

# Luminaire Dirt Depreciation

*The facts speak for themselves.*

*This summary paper reviews various sources of information concerning the issue of luminaire dirt depreciation as it relates to luminaire design and construction. These data compare the dirt depreciation performance of enclosed and gasketed fixtures to open-ventilated, borosilicate glass with hermetically sealed cover reflector systems.*

Luminaire dirt depreciation is defined as the efficiency of a new / clean luminaire to the efficiency of the luminaire due to accumulation of dirt on the luminaires' reflecting and refracting surfaces. We can use the formula,  $LDD = (1 - \text{light loss due to dirt})$  to mathematically define luminaire dirt depreciation.

In a paper written by Ian Lewin, Ph.D., FIES and former Chairman of the IESNA Roadway Lighting Committee, he describes an investigation he conducted to determine how luminaire designs and reflector materials interact with airborne dust and other particulate matter thereby impacting the level of luminaire dirt depreciation and surface depreciation due to cleaning (1). His research includes a direct comparison of open-ventilated, borosilicate glass reflector units to enclosed and gasketed units. The initial stage of the research involved photometric testing of the new luminaires. The luminaires were then placed in close proximity of each other in an industrial atmosphere that consisted of "fairly high temperature air, with a high percentage content of carbon particles and oil droplets. An atmosphere of this type produces very arduous conditions for the operation of luminaires". The luminaires were operated for ten (10) months without cleaning. At the end of ten months, the luminaires were subjected to photometric testing to determine the amount of dirt depreciation. After ten months, the enclosed and gasketed (E&G) fixture - consisting of an anodized aluminum reflector with clear, flat, glass bottom closure - exhibited a performance loss of 56%. At the end of the same period, the open-ventilated, borosilicate glass reflector unit was also tested. The results of this test indicate a performance loss of 11%. (Initial lumen output vs. lumen output after ten months of operation).

Dr. Lewin states, "The 'chimney effect' is very important in considering luminaire maintenance. If we consider the normal nature of convection current, it will be realized that warm air must rise from the lamp, and be emitted through the top of the luminaire. This air will be replaced by cooler air from beneath the fixture. Thus, a constant air stream of relatively high velocity will pass through the [open, ventilated] reflector. The significance of this effect is that a constant rubbing of the reflecting surface by air particles is caused, which will result in an inherent cleaning action of the glass reflector. In the case of an aluminum reflector, however, it has been indicated that this metal is subject to surface electrostatic charges. The constant rubbing of an aluminum reflector by the air stream is likely to induce static charge, so worsening the situation, in contrast to the beneficial effect upon the glass surface. It is apparent from the foregoing, that there is clear evidence to indicate why the depreciation tests showed that the open top, open bottom prismatic [glass] luminaire maintained its performance so much better than the other luminaires."

The first of three luminaire dirt depreciation tests performed in 1980 was conducted to determine the luminaire type that provided the highest lumen output through its life (2). The performance characteristics of three luminaire types were analyzed: 1) enclosed and gasketed, anodized, aluminum reflector; 2) open-bottom, open-top, anodized aluminum reflector; 3) open-bottom, open-top, borosilicate glass reflector with sealed outer aluminum cover. The research study placed fixtures of each type in "a strongly polluted environment" for a period of six (6) months. At the end

of the six (6) month period, photometric tests were conducted to determine the lumen output compared to the lumen output of the fixtures when initially installed. The results indicate that the enclosed and gasketed fixtures experienced depreciation due to dirt of 23% (LDD = 0.77). The open units with aluminum reflector had a luminaire dirt depreciation (LDD) of 0.88 (Light Loss =12%) and the open-ventilated glass reflector unit had a LDD of 0.96 (4% light loss).

During the spring of 1980, General Motors sponsored luminaire dirt depreciation research for luminaires installed in their Grand Blanc, Michigan factory (3). The luminaires were open-ventilated, borosilicate glass with sealed outer cover reflectors that were sent to Independent Testing Laboratories (ITL) for testing after seven (7) years of continuous operation in either a press stamping area or welding area. The unit from the welding area had a luminaire dirt depreciation (LDD) of 0.76 (24% light loss) after seven years. The three luminaires tested from the press stamping area had LDD values of 0.891 (10.9% loss), 0.911 (8.9% loss) and 0.911 (8.9% loss) after seven years of service.

After nine (9) years of continuous service, General Motors sent open-ventilated, borosilicate glass reflector fixtures from their gear and axle plant in Detroit to be tested for LDD during the spring of 1980 (4). The tests indicate a light loss of 14% (LDD = 0.86) due to dirt accumulation on the reflector. In the summer of 1980, fixtures were removed from a Rockwell factory in Wellington, Ohio for LDD photometric testing (5). These units, which have an open-ventilated, borosilicate glass reflector with sealed aluminum cover were installed in 1969 and had never been cleaned. The test results showed the total LDD ranged from 0.98 to 0.985 (2.0% to 2.5% loss).

In the fall of 1980, enclosed and gasketed luminaires installed at the Marathon Electric foundry in Wausau, Wisconsin were tested for LDD (6). These units were in operation for five (5) years without cleaning. The LDD was 0.59 (41% loss).

A July, 1982 article published by Electrical Construction and Maintenance (EC&M) titled "What's the Story" refers to luminaire dirt depreciation (LDD) tests conducted on fixtures used in various automobile manufacturing plants that compared open-ventilated, borosilicate glass with

sealed outer cover reflector units to enclosed and gasketed units (7). The results reported by EC&M indicated a total LDD for the open-ventilated glass units was 0.86 (14% loss) after nine years in an automobile stamping shop. The LDD for the enclosed and gasketed unit was 0.594 (40.6% loss) after five years in a foundry. They report LDD of just 0.96 (4% loss) for the open-ventilated units compared to 0.77 (23% loss) for the enclosed and gasketed units after six months in a "strongly polluted environment".

During 1987, Mr. Herb Fouke, FIES, conducted a luminaire dirt depreciation study in an environment described as heavy industrial (8). The area was a glass making facility where high ambient temperatures were prevalent, and carbon particulate and oils were common. The test luminaires were placed in this environment for a period of twenty (20) months. At the end of the test period, the luminaires were tested to determine the lumen output of each luminaire in comparison to the lumen output of the luminaires at the time of installation. The results of this research indicate that the enclosed and gasketed (and filtered) luminaires experienced luminaire dirt depreciation (LDD) of 0.81 (19% loss) while the open-ventilated, borosilicate glass reflector experienced a lumen reduction of 13% due to dirt accumulation on the optical system.

In November 1999, testing was conducted on open-ventilated, borosilicate glass reflector units used in a high mast roadway lighting application (9). These units, installed at the intersection of I-35 & I-40 in Oklahoma, had been operating without cleaning since 1988. Heavy truck and automobile traffic is ever present there and the fixtures were located close to a river so a significant amount of sand and dust was found in the air. This major intersection carried a high traffic load and traffic slow-downs and stalled traffic were common. Consequently, the luminaires were subjected to the airborne dust and sand as well as a high level of exhaust fumes. After a period of 11 years of in-field operation, the efficiency of these luminaires dropped just one-half of one percent (0.5%), LDD = 0.995.

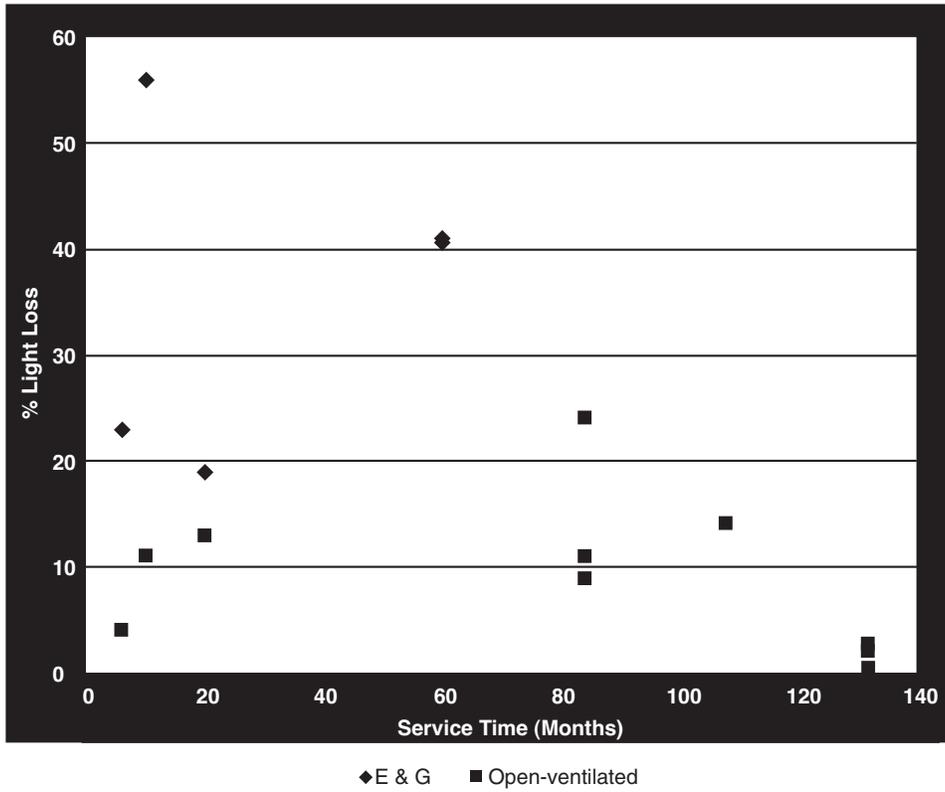
The data is conclusive! Open-ventilated, borosilicate glass reflectors with a sealed outer cover keep a higher lumen efficiency throughout their life than fixtures of an enclosed and gasketed design. A visual summary is shown on the attached graphs.

This TechTalk paper and all references can be found at [www.holophane.com/School/Tech.htm](http://www.holophane.com/School/Tech.htm)

#### References:

- (1) Lewin, Ian, "Surface Depreciation and Maintenance"
- (2) Opel Division, General Motors Corporation, 1980
- (3) General Motors Corporation, Grand Blanc, Michigan, 1980
- (4) General Motors Corporation, Detroit, Michigan, 1980
- (5) Rockwell International, Wellington, Ohio, 1980
- (6) Marathon Electric Corporation, Wausau, Wisconsin, 1980
- (7) Electrical Construction and Maintenance (EC&M), "What's the Story", July 1982
- (8) Fouke, Herb, Dirt Depreciation Test, 1987
- (9) Oklahoma Department of Transportation, Dirt Depreciation Test, November 1999

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