

The image shows a modern interior space. A large, dark green rectangular box is centered in the upper half of the frame, containing the text 'SPACE TYPES - DESIGN BRIEFS' in white, all-caps, serif font. The background is a photograph of a room with a vibrant orange wall. On the left, there is a square window with a dark frame and a light-colored sill. Below the window, a horizontal strip of recessed lighting illuminates a wall of large, rectangular, light-colored stone tiles. To the right of this tiled area, a dark, possibly black, fireplace or built-in cabinet is visible. The floor is made of light-colored, square tiles. The ceiling is a neutral, light color.

SPACE TYPES -
DESIGN BRIEFS

WAREHOUSE & STORAGE FACILITY DESIGN BRIEF

The NYC Department of Design and Construction (DDC) manages the construction and renovation of NYC’s municipal buildings, many of which contain warehouse and storage facilities. While different in function, these spaces share characteristics that suggest a similar approach to lighting design, including high open spaces, a pattern of tall storage units and open aisles, and the need to easily identify stored items. These guidelines are intended for light industrial buildings, but may have application to similar storage spaces in other building types such as offices, schools, retail, correctional facilities or other institutions.

LIGHTING QUALITY STRATEGIES

Warehouse and storage facilities have specific considerations because of their function and spatial characteristics. Please review and use these strategies, in concert with the basic design and quality issues discussed earlier in the Design Strategies section of this manual.

WAREHOUSE-SPECIFIC LIGHTING QUALITY AND QUANTITY ISSUES

ISSUE	IMPORTANCE
Relationship between light source and visual task and viewer	Very Important
Glare Control – Direct and Reflected Glare	Important
Daylight Integration	Important
Uniformity – No Shadows	Somewhat Important
Three-dimensional modeling of objects	Somewhat Important
Luminances of Room Surfaces	Somewhat Important

From the IESNA Lighting Handbook, 9th Edition.



courtesy: Lighting Research Center, RPI, Delta Publications

Tall shelving units must be considered in lighting calculations.

Relationship Between Light Source and Visual Task and Viewer

The relationship between the light source, the visual tasks and viewer is very important in warehouse because the tasks are usually on the vertical plane, and above eye level. Searching for an item on a high shelf is a task subject to direct glare (looking into the light source) or veiling reflections which obscure labels or writing on shiny or glossy surfaces.

Glare Control

The most common glare problems in warehouses occur from “veiling reflections” (i.e., reflections of light sources on shiny or glossy materials) on objects or their labels, and direct glare from luminaires or skylights when seeking objects above eye level.

Daylight Integration

Daylight can provide high levels of relatively uniform light appropriate for warehouse functions. Because warehouses are often one-story buildings they can be uniformly daylighted from the roof. In particular, consider diffuse (frosted) skylights, north facing monitors or clerestory windows. Control glare and sun patterns, and don’t overlight, to avoid undesirable heat gain and glare. See References for simple guidelines and software for skylight design in warehouses.

Uniformity

A wide range of illumination is unavoidable in most warehousing applications because of the difficulty of distributing light from top to bottom on vertical shelving. This is acceptable as long as the transitions are gradual. Harsh shadows make the job of retrieval much harder. Luminance ratios should be no more than 20:1 between the top and bottom vertical face of shelving, or between the darkest and lightest surfaces in view.

Three-dimensional Modeling Of Objects

Lighting to enhance the modeling of objects is only important when the correct selection of an object is dependent on its shape or texture more than its labeling. For example, the identification of nuts, bolts, plumbing connections, or fabrics might be faster by perusing the objects rather than labels. Modeling is enhanced by an increase in directional light over diffuse light, but even a diffuse light source such as fluorescent can provide adequate modeling if located in the right relationship of the light source to the object and the viewer.

Luminance Of Room Surfaces

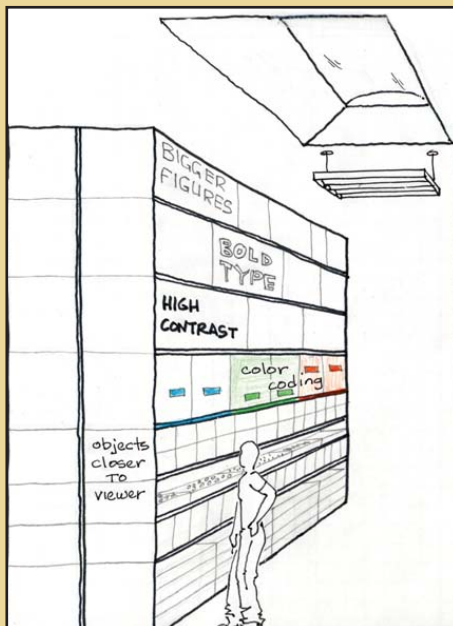
Reflectances and Finishes: To reduce the contrast and promote inter-reflections, every surface in view, and within the control of the design team, should be as light-colored as possible. Warehouses typically do not have finished ceilings, so use white-covered batt insulation, and/or paint exposed ceilings, structure, ductwork and other overhead obstructions white, especially near skylights. Shelving should be white, including the underside of shelves above eye level. Finishes should be eggshell or semi-gloss. Avoid metallic or shiny finishes. If natural metal is required, use a heavily brushed finish.

Flicker

Lamp flicker can be dangerous in an industrial environment, especially in industrial applications with low speed motors that may have similar frequencies. Use high-frequency electronic ballasts to prevent

TASK DIFFICULTY AND LIGHT LEVELS

In storage and warehouse spaces, the most common visual tasks are locating the area where an



object might be, locating the specific object, and retrieving it. Most storage tasks are on the vertical plane (shelving) rather than on the horizontal plane (countertops or flat files). An understanding of the specific details of the facility's operations should be known before designing the lighting.

REDUCING THE NEED FOR LIGHT

A visual task can be made easier not only by illumination, but also by:

- Improved task contrast (black letters on white background or white letters on black)
- Larger point size, bold print, upper and lower case letters
- Color contrast
- Locating objects at close proximity to viewer
- More time
- Familiarity with the task or the objects

FAMILIARITY

Regarding the last point, it is useful to know whether a knowledgeable employee or the general public will be performing the retrieval tasks. Full-time employees hired to retrieve materials from library archives or run a forklift in a warehouse are going to be less reliant on illumination to perform search tasks than the general public searching retail shelves for a product or library stacks for a book.

LOCATION OF LABELS OR OBJECTS

It will require less illumination to retrieve small objects at close range than to read small labels on a high shelf. It will be more difficult to distribute light deep into shelves and cabinets than to light boxes or labels that are flush with the face of the shelving.

fluorescent or metal halide sources from flickering. Defective or failing ballasts that create lamp flicker should be replaced immediately.

Color

Color can play an important role in object identification and good color rendering light sources will aid in visibility. Also, the warehouse may be part of a building type where good color rendering is desired for other tasks, and it is good practice to minimize the number of lamp types. The DDC requires the use of lamps with a CRI of 84 or higher. A correlated color temperature of 3500 to 5000 Kelvin is appropriate for warehousing functions.

LIGHT LEVELS RECOMMENDED AVERAGE MAINTAINED ILLUMINANCE, IN FOOTCANDLES (FC)

FUNCTION	TASK FC - HORIZONTAL OR VERTICAL	LOCAL TASK LIGHTING TYPE
Active Storage, fine	30	Local
Active Storage, bulky	10	
Aisles	5	
Loading docks	10	Articulated

From the IESNA Lighting Handbook, 9th Edition.

DESIGN AND LAYOUT STRATEGIES

LAYOUTS

Fluorescent lighting is a good choice for warehouse and storage facilities. It is diffuse, linear and energy efficient. Most important, fluorescent sources are easily controlled with occupancy sensors and photocells, and restrike instantly for emergency usage. New luminaires designed for this application are replacing metal halide as the source of choice for many warehousing projects, even in high bay applications (ceilings above 25'). Luminaires should be closely spaced and located over aisles. (See Layouts). Fluorescent luminaires are available with quantities of 4, 6, or 8 lamps for either T8 or T5 sources. Luminaire distribution should be designed for stack or aisle lighting. Because of the narrower diameter of T5 sources, reflectors can be tailored to the lamp to achieve more precise beam patterns.

OBSTRUCTIONS AND SPACING CRITERIA

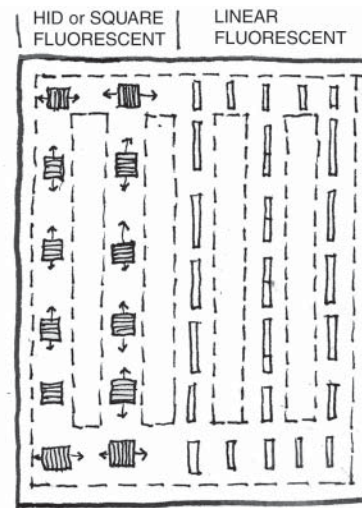
Calculations must take into account the obstructing and absorbing characteristics of shelving units. This guide assumes that warehouses have exposed ceilings, with a height of 15' to 25' above the floor. Luminaires should be pendant-mounted, so a small percentage (5-10%) of the light can be directed to the ceiling, and located to avoid shelving and other obstructions from ceiling structure and mechanical equipment.

TASK LIGHTING

Applications where local task lighting might be appropriate for storage and warehouse functions include fine storage, for searching deeply into shelves or cabinets, or for looking into trucks on loading docks.

SPECIALIZED LUMINAIRES

Fixtures adjacent to outside air and temperature swings near warehouse doors or loading docks should be listed for damp label and utilize ballasts appropriate for the potential temperature extremes. In general, all luminaire housings should be white or lightly colored to reduce contrast and glare.



PREVENT BREAKAGE

Lighting fixtures should be kept out of reach of moving ladders, lifts and materials. Lamps should be protected from breakage by lenses or cages. Sturdier fluorescent lamps are available for conditions of extreme vibration.

ENERGY EFFICIENCY STRATEGIES

WAREHOUSE-SPECIFIC ENERGY CONSERVING DESIGN STRATEGIES

- Evaluate tasks for potential improvements. For example:
 - Cluster tasks with similar visual needs together.
 - Separate bulk storage and fine storage areas. Consider local lighting for fine storage items.
 - Separate active storage and inactive storage. Control lights separately.
 - Color-code shelving and/or products.
 - Use large, high-contrast labels on shelving and products.
- Use daylighting to the greatest extent possible. If the warehouse is a one-story facility or is on the top floor, it is fairly easy to fully daylight the warehouse during most seasons and times of day using a grid of skylights. Choose the most diffusing material available for skylights. There is currently no precise language that can be used to specify good diffusion, thus diffusion is best assessed by direct visual inspection. For example, sunlight passing through the diffusing glazing material should not concentrate the light into local hot spots, nor cast a discernable shadow from a hand held three feet above the ground.
- Consider SkyCalc™ software to assist in the selection and placement of skylights, in order to optimize energy performance for a given layout and skylight-to-floor-area ratio (SFR). (See References).
- Control electric lights to reduce energy consumption.

ENERGY CODES: WATTS / SQUARE FOOT BUDGETS

FUNCTION	NYS ENERGY CODE		ANSI/ASHRAE/IESNA STD.90.1		NOTES
	2002	+/- 2006	1999/2001	2004	
WAREHOUSE BUILDING (Whole Building Type Method Only)	0.6	0.8	1.2	0.8	1,3
Warehouse, Active Storage, fine materials			1.6	1.4	2
Warehouse, Active Storage, medium / bulky materials	1.0	0.8	1.1	0.9	2,4
Warehouse, Inactive Storage			0.3	0.3	2

1. Multiply this value by the total square footage of the building, to determine the total building interior power allowance, using the Building Type method. 2. Multiply this value by the square footage of the dedicated warehouse spaces. Sum the results of all the individual spaces in the building to determine the total building interior power allowance using the space-by-space method. The design of an individual space is not required to meet the watt/sf limits, as long as the total building connected load does not exceed the total interior power allowance. 3. Listed as "Storage Building, industrial and commercial," in NYS Energy Code. 4. Listed as "Storage area, industrial and commercial," in NYS Energy Code.

LIGHTING CONTROLS

Provide multiple levels of controls. Occupancy sensors should only be used in a multiple level design, so that 5-10% of lights remain on after dark, but while the building is still occupied.

Provide daylight-compensating multiple-level switching with photocells located in skylight wells or adjacent to clerestories. Design the control system to prevent “cycling” of lamps on and off. No electric lights should be switched off until daylight alone provides at least 20% more than the desired illumination. See Technologies Section for daylighting controls.



North-facing monitors enable daylight to be the primary light source for the warehousing functions at Sunrise Yards, a current DDC project in Queens, NY.

OTHER CONSIDERATIONS

Locate storage racks, luminaires and skylights in relationship to each other so daylighting is maximized and luminaires are accessible from aisles for maintenance.

Night-lighting or weekend lighting should be off or minimal in buildings with long hours of no occupancy.

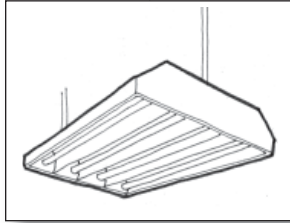
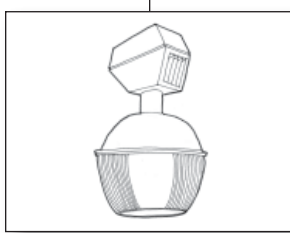
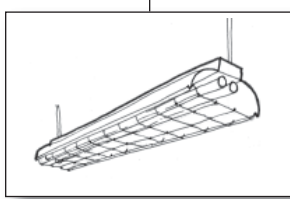
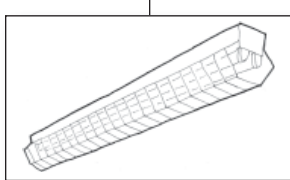
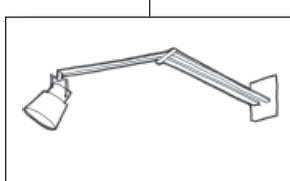
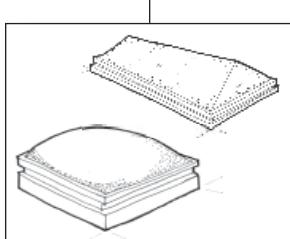
Dirt Depreciation

If the warehouse is open to the exterior, or if activities generate a high proportion of dust, the output of lamps and luminaires may be significantly depreciated due to dirt accumulation. Luminaires with open tops can reduce dirt accumulation by means of convection air currents. Annual cleaning and scheduled group relamping at 70% of rated lamp life can offset these losses. Avoid using excessively conservative light loss factors and overlighting the space.

Emergency Lighting

The design of the emergency lighting system should take into consideration the extensive blocking of views caused by the shelving units and storage materials in a warehouse.

SAMPLE LUMINAIRE SCHEDULE FOR WAREHOUSE & STORAGE FACILITIES

	<p>FLUORESCENT LOW BAY ASYMMETRICAL PENDANT</p> <p>Location: Warehouse Lamps: (4 to 6) 32W, High Performance T8 or 54W T5HO, 835 - 850 color Description: Pendant-mounted, open metal reflector housing. Instant-start, energy efficient multi-lamp ballasts. Mount a maximum of 30' above the floor. Minimum 90% efficiency.</p>
	<p>METAL HALIDE LOW-BAY AISLE LIGHT</p> <p>Location: Warehouse Lamps: (1) 250W, ED-18 ceramic metal halide, 3200 - 5000 Kelvin Description: Pendant-mounted, anodized, spun aluminum reflector and precision injection-molded prismatic acrylic refractor provide multiple distribution patterns for precise control. Open metal reflector housing. Ceramic metal halide. Mount a maximum of 25' above the floor. Minimum 68% efficiency.</p>
	<p>PENDANT FLUORESCENT INDUSTRIAL STRIP WITH SLOTTED REFLECTOR WITH CAGE</p> <p>Location: Warehouse, storage Lamps: (2) 28-32W, High Performance T8, 835 - 850 color Description: Pendant mounted fluorescent fixture, wired for continuous runs per row. White baked enamel reflector finish. Slotted for 20% uplight. Minimum 92% efficiency.</p>
	<p>INDUSTRIAL CHANNEL WITH CAGE</p> <p>Location: Warehouse, storage Lamps: (2) 28-32W, High Performance T8, 835 - 850 color Description: Suspended or surface-mounted fluorescent strip fixture, wired cage to protect lamps. White baked enamel finish. Minimum 89% efficiency.</p>
	<p>LOADING DOCK LIGHTS</p> <p>Location: Loading Dock Wall Lamps: (1) 60W Par-38 Halogen Description: Surface-mounted, adjustable-arm in three axes for aiming into truck beds. Powder-coated yellow for safety.</p>
	<p>SKYLIGHT</p> <p>Double-glazed, non-venting plastic unit skylights with condensate gutter attached to integral, insulating frame. Glazing Material: Choose highest light transmittance available. 70%+ visible light transmittance recommended. Require proof from unit manufacturer that light transmission will remain stable over life of the unit, without yellowing or loss of structural strength. Maximum diffusion: Clear diffusing materials include prismatic acrylic, clear fiberglass, and complex polycarbonate extrusions. Heat Gain and Loss: Solar Heat Gain Coefficient = 70% maximum. Unit U-factor = 1.0 maximum (including framing effects). Safety & Maintenance: Check local fire and safety codes for minimum strength and other performance requirements. Include a safety grate to prevent forced entry or accidental falls. Occasional washing of the skylights in urban locations will help maintain optimal performance.</p>