New Dirt Study Reveals New Energy-Saving Opportunities in Lighting

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The interNational Association of Lighting Management Companies (NALMCO) recently completed a three-year, EPA-funded study of luminaire (lighting fixture) dirt depreciation that may significantly impact lighting design and energy-saving upgrades.

Analysis of the results indicates that existing light loss factors related to dirt and dust buildup on fixture surfaces overestimate the extent of light loss.

In lighting designs, this offers the opportunity to reduce the number of fixtures required to achieve the target maintained light level -- reducing fixture initial and operating costs for the owner.

In retrofit situations, this offers the opportunity to select components that produce less light output while saving more energy. Significant energy savings can also be gained through facilitywide dimming.

The LDD study results are being incorporated into a new IESNA Recommended Practice (RP) on maintenance (RP-36) and future IESNA Handbook chapter by the IESNA and NALMCO Joint Committee. To make the LDD factor easier to calculate and use, a new calculation procedure has also been developed.

Background

Lighting systems are designed to provide a sufficient amount of light output so that -- when depreciated over time by various light loss factors -- required light levels on the workplane result. Dirt and dust build-up is a primary cause of light loss; as dirt and dust accumulate on luminaires (light fixtures) and lamps, the particles absorb light rather than reflect it, resulting in a light loss factor called Luminaire Dirt Depreciation (LDD).

The new maintenance study indicates that in a typical commercial environment, the extent of dirt depreciation on light fixtures is not as high as the accepted norms used by the lighting community for more than 50 years.

In the time frame of a two- to three-year cleaning cycle, for example, the new findings recommend an approximate 10 percent loss, for many areas, versus present lighting standards, which recommend allowing for light loss on the order of 20 percent.

The study was conducted 1996-1999 by the interNational Association of Lighting Management Companies (NALMCO), promoted by the IESNA and funded by

the U.S. EPA. The new data can translate to a reduction of overlighting of spaces for new lighting systems, resulting in a reduction in lighting equipment, installation and operating costs for the owner and additional "fat" that can be cut during a retrofit or dimming scenario. These benefits can be increased by incorporating planned lighting maintenance.

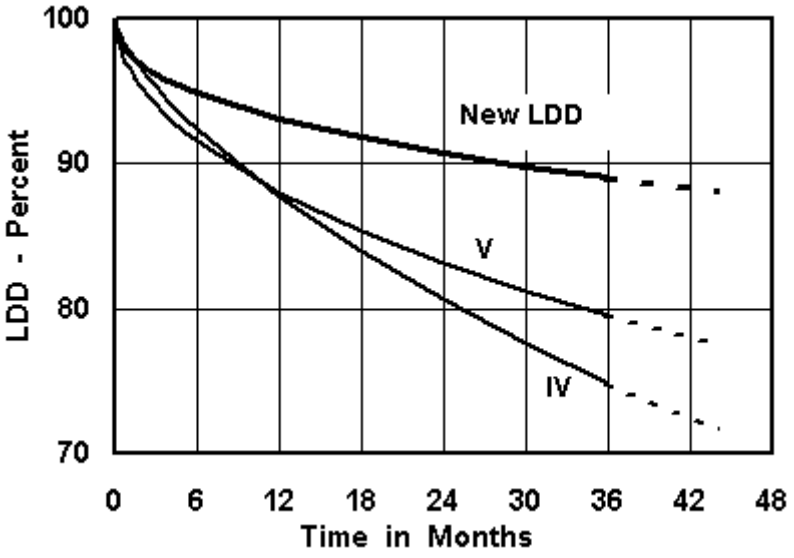
The Study

The controlled LDD field study included more than 200 sites at office, retail and school facilities in the U.S. Four popular recessed fluorescent lighting fixture types were studied: 2x4 lensed, 2x4 louvered, 2x2 louvered and 2x4 air exhaust louvered -- which collectively represented, based on some estimates, approximately 90 percent of recessed fixtures in operation in the United States in 1995. The split between lensed and louvered fixtures in the study was about 50-50. The technicians at 10 lighting management companies gathered the test data using an instrument specially designed to capture the total peak fixture light output emerging from the fixture.

Eight fixtures at each site were thoroughly cleaned and relamped. After six months, one fixture at each site was tested to record light output values 1) when dirty and 2) with the lamps and fixture cleaned. After 12 months, the test was repeated on another fixture at each site, and again after 18, 24, 30 and 36 months.

In Figure 1, the new LDD function, as determined by the test results, is contrasted with lensed and louvered fixtures in clean conditions (assumes better than average air filtration and some generated or ambient dirt). At 18 months, the LDD factor is 0.92 versus 0.84-0.85 using the traditional IESNA procedure, and at 36 months, the LDD factor is 0.89 versus 0.75-0.80. Lensed and louvered fixtures show virtually identical dirt depreciation and variable operating hours per year have negligible effect, according to the study.

Figure 1. The LDD function for both louvered and lensed fluorescent fixtures determined by analysis of the LDD study test results (top curve). Previous IESNA procedures place louvered fixtures into Maintenance Category IV and lensed fixtures into Maintenance Category V, with their LDD curves shown for comparison.



"This is the first study ever on the subject of dirt depreciation to be completed in both a comprehensive and scientific manner," said Dr. Robert E. Levin, senior scientist for Osram Sylvania and a primary technical advisor for the study. "Data was informally collected in the 1950s on maintenance, not as a controlled study."

Impact
The new LDD data can significantly impact lighting design of commercial facilities facilities where fluorescent, flat-bottomed and either recessed or ceiling-mounted fixtures are installed.
"Test results indicate that in very clean locations, about 8-10 percent fewer fixtures are required to provide a specific light level compared to using design calculations with earlier LDD values," said Norma Frank, CLMC, chair of the IESNA Maintenance Committee and vice president of Colorado Lighting. "Renovation projects in older facilities would result in the order of 15-20 percent fewer fixtures if this new data is utilized."

New Installations. For new installations, the required number of fixtures is determined:

N = [(Lighted Area) * (Desired Illuminance)] / [(Bare Lamp Lumens/Fixture) * CU * LLF * LDD]

Assuming a three-year cleaning cycle, the LDD factor for a lensed fixture in an open office plan using the new LDD procedure is 0.89 and the LDD factor using the old procedure is 0.80. The below example illustrates fixture savings resulting from application of the new LDD factor:

Area:	8,000 sq.ft.
Target light level:	50 fc
Other light loss factors:	Assume coefficient of utilization (CU) of 0.62 and the product of all other light loss factors (LLF) to be 0.75
Fixture type:	4-lamp louvered fixture with 9,000 lamp lumens/fixture

The number of fixtures required to achieve the target light level is:

Old LDD (0.80):	No. Fixtures = (50 * 8,000) / (9,000 * 0.62 * 0.75 * 0.80)
	No. Fixtures = ~119 fixtures
New LDD (0.89):	No. Fixtures = (50 * 8,000) / (9,000 * 0.62 * 0.75 * 0.89)
	No. Fixtures = ~107 fixtures

In this early design phase, about 10 percent fewer fixtures are required to achieve the desired maintained light level of 50 footcandles (fc) in the open office. This saves the owner initial costs and also operating costs in perpetuity.

Existing Installations. In existing spaces, lighting designs can be reevaluated

using the new data to retrofit or redesign to generate operating cost savings. Retrofits include a variety of ballast, lamp and dimming upgrade options with reduced light output that can generate significant energy savings. In addition, flexible facilitywide dimming systems can be used to reduce light output at the fixture and save energy.

"With more states mandating specific watts per square foot limitations for new and renovated facilities, more accurate LDD factors will help achieve improved designs and lower capital expenditure and energy usage," said Dr. Levin. "With this scientific data to support a change in design and maintenance standards, commercial facilities that collectively spend $27-$36 billion per year to operate their lighting systems can realize cost savings or 10 percent -- potentially as much as $3.6 billion annually."

"Another benefit that goes beyond tangible initial and operating cost savings is increased confidence in cost-benefit evaluation and lifecycle cost analysis," said Norma Frank. "By providing LDD values that are the result of scientific study, building owners and lighting specifiers can demonstrate the economic value of frequent maintenance procedures with greater certainty."

In the future, the LDD study will also likely have an impact on energy codes. A U.S. Department of Energy ruling, implementing a provision of the Energy Policy Act of 1992, requires all states to adopt an energy code at least as stringent as ASHRAE/IES 90.1-1999, or justify why they cannot do so. Standard 90.1-2001 is now on the stage. It is expected to be referenced in the 2003 International Energy Conservation Code, and ASHRAE recently signed a partnering agreement with the National Fire Protection Association (NFPA) to incorporate 90.1-2001 as the energy code portion of the ANSI-approved NFPA consensus code set, which will be published in April 2003. Regarding lighting, addendum "g" revises lighting power allowances downward even further, possibly by as much as 29 percent, to address the NALMCO LDD study and other factors.

RETURN TO KEY ISSUES