

LIGHTING AUDIT REPORT



British Columbia Institute of Technology: Factor IV Lighting Review

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1. EXECUTIVE SUMMARY

This report summarizes the lighting audit and analysis for the NE02, NE04 including attached canopy (referred to as NE04a) and NE06 buildings at British Columbia Institute of Technology, Burnaby Campus at 3700 Willingdon Avenue, Burnaby performed by Prism Engineering Ltd. Additionally, the NE01 parking kiosk, NE03 Centre for Architectural Ecology and NE08 were also reviewed for savings potential and were included in this study. The AFRESH building was not included in this study,

The recommendations presented in this report are broken into three stages; Stage 1 is the Base Retrofit actions, Stage 2 is the Expanded Retrofit Actions that could be layered onto Stage 1 actions, and Stage 3 is including Advanced Technology Retrofit options. All three stages, combined, present the greatest savings and technological advancement for the site.

Based on the individual proposed stages of the project, the breakdown of Stage 1 the project is as follows:

Stage 1: Base Retrofit Actions

The recommendations will result in energy savings of over 100,000 kWh and demand savings of 24 kW each year. These savings may be eligible for incentives from BC Hydro and NRCan that can be used to reduce the project payback.

Based on the findings of the lighting audit, the current electrical costs for lighting can be reduced by approximately \$9,740 plus \$5,300 in maintenance savings annually, a 22.1% reduction in energy usage and costs¹.

The estimated cost for implementing the Stage 1 recommendations is \$160,000. This cost includes material, labour, engineering, and project management but does not include incentives or HST.

The financial performance for Stage 1 of the project is summarized as follows:

- the simple payback for the project is 10.6 years;
- the equivalent before tax internal rate of return is 10.6% based on a 20 year life and a 0% escalation in rates;
- the net present value for the project is \$71,000 based on a 6% discount rate and 20 year life.

The lighting measures were selected based on the energy savings potential of the retrofit, upgrading of technology, consistency of lighting products installed and maintaining existing lighting levels.

In addition to the energy cost savings, other benefits include the reduction of greenhouse gas production (indirectly), reduced maintenance costs for lighting by renewal of systems and having all installed products being consistent from building to building.

Stages 1 to 3: Combined

Were the project expanded to take into account all three stages, the recommendations will result in energy savings of over 157,000 kWh and demand savings of 29 kW each year.

¹ The interactive impact of the lighting retrofit on the mechanical systems has not been addressed in this analysis. For example, the reduced lighting load in some buildings may result in additional heating energy required.

Based on the findings of the lighting audit, the current electrical costs for lighting can be reduced by approximately \$15,100 plus \$13,440 in maintenance savings annually, a 36.5% reduction in energy usage and cost.

While these measures make a significant reduction in energy usage, the overall cost and payback for the combination of all three stages is prohibitive at \$763,000 with a payback in excess of 26 years.

These measures would result in a negative NPV of -\$344,000 with an IRR of 0.0%.

As technology costs reduce over the next two to three years, it may become feasible to proceed with some of the advanced technology options presented here. However, at present, the costs, without significant incentive from utilities or government agencies, are prohibitive with excessively long paybacks.

BC Hydro and NRCan will often fund projects that highlight / showcase advanced energy savings products and opportunities. It is suggested that these groups be contacted to determine their potential interest in providing funding for the measures as part of a demonstration project.

2. METHODOLOGY

2.1 Objectives

This study was defined to meet the following objectives:

- *Survey* existing lighting conditions and compile inventory on a room-by-room basis;
- *Identify* occupant requirements and concerns regarding light levels in conjunction with the facility manager and key building occupants;
- *Determine* operating schedules and estimate hours of operation based on an estimate derived from metered data, discussions with occupants, and site visits;
- *Identify* lighting quantity and energy savings opportunities with respect to the lighting systems;
- *Review* and analyze existing systems with the intent to present up to three lighting schemes identifying potential lighting upgrades;
- *Determine* estimates of upgrade costs and installation requirements;
- *Compile* results in a lighting feasibility report, to include quantified cost savings and financial analysis, as well as options for partnering with BC Hydro for a demo project.

2.2 Study Methodology

2.2.1 Lighting Audit and Analysis

The lighting study includes audits of each the building's lighting systems and controls, an analysis of past retrofits performed, review of alternatives for further energy savings actions and a summary of recommendations. The audits included a detailed inventory of lighting in the buildings².

This information was obtained through physical, on-site reviews of the lighting system on a room-by-room basis and comparison to past information from the lighting upgrade in 2001 / 2003 and changes implemented since 2003.

2.2.2 Energy Analysis

Lighting energy use was determined based on the audited load and estimates of operating hours. Estimates based on this information were compared to the consumption figures obtained from monthly meter readings or utility account history records (where available) to ensure an accurate and objective analysis. Historical energy usage meter data, as provided by BCIT, from past projects were also utilized as reference for this analysis.

² Hardwired lighting only. Plug in floor or table lamps were not audited.

2.2.3 *Measure Selection Criteria*

Measures proposed for implementation on this project have been selected based on the viability of the measure against the following criteria:

- appropriateness for tasks performed in the space;
- condition of existing lighting systems;
- cost to retrofit existing system vs. cost to replace systems;
- low maintenance requirements;
- consistency of application (all areas of similar function are consistent);
- overall impact on occupants and general acceptance of changes.

The intent of the outlined criteria is to provide guidelines to determine which lighting measure is appropriate for the tasks performed.

2.2.4 *Cost/Benefit Analysis*

Different lighting retrofit / upgrade alternatives were evaluated for first cost, operating cost, maintenance costs and overall system energy performance. During the evaluation process, of the various options reviewed, measures included in this report were selected based on products maximize energy savings, potential for lower maintenance and future component availability costs.

While more systems and technologies than presented in this report were reviewed, those that did not provide adequate performance, energy savings or maintenance savings are not presented in this report or savings / cost estimates.

Overall project budget costs were considered for the Base Retrofit option with the intent to have the overall payback of approximately 10 year plus a positive NPV and IRR for the facilities included in the option. Other options were provided without payback filter to determine maximum savings potential for additional technologies and opportunities.

The readers are reminded to keep in mind that it is possible that costs and fees estimates included in the report could vary be up to 20% less than estimated; true costs will not be known until the work is tendered and market forces dictate the pricing. However, it is not anticipated that costs would be higher than estimated. Additionally, electric utility rebate incentives may also be significantly higher than estimated, based on the interest of the utility in supporting this project as a pilot or demonstration project.

Once various factors are reviewed and verified by other parties (utility rebates for example), the cost benefit analysis can be revised with greater accuracy.

3. EXISTING CONDITIONS

3.1 Lighting Systems Description

The majority of the lighting throughout the buildings is provided by fluorescent luminaires with T8 technology lamps and electronic ballasts. Lighting systems are either powered at 120 or 277 volts.

Most fluorescent lighting systems were retrofitted to 32 watt T8 lamps and instant start electronic ballasts during the 2001 / 2003 lighting upgrade. Some systems in some buildings, NE04 for example, had been previously retrofitted or installed with rapid start electronic ballasts.

Since 2003, instant start ballasted luminaires in some areas of buildings have been relamped with 30 watt energy saving T8 lamps; NE03 is one such building. Not all spaces were relamped with energy saving lamps as these lamps are temperature sensitive and only operate on instant start or programmed rapid start ballasts; standard rapid start ballasts will not operate T8 energy saving lamps.

The Welding building, NE08, main lighting systems were upgraded with T5 technology luminaires with 54 watt, high output (HO) lamps and programmed rapid start ballasts. This is the only facility of the buildings included in this study that utilize this technology of lamps and ballasts.

3.2 Lighting Audit

For this work, a room-by-room, detailed lighting audit was not conducted. Areas were reviewed for current conditions in comparison to information from previous studies. Any differences in the systems and equipment onsite were taken into account when preparing estimates and calculations.

The audits for the buildings have been assembled from past energy saving upgrade projects conducted in 2001 / 2003 on the lighting of these facilities, renovations undertaken by BCIT after the 2003 retrofits were implemented. Information was reviewed onsite for accuracy and for changes to the lighting systems in these facilities.

Lighting levels vary widely throughout the areas of the buildings. As a result, areas of similar usage (i.e.: classrooms) can have quite differing light levels. This results in illumination levels being adequate in some areas, but below or significantly below recommended levels in other areas. The recommendations made in this report will target WCB and IES recommended lighting levels.

3.3 Lighting Controls

Most interior lighting systems within the facilities are manually controlled; with the exception of washrooms and classrooms where occupancy sensor controls were installed during the 2001 / 2003 campus-wide lighting upgrade.

The main, large shop areas of NE02 and NE04 had been designed during the 2001 / 2003 lighting upgrade to utilize daylight sensors. However, observations during the site audit were that these controls had been disabled and / or removed from these buildings.

Additional modifications to the lighting controls scheme in NE02 were implemented since 2003. The main lighting was altered so that the lighting is controlled by one low voltage switch interwired with a relay cabinet and one row of main lighting in the space is utilized as nightlight / walk-through lighting after hour.

There appears to be no timed function or automated control for the main lighting in these facilities. As a result, based on notes from student prepared studies, main lighting systems in these buildings operate many hours per day and per week longer than building occupancy / use. Student reports noted that, for most buildings, the occupancy hours are from approximately 07:00 to 15:00, with required lighting hours from 07:00 to 16:00. Current operating hours are estimated as being 06:00 to 19:00 or 20:00, five days per week; with some Saturday occupancy.

If staff and custodians fail to turn off lighting when vacating the space, it falls onto security staff to turn off lighting when making rounds. The actual duration of lighting operation may not be consistent from day-to-day, week-to-week, and actual hours of operation and 'wasted' hours of operation may be greater or lower on differing weeks than conditions observed by the students.

The majority of the exterior lighting is typically photocell controlled and operates an average of 12 hours per day, seven day a week, year-round. One area that is not controlled by photocells is the NE04 Canopy; this area is reportedly controlled by occupancy sensors, but all indications are that this lighting is manually controlled by occupants.

3.4 Light Level Readings

Critical seeing areas have been reviewed for comfort of the visual environment and adequacy of illumination to meet occupant needs for light levels.

Illumination levels reported during the original audit in 2001, in post retrofit conditions in 2003 and during site work for this project shows that lighting levels are generally within IESNA recommended levels for the tasks performed.

Various student reports on the buildings that commented on spaces being overlit are incorrect. It is assumed that the authors of these reports did not identify the proper task classification for the usage type. As a result, illuminance criteria selections were skewed.

Of the facilities included in this study, NE06 and NE08 exhibited illumination levels in the main practicum areas that were at or below the minimum illumination levels for the tasks performed. In NE03, lighting levels in the areas that have been converted in to offices were found to be higher than recommended levels for the task type.

All other facilities illumination levels were either at or close to recommended levels; being +/- 5 to 8% of recommended illumination requirements.

4. PROPOSED MODIFICATIONS

4.1 General Modification Overview

The stated BCIT Factor IV project mandate is to review building systems, and behavioural habits of occupants with regard to operation of systems and equipment within facilities. The intent of the program is stated below:

"In the interest of achieving ecological sustainability, meaning use of ecological goods and services within nature's carrying capacity, the scientific community is calling for a four to ten-fold reduction in global levels of energy and materials consumption. Growing concerns about energy security coupled with evidence of anthropocentrically induced climate change point towards the relevance of the scientific community's challenge despite perceptions that such targets are "unrealistic."

"BCIT's School of Construction and the Environment seeks to apply leading edge technology coupled with the adoption of new behaviors to the challenge of achieving a four-fold reduction (75%) in energy and materials consumption of a portion of the BCIT Burnaby Campus known as the "Factor IV" area."

To this end, the buildings work reviewed from various aspects for energy savings, with the aim to answer the questions; is it feasible? If yes, at what cost. The following details the process and findings of the review conducted onsite:

- Determine what minimum actions or technological modifications can be made to existing systems to achieve energy savings and what would those savings be;
- Determine what controls changes could be implemented to achieve further savings over the minimum actions to enhance energy savings;
- Review other products and technologies that could be used in conjunction with the minimum actions to achieve additional savings;
- Review additional / more advanced controls options to more tightly control lighting operation with the aim to reducing operational run time of lighting during conditions when artificial lighting can be turned off or supplanted;
- Review up and coming technologies to determine if these technologies could be applied in these facilities to further reduce energy usage and connected load of the facilities.

From the review of the various possible upgrades to existing systems, applications of different technologies and controls options, various options / scenarios for energy savings were determined.

The review of potential upgrades started with a Base Retrofit option that consists of modifying or replacing existing lighting systems, as was determined to be appropriate for the system, and implementation of basic controls. Reviewing of options then progressed to adding additional technology and controls options that would layer upon the Base Retrofit and improved the savings more at each level.

Each 'layer' or option is presented below, with a table of savings potential of Base Retrofit savings and then incremental savings that could be achieved through the application of additional actions.

For each area that has been reviewed, various task factors (based on IES and WorkSafe BC requirements) have been taken into account to ensure that achieving maximum energy savings is achieved while maintaining compliance with required standards.

4.2 Student Studies

BCIT Factor IV project was subject of several energy manager student project studies.

The student project studies gave some good insight into the buildings, based on limited information gathered. These studies also showed some scenarios that would not work for this project.

Items presented in student reports that were not considered for this study:

- Replacement of existing T8 fluorescent systems with T5 fluorescent luminaires;
- Ultrasonic controls in high ceiling shop areas;
- Excessively long hours of operation;
- Delamping of existing luminaires.

With regard to T5 fluorescent lighting, the students made a common series of errors in their estimates and calculations for the replacement scenario. As a result, they failed to take into account that:

- T5 systems light output must be degraded in areas where temperatures fall below 30° Celsius ambient temperature: by up to a 20% reduction as ambient temperatures near 20 - 25 ° Celsius;
- Net efficacy of T5 systems is typically lower than T8 systems;
- T5 energy usage is about 9% higher than equivalent T8 systems (comparing systems with 1 – 51w T5 energy saving lamp vs. 2 – 32w T8 lamps);
- Maintenance costs of T5 systems are still three to five times that of T8 systems (costs of different components of the systems vary considerably (lamps, ballasts and lampholders).

With regard to use of ultrasonic sensors, these devices do not function properly in rooms with ceiling heights of greater than 14'. Additionally, for safety reasons, installing automatic 'On' / 'Off' switching controls in areas where operating machinery or chemical substances are present is not recommended due to potential injury or even death for occupants should lighting go out during a critical operation.

With regard to excessively long hours of operation reported versus occupancy; in some aspects we agree that the hours of operation are longer than needed. However, the lighting logger reports and student logs did not support the student conclusions that the hours of excess operation is as much as claimed or that the persistence of these longer hours over the course of an instructional year is quantifiable.

The student assumptions are based on one week of logged data; this data was then generalized as occurring every day and every week the same way, over the entirety of an instructional year. However, in reviewing the graphical outputs from the logger, the hours of operation shown do not show a consistent pattern of 'over operation' of lighting; but shows a pattern that varies from day to day. The assumption of the student observations was that occupancy and usage occurs the same way, each day. Occupancy and usages of BCIT spaces is much more dynamic than assumed, with some days having longer occupancy, some having shorter occupancy, some users turning off the lighting and some leaving the lighting on until security guards turn the lights off. Therefore, while there is excess usage and capturing this lost energy as savings is desirable, the quantification of how much the losses actually are is more difficult to estimate than a short-term sampling can predict.

With regard to delamping of luminaires, as stated before, the areas are not overlit and the illumination levels are within IESNA guidelines. It is possible that the students misread the requirements and came to a conclusion that is not supported by the onsite light level readings when compared to the IESNA Lighting Handbook 10th Edition tables.

4.3 Stage 1: Base Retrofit Actions

Stage 1 is envisioned as the 'minimum' action that could be taken to reduce energy usage for the buildings included in the study.

All building actions under the Base Retrofit include:

- Retrofit any remaining luminaires that are equipped with T12 lamps to T8 lamps and high efficiency Instant Start electronic ballasts;
- Relamp 4' T8 lamp equipped luminaires in areas with ambient temperatures above 15 degrees Celsius with 28 watt energy saving lamps;
- Reballast any luminaires that are equipped with T8 lamps and electromagnetic energy saving ballasts with new high efficiency Instant Start electronic ballasts;
- Reballast any luminaires that are equipped with T8 lamps and older Rapid Start electronic ballasts with new high efficiency Instant Start electronic ballasts;
- Relamp incandescent luminaires with solid-state, light emitting diode (LED) replacement lamps;
- Convert incandescent and compact fluorescent downlight luminaires with existing wattages greater than 15 watts with 9 or 15 watt LED hardwired retrofit modules;
- Replace exterior HID lighting systems with lower wattage LED replacement luminaires;
- Install daylight sensor controls in buildings with clerestory windows, in canopy with daylight contribution and in Parking Kiosk.

Building specific actions under the Base Retrofit include:

- Replace high intensity discharge (HID) highbay luminaires in NE04A with lower wattage LED replacement luminaires;
- Suspended and surface mounted box luminaires in NE03 will be replaced with new, direct / indirect luminaires with only two lamps per luminaire and redundant luminaires inappropriately spaced will be removed;
- Relamp 4' T5 HO lamp equipped luminaires in NE08 with 51 watt energy saving HO lamps;
- Nightlight / walk-through lighting in NE02, NE04 and NE06 will be rewired so that nightlighting consists on only one lamp in each three lamp luminaires along the North / South interior walkway.

Table 1: Stage 1: Base Retrofit Savings by Building:

Building	Demand Savings (kW)	Electrical Savings (kWh)	Energy kWh Reduction (%)	Total Cost Savings (\$)*	Budget Retrofit Costs (\$)**	Simple Payback (yrs)	NPV (20 yr)	IRR (20 yr)
NE01P Parking Kiosk	0.1	517	50.0	40	1,110	25.3	-520	-0.3%
NE02 Benchwork	6.9	23,938	34.7	4,940	53,822	10.9	13,499	8.7%
NE03 Tech Centre	0.9	2,833	15.1	380	6,004	15.7	-840	4.3%
NE04 Carpentry	3.8	12,390	15.4	1,980	28,832	14.6	-1,942	5.2%
NE04A Canopy	5.3	26,730	45.8	3,360	41,811	12.4	3,621	7.0%
NE06 Plumbing	4.3	14,272	13.7	1,720	4,502	2.6	17,816	38.7%
NE08 Welding	3.1	19,642	17.0	2,330	23,563	10.1	7,708	9.5%
Total	24.4	100,322		14,750	159,644	10.8	39,343	8.7%
% Savings			22.1					

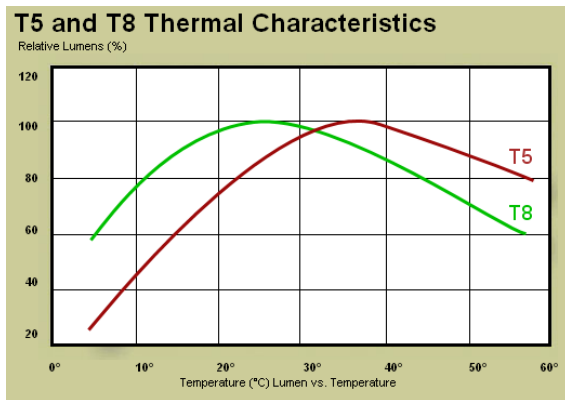
*Includes estimated annual maintenance savings of \$5,000

**Includes estimated utility incentives of approximately \$17,000; incentive will need to be verified by utility.

Selection of T5 vs T8 lamps:

The T5HO fluorescent lighting system has similar advantages and disadvantages as the T8 fluorescent system. One distinct difference, however, is how they are designed to operate in different temperature environments. T5 lamps emit their full light output at 35°C, which is 10 degrees higher than a T8 lamp. Due to the environment at this facility, we estimate that the ambient temperature near the luminaires is closer to 25°C. Therefore, at this temperature, the T8 system would be more ideally suited.

Figure 1: Thermal Characteristics of T5 and T8 Lamps:



4.4 Stage 2: Expanded Retrofit Actions

Stage 2 is envisioned as the layering of additional actions over and above Stage 1 actions that could be taken to further reduce energy usage for the buildings included in the study.

Building specific actions under the Expanded Retrofit include:

- Install roof mounted daylight collection system in NE02, NE04 and NE06, integrated with previously installed daylight sensors, to offset artificial lighting usage to a greater extent than simply using daylight sensors and clerestory windows daylight contribution;
- Install general purpose skylights in NE06 exterior practicum sheds, integrated with daylight sensor;
- Install solar panel and power system to take NE01P off-grid with 100% energy use offset for parking ticket dispensers, security camera and lighting controlled via occupancy sensor;
- Install sensor in NE04 shed to turn off lighting when space is unoccupied.

Table 2: Stage 2: Expanded Retrofit Savings by Building:

Building	Demand Savings (kW)	Electrical Savings (kWh)	Energy kWh Reduction (%)	Total Cost Savings (\$)*	Budget Retrofit Costs (\$)**	Simple Payback (yrs)
NE01P Parking Kiosk	0.3	2,838	50.0	270	8,305	30.5
NE02 Benchwork	0.0	2,644	0.5	470	26,352	55.7
NE04 Carpentry	0.0	6,022	0.8	760	26,025	34.3
NE06 Plumbing	0.0	3,128	0.3	530	28,484	53.7
Total	0.3	14,632		2,030	89,165	43.9
% Savings			3.2			
% Savings Stage 1 + 2			25.3			

*Includes estimated annual maintenance savings of \$800

**Includes estimated utility incentives of approximately \$3,500; incentive will need to be verified by utility.

4.5 Stage 3: Advanced Technology Retrofit Actions

Stage 3 is envisioned as the application of more advanced technology lighting systems over and above Stage 1 and Stage 2 actions.

At this level, it is envisioned that the majority of the fluorescent lighting would be supplanted by LED systems integrated with light-tube daylight collectors to channel light into the space and use of daylight controls. Building systems would be integrated with a building automation system or lighting control system that would activate lighting and HVAC based on a timed schedule and card-swipe access.

Solar panels could offset some electric heating or plug loads and periphery lighting system loads. Solar hot water systems could offset all domestic hot water needs. These factors are presented as considerations, but not included in savings calculations or costs presented in this report.

A daylight penetration system similar to the prototype unit installed on NE25 might be a future consideration, but at this time was not included as part of this study due to the system being still in development stage.

NE08 was not included in this option as the use of an LED system would not be appropriate in this building due to heat and welding soot, which would damage the LED systems in short order.

Table 3: Stage 3: Advanced Technology Retrofit Savings by Building:

Building	Demand Savings (kW)	Electrical Savings (kWh)	Energy kWh Reduction (%)	Total Cost Savings (\$)*	Budget Retrofit Costs (\$)**	Simple Payback (yrs)
NE02 Benchwork	3.7	14,790	21.4	3,510	159,075	44.0
NE03 Tech Centre	1.0	2,739	14.6	540	45,059	80.6
NE04 Carpentry	5.2	19,685	24.5	3,930	168,435	41.3
NE06 Plumbing	4.3	13,701	13.2	3,170	141,840	43.0
Total	14.1	50,916		11,150	514,408	44.5
% Savings			11.2			
% Savings All Stages			36.5			

*Includes estimated annual maintenance savings of \$7,000

**Includes estimated utility incentives of approximately \$10,000; incentive will need to be verified by utility.

4.6 Impact of Modifications on Lighting Levels

The impact of the modifications to lighting systems and schemes evaluated is anticipated to be neutral, with little change evident to occupants except for the use of natural lighting to supplement artificial lighting in more advanced scenarios. Illumination levels, regardless of scenario, should be within acceptable task classifications requirement ranges.

APPENDIX A: ILLUMINATION LEVELS

Table 4 : Illumination levels for task categories

Task category	Examples ¹	Minimum illumination level in lux
1. Simple orientation for short temporary visits	Inactive storage, waiting areas, VDT screens, log loading and unloading.	50
2. Working spaces where visual tasks are only occasionally performed	Stairways, freight elevators, truck loading, active bulk storage.	100
3. Visual tasks of high contrast or large size	Bakery mixing rooms, hospital central (clean) linen rooms, locker rooms, reading good quality text, casual reading, simple assembly, hand or simple spray painting, rough lumber grading, rough woodworking and benchwork.	200
4. Visual tasks of medium contrast or small size	Hair styling shops, kitchens, vehicle repair garages, sawmill filing room (work areas), reading poor quality text, prolonged or critical reading, medium bench or machine work, mail sorting, fine hand painting and finishing, fine woodworking and finishing.	500
5. Visual tasks of low contrast or very small size	Difficult assembly tasks, difficult inspections, weaving, clothing alteration, finished lumber grading.	1,000
6. Visual tasks of low contrast and very small size over a prolonged period	Very difficult assembly tasks, sewing, fine bench or machine work, extra-fine hand painting and finishing.	2,000
7. Very prolonged and exacting visual tasks	Exacting assembly or inspection, extra fine bench or machine work, precision manual arc-welding.	5,000
8. Very special visual tasks of extremely low contrast and small size	Very detailed cloth product inspection and examination.	10,000

Note 1: Further guidance in determining task categories that apply to specific work areas and activities is contained in the *IES Handbook*. This publication also provides information on acceptable measures to control brightness, reflectance and glare.

APPENDIX B: RECOMMENDED ILLUMINANCE TARGETS

Table 4.1 | Recommended Illuminance Targets

Category	Recommended Illuminance Targets (lux)					
	Visual Ages of Observers (years) where at least half are			Some Typical Application and Task Characteristics	Visual Performance Description	
	<25	25 to 65	>65			
interior and exterior applications	A	0.5	1	2	<ul style="list-style-type: none"> • Dark adapted situations • Basic convenience situations • Very-low-activity situations 	<p>Orientation, relatively large-scale, physical (less-cognitive) tasks</p> <p>Visual performance is typically not work-related, but related to dark sedentary social situations, senses of safety and security, and casual circulation based on landscape, hardscape, architecture, and people as visual tasks.</p>
	B	1	2	4		
	C	2	4	8	<ul style="list-style-type: none"> • Slow-paced situations • Low-density situations 	
	D	3	6	12	<ul style="list-style-type: none"> • Slow-to-moderate-paced situations • Moderate-to-high-density situations 	
	E	4	8	16		
	F	5	10	20		
	G	7.5	15	30	<ul style="list-style-type: none"> • Moderate-to-fast-paced situations • High-density situations • Some indoor very subdued circulation situations • Some indoor social situations 	
	H	10	20	40		
interior and exterior	I	15	30	60	<ul style="list-style-type: none"> • Congested and significant outdoor intersections, important decision-points, gathering places, and key points of interest • Some indoor social situations • Some indoor commerce situations 	
interior and exterior applications	J	20	40	80		<p>Common social activity and large and/or high-contrast tasks</p> <p>Visual performance involves higher-level assessment of landscape, hardscape, architecture, and people and can be work related.</p>
	K	25	50	100		
	L	37.5	75	150	<ul style="list-style-type: none"> • Some outdoor commerce situations • Some indoor social situations • Some indoor commerce situations 	
	M	50	100	200		
	N	75	150	300		
	O	100	200	400		
	P	150	300	600	<ul style="list-style-type: none"> • Some indoor social situations • Some indoor education situations • Some indoor commerce situations • Some indoor sports situations 	
	Q	200	400	800	<ul style="list-style-type: none"> • Some indoor education situations • Some indoor commerce situations • Some indoor sports situations • Some indoor industrial situations 	
	R	250	500	1000		
	S	375	750	1500		
interior applications	T	500	1000	2000	<ul style="list-style-type: none"> • Some sports situations 	<p>Small-scale, cognitive visual tasks</p> <p>Visual performance is work- or sports-related, close and distant fine inspection, very small detail, high-speed assessment and reaction.</p>
	U	750	1500	3000	<ul style="list-style-type: none"> • Some indoor commerce situations • Some indoor industrial situations 	
	V	1000	2000	4000		
	W	1500	3000	6000	<ul style="list-style-type: none"> • Some sports situations • Some indoor industrial situations • Some health care procedural situations 	<p>Unusual, extremely minute and/or life-sustaining cognitive tasks</p>
	X	2500	5000	10000	<ul style="list-style-type: none"> • Some health care procedural situations 	<p>Visual performance is of the highest order in respective fields of health care, industrial, and sports.</p>
	Y	5000	10000	20000		