

building's functional use, human occupancy requirements, and site characteristics. These areas will vary considerably from building to building depending upon function and service requirements, and shall be considered when applying the criteria of these standards.

2.3.2.2 Minimize loads by analyzing the external and internal loads to be imposed on building energy-using subsystems, both for peak-load and part-load conditions. Include a determination of how the building relates to its external environment in the analysis, either adaptively or defensively. Consider changes in building form, aspect ratio, and other attributes that reduce, redistribute, or delay (shift) loads.

2.3.2.3 Improve subsystems by analyzing the diversified energy and demand (power) requirements of each energy-using subsystem serving the functional requirements of the building. Consider static and dynamic efficiency of energy conversion and energy transport subsystems and include consideration of opportunities to reclaim, redistribute and store energy for later use.

2.3.2.4 Alternative ways to integrate systems into the building will be accomplished by considering both power and time components of energy use. Identify, evaluate, and design each of these components to control the overall design energy consumption. The following shall be considered when integrating major building subsystems:

2.3.2.4.1 Address more than one problem when developing design solutions, and make maximum use of building components already present for non-energy reasons (e.g., windows, structural mass);

2.3.2.4.2 Examine design solutions that consider time since sufficient energy may already be present from the environment (e.g., solar heat, night cooling) or from internal equipment (e.g., lights, computers) but available at different times than needed. Thus, active (heat pumps with water tanks) and passive (building mass) storage techniques may be considered;

2.3.2.4.3 Examine design solutions that consider anticipated space utilization. For example, in large but relatively unoccupied spaces, task or zone

heating may be considered. Transporting energy (light and heat) from locations of production and availability to locations of need shall be considered instead of the purchase of additional energy;

2.3.2.4.4 Never reject waste energy at temperatures usable for space conditioning or other practical purposes, without calculating the economic benefit of energy recovery;

2.3.2.4.5 Consider design solutions that provide more comfortable surface temperatures or increase availability of controlled daylight in buildings in which human occupancy is a primary function;

2.3.2.4.6 Use design solutions that are easily understood as they have a greater probability of use by building occupants; and

2.3.2.4.7 Where the functional requirements of the building may change, the installed environmental system should be designed to be adaptable to meet functional changes that can be anticipated as well as providing flexibility to meet indeterminate future changes in use, occupancy or other functions.

§ 435.103 Lighting.

3.1 General

3.1.1 This section contains principles of design, a set of minimum requirements, and two alternative compliance procedures, prescriptive and systems performance, for the design of building lighting and lighting control systems, and includes provisions for daylighting credit. The procedures in this section are solely for use in establishing lighting design budgets and are not intended for use as lighting design procedures.

3.1.2 *Scope.* The following are covered by this section:

3.1.2.1 Interior spaces of buildings;

3.1.2.2 Building exteriors and exterior areas, such as entrances, exits, and loading docks; and

3.1.2.3 Roads, grounds, parking, and other exterior areas where lighting is energized through the building electrical service.

3.1.3 *Exemptions.* The following are exempt from these standards:

3.1.3.1 Outdoor manufacturing, commercial greenhouses, and processing facilities;

3.1.3.2 Lighting power for theatrical production studios and stages, television broadcasting studios, audio-visual presentation, and entertainment facilities in spaces such as stages, hotel ballrooms, nightclubs, discos, and casinos, and where lighting is an essential technical element for the function performed;

3.1.3.3 Specialized luminaires for medical and dental purposes;

3.1.3.4 Outdoor athletic facilities;

3.1.3.5 Lighting power for display lighting required for art exhibits or displays in galleries, museums and monuments;

3.1.3.6 Exterior lighting for public monuments;

3.1.3.7 Special lighting needs for research;

3.1.3.8 Lighting power for lighting used solely for indoor plant growth during the hours of 10:00 p.m. to 6:00 a.m.;

3.1.3.9 Emergency lighting that is automatically "off" during normal operation;

3.1.3.10 High risk security areas or any area identified by local ordinances or regulations or by security or safety personnel as requiring additional lighting;

3.1.3.11 Lighting power densities for spaces with enhanced lighting specifically designed for primary use by the visually impaired, hard of hearing, or for senior citizens;

3.1.3.12 Lighting for signs;

3.1.3.13 Store-front exterior-enclosed display windows in retail facilities; and

3.1.3.14 Lighting for dwelling units.

3.1.4 *Building Lighting Power Allowance.* The lighting power allowance for a building consists of the Exterior Lighting Power Allowance (ELPA), in accordance with section 3.3, plus the Interior Lighting Power Allowance (ILPA) in accordance with section 3.4 or 3.5. This lighting power allowance is the upper limit to which the building can be designed, based on the criteria of the compliance alternative chosen.

3.1.4.1 The prescriptive criteria in section 3.4 provides a single compliance procedure based on calculating a lighting budget by building type or major

area type within which a designer can flexibly design a lighting solution. To obtain credit for specific lighting energy conservation measures, use section 3.5, section 11.0, or section 12.0.

3.1.4.2 The systems performance criteria in section 3.5 provides a more complex compliance procedure based on calculating a lighting budget by activity or spaces within which the designer can flexibly design a lighting solution and receive credit for energy conserving controls and daylighting measures. To receive credit for more complex lighting conservation measures use section 11.0 or 12.0.

3.1.5 *Credit for Daylighting.* Daylighting credit, for reduced use of electric lighting energy resulting from the use of automatic lighting control devices in conjunction with fenestration (e.g., windows and skylights), may be taken if the systems performance alternative in section 3.5 is chosen. However, if such daylighting credit is to be applied to other building subsystems, such as use of additional fenestration area, section 11.0 or 12.0 must be used. Thermal credit provisions for daylighting are found in Section 5.0.

3.1.6 *Compliance.* A building shall be considered in compliance with this section if the following conditions are met:

3.1.6.1 The minimum requirements of section 3.3 are met;

3.1.6.2 The exterior lighting power to be installed is not greater than the Exterior Lighting Power Allowance (ELPA), calculated using Equation 3.3-1;

3.1.6.3 The interior lighting power to be installed is not greater than the Interior Lighting Power Allowance (ILPA), based on either the Prescriptive Criteria in section 3.4 or the Systems Performance Criteria in section 3.5.

3.1.6.4 Tradeoffs between ILPA and ELPA are not allowed. Tradeoffs of the interior Lighting Power Budgets (LPB) among interior spaces are allowed as long as the total Connected Lighting Power (CLP) within the building does not exceed the Interior Lighting Power Allowance (ILPA) and Lighting Power Control Credits (LPCC) are used only for connected lighting power in those spaces for which credit is claimed.

Tradeoffs of exterior lighting power budgets among exterior areas are allowed as long as the total Connected Lighting Power (CLP) of exterior lighting does not exceed the Exterior Lighting Power Allowance (ELPA) and the allowance for the building exterior surfaces is not exceeded.

3.1.7 *Multi-Building Facilities.* The total lighting power allowances for each building in a multi-building facility shall be calculated separately.

3.2 Principles of Design

3.2.1 The lighting system is designed to provide a productive, safe, and pleasing visual environment for the intended use of the space. However, lighting is both a major energy end use in commercial buildings (especially in office buildings) and a major contributor to internal loads by increasing cooling loads and decreasing heating loads. Therefore, it is important to produce a design that meets the lighting functional criteria of the space as well as one that minimizes energy use. Recommended maintained illuminance levels for visual tasks and surrounding lighted areas are included in the *IES Lighting Handbook, Applications (1983) or Reference (1985)*. Principles of energy conserving design within that context are described below.

3.2.2 The following Design Concepts shall be considered in the design of lighting that is both energy efficient and visually effective.

3.2.2.1 Energy use is determined by the lighting load (demand power) and its duration of use (time). Minimize the actual demand load rather than just the apparent connected load, and control the load rather than just switching, if switching may adversely affect the quality of the luminous environment.

3.2.2.2 Consider daylighting along with the proper use of controls so that the savings from electric lighting can be realized. Design should be sensitive to window glare, sudden changes in luminances, and general use acceptance of controls. Window treatment (blinds, drapes and shades) and glazing should be carefully selected to control direct solar penetration and luminance extremes while still maintaining view and daylight penetration.

3.2.2.3 Design lighting systems so that illumination required for tasks is primarily limited to the location of the task and from a direction that will minimize direct glare and veiling reflections on the task. For example, the ideal positioning of work stations is between the rows of ceiling-mounted luminaires with the direction of view parallel to the primary task. In densely-occupied work spaces, uniform distribution of general lighting may be most appropriate. Where supplementary task illumination is necessary, general or ambient illumination should not be lower than a third of the luminance required for the task. This will help maintain luminance rates that are visually comfortable.

3.2.2.4 Use task lighting, whenever possible, to accommodate the need for higher lighting levels due to task visual difficulty, glare, intermittently changing requirements, or individual visual differences (poor and aging eyesight).

3.2.2.5 Group similar activities so high illuminance or special lighting for particular tasks are localized in certain rooms or areas, and so that less efficient fixtures required for critical glare control do not have to be installed uniformly when they are only required sparsely.

3.2.2.6 When indirect lighting is appropriate, use schemes that create reasonably uniform ceiling luminances. If this is achieved, work spaces may be located anywhere and occupants may face in any direction without being subject to excessive veiling reflection on the tasks. The indirect system may allow more effective use of the space than other types of lighting systems. However, indirect lighting systems generally have lower utilization factors, and may require increased ceiling height to provide uniform ceiling luminance.

3.2.2.7 Use lighting controls throughout that maintain proper lighting levels when and where it is needed but also allow reductions in lighting when tasks are less critical, or spaces are not fully occupied. The designer must consider user acceptance of control strategies to maximize energy efficiency.

3.2.2.8 Use lower levels of ambient lighting in situations such as merchandising, where the contrast between accent lighting and ambient lighting is critical. Accent lighting shall not exceed five (5) times the ambient level. Consider fewer, more effectively-accented displays, rather than more ineffectively-accented ones.

3.2.3 The following guidelines identify Fixture and Lamp selection strategies to be considered in the selection of luminaires and lamps for inclusion in an energy efficient, visually-effective design:

3.2.3.1 Consider the use of more efficient equipment with appropriate distribution, glare control and visual characteristics. Utilize fixture designs that will provide high lighting efficiency while meeting the other lighting objectives of the installation.

3.2.3.2 Review visual comfort probability (VCP) data, available from manufacturers, for specific luminaires when minimizing discomfort glare is a criterion.

3.2.3.3 Consider luminaire construction that minimizes light loss due to dirt collection.

3.2.3.4 Investigate the use of dimmers to reduce energy consumption when the system is new and capable of providing more light than the average depreciated design value.

3.2.3.5 Use more efficient lamps with appropriate luminous efficacy, life expectancy and spectrum distribution and color rendering characteristics.

3.2.3.6 Use more efficient ballasts for fluorescent and HID lamps with appropriate ballast factors, power factor, noise rating, starting and restarting characteristics.

3.2.3.7 Use luminaires with heat removal and heat recovery capabilities, thereby allowing the lighting equipment to operate more efficiently at a lower ambient temperature.

3.2.3.8 Limit the use of lower efficiency lamps, such as incandescent, to only those applications where their color, lumens or distribution characteristics cannot be duplicated by other sources. Due to their lower efficiency, the use of "extended service" incandescent lamps should be limited to those applications where fixtures are dif-

ficult to reach and/or maintenance costs for revamping will be excessive.

3.2.4 Space Design

3.2.4.1 It is important to carry through on the lighting design when completing the interior design. Reduce light absorption by encouraging the use of lighter finishes, particularly on ceilings, walls and partitions. Select colors and surface materials so that their reflectance values are within the ranges recommended by the IES. This will aid the efficient use of light and help to provide comfortable luminance ratios.

3.2.4.2 In offices with visual display terminals (VDT) that are susceptible to reflections, it may be necessary to use reflectances for some room surfaces at the low end of the recommended ranges to reduce unwanted reflections on the screens. Where practical, treat the screens of VDTs with anti-glare materials to avoid veiling reflection.

3.3 Minimum Requirements

3.3.1 Lighting Controls.

3.3.1.1 All lighting shall be provided with manual, automatic, or programmable controls.

3.3.1.1.1 *Exception to Section 3.3.1.1:*

(a) controls for emergency or exit lighting.

3.3.1.2 *Minimum Number of Lighting Controls.* Each space enclosed by walls or ceiling-height partitions shall be provided with control(s) that, together or alone are capable of controlling all lights within that space, excluding those requiring continuous operation for security purposes.

3.3.1.2.1 The minimum number of controls shall not be less than:

(a) One lighting control for each space; and

(b) One lighting control for each task or group of task locations within an area of 450 ft² or less.

3.3.1.2.2 *Equivalent Number of Controls.* The minimum number of controls may be reduced, by using an equivalent number of controls from Table 3.3-1, where control types listed in Table 3.3-1 are used. However, the minimum number of controls may not be reduced to less than one control for each 1500 W of connected lighting power.

Table 3.3-1
Equivalent Number of Controls

TYPE OF CONTROL	EQUIVALENT NUMBER OF CONTROLS
Manually operated on-off switch	1
Occupancy sensor	2
Timer-Programmable from the space being controlled	2
Three level, including off, step control or pre-set dimming	2
Four level, including off, step control or pre-set dimming	3
Automatic or continuous dimming	3

3.3.1.2.3 *Exceptions to Section 3.3.1.2:*

(a) Lighting control requirements for spaces that must be used as a whole, such as public lobbies of office buildings, hotels, and hospitals; retail and department stores and warehouses, storerooms, and service corridors under centralized supervision, shall be controlled by a lesser number of controls, but not less than one control for each 1500 W of connected lighting power, or a total of three (3) controls, whichever is greater. Lighting in such spaces shall be controlled in accordance with the work activities.

(b) Hotel and motel guest rooms shall have one or more master controls at the main entry door that turn off all permanently wired lighting fixtures and lighting and television receptacles. For multiple room suites, controls at the entry of each room, in lieu of a master switch, will meet these requirements.

3.3.1.3 Controls provided for task areas, if readily accessible, may be mounted as part of the task lighting luminaire.

3.3.1.4 Control of the same load from more than one location shall not be credited as additional control points.

3.3.1.5 All lighting controls shall be readily accessible to personnel occupying or using the space. Exceptions are automatic controls, programmable controls, lighting for safety hazards and security, controls requiring trained operators, and those controls for spaces that must be used as a whole.

3.3.1.6 Exterior lighting shall be automatically controlled by timer, photocell, or combination of timer and photocell. Timers shall be of the automatic type or otherwise capable of adjustment for seven days and for seasonal daylight schedule variations. All time-controllers shall be equipped with back-up mechanisms to keep time during a four hour power outage.

3.3.1.7 When the building is served by an energy management system, programmable controls, shared tenant services that affect interior environments, or “intelligent building” systems, provisions shall be made to incorporate lighting controls into the system if a separate automatically-controlled lighting system is not provided.

3.3.2 Fluorescent Lamp Ballasts.

3.3.2.1 Fluorescent lamp ballasts shall have a ballast efficacy factor not less than that shown in Table 3.3-2.

3.3.2.1.1 *Exception to 3.3.2.1:* Ballasts not included in Table 3.3-2 and ballasts designed for use with dimming controls are excluded from these criteria.

Table 3.3-2
Fluorescent Ballast For Efficacy Factors*

NUMBER OF LAMPS	LAMP TYPE	NOMINAL OPERATIONAL INPUT VOLTAGE	DESIGN STARTING TEMPERATURE	INPUT FREQUENCY	MAX. LAMP OPERATING TEMPERATURE	MIN. BALLAST EFFICIENCY FACTOR
1	4 ft rapid start	120 or 277	>40 °F	60Hz	<1000 m amp	1.805
2	4 ft rapid start	120	>40 of	60Hz	<1000 m amp	1.060
2	4 ft rapid start	277	>40 °F	60Hz	<1000 m amp	1.050
2	8 ft slimline	120 - 277	>40 °F	60Hz	<1000 m amp	0.570
2	8 ft high output, rapid start	120 - 277	<40 °F	60Hz	<1000 m amp	0.390

* For ballasts not specifically designed for use with dimming controls.

3.3.2.2 The Ballast Efficacy Factor shall be calculated in accordance with Equation 3.3-1:

$$BEF = \frac{BF}{\text{Power Input}}$$

Equation 3.3-1

Where:

BEF=Ballast Efficacy Factor.
BF=Ballast Factor, expressed as a percent.
Power Input=Total Wattage of combined lamps and ballasts

3.3.2.2.1 Tests for ballast factor and power input shall be in accordance with *ANSI Standard C-82.2-1984* "Method of Measurement for Fluorescent Lamp Ballasts", using "Standard" F40T1240A, F96T12 75 watt, or F96T12H0 110 watt lamps.

3.3.2.3 One-lamp or three-lamp fluorescent luminaires shall be tandem-wired to eliminate unnecessary use of single lamp ballasts if they are: used for general lighting; recess mounted within ten feet center-to-center of each other; or pendant or surface mounted within 1 ft of each other, and within the same room. Tandem wiring consists of pairs of luminaires operating with one lamp in a luminaire powered

from a single two-lamp ballast contained in a second luminaire.

3.3.2.3.1 *Exception to Section 3.3.2.3:*

(a) Three-lamp ballasts may be used.

3.3.2.4 Fluorescent lamp ballasts shall have a power factor equal to or greater than 80%.

3.3.2.4.1 *Exception to 3.3.2.4:* Ballasts for circline and compact fluorescent lamps and low wattage, high intensity discharge lamps of less than 100 watts.

3.4 Lighting—Prescriptive Compliance Alternative

3.4.1 Purpose

3.4.1.1 This subsection provides a prescriptive procedure for determining an exterior lighting power allowance and the Interior Lighting Power Allowances for illumination systems installed in six types of new buildings. It is intended for use with buildings having simple lighting requirements and where the minimum amount of calculation and effort to achieve compliance is of primary concern. For other building types, to receive credit for switching, daylighting, or other trade-offs, or to receive credit for lighting optimization, use section 3.5, section 11.0, or section 12.0.

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3.4.1.2 This section also serves as the basis for calculating the skylight area in section 5.3.9.6, and may be used for estimating the lighting heat gain for calculating the internal load density in Equation 5.4-1 and section 5.5.6.2.

3.4.2 General

3.4.2.1 This method for compliance prescribes a total allowable Unit Lighting Power Allowance (ULPA) for interior lighting for the building type/area as listed in Table 3.4-1. There is no recognition of specific makeup of spaces and activities within the building.

Table 3.4-1
Prescriptive Unit Lighting Power Allowance (ULPA), W/ft²

BUILDING TYPE/AREA FUNCTION	Gross Lighted Area Ranges						Effective Date
	0 to 2,000 ft ²	2,001 to 10,000 ft ²	10,001 to 25,000 ft ²	25,001 to 50,000 ft ²	50,001 to 250,000 ft ²	> 250,000 ft ²	
Food Service	1.50	1.38	1.34	1.32	1.31	1.30	1988
	0.92	0.85	0.82	0.81	0.81	0.80	1993
Leisure Dining/Bar	2.20	1.91	1.71	1.56	1.46	1.40	1988
	1.60	1.56	1.52	1.48	1.44	1.40	1993
Offices	1.90	1.81	1.72	1.65	1.57	1.50	1988
	1.40	1.34	1.27	1.22	1.16	1.11	1993
Retail ¹	3.30	3.08	2.83	2.50	2.28	2.10	1988
	2.70	2.52	2.32	2.05	1.87	1.72	1993
Mall Concourse	1.60	1.58	1.52	1.46	1.43	1.40	1988
	0.69	0.68	0.65	0.63	0.61	0.60	1993
Service Establishment	2.70	2.37	2.08	1.92	1.80	1.70	1988
	2.81	2.03	1.78	1.65	1.54	1.46	1993
Garages	0.30	0.28	0.24	0.22	0.21	0.20	1988
	0.25	0.24	0.23	0.22	0.21	0.20	1993
Schools	1.80	1.80	1.72	1.65	1.57	1.50	1988
	1.33	1.33	1.27	1.22	1.16	1.11	1993
Jr. High/High School	1.90	1.90	1.88	1.83	1.76	1.70	1988
	1.40	1.40	1.39	1.35	1.30	1.26	1993
Technical/Vocational	2.40	2.33	2.17	2.01	1.84	1.70	1988
	1.77	1.72	1.60	1.49	1.36	1.26	1993
Warehouse/Storage	0.80	0.66	0.56	0.48	0.43	0.40	1988
	0.60	0.50	0.42	0.36	0.32	0.30	1993

Notes:

1. Includes general, merchandising and display lighting.

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3.4.3 Exterior Lighting Power Allowance

3.4.3.1 Building exteriors and exterior areas, as defined in section 3.1.2.2, and roads, grounds, parking, and other exterior areas, defined in section

3.1.2.3, shall have a lighting power density not to exceed the Exterior Lighting Power Allowance (ELPA), which is the sum of the allowances for each of the areas listed above, as calculated by Equation 3.4-1 using unit power densities from Table 3.4-2.

Table 3.4-2
Exterior Lighting Unit Power Density

AREA DESCRIPTION	UNIT POWER DENSITY (UPD)
Exit (with or without canopy)	25 W/lin. ft of door opening
Entrance (without canopy)	30 W/lin. ft of door opening
Entrance (with canopy)	
High Traffic (retail, hotel, airport, theater, etc.)	10 W/ft ² of canopied area
Light Traffic (hospital, office, school, etc.)	4 W/ft ² canopied area
Loading area	0.40 W/ft ²
Loading door	20 W/lin. ft of door opening
Building Exterior Surfaces/facades	0.25 W/ft ² of surface area to be illuminated
Storage and non-manufacturing work areas	0.20 W/ft ²
Other activity areas for casual use such as picnic grounds, gardens, parks, and other landscaped areas	0.10 W/ft ²
Private driveways/walkways	0.10 W/ft ²
Public driveways/walkways	0.15 W/ft ²
Private parking lots	0.12 W/ft ²
Public parking lots	0.18 W/ft ²

$$ELPA = \sum DO_i UPD_{D_i} + \sum A_i UPD_{A_i} = \sum [(DO_1 \times UPD_{D1} \dots + DO_n \times UPD_{Dn}) + (A_1 \times UPD_{A1} \dots A_n \times UPD_{An})]$$

Equation 3.4-1

Where:
ELPA=Exterior lighting power allowance, in Watts.

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i=numerical subscript (1,2, . . . n) for each occurrence of exterior openings or exterior areas of the building.
 n=total number of occurrences of exterior openings or areas of the building.
 DO=Door opening, linear feet.
 UPD_D=Unit power density for the door, W/lin. ft, from Table 3.4-2.
 UPD_A=Unit power density for the area in W/ft², from Table 3.4-2.
 A=Exterior area in ft².

3.4.4 Interior Lighting Power Allowance

3.4.4.1 The Interior Lighting Power Allowance (ILPA) shall be calculated using the prescriptive Unit Lighting Power Allowances (ULPA) in Table 3.4-1. First, determine if the predominant function of the proposed building is one of the six building types listed in Table 3.4-1. If not, section 3.5, 11.0, or 12.0 must be used. Next, determine whether the proposed design has secondary functions that are 10% or more of the gross lighted area of the building and are listed in Table 3.4-1. If so, the designer has the option of using the predominant building function to calculate the ILPA or using the calculation method for multiple-use buildings in section 3.4.4.1.2 below.

3.4.4.1.1 If the proposed building has only one function, has no secondary functions with 10% or more of the gross lighted area, or the designer chooses to determine the ILPA based on only one function, Equation 3.4-2 shall be used to determine the building ILPA. First, select the appropriate building type in Table 3.4-1, and the appropriate column for the Gross Lighted Area (GLA) of the proposed building. This value is the Unit Lighting Power Allowance (ULPA). Determine the ILPA by multiplying the ULPA by the GLA as shown in Equation 3.4-2.

$$ILPA=ULPA \times GLA$$

Equation 3.4-2

Where:
 ILPA=Interior Lighting Power Allowance, in Watts.
 ULPA=Unit Lighting Power Allowance, in W/ft², from Table 3.4-1.
 GLA=Gross Lighted Area of the Proposed Building, in ft².

3.4.4.1.2 If a building design has more than one function listed in Table 3.4-1, such as an office building with parking and retail stores, with more

than 10% of the gross lighted area, Equation 3.4-3 may be used to calculate the building Interior Lighting Power Allowance (ILPA). First, determine the gross lighted area of the building (GLA) and the gross lighted area for each qualifying secondary function (GLA_f) in the building. Select the ULPA from Table 3.4-1 under the column corresponding to the gross lighted area of the entire proposed building and multiply it by the gross lighted area of that function. Sum the products to determine the building ILPA, as shown in Equation 3.4-3 below.

$$ILPA=ULPA_p GLA_p + \sum (ULPA_i GLA_i) = [ULPA_p GLA_p + (ULPA_{f1} GLA_{f1} + ULPA_{f2} GLA_{f2} . . . ULPA_{fn} GLA_{fn})]$$

Equation 3.4-3

Where:

i=numerical subscript (1,2, . . . n) for each secondary function with 10% or more of the gross lighted area of the building.
 n=number of secondary functions.
 ILPA=Interior Lighting Power Allowance, in Watts.
 ULPA_p=Unit Lighting Power Allowance of the predominant function based on the gross lighted area of the entire building, from Table 3.4-1, in W/ft².
 ULPA_f=Unit Lighting Power Allowance of qualifying secondary functions based on the gross lighted area of the entire building, from Table 3.4-1, in W/ft².
 GLA_p=Gross lighted area of the predominant function of the proposed building.
 GLA_f=Gross lighted area of each qualifying secondary function.

3.4.4.3 *Lighting compliance in partially defined speculative buildings.* For defined functions in partially defined speculative buildings, the total connected lighting power shall not exceed the interior lighting power allowance for that portion of the building. When determining the ILPA for those cases, the gross lighted area of the entire building must be used.

3.5 Lighting—System Performance Compliance Alternative

3.5.1 Purpose

3.5.1.1 This subsection provides a procedure for determining the maximum lighting power allowance for buildings, roads and grounds. It allows the designer to take credit for the use

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of daylighting and other lighting controls. It also serves as a basis for estimating the lighting heat gain and lighting energy use for Section 5.0.

3.5.2 General

3.5.2.1 The total Connected Lighting Power (CLP) in a building, including permanently installed lighting plus supplemental or task related lighting provided by movable fixtures or plug-in luminaires, shall not exceed the Interior Lighting Power Allowance (ILPA). A Lighting Power Control Credit (LPCC), taken for individual spaces, may only be utilized for credit to connected lighting power in those spaces for which credit is claimed.

3.5.2.2 *Compliance for lighting in partially defined speculative buildings.* The total connected lighting power of lighting designs of defined areas of partially defined speculative buildings shall not exceed the interior lighting power allowance for those areas of the building for which lighting has been designed.

3.5.3 The Lighting Power Budget (LPB) of each interior space shall be determined in accordance with Equation 3.5-1.

$$LPB=(A \times UPD_b \times AF)+LPCC$$

Equation 3.5-1

Where:

LPB=Lighting power budget of the space, in watts

A_r=Area of the room at the horizontal lighted working place, ft²

UPD_b=Base Unit Power Density, W/ft², (Table 3.5-1)

AF=Area factor of the room, (Figure 3.5-1)

LPCC=Lighting Power Control Credit, as determined by §3.5.6

3.5.3.1 The room area (A) shall be calculated from the inside dimensions of the room.

3.5.3.2 The Base Unit Power Density (UPD) shall be selected from Table 3.5-1. For applications to areas or activities other than those given, select values for similar areas or activities.

TABLE 3.5-1
BASE UPD (P_b) FOR AREA/ACTIVITY

1989				1993				1989				1993			
AREA/ACTIVITY		UPD	NOTE	AREA/ACTIVITY		UPD	NOTE	AREA/ACTIVITY		UPD	NOTE	AREA/ACTIVITY		UPD	NOTE
COMMON ACTIVITY AREAS				COMMON ACTIVITY AREAS				COMMON ACTIVITY AREAS				COMMON ACTIVITY AREAS			
Auditorium	-----	1.6	(d)	1.4	(d)	Offices	-----								
Corridor	-----	0.8	(a)	0.8	(a)	Enclosed offices of less than	-----		(h)			(h)			
Classroom/Lecture Hall	-----	2.0		1.0		900 ft ² and all open plan offices	-----								
Elec/Mech Equipment Room	-----					w/out partitions or w/partitions	-----								
General	-----	0.7	(a)	0.7	(a)	lower than 4.5 ft below ceiling.	-----								
Control Rooms	-----	1.5	(a)	1.5	(a)	Reading, Typing and Filing	-----	1.8	(g)	1.3	(g)				
Food Service	-----					Drafting	-----	2.6	(g)	2.2	(g)				
Fast Food/Cafeteria	-----	1.3		0.8		Accounting	-----	2.1	(g)	1.8	(g)				
Leisure Dining	-----	2.5	(c)	1.4	(c)	Open plan offices, 900 ft ² or	-----		(h)			(h)			
Bar/Lounge	-----	2.5	(c)	1.3	(c)	larger, w/medium height	-----								
Kitchen	-----	1.4		1.4		partitions 3.5 to 4.5 ft below	-----								
Recreation/Lounge	-----	0.7		0.5		ceiling.	-----	1.9	(a)	1.5	(a)				
Stairs	-----					Reading, Typing and Filing	-----	2.9	(a)	2.6	(a)				
Active Traffic	-----	0.6		0.6		Drafting	-----	2.4	(a)	2.1	(a)				
Emergency Exit	-----	0.4		0.4		Accounting	-----								
Toilet & Washroom	-----	0.8		0.5		Open plan offices, 900 ft ² or	-----								
Garage	-----					larger, w/partitions higher	-----								
Auto/Pedestrian Circulation	-----	0.3		0.25		higher than 3.5 ft below	-----	2.2	(a)	1.7	(a)				
Parking Area	-----	0.2		0.2		ceiling.	-----	3.4	(a)	3.0	(a)				
Laboratory	-----	2.3		2.2		Reading, Typing and Filing	-----	2.7	(a)	2.4	(a)				
Library	-----					Drafting	-----								
Audio Visual	-----	1.1		1.1		Accounting	-----								
Stack Area	-----	1.5		1.5		Common Activity Areas	-----								
Card File & Cataloging	-----	1.6		0.8		Conference/Meeting Room	-----	1.8	(d)	1.3	(d)				
Reading Area	-----	1.9		1.0		Computer/Office Equipment	-----	2.1		2.1					
Lobby (General)	-----					Filing, Inactive	-----	1.0		1.0					
Reception & Waiting	-----	1.0		0.55		Mail Room	-----	1.8		1.8					
Elevator Lobbies	-----	0.8		0.4		Shop (Non-Industrial)	-----								
Atrium (Multi-Story)	-----					Machinery	-----	2.5		2.5					
First 3 Floors	-----	0.7		0.4		Electrical/Electronic	-----	2.5		2.5					
Each Additional Floor	-----	0.2		0.15		Painting	-----	1.6		1.6					
Locker Room & Shower	-----	0.8		0.6		Carpentry	-----	2.3		2.3					
	-----					Welding	-----	1.2		1.2					
	-----					Storage & Warehouse	-----								
	-----					Inactive Storage	-----	0.3		0.2					
	-----					Active Storage, Bulky	-----	0.3		0.3					
	-----					Active Storage, Fine	-----	1.0		0.9					
	-----					Material Handling	-----	1.0		1.0					
	-----					Unlisted Space	-----	0.2		0.2					

TABLE 3.5-1 (Continued)
BASE UPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY SPECIFIC BUILDINGS	1989		1993		AREA/ACTIVITY SPECIFIC BUILDINGS	1989		1993	
	UPD	NOTE	UPD	NOTE		UPD	NOTE	UPD	NOTE
Airport, Bus and Rail Station					Hotel/Conference Center				
Baggage Area -----	0.8		0.75		Banquet Room/Multipurpose----	2.4	(d)	1.4	(d)
Concourse/Main Thruway ----	0.9		0.45		Bathroom/Powder Room -----	1.2		0.6	
Ticket Counter -----	2.5		1.3		Guest Room -----	1.4		0.7	
Waiting & Lounge Area -----	1.2		0.6		Public Area -----	1.1		0.8	
Bank					Exhibition Hall -----	2.6		1.3	
Customer Area -----	1.0		0.8		Conference/Meeting -----	1.8	(d)	1.5	(d)
Banking Activity Area -----	2.8		2.2		Lobby -----	1.9		1.3	
Barber & Beauty Parlor -----	2.0		1.6		Reception Desk -----	2.4		2.4	
Church, Synagogue, Chapel					Laundry				
Worship/Congregational ----	2.3		1.3		Washing -----	0.9		0.6	
Preaching & Sermon/Choir --	2.7		1.8		Ironing & Sorting -----	1.3		1.3	
Dormitory					Museum & Gallery				
Bedroom -----	1.0		0.6		General Exhibition -----	1.9		1.2	
Bedroom with Study -----	1.3		1.3		Inspection/Restoration -----	3.9		3.0	
Study Hall -----	1.8		0.9		Storage (Artifacts)				
Fire & Police Department					Inactive -----	0.6		0.25	
Fire Engine Room -----	0.7		0.7		Active -----	0.7		0.5	
Jail Cell -----	0.8		0.4		Post Office				
Hospital/Nursing Home					Lobby -----	1.1		0.8	
Corridor -----	1.3	(a)	0.9	(a)	Sorting & Mailing -----	2.1		2.1	
Dental Suite/Exam/Treat ---	1.6		1.4		Service Station/Auto Repair --	1.0		0.8	
Emergency -----	2.3		2.0		Theater				
Laboratory -----	1.9		1.7		Performance Arts -----	1.5		1.1	
Lounge/Waiting Room -----	0.9		0.6		Motion Picture -----	1.0		0.75	
Medical Supplies -----	2.4		2.4		Lobby -----	1.5		1.0	
Nursery -----	2.0		1.6		Retail Establishments				
Nurse Station -----	2.1		1.8		(Merchandising & Circulation Area)				
Occu./Physical Therapy-----	1.6		1.4		Applicable to all lighting, including				
Patient Room -----	1.4		0.9		accent and display lighting, installed				
Pharmacy -----	1.7		1.5		in merchandising and circulation areas				
Radiology -----	2.1		1.8		Type A -----	5.6	(e)	6.0	(e)
Surgical & O.B. Suites					Type B -----	3.2	(e)	2.9	(e)
General Area -----	2.1		1.8		Type C -----	3.3	(e)	2.7	(e)
Operating Room -----	7.0		6.0		Type D -----	3.0	(e)	2.5	(e)
Recovery -----	3.0		2.0		Type E -----	2.8	(e)	2.4	(e)
					Type F -----	2.7	(e)	2.6	(e)
					Mall Concourse -----	1.4		0.6	
					Retail Support Area				
					Tailoring -----	2.1		2.1	
					Dressing/Fitting Rooms --	1.4		1.1	

TABLE 3.5-1 (Continued)
BASE UPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY INDOOR ATHLETIC AREAS	1989		1993		
	UPD	NOTE (b)	UPD	NOTE (b)	
Seating Area, All Sports-----	0.4		0.4		
Badminton					
Club -----	0.5		0.5		
Tournament -----	0.8		0.8		
Basketball/Volleyball					
Intramural -----	0.8		0.8		
College -----	1.3		1.3		
Professional -----	1.9		1.9		
Bowling					
Approach Area -----	0.5		0.5		
Lanes -----	1.1		1.1		
Boxing or Wrestling (platform)					
Amateur -----	2.4		2.4		
Professional -----	4.8		4.8		
Gymnasium					
General Exercising & Recreation Only -----	1.0		1.0		
Handball/Racquetball/Squash					
Club -----	1.3		1.3		
Tournament -----	2.6		2.6		
Hockey, Ice					
Amateur -----	1.3		1.3		
College or Professional ----	2.6		2.6		
Skating Rink					
Recreational -----	0.6		0.6		
Exhibition/Professional ----	2.6		2.6		
Swimming					
Recreational -----	0.9		0.9		
Exhibition -----	1.5		1.5		
Underwater -----	1.0		1.0		
Tennis					
Recreational (Class III) ---	1.3		1.3		
Club/College (Class II) ----	1.9		1.9		
Professional (Class I) -----	2.6		2.6		
Tennis, Table					
Club -----	1.0		1.0		
Tournament -----	1.6		1.6		

NOTES:

- (a) Area Factor of 1.0 shall be used for these spaces.
- (b) Area Factor of 1.0 shall be used for all indoor athletic spaces.
- (c) Base UPD includes lighting power required for clean-up purpose.
- (d) A 1.5 adjustment factor is applicable for multi-functional spaces
- (e) See Section 11.0 - Definitions for Classification of Retail Facilities
- (f) These Standards do not prescribe UPD for dwelling units.
- (g) Area factor shall not exceed 1.55.
- (h) Minimum of 90% of all work stations shall be enclosed with partitions of the height prescribed.

3.5.3.3 The Area Factor (AF) shall be determined from Figure 3.5-1 based on the floor area and ceiling height of the room. Rooms with identical ceiling

height and activities, and with similar size may be treated as a group. The AF

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of such a group of rooms shall be determined from the average area of the rooms. Equation 3.5-2 gives the formula used in developing Figure 3.5-1.

$$AF = 0.2 + 0.8 \exp. - \left[\left[\frac{10.21 \times (CH - 2.5)}{\sqrt{A_r}} - 1 \right] \times \text{Ln} (0.9) \right]$$

Equation 3.5-2

Where:

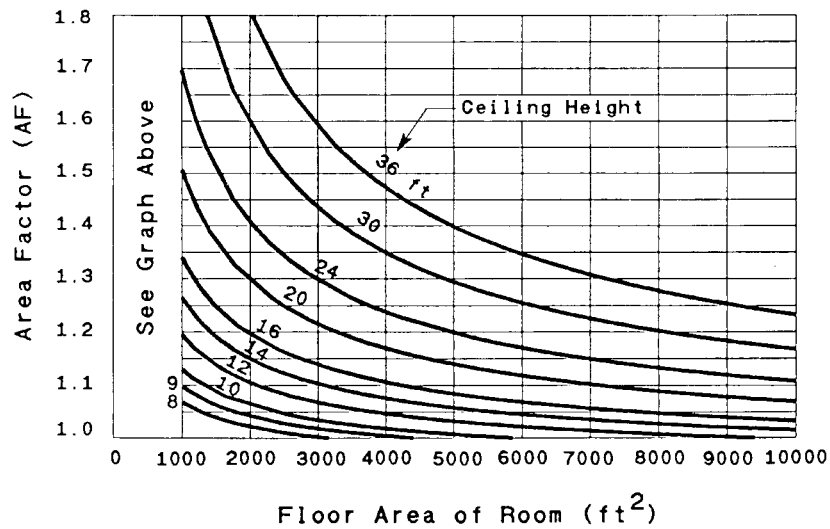
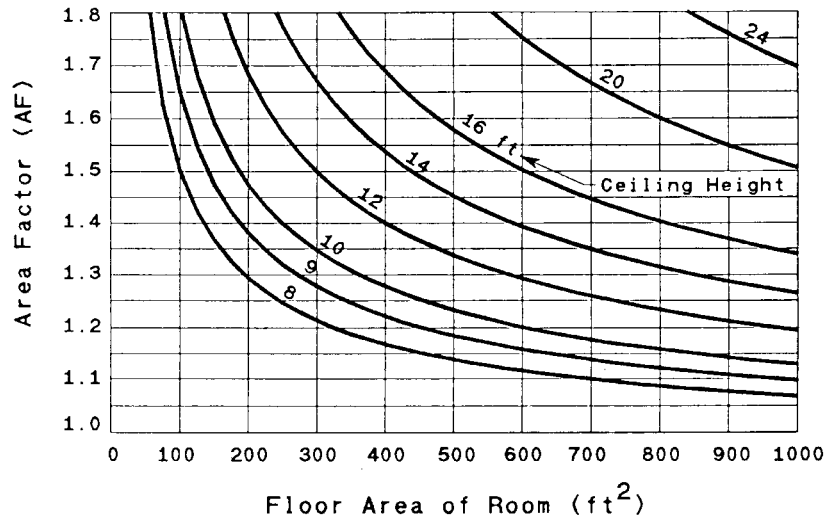
AF=Area Factor
CH=Ceiling Height

A_r=Floor Area of Room, ft²

If AF<1.0 then AF=1.0

If AF>1.8 then AF=1.8

Figure 3.5-1 Base Unit Power Density Area Factor



3.5.4 Special Spaces and Activities.
 3.5.4.1 Multi-Function Rooms.
 3.5.4.1.1 For rooms serving multi-functions, such as hotel banquet/meeting rooms and office conference/presentation rooms, an adjustment factor of 1.5 times the base UPD may be used if

a supplementary lighting system is actually installed to serve the secondary function of the room and the design meets the following conditions:

(a) The installed power for the supplementary system shall not be greater than 33% of the adjusted LPB calculated for that room; and

(b) Independent controls shall be installed for the supplementary lighting system.

3.5.4.2 Simultaneous Activities.

3.5.4.2.1 In rooms containing multiple simultaneous activities, such as a large general office having separate accounting and drafting areas within the same room, the LPB for the rooms shall be the weighted average of the activities in proportion to the areas being served.

3.5.4.3 Indoor Sports.

3.5.4.3.1 The floor area of indoor sports activities areas shall be considered as the area within the playing boundaries of the sport, plus the floor area 10 ft beyond the playing boundaries, not to exceed the total floor area of the indoor room less the spectator seating area.

3.5.5 Calculation of Interior Lighting Power Allowance. The system performance Interior Lighting Power Allowance (ILPA) shall be calculated in accordance with Equation 3.5-3. The ILPA shall include a 0.20 W/ft² allowance for unlisted spaces.

$$ILPA = (LPB_1 \times LS_1 + LPB_2 \times LS_2 + \dots + LPB_n \times LS_n) + 0.2 \text{ W/ft}^2 \times (\text{Unlisted Space})$$

Equation 3.5-3

Where:

ILPA=Interior Lighting Power Allowance, W/ft²

$$\text{Unlisted space} = \frac{i-1}{(GLA - n \sum LS_{i-n}), \text{ft}^2}$$

GLA=Gross Lighted Area, ft²

LPB=Lighting Power Budget, Watts

LS=Listed Space Area, ft²

3.5.6 Lighting Power Controls Credit and Power Adjustment Factor

3.5.6.1 When calculating the ULPA in this section, the connected power for lights automatically controlled by daylighting sensors, occupancy sensor, programmable timing controls, or lumen maintenance controls may be

reduced by factoring control credits on a specific area by area basis. This credit is termed the Lighting Power Controls Credit (LPCC) and shall be determined in accordance with Equation 3.5-4:

$$LPCC = CLP \times PAF$$

Equation 3.5-4

Where:

LPCC=Lighting Power Controls Credit, Watts

CLP=Connected Lighting Power for the luminaires controlled by the automatic control device, Watts

PAF=Power Adjustment Factor, from Table 3.5-2

The adjusted lighting power (ALP) is then equal to CLP minus the LPCC.

3.5.6.2 The Lighting Power Controls Credit is limited to the specific luminaires controlled by the automatic control device.

3.5.6.2.1 Only one adjustment factor may be used for each building space or luminaire, and 50% or more of the controlled luminaire shall be within the applicable space to qualify for the power adjustment factor.

3.5.6.2.2 Controls shall be installed in series with the lights and in series with all manual switching devices in order to qualify for an adjustment factor.

3.5.6.2.3 When sufficient daylight is available, daylight sensing controls shall be capable of reducing electrical power consumption for lighting, continuously or in steps, to 50% or less of maximum power consumption.

3.5.6.2.4 Daylight sensing controls shall control all luminaires to which the power adjustment factor is applied and that direct a minimum of 50% of their light output into the daylight zone.

3.5.6.2.5 Occupancy sensors located in daylighted spaces should be installed in conjunction with a manual ON switch, or photocell override for ON.

3.5.6.2.6 Programmable timing controls used for credit in conjunction with Table 3.5-2 shall be:

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Table 3.5-2
Power Adjustment Factor (PAF)

AUTOMATIC CONTROL DEVICE(S)	STANDARD PAF*
(1) Occupancy sensor	0.30
(2) Daylight Sensing continuous dimming	0.30
(3) Daylight Sensing multiple step dimming	0.20
(4) Daylight Sensing ON/OFF	0.10
(5) Lumen maintenance	0.10

* - Power Adjustment Factor cannot be used for incandescent fixtures.

- (a) Programmable for different schedules for occupied and unoccupied days;
- (b) Accessible for temporary override by occupants of individual zones, spaces or tasks, with automatic return to the original schedules; and
- (c) Capable of keeping time during power outages for a minimum of four hours.

§ 435.104 Auxiliary systems and equipment.

4.1 General

This section contains a few minimum requirements for auxiliary systems and equipment. Because auxiliary systems and equipment vary greatly among buildings, the section is not more comprehensive.

4.2 Principles of Design

4.2.1 Energy recovery should be used when coincident thermal and refrigeration loads of similar magnitude are expected.

4.2.2 Consideration shall be given to the use of waste heat, energy recovery or heat tape systems to conserve energy.

4.3 Minimum Requirements

4.3.1 Transportation Systems.

4.3.1.1 Automatic elevator and/or conveyor systems shall incorporate schedule controls and efficient motor controls, such as solid state control devices.

4.3.2 Freeze Protection System.

4.3.2.1 Boilers or water heaters used for purposes such as freeze protection in fire protection storage vessels and defrosting sidewalks and driveways

shall meet the efficiency requirements of sections 8.3 or 9.3 when they operate in excess of 750 hours per year.

4.3.3 Retail Food and Food Service Refrigeration.

4.3.3.1 Refrigeration systems containing multiple compressors shall have compressors sized to optimally match capacity with loads.

4.3.3.2 Variable speed shall be considered.

§ 435.105 Building Envelope.

5.1 General

5.1.1 This section contains requirements for the energy conscious design of building envelopes. It sets principles of good envelope design, and provides a set of minimum requirements and two alternative compliance paths—prescriptive and system performance.

5.1.2 Compliance. A building shall be considered in Compliance with this section if the following conditions are met:

5.1.2.1 The minimum requirements of Section 5.3 are met;

5.1.2.2 The design of the building envelope complies with either the prescriptive criteria of section 5.4 or the system performance criteria of section 5.5. For the design of buildings with high internal heat gains, unusual operating schedules, or that incorporate innovative design strategies, consideration shall be given to using the compliance paths set forth in sections 11.0 or 12.0.

5.1.3 The prescriptive compliance alternative of section 5.4 provides requirements for buildings designed to take advantage of perimeter daylighting, thermal mass, high performance glazings, and fenestration shading. The designer is allowed to make trade-offs between thermal mass, wall insulation, amount of fenestration, shading coefficients, shading projections, thermal transmittance of the glazing, daylighting for several different climate locations.

5.1.4 The systems performance compliance alternative of section 3.5 provides calculation procedures that give credit for the benefits of more complex energy conserving envelope designs.