.	Lighting controls (including for daylighting) must be commissioned.
	Minimum energy performance (prerequisite)	Meet ASHRAE/IESNA 90.1 - 2004 or local energy code (whichever is more stringent)	Achieve an EPA energy performance rating of at least 60 using the portfolio manager.	Meet ASHRAE/IESNA 90.1 - 2004 with amendments or local energy code (whichever is more stringent)
	Optimize energy performance (1-10 credits)	Reductions in energy use below that set in ASHRAE/IESNA 90.1 - 2004 without amendments: • 10.5% = 1 point • 14.0% = 2 • 17.5% = 3 • 21.0% = 4 • 24.5% = 5 • 28.0% = 6 • 31.5% = 7 • 35.0% = 8 • 38.5% = 9 • 42.0% = 10	Achieve an EPA energy performance rating of at least: • 63 = 1 point • 67 = 2 • 71 = 3 • 75 = 4 • 79 = 5 • 83 = 6 • 87 = 7 • 91 = 8 • 95 = 9 • 99 = 10	Reductions in lighting power density below that set in ASHRAE/IESNA 90.1 - 2004 with amendments: • 15% = 1 point • 25% = 2 • 35% = 3 And install daylight responsive controls in regularly occupied spaces within 15' of windows and under skylights = 1 point.
	Enhanced metering (¼ credit)	Lighting systems and controls are optional.	Lighting systems and controls are optional.	Lighting systems and controls are not optional.
Materials & Resources	Mercury content in lamps (prerequisite)		Below 100 picograms per lumen-hour.	
	Mercury content in lamps (1 credit)		Below 80 picograms per lumen-hour.	
	Recycled content	Lighting equipment is specifically excluded from this credit.		Lighting equipment is specifically excluded from this credit.
	Regional materials	Lighting equipment is specifically excluded from this credit.		Lighting equipment is specifically excluded from this credit.
Indoor Environmental Quality	Controllability of systems (1-2 credits)	• Provide individual lighting controls for 90% (minimum) of the building occupants to enable adjustments to suit individuals task needs and preferences AND • Provide lighting system controllability for all shared multi-occupant spaces to enable lighting adjustment that meets group needs and preferences.	Provide lighting control for: • 50% of all occupants allowing for individual adjustments, and • All shared areas	Provide lighting control for: • 90% of all occupants allowing for individual adjustments, and • All shared areas

RTS™ Volumetric Recessed Lighting

Direct-Indirect Lighting

Architectural Grade Downlighting

Industrial Spaces

Commercial Downlighting

Exit Signs

Superior optics in the lighting will help the designer toward a goal of meeting the energy prerequisite of LEED and to maximize the number of optional points to be obtained while meeting the vision needs of the occupants. In interior spaces, high efficiency products such as these minimize energy use while providing excellent visual acuity and a safe and secure environment. Links are provided to web-based examples of using these products to meet LEED requirements.

RT5™ Volumetric Recessed Lighting

Looking for something better than the harsh overhead light and confining cave effect of parabolics? Choose the new standard in fluorescent lighting – RT5 volumetric recessed lighting from Lithonia Lighting. Unlike parabolics, RT5 luminaires are designed to deliver the right amount of soft, comfortable light throughout a room, truly enhancing the work environment. This makes this new fixture an ideal solution for offices, schools, hospitals, retail and other workspaces.

Producing 52 fc on 8'x10' spacing allows RT5 luminaires to consume up to 33% less energy then the standard 18-cell, 3-lamp, T8 parabolic for a lighting power density of only 0.75 watts per square foot. This is 43% less than the 90.1-1999 requirement for offices helping you toward six points under EAc1-Optimizing Energy Performance. Intelligent technology includes stepped switching bi-level output, and for even greater energy savings, end-of-life sensing.

Direct-Indirect Lighting

Peerless has always designed lighting fixtures that use high efficiency fluorescent lamps, and in fact, we pioneered the concept of indirect lighting, a healthier, more energy-efficient approach to lighting offices and educational environments. Recently conducted research into the effects of lamp operating temperatures on performance, allowed us to further increase efficiency by ensuring all our luminaires are thermally optimized. We also have designed HOT-5 + products to achieve the lamp manufacturers' peak output rating of 5000 lumens, reducing energy and materials usage, reducing lamp maintenance and disposal costs.

Architectural Grade Downlighting

Make a distinct visual statement while using highly efficient sources such as compact fluorescent. Differentiate a space with light. Add unique character; give your design an edge. You want to play with light. So do we. ICE™ is about having some fun with lighting while saving energy.

Industrial Spaces

Lithonia's new I-BEAM™ unit is the perfect match for high bay situations. Available in 4 or 6 high performance T8 lamps with wide or narrow distributions, the I-BEAM Series ranges in efficiency from 87% to more than 96%. When HID is still the right choice, we have a wide range of luminaires using pulse-start technology. A change in the lamp and ballast construction allows pulse-start metal halide lamps to start using a high voltage ignitor in the ballast instead of a starting electrode (probe) in the lamp. The result is a "white light" system that challenges high pressure sodium's long lamp life, high lumen output and quick starts capabilities.

Lithonia Commercial Downlighting

Compact fluorescent downlights are ideal for energy-efficient illumination in many applications. Reduced energy consumption coupled with long lamp life reduces energy and maintenance costs. Lithonia Downlighting products offer exceptional quality, performance, availability, versatility and selection to help you meet your design needs.

Exit Signs

The Precise® edge-lit, Signature® die-cast aluminum, Extreme® all-conditions cast aluminum and Quantum® thermoplastic exit sign families provide a broad range of attractive products for many building applications where low energy consumption and longevity are required. Our LED lighting sources provide bright and even illumination that lasts more than 25 years with energy requirements of as little as 0.62-watts. The high performance levels of Lithonia Lighting exit signs easily surpass the stringent guidelines that have been set by the EPA and U.S. Department of Energy.

LEED with Lighting – Controlling the Lights

To make the most of the LEED criteria EAp2-Minimum Energy Performance, EAc1-Optimize Energy Performance, EAc5-Measurement & Verification and EQc6-Controllability of Systems lighting controls are a must, including:

- Automatic shutoff
- Occupancy sensors
- Lighting load reduction
- Daylight harvesting
- Outdoor lighting control

Synergy® System

A unique lighting control system that integrates all aspects of lighting control into a single system platform. Synergy combines architectural dimming, low-voltage switching, lighting automation and energy management functions into a single scalable package capable of meeting the requirements of virtually any lighting control application.

Synergy® System

Occupancy Sensors

The ABL sensor line consists of multiple sensing technologies including Infrared, Ultrasonic and combined multi-technology offering directional or omni-directional sensing. These sensors provide effective coverage for automatic on/off lighting control in indoor applications, immediately switching lights on when movement is detected. After the room is vacated for a preset length of time, the sensor automatically switches lights off.

Occupancy Sensors

KiloWatch® System

Ideal for warehouses, storage areas, parking garages, shipping docks and gymnasiums. Energy savings for HID lighting through a multi-level control system. With energy costs on the rise, there is a need for a better control of energy usage. Efficient, well-designed lighting systems offer a tremendous opportunity to reduce energy consumption while maintaining productivity. The KiloWatch system from Lithonia Lighting combines the high efficiencies and energy savings of high intensity discharge lighting with proven control technology, allowing you to have light when you need it and save energy when you don't. KiloWatch systems can reduce lighting power cost by up to 40%.

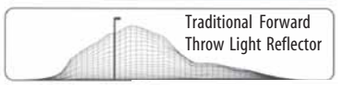
KiloWatch® System

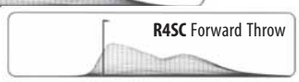
Multi-Level Outdoor Lighting

Acuity Brands Lighting offers a compact and economical lighting control panel that offers simplified solutions for exterior lighting control applications. This time-based controller switches lighting On/Off at pre-set times while managing a variety of low-voltage inputs for photocells and switches. The built-in astronomic time clock function with daylight savings capability meets many outdoor lighting control code requirements. Relays are rated to directly switch 20A or 30A lighting loads, eliminating the need for external contactors or relays.

Multi-Level Outdoor Lighting

Full Cutoff Luminaires





Superior Optical Designs

Eurotique® Luminaires

Full Cutoff Luminaires

Whatever your needs, 150W to 1000W, square or round housings, architectural styling or economic solutions, Acuity Brands Lighting has the right full cutoff product to assist you in meeting LEED criteria SSc8 (Light Pollution Reduction). Full cutoff distributions are available in area, roadway and wall mounted fixtures.

Superior Optical Designs

The Aeris™ Series provides nighttime performance as dramatic as its daytime appearance. High performance optics make the best use of new efficient lamps, resulting in low energy consumption. These reflectors are tuned for improved performance at lower mounting heights ensuring pole-mounted luminaires will maintain proper scale with the structure. Distribution types SR2, SR3, SR4SC (sharp cutoff), SR4W (wide), and SR5S provide choices for effective coverage of roadways, parking lots, walkways and campuses, All reflectors are interchangeable and can be rotated in 90° increments. The unique nature of the Aeris optics virtually eliminates the stripes, or striations, normally associated with horizontal lamp luminaires. For more than 10 years, the SR4SC distribution has been the industry's best solution to controlling stray light behind the pole. With a new and improved design, the SR4SC now provides even more light in front of the pole while improving cutoff of back light. Aeris luminaires are true architectural lighting instruments. The SR4SC optics package is available in a wide range of outdoor products including projects looking for an economical solution.

Eurotique® Luminaires

Performance with style! Eurotique luminaires offer superior nighttime performance without jeopardizing the architectural integrity of your project. The carefully scaled family approach to design offers you the ability to begin at the building and continue through the parking lot and into the street with continuity in your design. The multiple fixture and arm styles along with the availability of two different sizes gives you the ability to match virtually any architectural style. The modular design concept of Eurotique offers ease of installation and simple lamp and ballast access for maintenance. Eurotique products are available in a Full Cutoff distribution to meet SSc8 – the Light Pollution Reduction credit.

Energy and Environmental Information

Luminaire Efficacy Rating (LER)

The Energy Policy Act of 1992 requires that the lighting industry develop a rating for luminaires that allows designers to compare the energy efficiency of lighting products.

Luminaire Efficacy Rating (LER) has been developed by the National Manufacturer's Association (NEMA) and approved by the National Lighting Collaborative to fulfill the requirements for the Energy Policy Act.

The Collaborative represents a broad spectrum of industry professionals including manufacturers, industry associations, government, designers and energy conservation groups.

This rating already has begun to be incorporated on Lithonia specification sheets and catalog information. NEMA document LE5 describes the calculation of LER as:

$$LER = \frac{EFF \times TLL \times BF}{Input\ Watts}$$

where

EFF = luminaire efficiency

TLL = # lamps per luminaire X rated lumens per lamp

BF = ballast factor

Input watts = total system watts of the luminaire

This results in a lumens-per-watt rating that can be used to compare the energy efficiency of various products.

The initial implementation of rating luminaires covers categories of common fluorescent 4′ and 8′ luminaires, downlights and HID industrial luminaires. In addition to the LER value, a prefix indicating the type of source and general category of luminaire (such as FL for Fluorescent Lensed, FP for Fluorescent Parabolic or HO for HID Open Industrial) ensures that comparisons can be made among similar products.

As part of the Lithonia Lighting commitment to quality, our laboratory has been accredited by the National Voluntary Laboratory Accreditation Program (NVLAP), administered by the National Institute of Standards and Technology (NIST).

The Acuity Brands Lighting – Conyers Lab is NVLAP-accredited for the scope of accreditation under NVLAP Lab Code 200007-0. NVLAP accreditation is based on an assessment of a laboratory's quality system, technical qualifications and competence to perform tests in accordance with specific test methods.

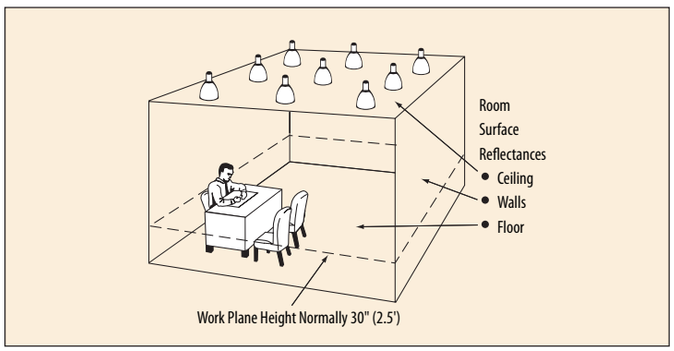
Our accreditation is under the NVLAP Energy Efficient Lighting Products Program. For a complete listing of the scope of accreditation, go to the website:

ts.nist.gov/ts/htdocs/210//214/scopes/2000070.htm.

Lighting Calculations

Well-balanced illumination is the signature of quality lighting design. Whether lighting for visual task performance or for aesthetic appeal, calculations are the mechanism through which quality design is achieved. The following methods are instrumental in designing and evaluating potential systems.

The Lumen Method



The lumen method is used when an average horizontal illuminance level is desired. It is based on the fundamental equation for illuminance, or

$$\text{Illuminance} = \frac{\text{Luminous flux in lumens}}{\text{Area}}$$

The general lumen method equation, also known as the zonal cavity method, is:

$$E_{ave} = \frac{(\#\text{Luminaires})\ (\#\text{Lamps})\ (\#\text{Lumens})\ (CU)\ (LLF)}{\text{Room Length} \times \text{Room Width}}$$

E_{ave}: Average horizontal work plane illuminance (fc or lux)

(#Luminaires): Number of luminaires in the space

(#Lamps): Number of lamps in each luminaire

(#Lumens): Manufacturer's rated lamp lumen output per lamp

(CU): Application coefficient of utilization

(LLF): Application light loss factor

An alternate form via algebraic manipulation is:

$$\#\text{ of Luminaires Required} = \frac{(E_{ave}\ \text{desired})\ (L)\ (W)}{(\#\text{Lamps})\ (\#\text{Lumens})\ (CU)\ (LLF)}$$

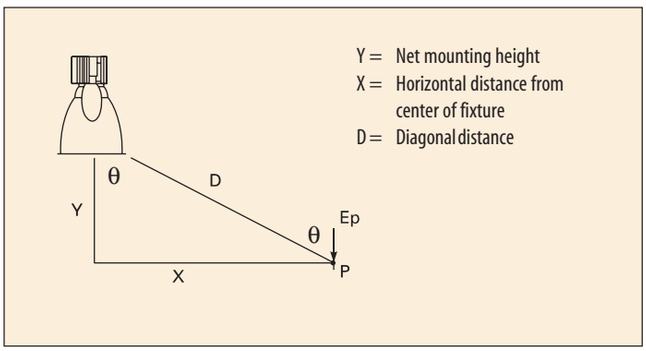
The *coefficient of utilization* is based on the photometric distribution of the luminaire and the geometry and surface reflectances of the space. It is typically less than 1.0 and represents the percentage of the total lamp lumens that ultimately reach the horizontal work plane (see figure above). Pre-calculated values can be found on the appropriate product's specification sheet.

The *light loss factor* accounts for decreased light output over time. It addresses variations from test conditions, equipment operating characteristics, depreciating lamp lumen output, dirt buildup, material degradation and ballast factor.

This calculation method is valid for an empty rectangular room geometry, a uniform layout of lighting equipment and uniform luminance on room surfaces.

The Visual® Lumen Method Tool is lighting design sofware that provides step-by-step guidance through the Lumen Method calculation, as described in the IESNA handbook. It is included with both the Visual Basic and Professional Editions, and is available from Acuity Brands Lighting Group at www.visuallightingsoftware.com.

The Point Method



The point method is used to determine the specific illuminance at a point in space. These calculations are invaluable for analyzing the variations in illuminance over a region. Based on spatial geometry, the point method equation, also known as the inverse square and cosine laws, is:

$$E_p = \frac{I_p}{D_2} \text{Cosine}\,\theta$$

E_p: Horizontal illuminance at point P

I_p: Luminous intensity in the direction of point P

D_2: Distance from source to point P

The *luminous intensity* is found in a luminaire's photometric report, and the distance is computed using a standard geometric formula. Referring to the figure above, the formula for the diagonal distance D is:

$$D = \sqrt{(X^2 + Y^2)}$$

Because light is additive, the total direct point illuminance is simply the sum of the individual contributions from each luminaire or source.

The point method as presented here does not account for light that is reflected from room surfaces.

While point illuminance can be calculated using the inverse square cosine law, this method does not account for light that is reflected from room surfaces or shadows from obstructions. Visual® software from Acuity Brands Lighting Group is a collection of lighting calculation tools and powerful 3D modeling software engineered to simplify the design process and provide a comprehensive analysis for advanced lighting projects. The Visual Professional Edition is a comprehensive lighting analysis tool designed for demanding interior and exterior applications. The Professional Edition combines an intuitive user interface with the latest advances in radiosity theory to provide efficient and highly accurate analysis of complex modeling environment, resulting in an intuitive and powerful design experience. A trial edition of Visual software can be obtained from www.visuallightingsoftware.com.

Most lighting installations provide reliable service for many years with no maintenance except for routine cleaning and lamp replacement. If a malfunction does occur, use the information below to diagnose and correct the problem. *Disconnect the power before servicing any lighting system.* Do not perform service while the fixture is engaged. Contact the Lithonia Customer Service Department if you need further assistance.

The following is a list of common malfunctions, possible causes and appropriate corrective action.

Lamp Will Not Start

Incorrect lamp or ballast – Check fixture label against lamp type. Check lamp and ballast ANSI numbers to ensure they match. Check that lamp is in proper burning position (Metal Halide).

Lamp is improperly seated in socket – Back out lamp and retighten. Check pin connection with socket. HID: Check to see if center contact of socket is compressed. If so, disconnect fixture from power supply and bend contact into position with a screwdriver.

Incorrect or loose wiring – Disconnect from power. Check wiring connections. HID: Connect fixture lead marked with proper voltage to voltage supply lead. 120V, 277V and 347V: Connect lead marked COM to neutral supply. 208V, 240V and 480V: Connect lead marked COM to other voltage supply lead.

Lamp at or near end of life – Replace with new lamp. HID arc tubes will blacken near end of life. Mercury and metal halide lamps will produce low light output and may exhibit intermittent starting. Metal halide will suffer severe color changes. High pressure sodium lamps will exhibit normal starting but will turn on and off (cycle) during operation. The envelope of a high pressure sodium lamp may develop a brownish discoloration. Low pressure sodium lamps will operate at nearly full light output but starting will become impossible at end of life.

Photoelectric control defective – Disconnect button type cell from circuit or replace NEMA twist-lock cell with shorting cap, test fixture. If lamp starts, replace PE control.

Line or ballast output voltage low – Check line voltage at the fixture. Check open circuit voltage. See page 722 for HID ballasts.

Ballast burned out – Check circuit continuity. See page 711 for fluorescent ballasts. See page 722 for HID ballasts.

Starter circuit failure – Replace lamp with known good lamp. If lamp fails to start, replace starter.

Improper ambient temperature – Check ballast or fixture rating against existing environmental conditions. Fluorescent lamps experience starting problems when the ambient temperature is below 50°F. Mercury and metal halide will start above -20°F and high pressure sodium above -40°F.

Incorrect or loose wiring – Disconnect from power. Check wiring connections.

Slow or Erratic Starting

Lamp at or near end of life – Replace with new lamp. HID arc tubes will blacken near end of life. Mercury and metal halide lamps will produce low light output and may exhibit intermittent starting. Metal halide will suffer severe color changes. High pressure sodium lamps will exhibit normal starting but will turn on and off (cycle) during operation. The envelope of a high pressure sodium lamp may develop a brownish discoloration. Low pressure sodium lamps will operate at nearly full light output but starting will become impossible at end of life.

Line or ballast output voltage low – Check line voltage at the fixture. Check open circuit voltage. See page 722 for HID ballasts.

Line voltage varies – Check incoming voltage with recording voltmeter (if this is the problem, check other equipment on the same circuit).

Incorrect lamp or burning position – Check fixture label against lamp type. Check lamp and ballast ANSI numbers to ensure they match. Check for proper lamp operating position (metal halide).

Improper ambient temperature – Check ballast or fixture rating against existing environmental conditions. Fluorescent lamps experience starting problems when ambient temperature is below 50°F. Mercury and metal halide will start above -20°F and high pressure sodium above -40°F.

Hard-starting lamp – Replace with new lamp if delay is lengthy.

Incorrect or loose wiring – Disconnect from power. Check wiring connections.

Ballast near or at end of life – Test ballast. See page 711 for fluorescent ballasts.

Blinking, "Snaking" or Flickering (Fluorescent)

New lamp may need to be seasoned – Turn fixture on and off several times at 30-minute intervals.

Ambient temperature too low – If ambient temperature is below 50°F, change to ballast rated for conditions.

Significant air movement across lamps – Check for fans or air conditioning blowing across lamps.

Incorrect or loose wiring – Disconnect from power. Check wiring connections.

Line voltage varies – Check voltage supply. See page 711 for fluorescent ballasts.

Cycling (Lamp Turns On and Off)

Line voltage varies – Check voltage supply.

Faulty insulation detector (recessed fixtures) – Bypass to verify or move insulation if in contact. Insulation must be kept at least 3" from the side and 1/2" from the top of the fixture.

High Intensity Discharge:

Lamp at end of life or defective HPS lamp – Replace with new lamp.

PE control receives reflected light – Cover PE control and test fixture.

Incorrect lamp or ballast – Compare fixture and lamp labels for matching wattage and source. Compare fixture and system voltage rating.

Ballast output voltage low – Check line voltage at fixture. Check open circuit voltage. See page 722 for HID ballasts.

Incorrect lamp operating position (metal halide) – Check lamp specifications for proper operating position.

Fluorescent:

Incorrect or loose wiring – Disconnect from power. Check wiring connections.

Ballast is operating too hot – Check for high ambient temperatures, ventilate or suspend fixture.

Ballast near or at end of life – Test ballast. See page 711 for fluorescent ballasts.

Reduced Light Output

Improper ambient temperature – Fluorescent: Check for ambient temperature significantly above or below 77°F.

Air movement across lamps – Fluorescent: Check for fans or air conditioning blowing across lamps.

Lamp at or near end of life – Replace with new lamp. HID arc tubes will blacken near end of life. Mercury and metal halide lamps will produce low light output and may exhibit intermittent starting. Metal halide will suffer severe color changes. High pressure sodium lamps will exhibit normal starting, but will turn on and off (cycle) during operation. The envelope of a high pressure sodium lamp may develop a brownish discoloration. Low pressure sodium lamps will operate at nearly full light output but starting will become impossible at end of life.

Incorrect or loose wiring – Disconnect from power. Check wiring connections.

Ballast near or at end of life – Test ballast. See page 711 for fluorescent ballasts. See page 722 for HID ballasts.

Short Lamp Life

Incorrect lamp or ballast – Compare fixture label against lamp type. Check lamp and ballast ANSI numbers to ensure they match. Check that lamp is in proper burning position.

Line voltage or ballast output voltage low – Check line voltage at fixture. Check open circuit voltage. See page 722 for HID ballasts.

Lamp operates less than 10 hours per start – Rated lamp life is based on 10 hours of operation per start. General rule for expected lamp life is: 50% reduction in burn time per start results in 25% reduction in lamp life.

Faulty lamp – Replace with new lamp.

Radio Interference (Fluorescent)

Interference from electronic equipment – Move electronic equipment at least 10 feet away from lamps. Install radio frequency shielding. Install radio interference filter. Improve equipment grounding. Install shielded and grounded radio antenna.

Blown Fuses or Tripped Circuit Breaker (HID)

Improper fuses installed in fixture – Check fuses to fixture manufacturer's specification. Replace if incorrect.

Overloaded circuit – Verify that total circuit load is less than circuit rating.

Shorted (grounded) fixtures – Check with shorted (grounded) test. If shorted, replace fixture. See page 722 for HID ballasts.

Ingress Protection

The IEC (International Electrotechnical Commission) uses the term "International Protection" or IP to define the environmental protection of an enclosure. This is described in IEC Standard 529. The IP rating system designates, by means of a two-digit number, the degree of protection against ingress of dust and moisture. The first digit defines the level of protection against solid objects, while the second digit defines the level of protection against moisture. The higher the digit, the greater is the level of protection.

First Digit Degree of protection against solid objects	Second Digit Degree of protection against water
0 Non-protected	0 Non-protected
1 Protected against a solid object greater than 50mm such as a hand	1 Protected against water dripping vertically
2 Protected against a solid object greater than 12mm such as a finger	2 Protected against dripping water when incident up to 15° from vertical
3 Protected against a solid object greater than 2.5mm such as a wire or a tool	3 Protected against water spraying at an angle of up to 60°
4 Protected against a solid object greater than 1.0mm such as a wire or thin strip	4 Protected against water splashing from any direction
5 Dust-protected. Prevents ingress of dust sufficient to cause harm	5 Protected against jets of water from any direction
6 Dust-tight. No dust ingress.	6 Protected against heavy seas or powerful jets in harmful quantities
	7 Protected against harmful ingress of water when immersed between a depth of 150mm and 1 meter
	8 Protected against submersion. Suitable for continuous immersion in water

Protection Against Moisture

UL and CSA define several levels of protection against moisture damage to a luminaire. These definitions describe the space in which the luminaire is intended to operate without damage to the electrical or mechanical components from the environment. These definitions cover pure water protection only, not damage protection from acidic or alkaline conditions.

Dry Location – A location not normally subject to dampness, but may include a location subject to temporary dampness as in the case of a building under construction, provided that ventilation is adequate to prevent an accumulation of moisture.

Damp Location – An exterior or interior location that is normally or periodically subject to condensation of moisture in, on, or adjacent to electrical equipment, and includes partially protected locations.

Wet Location – A location in which water may drip, splash, or flow on or against electrical equipment. A wet location fixture is constructed so that water cannot enter or accumulate in the wireway, lampholders or other electrical parts. Wet location does not mean *hosedown*. A rating for low-pressure (100psi) or high-pressure (200psi) hosedown is an additional option.

Hazardous Areas

Hazardous areas are locations where atmospheres may be exposed to the release of flammable dusts, vapors or gases in explosive concentrations. The National Electrical Code requires that these areas be classified and sets rules for the types of luminaires that may be installed in them. Luminaires are typed in Article 500 of the NEC as Class I, Class II and Class III locations. All electrical equipment must be tested and listed (or approved) by class, division and group for use in each respective area. The hazardous materials defined in each of these classifications are: Class I, Flammable gases or vapors; Class II, Combustible dust and Class III, Combustible fibers or flyings. Each class is subdivided into two divisions depending on the likelihood that the hazard will be present. Division 1 applies to an area where the hazardous condition would normally exist, while Division 2 applies to an area where there is a potential for the hazardous condition to exist.

Each classification also is subdivided by groups representing the types of gas or dust that will or might be present. Gases fall into Groups A, B, C or D. Dusts fall into Groups E, F or G. There is no group subdivision for fibers or flyings.

Environmental Constraints

Lighting equipment must be chosen from the listing for the class, group and division of the hazardous material present in the areas where they are to be used. Improper application of a luminaire can result in fire or explosion, which could cause serious injury or death to the occupants. Classification of these areas within a plant must be made prior to selection of the light source and luminaire type.

Class	Division	Group
I Gas	1. Area where gases or vapors are normally present 2. Area where gases or vapors are handled or stored but are normally confined	A. Acetylene B. Hydrogen C. Ethyl ether etc. D. Gasoline, natural gas etc.
II Dust	1. Area where combustible dust is always present 2. Area where combustible dust may be present	E. Metal dust F. Carbon black, coal dust etc. G. Flour or grain
III Fibers	1. Production areas 2. Handling or storage areas	Atmospheres containing wood, textile or synthetic fibers

Food Processing

Sanitation is a critical part of the food processing industry. Because of this, a thorough cleaning and sanitizing program must be incorporated into the food production process. High-pressure wash-down with hot water and/or sanitation chemicals may approach 1000-psi nozzle pressure. Lighting fixtures must be designed and manufactured so as not to leak, corrode, harbor bacteria, or cause fires or electrical problems. Lamps must be protected so if they break, glass or other materials shall not contaminate the food production area.

The National Sanitation Foundation (NSF) is a not-for-profit, independent, third-party certifier of products and systems for conformity with consensus and official regulations and specifications, industry standards, and product-specific test protocols. NSF requires that all materials, which could come in contact with food products, meet the stringent requirements of the Federal Food, Drug, and Cosmetic Act (FDA). In order to determine its suitability for use in food processing and food handling areas, the equipment and the manufacturer must pass a stringent series of tests. NSF performs all tests in their own laboratories.

Lighting equipment falls under the NSF C-2 listing procedure (Special Equipment and/or devices). The C-2 procedure has protocols that analyze the physical design of, the specific properties of each substance used in the manufacture of, and the fabrication of the fixture. In addition, NSF investigates the reliability of the manufacturer and the manufacturing process as it relates to the listed product.

There are three certifiable locations for equipment used in food processing.: Non-food Zone, Splash Zone and Food Zone. Only the first two are applicable to lighting fixtures. These zones are defined in the following NSF table:

NSF Certification	Description Of Location/Use and Commentary	Typical Lighting Applications
Non-Food Zone	Areas where direct contact with food products during normal operations would not be expected. Equipment is located outside the normal wash-down area. There is a concern that the fixture will add contamination to the protected space or food product (i.e. cleanability – will the finish withstand cleaning, chipping paint, deteriorating paints or finishes, lens impact resistance, lamp glass breakage, etc.)	Kitchens; food storage; dry process areas; damp process areas – no drip possibility.
Splash Zone	Areas where direct contact with food products during normal operations would not be expected; however, the fixture may be situated such that liquids used in the processing or cleaning procedures, may splash, spill or otherwise soil – either intentionally or inadvertently – the surface of the fixture. Then there is the potential for dripping or draining onto other surfaces or even the process. Since these fixtures often are used in wash-down areas, a wet-location listing is not sufficient. Fixtures must be tested to withstand high-pressure hose wash-down. The concerns of non-food zone also apply.	Wet or damp process areas; high pressure purging or decontamination used in the process; area using hose wash-down.
Food Zone	Areas where direct contact with food products is normally expected and surfaces from which the food may drip, drain, or splash back onto surfaces normally in contact with food. Equipment other than lighting fixtures typically require this certification (i.e. work tables, cutting boards, other direct contact equipment).	Category not typically used for lighting.

Cleanrooms

A cleanroom is a room in which the concentration of airborne particles is controlled to specified limits. These particles can be in the form of dust, spores, vapors, skin flakes, hair fragments etc. If present in a sensitive environment, they can destroy or severely alter products being manufactured. To keep contamination to a minimum, a cleanroom must be designed and constructed according to very strict guidelines, and the lighting fixtures selected need to maintain the integrity of the space.

Cleanrooms are classified according to the number and size of particles found in a given cubic measure of space. Particle limits are set forth by Federal Standard 209E and, more recently, by ISO standards 14644-1 and 14644-2. Because these ISO standards are international in scope and are directly impacted by ISO 9000 and ISO 14000 certification criteria, they often are accepted as replacing Federal Standard 209E classes. Both of these standards refer to the maximum allowable number of particles of a given diameter per cubic area of measure, but differ in describing both the size particle and the area of concentration. Also different under each system are procedures for testing and measuring these environments, both initially and for ongoing conformance.

In order to achieve a Class 1 or Class 10 (Federal Standard 209E) or ISO Class 3 or Class 4 level, laminar airflow design is incorporated into the cleanroom. Laminar airflow moves all air in a vertical or a horizontal pattern through the space. With vertical airflow, the entire ceiling system consists of high-efficiency particulate air (HEPA) filters or ultra-low penetration air (ULPA) filters, which screen out 99.995% and 99.999% of the particles respectively. All incoming purified air moves in a vertical pattern through the ceiling, down to a raised, ducted floor, and back up through the outer walls. With horizontal laminar flow, the same principle is used with a horizontal pattern and filtered walls.

As the process in the cleanroom becomes less critical, greater quantities of particles may be present in the air without causing problems in the manufacturing process. Thus, the class of the cleanroom may be higher. Federal Standard 209E will determine the class of cleanroom required for the activity to be performed.

Federal Standard 209E

Airborne particle size/limits											
Cleanroom Class		0.1 microns		0.2 microns		0.3 microns		0.5 microns		5.0 microns	
English	SI	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	M1.5	35	1,240	7.5	265	3	106	1	35	–	
10	M2.5	350	12,400	75	2,650	30	1,060	10	353	–	
100	M3.5	–		750	26,500	300	10,600	100	3,530	–	
1,000	M4.5	–		–		–		1,000	35,300	7	247
10,000	M5.5	–		–		–		10,000	353,000	70	2,470
100,000	M6.5	–		–		–		100,000	3,530,000	700	24,700

ISO Classification Chart – Selected ISO airborne particulate cleanliness classes for cleanrooms and clean zones

Maximum concentration limits (particles/m^3 of air) for particles equal to and larger than the considered sizes below						
Classification number	0.1 microns	0.2 microns	0.3 microns	0.5 microns	1.0 microns	5.0 microns
ISO 1	10	2	–	–	–	–
ISO 2	100	24	10	4	–	–
ISO 3	1,000	237	102	35	8	–
ISO 4	10,000	2,370	1,020	352	83	–
ISO 5	100,000	23,700	10,200	3,520	832	29
ISO 6	1,000,000	237,000	102,000	35,200	8,320	293
ISO 7	–	–	–	352,000	83,200	2,930
ISO 8	–	–	–	3,520,000	832,000	29,300
ISO 9	–	–	–	35,200,000	8,320,000	293,000

Acrylic reflectors, refractors or lenses should not be used in any location where they will be exposed to environmental contaminants that may diminish their integrity. Many chemicals can be vaporized and attack the acrylic as an airborne contaminant. Exposure of Acrylic (PMMA – Polymethylmethacrylate) materials to certain chemicals can cause deterioration of the material, which may lead to discoloration, crazing, cracking and mechanical failure. Products with visually noticeable deterioration have diminished integrity and must be replaced immediately. Acrylic products should not be used in any application where they will be exposed directly or indirectly to compounds identified as "Not Recommended". This chart identifies the most common chemicals and is not intended to be all-inclusive. Prolonged exposure to compounds identified, as "Not Recommended" will void any warranty associated with the product. Consult factory for compatibility of compounds not identified.

Acceptable

2-Ethylhexyl Sebacate
Acetic Acid, 5%
Ammonia-based Cleaners
Ammonia Gas
Ammonium Hydroxide, 28%
Ammonium Nitrate
Ammonium Phosphate
Aniseed, Bay leaves, Nutmeg
Anti-freeze
Beer
Bleaching Powder Paste
Bleaching Powder Solution, 2%
Calcium Hypochlorite
Car Wash Detergent
Carbon Dioxide Gas
Carbon Monoxide Gas
Caustic Potash
Chlorine Based Cleaners
Chlorine, Aqueous, 2%
Citric Acid, 10%
Coffee
Cooking Oil
Cottonseed Oil
Diethylene Glycol
Epoxy Adhesives
Ethyl Alcohol, 15%
Ethylene Glycol E
Ethylene Oxide (Dry)
Ferric Chloride, Aqueous, 10%
Formaldehyde, Aqueous, 40%
Fruit Juice
Glycerol
Heptane
Hexane
Hydrochloric Acid, 38%
Kerosene
Lactic Acid
Metal Carbonates
Metal Chlorides
Metal Sulfates
Methane gas
Milk
Milk, Chocolate
Motor Fuel Mixture, without Benzene
Motor Oil
Natural Gas
Nitric Acid, 10%
Nitrogen Dioxide Gas
Nitrogen Monoxide Gas
Olefric Carbolic Acids
Oleic Acid
Olive Oil
Oxalic Acid, 100%
Oxygen Gas
Ozone Gas
Paraffin, Medicinal
Pepper, Cinnamon, Onions
Phosphoric Acid, 10% @ 20C
Photographic Baths
Polishing Compounds
Potassium Chlorate
Potassium Cyanide
Potassium Dichromate, 10%
Potassium Hydroxide @ 20C
Potassium Permanganate
Potassium Sulfite
Power Steering Fluid
Propylene
Pure-oil Paints
Silicone Oil
Silver Nitrate
Soap Suds
Soda
Sodium Chloride, 10%
Sodium Cyanide
Sodium Fluoride
Sodium Hydroxide, 60%
Sodium Nitrate
Sodium Thiosulphate, 40%
Stearic Acid
Sulfur Dioxide, Dry Gas
Sulfuric Acid, 30%
Sulfurous Acid, 5%
Tararic Acid, 50%
Transmission Fluid
Tricresyl Phosphate
Triethyl Amine
Vinegar
Water, Mineral Water
Wax Polish
White Spirit
Whitewash
Wine

Rating is based on visual appearance at ambient temperature 68°F, 50% humidity.
Consult factory where applicable.
All technical information is believed to be accurate as of May 5, 2005.

Not Recommended

Acetandehyde, 100%
Acetates
Acetic Acid, Glacial, 100%
Acetic Anhydride
Acetone
Acetonitrile
Acetophenone
Acrylic paints
Alcohol, Allyl
Alcohol, Amyl
Alcohol, Benzyl
Alcohol, Ethyl, 100%
Alcohol, Ethyl, 50%
Alcohol, Isopropyl, 100%
Alcohol, Methyl, 10%
Alcohol, Methyl, 100%
Alcohol, Methyl, 50%
Alcohol, n-butyl
Amyl Acetate
Aniline
Aviation Fuel (100 Octane)
Bathroom Cleaners
Benzaldehyde
Benzene
Benzoic Aldehyde
Brake Fluid
Bromine Gas
Butanol
Butraldehyde
Butyl Acetyl Ricinoleate
Butyl Stearate
Carbolic Acid
Carbon Disulfide
Carbon Disultide
Cellulose Paints
Chlorinated Hydrocarbons
Chlorinated Solvents
Chlorine Gas
Chlorophenol
Chromic Acid, 40%
Cloves
Coffee
Cosmoline Removers
Cresol
Cyclohexane
Cyclohexanone
Cyclohexene
Detergent Solution
Diacetone Alcohol
Diamyl Phthalate
Dibutyl Sebacate
Diethyl Ether
Dimethyl Formamide
Dioctyl Sebacate
Dioxane
Ether
Ethyl Acetate
Ethyl Alcohol, Concentrated
Ethyl Bromide
Ethyl Butyrate
Ethylene Bromide
Ethylene Dibromide
Ethylene Oxide (Moist)
Glass Cleaners
Glycol
Hydrogen Peroxide, 28%
Hydrogen Peroxide, 3%
Iron Perchloride
Isoctane
Isopropyl alcohol
Lacquer Thinner
Lactic Acid Butyl Ester
Mercury Chloride
Meta-Cresol
Methanol, 15%
Methanol, Concentrated
Methyl Benzoate
Methyl Chloride
Methyl Cycohexanol
Methyl Ethyl Ketone
Methyl Naphthalene
Methyl Salicyclate
Methylamine
Methylene Dichloride
Mineral Oil
Motor Fuel Mixture, with Benzene
Nail Polish
Naphtha
n-butyric Acid, 100%
Nitric Acid, 40%
Nitric Acid, 70%
Nitrobenzene
n-Octane
Paint Removers
Paint Thinner
Perchlorethylene
Petroleum Ether (100-120C)
Phenois
Phenol, Aqueous, 5%
Phosphoric Acid, 95% @ 20C
Phthalates
Pyridine
Soap Solution
Sodium Carbonate, 2%
Sodium Carbonate, 20%
Sodium Phosphate
Sulfur Dioxide, Liquid
Sulfuric Acid, 98%
Sulfurous Acid, Concentrated
Tea
Tincture of Iodine, 5%
Toluene
Transformer Oil
Trichloraethane
Trichloroacetic Acid
Trichloroethylene
Turpentine
Unleaded Gasoline
Vegetable Oil
Xylene