

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, uppercase, 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 the wall. At the bottom of the image, a wall of large, light-colored, textured tiles is visible, with a dark, possibly black, fireplace or built-in unit on the right side. The floor is made of light-colored, square tiles. The overall lighting is warm and focused on the architectural details.

SPACE TYPES -  
DESIGN BRIEFS

## WORKSHOP DESIGN BRIEF

The NYC Department of Design and Construction (DDC) manages the construction and renovation of NYC’s municipal buildings, many of which contain small industrial facilities such as carpentry shops, plumbing shops, electrical shops, auto maintenance shops, paint shops and the like. While different in function, these spaces share characteristics that suggest a similar approach to lighting design, including high open spaces, a variety of equipment or workstations, special concern for worker safety, and maintenance considerations. These guidelines are intended for these types of light industrial uses, but may have application to other similar space types.

### LIGHTING QUALITY AND QUANTITY STRATEGIES



courtesy: Lighting Research Center, RPI, Delta Publications

*Fluorescent lighting reduces undesirable shadows*

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

#### WORKSHOP—SPECIFIC LIGHTING QUALITY AND QUANTITY ISSUES

General requirements for small industrial workshops: Provide uniform general ambient lighting. Use more fixtures with lower wattages to insure uniformity and reduce glare. Provide additional general lighting in limited areas with more difficult task requirements. Provide local task lighting at benches and machinery when appropriate.

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

*From the IESNA Lighting Handbook, 9th Edition.*

#### Relationship between light source and visual task and viewer

Because the visual task in workshops often involves materials that are shiny or glossy, or are combined with dangerous machinery, the relationship of the light source to the task and to the viewer is extremely important to avoid direct glare or veiling reflections. Local task lighting is often the best strategy to insure the proper physical orientation between the light source, visual task, and the viewer.

#### Glare Control – Direct and Reflected Glare

Certain workshop tasks require more glare control than others. Visually disabling glare can be hazardous in such environments because of dangerous machinery, finer tasks and visual obstructions. Distribute light to ceilings (5%-10% uplight) to reduce contrast from bright luminaires. Provide glare shielding in the 45 to 85 degree zone (See “cutoff angle” in Glossary). Polished or machined metal can produce disabling reflected glare. Use task lights at an angle to offset glare.

### Three-dimensional Modeling of Objects

For some tasks in workshops, such as painting or sanding or assembly, the ability to see three-dimensional form or texture makes visual performance easier. Modeling is enhanced by an increase in directional light in relation to totally diffuse light, and may be accomplished with diffuse sources, such as fluorescent, just by the correct placement of the sources in relation to the task. The angle should create slight shadows and enhance definition, rather than flattening the appearance of an object. Too much directional light should be avoided, as it creates harsh shadows that detract from seeing, and may actually be dangerous in conjunction with moving parts. Local task lighting combined with diffuse ambient lighting is an effective way to provide adequate definition of three-dimensional form. Lights that are adjustable in position and in the control of the worker are usually preferred on workbenches. Manufacturers of machinery often provide integrated task lighting that is designed for the function.

### Luminances of Room Surfaces

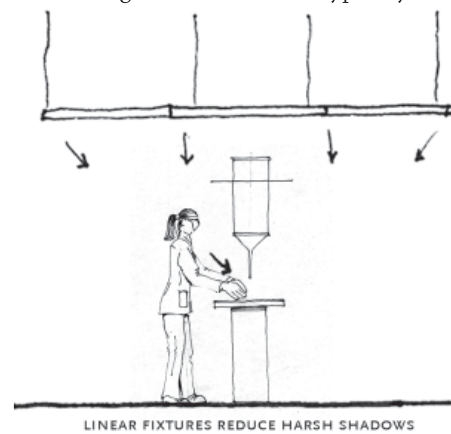
Luminance ratios should be close to uniform, not exceeding 1:6 ratio between the average and maximum luminance of room surfaces, or 6:1 ratio between minimum and average. The task should typically have the highest luminance in the field of view.

### Uniformity – Minimize Shadows

For safety purposes, harsh shadows should be avoided in workshops, especially near machinery. Machines and objects may obstruct the light, so diffuse sources should be used to promote uniform ambient lighting.

### Reflectances and Finishes

In order to achieve the desired luminance ratios and uniformity, reflectances should be high and finishes should be matte. Ceilings should be a minimum of 80% reflectance (90% preferred). Walls should be a minimum of 70% reflective, equipment and workbenches between 35 and 65% reflective, and floors not less than 20% reflective. Polished, glossy and shiny surfaces should be avoided, because specular reflections can reduce visibility and distract the worker. The most matte finish available that will provide acceptable maintenance should be used. Use matte or eggshell paints. Paint metal surfaces or use heavily brushed natural metal finishes.



LINEAR FIXTURES REDUCE HARSH SHADOWS

### Daylight Integration

Daylight can provide high levels of relatively uniform light appropriate for industrial activities. Because many shops are often in one-story buildings, they can be daylighted from the roof, with little to no electric light required during daylight hours. In particular, consider diffuse (frosted) skylights, north facing monitors or clerestory windows, or high perimeter windows in double height spaces. The visual connection to the out-of-doors can have a positive effect on work productivity. Control glare and sun patterns, using diffusers, fins or screens so that there are no dangerous patterns or distractions to the use of dangerous machinery or tools.

### No 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 fluorescent or metal halide sources from flickering. Defective or failing ballasts that manifest lamp flicker should be replaced immediately. If only magnetic ballasts are available, the ballast should be circuited to different electrical phases than the motorized equipment in the workshops.

### Color

Use better color rendering lamps, with a CRI of 84 or higher. A correlated color temperature of 3500 to 5000 Kelvin is appropriate for most workshops. Good color rendering will aid in visibility. A special lighting comparison “booth” can be provided for color-matching paints. See the *IESNA Lighting Handbook* for specialized industrial applications.

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

SHOP TYPE	AMBIENT FC	BENCH / TASK FC	MACHINERY FC	STORAGE FC	LOCAL TASK LTG. TYPE
Plumbing	30	30-50	50	5-10	Undershelf
Electrical	30	30-75	-	5-15	Articulated
Carpentry	30	30-50	50-75	5	Undershelf, Articulated or Equipment-mounted
Metal	30	30-50	50-75	5-10	Undershelf
Auto Repair	30	30-50	50-75	5-10	Portable
Paint Shop	30	30-50	-	5-10	Undershelf*

Adapted from the IESNA Lighting Handbook, 8th and 9th Edition. \* special lamps may be required for paint matching.

## DESIGN AND LAYOUT STRATEGIES

### Obstructions and Spacing Criteria

Calculations for uniformity should incorporate a realistic assessment of the potential obstructions to the light distribution, such as machinery, vents, or stored materials that extend above the working plane. This guide assumes that the workshops are located in spaces with exposed ceilings, with a clear height of 15' to 25' above the floor. Luminaires should be pendant-mounted (so that 5-10% of the light can be redirected to the ceiling) and located to avoid obstructions from ceiling structure and mechanical equipment.

### Task Lighting

Local task lighting should be provided for tasks requiring significantly higher light levels, for inspection tasks, or for tasks that are obstructed from receiving ambient lighting. Task lights can be mounted on or above work benches, and are often available from equipment manufacturers. Depending on the specific conditions, task luminaires should be fixed in the optimal position for task viewing and operator eye position, or should be articulated in three directions to allow full adjustability by the operator. Consider task lights that are combined with optical magnifiers. Portable task lighting should be provided for auto repair and loading docks, where it is necessary to look under or into objects. Use fluorescent or LED sources, to minimize heat or burning hazard. Lamps should be protected with guards, and be suitable for vibration and rough handling.

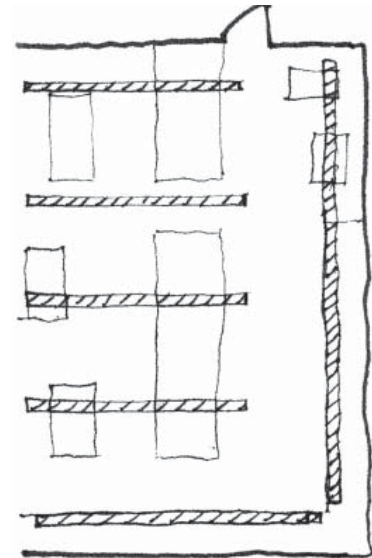
### Specialized Luminaires

In addition to the typical industrial luminaires shown in the Fixture Schedule below, there are also specialized luminaires manufactured that are explosion proof, or appropriate for hazardous conditions or wet locations, or "clean rooms". Areas with vibration may require luminaires with safety cages, flexible socket sleeves, vibration resistant lamps, etc. Areas with intense dirt generation may require luminaires that are sealed and gasketed with breathable filters, although the extra expense should be justified. In general, all luminaire housings should be white or lightly colored to reduce contrast and glare.

### Safety

Not only should the space be lighted for intended task performance, but the design should also adequately illuminate any potential dangers or hazards in the building. Paths of egress and layouts should be carefully designed in spaces where protective eyewear, tinted lenses, face guard and use of respirators reduce amount of light reaching the eye. The recommended illumination levels listed below take protective eyewear into account.

Electrical cut-off "panic" switches for carpentry machinery are required in numerous accessible locations throughout carpentry shops and other workshops with moving equipment.



LOCATE AMBIENT FIXTURES OVER WORK BENCHES AND/OR PERPENDICULAR TO TABLES

## ENERGY EFFICIENCY STRATEGIES

### WORKSHOP-SPECIFIC STRATEGIES

- Evaluate tasks for potential improvements in contrast or background.
- Cluster tasks with similar visual needs together. Separate storage areas from task areas.
- Paint moving parts of machinery contrasting colors from stationary parts, to reduce accidents.
- For small, difficult tasks, use optical magnification to improve visibility.

### ENERGY CODES: WATTS / SQUARE FOOT BUDGETS

FUNCTION	NYS ENERGY CODE		ASHRAE/IESNA STD.90.1		NOTES
	2002	+/- 2006	1999/2001	2004	
WORKSHOP BUILDING (Whole Building Type Method Only)			1.7	1.4	1
Workshops (less than 20' ceiling)	2.1	1.2	2.5	1.9	2,3
Workshops (20' or higher ceiling)	3.0	1.7	2.5	1.9	2,3
Storage, Active	1.0	0.8	1.1	0.8	2
Storage, Inactive			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. If no value is shown, use the space-by-space method. 2. Multiply this value by the square footage of the dedicated workshop 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. NYS Energy Code uses the title "industrial work" instead of "workshop".

### LIGHTING CONTROLS

Provide multiple levels of controls. Occupancy sensors should only be used in a multiple level design, so that the space cannot be totally darkened while a worker is performing a dangerous activity. Specify dual-technology occupancy sensors, to prevent false offs and ons. (See technology section)

For daylight compensating, dimming is preferred over switching because of hazardous machinery. However, for spaces where daylight provides the desired light levels for the greater majority of the day or year, a switching system may be a cost-effective choice. Special care should be taken to avoid large changes in light levels, or "cycling" of lamps on and off. (See Technologies Section for daylighting controls).

### OTHER CONSIDERATIONS

#### DIRT DEPRECIATION

Many light industrial activities generate a high proportion of dust, paint or air-borne particulates that adhere to lamps and luminaires as well as walls and other room surfaces. For the safety and health of



North-facing monitors and angled louvers ensure that daylighting is the primary source of light for the workshops at Sunrise Yard. The direct sunlight is never allowed to hit the work surfaces during work hours.

workers, as well as the efficiency of the lighting system, every effort should be made to reduce airborne pollution, including machinery-mounted vacuums and powdercoat paint processes. Depending on the application, luminaires with open tops and bottoms can reduce dirt accumulation by means of convection air currents. Clean lamps and lighting fixtures at least once a year. Enclosed and gasketed luminaires will keep the lamps cleaner, but still require cleaning of the external lens.

Wide distribution luminaires aids uniformity even when lamps burnout. Since spot-relamping is so difficult in a heavily obstructed environment, group relamping should be mandatory. Night and weekend lighting should be off or minimal in buildings with long hours without occupancy.

## EMERGENCY LIGHTING

Special care should be taken to ensure all exits and paths of egress are clearly visible, in spite of machinery and obstructions in workshop settings.

## TEMPERATURE EXTREMES

It is not expected that the workshops types covered by this guideline will be outside of the range of normal interior temperature ranges. However, luminaires, ballasts and components do exist to accommodate extremes in temperature or humidity in industrial environments.

## HAZARDOUS AREA CLASSIFICATION FOR LUMINAIRES

The design team engineers, in conjunction with the building owner, must determine if any spaces in the building are to be considered Hazardous (Classified) under the definitions of the National Electric Code or other provisions of the NYC Electrical Code. A Hazardous classification has an impact on all electrical equipment used in that space must be documented and made available for use by the design team members, the contractor, and building owners and maintenance personnel. Once the classification has been made, the specified luminaires must be Hazardous-rated to meet the requirements of that specific Class, Division and Group.

RISK	AREA CLASSIFICATION	BASIC TYPE OF FIXED LUMINAIRE*
Normally flammable or volatile gases, liquids, or solids	Class I† Division 2	Explosion-proof
Occasionally hazardous volatile gases, liquids, or solids	Class I Division 2	Enclosed and gasketed
Normally combustible dust	Class II	Dust-ignition proof
Occasionally hazardous dust (grain, flour, wood, plastic, and chemical dusts)	Class II Group G Division 2 only	Enclosed and gasketed
Combustible fibers or flyings	Class III	Enclosed and gasketed

Courtesy The IESNA Lighting Handbook, 9<sup>th</sup> Edition, Chapter 19.

*Note: The National Electric Code (NEC) sections 500-5, 500-6, and 500-7 recognize three classes of hazardous (classified) locations, based on the type of material involved. Within each class there are varying degrees of hazard, so each class is subdivided into two divisions. The classification by division is based on the likelihood the material will be present. The requirements for Division 1 of each class are more stringent than those for Division 2.*

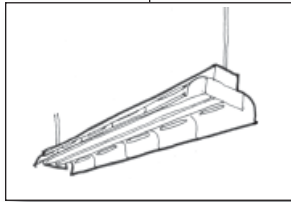
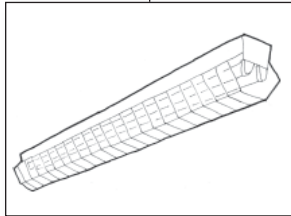
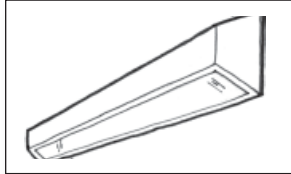


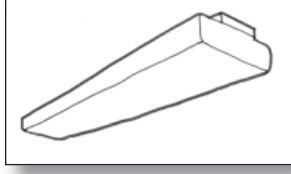
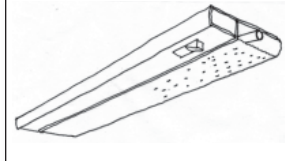
*The materials in the three classes are defined as follow: Class I, flammable glass or vapors; Class II. Combustible dust; and Class III, combustible fibers or flyings.*

*Where a given location is classified as hazardous, it should not be difficult to determine in which of the three classes it belongs. Common sense and good judgement must prevail in classifying an area that is likely to become hazardous and in determining those portions of the premises to be classified Division 1 or Division 2.*

*\* The terms, explosion-proof, dust-ignition-proof, and enclosed and gasketed are generic types of [luminaire] construction only. The class, group, division, and operating temperatures must be known to select the appropriate luminaire that is Hazardous-rated for that classification.*

*† Group and temperature markings shown on the luminaire are used to determine its classification.*

## SAMPLE LUMINAIRE SCHEDULE FOR WORKSHOPS

	<p><b>PENDANT FLUORESCENT INDUSTRIAL STRIP WITH SLOTTED REFLECTOR</b></p> <p><b>Location:</b> Workshop  <b>Lamps:</b> (2) 28-32W, High Performance T8, 835 – 841 color  <b>Description:</b> Pendant mounted fluorescent fixture, wired for continuous runs per row. White baked enamel reflector finish. Slotted for 20% uplight. Minimum 92% efficiency.</p>
	<p><b>FLUORESCENT INDUSTRIAL CHANNEL WITH CAGE</b></p> <p><b>Location:</b> Workshop  <b>Lamps:</b> (2) 28-32W, High Performance T8, 835 – 841 color  <b>Description:</b> Suspended or surface-mounted fluorescent strip fixture, wired cage to protect lamps. White baked enamel finish. Minimum 89% efficiency. Sealed, gasketed, and hazardous-rated if required.</p>
	<p><b>WALL-MOUNTED FLUORESCENT DIRECT/INDIRECT</b></p> <p><b>Location:</b> Workshop  <b>Lamps:</b> (2) 28-32W, High Performance T8, 835 – 841 color  <b>Description:</b> Wall-mounted fluorescent fixture, wired for continuous runs per row. White baked enamel reflector finish. 50% minimum uplight. 50% downlight. Minimum 41% efficiency. Hazardous-rated if required.</p>
	<p><b>FLUORESCENT LOW BAY PENDANT</b></p> <p><b>Location:</b> Workshop  <b>Lamps:</b> (4 to 6) 32W High Performance T8 or 54W T5HO, 835 - 841 color  <b>Description:</b> 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><b>METAL HALIDE LOW BAY</b></p> <p><b>Location:</b> Workshop  <b>Lamps:</b> (1) 250W, ED-18 ceramic metal halide, 3200 – 5000 Kelvin  <b>Description:</b> Pendant-mounted open prismatic glass refractor housing with approximately 25% +/- uplight component. Field adjustable light pattern for medium to wide light distribution for various ceiling heights. Minimum 80% efficiency. Hazardous-rated if required.</p>
	<p><b>FLUORESCENT WRAP-AROUND PENDANT/SURFACE-MOUNTED</b></p> <p><b>Location:</b> Workshop, storage  <b>Lamps:</b> (2) 28-32W, High Performance T8, 835 – 841 color  <b>Description:</b> Pendant or surface-mounted fluorescent wrap-around with injection molded clear acrylic plastic lens. Instant-start energy-efficient ballast. Minimum 81% efficiency.</p>
	<p><b>UNDERSHELF FLUORESCENT TASKLIGHT</b></p> <p><b>Location:</b> Workbench  <b>Lamps:</b> (1) 28-32W, High Performance T8, 835 – 841 color  <b>Description:</b> Shelf-mounted linear fluorescent tasklight with solid front and clear prismatic acrylic lay-in diffuser.</p>