

Heat management techniques for residential lighting fixtures

What is the problem?

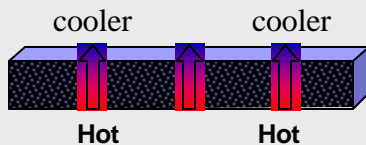
Ballast case temperatures that exceed manufacturers' recommendations

What can be done to solve the problem?

Utilize in varying combinations the three heat management techniques

Conduction

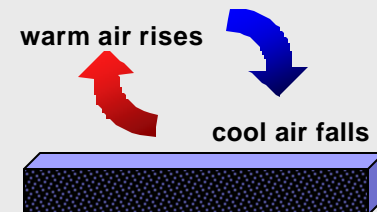
Transfer of heat energy through a medium



Convection

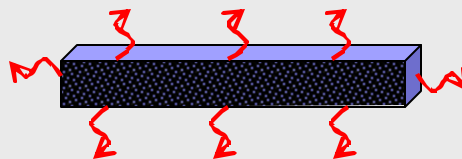
Transfer of heat energy to a moving fluid such as air.

Natural convection is caused by a temperature gradient (ΔT) (warm air is less dense and rises)



Radiation

Transfer of heat energy via infrared electromagnetic radiation



What is a simple and effective solution?

Maximizing Natural Convection

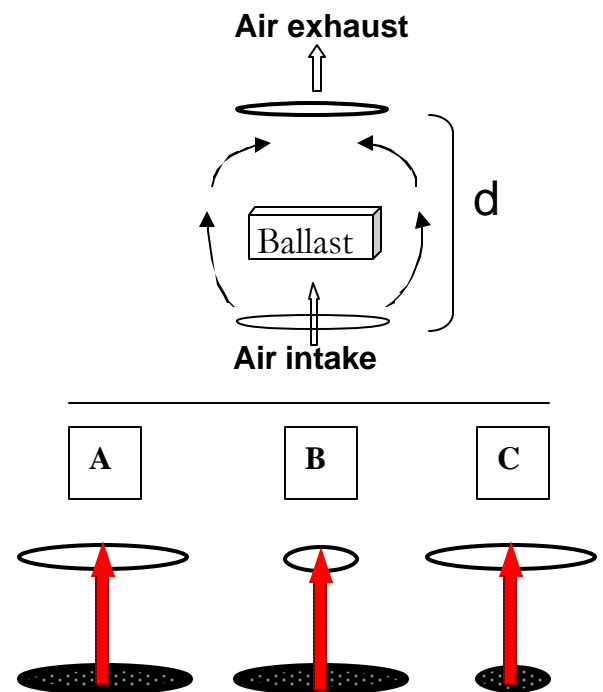
The concepts presented in this pamphlet are suggestions for how to enhance natural convection in a flush mounted ceiling fixture. Fixture designers, keeping in mind the general principles for natural convection, will have to tailor a solution to meet their unique needs.

Ballast case temperature and natural convection

- The majority of ballast manufacturers recommend that ballast case temperatures do not exceed 65-70 °C at specific locations.
- Pilot studies conducted by the LRC have shown that drawing cool air into the fixture by natural convection can reduce ballast case temperatures by up to 11.5 °C.
- See the LRC's report for details of the experimental conditions.
(www.lrc.rpi.edu)

How to maximize cooling by natural convection

- **Air intake** (towards bottom of fixture/ some distance below ballast) is required.
- **Air exhaust** (towards top of fixture/ some distance above ballast) is required.
- There must be a vertical displacement (d) between the locations of the intake and exhaust openings.
- The size (total area) of the smallest opening (either intake or exhaust) limits air flow.
- The greater the airflow, the cooler the ballast.



Potential airflow for **A** is greater than for **B** and **C**. While potential air flow for **B** and **C** will be similar since the smallest area is the limiting factor.

Suggestions for reducing ballast case temperatures in flush mounted fluorescent ceiling fixtures

The following heat management suggestions are intended as basic concepts for the fixture designer to consider. Obviously other critical issues to the design (e.g., placement of internal fixture components and light distribution) will have to be taken into consideration as well.

Air intake strategies

- **Air intake is recommended to occur through the bottom of the diffuser.**
- **Placement of the air intake needs to achieve the greatest area while still positioning it below the ballast.**



- **Position A might be the most convenient location, but will provide only a small intake area.**
- **Position B, due to a larger available surface area, offers the potential for a larger intake area.**

Air intake strategies

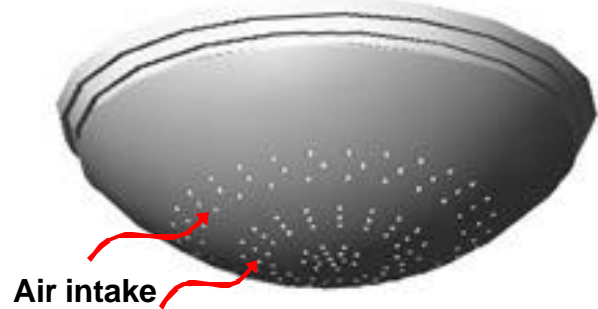
- Design suggestions are given below.
- These concepts are intended merely to give the fixture designer a general idea how to address the problem, keeping in mind the principles for successful natural convection.
- The concepts may be used in various combinations.

Example A



Cap allows air intake through bottom of diffuser.

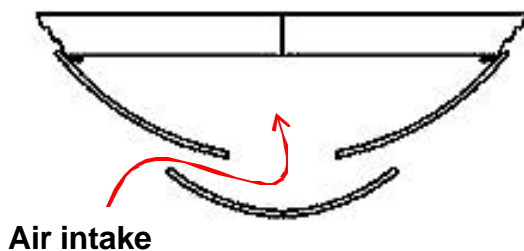
Example B



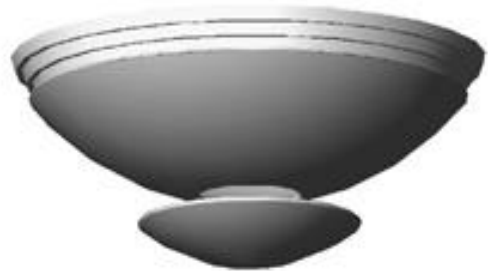
Perforations serve as intake. The 'total area' of the perforations represents the air intake area.

It should be noted that an air intake consisting of small openings will be less effective (due to physical obstruction) than an air intake consisting of a large opening with an equivalent total area.

Example C

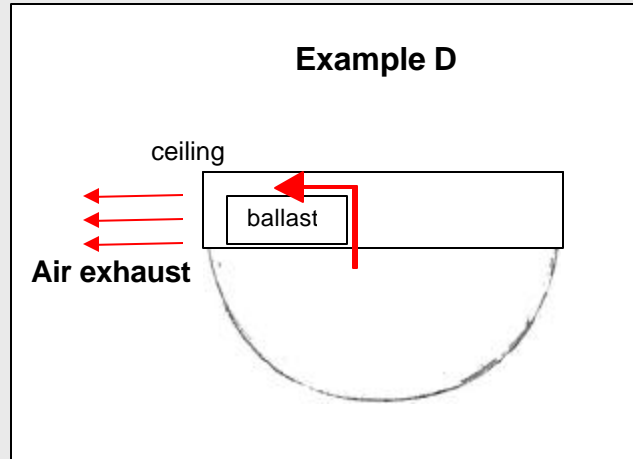


Diffuser is divided into sections, providing a large area to serve as an air intake.

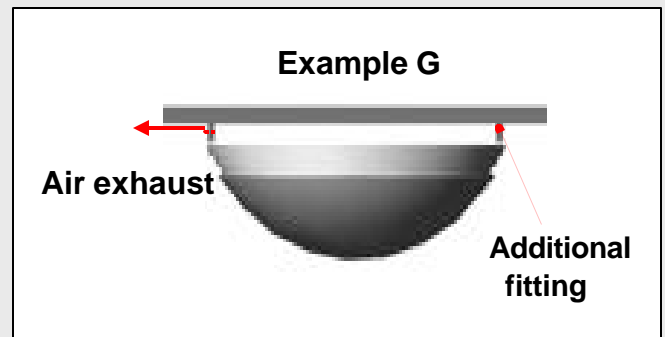
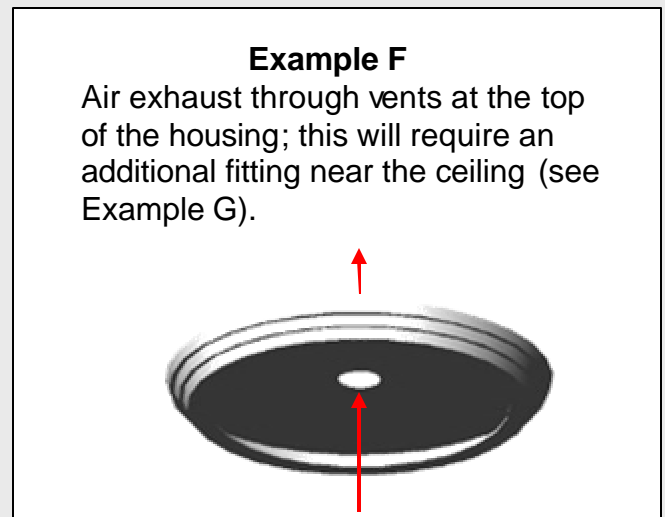
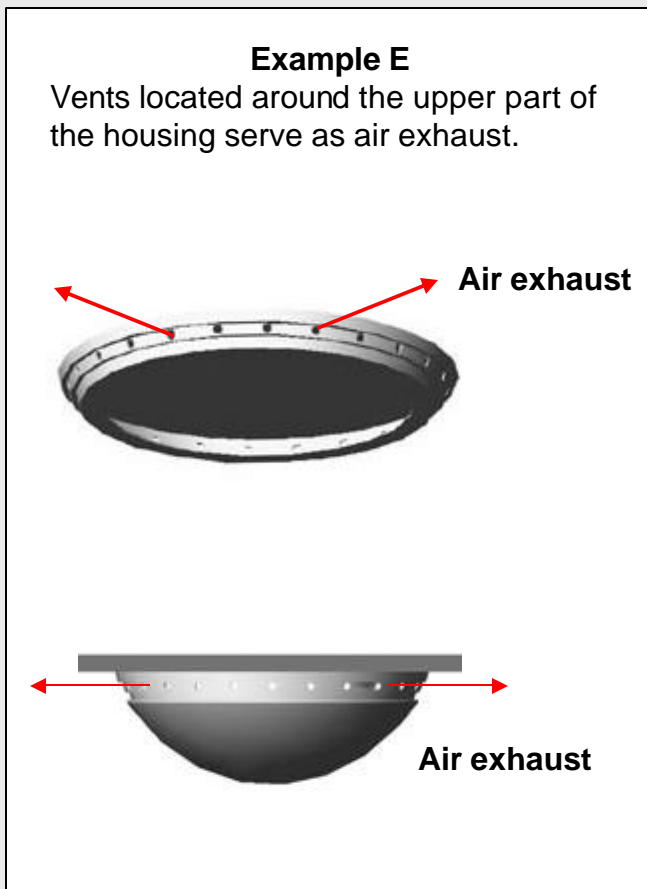


Air exhaust strategies

- The air exhaust should be positioned as high above the ballast as possible.
- The air exhaust should be positioned so that the air flow circulates near/around the ballast, preferably the hottest spot on the ballast.

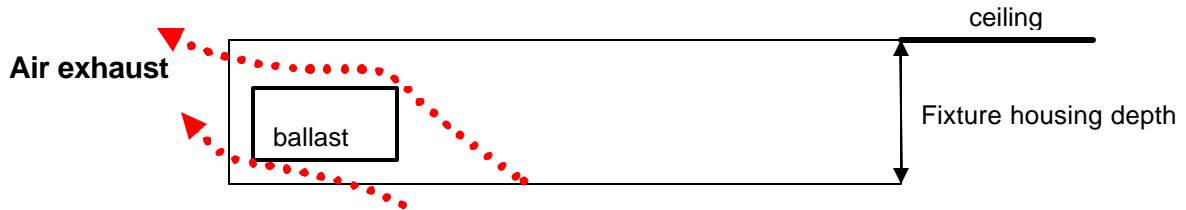


Examples E and F suggest possible exhaust openings. Each suggestion is associated with design and system efficacy issues.



Air exhaust strategies

Example H

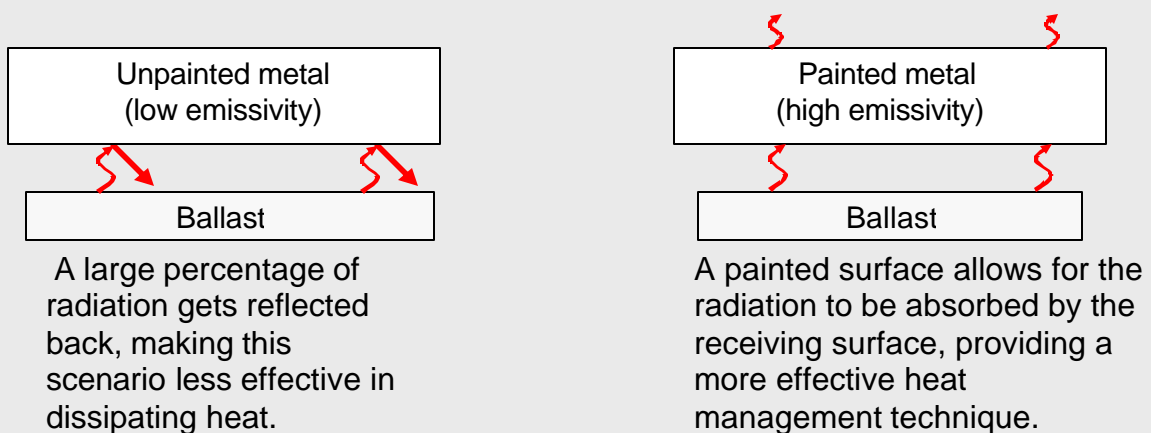


- **Maximizing the depth of the housing offers more options for placement of the exhaust openings, the lamp, and the ballast.**
- **Example H illustrates how deepening the fixture housing allows for the ballast to be mounted on the side of the housing, near the exhaust opening. This strategy will allow air to circulate around the ballast.**

While enhancing natural convection is an effective solution for dealing with excessive ballast case temperatures, the designer should consider utilizing the other two heat management techniques (radiation and conduction) as well.

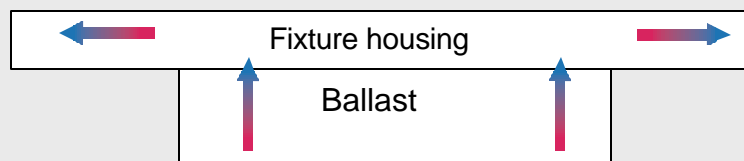
Radiation

Radiation can be increased by increasing the emissivity of both the interior and exterior surfaces of the fixture. A low emissive surface will absorb less heat than a high emissive surface, and re-radiate less heat to the environment outside the fixture. Painting a surface is a common way of increasing emissivity and thereby increasing the effectiveness of radiation as a heat management technique.



Conduction

If the ballast case housing is metal, conduction can aid heat removal by attaching the ballast directly to the fixture housing. Conduction is directly related to the surface area of contact (a larger surface area will conduct more heat energy). This method of heat management will only be effective if the fixture housing is able to release the heat energy to the environment outside the fixture (via convection, conduction, and radiation).



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**Lighting
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