Final Report
for the
Fluorescent Lamp Replacement Study

AD No. _____
ATEC Project No. 2016-DT-ATC-ARSPT-G6172
Report No. ATC-12158

Gene L. Fabian
Threat Detection and Systems Survivability Branch
Maritime/Threat Detection and Systems Survivability Division
Survivability/Lethality Directorate

Carl E. Johnson, Jr.
Aberdeen Test Support Services
Jacobs Technology, Inc.

July 2017

Report Produced by:
U.S. Army Aberdeen Test Center
Aberdeen Proving Ground, MD 21005-5059

Report Produced for:
U.S. Army Environmental Command
JBSA Fort Sam Houston, TX 78234-7664

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DEPARTMENT OF THE ARMY
U.S. ARMY ABERDEEN TEST CENTER
400 COLLERAN ROAD
ABERDEEN PROVING GROUND, MARYLAND 21005-5059

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MEMORANDUM FOR U.S. Army Environmental Command (IMAE-TT/Mr. Curtis Fey), 2450 Connell Road, JBSA Fort Sam Houston, TX 78234-7664

SUBJECT: Final Report for the Fluorescent Lamp Replacement Study, ATEC Project No. 2016-DT-ATC-ARSPT-G6172.

1. Subject report has been approved by this headquarters and is submitted for your information and retention.

2. The point of contact for this office is Mr. Gene Fabian, TEDT-AT-SLM, 410-278-7421, or gene.l.fabian.civ@mail.mil.

FOR THE COMMANDER:

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REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
July 2017	Final Report	March through June 2017

4. TITLE AND SUBTITLE

Final Report for the Fluorescent Lamp Replacement Study

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Johnson, Carl E., Jr.
Fabian, Gene L.

5d. PROJECT NUMBER

2016-DT-ATC-ARSPT-G6172

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Commander
U.S. Army Aberdeen Test
Center ATTN: TEDT-AT-SLM
Aberdeen Proving Ground, MD 21005-5059

8. PERFORMING ORGANIZATION REPORT NUMBER

ATC-12158

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Commander
U.S. Army Environmental Command
ATTN: IMAE-TT
JBSA Fort Sam Houston, TX 78234-7664

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

Same as Item 8

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report documents the efforts of the U.S. Army Aberdeen Test Center (ATC) to assess the benefits of converting fluorescent tube lighting to light-emitting diode (LED) technology. The report documents the waste reduction, energy conservation, and economic benefits of converting the lighting in several ATC facilities to LED lighting.

15. SUBJECT TERMS

Light-emitting diode, LED, lighting, fluorescent, waste reduction, energy conservation, net zero, mercury

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(Include area code)*
Unclassified	Unclassified	Unclassified	SAR	84	

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SECTION 1. EXECUTIVE DIGEST

1.1 SYSTEM DESCRIPTION

a. Solid-state lighting (SSL) is an emerging lighting technology that functions through light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs). Unlike fluorescent or incandescent tubes that produce light through filaments, plasma, or gases that are enclosed in a bulb, SSL uses semiconductors that convert the electricity efficiently into light (app F, ref 2). SSL technology is much different than other conventional lighting technologies because SSL has unlimited potential and could reduce lighting energy use and costs in the United States by as much as 65 percent by the year 2030, while also reducing our fossil fuel consumption and carbon footprint (ref 2).

b. Interest in SSL, specifically LED technology, has increased significantly with the evolution of new environmentally friendly products, advances in efficiency, and lower production costs for lamps. The conversion of fluorescent bulbs to LED technology has many benefits and may provide a significant return on the initial investment. These benefits include:

(1) LEDs do not contain mercury, have potential for recycling, and can be disposed safely in a landfill.

(2) LEDs offer reduced maintenance costs and fewer bulb replacements, significantly reducing future landfilling of waste.

(3) LEDs offer a Green Technology that produces less heat than fluorescent lights, resulting in a decreased need for air conditioning.

(4) LEDs can be retrofitted with occupancy sensor controls while fluorescent lights will deteriorate quickly when they are repeatedly turned on and off.

(5) LEDs can be used in existing fluorescent lighting fixtures using LED retrofit kits or replacement lamps.

(6) Using LEDs can result in a 40-percent energy reduction over using fluorescent lights and payback can occur within a few years.

(7) LEDs offer improved light quality (directional versus spherical) over fluorescent lights.

(8) LEDs work in extreme hot and cold temperatures and LEDs are less affected by temperature fluctuations than fluorescent lamps.

c. To combat hazardous waste (HW) disposal costs and promote increased energy efficiency and environmental stewardship, three types of LED technology have been approved for modification in Department of Defense (DoD) facilities based on design practice and material selection policy and practices for both internal and external lighting guidance as specified by the Unified Facilities Criteria (UFC). The first two technologies include the conversion of existing fluorescent lamp fixtures to LED technology through lamp-to-lamp replacements with compatible ballasts (also known as type-A, direct fit, or plug-in designs) and the use of luminaire retrofit conversion kits that limit compatibility concerns by matching an Underwriters Laboratories (UL) certified kit to the existing luminaire. A third option, luminaire replacement, is also a viable option, if UFC policy is met, and requires upgrading of the entire lighting fixture, including lamps, sockets, ballasts and hardware.

1.2 SUMMARY

a. Authority. On 6 June 2016, the U.S. Army Test and Evaluation Command (ATEC) authorized the U.S. Army Aberdeen Test Center (ATC), Aberdeen Proving Ground (APG), Maryland, to plan, assess, and report on converting fluorescent bulbs to new LED technology through the Fluorescent Lamp Replacement Study. This was done through the establishment of ATEC Project No. 2016-DT-ATC-ARSPT-G6172 (ref 1) in support of the U.S. Army Environmental Command (USAEC)-provided Statement of Work (SOW) (ref 3).

b. Study Concept. This study was performed to assess current and upgraded lighting in ATC facilities and generate a Fluorescent Lamp Replacement Guidance Manual that will assist other military installations during conversion of existing fluorescent lighting to LED technology. The Guidance Manual (ref 4) includes detailed procedures, UFC policy, educational literature and searchable databases that can be leveraged during system upgrades and design selection. In addition to the Guidance Manual, this study documents the results of:

(1) An economic analysis (Section 2.3) that determines the Total Savings and Break-Even Point based on lamp replacement costs, cost for luminaires and retrofit conversion kits, installation costs, longer life-cycle of bulbs resulting in reduced maintenance costs, and total energy savings based on the life expectancy of the LED technology.

(2) Inconsistencies found within the UFC guidance with respect to conversion to LED lighting (Section 1.4).

(3) Importance of using the Design Lights Consortium (DLC) Qualified Products List (QPL) to identify appropriate LED products (Section 1.2.5).

(4) Inability to locate GSA advantage LED products that conform to UFC policy (Section 1.4).

(5) A comparison of a 5 year versus 10 year LED lighting warranty (Section 1.4).

c. Study Objectives. USAEC is investigating the environmental and economic benefits of replacing fluorescent lighting with energy efficient LED lamps at ATC. This Final Report provides study procedures, study findings and guidance material that was used to perform the study. Study objectives are provided in Table 1-1.

TABLE 1-1. STUDY OBJECTIVES

Subtest	Objective
2.1 - Hazardous Waste Reduction	Determine the amount of hazardous waste material that was being eliminated from the waste stream at ATC as a result of converting the existing fluorescent lighting to LED lighting at nine facilities.
2.2 - Energy Efficiency Savings	Assess the energy efficiency savings created from upgrading the existing fluorescent lighting to LED technology at nine facilities.
2.3 - Economic Analysis	Determine the cost to upgrade the existing fluorescent lighting to LED technology at nine facilities and calculate the Total Savings and Break-Even Point.

d. Study Approach. The following specific actions were performed during this study by ATC Threat Detection and Systems Survivability (TDSS) personnel:

(1) A demonstration plan was prepared.

(2) A market survey was conducted, and a literature search of current commercially available LED product designs and suppliers (lamp replacement versus retrofit conversion kits versus luminaire replacement, General Services Administration (GSA) products, etc.) was performed.

(3) ATC contacted and met with the U.S. Army Garrison APG Energy Manager and representatives from the APG Department of Public Works (DPW) to discuss the process for upgrading fluorescent lights to LED technology at ATC facilities. Discussions were conducted to identify the following:

(a) Which facilities have already been updated?

(b) Which facilities are available for conversion?

(c) What documentation is required to complete the facility upgrades?

(d) Whether there are any restrictions on conversion to LED.

(e) What is the approval process?

(f) Who can perform the work?

(g) Whether there are any existing energy conservation programs.

(4) Several potential facilities at ATC were inspected to determine the compatibility for upgrading to LED technology. Each proposed facility was characterized based on the following:

(a) Anticipated usage.

(b) Current lighting conditions.

(c) Condition and size.

(d) Modifications necessary for upgrading to LED technology.

(5) ATC personnel finalized the facility selections and upgraded each with new luminaires, retrofit conversions kits or a combination of both designs. All of the LED products installed feature a one-lamp design that will not require future bulb replacements. When the lifecycle of the LED technology has deteriorated enough to require replacement, the entire fixture will be removed and upgraded with a new LED technology.

(a) Three types of LED designs were used when upgrading the facilities at ATC. The first design, Sylvania LEDVANCE Edge-Lit panel luminaires (fig. 1-1), features a high efficacy of 110 lumens per watt (LPW), low glare, uniform illumination and a projected life cycle of greater than 50,000 hr. This design is compliant with the Restriction of the Use of Hazardous Substances

(RoHS) and is listed on the DLC QPL because testing has determined this product to be a high quality, energy efficient commercial lighting system. The Sylvania LEDVANCE is a one-lamp troffer design that works optimally in drop-ceilings. Both Sylvania LEDVANCE 2- by 2-ft and 2- by 4-ft designs were used during conversion at ATC.

Figure 1-1. Sylvania LEDVANCE Luminaires Edge-Lit panel.

(b) The second design installed was the Eaton Metalux WNLED utility wraparound luminaire (fig. 1-2) that measures 1 x 4 ft long and features a series of strip LED lights with linear (sides) and pyramidal (bottom) prisms for low brightness control. This product was selected for installation because it has a high efficacy of 113 LPW, uniform illumination and a projected life cycle of 60,000 hr. The Eaton Metalux was designed to be surface mounted on the ceiling, is RoHS compliant and is listed on the DLC QPL.

Figure 1-2. Eaton Metalux WNLED utility wraparound strip light luminaire without lens cover.

(c) The third LED technology installed was the Orion Harris LDRE1 troffer retrofit conversion kit (fig. 1-3) that measures 2 x 4 ft. long and was designed to be installed in drop-ceilings. This product was selected for installation because it features an extremely high efficacy of 121 LPW, contour lens that provides glare diffusion and uniform light distribution, fast installation time, and a projected life cycle of 100,000 hr. The Orion Harris retrofit conversion kit frame is constructed out of aluminum so it is lightweight and can be installed in 15 min or less by qualified electricians. Due to the high performance of this product in terms of efficacy and lumen maintenance requirements, the Orion Harris LDRE1 retrofit conversion kit is acknowledged as a DLC premium product.

Figure 1-3. Orion Harris LDRE1 troffer retrofit conversion kit.

(6) The nine facilities that were upgraded with LED technology include the technical imaging-matting room of Building 322 and eight firing positions at the Michaelsville Range Area. The firing positions at Michaelsville Range Area are equipped with test chambers and observation rooms that accommodate data collection during weapons testing. As shown in Figures 1-8 and 1-9, internal lighting is very important because some of the firing positions are designed with gun mounts and individual windows for discharging firearms towards the target line. The lighting upgrades in each building include:

(a) Building 322 - Technical Imaging - Matting Room. Three Sylvania LEDVANCE 2- by 2-ft luminaire fixtures were installed in the matting room, and six of the existing 2- by 4-ft fluorescent lights in the office were converted to 2- by 4-ft Sylvania LEDVANCE technology. Based on UFC guidance, a redesign was necessary and warranted because the illuminance levels in the matting room were too low and created shadows when attempting to mat photographs. Also, the layout of the luminaires was ineffective because both the tasks and layout recently changed in the office space.

(b) Buildings 726, 734A, 735A, 736A, 737A - Michaelsville Range Area - Firing Positions. Six Eaton Metalux surface wraparound utility luminaires measuring 1 by 4 ft long were installed in each.

(c) Building 738A - Michaelsville Range Area - Firing Positions. Four Eaton Metalux surface wraparound utility luminaires measuring 1 by 4 ft long and ten Orion Harris retrofit conversion kits measuring 2 by 4 ft were installed in this building.

(d) Building 738B - Michaelsville Range Area - Firing Positions. Five Sylvania LEDVANCE 2- by 4-ft luminaires were installed in this building.

(e) Building 734 - Michaelsville Range Area - Firing Positions, Offices, and Workspaces. Retrofit conversions kits and luminaires were installed. This location is unique because it serves as not only a firing position, but also offers additional office space that is currently being used for workspaces, instrumentation, and conference rooms. Building 734 is the newest and largest of the firing positions at Michaelsville and required converting 26 fixtures to LED technology. The conversion in Building 734 included the installation of sixteen Sylvania LEDVANCE luminaires, five Orion Harris retrofit conversion kits and five Eaton Metalux surface wraparound utility luminaires.

(f) Original and upgraded facility lighting conditions are shown in Figures 1-4 through 1-13.

Figure 1-4. Inadequate fluorescent lighting in matting room of Building 322.

Figure 1-5. New LED Sylvania LEDVANCE luminaires in matting room of Building 322.

Figure 1-6. Fluorescent lighting in Building 726.

Figure 1-7. New LED Eaton Metalux wraparound luminaires installed in Building 726.

Figure 1-8. Fluorescent lighting at firing positions in Building 738A.

Figure 1-9. New LED Orion Harris retrofit conversion kits installed in Building 738A.

Figure 1-10. Fluorescent lighting in Building 734.

Figure 1-11. Fluorescent lighting in Building 734.

Figure 1-12. Upgraded Sylvania LEDVANCE lighting in Building 734.

Figure 1-13. Upgraded Sylvania LEDVANCE LED lighting in Building 734.

(7) ATC developed a draft Fluorescent Lamp Replacement Guidance Manual (ref 4) that is intended to be used for selecting one or more of the best available LED lamp/retrofit designs for installation at ATC. The Guidance Manual includes the different LED technologies available, the strengths and weaknesses of each LED technology, lighting guidance based on UFC policy, procedures for evaluating and selecting appropriate LED options, online resources with searchable databases for selecting compatible LED systems and locating incentive programs, and general guidance for handling and disposing of fluorescent lamps and ballasts.

(8) Selected LED designs were purchased through a distributor and shipped to ATC for installation.

(9) Before installation began, TDSS personnel met with the Michaelsville Facility Manager to coordinate the LED conversion based on the established firing schedule.

(10) All products were installed in the selected facilities during a 2-week time period.

(11) All waste material from the old fluorescent fixtures (metal housings, plastic grates, old wiring) and the new LED technology (cardboard packaging) were broken down and separated into the appropriate container for recycling. Several fixtures, ballasts and energy efficient fluorescent bulbs that were determined to be in pristine condition were returned to ATC Facilities for re-use at other sites. The remaining outdated fluorescent bulbs and ballasts were transferred to ATC Facilities personnel for recycling at Building 5110, U.S. Army Garrison Hazardous Waste Disposal Facility, APG.

e. Results. Determining the hazardous waste reduction resulting from the conversion of fluorescent light to LED technology at the nine ATC facilities was accomplished by documenting the bulb type, bulb weight, mercury content and quantity removed during the system upgrades. Based on the data that were collected, the calculated weight of the 238 T-8 fluorescent bulbs that were removed during LED modifications was measured at 68.40 lb by TDSS personnel. By using the recycling cost of $1.75/lb. that was extracted from the 2015 Waste Generation Report provided by the APG U.S. Army Garrison-Environmental Office, a disposal cost of $119.70 was calculated. Manufacturer's specification sheets obtained for the 238 fluorescent bulbs that were removed from the fixtures, indicated that an estimated 536.65 mg of mercury was removed from the waste stream at ATC.

The energy usage for both the original fluorescent fixtures and the updated LED technology was calculated for the nine facilities to determine the energy efficiency savings. Based on the data that were collected during the LED conversion, it was estimated that the 81 fluorescent fixtures removed from the nine facilities used 7616 W of electricity. After the facilities were converted from fluorescent to LED technology, the wattage was significantly reduced to 2889 W, resulting in a 62-percent reduction or a savings of 4727 W.

An economic analysis was calculated to compare the various lighting technologies that were implemented at ATC and the cost benefits of each based on the wattage, price per unit, anticipated lifespan of technology, energy rate and hours of operation. As part of the economic analysis, a lifecycle comparison was made between the fluorescent bulbs and the new LED technology using the LED Waves' LED Savings Calculator (https://www.ledwaves.com/pages/led-calc). A price per unit cost was calculated for each fixture by totaling the product cost together with the labor charges to install the technology (fluorescent or LED) based on a labor rate of $64 per hour. The costs for upgrading each facility were tracked through purchase requests and the documented time required to upgrade the designs as witnessed during the facility upgrades (table 2.3-1). For the Sylvania LEDVANCE Edge-Lit luminaires, the price per unit cost was estimated at $148 which includes the $100 product cost for a 2- by 4-ft panel and $48 labor, based on 45 min of installation. For the Eaton Metalux wraparound strip light, the price per unit cost was estimated at $130.00 which includes the $82 product cost and $48 labor, based on 45 min of installation. For the Orion Harris retrofit conversion kit, the price per unit cost was estimated at $110.34 which includes the $94.34 product cost and $16.00 labor, based on 15 min of installation.

The Total Savings and Break-Even Point was calculated for fluorescent bulb replacement versus LED technology using the LED Waves' LED Saving Calculator and in accordance with the simplified payback economic analysis used by the Office of the Assistant Chief of Staff for Installation Management (ACSIM) (ref 6) (tables 2.3-2 and 2.3-3). Based on the three technologies that were installed at the nine ATC facilities, a Total Savings of $31,231 was calculated based on the combined maintenance and electricity savings over the lifecycle of the LED technologies. For facilities that originally had 128-W fixtures, the conversion to any of the three LED designs resulted in a break-even point ranging from 2.12 years to 3.46 years. For facilities that originally had 64-W fixtures, the conversion to any of the three LED designs resulted in a break-even point ranging from 5.02 years to almost 7.33 years. The effect that increased energy reduction has on the payback period for conversion to LED lighting is summarized in Tables 2.3-4 and 2.3-5.

A second scenario was also analyzed for three of the upgraded facilities that compared upgrading the ATC facilities with new fluorescent luminaires versus the installation of new LED designs. Three facilities were selected so that each LED design could be compared against the new fluorescent luminaire replacement. Similar to the first scenario, the total wattage, price per unit, energy rate, hours of operation and annual electricity costs were compared based on the lifespan of the LED technology for the three facilities. The data revealed that for Building 322, selecting the Sylvania LEDVANCE technology over the new 128-W fluorescent luminaires would require investing 70 percent more and would result in a wattage reduction of 528 W and an annual energy cost savings of $168.03. For Building 726, selecting the Metalux Eaton luminaire over the new 64-W fluorescent luminaire would cost 49 percent more and would deliver a wattage reduction of 168 W and an annual energy cost savings of $53.46. For Building 734, selecting the Orion Harris retrofit conversion kit over the new 128-W fluorescent luminaires would cost 27 percent more but would provide a wattage reduction of 505 W and an annual energy cost savings of $160.71.

The Total Savings and Break-Even Point was calculated for fluorescent luminaire replacement versus LED technology through the LED Waves' LED Saving Calculator (table 2.3-7). Other LED vendors use similar software to calculate both Total Savings and Break-Even Point for LED conversions and produced identical results. For the three facilities that were analyzed, the total savings for implementing LED technology over fluorescent luminaires was determined to be $13,648 and the break-even point for the LED investment ranged from 0.50 to 1.81 years. Based on the data that were obtained, the three LED technologies present a more cost-effective and energy efficient option than upgrading with fluorescent fixtures despite the higher initial cost.

1.3 CONCLUSIONS

The upgrading of the nine facilities at ATC revealed that both fixture wattage and the rated lifecycle of a lighting design had the most influence on the Total Savings and the Break-Even Point when comparing fluorescent light to LED technology. For facilities such as Buildings 322, 734 and 738B that were originally fitted with four 32-W bulbs in the fluorescent fixtures (128 W total), the conversion to efficient LED technology with significantly less wattage per fixture such as the Orion Harris LED retrofit conversion kit, (27 W,) Metalux Eaton LED luminaire (36 W) or Sylvania LEDVANCE luminaire (40 W), yielded energy reductions ranging from 69 to 71 percent (table 2.2-1). The remaining facilities that were originally fitted with two 32-W fluorescent lights (64 W total) did not produce energy reductions as significant as the 128-W facilities when upgraded to LED technology. However, the conversion still exceeded a 40 percent energy reduction using one or a combination of the three new LED technologies.

The rated lifecycle was another critical contributor for determining the Total Savings and Break-Even Point for comparing LED versus fluorescent light technology. Based on the different lifecycles associated with each LED technology, a fluorescent fixture would have to be replaced two times during the lifecycle of the Sylvania LEDVANCE luminaire (50,000 hr) or the Eaton Metalux strip light luminaire (60,000 hr). For the Orion Harris retrofit conversion kit that has an estimated lifecycle of 100,000 hr, an old fluorescent bulb would require replacing four times during the projected lifecycle of the Orion Harris retrofit conversion kit design. As a result, the implementation of the LED designs into the facilities at ATC has prevented the disposal of two to four lifecycles of mercury into the waste stream at APG and any associated maintenance and labor costs such as re-lamping of the fluorescent fixtures or ballast replacement over the LED lifespan.

An analysis of the data used to determine the Total Savings and Break-Even Point revealed that the product and installation costs associated with the LED conversion did not make a considerable impact on the final analysis. In fact, all three of the LED products were similarly priced (within $20) and the labor costs that varied (within $32) were absorbed in the Total Savings because they were one-time costs. The real impact came from the recurring annual costs over the LED's life cycle such as the reduction in wattage and electricity costs resulting from the LED conversion, avoiding the labor to replace the fluorescent bulbs, and the labor cost for re-lamping the fluorescent fixtures over a typical LED lifecycle ranging from 16 to 32 years.

A comparison of the three LED technologies was also completed and revealed that the Orion Harris retrofit conversion kit provided the best Total Savings and Break-Even Point due to several contributing factors. First, the Orion Harris retrofit conversion kit was recognized as a DLC premium product because it has an expected life cycle of 100,000 hr, which is 40 percent higher than the Metalux Eaton luminaire and 50,000 hr higher than the Sylvania LEDVANCE luminaire. The Orion Harris technology has an extremely low fixture wattage (27 W) compared to the Eaton Metalux (36 W) and Sylvania LEDVANCE (40 W) which factors into the Total Savings equation significantly over an expected 32-year lifecycle. Also, the price per unit cost for the Orion Harris LED technology was the lowest of the three designs because installation took 15 min or less and the material cost was lower than the other two LED technologies.

The Metalux Eaton luminaire had a low break-even point of 2.84 years when Building 734 was converted from 128 W to 36 W; however it also had the highest break-even point of 7.33 years when converting 64-W fixtures to LED technology as demonstrated in six of the facilities upgraded. The data for Sylvania LEDVANCE are deceiving since it had a break-even point of 3.46 years when converting 128-W facilities. If the Sylvania LEDVANCE technology would have been installed in 64-W facilities, the break-even point would have been much higher because the lifecycle of the technology was the lowest, the wattage per fixture was the largest and it has the highest price per unit cost due to material costs and an estimated installation time of 30 min.

Online resources such as the LED Lighting Facts Products Database and the DLC QPL are excellent resources for facility managers to locate new LED technology that has been tested and verified by an independent laboratory prior to procurement. These databases allow the user to search for compatible designs based on product categories, product size and use location using inputs such as lumen output, wattage, color rendering index (CRI), correlated color temperature (CCT), efficacy, certifications (ENERGY STAR or DLC QPL), warranties and the rated lifecycle of the design.

1.4 RECOMMENDATIONS

ATC recommends that the following be considered before procuring LED products:

a. Five-Year Versus 10-Year Warranties. Section 2-4.1.1 of the UFC titled, Solid State Lighting, indicates that consistent with industry standard, all LED luminaires require a 10-year warranty. However, after providing UFC design specifications to numerous LED vendors and speaking with them directly regarding warranties, it was revealed that a 5-year or 50,000-hr warranty is standard from the majority of LED manufacturers.

For the limited LED lighting manufacturers that still offer 10-year warranties, the extended warranty is an insurance policy for driver failure that is expected to begin after 5 years of use. Basically, when a buyer purchases an LED product with a 10-year warranty, they are getting the same 5-year LED design with a 50- to 75-percent premium that is incorporated into the product cost as a cushion for additional LED drivers that the buyer will need in the future.

Based on discussions conducted with several product manufacturers and vendors, it appears that the concept of a 10-year warranty on LED technology has almost disappeared for several reasons. First, the cost for a 10-year warranty has limited the competitiveness of the product and secondly, LED technology is evolving so quickly in terms of product development and efficiency, that a 5-year extension may not be a wise investment.

Another consideration on warranties is the language in the warranty. Many of the manufacturer's warranties can vary from Premium Warranties that cover both product and service to limited warranties that replace only the defective parts (ref 5).

b. Manufacture Date on LED Products. To get the most updated and efficient LED products that are available and maximize the lifecycle benefits and product warranty, it is recommended to purchase products that have been produced within the last 12 months.

c. Government Services Administration (GSA) Products. An extensive product search was conducted on the GSA website to locate LED retrofit conversion kits and luminaires that conform to UFC specifications. The product search revealed that none of the available designs could meet the minimum efficacy of 120 LPW for LED retrofit conversion kits and only a few recessed troffer luminaires were available with a CCT of 4100K or less. However, none of the luminaires found during the GSA product search were competitively priced compared to the LED designs that were purchased from the distributors.

d. Target 128-W Fluorescent Fixtures. To reap the maximum energy savings and environmental benefits from an investment in LED technology, target facilities should upgrade the fluorescent fixtures that use the most wattage first. With most of the new LED technology using 27 to 40 W per fixture, conversion to LED technology of 128-W fluorescent fixtures (fig. 1-14) can reduce energy costs by nearly 70 percent, while 64-W fixture conversions can yield a 40-percent energy reduction.

e. Fluorescent Bulb Replacement Versus Luminaire Replacement. Revised guidance with respect to the replacement of fluorescent light tubes with tubular LED bulbs to extend the life of existing lighting fixtures was published during development of this document by the Department of Energy (DOE) SSL program, LED Lighting Facts. Because of the recent commercially available advancements in LED luminaires and retrofit kits, the DOE was shifting away from fluorescent bulb replacements to recommending luminaire retrofits/replacements because the current luminaire technologies provide the greatest potential for performance improvement and savings.

f. An efficacy of 120 LPW was specified in the UFC for LED retrofit conversion kits, however; no efficacy has been established for the LED luminaires.

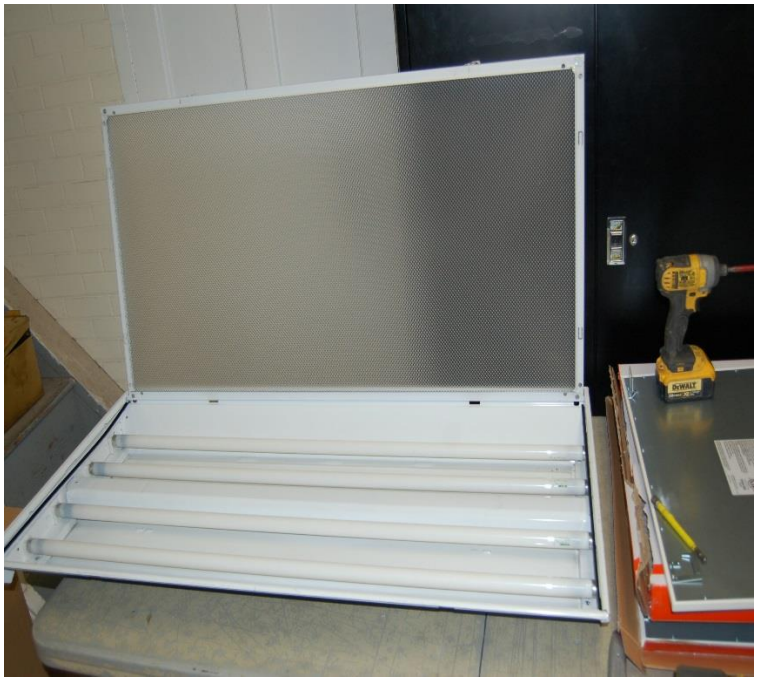


Figure 1-14. Typical 128 W. Fluorescent Lamp Fixture.

g. Efficacy standards in the UFC should dictate guidance for efficacy with and without lens covers.

SECTION 2. SUBTESTS

2.1 HAZARDOUS WASTE REDUCTION

2.1.1 Objective

Determine the amount of hazardous waste material that was being eliminated from the waste stream at ATC due to converting from fluorescent to LED lighting.

2.1.2 Criterion Compliance and Analysis

None. No waste reduction criterion was established for waste reduction. The analysis was performed for informational purposes only.

2.1.3 Analysis Procedures and Findings

a. While ATC Facilities personnel were installing the lighting modifications at each facility, TDSS personnel took photographs of the modifications (fig. 1-4 through 1-13) and recorded detailed information on both the old fluorescent bulb design and the new LED technology that was installed on LED Conversion Field Logs (app B). For the old fluorescent bulb design that was removed, data collected included: the type of bulbs, model numbers, wattage, bulb measurements, projected lifespan of bulb, bulb condition, weight of each bulb, number of fixtures and bulbs removed from each facility, type and condition of the ballast that was removed (if applicable) and the anticipated hours of operations.

b. For the LED lighting upgrades, detailed records were collected based on the type of LED design that was selected. Data recorded included: model of the luminaire/lamp/retrofit kit installed, lamp size, lamp weight, number of lamps installed into the new design, projected lifespan of LED design, efficacy in LPW, UL certification, values for CCT, CRI, total harmonic distortion (THD) and power factor (PF), and the date that the product was manufactured. Also, LED specification sheets were obtained from each vendor specifying the rated lifecycle and warranty information for each upgraded design (app C).

c. After the fluorescent waste bulbs were removed from the existing fixtures and the details were documented on the field logs, the specific bulb models were researched to determine the mercury content that was removed from the waste stream and replaced with a nonhazardous LED light source. Locating the estimated mercury content for each T-8 fluorescent bulb was quite tedious since some of the lamps were discontinued. Archived product data were not available on the bulb manufacturer's website, Safety Data Sheets (SDSs) only provided the mercury value in percentage of bulb weight and the majority of the product literature available was focused on the projected life expectancy of the lamps and refrained from quantifying the mercury content by volume. They do however; acknowledge that rapid improvements in fluorescent light technology have resulted in new environmentally friendly products that are low in mercury, toxicity characteristic leaching procedure (TCLP) compliant and 50 to 66 percent less in mercury concentration than designs sold prior to 1999.

d. The necessary mercury data were successfully located by extracting specification sheets from distributors' websites that once sold the discontinued fluorescent light products (app D). Then, for each facility, the fluorescent bulb type, bulb model, quantity of bulbs removed and estimated mercury content of the bulbs were summarized (table 2.1-1). Based on the removal of 238 bulbs from 81 fixtures at nine facilities on ATC, an estimated 536.65 mg of mercury was removed from the waste stream.

TABLE 2.1-1. TOTAL MERCURY CONTENT REMOVED BY MANUFACTURER AND BULB TYPE

Building No.	Fluorescent Bulb Type	Bulb Model No.	No. of Bulbs Removed	Mercury (Hg) Content, mg/bulb	Total Hg, mg
322	Sylvania Octron Eco	F032/741/Eco	24	3.5	84.0
726	Sylvania Octron Eco	F032/741/Eco	2	3.5	7.0
	General Electric (GE)Trimline	F32T8-SP41	8	2.95	23.6
	Philips TL-80	F32T8/TL841	2	1.7	3.4
734	Philips Alto II-700 Series	F32T8/741	104	1.7	176.8
734A	Sylvania Octron	F032/741	12	3.5	42.0
735A	Sylvania Octron Eco	F032/741/Eco	4	3.5	14.0
	GE Trimline	F32T8-SP41	8	2.95	23.6
736A	Sylvania Octron Eco	F032/T41/Eco	4	3.5	14.0
	GE Trimline	F32T8-SP41	8	2.95	23.6
737A	Philips Hi-Vision Alto	F32T8/TL841	1	1.7	1.7
	Sylvania Octron Eco	F032/T41/Eco	10	3.5	35.0
	GE Trimline	F32T8-SP41	1	2.95	2.95
738A	Philips TL-70 Alto Collection	F32T8/TL 741	22	1.7	37.4
	Philips Alto II-800 Series	F32T8/TL841	8	1.7	13.6
738B	Philips Alto-700 Series	F32T8/TL 741	20	1.7	34.0
		Total No. Bulbs Removed:	238	Total:	536.65

e. The calculated weight of the 238 T-8 fluorescent bulbs that were removed during LED modifications was measured at 68.40 lb by TDSS personnel. By using the recycling cost of $1.75/lb that was extracted from the 2015 Waste Generation Report provided by the APG U.S. Army Garrison-Environmental Office, a disposal cost of $119.70 was calculated (table 2.1-2). This information was useful to project the hazardous waste disposal costs that are being eradicated by converting from fluorescent to LED technology.

TABLE 2.1-2. ESTIMATED DISPOSAL COSTS BASED ON WEIGHT OF FLUORESCENT LAMPS

Building No.	Fluorescent Lamp Type	Bulb Model No.	No. of Bulbs Removed	Weight of Bulbs, lb	Estimated Disposal Cost
322	Sylvania Octron Eco	F032/741/Eco	24	9.60	$16.80
726	Sylvania Octron Eco	F032/741/Eco	2	0.80	$1.40
	GE Trimline	F32T8-SP41	8	3.20	$5.60
	Philips TL-80	F32T8/TL841	2	0.40	$0.70
734	Philips Alto II-700 Series	F32T8/741	104	20.80	$36.40
734A	Sylvania Octron	F032/741	12	4.80	$8.40
735A	Sylvania Octron Eco	F032/741/Eco	4	1.60	$2.80
	GE Trimline	F32T8-SP41	8	3.20	$5.60
736A	Sylvania Octron Eco	F032/T41/Eco	4	1.60	$2.80
	GE Trimline	F32T8-SP41	8	3.20	$5.60
737A	Philips Hi-Vision Alto	F32T8/TL841	1	0.40	$0.70
	Sylvania Octron Eco	F032/T41/Eco	10	4.00	$7.00
	GE Trimline	F32T8-SP41	1	0.40	$0.70
738A	Philips TL-70 Alto Collection	F32T8/TL 741	22	8.80	$15.40
	Philips Alto II-800 Series	F32T8/TL841	8	1.60	$2.80
738B	Philips Alto-700 Series	F32T8/TL 741	20	4.00	$7.00
		Total:	238	68.40	$119.70

f. A lifecycle comparison between the fluorescent bulbs and the new LED technology was made using the LED Waves' LED Savings Calculator (https://www.ledwaves.com/pages/led-calc). The lifecycle comparison was calculated to determine the projected lifespan for both the fluorescent light and new LED design, the estimated number of times that an old fluorescent fixture will be replaced per year based on the inputs and the estimated number of fixture replacements that will occur over the lifecycle of the LED lamp.

Based on a standard 60-hr work week, a fluorescent fixture would have to be replaced two times during the expected lifecycle of the Sylvania LEDVANCE luminaire (50,000 hr) or the Eaton Metalux strip light luminaire (60,000 hr). For the Orion Harris retrofit conversion kit that has a projected lifecycle of 100,000 hr, an old fluorescent bulb would require replacing four times during the 32-year projected lifespan of the Orion design. Therefore, the implementation of the LED designs into the facilities at ATC has prevented the introduction and disposal of two to four lifecycles of fluorescent bulbs containing mercury into the waste stream at APG. A lifecycle comparison of fluorescent to LED technology is provided in Table 2.1-3.

Table 2.1-3. LIFECYCLE COMPARISON OF FLUORESCENT TO LED TECHNOLOGY

	Lifespan of Technology (Continuous Use), hr	Lifespan when Used 12 Hours a Day 5 Days a Week	No. of Times an Old Fluorescent Fixture is Replaced During LED Lifespan
Fluorescent bulbs	22,500	7.21 years	Two times per fixture
Sylvania LEDVANCE luminaires	50,000	16.03 years	-
Fluorescent bulbs	22,500	7.21 years	Two times per fixture
Eaton Metalux strip light luminaire	60,000	19.23 years	-
Fluorescent bulbs	22,500	7.21 years	Four times per fixture
Orion Harris retrofit conversion kit	100,000	32.05 years	-

2.2 ENERGY EFFICIENCY SAVINGS

2.2.1 Objective

Assess the energy efficiency savings by upgrading from fluorescent to LED technology.

2.2.2 Criterion Compliance and Analysis

None. The Fluorescent Lamp Replacement Study was performed to determine whether the LED luminaires and LED retrofit conversion kits achieved a 40-percent energy reduction. A 40-percent energy reduction was forecasted by the Department of Energy (DOE) as an expected energy savings for a fluorescent to LED conversion.

2.2.3 Analysis Procedures and Findings

a. During lighting modifications, TDSS personnel recorded detailed information from each facility such as the number of fixtures, the number of fluorescent lamps, the wattage of the original fluorescent bulbs and the upgraded LED designs to determine wattage reductions and energy savings (table 2.2-1).

TABLE 2.2-1. WATTAGE AND ENERGY REDUCTIONS

Building No.	No. of Fixtures	No. of Fluorescent Lamps	Old Fluorescent Wattage	No. of LED Lamps	New LED Wattage	Reduction in Watts	Energy Reduction, %
[a]322	6	24	768	6	240	-528	69
726	6	12	384	6	216	-168	44
734	26	104	3328	26	955	-2373	71
734A	6	12	384	6	216	-168	44
735A	6	12	384	6	216	-168	44
736A	6	12	384	6	216	-168	44
737A	6	12	384	6	216	-168	44
738A	14	30	960	14	414	-546	57
738B	5	20	640	5	200	-440	69
Totals	81	238	7616	81	2889	-4727	62

[a]Data for Building 322 reflects the six fixtures that were upgraded from fluorescent to LED technology and does not include the three LED fixtures that were added to support the modified use of the office space.

b. Based on the data that were obtained, it was estimated that the 81 fluorescent fixtures removed from the nine facilities used 7616 W of electricity. After the facilities were converted from fluorescent to LED technology, the wattage was reduced to 2,889 W, resulting in a 62-percent reduction or a savings of 4727 W.

c. The distribution and wattage of the three LED technologies at the nine facilities have been summarized in Table 2.2-2.

TABLE 2.2-2. WATTAGE OF LED UPGRADES BY LOCATION

Building No.	No. of Fixtures	No. of Sylvania Edge-Lit Panel (40 W)	No of Eaton Metalux Wraparound (36 W)	No. of Orion Harris Retrofits (27 W)	Total Watts
[a]322	6	6			240
726	6		6		216
734	26	16	5	5	955
734A	6		6		216
735A	6		6		216
736A	6		6		216
737A	6		6		216
738A	14		4	10	414
738B	5	5			200
Totals	81	27	39	15	2889

[a]Data for Building 322 reflects the six fixtures that were upgraded from fluorescent to LED technology and does not include the three LED fixtures that were added to support the modified use of the office space.

d. For facilities such as Buildings 322, 734 and 738B that were originally fitted with four 32-W bulbs in the fluorescent fixtures (128 W total), the conversion to efficient LED technology with significantly less wattage per fixture, yielded energy reductions ranging from 69 to 71 percent (table 2.2-1). For the remaining facilities that were originally fitted with two 32-W fluorescent lights (64 W total), upgrading to LED technology did not produce energy reductions as significant as the 128-W facilities. However, the conversion still exceeded a 40-percent energy reduction using one or a combination of the three new LED technologies.

2.3 ECONOMIC ANALYSIS

2.3.1 Objective

Determine the costs of upgrading to LED technology at nine facilities on ATC and to calculate the Total Savings and Break-Even Point.

2.3.2 Criteria Compliance and Analysis

No criterion has been established for the economic analysis.

2.3.3 Analysis Procedures and Findings

a. To demonstrate the various lighting technologies that were implemented at ATC and the cost benefits of each, a lifecycle comparison was made between the fluorescent bulbs and the new LED technology using the LED Waves' LED Savings Calculator (https://www.ledwaves.com/pages/led-calc). This scenario, which was the first and primary scenario, compared the re-lamping of the old fluorescent fixtures with new fluorescent bulbs versus the installation of new LED technology at each of the nine ATC facilities (table 2.3-1). Inputs that were loaded into the LED Waves' LED Savings Calculator included the number of fixtures to be replaced, the wattage of both the old fluorescent fixtures and the new LED technology, price per unit, anticipated technology lifespan, energy rate and hours of operation.

b. Several assumptions were calculated to populate the LED Waves' LED Savings Calculator and determine the initial investment energy savings and the Total Savings for each design and facility based on the estimated lifecycle of each technology. An example of the product produced by the LED Waves' LED Savings Calculator has been provided in Appendix E for reference purposes. Assumptions loaded into the LED Waves' LED Savings Calculator with justification include:

(1) The price per unit cost was calculated by totaling the product cost together with the labor charges to install the technology (fluorescent or LED) based on a labor rate of $64 per hour. The costs for upgrading each facility including labor charges and material costs were tracked through labor reports, purchase requests and the documented time required to upgrade the designs as witnessed during facility upgrading.

(2) For the Sylvania LEDVANCE Edge-Lit luminaires, the price per unit cost was estimated at $148 which includes the $100 product cost for a 2- by 4-ft panel and $48 labor, based on 45 min of installation. For the Eaton Metalux wraparound strip light, the price per unit cost was estimated at $130.00 which includes the $82 product cost and $48 labor, based on 45 min of installation. For the Orion Harris retrofit conversion kit, the price per unit cost was estimated at $110.34 which includes the $94.34 product cost and $16.00 labor, based on 15 min of installation.

(3) The 45-min labor charge for the Metalux wraparound strip light includes installation of the design, rewiring of the fixture and installation of new metal conduit. The 45-min labor charge for the Sylvania LEDVANCE Edge-Lit luminaire includes installation of the design, rewiring of the fixture, splicing into existing junction boxes and time spent hanging/inserting luminaries in the ceiling around obstacles such as ductwork and insulation. The 15-min of labor time for the Orion Harris retrofit conversion kit includes inserting the new troffer, inserting the mounting brackets and plugging in the connectors to the line voltage.

(4) The price per unit cost for replacing the old fluorescent lamp fixture with a new fluorescent light luminaire was estimated at $87. This cost includes a $55 luminaire cost to upgrade to a similar fluorescent light fixture based on the average cost of similar fluorescent luminaires available from GSA and commercial sources and a $32 labor charge based on 30 min of installation.

(5) For fluorescent bulb replacement, the cost was estimated at $28 for 128-W fixtures (four 32-W bulbs) and $22 for 64-W (two 32-W bulbs). The cost for fluorescent bulbs was estimated at $3 each (the average GSA cost per bulb) and the labor charge to switch out the bulbs which was estimated at $16 based on 15 min of installation and disposal fees.

(6) The lifespan for old fluorescent lamp fixtures was estimated at 22,500 hr. Fluorescent lamps extracted ranged between 21,000 and 30,000 hr for the expected life cycle based on 12-hr instant start specifications. Therefore, based on an 12-hr/day and 60-hr work week and a variety of bulb designs, 22,500 hr were used as the average expected life cycle to populate the database for fluorescent fixture lifespan.

(7) Re-lamping is the replacement of bulbs in light fixtures that is completed either on a regular schedule or as each bulb fails. The labor cost for re-lamping cost was estimated at $20 per fixture based on 15 min of installation, fixture cleaning and disposal fees.

(8) An energy rate (electricity cost) of 10.2¢/kWh was used to populate the LED Waves LED Savings database. The data were provided by the U.S. Army Garrison APG Energy Manager and represent the Army tenant energy rate for fiscal year (FY) 2017. The annual electricity cost was calculated by using the Army tenant energy rate and the hours of operation (5 days a week, 12 hr/day) based on a 60-hr work week to populate the LED savings database.

(9) The total wattage was calculated based on the wattage of each fixture and the total number of fixtures per facility.

c. As part of the modification process, TDSS personnel documented any design deficiencies, maintenance issues or product damage that were uncovered during design implementation. The only issue that was encountered during installation was that one of the Eaton Metalux luminaries had a crushed lens cover when opened from its original packaging. Since the luminaire was under warranty, the defective luminaire was returned to the vendor and a replacement unit was supplied promptly for installation without any setbacks to the schedule.

d. For determining the Total Savings, TDSS investigated energy incentives, discounts and rebates that were available for LED products prior to completing the procurement process. Energy incentives/rebates were available for LED technology through Baltimore Gas & Electric (BGE), however, the energy incentives could not be leveraged because they have to be reviewed, submitted and approved prior to the purchase of the LED equipment which would delay product installation and evaluation. The BGE representative that was consulted indicated that this would be a minimum 4- to 6-month process for application submission and approval.

TABLE 2.3-1. DESIGN AND LIFESPAN COMPARISON BASED ON LED WAVES' LED SAVINGS CALCULATOR

Building No.	Fixture Type	No. of Fixtures	Initial Cost	Total Wattage	Annual Electricity Cost	Lifespan, hr	Lifespan for 60-hr Week, years
322	Fluorescent (bulb replacement)	6	$168	768	$244.41	22,500	7.21
	Sylvania LEDVANCE	6	$888	240	$76.38	50,000	16.03
726	Fluorescent (bulb replacement)	6	$132	384	$122.20	22,500	7.21
	Metalux Eaton	6	$780	216	$68.74	60,000	19.23
734	Total Fluorescent (bulb replacement)	26	$728	3328	$1059.10	22,500	7.21
	Sylvania LEDVANCE	16	$2368	640	$203.67	50,000	16.03
	Metalux Eaton	5	$650	180	$57.28	60,000	19.23
	Orion Harris Retrofit	5	$551	135	$42.96	100,000	32.05
734A	Fluorescent (bulb replacement)	6	$132	384	$122.20	22,500	7.21
	Metalux Eaton	6	$780	216	$68.74	60,000	19.23
735A	Fluorescent (bulb replacement)	6	$132	384	$122.20	22,500	7.21
	Metalux Eaton	6	$780	216	$68.74	60,000	19.23
736A	Fluorescent (bulb replacement)	6	$132	384	$122.20	22,500	7.21
	Metalux Eaton	6	$780	216	$68.74	60,000	19.23
737A	Fluorescent (bulb replacement)	6	$132	384	$122.20	22,500	7.21
	Metalux Eaton	6	$780	216	$68.74	60,000	19.23
738A	Fluorescent (bulb replacement)	14	$308	896	$285.14	22,500	7.21
	Orion Harris Retrofit	10	$1103	270	$85.92	100,000	32.05
	Metalux Eaton	4	$520	144	$45.83	60,000	19.23
738B	Fluorescent bulbs	5	$140	640	$203.67	22,500	7.21
	Sylvania LEDVANCE	5	$740	200	$63.65	50,000	16.03

e. Data entered into the LED Saving Calculator for the first scenario included the initial cost of fluorescent bulb replacements versus the LED design(s), the total wattage and annual electricity cost at each facility based on the design and the lifespan for each technology based on a 60-hr work week (table 2.3-1). For facilities that were upgraded with more than one LED technology such as for Building 734, the 26 fluorescent fixtures were calculated against the 16 Sylvania LEDVANCE luminaires, 5 Metalux Easton LED luminaires and 5 Orion Harris retrofit conversion kits. This breakdown was necessary to determine the initial cost, total wattage and annual electricity cost based on the specific LED design. For this example, the combination of the three different LED technologies in Building 734 used 955 W at an annual electrical cost of $303.91 compared to the fluorescent lamps that use 3328 W at an annual electrical cost of $1059.10.

f. As shown in Table 2.3-1, the initial cost for replacing the fluorescent bulbs in the fixtures was the lowest cost option compared to the cost for purchasing and installing any of the three LED technologies. However, when the wattage requirements (energy usage) of the fluorescent bulbs per fixture (64 or 128 W) are compared to the Orion Harris LED retrofit conversion kit (27 W), the Metalux Eaton LED luminaire (36 W) or the Sylvania LEDVANCE luminaire (40 W) that have lifecycles ranging from 16 to 32 years, the energy savings alone justifies the integration of LED technology into the facilities as shown in Table 2.3-2. The Total savings and break-even analysis are given below.

g. For each facility, the specific LED technology installed was compared against fluorescent bulb replacement based on maintenance practices such as the cost of bulb replacements and re-lamping each year, the total annual cost to operate the technology, total cost over the lifecycle of the technology, and the total savings by converting to the LED technology (table 2.3-2). This information and the total savings was determined by loading facility specific data into the LED Waves' LED Savings Calculator. Based on the three LED technologies that were installed at the nine ATC facilities, a total savings of $31,231 was achieved through maintenance and electricity savings over the lifecycle of the LED technology.

Clarification on how each figure was determined has been provided below:

(1) Cost of Replacements/Year = (Bulb cost) x (number of replacements per year).

(2) Annual Labor Cost for Re-Lamping = (Labor cost for re-lamping) x (Number of replacements per year).

(3) Total Annual Cost = (Cost of replacing fixtures) + (electricity) + (labor cost).

(4) Total Cost = (Initial Technology Cost) + ((Total annual cost of technology) x (lifecycle of LED in years)).

(5) Total Savings with the LED Fixture = (Total cost of old fluorescent fixture) - (Total cost of LED fixture) based on the lifecycle of the LED.

TABLE 2.3-2. TOTAL SAVINGS FOR FLUORESCENT BULBS REPLACEMENT VERSUS LED TECHNOLOGY

Building	Technology	Cost of Replacements each year	Annual Labor Cost for Re-Lamping	Annual Electricity Cost	Total Annual Cost	Annual Cost Savings with LED fixture	Total Cost-Based on Lifespan of LED	Total Savings with LED fixture
322	Fluorescent bulbs	$23.30	$16.64	$244.41	$284.34	+$207.96	$4,724	+$2,612
	Sylvania LEDVANCE	-	-	$76.38	$76.38		$2,112	
726	Fluorescent bulbs	$18.30	$16.64	$122.20	$157.15	+$88.41	$3,154	+$1,053
	Metalux Eaton	-	-	$68.74	$68.74		$2,101	
734	Fluorescent bulbs	$62.12	$44.37	$651.76	$758.25	+$554.58	$12,599	+$6,967
	Sylvania LEDVANCE	-	-	$203.67	$203.67		$5,632	
	Fluorescent bulbs	$19.41	$13.87	$203.67	$236.95	+$179.67	$4,696	+$2,945
	Metalux Eaton	-	-	$57.28	$57.28		$1,751	
	Fluorescent bulbs	$19.41	$13.87	$203.67	$236.95	+$193.99	$7,734	+$5,806
	Orion Harris Retrofit	-	-	$42.96	$42.96		$1,928	
734A	Fluorescent bulbs	$18.30	$16.64	$122.20	$157.15	+$88.41	$3,154	+$1,053
	Metalux Eaton	-	-	$68.74	$68.74		$2,101	
735A	Fluorescent bulbs	$18.30	$16.64	$122.20	$157.15	+$88.41	$3,154	+$1,053
	Metalux Eaton	-	-	$68.74	$68.74		$2,101	
736A	Fluorescent bulbs	$18.30	$16.64	$122.20	$157.15	+$88.41	$3,154	+$1,053
	Metalux Eaton	-	-	$68.74	$68.74		$2,101	
737A	Fluorescent bulbs	$18.30	$16.64	$122.20	$157.15	+$88.41	$3,154	+$1,053
	Metalux Eaton	-	-	$68.74	$68.74		$2,101	
738A	Fluorescent bulbs	$30.51	$27.73	$203.67	$261.91	+$175.99	$8,614	+$4,757
	Orion Harris Retrofit	-	-	$85.92	$85.92		$3,857	
	Fluorescent bulbs	$12.20	$11.09	$81.47	$104.77	+$58.94	$2,102	+$701
	Metalux Eaton	-	-	$45.83	$45.83		$1,401	
738B	Fluorescent bulbs	$19.41	$13.87	$203.67	$236.95	+$173.30	$3,937	+$2,178
	Sylvania LEDVANCE	-	-	$63.65	$63.65		$1,759	
Total Savings Resulting from ATC Facility Lighting Conversions During LED Lifespan:								+$31,231

h. The break-even point (or payback period) was calculated for fluorescent bulb replacement versus LED technology through the LED Waves' LED Saving Calculator and in accordance with the simplified payback economic analysis used by the ACSIM (ref 6) for the evaluation of pollution prevention projects. Both methods were used to recognize and compare the results of economic analysis methods used by the Army and the LED lighting industry. Additionally, the LED Waves' LED Savings Calculator was used to determine the payback period using energy savings only and combined energy and maintenance savings to highlight the relative importance of these factors in the economics of conversion to LED technologies. Descriptions of the formulas used for each payback analysis method is provided below. Examples of the use of each formula are provided using data obtained during the Building 322 LED conversion. The results of the payback analyses are summarized in Table 2.3-3.

(1) ACSIM Simplified Payback Period Analysis: The ACSIM payback period formula is a simplified analysis method identified for use in the economic analysis of pollution prevention projects. The formula below divides the implementation cost (equipment purchase and installation) by the total of the recurring cost savings (annual costs of the technology being replaced) minus the recurring cost of the new technology (annual LED energy usage).

$$Payback\ Period = \div \frac{Implementation\ Cost}{(Annual\ Recurring\ Cost\ Savings - Annual\ Recurring\ Costs)}$$

As an example, the Building 322 LED technology implementation cost was $888 (installation of six fixtures at $148/fixture). The annual recurring cost savings (annual energy and maintenance cost to maintain and operate the original fluorescent lighting) was $284.34/year and the annual recurring costs (annual energy to operate the LED lighting) was $76.38/year (table 2.3-2). (Note: There are no annual maintenance costs associated with the LED lighting.) Based on this analysis method, the payback period for the Building 322 LED implementation is 4.27 years.

$$Payback\ Period = \frac{\$888}{(\$284.34/year - \$76.38/year)} = 4.27\ years$$

(2) LED Waves' Payback Period Analysis Using Power Savings Only (PSO): The payback period analysis used by the LED Waves' LED Saving Calculator differs from the simplified payback period analysis used by the ACSIM. LED Waves' adjusts the implementation cost by subtracting the cost of re-lamping or replacing the fluorescent fixtures from the implementation cost of the LED fixtures. This adjusts the implementation costs to reflect the implementation "cost growth" and determines the payback period for that implementation cost growth. The annual energy cost savings is the difference between the annual energy cost of the fluorescent fixtures and the annual energy cost of the LED fixtures.

$$Payback\ Period(PSO) = \frac{(LED\ Implementation\ Cost - Original\ Fixture\ Relamping\ Cost)}{Annual\ Energy\ Cost\ Savings}$$

As an example, the Building 322 LED technology implementation cost was $888 (installation of 6 fixtures at $148/fixture) and the fluorescent fixture re-lamping cost was estimated to be $168 (re-lamping of the six each 128-W fixtures at $28/fixture). The annual electricity cost data for both the fluorescent fixtures and LED fixtures (table 2.3-1) is used to determine the annual energy cost savings ($244.41/year - $76.38/year = $168.03/year). Based on this analysis method which only considers energy costs as recurring costs, the payback period for the Building 322 LED implementation is 4.28 years.

$$Payback\ Period(PSO) = \frac{(\$888 - \$168)}{\frac{\$168.03}{year}} = 4.28\ years$$

(3) LED Waves' Payback Period Analysis Using Total Cost Savings (TCS): This payback period analysis is essentially the same as the previously described analysis method used by the LED Waves' LED Saving Calculator with the exception that all annual recurring costs and savings (maintenance, energy, etc.) are used to determine the payback period. The annual costs used in the denominator of the equation are the same as those used by the simplified payback period analysis used by the ACSIM. Again, the LED Waves' LED Saving Calculator adjusts the implementation cost by subtracting the cost of re-lamping or replacing the fluorescent fixtures from the implementation cost of the LED fixtures in order to reflect the implementation "cost growth". The calculated payback period is for that implementation cost growth.

$$Payback\ Period(TCS) = \frac{(LED\ Implementation\ Cost - \ Original\ Fixture\ Relamping\ Cost)}{Annual\ Total\ (Maintenance\ \&\ Energy)\ Cost\ Savings}$$

Using the Building 322 LED technology implementation again as an example, the LED implementation cost was $888 (installation of six fixtures at $148/fixture) and the fluorescent fixture re-lamping cost was estimated to be $168 (re-lamping of the six each 128 W fixtures at $28/fixture). The annual total recurring cost savings data for the fluorescent fixtures and the annual recurring cost data for the LED fixtures (table 2.3-2) is used to determine the annual total cost savings ($284.34/year - $76.38/year = $207.96/year). Based on this analysis method which considers all annual recurring costs, the payback period for the Building 322 LED implementation is 3.46 years.

$$Payback\ Period(TCS) = \frac{(\$888 - \$168)}{\left(\frac{\$284.34}{year} - \frac{\$76.38}{year}\right)} = 3.46\ years$$

TABLE 2.3-3. PAYBACK PERIOD FOR FLUORESCENT BULBS REPLACEMENT VERSUS LED TECHNOLOGY

Building	Technology	Implementation Cost	Recurring Cost (Fluorescent Technology Total Annual Cost)	Recurring Cost (LED Technology)	Payback Period (Break-Even Point) Analyses, years		
					ACSIM Method	LED Waves Method (Power Savings only)	LED Waves Method (Total Cost Savings)
322	Fluorescent bulbs	$168	$284.34		4.27	4.28	3.46
	Sylvania LEDVANCE	$888		$76.38			
726	Fluorescent bulbs	$132	$157.15		8.82	12.12	7.33
	Metalux Eaton	$780		$68.74			
734	Fluorescent bulbs	$448	$758.25		4.27	4.28	3.46
	Sylvania LEDVANCE	$2368		$203.67			
	Fluorescent bulbs	$140	$236.95		3.62	3.48	2.84
	Metalux Eaton	$650		$57.28			
	Fluorescent bulbs	$140	$236.95		2.84	2.56	2.12
	Orion Harris Retrofit	$551		$42.96			
734A	Fluorescent bulbs	$132	$157.15		8.82	12.12	7.33
	Metalux Eaton	$780		$68.74			
735A	Fluorescent bulbs	$132	$157.15		8.82	12.12	7.33
	Metalux Eaton	$780		$68.74			
736A	Fluorescent bulbs	$132	$157.15		8.82	12.12	7.33
	Metalux Eaton	$780		$68.74			
737A	Fluorescent bulbs	$132	$157.15		8.82	12.12	7.33
	Metalux Eaton	$780		$68.74			
738A	Fluorescent bulbs	$220	$261.91		6.23	7.50	5.02
	Orion Harris Retrofit	$1103		$85.92			
	Fluorescent bulbs	$88	$104.77		8.82	12.12	7.33
	Metalux Eaton	$520		$45.83			
738B	Fluorescent bulbs	$140	$236.95		4.27	4.29	3.46
	Sylvania LEDVANCE	$740		$63.65			

i. A comparison of the three LED technologies in Tables 2.3-2 and 2.3-3 revealed that the Orion Harris retrofit conversion kit provided the best Total Savings and Break-Even Point. The Orion Harris retrofit conversion kit was recognized as a DLC premium product because it has an expected life cycle of 100,000 hr which is 40 percent higher than the Metalux Eaton luminaire and 50 percent higher than the Sylvania LEDVANCE luminaire. The Orion Harris technology has a low fixture wattage (27 W) compared to the Eaton Metalux (36 W) and Sylvania LEDVANCE (40 W). Also, the price per unit cost for the Orion Harris LED technology was the lowest of the three designs. Installation took 15 min or less and the material cost was lower than the other two LED technologies. The Metalux Eaton luminaire had a low break-even point of 2.84 years when Building 734 was converted from 128 to 36 W. However it also had the highest break-even point of nearly 7.33 years when converting 64-W fixtures to LED technology as demonstrated in six of the facilities upgraded. The data for Sylvania LEDVANCE are deceiving since it had a break-even point of 3.46 years when converting 128-W facilities. If the Sylvania LEDVANCE technology had been installed in facilities with 64-W fixtures, the break-even point would have been higher because the lifecycle of the technology was the lowest, the wattage per LED fixture was the largest and it has the highest price per unit cost due to the cost of materials and a 45-min installation time. Of the factors influencing the economic analysis of converting fluorescent lighting to LED lighting, the projected annual energy savings are the major determinant in reducing the payback period. The reduction in energy use (fixture wattage) between the fluorescent lighting and LED lighting is summarized in Table 2.3-4 along with the payback period calculated using the LED Waves' TCS method. The data are further summarized in Table 2.3-5 and clearly show that as the reduction in fixture energy usage increases, the payback period for conversion to LED lighting decreases.

TABLE 2.3-4. FIXTURE WATTAGE VERSUS PAYBACK PERIOD COMPARISON

Building	Technology	Fixture Wattage	Fixture Wattage Reduction	Payback Period, years
322	Fluorescent bulbs	128	88	3.46
	Sylvania LEDVANCE	40		
726	Fluorescent bulbs	64	28	7.33
	Metalux Eaton	36		
734	Fluorescent bulbs	128	88	3.46
	Sylvania LEDVANCE	40		
	Fluorescent bulbs	128	92	2.84
	Metalux Eaton	36		
	Fluorescent bulbs	128	101	2.12
	Orion Harris Retrofit	27		
734A	Fluorescent bulbs	64	28	7.33
	Metalux Eaton	36		
735A	Fluorescent bulbs	64	28	7.33
	Metalux Eaton	36		
736A	Fluorescent bulbs	64	28	7.33
	Metalux Eaton	36		
737A	Fluorescent bulbs	64	28	7.33
	Metalux Eaton	36		
738A	Fluorescent bulbs	64	37	5.02
	Orion Harris Retrofit	27		
	Fluorescent bulbs	64	28	7.33
	Metalux Eaton	36		
738B	Fluorescent bulbs	128	88	3.46
	Sylvania LEDVANCE	40		

TABLE 2.3-5. CORRELATION OF FIXTURE WATTAGE AND PAYBACK PERIOD

Fixture Wattage Difference	Payback Period for LED Investment, years
101	2.12
92	2.84
88	3.46
37	5.02
28	7.33

j. The second scenario that was analyzed for three of the upgraded facilities involved replacing the old fluorescent fixtures with new fluorescent light fixtures versus the installation of a LED design. Three facilities were selected so that each LED implementation could be compared to the new fluorescent luminaire replacement. As demonstrated in Table 2.3-6, the initial costs, total wattage and annual electricity costs were compared based on the lifespan of the LED technology for the three facilities. The data revealed that for Building 322, selecting the Sylvania LEDVANCE technology over the new 128-W fluorescent luminaires would require investing 70 percent more and would result in a wattage reduction of 528 W and an annual energy cost savings of $168.03. For Building 726, selecting the Metalux Eaton luminaire over the new 64-W fluorescent luminaire would cost 49 percent more and would deliver a wattage reduction of 168 W and an annual energy cost savings of $53.46. For Building 734, selecting the Orion Harris retrofit conversion kit over the new 128-W fluorescent luminaires would cost 27 percent more but would deliver a wattage reduction of 505 W and an annual energy cost savings of $160.71.

TABLE 2.3-6. NEW FLUORESCENT VERSUS LED LUMINAIRE REPLACEMENT COMPARISON

Building No.	Fixture Type	No. of Fixtures	Initial Cost	Total Wattage	Annual Electricity Cost	Lifespan, hr	Lifespan for 60-hr Week, years
322	Fluorescent (luminaire replacement)	6	$522	768	$244.41	22,500	7.21
	Sylvania LEDVANCE	6	$888	240	$76.38	50,000	16.03
726	Fluorescent (luminaire replacement)	6	$522	384	$122.20	22,500	7.21
	Metalux Eaton	6	$780	216	$68.74	60,000	19.23
734	Fluorescent (luminaire replacement)	5	$435	640	$203.67	22,500	7.21
	Orion Harris retrofit	5	$552	135	$42.96	100,000	32.05

k. The Total Savings and Break-Even Point was calculated for fluorescent luminaire replacement versus LED technology through the LED Waves' LED Saving Calculator (table 2.3-7). For the three of the nine facilities that were analyzed, the total energy savings for implementing LED technology over fluorescent luminaires was determined to be $13,648 and the payback period for the LED investment calculated using the LED Waves' LED Saving Calculator ranged from 0.50 to 1.81 years. Based on the data that were obtained, the three LED technologies present a more cost-effective and energy efficient option than upgrading with fluorescent fixtures despite the higher initial costs.

TABLE 2.3-7. SAVINGS AND PAYBACK COMPARISON FOR FLUORESCENT VERSUS LED FIXTURES

Building No.	Technology	Annual Cost of Lamp Replacements	Annual Re-lamping Labor Cost	Total Annual Cost	Total Cost Based on Lifespan of LED	Total Savings with LED Fixture	Break-Even Point For LED Investment, years
322	Fluorescent fixture	$72.38	$16.64	$333.43	$5865	+$3753	1.42
	Sylvania LEDVANCE	-	-	$76.38	$2112		
726	Fluorescent fixture	$72.38	$16.64	$211.23	$4584	+$2483	1.81
	Metalux Eaton	-	-	$68.74	$2101		
734	Fluorescent fixture	$60.32	$13.87	$277.86	$9340	+$7412	0.50
	Orion Harris Retrofit Kit	-	-	$42.96	$1928		

SECTION 3. APPENDIXES

APPENDIX A. STUDY CRITERIA

None. Study is being performed for informational purposes. No specific performance criteria has been established.

APPENDIX B. LIGHT-EMITTING DIODE (LED) CONVERSION FIELD LOGS

Date:	20 March 2017	Building No.:	**322 Technical Imaging**
Start Time , hr:	0830	End Time, hr:	1530
No. of Light Fixtures Upgraded:	9 Luminaires - 6 (2- by 4-ft) and 3 (2- by 2-ft)		
Installers:	Phil Hooker and Gregg Mergler		

Fluorescent

Bulb Type(s):	Sylvania Eco Friendly	Model No:	Octron/Eco F-032/741/ECO	Wattage:	32W, 4100K	Bulb Weight	0.4 lb
Bulb Size:	T-8 (48-in. tube)			Bulb Condition:	Good		
Projected Lifespan of Bulb:	28,000 hr based on 12-hr start on IS Ballast			Anticipated Hours of Operation:			9
Type of Ballast:	Model No.:			Condition of Ballast:			
Advance Transformer	REL-4P-32-LW-RH-TP			Good			
Howard Industries	EP4/32IS/MV/MC			Good			
Philips Advance National Electrical Manufacturers Association (NEMA) Premium	Centium ICN-4P32-SC			Good			
Triad Lighting Technologies	B432IUNVHP-A			Good			
Triad MagneTek	B432I120RH			Good			
No. of Bulbs per Fixture:	4			Total No. of Bulbs Removed:			24
Photographs:	0574-0582, ballast 0585-0588						

LED Conversion-Luminaires

Type of LED Design:	Sylvania LEDVANCE	Model No.:	74250	Lamp Size:	2- by 4-ft Edge-Lit Panel
Lamp Weight, lb:	15.0	Efficacy/Lumens:		110 LPW/4400	
Lumen Depreciation Value:	L70 at 50,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>80	THD Value:	<20
PF Value:	≥0.9 or ≥90 percent	Date Product was Manufactured		10-2016	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		50,000 hr	
No. of Lamps per Fixture:	1 Edge-Lit Panel	Total No. of Lamps Installed:		6	
Photographs:	0589-0590, 0583-0584				

LED Conversion-Luminaires

Type of LED Design:	Sylvania LEDVANCE	Model No.:	74252	Lamp Size:	2- by 2-ft Edge-Lit Panel
Lamp Weight, lb:	7.6	Efficacy/Lumens:	110 LPW/3500	Watts:	32
Lumen Depreciation Value:	L70 at 50,000 hr	Warranty, years:	5		
CCT Value:	4000K	CRI Value:	>80	THD Value:	<20
PF Value:	≥0.9 or ≥90 percent	Date Product was Manufactured	10-2016		
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:	50,000 hr		
No. of Lamps per Fixture:	1 Edge-Lit Panel	Total No. of Lamps Installed:	3		
Photographs:	0591-0595				

Date:	4 April, 5 April 2017	Building No.:	**726 FP#11**
Start Time:	4 April 2017: 1245 to 1345,	End Time:	5 April 2017: 0730 to 0830
No. of Light Fixtures Upgraded:	6 Metalux Eaton Surface Wraparound Luminaires		
Installers:	Phil Hooker and Gregg Mergler		

Fluorescent

Bulb Type(s):	Sylvania Octron/Eco	Model No:	F032/741/Eco	Wattage:	32 W	Bulb Weight	.0.4 lb
Bulb Type(s):	GE Trimline (Made in Canada)	Model No:	F32T8-SP41	Wattage:	32 W	Bulb Weight	.0.4 lb
Bulb Type(s):	Philips TL-80	Model No:	F32T8/TL841	Wattage:	32 W	Bulb Weight	.0.2 lb
Bulb Size:	T-8 (48” tube)			Bulb Condition:	Good		
Projected Lifespan of Bulb:	Sylvania: 28,000 hr GE: 30,000 hr Philips: 24,000 hr			Anticipated Hours of Operation:	9		
Type of Ballast:	Model No.:			Condition of Ballast:			
Advance Centium	ICN-2P32-SC			Good-Electronic, Instant Start design			
Basic 12	B234SR120M-A			Good-Electronic, Instant Start design			
No. of Bulbs per Fixture:	2			Total No. of Bulbs Removed:	12		
Photographs:	0662						

LED Conversion-Luminaires

Type of LED Design:	Metalux Eaton Wraparound Strip Light	Model No.:	4WNLED-LD4-40SL-F-UNV-840-CD-1-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW/4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>82	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:		6	
Photographs:	0657-0666				
Notes:	• Must rewire fixtures and cut new metal conduit for each facility upgrade.				

Date:	22 March 2017	Building No.:	**734, FP#23**
Start Time, hr:	0800 to 1530 (LEDVANCE), 0800 to 1045 (Metalux)	End Time, hr:	1330 to 1445 (Orion retrofit kits)
No. of Light Fixtures Upgraded:	26 total (16 LEDVANCE luminaires, 5 Orion retrofit kits and 5 Metalux strip lights)		
Installers:	Phil Hooker/Gregg Mergler		

Fluorescent

Bulb Type:	Philips Alto II-700 series	Model No:	F32T8/TL/741	Wattage:	32 W	Bulb Weight:	0.2 lb
Bulb Type:	TCP	Model No:	IG217-4ELU-HPF	Wattage:	32 W	Bulb Weight:	0.4 lb
Bulb Size:	T-8 (48-in. tube)	Lumens:	Philips: 2600 TCP: 2350	Bulb Condition:	Great	Hg Content:	1.7 mg
Projected Lifespan of Bulb:	Philips: 30,000 hr TCP: 24,000 hr			Anticipated Hours of Operation:	9		
Type of Ballast:	Model No.:			Condition of Ballast:			
General Electric	Multi-Volt Pro GE-432-MV-N-42T			Great			
No. of Bulbs per Fixture:	4			Total No. of Bulbs Removed:	104 bulbs (26 fixtures upgraded)		
Photographs:	0630-0631, 0637-0638						
Notes:	• The fixtures, ballasts and energy efficient fluorescent bulbs were removed and returned to ATC Facilities for re-use at other sites, as needed. • Cardboard from the new LED fixtures were placed in ATC roll offs that were designated for cardboard recycling.						

LED Conversion-Luminaires

Type of LED Design:	LEDADVANCE Luminaires	Model No.:	74250	Lamp Size:	2- by 4-ft Edge-Lit Panel
Lamp Weight, lb:	15.0	Efficacy/Lumens:		110 LPW/4400	
Lumen Depreciation Value:	L70 at 50,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>80	THD Value:	<20
PF Value:	≥0.9 or ≥90 percent	Date Product was Manufactured		09/2016 and 10/2016	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		50,000 hr	
No. of Lamps per Fixture:	1 Edge-Lit Panel	Total No. of Lamps Installed:		16	
Photographs:	0626-0628, 0632-0636, 0639-0646				
Notes:	• Installation time for luminaires averaged 30 to 45 min per fixture. Fixtures located around ductwork required more time to install. Must splice in junction box to fixtures (three wires) for luminaires.				

LED Conversion-Luminaires

Type of LED Design:	Metalux EATON LED Wraparound Strip Lights	Model No.:	4WNLED-LD4-40SL-F-UNV-L840-CD1-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW, 4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	Unknown	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:		5	
Photographs:	0689-0696				
Notes:	• For wraparound LED fixtures, several design options were researched with Master Electricians and local vendor to locate compatible system. The cheapest option, LED bulb and ballast replacement, were not a viable option for these facilities because the fear is that vibration from firing exercises may shatter lamps and create a safety issue.				

LED Conversion-Retrofit Conversion Kits

Type of LED Design:	Harris Orion Edge Retrofit Conversion Kit	Model No.:	SO-0071122	Lamp Weight, lb	5.4
Efficacy/Lumens:	121 LPW/3000 lumens	Lamp Size:	T-8, 2- by 4-ft	Watts:	27
CCT Value:	4000K	CRI Value:	80		
Lumen Depreciation Value:	100,000 hr per L-70 W at 25 °C	Warranty, years:	5		
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:	100,000 hr		
Date of Manufacturer:	22 February 2017	No. of Lamps per fixture	1 lamp		
Total No. of Lamps Installed:	5	Photographs:	0622-0625 (office and restroom)		
Notes:	• Existing ductwork did not interfere with the placement or installation time of LED retrofit conversion kits. • Installation time for Orion edge retrofit conversion kit averaged 10 min.				

Date:	6 April 2017	Building No.:	**734A, FP#22**
Start Time, hr:	1330	End Time, hr:	1530
No. of Light Fixtures Upgraded:	6 Metalux Eaton Surface Mounted Wraparound Luminaires		
Installers:	Phil Hooker/Gregg Mergler		

Fluorescent

Bulb Type:	Sylvania Octron	Model No:	F032/741	Wattage:	32 W	Bulb Weight, lb:	0.4
Bulb Size:	T-8 (48-in. tube)	Lumens:	2600	Bulb Condition:	Fair, black ends on bulb		
Projected Lifespan of Bulb:	20,000			Anticipated Hours of Operation:	9		
Type of Ballast:	Model No.:			Condition of Ballast:			
Advance Transformer	REL-2P32-LW-RH-TP			Good			
No. of Bulbs per Fixture:	2			Total No. of Bulbs Removed:	12		
Photographs:							
Notes:	• The acrylic grid cover for the fluorescent light fixture was severely cracked and held together with duct-tape to stay intact.						

LED Conversion-Luminaires

Type of LED Design:	Metalux EATON LED Wraparound Strip Lights	Model No.:	4WNLED-LD4-40SL-F-UNV-L840-CD1-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW, 4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>82	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:		6	
Photographs:	0686-0688				

Date:	5 April 2017	Building No.:	**735A, FP#21**
Start Time, hr :	1300	End Time, hr:	1500
No. of Light Fixtures Upgraded:	6 Metalux Eaton Surface Mounted Wraparound Luminaires		
Installers:	Phil Hooker/Gregg Mergler		

Fluorescent

Bulb Type:	General Electric Trimline	Model No:	F32-T8-SP41	Wattage:	32 W	Bulb Weight, lb:	0.4
Bulb Type:	Sylvania Octron/Eco	Model No:	F032/T41/Eco	Wattage:	32 watts	Bulb Weight, lb:	0.4
Bulb Size:	T-8 (48-in.	Lumens:	GE: 2450 Sylvania: 2600	Bulb Condition:	Fair, black ends on bulb		
Projected Lifespan of Bulb:	GE: 30,000 hr Sylvania: 28,000 hr			Anticipated Hours of Operation:	9		
Type of Ballast:	Model No.:			Condition of Ballast:			
Howard Industries	EC2/32IS-120			Good			
Philips Advance	ICN-2P32-N			Good			
No. of Bulbs per Fixture:	2			Total No. of Bulbs Removed:	12		
Notes:	• The acrylic grid cover for the fluorescent light fixture was severely cracked and held together with duct-tape to stay intact.						

LED Conversion-Luminaires

Type of LED Design:	Metalux EATON LED Wraparound Strip Lights	Model No.:	4WNLED-LD4-40SL-F-UNV-L840-CD1-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW, 4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>82	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:		6	
Photographs:	0678-0679				

Date:	6 April 2017	Building No.:	**736A, FP#20**
Start Time, hr:	0800	End Time, hr:	1030
No. of Light Fixtures Upgraded:	6 Metalux Eaton Surface Mounted Wraparound Luminaires		
Installers:	Phil Hooker/Gregg Mergler		

Fluorescent

Bulb Type:	General Electric Trimline	Model No:	F32-T8-SP41	Wattage:	32 W	Bulb Weight, lb:	0.4
Bulb Type:	Sylvania Octron/Eco	Model No:	F032/741/Eco	Wattage:	32 W	Bulb Weight, lb:	0.4 lb.
Bulb Size:	T-8 (48-in.)	Lumens:	GE: 2450 Sylvania: 2600	Bulb Condition:	Mixture of good and fair (black ends on bulb)		
Projected Lifespan of Bulb:		GE: 30,000 hr Sylvania: 28,000 hr		Anticipated Hours of Operation:	9-hours		
Type of Ballast:		Model No.:		Condition of Ballast:			
MagneTek		B232I120L		Good			
No. of Bulbs per Fixture:		2		Total No. of Bulbs Removed:	12		
Photographs:							

LED Conversion-Luminaires

Type of LED Design:	Metalux Eaton LED Wraparound Strip Lights	Model No.:	4WNLED-LD4-40SL-F-UNV-L840-CD1-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW, 4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5-years	
CCT Value:	4000K	CRI Value:	>82	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:		6	
Photographs:	0680-0685				

Date:	5 April 2017	Building No.:	**737A, FP#19A**
Start Time, hr:	0900	End Time, hr:	1100
No. of Light Fixtures Upgraded:	6 Metalux Eaton Surface Mounted Wraparound Luminaires		
Installers:	Phil Hooker/Gregg Mergler		

Fluorescent

Bulb Type:	General Electric Trimline	Model No:	F32-T8-SP41	Wattage:	32 W	Bulb Weight, lb:	0.4
Bulb Type:	Sylvania Octron/Eco	Model No:	F032/T41/Eco	Wattage:	32 W	Bulb Weight, lb:	0.4
Bulb Type:	Philips Alto Long Life (HiVision)	Model No:	F32T8/TL841	Wattage:	32 W	Bulb Weight, lb:	0.4
Bulb Size:	T-8 (48-In.)	Lumens:	GE: 2450 Sylvania: 2650 Philips: 2950	Bulb Condition:	Mixture of good and fair (black ends on bulb)		
Projected Lifespan of Bulb:		GE: 30,000 hr Sylvania: 28,000 hr Philips: 24,000 hr		Anticipated Hours of Operation:	9		
Type of Ballast:		Model No.:		Condition of Ballast:			
Ultra-Miser Valmont Electric		E232PI-120L		Rusted, fair condition			
Philips Advance Centium		ICN-2P32-N		Good			
Howard Industries		E2/32IS-120MC		Fair, labels missing			
No. of Bulbs per Fixture:		2		Total No. of Bulbs Removed:	12		

LED Conversion-Luminaires

Type of LED Design:	Metalux Eaton LED Wraparound Strip Lights	Model No.:	4WNLED-LD4-40SL-F-UNV-L840-CD1-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW, 4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>82	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:		6	
Photographs:	0667-0677				

Date:	22 March 2017	Building No.:	**738A FP #16,17**
Start Time, hr:	0830 to 1050 (Orion retrofits)	End Time, hr:	0930 to 1045 (Metalux luminaires)
No. of Light Fixtures Upgraded:	14 = 10 (Orion retrofits) + 4 (Metalux luminaires)		
Installers:	Phil and Gregg		

Fluorescent

Bulb Type(s):	PhilipsTL-70-Alto Collection	Model No:	F32T8/TL741	Wattage:	32 W	Bulb Weight, lb/Qty	0.4 (22)
Bulb Type(s):	Philips Alto II, 800 series	Model No:	F32T8/TL841	Wattage:	32 W	Bulb Weight, lb/Qty	0.2 (8)
Bulb Size:	4-ft T-8 bulb			Bulb Condition:	Good		
Projected Lifespan of Bulb:	Philips Alto: 30,000 hr Philips Alto II: 30,000 hr			Anticipated Hours of Operation:	9		
Type of Ballast:	Model No.:			Condition of Ballast:			
(1) Advance Transformer	REL-4P32-LW-RH-TP			Good			
(2) Philips Advance Intelli Volt	ICN-4P32-N			Good			
(3) Howard Industries	EL2/32/IS-120			Good			
(4) Advance Centium	ICN-2P32-SC			Good			
No. of Bulbs per Fixture:	2			Total No. of Bulbs Removed:	30 (14 fixtures removed, 1 fixture had 4 bulbs)		
Photographs:	0605-0612						

LED Conversion-Luminaires

Type of LED Design:	Metalux Eaton Cooper Lighting	Model No.:	4WNLED-LD4-40SL-F-UNV-L840-CDL-U	Lamp Size:	2- by 4-ft
Lamp Weight, lb:	9.2	Efficacy/Lumens:		113 LPW/4062 lumens	
Lumen Depreciation Value:	L70 at 60,000 hr	Warranty, years:		5	
CCT Value:	4000 K	CRI Value:	>82	THD Value:	Unknown
PF Value:	Unknown	Date Product was Manufactured		Unknown	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		60,000 hr	
No. of Lamps per Fixture:	1 strip light	Total No. of Lamps Installed:		4	
Photographs:	0647-0656				

LED Conversion-Retrofit Conversion Kits

Type of LED Design:	Harris Orion LED Edge Retrofit	Model No.:	S0-0071122, LDRE1D1UNVFDSX84024MST
Lamp Weight, lb:	5.4	Efficacy/Lumens:	121 LPW/ 3000 lumens
Lamp Size:	2- by 4-ft	Watts:	27
CCT Value:	4000K	CRI Value:	80
Lumen Depreciation Value:	100,000 hours per L-70 at 25°C	Warranty, years:	5
Anticipated Hours of Operation:	9	Manufacturing Date:	22 February 2017
No. of Lamps per Fixture:	1	Total No. of Lamps Installed:	10
Photographs:	0613-0621		
Notes:	• Installation time for Orion retrofit fixtures averaged 10 to 15 min each.		

Date:	21 March 2017	Building No.:	**738B FP#18, 19**
Start Time, hr:	0800	End Time, hr:	1430
No. of Light Fixtures Upgraded:	5		
Installers:	Phil Hooker, Gregg Mergler		

Fluorescent

Bulb Type(s)	Philips Alto 700 Series	Model No:	F32T8/TL741	Wattage:	32 W	Bulb Weight, lb	0.2
Bulb Size:	4-foot, 2600 lumens			Bulb Condition:	Good	Mercury Content	1.7 mg
Projected Lifespan of Bulb:	36,000 hr			Anticipated Hours of Operation:	9		
Type of Ballast:	Model No.:			Condition of Ballast:			
Sylvania Quick Tronic	QTP 4x32T8/UNV ISN-SC			Good			
No. of Bulbs per Fixture:	4			Total No. of Bulbs Removed:	20		
Photographs:	0596-0599						

LED Conversion-Luminaires

Type of LED Design:	LEDVANCE Luminaires	Model No.:	74250	Lamp Size:	2- by 4-ft Edge-Lit Panel
Lamp Weight, lb:	15.0	Efficacy(LPW)/Lumens:		110 LPW/4400 lumens	
Lumen Depreciation Value:	L70 at 50,000 hr	Warranty, years:		5	
CCT Value:	4000K	CRI Value:	>80	THD Value:	<20 percent
PF Value:	≥0.9 or ≥90 percent	Date Product was Manufactured		10-2016	
Anticipated Hours of Operation:	9	Projected Lifespan of Lamp:		50,000 hr	
No. of Lamps per Fixture:	1 Edge-Lit Panel	Total No. of Lamps Installed:		5	
Photographs:	0600-0604				
Notes:	• Fluorescent bulbs removed from fixtures during LED conversion were retained by Range Facility Manager for future fluorescent lamp replacements. • Ballasts removed during conversion were retained by facility personnel as replacement parts. • Fixtures were stripped down and unloaded into ATC scrap metal roll-off for recycling. • Cardboard from fixtures was broken down and unloaded into ATC roll-off dedicated to cardboard recycling.				

APPENDIX C. LED TECHNOLOGY SPECIFICATION SHEETS

The specification sheets for the LED technologies used in this study are provided in this appendix. Web links to each of these specification sheets are also provided below:

Orion Harris LED LDRE1 Troffer Retrofit Edge data sheet:
http://www.orionlighting.com/product/harris-led-retrofit-edge-ldre/

Sylvania LEDVANCE Luminaires Edge-Lit panel cut sheet:
http://www.sylvania.com/en-us/products/luminaires/Luminaires/Pages/Indoor-Luminaires-Literature-Resources.aspx

Metalux WNLED Utility LED Wraparound spec sheet and brochure:
http://www.cooperindustries.com/content/public/en/lighting/products/indoor_ceiling_wall_mount_lighting/ceiling_mount/_848409.ssd.brands.lighting!metalux!wraps.html

LDRE1

Features and Specifications

Applications
Retrofits existing 2'x2' and 2'x4' fluorescent troffers to LED. Industry's first Patented LED troffer retrofit contained within the door frame.

Features
- Installs in as little as two minutes.
- Low environmental impact.
- Ultra-light, highly efficient troffer retrofit solution.
- Multiple bracket options to fit application need.
- Matte finish, acrylic contour lens provides glare diffusion in the work environment.
- Integrated intelligent control options.

Certification & Listings
- Patented LDR® design.
- UL Damp Listed.
- DesignLights Consortium™ Premium qualified .
- Visit DLC QPL for listed models.

Construction
Aluminum frame with white powder coat finish. LDR® fits most existing fluorescent troffer fixtures with either prismatic lens or parabolic louvers.

Electrical
120-277v. Hardwired fixture.

Rated Life
100,000 hours per L70 TM-21 at 25°C.

Ambient Operating Range
32°F to 122°F (0°C to 50°C).

Warranty
Orion LED HARRIS class fixtures are covered by a five-year limited warranty. Accessories and individual components are covered by separate OEM supplier warranties.

Ordering Information Example

Series	Nominal Lumens	Voltage	Driver Type	CRI; Color Temp.	Fixture Size	Lens Material	Bracket Type	Additional Options
LDRE1	D1	UNV	FDXX	835	24	M	ST	-BB

Ordering Information

Series	Nominal Lumens	Volt-age	Driver Type	CRI; Color Temp.	Fixture Size	Lens Material	Bracket Type	Additional Options
LDRE1= LED Retrofit Edge Gen1	**2x2** **A1**= 2000lm **B1**= 4000lm **2x4** **D1**= 3000lm **E1**= 4000lm **F1**= 6000lm[1] **G1**= 8000lm[1]	**UNV**= 120-277v	**FDXX**= Full Dimming 0-10v EDHB= Lutron Hi-lume dim to 1%, Fade to Black EDH1= Lutron Hi-lume dim to 1% EDH2= Lutron Hi-lume dim to 1% 2wire 120v EDH3= Lutron Hi-lume dim to 1% 3wire 120-277v EDS5= Lutron 5-series dim to 5%	**835**= 80CRI, 3500K **840**= 80CRI, 4000K **850**= 80CRI, 5000K	**22**= 2x2 **24**= 2x4	**M**= Opaque Matte	**ST**= Standard **PL**= Plenum **LF**= Lift	**-BB**= Battery Back up **-DD**= Dial Dimmer -EN = Enlighted Sensor -BT= Bluetooth Sensor -ZB= Zigbee Wireless Control System -ME= Magnum EnOcean Control Systems

HARRIS LDR® TROFFER RETROFIT EDGE

LDRE1

Physical and Performance Information[4]

Series	Lumen Code	Actual Lumens	Fixture Size	Lumens Per Watt	Light Output	CCT	CRI	Input Voltage	Input Power (watts)	Input Current	Power Factor
LDRE1- LED Retrofit Edge Gen1	A1*	2000	2x2	106	2331 lm	4000K	≥80	120	22	0.18 A	≥0.99
	B1*	4000	2x2	109	4745 lm	4000K	≥80	120	38	0.32 A	≥0.99
	D1	3000	2x4	121	3254 lm	4000K	≥80	120	27	0.23 A	≥0.99
	E1	4000	2x4	123	4297 lm	4000K	≥80	120	35	0.29 A	≥0.99
	F1	6000	2x4	117	5882 lm	4000K	≥80	120	50	0.4 A	≥0.99
	G1	8000	2x4	121	7891 lm	4000K	≥80	120	65	0.53 A	≥0.99
	*These products, A1 and B1 only meet DLC standard. For more information, visit www.designlights.org.										

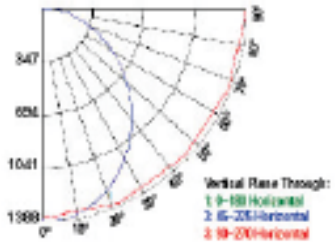
Physical Information

Size	Length	Width	Depth[4]	Weight[5]
2x4	46.75"	20.5"	3.125"	11 lbs.
2x2	22.75"	20.5"	3.125"	6 lbs.

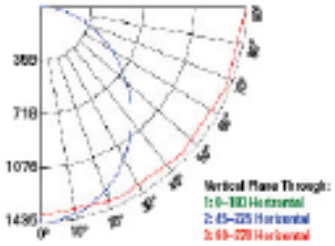
Additional Performance Information for a fixture

Visit orionlighting.com for all .IES files

2x2 B1 4K



2x4 E1 4K



orion |

LDRE1

Fixture Option - Factory Installed

-BB- Battery Backup

-DD- Dial Dimmer

-EN- Enlighted wireless networked sensor

-BT- Bluetooth smart device sensor

-MG- Magnum EnOcean control system

-ZB- Zigbee wireless control system

Fixture Options - Field Installed

SC- Seismic cable

Additional Specification Information

[1] **F1** and **G1** not available for Lutron dimming options or other sensor and control options

[2] FDXX 0-10v driver configurations are compatible with most third party control systems

[3] "XX" in part number is a character placeholder for the manufacturing configuration

[4] Actual performance may vary by up to ±10% of values listed

[5] Depth varies by model; dependent on driver selection

[6] Weight will vary based on option selected

SYLVANIA

LEDVANCE Luminaires

Edge-Lit Panel

Catalog #	Type
Project	
Notes	
Date	
Prepared by	

Product Features

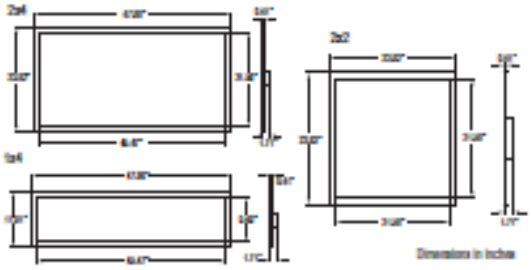
The Edge-Lit Panels are environmentally preferable LED alternatives to traditional fluorescent luminaires, offering up to 47% in energy savings. Ideal in place of traditional luminaires, or as new installations, the Edge-Lit Panels are offered in three sizes for illuminating offices, retail or hospitality areas.

The slim design of these luminaires is beneficial for installation in tight ceilings spaces and they offer low glare and uniform illumination. LEDVANCE luminaires assure optimum light engine performance for extended service and rated life (>50,000 hours L_{70}).

Wattage Comparison Chart

Edge-Lit Panel Size	Traditional Source	Traditional System Wattage	LED System Wattage	Energy Savings
1x4	2x28W T8	60	32	35%
	2x32W T8	66	32	43%
2x2	3x17W T8	48	32	33%
	2031 T8	56	32	43%
2x4	2x28W T8	60	32	35%
	2x32W T8	66	32	43%
	3x28W T8	88	40	31%
	3x32W T8	75	40	47%

Dimensions



Dimensions in inches

Specifications

Weight: 1x4 & 2x2: 7.96lbs (3.6 kg) Standard 2x4: 14.33lbs (6.5 kg) Standard
1x4 & 2x2: 10.14lbs (4.6 kg) Emergency 2x4: 16.54lbs (7.5 kg) Emergency

Construction: Extruded aluminum frame with sheet metal back plate, earthquake clips and PMMA diffused flat lens. The standard color is white.

LED System: LED system with a life rating of >50,000 hours at L_{70} @ 25°C. Luminaire efficacy up to 110 LPW.

Electrical: Offered in 32 and 40Watts, the luminaire is designed to operate through the 120-277 Vac universal voltage range. The LED driver has a 0.5kV inherent surge suppression and is a constant current device. The power factor is >.90% and THD is <20%.

Dimming: The driver is 0-10V dimmable (down to 10%). Please reference the dimmer compatibility document (LEDLUM012).

Color Characteristics: CRI>80; CCT of 3500K or 4000K.

Optics: White flat edge-lit PMMA diffuser lens.

Installation: Luminaire lays in standard 15/16" and 9/16" T-grid ceilings.

Operating Temperature: -4°F to +104°F (-20°C to +40°C);
EM: +32°F to +104°F (0°C to +40°C).

Listings: cETLus listed to UL1598 standards and IC rated for dry locations.

Warranty: Standard 5-year luminaire warranty (LEDLUM002).

Note: Specifications subject to change without notice. IES files available online.

Ordering Guide

Item Number:

PANELF	1A	/ XXX	XXX	D	8	XX	/ XX	G	/ WH	/ X
Product Name	Generation	Wattage	Voltage	Dimming	CRI	Color Temp (CCT)	Dimension	Mounting	Color Finish	Option
PANELF	1A	032 = 32 Watts 040 = 40 Watts*	UNV = 120-277V	D = 0-10V	8 = >80	35 = 3500K 40 = 4000K	14 = 1x4 22 = 2x2 24 = 2x4	G = Grid	WH = White	Blank = No Option E = Emergency

*Only available in 2x4 size.

**DLC not applicable to emergency versions.

LEDLUM01084 11-16

Photometric Data

Average Illuminance (FC) at 30" AFF and avg/min uniformity
80/50/20 Reflectances

			8 ft Mounting Height			10 ft Mounting Height			12 ft Mounting Height		
			On Center Fixture Spacing			On Center Fixture Spacing			On Center Fixture Spacing		
			8'x10'[1]	10'x10'[1]	10'x12'[1]	8'x10'[1]	10'x10'[1]	10'x12'[1]	8'x10'[1]	10'x10'[1]	10'x12'[1]
1'x4'	32W	PANELFIA/032UNV/0835/14Q/WH	44fc / 3.2	36fc / 2.9	32fc / 2.0	43fc / 2.7	35fc / 2.4	31fc / 1.8	42fc / 2.5	34fc / 2.3	31fc / 1.8
		PANELFIA/032UNV/0840/14Q/WH									
2'x2'[2]	32W	PANELFIA/032UNV/0835/22Q/WH	47fc / 3.2	39fc / 2.9	35fc / 2.0	46fc / 2.7	38fc / 2.4	33fc / 1.8	44fc / 2.4	37fc / 2.3	33fc / 1.8
		PANELFIA/032UNV/0840/22Q/WH									
2'x4'[2]	32W	PANELFIA/032UNV/0835/24Q/WH	44fc / 3.3	36fc / 2.8	32fc / 2.0	43fc / 2.7	35fc / 2.4	31fc / 1.8	42fc / 2.5	34fc / 2.3	31fc / 1.7
		PANELFIA/032UNV/0840/24Q/WH									
	40W	PANELFIA/040UNV/0835/24Q/WH	62fc / 3.3	51 fc /2.8	46fc / 2.0	60fc / 2.7	50fc / 2.4	44fc / 1.8	59fc / 2.5	48fc / 2.3	43fc / 1.7
		PANELFIA/040UNV/0840/24Q/WH									

*Table also applicable to emergency versions.

Ordering Information

Item Number	Ordering Abbreviation	Power (W)	Input Voltage	Dimming	CRI	Color Temp (CCT)	Size	Total Fixture Lumens	LPW*	DLC	Options
74243	PANELFIA/032UNV/0835/14Q/WH	32	120-277V	0-10V	>80	3500K	1x4	3200	102	Std	--
74244	PANELFIA/032UNV/0840/14Q/WH	32	120-277V	0-10V	>80	4000K	1x4	3300	104	Std	--
74251	PANELFIA/032UNV/0835/22Q/WH	32	120-277V	0-10V	>80	3500K	2x2	3500	110	Std	--
74252	PANELFIA/032UNV/0840/22Q/WH	32	120-277V	0-10V	>80	4000K	2x2	3500	110	Std	--
74247	PANELFIA/032UNV/0835/24Q/WH	32	120-277V	0-10V	>80	3500K	2x4	3300	104	Std	--
74248	PANELFIA/032UNV/0840/24Q/WH	32	120-277V	0-10V	>80	4000K	2x4	3300	104	Std	--
74249	PANELFIA/040UNV/0835/24Q/WH	40	120-277V	0-10V	>80	3500K	2x4	4200	109	Std	--
74250	PANELFIA/040UNV/0840/24Q/WH	40	120-277V	0-10V	>80	4000K	2x4	4200	110	Std	--
74245	PANELFIA/032UNV/0835/14Q/WH/E	32	120-277V	0-10V	>80	3500K	1x4	3200	102	Std	Emergency Battery Backup
74246	PANELFIA/032UNV/0840/14Q/WH/E	32	120-277V	0-10V	>80	4000K	1x4	3300	104	Std	Emergency Battery Backup
74253	PANELFIA/032UNV/0835/22Q/WH/E	32	120-277V	0-10V	>80	3500K	2x2	3500	110	Std	Emergency Battery Backup
74254	PANELFIA/032UNV/0840/22Q/WH/E	32	120-277V	0-10V	>80	4000K	2x2	3500	110	Std	Emergency Battery Backup
74239	PANELFIA/032UNV/0835/24Q/WH/E	32	120-277V	0-10V	>80	3500K	2x4	3300	104	Std	Emergency Battery Backup
74240	PANELFIA/032UNV/0840/24Q/WH/E	32	120-277V	0-10V	>80	4000K	2x4	3300	104	Std	Emergency Battery Backup
74241	PANELFIA/040UNV/0835/24Q/WH/E	40	120-277V	0-10V	>80	3500K	2x4	4200	109	Std	Emergency Battery Backup
74242	PANELFIA/040UNV/0840/24Q/WH/E	40	120-277V	0-10V	>80	4000K	2x4	4200	110	Std	Emergency Battery Backup

*LPW per LM79 report.
For further information and to learn more about utility rebates, contact your local SYLVANIA sales representative.

Options Information

Emergency Battery Backup:
Activates when normal power supply to the fixture fails, providing a minimum of 650 lumens (700 nominal lumens) for at least 90 minutes.

LEDVANCE LLC
200 Ballardvale Street
Wilmington, MA 01887 USA
Phone: 1-800-LIGHTBULB (1-800-544-4828)
www.sylvania.com

/sylvania /sylvania

Metalux

DESCRIPTION

Our updated WNLED series is a versatile utility based, traditionally styled LED wraparound series which can be used in a broad range of commercial, schools, institutional, retail and residential applications. This high quality luminaire series utilizes the latest solid state LED lighting and advanced electronic driver technology which provides optimal lighting performance and maximizing energy savings. WNLED is designed to provide long service life eliminating re-lamping issues and minimizing maintenance common with traditional fluorescent.

Catalog #		Type	
Project			
Comments		Date	
Prepared by			

SPECIFICATION FEATURES

Construction
Housing consists of die formed cold rolled steel. Ends formed with the housing for strength and provisions for continuous row aligners. Steel end plates with 7/8" KO and light-seal embossment. Driver cover can be removed by taking out four pan screws.

Controls
WNLED is Powered by Fifth Light, with standard a 0-10V continuous dimming driver that works with any 0-10V control/ dimmer. Combine with energy saving products like occupancy sensors, daylighting controls and lighting relay panels to maximize energy savings. Dimming range is 10% to 100%; varies by control device.

Electrical
Long-Life LED system coupled with electrical driver to deliver optimal performance. LED's available in 3000K, 3500K, 4000K and 5000K with a typical CRI 85. Projected life is 60,000 hours at 70% lumen output. UL listed. Electronic drivers are available for 120-277V applications. A 0-10V dimming driver is standard.

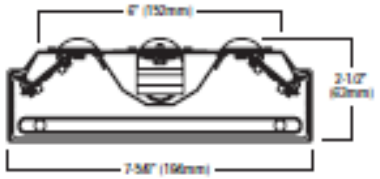
Finish
Multistage iron phosphate pretreatment ensures maximum bonding and rust inhibitor. High reflective paint after fabrication, baked white enamel finish is standard.

Channel/Wireway Cover
Die formed heavy gauge steel. Tight fit for ease of maintenance.

Shielding
Acrylic, high performance, frost blend. Sides have inside linear prisms and bottom has pyramidal prisms for low brightness control.

Installation
Fixture may be surface, pendant, or stem mounted. See accessories below for ordering information.

Compliance
Modules are UL recognized components and indoor luminaires are cULus listed for 25ºC ambient environments, damp location listed, RoHS compliant, and LED modules comply with IESNA LM-79 and LM-80 standards. DesignLights Consortium™ Qualified and classified for DLC Standard, refer to www.designlights.org for details.

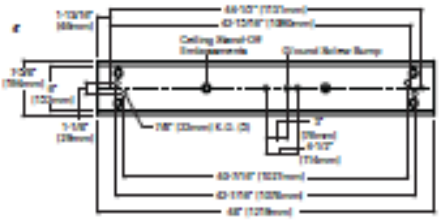


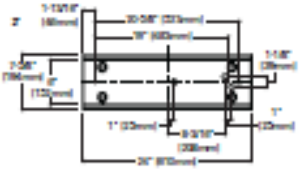
WNLED
LED

Utility LED Wraparound

powered by fifthlight

MOUNTING DATA





WATTAGE

Length	Lumens	Wattage
2 ft.	2800	28
4 ft.	3200	28
4 ft.	4000	36
4 ft.	5000	47

ENERGY AND PERFORMANCE DATA BY CATALOG NUMBER

Stock*/ MTO**	Lumen Type	Length	Catalog Number	Nomial Lumens	Wattage	lm/W
MTO	Standard	2 ft.	2WNLED-LD4-28SL-F-UNV-L8XX-CD1-U	2786	28	101
MTO	Standard	4 ft.	4WNLED-LD4-32SL-F-UNV-L8XX-CD1-U	3298	28	118
Stock	Standard	4 ft.	4WNLED-LD4-40SL-F-UNV-L8XX-CD1-U	4062	36	113
Stock	Standard	4 ft.	4WNLED-LD4-50SL-F-UNV-L8XX-CD1-U	4966	47	107

* Stocked in 2500K and 4000K
** Also available in 3000k, 5000K

EATON
Powering Business Worldwide

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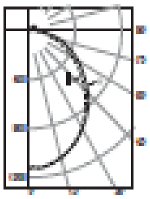
PHOTOMETRICS



4WNLED-LD4-32SL-F-UNV-L825-CD1-U

Electronic Driver

Linear LED 2500K

Spacing criterion: (II) 1.2 x mounting height, (⊥) 1.2 x mounting height

Lumens: 3298

Input Watts: 28.0W

Efficacy: 117.8 lm/W

Test Report: 4WNLED-LD4-32SL-F-UNV-L825-CD1-U.IES

Candlepower

Angle	Along II	45°	Across ⊥
0	1134	1134	1134
5	1134	1136	1136
10	1103	1103	1100
15	1080	1071	1071
20	1023	1029	1027
25	960	975	978
30	898	913	915
35	828	845	850
40	747	771	783
45	668	690	707
50	580	613	633
55	504	532	554
60	423	458	478
65	342	377	400
70	265	300	327
75	180	231	257
80	117	164	190
85	36	100	122
90	0	44	70

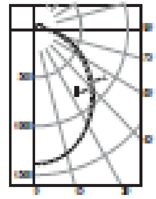
Coefficients of Utilization

Effective floor cavity reflectance 20%

rc	80%				70%				50%			30%			10%			0%
rw	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
RCR																		
0	118	118	118	118	114	114	114	114	108	108	108	103	103	103	97	97	97	94
1	107	102	97	93	103	99	93	91	94	90	87	89	88	84	84	82	80	76
2	97	88	82	76	94	86	80	74	82	78	72	76	73	69	74	70	67	64
3	88	78	69	63	85	76	68	63	73	65	60	68	63	58	65	60	57	54
4	81	69	60	53	78	67	58	53	64	57	51	61	55	50	58	53	49	46
5	74	62	53	46	72	60	52	45	58	50	44	55	48	43	53	47	42	40
6	68	55	46	40	66	54	46	40	52	44	39	50	43	38	47	42	37	35
7	64	50	41	35	62	49	41	35	47	40	34	45	39	34	43	38	33	31
8	59	46	37	32	57	45	37	31	43	36	31	41	35	30	40	34	30	28
9	55	42	34	28	54	41	33	28	40	33	28	38	32	27	37	31	27	25
10	52	39	31	26	50	38	31	26	37	30	25	35	29	25	34	29	24	23

Zonal Lumen Summary

Zone	Lumens	% Fixture
0-30	855	25.9
0-40	1381	41.9
0-60	2390	72.5
0-90	3108	94.3
0-180	3298	100.0



4WNLED-LD4-40SL-F-UNV-L825-CD1-U

Electronic Driver

Linear LED 2500K

Spacing criterion: (II) 1.2 x mounting height, (⊥) 1.2 x mounting height

Lumens: 4062

Input Watts: 36.0W

Efficacy: 112.8 lm/W

Test Report: 4WNLED-LD4-40SL-F-UNV-L825-CD1-U.IES

Candlepower

Angle	Along II	45°	Across ⊥
0	1388	1388	1388
5	1382	1380	1372
10	1360	1357	1354
15	1318	1320	1320
20	1261	1268	1268
25	1190	1201	1203
30	1108	1123	1130
35	1018	1042	1048
40	922	951	964
45	823	857	868
50	722	758	773
55	620	660	678
60	521	561	584
65	427	464	492
70	328	373	403
75	234	285	317
80	146	201	233
85	70	123	134
90	1	57	88

Coefficients of Utilization

Effective floor cavity reflectance 20%

rc	80%				70%				50%			30%			10%			0%
rw	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
RCR																		
0	118	118	118	118	114	114	114	114	108	108	108	103	103	103	97	97	97	94
1	107	102	97	93	103	99	93	91	94	90	87	89	88	84	84	82	80	76
2	97	88	82	76	94	86	80	74	82	78	72	76	73	69	74	70	67	64
3	88	78	69	63	85	76	68	63	73	65	60	68	63	58	65	60	57	54
4	81	69	60	53	78	67	58	53	64	57	51	61	55	50	58	53	49	46
5	74	62	53	46	72	60	52	45	58	50	44	55	48	43	53	47	42	40
6	68	55	46	40	66	54	46	40	52	44	39	50	43	38	47	42	37	35
7	64	50	41	35	62	49	41	35	47	40	34	45	39	34	43	38	33	31
8	59	46	37	32	57	45	37	31	43	36	31	41	35	30	40	34	30	28
9	55	42	34	28	54	41	33	28	40	33	28	38	32	27	37	31	27	25
10	52	39	31	26	50	38	31	26	37	30	25	35	29	25	34	29	24	23

Zonal Lumen Summary

Zone	Lumens	% Fixture
0-30	1054	25.9
0-40	1702	41.9
0-60	2960	72.9
0-90	3832	94.3
0-180	4062	100.0

LUMEN MAINTENANCE

Ambient Temperature	TM-21 Lumen Maintenance (12,000 hours)	Theoretical L70 (Hours)
25°C	80.7%	85,000

Max Ambient temp in compliance with UL: 40°C

ORDERING INFORMATION

SAMPLE NUMBER: 4WNLED-LD4-40SL-F-UNV-L850-CD1-U

Length
2–2 ft.
4–4 ft.

Series *
WNLED–Utility LED Wraparound

Lamp Type
LD4–LED 4.0

LED Lumens Output
26SL–2600 **
32SL–3200
40SL–4000
50SL–5000

Lens
F–Frost Acrylic (standard)

Voltage
347–347V***
480–480V***
UNV–Universal Voltage 120-277

CCT
L830–3000K
L835–3500K
L840–4000K
L850–5000K

Driver Type
CD–0-10V Dimming Driver (10% - 100% Dimming)

Number of Drivers
1–1 Driver

Packaging
U–Unit Pack

ACCESSORIES

SCF–Fixed Stem Set (Specify Length)
SCS–Swivel Stem Set (Specify Length)
SCA–Adjustable 48" Stem Set
A18/Spacer-U–Spacer 1-1/2" to 2-1/2" from ceiling (Use 2 per fixture)

NOTES: * 2 ft. model. ** 4 ft. model only. *** DesignLights Consortium™ Qualified and classified for DLC Standard, refer to www.designlights.org for details.
Specifications & dimensions subject to change without notice. Consult your Eaton Representative for availability and ordering information.

SHIPPING DATA

Catalog No.	Wt.
2WNLED	5 lbs.
4WNLED	9 lbs.

EATON
Powering Business Worldwide

Eaton
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

Specifications and dimensions subject to change without notice.

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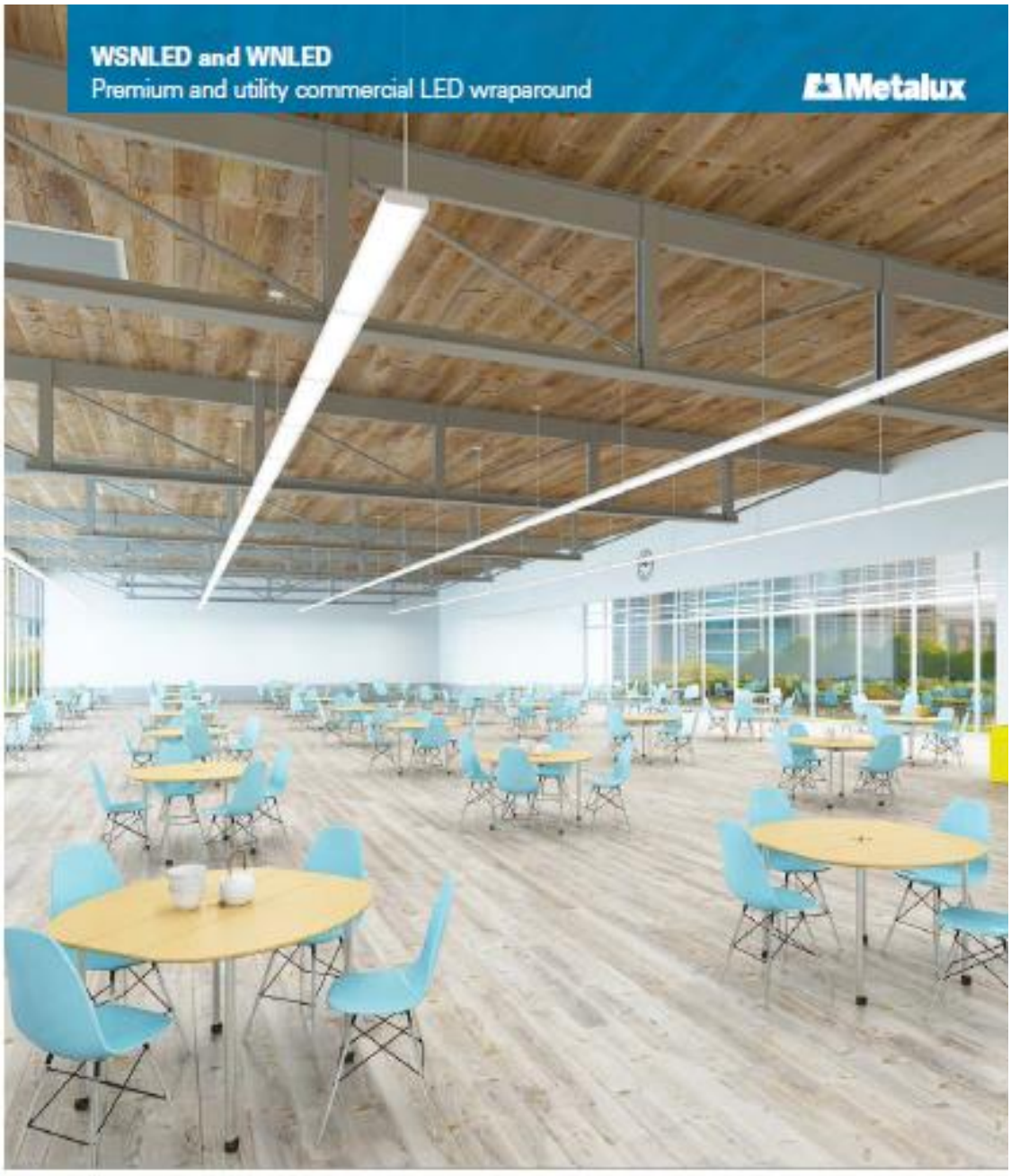
2016-06-27 12:07:00



Powering Business Worldwide

These two new product lines offer traditionally styled wraparound with Eaton's latest market leading LED and energy efficiency driver technologies. Offered in a number of lumen packages, color temperatures and driver options with excellent controls compatibility, the **WSNLED** and **WNLED** series enables customers to have the ideal balance with aesthetics, performance and energy efficiency. Additionally, the WSNLED series utilizes premium optical material which enhances the visual aesthetics providing customers with even, clean illumination eliminating lamp image commonly associated with traditional fluorescent solutions.

Product performance

- 4' and 2' product configurations
- Lumen package - WSNLED (15) and WNLED (4)
- Evenly illuminated lens (WSNLED) for premium aesthetic or new frost prismatic lens (WNLED)
- Multiple CCT: 3000K, 3500K, 4000K, 5000K at 82+ CRI
- Excellent performance, up to 118 lm/W
- Powered by Fifth Light. 0-10V dimming driver is standard for compatibility with 0-10V wallbox dimmers (10% -100%)
- Go Digital: Upgrade to the Powered by Fifth Light DALI drivers
- Ideal for surface and suspended applications
- L70 at 60,000 hours
- Five-year warranty

Compliances

- LED modules comply with IESNA LM-79 and LM-80 standards
- cULus listed 1598 for damp locations
- RoHS compliant

Product controls

All WSNLED and WNLED models come with standard drivers, which work with wall dimmers and sensors, and can also scale up to digital drivers that work with Fifth Light whole-building systems. WNLED luminaires with integrated Eaton lighting controls will improve energy savings and user comfort for any space.

- **0 - 10V Dimming Standard**
  WSNLED and WNLED include 0-10V (analog) dimming for direct control using Eaton wall dimmers, as well as Greengate room controllers, sensors, and lighting control panels.
- **120/277V Occupancy and Daylight Sensors**
  Both WSNLED and WNLED save money and energy when paired with Eaton occupancy and/or daylight sensors, including dimming daylight sensors using the 0-10V dimming interface.
- **Fifth Light Digital Addressable Lighting Interface (DALI) Control Systems**
  WSNLED and WNLED are available with native Fifth Light DALI drivers for complete digital energy management using capable and scalable Fifth Light controllers and software. For details on the Fifth Light solution, please visit www.eaton.com/lightingsystems

Ordering Information

WSNLED

Sample Number: 4WSNLED-LD4-40SL-F-UNV-L840-CD1-U

Length	Series	Lamp Type	LED Lumens Output	Lens	Voltage	Options
2=2 ft. 4=4 ft.	**WSNLED**=Premium Commercial LED Wraparound	**LD4**=LED 4.0	**20SL**=2000 Lumens [1] **24SL**=2400 Lumens **28SL**=2800 Lumens **32SL**=3200 Lumens **36SL**=3600 Lumens **40SL**=4000 Lumens **44SL**=4400 Lumens **48HL**=4800 Lumens **52HL**=5200 Lumens **56HL**=5600 Lumens **60HL**=6000 Lumens **64HL**=6400 Lumens	F=Frost Acrylic (Standard)	**347**=347V [2] **480**=480V [2] **UNV**=Universal Voltage 120-277	<u>Emergency</u> **EL7W**=7-watt, 120V-277V emergency battery pack installed [4] **EL14W**=14-watt, 120V-277V emergency battery pack installed [4]

CCT	Driver Type	Number of Drivers	Packaging	Accessories (Order Separately)
<u>CCT</u> **L830**=3000K **L835**=3500K **L840**=4000K **L850**=5000K	**CD**=0-10V Dimming Driver (10% - 100% Dimming) **SD**=Step-Dim (Bi Level) [3] **SLTD**=Fifth Light DALI Driver (10% - 100% Dimming) [2, 5]	**1**=1 Driver	**U**=Unit Pack	**SCF**=Fixed Stem Set (Specify Length) **SCS**=Swivel Stem Set (Specify Length) **SCA**=Adjustable 48" Stem Set **A18/Spacer-U**=Spacer 1-1/2" to 2-1/2" from ceiling (Use 2 per fixture)

NOTES: 1. 2 ft. models. 2. 4 ft. models only. 3. Step-dim only available for 4000, 5000 and 6400 lumen units. 4. With integral test switch/indicator/laser test. For approximate delivered lumens multiply the lumens per watt of the desired fixture by the wattage of the emergency battery pack. (100 lm/W x 7 = 700 lumens). Bi-Lumi photometry for luminaire under emergency operation available. 5. SLTD DALI driver available for 4000 lumen unit only.

Specifications & dimensions subject to change without notice. Consult your Eaton representative for availability and ordering information.

WNLED

Sample Number: 4WNLED-LD4-40SL-F-UNV-L840-CD1-U

Length	Series	Lamp Type	LED Lumens Output	Lens	Voltage	CCT
2=2 ft. 4=4 ft.	**WNLED**=Utility LED Wraparound	**LD4**=LED 4.0	**28SL**=2800 Lumens [1] **32SL**=3200 Lumens **40SL**=4000 Lumens **50SL**=5000 Lumens	F=Frost Acrylic (Standard)	**347**=347V [2] **480**=480V [2] **UNV**=Universal Voltage 120-277	<u>CCT</u> **L830**=3000K **L835**=3500K **L840**=4000K **L850**=5000K

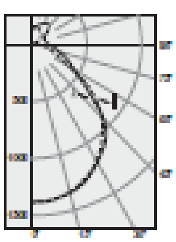
Driver Type	Number of Drivers	Packaging	Accessories (Order Separately)
CD=0-10V Dimming Driver (10% - 100% Dimming)	**1**=1 Driver	**U**=Unit Pack	**SCF**=Fixed Stem Set (Specify Length) **SCS**=Swivel Stem Set (Specify Length) **SCA**=Adjustable 48" Stem Set **A18/Spacer-U**=Spacer 1-1/2" to 2-1/2" from ceiling (Use 2 per fixture)

NOTES: 1. 2 ft. models. 2. 4 ft. models only.

Specifications & dimensions subject to change without notice. Consult your Eaton representative for availability and ordering information.

Photometrics

4WSNLED-LD4-44SL-F-UNV-L835-CD1-U



Coefficients of Utilization

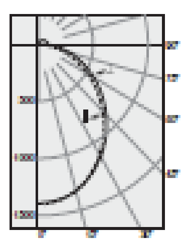
	Effective floor cavity reflectance 20%									
rc	80%				50%			30%		
rw	70	50	30	10	50	30	10	50	30	10
RCR										
0	116	116	116	116	101	101	101	93	93	93
1	106	100	95	92	88	88	83	82	80	77
2	96	88	82	78	78	73	68	72	68	65
3	88	78	70	65	69	65	58	64	60	56
4	80	69	61	56	63	58	51	58	53	50
5	74	62	55	47	56	48	44	52	48	42
6	68	56	47	41	50	45	38	47	41	37
7	64	51	42	37	46	38	34	43	37	33
8	59	46	38	33	42	35	31	39	34	30
9	56	42	35	29	38	32	28	36	31	27
10	52	38	32	28	38	29	25	34	29	28

Electronic Driver
3500K LEDs
Spacing criterion: (||) 1.3 x mounting height, (⊥) 1.3 x mounting height
Lumens: 4426
Input Watts: 43.8W
Efficacy: 101.0 lm/W
Test: 4WSNLED-LD4-44SL-F-UNV-L835-CD1-U.IES

Zonal Lumen Summary

Zone	Lumens	%Fixture
0-30	1084	24.6
0-40	1778	40.2
0-60	3562	80.6
0-90	3636	82.1
0-180	4426	100.0

4WNLED-LD4-40SL-F-UNV-L835-CD1-U



Coefficients of Utilization

	Effective floor cavity reflectance 20%									
rc	80%				50%			30%		
rw	70	50	30	10	50	30	10	50	30	10
RCR										
0	118	118	118	118	108	108	108	102	102	102
1	107	102	97	93	94	90	87	88	86	84
2	97	88	82	78	82	78	72	78	73	68
3	88	78	69	63	73	65	60	68	63	58
4	81	69	60	53	66	57	51	61	56	50
5	74	62	53	48	57	50	46	56	50	45
6	68	56	48	43	53	48	39	50	43	39
7	64	50	41	36	47	40	36	45	38	34
8	58	46	37	33	43	36	31	41	35	32
9	56	43	34	30	40	33	30	38	33	27
10	52	39	31	28	37	30	25	35	29	25

Electronic Driver
3500K LEDs
Spacing criterion: (||) 1.2 x mounting height, (⊥) 1.2 x mounting height
Lumens: 4062
Input Watts: 36.0W
Efficacy: 112.8 lm/W
Test: 4WNLED-LD4-40SL-F-UNV-L835-CD1-U.IES

Zonal Lumen Summary

Zone	Lumens	%Fixture
0-30	1094	26.8
0-40	1702	41.8
0-60	2985	73.5
0-90	3502	86.2
0-180	4062	100.0

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Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

Canada Sales
6825 McLaughlin Road
Mississauga, Ontario L5R 1B8
P: 905-501-3000
F: 905-501-3172

Printed in USA
Publication No. BR6180171EN
April 15, 2016

APPENDIX D. FLUORESCENT BULB SPECIFICATION SHEETS

The specification sheets for the fluorescent bulbs replaced in this study are provided in this appendix. Web links to each of these specification sheets are also provided below:

GE Lighting Ecolux® Starcoat® T8 spec sheet:
http://commercial.gelighting.com/catalog/p/26668

Philips T8 Standard F32T8/TL741 spec sheet:
https://www.irby.com/Images/img/046677/1086143%20spec.pdf

Philips ALTO II Technology brochure:
http://www.newgreenmovement.com/FILES/doc/23_Philips%20T8%20spec%20sheet.pdf
http://images.philips.com/is/content/PhilipsConsumer/PDFDownloads/United%20States/ODLI20150929_001-UPD-P-5338-J.pdf

Philips T8 Standard F32T8/TL841/ALTO spec sheet:
http://www.usa.lighting.philips.com/prof/lamps/fluorescent-lamps-and-starters/tl-d/t8-standard/927869784105_NA/product

Sylvania T8 Standard FO32/741/ECO spec sheet:
https://s3.amazonaws.com/cesco-content/unilog/Batch5/046135/499126-AttachmentURL.pdf

TCP, Inc. Lamp code F32T8/741 spec sheet:
https://www.platt.com/CutSheets/TCP/TCPI_F32T8741_PDF.PDF

GE Lighting

26668 - GE Ecolux® Starcoat® T8

F32T8/SP41/ECO

Passes TCLP, which can lower disposal costs.

Product Photo

GENERAL CHARACTERISTICS

Base Description	Medium Bi-Pin
Base Type	Pin/Plug-In
Mercury Content	2.95 mg
Mercury Picogram per mean lm hr	36.3
Rated Life: Instant Start-Hrs	21000 h @ 3 h 30000 h @ 12 h
Rated Life: Rapid Start - Hrs	30000 h @ 3 h 36000 h @ 12 h
Starting Temp (MIN) C-degrees	10 °C
Bulb Material	Soda lime
Rated Life Hours-nominal	30000 h
Primary Application	Full Wattage
Product Technology	Linear Fluorescent
Base	G13
Bulb Shape	T8

PHOTOMETRIC CHARACTERISTICS

Mean Lumens-nominal	2300 lm
Nominal Initial Lumen per Watt	77
Initial Lumens-nominal	2450 lm
Color Rendering Index-CRI	78
Color Temperature	4100 K

PRODUCT INFORMATION

Product Code	26668
Description	F32T8/SP41/ECO
Alternative Unit Of Measure	Case
Standard Package Quantity	36
Ean UPC	043168266680
Standard Package GTIN	10043168266687
No Of Items Per Sales Unit	1
No Of Items Per Standard Package	36
Sales Unit	Unit
UCC	043168266680

DIMENSIONS

Bulb Diameter (DIA) <Max>	1.1 in
Bulb Diameter (DIA) <Min>	0.94 in
Diameter	1 in
End of Base Pin to Pin	47.67 in
Face to End of Opposing Pin (B) <Max>	47.5 in
Face to End of Opposing Pin (B) <Min>	47.4 in
Nominal Length	48 in

ELECTRICAL CHARACTERISTICS

Scotopic/Photopic Ratio	1.6
Current Crest Factor (MAX)	1.7
Open Circuit Voltage (rapid start) Min @ Temperature	315.00 V @ 10 °C
Cathode Resistance Ratio - Rh/Rc (MIN)	4.250
Cathode Resistance Ratio - Rh/Rc (MAX)	6.500
Rated power (Watts)	32 W

CAUTIONS & WARNINGS

Caution

Lamp may shatter and cause injury if broken

Wear safety glasses and gloves when handling lamp.

Do not use excessive force when installing lamp.

Warning

Risk of Electric Shock

Turn power off before inspection

T8 Standard

F32T8/TL741 ALTO

Philips T8 lamps are energy-efficient lighting solutions.

Product data

• General Characteristics

Base	Medium Bi-Pin (Medium Bi-Pin Fluorescent)
Base Information	Green Base
Bulb	T8
Energy Saving	Energy Saving
Rated Avg Life (12-Hr Prog St)	36000 hr
Rated Avg Life (12-Hr Inst St)	30000 hr
Rated Avg Life (3-Hr Prog St)	30000 hr
Rated Avg Life (3-Hr Inst St)	24000 hr

• Light Technical Characteristics

Color Code	TL741 (CCT of 4100K)
Color Rendering Index	78 Ra8
Color Designation	TL741
Color Temperature	4100 K
Initial lumen	2600 Lm
Design Mean Lumens	2470 Lm

• Electrical Characteristics

Watts	32 W

• Environmental Characteristics

Mercury (Hg) Content	1.7 mg
Picogram per Lumen Hour	27 g/LuHr

• Product Dimensions

Nominal Length (inch)	48

• Footnotes

Footnotes Fluorescent/CFL	920 (Circle E- The encircled E means this bulb meets Federal minimum efficiency standards.)

• Product Data

Product number	281576
Full product name	F32T8/TL741 ALTO
Short product name	F32T8/TL741 ALTO
Pieces per Sku	1
eco_pck_cfc	30
Skus/Case	30
Bar code on pack	46677281571
Bar code on case	50046677281576
Logistics code(s)	927869774118
eco_net_weight_po	0.001 kg

PHILIPS

sense and simplicity

Philips ALTO II Technology

Philips T8 Fluorescent Lamps featuring ALTO II Technology
Better for your business, better for the environment

ALTO lamps with green endcaps have become synonymous with environmental responsibility and low mercury. Since the launch of ALTO Lamp Technology in 1995, 2.0 billion Philips fluorescent lamps with ALTO Lamp Technology have been produced with over 20 tons less mercury than previous non-ALTO lamps[1].

Philips launched ALTO II Technology in 2007. ALTO II Technology has 50% less mercury than prior T8 lamps featuring ALTO Technology, making these lamps the most sustainable linear fluorescents available. Best of all, these lamps offer the same performance levels as ALTO lamps (life, energy, and light output).

Philips T8 Lamp Warranty Periods[2]

Philips Lamp	Instant Start Warranty (3hr/12hr starts)	Programmed Start Warranty (3hr/12hr starts)
T8 700 and 800 Series	30/30 Months	30/36 Months
Advantage T8 32W High Lumen	30/30 Months	36/36 Months
PLUS T8 32W	36/42 Months	42/48 Months
EnergyAdvantage and Value EnergyAdvantage 25W and 32W	36/42 Months	48/54 Months
T8 32W Extra Long Life (XLL)	42/48 Months	48/60 Months
EnergyAdvantage T8 25W and 28W (XLL) Extra Long Life	42/48 Months	48/60 Months

Did you know?

- ALTO II T8 lamps have warranty periods ranging from 2½–4 years[3]
- ALTO II T8 lamps require no burn in before dimming
- ALTO II T8 lamps can contribute to LEED-EB certification. For more information, go to www.usgbc.org

Philips T8 Lamp Family—Life ratings

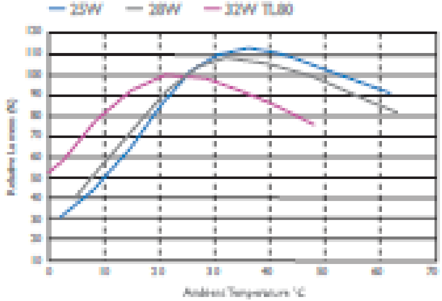
Philips Lamp	Instant Start[4]		Programmed Start[5]	
	3 hours	12 hours	3 hours	12 hours
T8 700 and 800 Series	24,000	30,000	30,000	36,000
Advantage T8 32W High Lumen	24,000	30,000	30,000	36,000
PLUS T8 32W	30,000	36,000	38,000	44,000
EnergyAdvantage and Value EnergyAdvantage 25W and 32W	32,000	38,000	38,000	44,000
T8 32W Extra Long Life (XLL)	40,000	46,000	46,000	52,000
EnergyAdvantage T8 25W and 28W (XLL) Extra Long Life	40,000	46,000	46,000	52,000

1) [1994 Industry average [illegible] - PLC average [illegible]] x 2 billion lamps. Convert to pounds by dividing by 454. Convert to tons by dividing by 2000.
2) Conditions apply—Based on maximum annual burn hours of [illegible]. Please contact Philips for warranty conditions for use of other equipment, including sensors.
3) Warranty Periods [illegible]
4) Average life under engineering data on instant start ballast with lamps turned off and restarted once every 3 or 12 operating hours as indicated.
5) Average life under engineering data on programmed start ballast with lamps turned off and restarted once every 3 or 12 operating hours as noted.

Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg. Qty.	Description	Nom. Length (in)	Rated Average Life 3 Hr. Start (IS)	Rated Average Life 12 Hr. Start (IS)	Approx. Initial Lumens	Design Lumens	CRI
Energy Advantage T8 25 Watt Fluorescent Lamps											
T8 Medium Bipin Featuring ALTO II Technology											
25	28204-6	$ ✦ • †	F32T8/ADV830/XEW/ALTO 25Watt	30	Advantage 830, 3000K	48	32,000	38,000	2500	2450	85
	28209-5	$ ✦ • †	F32T8/ADV835/XEW/ALTO 25Watt	30	Advantage 835, 3500K	48	32,000	38,000	2500	2450	84
	28078-4	$ ✦ • †	F32T8/ADV841/XEW/ALTO 25Watt	30	Advantage 841, 4100K	48	32,000	38,000	2500	2450	82
	15238-9	$ ✦ •	F32T8/ADV841/XEW/ALTO 25Watt	10	Advantage 841, 4100K, 10PK	48	32,000	38,000	2500	2450	82
	28079-2	$ ✦ • †	F32T8/ADV850/XEW/ALTO 25Watt	30	Advantage 850, 5000K	48	32,000	38,000	2400	2350	82
Energy Advantage T8 28 Watt Fluorescent Lamps											
T8 Medium Bipin Featuring ALTO II Technology											
28	28101-4	$ ✦ • †	F32T8/ADV830/EW/ALTO 28 Watt	30	Advantage 830, 3000K	48	32,000	38,000	2725	2645	85
	28102-2	$ ✦ • †	F32T8/ADV835/EW/ALTO 28 Watt	30	Advantage 835, 3500K	48	32,000	38,000	2725	2645	84
	28103-0	$ ✦ • †	F32T8/ADV841/EW/ALTO 28 Watt	30	Advantage 841, 4100K	48	32,000	38,000	2725	2645	82
	28105-5	$ ✦ • †	F32T8/ADV850/EW/ALTO 28 Watt	30	Advantage 850, 5000K	48	32,000	38,000	2675	2595	82

For the most current product information, go to the catalog on www.[illegible].com
Fluorescent symbols and footnotes located on page [illegible]

Relative Light Output vs. Ambient Temperature
4' T8 Lamps—0.88 BF Ballast



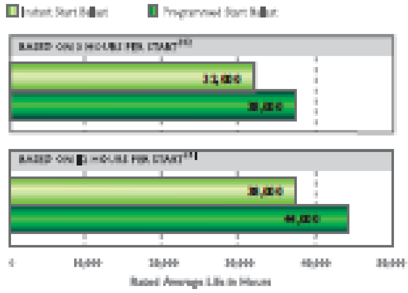
Relative light output with respect to 25°C rated temperature

Energy Advantage 25W T8 Savings

Save 7 Watts Instantly			
7 watts per lamp saved	Energy Saving Calculator		
	Annual Operating Hours**		Savings Over Lamp Life
KWH Rate	4380	8760	38,000 hrs.
$ 0.06	$1.84	$3.68	$15.96
$ 0.08	$2.45	$4.90	$20.28
$ 0.10	$3.07	$6.13	$26.60
$ 0.12	$3.68	$7.36	$31.92
$ 0.20	$6.13	$12.26	$53.20

**4380 hours are based on operating the lamps 12 hours per day/7 days per week.
8760 hours are based on operating the lamps 24 hours per day/7 days per week.

Rated Average Life



Cost of Ownership Savings
Energy Advantage T8 fluorescent lamps vs. standard T8 lamps.

General Overview
Energy Advantage 25W T8 fluorescent lamps provide energy savings of up to 25% versus standard 32W T8, so the benefits and financial impact can be significant.

Benefits
By using Energy Advantage 25W T8 lamps the energy saving of 7 watts per lamp can be achieved instantly by simply changing the lamp.

Financial Impact

Energy Saving per Lamp	7 W
Operating Hours per Year	8760 hours, continuous burn
Cost per kWh	$ .10

Cost of Ownership Savings = $6.13 per lamp per year

Fluorescent Lamps

Value Energy Advantage T8 Lamps

Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg Qty.	Description	Nom. Length (in)	Rated Average Life 3 Hr. Start (333)	Rated Average Life 12 Hr. Start (341)	Approx. Initial Lumens (333,334)	Design Lumens (333,339)	CRI
Energy Advantage T8 Value 25 Watt Fluorescent Lamps											
T8 Medium Bipin Featuring ALTO II Technology											
25	424184	$ ✣ • ǂ	F32T8/VEA835/XEW/ALTO 25W	30	Value Energy Advantage 835, 3500K	48	32,000	38,000	2300	2250	82
	424200	$ ✣ • ǂ	F32T8/VEA841/XEW/ALTO 25W	30	Value Advantage 841, 4100K	48	32,000	38,000	2300	2250	82
	424226	$ ✣ • ǂ	F32T8/VEA850/XEW/ALTO 25W	30	Value Advantage 850, 5000K	48	32,000	38,000	2300	2250	82
Energy Advantage T8 Value 28 Watt Fluorescent Lamps											
T8 Medium Bipin Featuring ALTO II Technology											
28	424176	$ ✣ • ǂ	F32T8/VEA835/EW/ALTO 28W	30	Value Energy Advantage 835, 3500K	48	32,000	38,000	2600	2550	82
	424192	$ ✣ • ǂ	F32T8/VEA841/EW/ALTO 28W	30	Value Advantage 841, 4100K	48	32,000	38,000	2600	2550	82
	424218	$ ✣ • ǂ	F32T8/VEA850/EW/ALTO 28W	30	Value Advantage 850, 5000K	48	32,000	38,000	2600	2550	82

For the most current product information, go to the [illegible] www.[illegible].com
Footnotes, symbols and [illegible] on page [illegible]

T8 Medium Bipin

Fluorescent Lamps

Extra Long Life (XLL) T8 Lamps

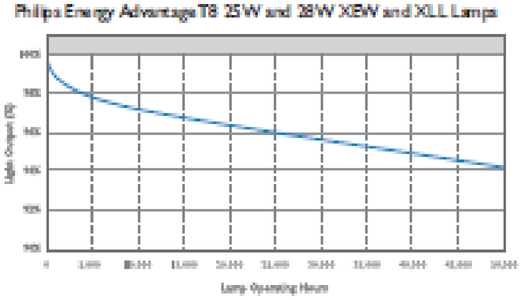
Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg. Qty.	Description	Nom. Length (In.)	Rated Average Life 3 Hr. Start (83)	Rated Average Life 12 Hr. Start (44)	Approx. Initial Lumens (38,84)	Design Lumens (88)	CRI
Extra Long Life Energy Advantage 25 Watt T8 Fluorescent Lamp											
T8 Medium Bipin featuring ALTO II Technology											
25	28121-2	$ + †	F32T8/ADV830/XLL/ALTO 25Watt	30	Advantage 830, 3000K	48	40,000	46,000	2400	2330	85
	28122-0	$ + †	F32T8/ADV835/XLL/ALTO 25Watt	30	Advantage 835, 3500K	48	40,000	46,000	2400	2330	84
	28123-8	$ + †	F32T8/ADV841/XLL/ALTO 25Watt	30	Advantage 841, 4100K	48	40,000	46,000	2400	2330	82
	28125-3	$ + †	F32T8/ADV850/XLL/ALTO 25Watt	30	Advantage 850, 5000K	48	40,000	46,000	2350	2280	82
Extra Long Life Energy Advantage 28 Watt T8 Fluorescent Lamp											
T8 Medium Bipin featuring ALTO II Technology											
28	28146-9	+ †	F32T8/ADV830/XLL/ALTO 28Watt	30	Advantage 830, 3000K	48	40,000	46,000	2675	2595	85
	28148-5	+ †	F32T8/ADV835/XLL/ALTO 28Watt	30	Advantage 835, 3500K	48	40,000	46,000	2675	2595	84
	28127-9	+ †	F32T8/ADV841/XLL/ALTO 28Watt	30	Advantage 841, 4100K	48	40,000	46,000	2675	2595	82
	28128-7	+ †	F32T8/ADV850/XLL/ALTO 28Watt	30	Advantage 850, 5000K	48	40,000	46,000	2625	2545	82
Extra Long Life 32 Watt T8 Fluorescent Lamps											
T8 Medium Bipin featuring ALTO II Technology											
32	28115-4	$ ⊕ + †	F32T8/TL835/XLL/ALTO	30	TL 835, 3500K	48	40,000	46,000	2950	2800	84
	28116-2	$ ⊕ + †	F32T8/TL841/XLL/ALTO	30	TL 841, 4100K	48	40,000	46,000	2950	2800	82
	28120-4	$ ⊕ + †	F32T8/TL850/XLL/ALTO	30	TL 850, 5000K	48	40,000	46,000	2850	2700	82

For the most current product information, go to the e-catalog at www.philips.com

Fluorescent symbols and footnotes located on page [illegible]

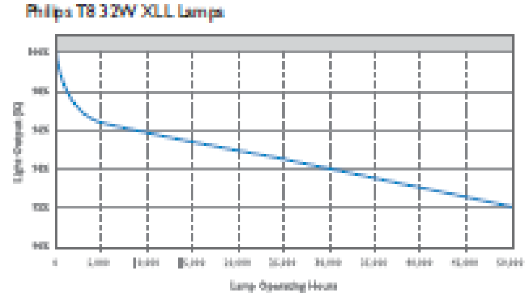
97% Lumen Maintenance

Philips Energy Advantage T8 25W and 28W XEW and XLL Lamps

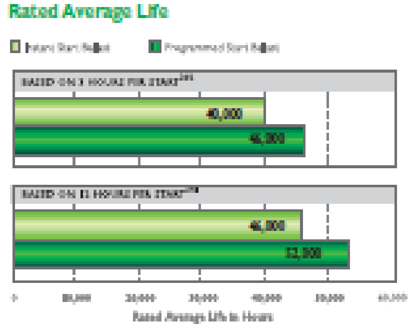


95% Lumen Maintenance

Philips T8 32W XLL Lamps



Rated Average Life



Fluorescent Lamps

Advantage T8 Lamps

Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg Qty	Description	Nom. Length (in.)	Rated Average Life 3 Hr. Start (30)	Rated Average Life 12 Hr. Start (40)	Approx. Initial Lumens (30/40)	Design Lumens (100/35)	CRI
Advantage T8 High Lumen Fluorescent Lamps											
T8 Medium Bipin Featuring ALTO II Technology											
17	28130-3	$ ◈ ● †	F17T8/ADV830/ALTO	30	Advantage 830, 3000K	24	24,000	30,000	1500	1480	85
	28131-1	$ ◈ ● †	F17T8/ADV835/ALTO	30	Advantage 835, 3500K	24	24,000	30,000	1500	1480	86
	28132-9	$ ◈ ● †	F17T8/ADV841/ALTO	30	Advantage 841, 4100K	24	24,000	30,000	1500	1480	82
25	28140-2	$ ◈ ● †	F25T8/ADV835/ALTO	30	Advantage 835, 3500K	36	24,000	30,000	2300	2300	86
	28143-8	$ ◈ ● †	F25T8/ADV841/ALTO	30	Advantage 841, 4100K	36	24,000	30,000	2300	2300	82
32	28000-0	□ $ ◈ ● †	F32T8/ADV830/ALTO	30	Advantage 830, 3000K	48	24,000	30,000	3100	3000	85
	28001-8	□ $ ◈ ● †	F32T8/ADV835/ALTO	30	Advantage 835, 3500K	48	24,000	30,000	3100	3000	86
	28005-9	□ $ ◈ ● †	F32T8/ADV841/ALTO	30	Advantage 841, 4100K	48	24,000	30,000	3100	3000	82
	28009-1	□ $ ◈ ● †	F32T8/ADV850/ALTO	30	Advantage 850, 5000K	48	24,000	30,000	3000	2910	82

For the most current product information, go to this website: www.philips.com
Fluorescent symbols and footnotes listed on page 43

Energy Savings: Two Lamp vs. Two Lamp System

Electronic Ballast	Ballast Factor	No. of Lamps	Lamp Watts	Standard T8 Lumens	Advantage T8 Lumens	System Watts	Savings
Standard T8	0.87	2	32	2650	—	58	—
Reduced Light Output T8	0.75	2	32	—	2300	51	$2.80/yr

Combine Advantage T8 lamps with reduced light output electronic ballasts, with these results:

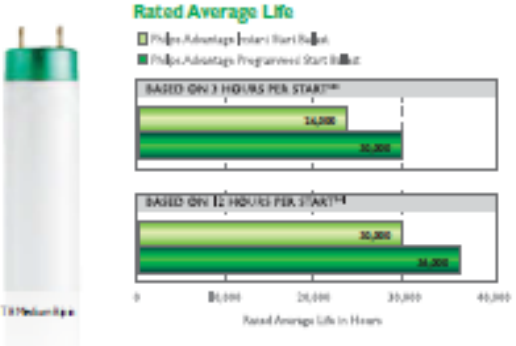
- Saves 7 system watts vs. standard T8 system
- Saves $2.80 per fixture per year
- Energy savings based on 4000 hrs/yr @ $.10 kw/hr

Energy Savings: Two Lamp vs. Three Lamp System

Electronic Ballast	Ballast Factor	No. of Lamps	Lamp Watts	Standard T8 Lumens	Advantage T8 Lumens	System Watts	Savings
Standard T8	0.87	3	32	2650	—	88	—
Increased Light Output T8	1.20	2	32	—	3100	78	$4.00/yr

Combine advantage T8 lamps with increased light output ballasts. A two lamp advantage T8 system vs. a three lamp standard T8 system will:

- Save 10 system watts
- Save $4.00 per fixture per year
- Save energy based on 4000 hrs/yr @ $.10 kw/hr
- Reduce lighting installation costs (lamps, ballasts, fixtures and labor)
- Operate on ballast with ballast factors up to 1.32 with warranty intact



Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg. Qty.	Description	Nom. Length (In.)	Rated Average Life 3 Hr. Start (303)	Rated Average Life 12 Hr. Start (441)	Approx. Initial Lumens (303,304)	Design Lumens (305,320)	CRI

PLUS 800 Series Long Life T8 Fluorescent Lamps

T8 Medium Bipin Featuring ALTO II Technology

Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg. Qty.	Description	Nom. Length (In.)	Rated Average Life 3 Hr. Start (303)	Rated Average Life 12 Hr. Start (441)	Approx. Initial Lumens (303,304)	Design Lumens (305,320)	CRI
17	28093-3	$ ✣ • ‡	F17T8/TL830/PLUS/ALTO	30	TL 830, 3000K	24	30,000	36,000	1400	1330	85
	28094-1	$ ✣ • ‡	F17T8/TL835/PLUS/ALTO	30	TL 835, 3500K	24	30,000	36,000	1400	1330	85
	28095-8	$ ✣ • ‡	F17T8/TL841/PLUS/ALTO	30	TL 841, 4100K	24	30,000	36,000	1400	1330	85
	28096-6	$ ✣ • ‡	F17T8/TL850/PLUS/ALTO	30	TL 850, 5000K	24	30,000	36,000	1325	1260	82
	28193-1	$ ✣ • ‡	F17T8/TL865/PLUS/ALTO	30	TL 865, 6500K	24	30,000	36,000	1275	1210	82
25	28097-4	$ ✣ • ‡	F25T8/TL830/PLUS/ALTO	30	TL 830, 3000K	36	30,000	36,000	2225	2115	85
	28098-2	$ ✣ • ‡	F25T8/TL835/PLUS/ALTO	30	TL 835, 3500K	36	30,000	36,000	2225	2115	85
	28099-0	$ ✣ • ‡	F25T8/TL841/PLUS/ALTO	30	TL 841, 4100K	36	30,000	36,000	2225	2115	85
32	28165-9	$ ✣ • ‡	F32T8/TL830/PLUS/ALTO	30	TL 830, 3000K	48	30,000	36,000	2950	2800	85
	28167-5	$ ✣ • ‡	F32T8/TL835/PLUS/ALTO	30	TL 835, 3500K	48	30,000	36,000	2950	2800	85
	28179-0	$ ✣ • ‡	F32T8/TL841/PLUS/ALTO	30	TL 841, 4100K	48	30,000	36,000	2950	2800	85
	30277-0	$ ✣ •	F32T8/TL841/PLUS/ALTO	10	TL 841, 4100K, 10 PK	48	30,000	36,000	2950	2800	85
	28181-6	$ ✣ • ‡	F32T8/TL850/PLUS/ALTO	30	TL 850, 5000K	48	30,000	36,000	2850	2710	82

PLUS 700 Series Long Life T8 Fluorescent Lamps

T8 Medium Bipin Featuring ALTO II Technology

Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg. Qty.	Description	Nom. Length (In.)	Rated Average Life 3 Hr. Start (303)	Rated Average Life 12 Hr. Start (441)	Approx. Initial Lumens (303,304)	Design Lumens (305,320)	CRI
32	28182-4	$ ✣ • ‡	F32T8/TL730/PLUS/ALTO	30	TL 730, 3000K	48	30,000	36,000	2800	2660	78
	28183-2	$ ✣ • ‡	F32T8/TL735/PLUS/ALTO	30	TL 735, 3500K	48	30,000	36,000	2800	2660	78
	28184-0	$ ✣ • ‡	F32T8/TL741/PLUS/ALTO	30	TL 741, 4100K	48	30,000	36,000	2800	2660	78
	28185-7	$ ✣ • ‡	F32T8/TL750/PLUS/ALTO	30	TL 750, 5000K	48	30,000	36,000	2700	2550	78
	42806-1	$ ✣ • ‡	F32T8/TL765/PLUS/ALTO	30	TL 765, 6500K	48	30,000	36,000	2750	2610	78

For the most current product information, go to the e-catalog at www.philips.com
Fluorescent symbols and footnotes located on page 48

T8 Medium Bipin

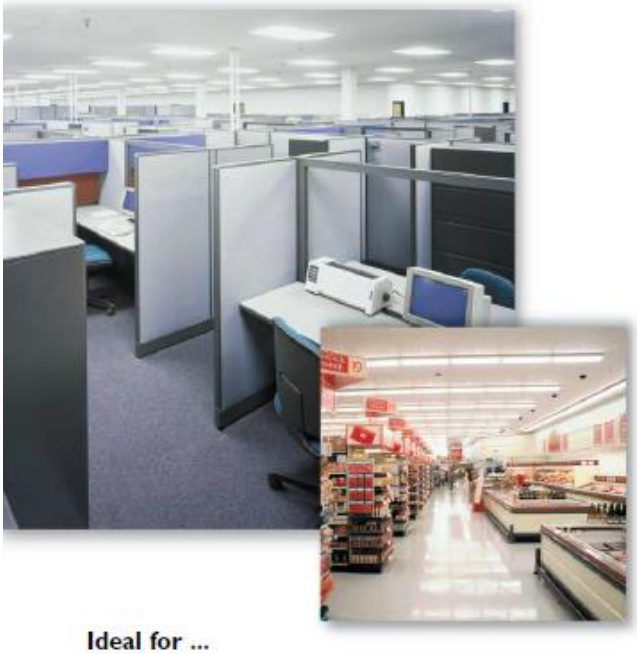
Rated Average Life

Alto® Universal T8 Fluorescent Lamps

Featuring Full Rated Life on all T8 Ballast Types*

*Instant Start, Rapid Start, Programmed Start, and Hybrid ballasts

NEW!
Philips Exclusive!
The first T8 that delivers full rated life on Instant Start ballasts!



Ideal for ...

Any lighting application requiring maximum quality of light and maintained light output.

- **Reduced Cost-of-Ownership**
  - –33% longer life on Instant Start ballasts
  - –Pair T8 lamps with electronic ballasts
  - –Lower energy costs by 40% and provide light output equal to electromagnetic T12 systems
- **Outstanding Lumen Maintenance**
  - –HI-VISION® Phosphor delivers 95% lumen maintenance in both TL70 and TL80 lamps
  - –HI-VISION Phosphor, combined with Philips exclusive cathode guard, ensures superior lumen maintenance throughout lamp life and reduces lamp end blackening
- **Enhanced CRI**
  - –86 CRI TL80 T8 lamps
  - –78 CRI TL70 T8 lamps
- **ALTO® Advantage™ and ALTO PLUS deliver 24,000 hours of rated life**
  - –A 20% increase over standard T8 lamps
  - –ALTO® Advantage lamps deliver 10% more lumens than standard T8 lamps
- **Low-Mercury, TCLP Compliant**
  - Reduction in mercury content of more than 66% when compared to the 1999 industry average
- **Green End-Caps™**
  - Allow for product differentiation at time of purchase and at end of lamp life

ALTO® Universal T8 Fluorescent Lamps (Featuring Full Rated Life on all T8 Ballast Types*)

Electrical, Technical and Ordering Data (Subject to change without notice)

Product Number 046677-	Ordering Code	Package Quantity	Description	Nominal Length (In.)	Rated Life (Hrs.)[1] Instant Start	Rapid Start	Initial Lumens	Approx. Design Lumens[2]	CRI	Lumen Maintenance
Advantage® Ultimate Performance Lamps / T8 Medium Bi-pin featuring HI-VISION® Phosphor 24,000 Hour										
27064-5	F32T8/ADV830/ALTO	25	Advantage T8, 3000K	48	24,000	24,000	3100	2950	86	95%
27065-2	F32T8/ADV835/ALTO	25	Advantage T8, 3500K	48	24,000	24,000	3100	2950	86	95%
27066-0	F32T8/ADV841/ALTO	25	Advantage T8, 4100K	48	24,000	24,000	3100	2950	86	95%
27068-6	F32T8/ADV850/ALTO	25	Advantage T8, 5000K	48	24,000	24,000	3100	2950	86	95%
Long Life PLUS Fluorescent Lamps / T8 Medium Bi-pin featuring HI-VISION Phosphor 24,000 Hour										
36000-8	F32T8/TL830PLUS/ALTO	25	TL 80, 3000K, Long Life	48	24,000	24,000	2950	2800	86	95%
36001-6	F32T8/TL835PLUS/ALTO	25	TL 80, 3500K, Long Life	48	24,000	24,000	2950	2800	86	95%
36002-4	F32T8/TL841PLUS/ALTO	25	TL 80, 4100K, Long Life	48	24,000	24,000	2950	2800	86	95%
36003-2	F32T8/TL850PLUS/ALTO	25	TL 80, 5000K, Long Life	48	24,000	24,000	2950	2800	86	95%
38261-4	F32T8/TL865PLUS/ALTO	25	TL 80, 6500K, Long Life	48	24,000	24,000	2850	2710	86	95%
36004-0	F32T8/TL730PLUS/ALTO	25	TL 70, 3000K, Long Life	48	24,000	24,000	2850	2710	78	95%
36005-7	F32T8/TL735PLUS/ALTO	25	TL 70, 3500K, Long Life	48	24,000	24,000	2850	2710	78	95%
36013-1	F32T8/TL741PLUS/ALTO	25	TL 70, 4100K, Long Life	48	24,000	24,000	2850	2710	78	95%
36014-9	F32T8/TL750PLUS/ALTO	25	TL 70, 5000K, Long Life	48	24,000	24,000	2850	2710	78	95%
TL80 Fluorescent Lamps / T8 Medium Bi-pin featuring HI-VISION Phosphor										
24667-8	F32T8/TL830/ALTO	25	TL 80, 3000K	48	20,000	20,000	2950	2800	86	95%
24670-2	F32T8/TL835/ALTO	25	TL 80, 3500K	48	20,000	20,000	2950	2800	86	95%
24671-0	F32T8/TL841/ALTO	25	TL 80, 4100K	48	20,000	20,000	2950	2800	86	95%
27229-4	F32T8/TL850/ALTO	25	TL 80, 5000K	48	20,000	20,000	2950	2800	86	95%
TL70 Fluorescent Lamps / T8 Medium Bi-pin featuring HI-VISION Phosphor										
27252-6	F32T8/TL730/ALTO	25	TL 70, 3000K	48	20,000	20,000	2850	2710	78	95%
27249-2	F32T8/TL735/ALTO	25	TL 70, 3500K	48	20,000	20,000	2850	2710	78	95%
27248-4	F32T8/TL741/ALTO	25	TL 70, 4100K	48	20,000	20,000	2850	2710	78	95%
27268-2	F32T8/TL750/ALTO	25	TL 70, 5000K	48	20,000	20,000	2750	2550	78	95%

Features ALTO Lamp Technology

[1] Average life under specified test conditions with lamps turned off and restarted once every three operating hours.
[2] Approximate lumens at 40% of rated average life.

Cost of Ownership Savings: ALTO Universal 4-Ft. T8 Lamps vs. Standard 4-Ft. T8 Lamps

General Overview

ALTO Universal T8 lamps provide 33% longer life than standard T8 products on Instant Start Ballasts. With no incremental cost, the benefits and financial impact can be significant.

Benefits

By using ALTO Universal T8 lamps, the lamp replacement and labor costs are extended by an extra 15 months on a facility that operates an average of 4,000 hours per year. For example, current T8 products, with a rated average life expectancy of 15,000 hours on Instant Start ballasts, will last 3 years and 9 months. Conversely, ALTO Universal T8 lamps will operate for 5 years due to their rated average life expectancy of 20,000 hours on Instant Start ballasts.

Financial Impact

With the extended life expectancy of 15 months, combined with the benefits of Philips' exclusive ALTO TCLP-compliant, low mercury technology, the positive financial impact of installing ALTO Universal T8 lamps will provide cost of ownership savings per lamp as follows:

Incremental Cost	($ .00)
Material Cost Avoidance[A]	$ .62
Labor Cost Avoidance[B]	$ 1.11
Disposal Cost Avoidance[C]	$ .36
Cost of Ownership Savings	**$ 2.09**

A Material Cost Avoidance is the annualized acquisition cost per lamp (average cost per lamp of $2.50 for standard T8 product / 5 years = $.50 per year). By installing ALTO PLUS T8 lamps, a material cost per lamp of $.50 is avoided in the sixth year due to the extra year of life expectancy. Note that the average cost per lamp may vary.

B Labor Cost Avoidance is the annualized labor replacement cost per lamp (labor replacement cost per lamp of $4.45 / 5 years = $.89 per year). By installing ALTO PLUS T8 lamps, a labor replacement cost per lamp of $.89 is avoided in the sixth year due to the extra year of life expectancy. Note that the labor replacement cost per lamp may vary. Source: National Lighting Bureau Guide to Office Lighting and Productivity.

C Disposal Cost Avoidance is based on an average of $.09 per ft. for lamp recycling or $.36 per 4-ft. lamp. Philips Lighting Company encourages the recycling of all fluorescent lamps.

ALTO Universal T8 Fluorescent Lamps Featuring Full Rated Life on all T8 Ballast Types*—Lamp Specification

Lamps shall be Philips HI-VISION™ T8 Lamps having:

- Full rated life on Instant Start, Rapid Start, Programmed Start and Hybrid ballasts
- Color rendering index of (78 or 86)
- T8 diameter bulb
- Medium bi-pin bases
- Color temperature of _____K (3000, 3500, 4100, 5000, and 6500)
- Initial lumens of (2750–3100)
- Design lumens of (2550–2950)
- Nominal wattage of 32
- A cathode guard
- Featuring HI-VISION Phosphor.

Philips Lighting Company

PHILIPS

T8 Standard

F32T8/TL841/ALTO 30PK

Product information

Downloads

Leaflet
Size:101.7 kB

See all downloads ›

Where to Buy



Specifications

General Information	
Cap-Base	G13 [Medium Bi-Pin Fluorescent]
Life 12-Hr Programstart [Hrs]	36000 h
Life 12-Hr Instant Start [Hrs]	30000 h
Life 3-Hr Program Start [Hrs]	30000 h
Life 3-Hr Instant Start [Hrs]	24000 h
Features	ALTO® (ALTO)
Footnotes Fluorescent/CFL 1	Circle E- The encircled E means this bulb meets Federal minimum efficiency standards.
Light Technical	
Color Code	TL841 [CCT of 4100K (841)]
Initial lumen (Nom)	2850 lm
Color Designation	TL841
Design Mean Lumens	2710 lm
Correlated Color Temperature (Nom)	4100 K
Color Rendering Index (Nom)	85
Operating and Electrical	
Power (Rated) (Nom)	32 W
Mechanical and Housing	
Cap-Base Information	Green Base
Nominal Length (Inch)	48
Approval and Application	

Energy Saving Product	Energy Saving
Picogram Per Lumen Hour	25 pg/lm.h
Mercury (Hg) Content (Nom)	1.7 mg
Product Data	
Order product name	F32T8/TL841/ALTO 30PK
EAN/UPC - Product	046677281557
Order code	281550
Numerator - Quantity Per Pack	1
Numerator - Packs per outer box	30
Material Nr. (12NC)	927869784105
Net Weight (Piece)	0.001 kg

Product Number: 21999

Order Abbreviation: FO32/741/ECO

General Description: 32W, 48" MOL, T8 OCTRON fluorescent lamp, 4100K color temperature, rare earth phosphor, 78 CRI, suitable for IS or RS operation, ECOLOGIC

Product Information

Abbrev. With Packaging Info.	FO32741ECO 30/CS 1/SKU
Actual Length (in)	48.000
Actual Length (mm)	1219.20
Average Rated Life (hr)	20000
Base	Medium Bipin
Bulb	T8
Color Rendering Index (CRI)	78
Color Temperature/CCT (K)	4100
Diameter (in)	1.098
Diameter (mm)	27.90
Family Brand Name	Octron® 700, Ecologic
Industry Standards	ANSI C78.81 - 2001
Initial Lumens at 25C	2600
Mean Lumens at 25C	2390
Nominal Length (in)	48.000
Nominal Length (mm)	1219.20
Nominal Wattage (W)	32.00
Life at 3 hrs./start on IS ballasts	24000
Life at 12 hrs./start on IS ballasts	28000
Life at 3 hrs./start on PRS ballasts	30000
Life at 12 hrs./start on PRS ballasts	35000

ECOLOGIC™

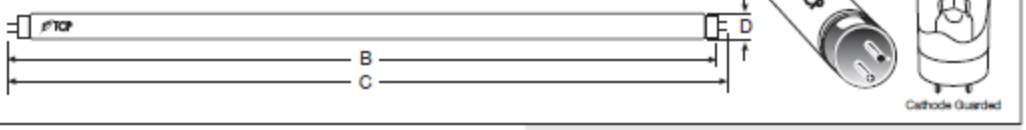
Footnotes

- e 30,000 hour average rated life of OCTRON® 700 Series lamps is based on operation at 3 hours per start on a QUICKTRONIC® programmed rapid start ballast. Average rated life is 35,000 hours at 12 hours per start on a programmed rapid start ballast. On an instant start ballast, the average rated life is 28,000 hours at 12 hours per start, and 24,000 hours at 3 hours per start.

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Minimum starting temperature is a function of the ballast; consult the ballast manufacturer.
- OCTRON lamps should be operated only with magnetic rapid start ballasts designed to operate 265 mA, T-8 lamps or high frequency (electronic) ballasts that are either instant start, or rapid start, or programmed rapid start specifically designed to operate T8 lamps. OCTRON lamps may be operated on instant start ballasts with ballast factors ranging from a minimum of 0.71 to a maximum of 1.20 at the nominal ballast input voltage. When OCTRON lamps are operated in the instant start mode, the two wires or two contacts of each socket should be connected to each other. They should then be connected to the appropriate ballast lead wire using National Electric Code techniques.
- SYLVANIA ECOLOGIC fluorescent lamps are designed to pass the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste in most states. TCLP test results are available upon request. Lamp disposal regulations may vary, check your local & state regulations. For more information, please visit www.lamprecycle.org

F32T8/741 Lamp Specifications

TCP Item Number: 31032741 Lamp code: F32T8/741



Average Rated Life (hours)
3 hours per start ---------- 24,000

TCLP Compliant ---------- Yes
Low Mercury ---------- Yes

Physical Characteristics

Lamp type ---------- T8
Base type ---------- BiPin (G13)
Lamp Material ---------- Soda Lime
Phosphor ---------- Halo-Phosphor
Lamp Diameter (inches)
Nominal (D) ---------- 1.00
Maximum (D) ---------- 1.10
Minimum (D) ---------- .94
Overall Length (inches)
Nominal (C) ---------- 48.00
Maximum (C) ---------- 47.78
Minimum (C) ---------- 47.67
Face to End of opposing pin (inches)
Maximum (B) ---------- 47.50
Minimum (B) ---------- 47.40

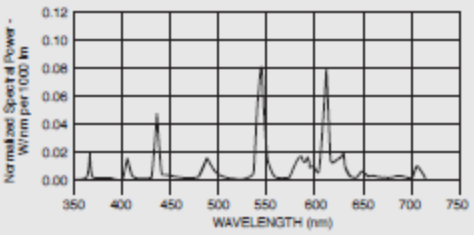
Photometric Characteristics

Initial Lumens ---------- 2350
Mean Lumens (40% of rated life) ---------- 2230
Correlated Color Temperature (Kelvin) ------ 4100
Color Rendering Index (CRI) ---------- 77
Normal Efficacy (Lumens/Watts) ---------- 74

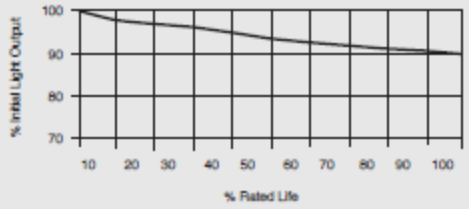
Electrical Characteristics

Lamp Watts ---------- 32
Nominal Lamp Volts ---------- 137
Nominal Lamp Operating Frequency (Hz) -- 50-60 Hz
Min. Starting Lamp Voltage at 10°C -------- 300
Min. Cathode Resistance (Rh/Rc) ---------- 4.25
Max. Cathode Resistance (Rh/Rc) ---------- 6.50

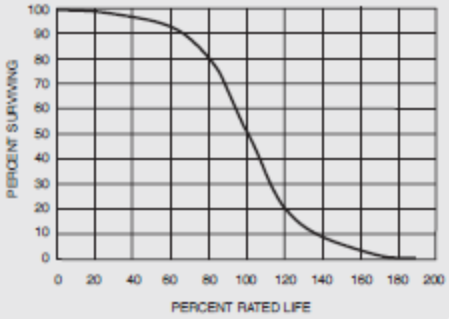
Spectral Power Distribution



Lamp Lumen Maintenance



Typical Lamp Mortality



24 MONTH STANDARD WARRANTY

For the most up-to-date specs, please visit www.tcpi.com

TCP, Inc.
325 Campus Dr. | Aurora, Ohio 44202 | P: 1-800-324-1496 | F: 330-995-6188 | tcpi.com

TCP is proud to have been awarded ENERGY STAR® Partner of the Year 2013.

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APPENDIX E. LED WAVES' LED SAVINGS CALCULATOR EXAMPLE

(800) 986-0169

Call us for special orders, technical assistance, or a free lighting consultation.

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LED Waves' LED Savings Calculator

Making the switch to LED lighting?

Answer the following questions on your current lighting usage, plus the LED replacement, to calculate your savings.

Form

Number of fixtures to be replaced

6 units

Old fixture (to be replaced)

Wattage: 128 Watt

Price per unit: 28 US$

Lifespan: 22,500 hr

Incandescent / Halogen: 1,250 hours
Metal Halide: 6,000 hours
Fluorescent/CFL: 8,000 hours
Pulse Start Metal Halide (PSMH): 15,000 hours
High Pressure Sodium (HPS): 20,000 hours

LED fixture (new fixture)

Wattage: 40 Watt

Price per unit: 132 US$

Lifespan: 50,000 hr

LED: 50,000 hours

Energy rate (electricity cost)

10.2¢/kWh

The average residential price of electricity in the U.S. in 2015 was 12.66¢/kWh.
To find the price per kWh (Kilo Watt hour) for your state and sector, check your energy bill or go to the EIA website.

Hours of operation

Used 5 days a week | 8 hours/day

Other factors (optional)

Labor cost for relamping: $20 per fixture

Calculate savings

Results

Number of light units to be replaced to LED units: 6 units

	Old fixture	LED fixture
Initial cost	Total of $168.00 ($28.00 each)	Total of $792.00 ($132.00 each)
Wattage	Total of 768 Watt (128 Watt each)	Total of 240 Watt (40 Watt each)
Electricity cost (10.2¢/kWh)	$162.94 per year	$50.92 per year
Lifespan (continuous use)	22,500 hours	50,000 hours
Lifespan when used for 8 hours a day, 5 days a week	10 years 9 months 25 days	24 years 14 days
No. of times an old fixture to be replaced each year	Total of 0.55 times (0.09 times each fixtures)	-
No. of times an old fixture to be replaced during the LED fixture's lifespan (24 years 14 days)	Total of 12 times (2 times each fixtures)	-
Cost of replacements each year ([Incand. bulb cost] × [Number of replacement per year])	Total of $15.53 ($2.59 each fixtures)	-
Annual labor cost for relamping ([Labor cost per relamping] × [Number of replacement per year])	$11.09 per year	-
Total annual cost ([Cost of replacing fixtures] + [Electricity] + [Labor cost])	$189.56 per year	$50.92 per year (same as the annual electricity cost)
Total cost (after 24 years 14 days)	$4,724	$2,015
Total savings /w LED fixture (ROI) (after 24 years 14 days)	$4,724 − $2,015 = $2,709	
Break-even point (The amount of time necessary to save as much money as you invested initially)	4 years 6 months	

Print the result

APPENDIX F. REFERENCES

1. Email, ADSS alert, 5 June 2016, subject: Test Support Order Approved by HQ (Fluorescent Lamp Replacement Study), ATEC Project No. 2016-DT-ATC-ARSPT-G6172.

2. Lighting Research Center. Solid State Lighting. Retrieved from http://www.lrc.rpi.edu/programs/solidstate/SSLWhat.asp.

3. USAEC SOW, Fluorescent Lamp Replacement Study, ATEC Project No. 2016-DT-ATC-ARSPT-G6172.

4. ATC, Fluorescent Lamp Replacement Guidance Manual.

5. ASG Energy. The 10-Year Warranty -The Truths and Myths of the 10-Year Warranty. Retrieved from http://asgenergyllc.com/asg-blogs/

6. ACSIM Memorandum dated 18Oct 2015, Subject: Fiscal Year 2016 Non-recurring Pollution Prevention Project Submission.

APPENDIX G. ABBREVIATIONS

ACGIH	= American Conference of Governmental Industrial Hygienists
ASHRAE	= American Society of Heating, Refrigerating and Air-Conditioning Engineers
APG	= Aberdeen Proving Ground
ATC	= U.S. Army Aberdeen Test Center
ATEC	= U.S. Army Test and Evaluation Command
BG&E	= Baltimore Gas and Electric
BTU	= British thermal unit
CALC	= Commercial Advanced Lighting Controls
CALiPER	= Commercially Available LED Product Evaluation and Reporting
CCT	= correlated color temperature
Ce	= cerium
CEE	= Consortium for Energy Efficiency
CFL	= compact fluorescent lamp
CRI	= color rendering index
CW	= Spectra-COLWITE ™
DEHP	= di (2-ethulhexyl) phthalate
DLC	= Design Lights Consortium
DoD	= Department of Defense
DOE	= Department of Energy
DOT	= Department of Transportation
DPW	= Department of Public Works
DSIRE	= Database of State Incentives for Renewables and Efficiency
DTC	= drum-top crusher
EE	= energy efficiency
EISA 2007	= Energy Independence and Security Act of 2007
EPA	= Environmental Protection Agency
EPACT 2005	= Energy Policy Act of 2005
Eu	= europium
FB	= fluorescent U-bend
FC	= fluorescent circline
FDA	= Food and Drug Administration
FEMP	= Federal Energy Management Program
Ga	= gallium
GE	= General Electric
GSA	= General Services Administration
HEPA	= high-efficiency particulate air
HID	= high intensity discharge
HW	= hazardous waste
IESNA	= Illuminating Engineering Society of North America
In	= indium
IR	= infrared
Klm	= kilolumen
LCCA	= life cycle cost analysis
LED	= light-emitting diode
LPD	= lighting power density
LPW	= lumens per watt
LQHUW	= large quantity handler of universal waste
LRC	= Lighting Research Center

Lu = lutetium
NEEP = Northeast Energy Efficiency Partnerships
NEMA = National Electrical Manufacturers Association
NGLI = Next Generation Lighting Initiative
NGLIA = Next Generation Lighting Initiative Alliance
OLED = organic-light emitting diode
OSHA = Occupational Safety and Health Administration
PCB = polychlorinated biphenyl
PEL = permissible exposure limit
PF = power factor
PPE = personal protective equipment
ppm = parts per millions
PSO = power savings only
QPL = Qualified Product List
R&D = research and development
RCRA = Resource Conversion and Recovery Act
RoHS = Restriction of the Use of Hazardous Substances
SDS = Safety Data Sheet
SKU = stock keeping unit
SOW = Statement of Work
SQHUW = small quantity handler of universal waste
SSL = solid-state lighting
SSLP = Solid State Lighting Program
TCLP = toxicity characteristic leaching procedure
TCS = total cost savings
TDSS = Threat Detection and Systems Survivability
THD = total harmonic distortion
TLED = tubular light emitting diode
TLV = threshold limit value
UFC = Unified Facilities Criteria
UL = Underwriters Laboratories
USAEC = U.S. Army Environmental Command
UV = ultraviolet
UW = universal waste
VDL = Vision Digital Library
VISION = Versatile Information Systems Integrated On-Line
WEEE = waste electrical and electronic equipment

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ATEC Project No. 2016-DT-ATC-ARSPT-G6172

Note: A copy of the test plan will be posted on the Versatile Information Systems Integrated On-Line (VISION) Digital Library (VDL), https://vdls.atc.army.mil.

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