

White Paper:
CFL Light Output In Air-Handling Plenums

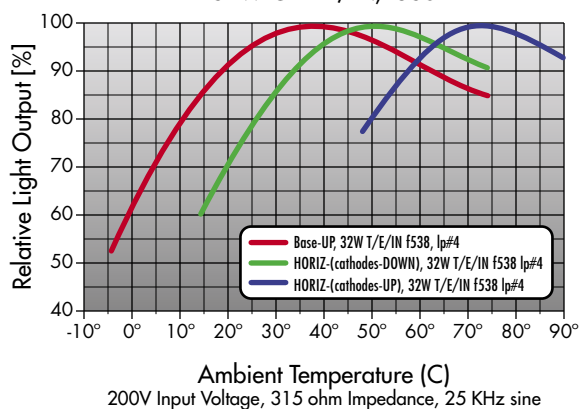
Amalgam technology has been a cornerstone of compact fluorescent lamps for many years. This change in CFL design was driven by the need to overcome performance issues that non-amalgam lamps had experienced when exposed to the broad range of ambient temperatures typical in both indoor and outdoor applications. In general, amalgam technology makes the CFL lamp more resilient to ambient temperature variations, maintaining light output closer to rated lumens in both warmer and cooler ambient temperature environments. Since their introduction, amalgam has become common in CFL downlighting in 26W-42W triple tube lamps and other higher wattage CFLs that are available up to 120W. The benefits of amalgam CFL lamps are numerous, including:

- Universal burn positions for same light output
- 12,000 hour lamp life
- High efficacy (up to 74 lm/W)
- High CRI up to 82
- Multiple color options (2700-5000K)
- Dimmable
- Integral End of Life protection
- Maintain 90% of light output over broad range of ambient temperatures of 5° – 60°C.
(This can vary slightly by manufacturer and lamp wattage.)

While amalgam lamps have solved many design challenges, they are not without their limitations. Although amalgam lamps are resilient under a wide range of ambient temperatures, they cannot withstand temperature reductions in the amalgam reservoir (located in the lamp’s base) created by convected air, such as those created in air-handling plenums. Convected air across the lamp creates a reduction in light output due to the rapid transfer of heat from the lamp’s base, rather than across the lamp’s surface as intended when the lamp was designed. This condition can exist in downlights or other lighting fixtures incorporating clearance holes in the reflector for lamp replacement. These openings are standard and common for most horizontal CFL downlights. Such clearance holes exist to provide a means for the lamp to be installed and replaced. The use of lensed trims in horizontal CFL downlights will, in most instances, substantially alleviate this condition by cutting off the access to the pressure differences between the plenum and room, thereby preventing the air from excessively convecting across the lamp’s surface and, more importantly, across the amalgam reservoir. It is important to note that vertical downlights do not typically have substantial reflector penetrations that would allow significant air flow to inhibit the lamp’s output. Hence, open downlights with vertical lamp orientations typically do not suffer from reduced light output in air flow conditions. It is also notable that base-up orientation is the optimum burning position for amalgam lamps in typical thermal applications (see **Figure A**).

Figure A

Relative Light Output vs. Amalgam Temperature
Various Burning Orientations
Reference Ballast Settings
32W CFL TE/IN, f538

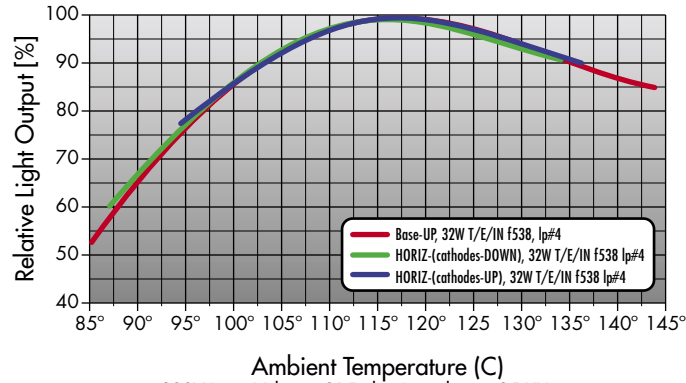


*Data courtesy of Osram Sylvania

Although amalgam lamps are resistant across a wide range of ambient temperatures, the amalgam reservoir must be at a much higher temperature than the typical ambient environment in order for the lamp to provide more than 90% light output (see **Figure B**).

Figure B

Relative Light Output vs. Amalgam Pump Stem Temperature
Various Burning Orientations
Reference Ballast Settings
32W CFL TE/IN, f538



200V Input Voltage, 315 ohm Impedance, 25 KHz sine

*Data courtesy of Osram Sylvania

Convected air in horizontal downlights reduces the high ambient temperatures at the base of the lamp required for optimal performance.

All downlighting manufacturers incorporate clearance windows for lamp replacement in their horizontal downlight reflectors and all manufacturers have the same potential for reduced amalgam CFL light output in air-handling plenums. The movement of air over the lamps in air plenum applications and the resulting reduction in light output is entirely a function of the lamp itself. Unfortunately, this is a little known but common condition. Lamp manufacturers only publish "ambient" (draft-free condition) temperature performance data for amalgam lamps with virtually no published information on how light output can be reduced when air moves across the base of the lamp. In addition, each lamp manufacturer publishes different ranges of ambient temperatures within which the lamp will operate at 90% or higher.

In order to better quantify the behavior of CFL lamps in air flow conditions, Prescolite commissioned a series of tests at Architectural Testing Laboratory in York PA. The results of these tests follow.

Testing Protocol

A series of tests in both air handling (see **Figure C**) and air return conditions (see **Figure D**) were conducted in cooperation between Prescolite, GE, Philips, and OSRAM-Sylvania. Both amalgam and non-amalgam lamps were burned in for 12 hours and tested in a stabilized condition in a 6" 1-lamp horizontally-lamped luminaire. Lamp amalgam reservoir temperature, fixture light output (illuminance in footcandles), and air velocity were measured during the test. All illuminance measurements were taken directly beneath the luminaire at a distance of 45" using a calibrated Minolta illuminance meter. For all three tests, baseline data was collected under test conditions of 16 FPM of air flow, the minimal air velocity required to maintain the temperature of the test chambers.

Figure C: Fan distance from reflector and lamp – air-handling plenum

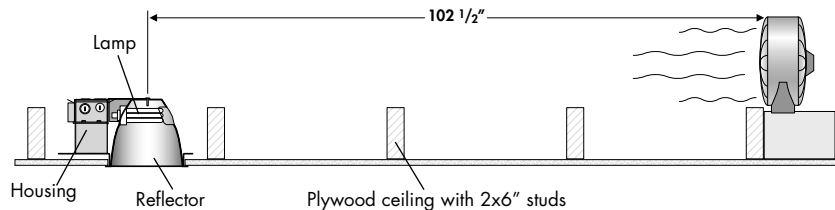
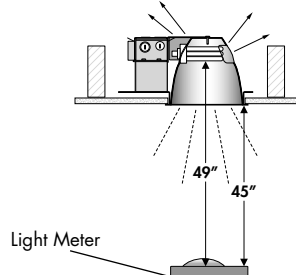


Figure D: Air return plenum with pressure differential



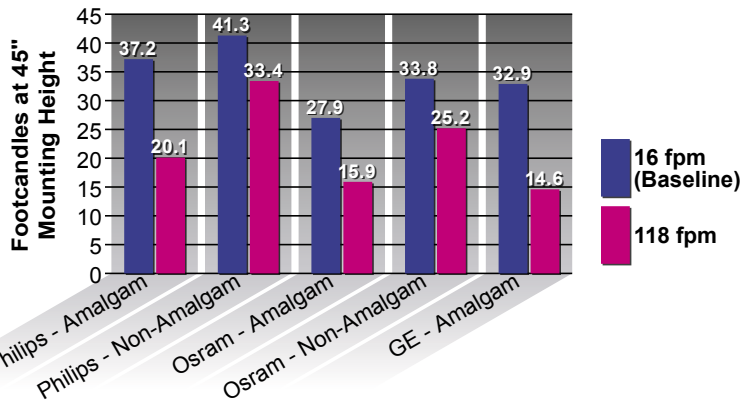
Test #1: Air Handling

Plenum air temperature: 77°F
 Room air temperature: 77°F
 Air velocity: 118 FPM (against 16 FPM baseline)

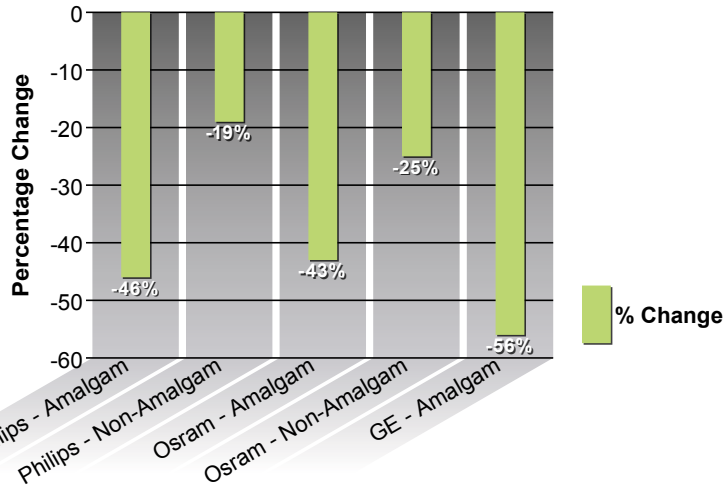
Test 1 simulates an air supply plenum condition where the plenum is fed with conditioned air intended to be distributed to the room through air vents located in the ceiling. Because the luminaire has openings in the reflector, it also (unintentionally) acts as an air supply vent in the ceiling through which conditioned air flows.

This test illustrates the negative impact on CFL light output that results from the use of CFL lamps in an air-handling application. It is notable, however, that the reduction in light output of non-amalgam lamps is less severe than for amalgam lamps, which lose about half of their light output.

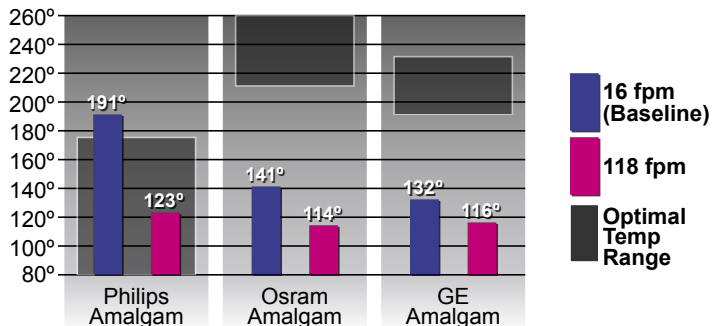
Air Handling: Light Intensity 77°F Plenum/77°F Room



Air Handling: Percentage Change



Air Handling: Amalgam Temperature 77°F Plenum/77°F Room



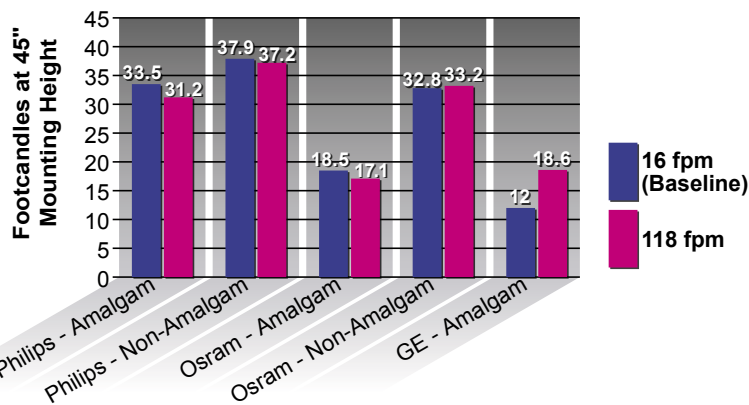
Test #2: Air Handling

Plenum air temperature: 60°F
 Room air temperature: 77°F
 Air velocity: 118 FPM (against 16 FPM baseline)

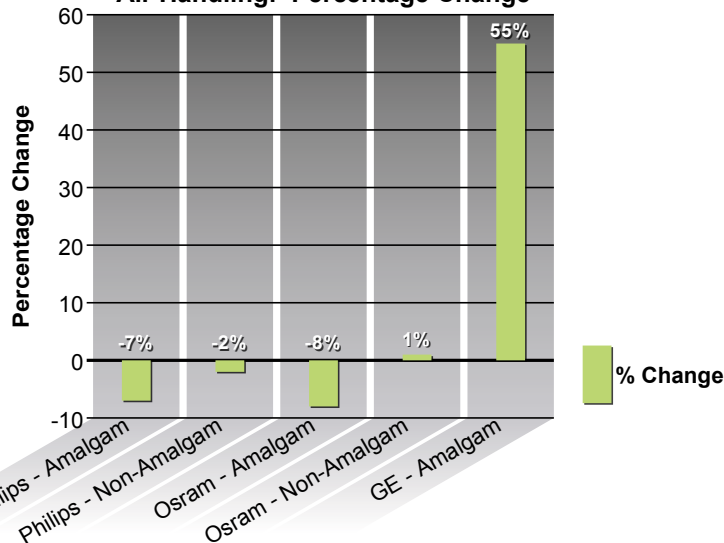
Test 2 simulates essentially the same air supply plenum condition as Test 1 but with in a condition where the plenum air is cooler than the room air. This is likely a more common condition.

The results of this test did not yield the light output differences one would expect based on the results of Test 1. Data did not differ substantially for the two air velocities, except for the GE lamp that actually showed a 55% increase light output in the air handling condition over the 16 FPM baseline condition. GE requires a fairly high range of temperatures on the amalgam reservoir to maintain 90% light output and it is believed that the cooler conditions of Test 2 made the lamp less stable. It is also noteworthy that the stabilized light levels of Test 2 are starting at lower light levels in the 16 FPM baseline condition compared with Test 1 for all lamp types. This to some degree accounts for the lower percentage in light output reduction in Test 2.

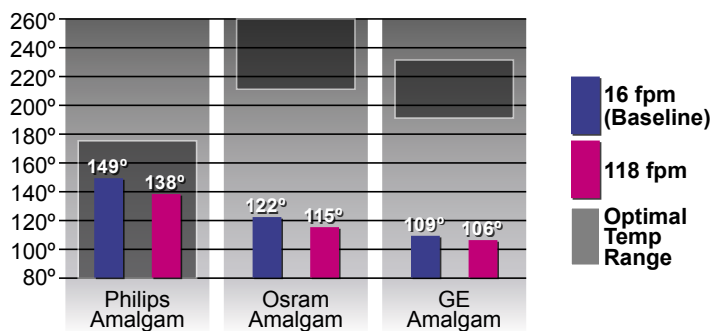
Air Handling: Light Intensity 60°F Plenum/77°F Room



Air Handling: Percentage Change



Air Handling: Amalgam Temperature 60°F Plenum/77°F Room



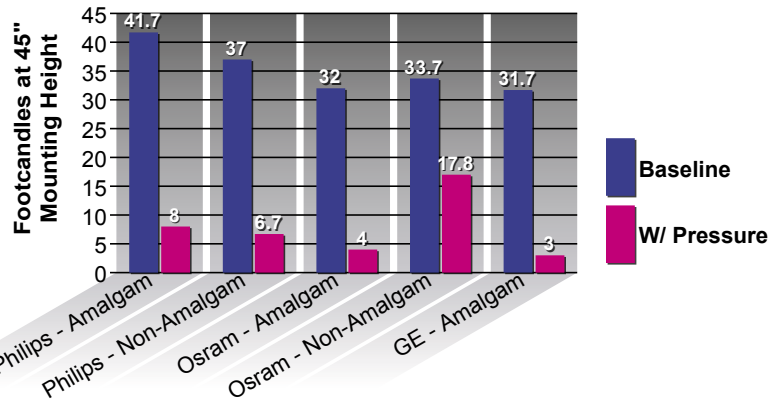
Test #3: Air Return

Plenum air temperature: 77°F
 Room air temperature: 77°F
 Pressure differential: 0.23" H2O plenum side, 0.02" H2O room side
 Air velocity: Not measurable due to the variability of air velocity at various positions although observed air velocity through the luminaire was significantly greater than test 1 or test 2. This test simulates the natural flow of return air from a room pressurized to a typical differential to its return plenum.

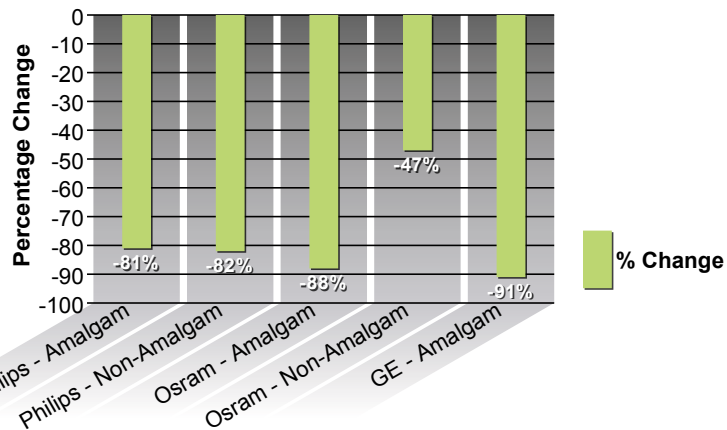
Test 3 simulates a typical air return condition where air from the room is being pulled through the luminaire into the plenum. In essence, the luminaire acts as an air return vent in the ceiling.

In this condition, illuminance is reduced 81% - 91% with amalgam lamps and 47% - 82% with non-amalgam.

Air Handling: 77°F Plenum/77°F Room & .23 H₂O Press Diff Plenum/0.02 Press Diff Room



Air Handling: Percentage Change



Testing Results & Conclusions

The tests confirm that the light output of both amalgam and non-amalgam CFL lamps is reduced when they are used in air flow conditions.

- Both air supply and air return applications reduce CFL light output meaningfully.
 - The least dramatic reduction in light output is 1% to 2%, when non-amalgam lamps are applied in an air handling application.
 - The most dramatic reduction in light output is 81% to 91%, when amalgam lamps are applied in an air return application.
- Air return applications have a much more pronounced negative effect than in air supply applications.
- Performance under air flow conditions varies between lamp manufacturers.
- Amalgam lamps are somewhat resistant to changes in ambient temperatures (in minimal flow to stagnant air), but their light output is reduced dramatically in air flow conditions.
- Non-Amalgam lamps have a less pronounced reduction in light output than amalgam lamps under air flow conditions but still exhibit a loss of light output.

Recommendations

Prescolite has published this white paper to better educate our customers about the potential for reduced light output when amalgam CFL lamps are used in conditions that allow air flow across the lamp. We are in constant contact with the lamp manufacturers and continue to encourage the lamp industry to produce better information to the specification community and develop products that will better perform to customer expectations in common applications. Prescolite continues to pursue product solutions that address the condition described herein.

It is recommended that the lighting specifier be mindful of the air flow behavior in the ceilings for their projects to ensure that the building and HVAC design will not compromise the lighting design. Special care should be exercised in using open, horizontally-lamped CFL downlights in air handling and air return applications, especially with amalgam CFL lamps and in air-return plenums. In conditions where the potential for air flow through the downlight is high, it is recommended that Prescolite vertically lamped or lensed downlights be used since these products do not have significant openings through which air can flow.