# TEMPERATURE EFFECTS ON AIR OUTLET THROWS

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### BACKGROUND

The industry standard for testing and cataloguing throw is to test and present the information at isothermal conditions. “Isothermal” means that the room air and supply air are both kept at the same temperature. Isothermal testing is specified in ASHRAE Standard 70, “Method of Testing the Performance of Air Outlets and Air Inlets” in order to simplify the data collection process and generate repeatable results. If an air outlet were tested in cooling/heating conditions the room air temperature would change during the test and necessarily require adding precise heat loads to maintain steady-state conditions. This greatly increases the complexity of the test, so isothermal air is preferred.

Outside of the testing laboratory, in the real world, air outlets do not often deliver isothermal air to the space being served. Depending on the time of year, location, and processes in the room being served, the air delivered to the space could be cooled, or heated, a majority of the time. At these non-isothermal temperature conditions, is the catalog performance data still valid? Can it be used to select air outlets for these applications?

The industry standard is to catalog the throw at isothermal conditions, to terminal velocities of 150, 100 and 50 feet per minute. At an air velocity of 150 feet per minute, a difference between the supply air temperature and the room temperature will have minimal effect on the throw. At an air velocity of 100 feet per minute, throw distance is only slightly affected by temperature. However, the 50 feet per minute throw can vary significantly depending on the magnitude of the temperature difference between the supply air and room air.

A good rule of thumb to approximate the throw to a terminal velocity of 50 feet per minute at non-isothermal conditions is that the throw, in feet, will change one percent for every degree Fahrenheit (°F) difference between the supply air and room temperatures. Whether the change in throw will be an increase or decrease will depend on the temperature difference and discharge pattern. If the supply air is heated, the discharge air is going to be less dense and more buoyant. This will give the air the tendency to rise upwards. If the supply air is cooled, the discharge air is going to be denser, less buoyant, and will tend to fall.

If we have a ceiling mounted air outlet which is discharging air horizontally along the ceiling (shown in Figure 1), heated supply air is going to extend the throw to a terminal velocity of 50 FPM 1% for every 1°F temperature difference between the room air and supply air. The heated air is more buoyant and will stay up at the ceiling longer travelling further than the isothermal air would have.

If the supply air is cooled, the resulting throw to a terminal velocity of 50 feet per minute is going to be reduced 1% for every 1°F temperature difference between the room air and supply air. The cool air is denser and will tend to fall away from the ceiling giving shorter throws than with isothermal air **(Table 1)**.

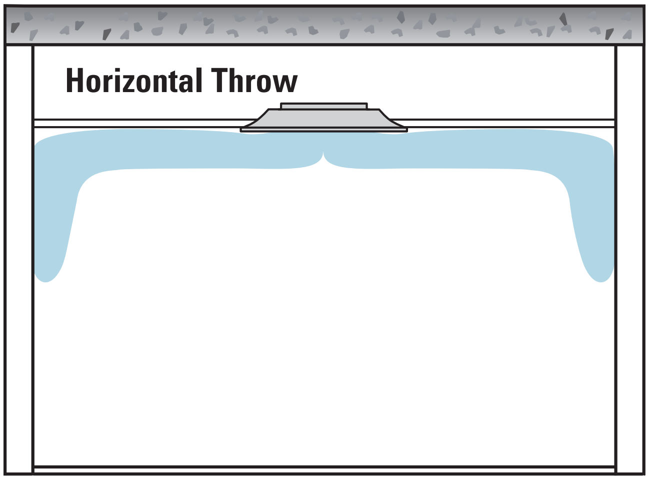


*Figure 1: Ceiling-mounted Diffuser Discharging Horizontally*

If the ceiling mounted diffuser was discharging the air vertically downwards, we will have the opposite effect, as shown in Figure 2. The buoyant, heated air will now tend to shorten the throw. If the supply air is cooled in this situation, the resulting throw will be increased. The denser, cool air tends to fall away from the ceiling, which increases the throw over that of isothermal air.

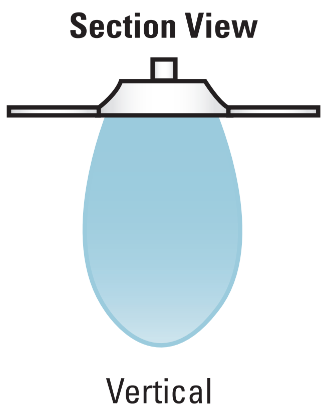


*Figure 2: Ceiling Mounted Diffuser Discharging Air Vertically Downwards*

A sidewall grille, mounted at high level, discharging horizontally is going to perform similar to the ceiling mounted diffuser, discharging horizontally (shown in Figure 3). Heating the supply air is going to increase the throw to a terminal velocity of 50 feet per minute, while cooling the supply air will decrease the throw to a terminal velocity of 50 feet per minute.

The final case is a floor mounted, or sill mounted grille, discharging vertically upwards (shown in Figure 4). In this case, the natural rise of the heated air will increase the throw to a terminal velocity of 50 feet per minute while the tendency of cool air to fall will shorten the throw to a terminal velocity of 50 feet per minute.

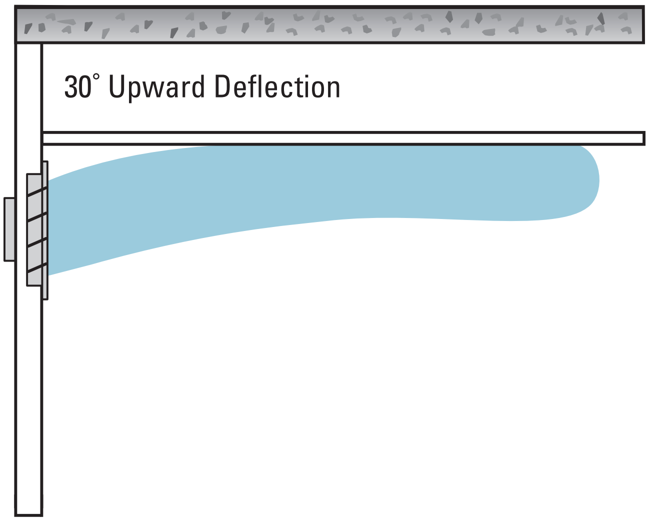


*Figure 3: Sidewall Grille Mounted at High Level Discharging Horizontally*

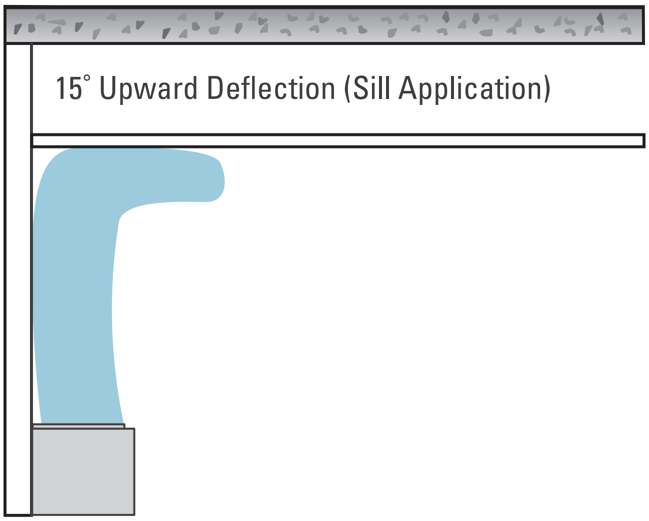


*Figure 4: Floor Mounted or Sill Mounted Grill Discharging Vertically Upwards*

**Table 1: Air Outlet Throw Performance Due to Non-Isothermal Conditions**

1% Change to Isothermal Throw* for Every 1°F Difference in Temperature (DT).

| Installation | Discharge | Heating DT | Cooling DT |
|---|---|---|---|
| Ceiling | Horizontal | Increase | Decrease |
| Ceiling | Vertical Down | Decrease | Increase |
| High Sidewall | Horizontal | Increase | Decrease |
| Floor / Sill | Vertical Upwards | Increase | Decrease |

** Throw to a terminal velocity of fifty feet per minute*

The application where temperature differentials have the greatest effect is a vertical downward discharge air in heating mode. Heating temperature differentials can be as high as 40°F above room temperature, which means throws can be reduced by up to 40% compared to the catalog.

The vertical downward discharge air becomes even more challenging if the air system is used for both heating and cooling. The same air volume will result in an even greater change in throw distance between heating and cooling operation. The designer must check that the throw under both conditions is within acceptable limits. If the air volume cannot be controlled between heating/cooling operation, and the air jet is intended to condition an exterior surface such as a window, then it is generally recommended to size the air outlet for heating mode to minimize the risk of condensation on the cool surface.

## MAIN TAKEAWAYS

- Catalog throw data of air outlets assumes the supply air is the same temperature as the room air (isothermal conditions).
- Warm air is more buoyant and rises towards the ceiling. Cool air is more dense and drops towards the floor. Buoyancy affects the throw performance of air outlets. Warm air will travel further horizontally and upwards. Cool air will travel shorter horizontally, but longer downwards. The magnitude of this affect is approximated as 1% change in throw distance per 1°F difference from room air temperature.
- Take careful consideration when designing long throws for heating/cooling applications. Size heating throws to prevent condensation. Implement VAV controls or adjustable throw patterns for seasonal changes in supply air temperature.

## REFERENCES


1. ASHRAE (2017). *ASHRAE Handbook - Fundamentals*. Atlanta, GA: American Society of Heating, Refrigeration, Air-Conditioning Engineers.
2. ASHRAE (2006) Standard 70, *Method of Testing the Performance of Air Outlets and Air Inlets*
3. Price Industries (2016) *Price HVAC Engineer's Handbook*. Winnipeg, MB.