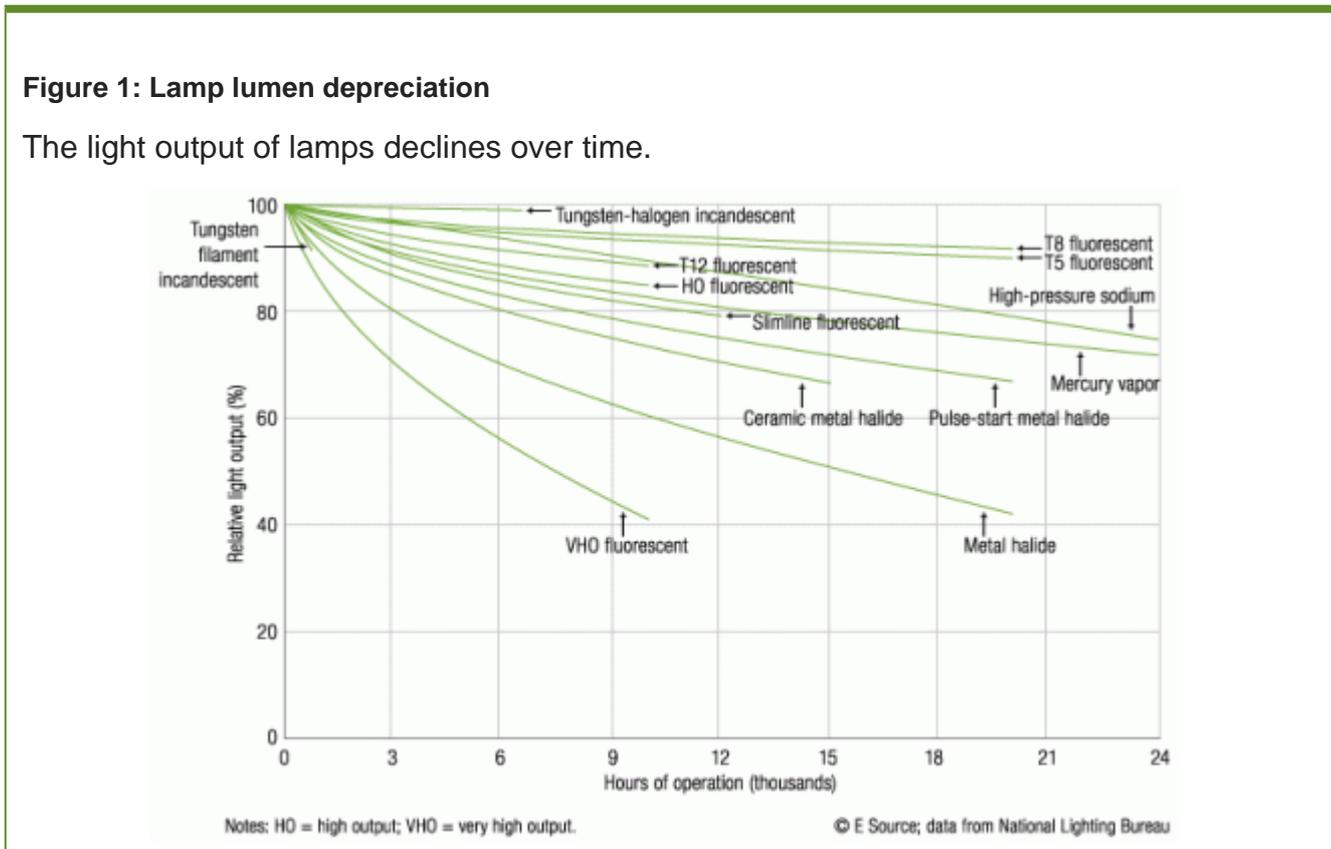


Light Output Declines with Time

Light output from a given fixture declines over time for two reasons: One is that the lamp output itself decreases—an effect known as lumen depreciation. The other is that dirt accumulates on lamps and fixtures.

Lumen depreciation. Data on lumen depreciation vary with the type of lamp, as shown in **Figure 1**. Data for a particular lamp can be found in the technical information that is available from each lamp's manufacturer. The output of incandescent lamps decreases as the filament is depleted and tungsten particles accumulate on the wall of the bulb. Fluorescent lamp output degrades because of the degradation of the lamp's phosphors and the deposit, over time, of light-absorbing materials on the lamp walls.



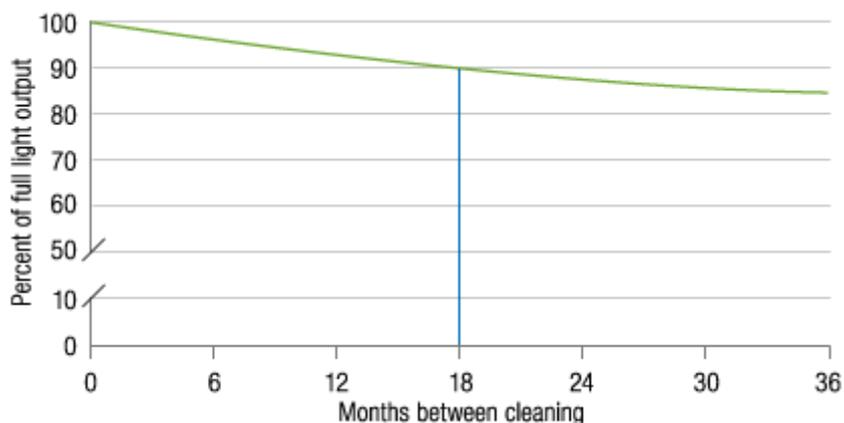
The degradation of light output of light emitting diodes (LEDs) is not covered in Figure 1 because of the wide variations among products. LEDs generally don't fail catastrophically, but their output does degrade over time the rate varies widely with both the particular LED and the

conditions under which it is used. One commonly used definition of the end of life for an LED light source is that point at which the output has degraded to 70 percent of its initial value—a value estimated based on a particular set of ideal conditions. When LEDs are installed in a fixture, a number of factors can affect the rate of lumen depreciation. These include temperature extremes (output degrades more slowly at cold temperatures, more rapidly at high temperatures), humidity, voltage or current fluctuations, degradation of the encapsulant material covering the LEDs, and degradation of the phosphors that many products use to generate white light.

Dirt accumulation. The depreciation in light output from dirt accumulation depends on both the frequency of cleaning (**Figure 2**) and the cleanliness of the environment.

Figure 2: Dirt depreciation for a typical fluorescent fixture in a very clean environment

Even if fixtures are cleaned every 18 months, dirt buildup can reduce light output by 10 percent between cleanings.



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To quantify the effects of dirt accumulation, lighting designers use luminaire dirt depreciation (LDD) factors. The LDD factor curves that were used for many years were based on studies done in the 1950s, when open-window ventilation and smoking were the norm. From 1996 to 1999, the International Association of Lighting Management Companies (NALMCO) conducted a study, with funding from the U.S. Environmental Protection Agency, to update LDD calculations for modern building environments. The results of these studies and new models for LDD were published by the Illuminating Engineering Society of North America (IESNA) as IESNA/NALMCO RP-36-03 in late 2003. Test results show that dirt depreciation is less severe than the old calculations indicated. So, for example, in very clean locations, 8 to 10 percent fewer fixtures are required to provide a specific light level when design calculations are based on new models instead of earlier LDD values.

RP-36-03 describes a process for calculating LDD factors, which depend on the type of fixture in use, how clean the environment is, and the time that has elapsed since the last cleaning. Representative numbers derived from this process are shown in Table 1.

Table 1: Representative luminaire dirt depreciation factors

To estimate the effect of dirt on the lumen output of a fixture after a certain period of time, multiply the initial lumen output from the fixture by the relative light output, as determined from Figure 1 or the manufacturer's data for a particular lamp, and then multiply by the luminaire dirt depreciation (LDD) factor.

	LDD factors	
	18 months since last cleaning	36 months since last cleaning
Fixture: open, unventilated, direct Environment: clean	0.92	0.89
Fixture: open, unventilated, indirect Environment: moderate	0.76	0.67
Fixture: other types, semi-indirect Environment: dirty	0.65	0.48

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