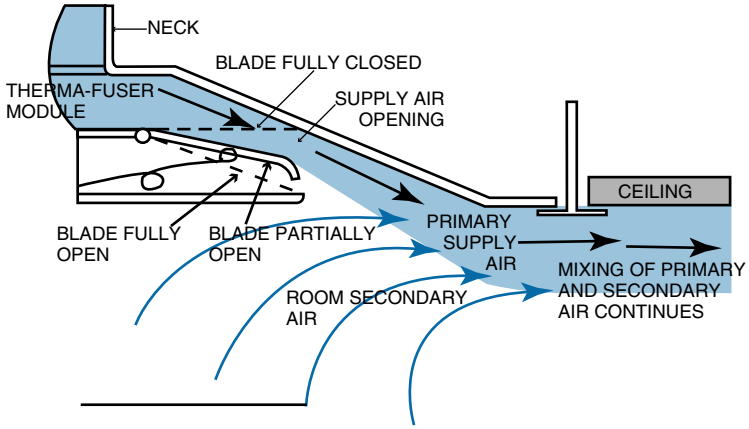
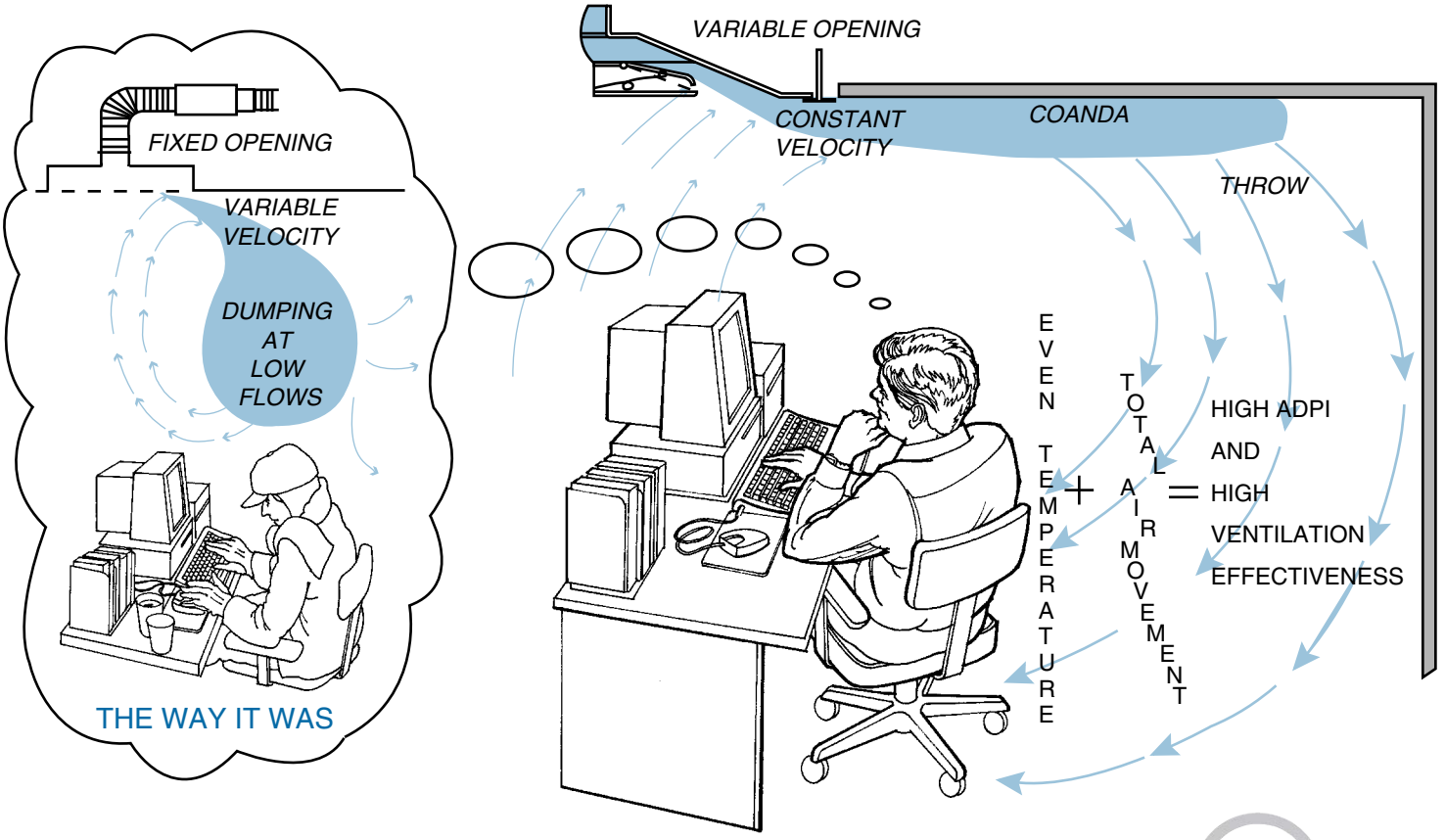
THERMA-FUSER™ VAV MODULES PROVIDE SUPERIOR AIR DISTRIBUTION

- Lowest energy VAV terminal
- Easily adapts to office layout change
- Lowest cost per zone of control
- **Superior air distribution**
- Low to no maintenance

Systems with Therma-Fuser VAV modules are better than systems with VAV boxes because they have superior air distribution. Unlike the fixed opening diffusers used with VAV boxes, Therma-Fuser modules vary the discharge opening as they vary air volume. The result is an almost constant discharge velocity, with the benefits of better throw, higher room air movement, and uniform temperature distribution, especially with lower turn down air flow. Other benefits are no dumping of cold air, and superior penetration of warm air into the occupied space.

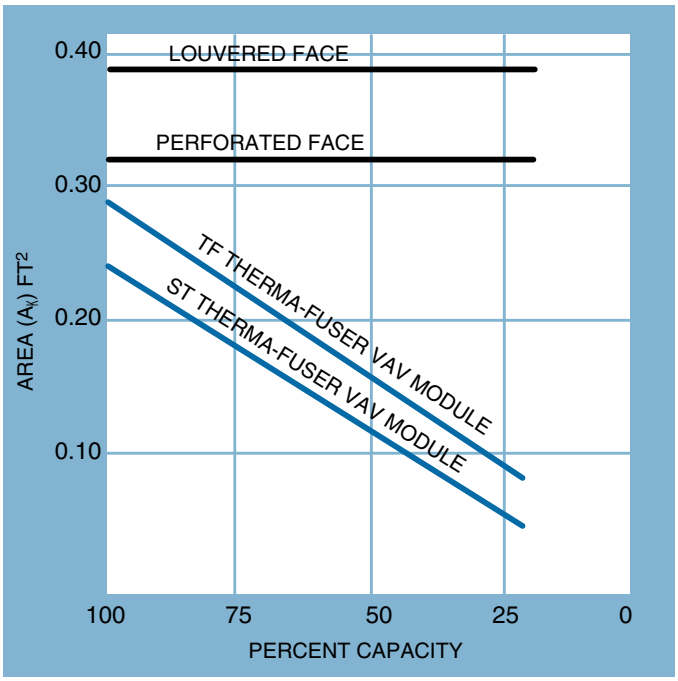
This report compares design and turndown air distribution of Therma-Fuser modules to that for VAV boxes used with fixed opening diffusers—both perforated and louvered face. Comparisons are made in area, velocity, throw, Coanda, total room air movement, temperature distribution, ADPI and ventilation effectiveness.





AREA

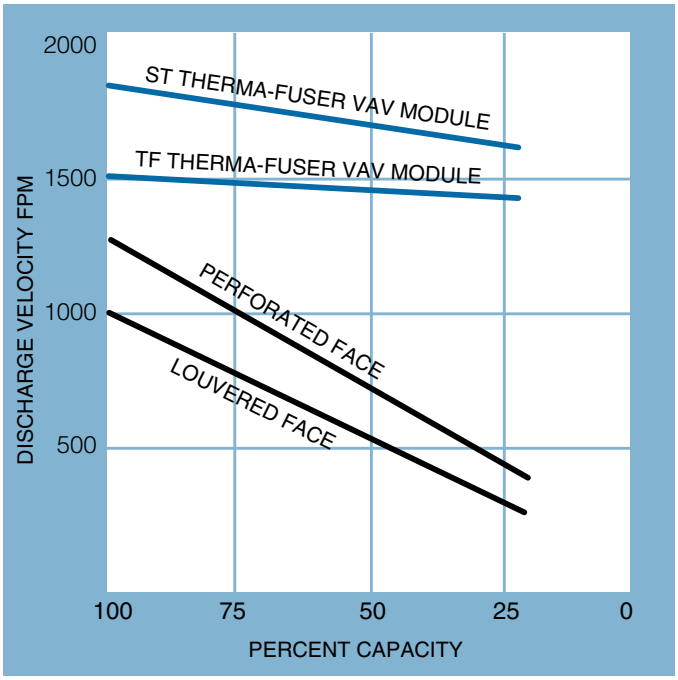
Therma-Fuser modules vary the area of the discharge air opening to control air flow as a function of room temperature. VAV boxes use fixed opening (fixed area) diffusers and control air flow and diffuser static pressure as a function of room temperature by positioning a valve in an upstream box.



VELOCITY

Therma-Fuser modules adjust the opening to control air flow which results in a relatively constant discharge velocity if the static pressure and hence the pressure drop are constant. If instead of holding static pressure constant, it is allowed to increase at reduced flow, discharge velocities will increase along with the benefits of greater air circulation and warm air penetration.

VAV boxes reduce air flow through fixed opening diffusers by decreasing static pressure. The result is a drop in discharge velocity.

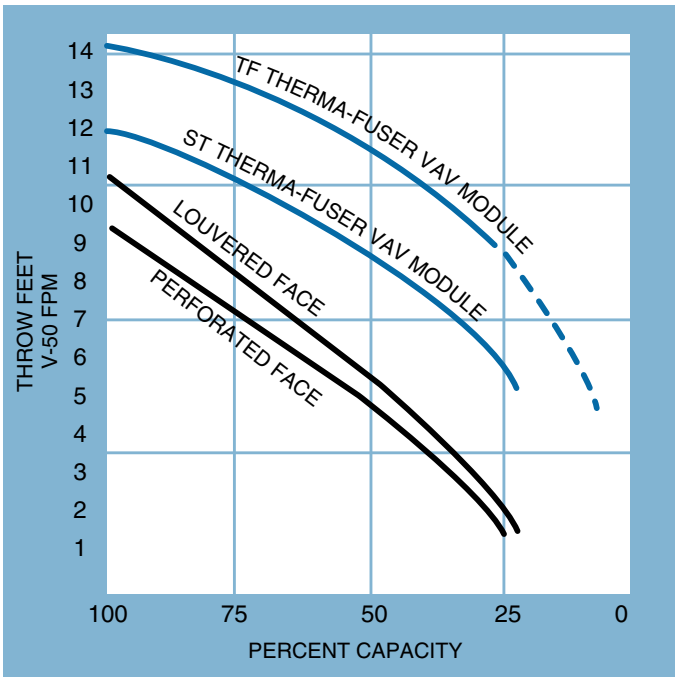


THROW

Throw depends on discharge air momentum—mass at a velocity. Therma-Fuser modules reduce air flow (mass) without reducing discharge velocity. The high velocity at reduced air flow results in longer throws compared to fixed opening diffusers.

VAV boxes reduce both air flow and velocity together through fixed opening diffusers causing throw to quickly drop off.

Note from the graph that the throw for Therma-Fuser modules at reduced capacities is better than throw for fixed opening diffusers at 100% capacity. Greater throw at part loads counteracts the tendency of cold supply air to dump and allows buoyant warm supply air to be driven down a wall or over a window.



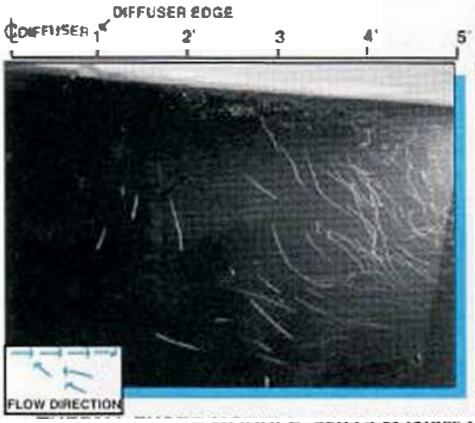
COANDA

Coanda effect, the ability of more dense cold air to attach to the ceiling, is dependent on discharge velocity. Because Therma-Fuser modules maintain discharge velocity, they maintain Coanda. Even though throw may decrease at low air flow, Therma Fuser modules will not dump. Cold supply air is held at the ceiling longer allowing temperature mixing above the occupied space. When supplied with heavier cool air, fixed opening diffusers are very susceptible to dumping at low air flows. This is illustrated by the following photos of neutrally buoyant helium bubbles injected into the air stream. (See note 7 of *Notes and References* for a further description.) Note that the perforated diffuser loses Coanda around 70% of design air flow and requires more than 75% design air flow to regain Coanda.

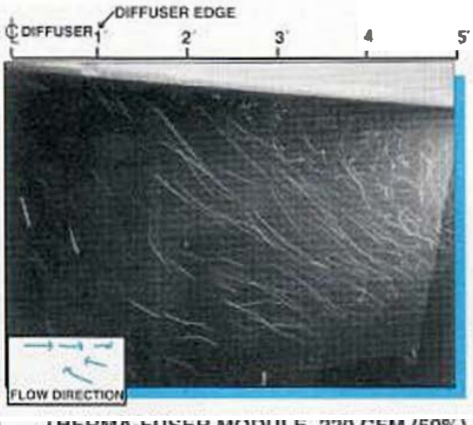
PHOTOGRAPHS OF NEUTRALLY BOUYANT BUBBLES INJECTED INTO THE AIR STREAM

NOTE: Distance to the wall for all photos is 13 feet.

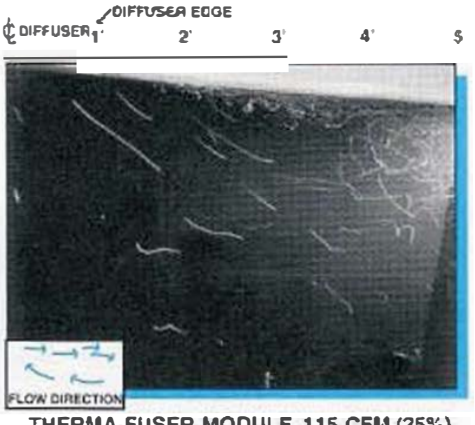
CONDITIONS: SUPPLY AIR TEMPERATURE 55° - 58° ROOM AIR TEMPERATURE 74° - 75°



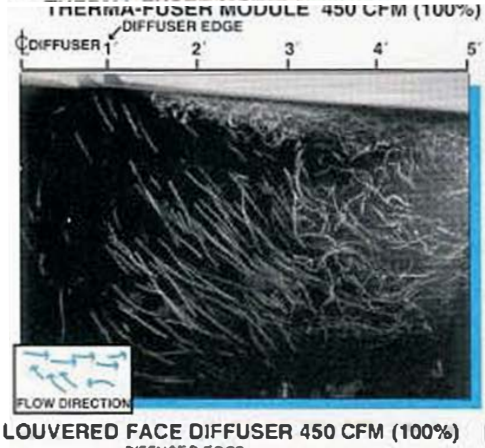
THERMA-FUSER MODULE 450 CFM (100%)



THERMA-FUSER MODULE 220 CFM (50%)

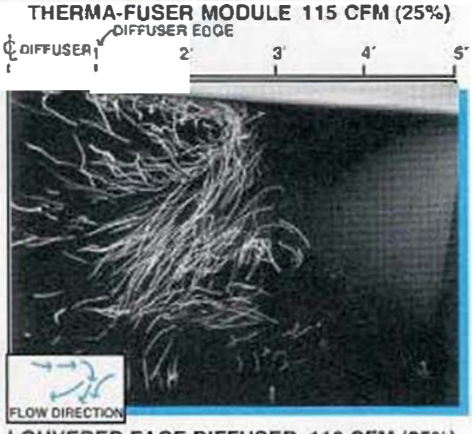


THERMA-FUSER MODULE 115 CFM (25%)

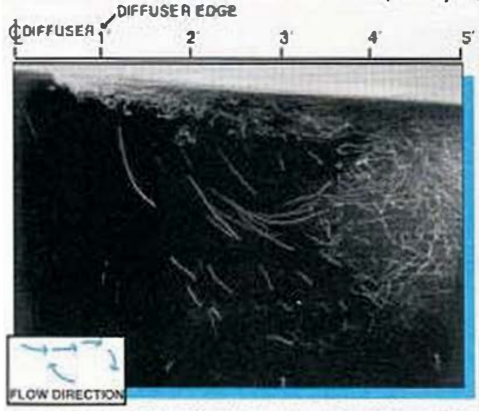


LOUVERED FACE DIFFUSER 450 CFM (100%)

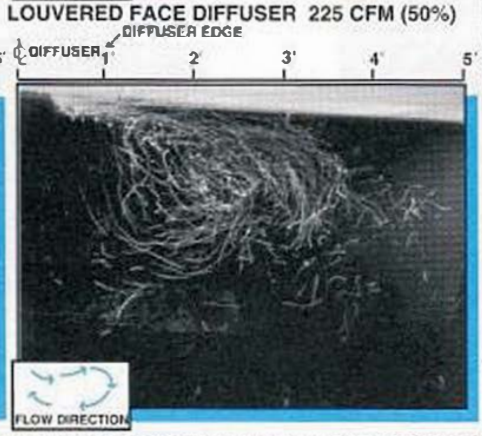
LOUVERED FACE DIFFUSER 225 CFM (50%)



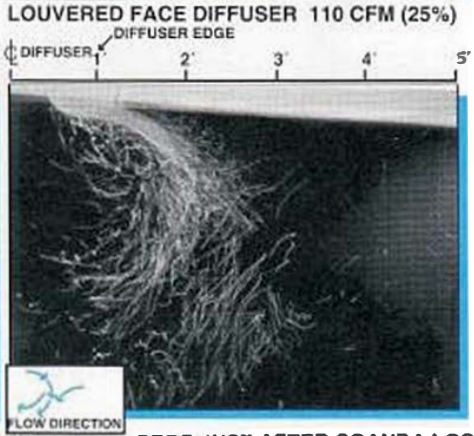
LOUVERED FACE DIFFUSER 110 CFM (25%)



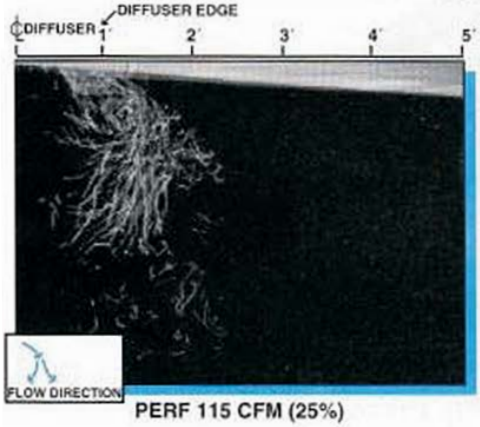
PERFORATED DIFFUSER 450 CFM (100%)



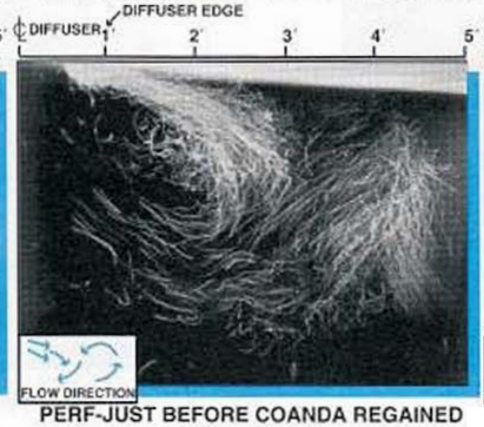
PERF-JUST BEFORE COANDA LOST 320 CFM (71%)



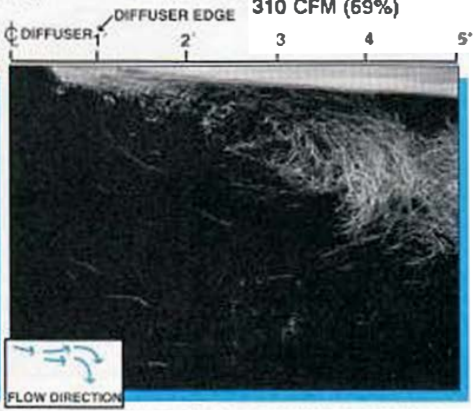
PERF-JUST AFTER COANDA LOST 310 CFM (69%)



PERF 115 CFM (25%)



PERF-JUST BEFORE COANDA REGAINED 340 CFM (75%)



PERF-JUST AFTER COANDA REGAINED 350 CFM (78%)

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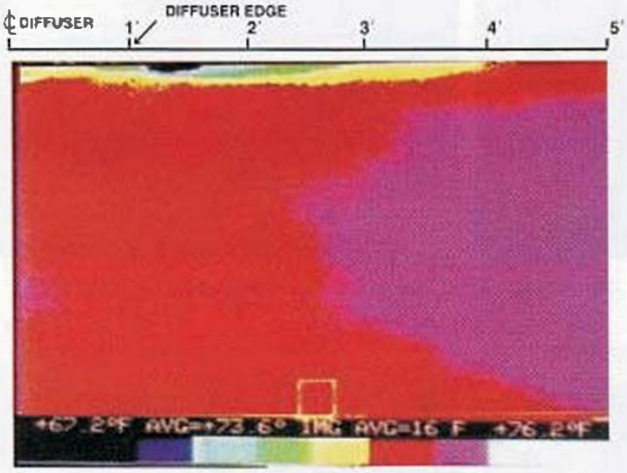
ROOM TEMPERATURE DISTRIBUTION

Color-temperature photographs taken of a screen in a plane centered in the airstream of a diffuser using an infra-red thermal imaging camera.

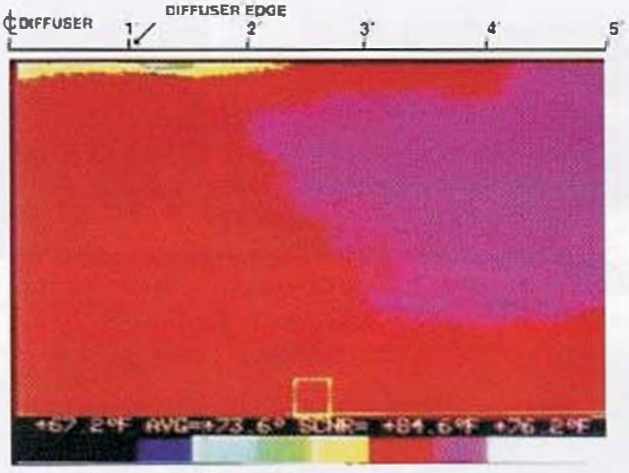
NOTE: These photos show temperature only. They do not show pockets of stagnant air or poor room air motion. These photos should be viewed in conjunction with the air motion photos on page 3.

CONDITIONS: SUPPLY AIR VOLUME 275 CFM (100%)
SUPPLY AIR TEMPERATURE 55° AVERAGE ROOM AIR TEMPERATURE 73.6°



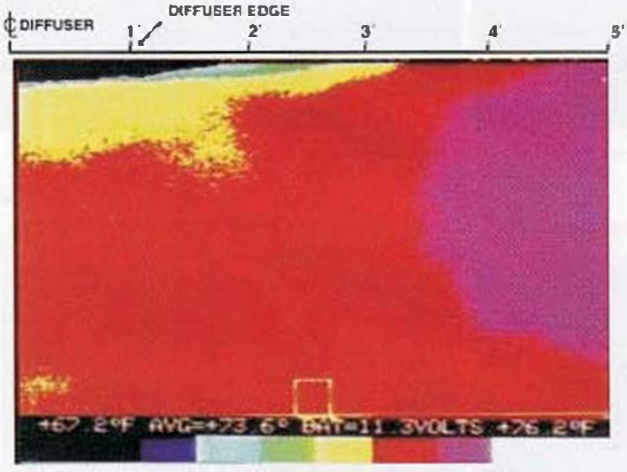
TEMP. SCALE 69° | 70° | 71° | 72° | 73° | 74° | 75° | 76°

THERMA-FUSER MODULE 100%



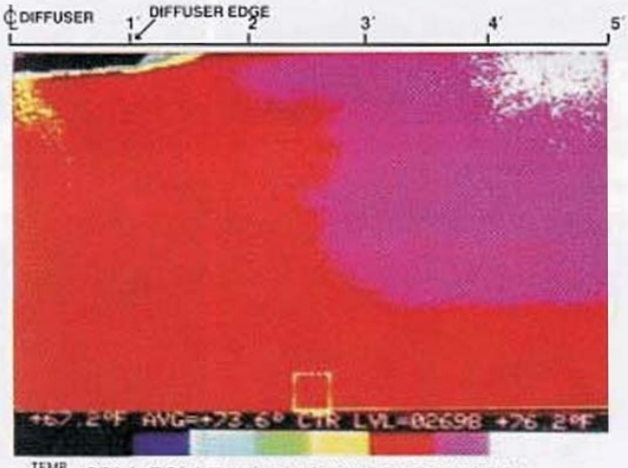
TEMP. SCALE 69° | 70° | 71° | 72° | 73° | 74° | 75° | 76°

THERMA-FUSER MODULE 25%



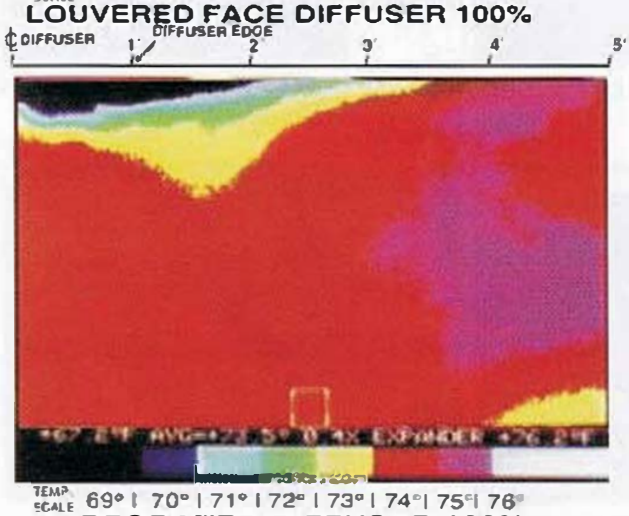
TEMP. SCALE 69° | 70° | 71° | 72° | 73° | 74° | 75° | 76°

LOUVERED FACE DIFFUSER 100%



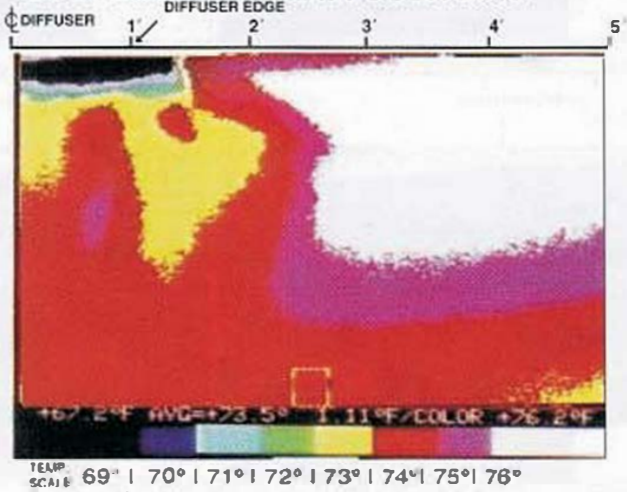
TEMP. SCALE 69° | 70° | 71° | 72° | 73° | 74° | 75° | 76°

LOUVERED FACE DIFFUSER 25%



TEMP. SCALE 69° | 70° | 71° | 72° | 73° | 74° | 75° | 76°

PERFORATED DIFFUSER 100%



TEMP. SCALE 69° | 70° | 71° | 72° | 73° | 74° | 75° | 76°

PERFORATED DIFFUSER 25%

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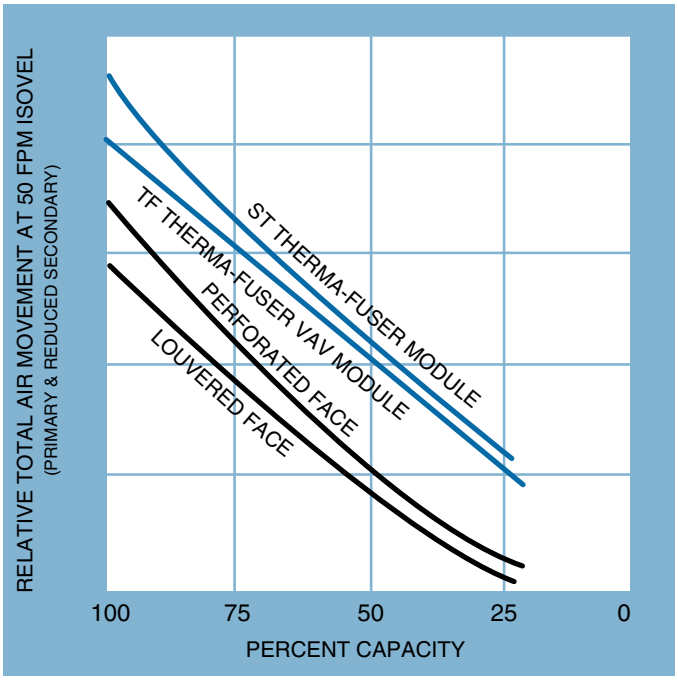
TOTAL ROOM AIR MOVEMENT

Good room air circulation of both primary (discharge) and secondary (induced) air is a function of primary air velocity. Higher discharge velocities from Therma-Fuser modules result in more secondary air induced or entrained which in turn results greater total air circulation in the space especially at low loads. The occupied area is filled with gently moving air usually between 15 and 35 fpm velocity. Pockets of stagnation are eliminated and comfort is improved over fixed diffusers.

Note from the graph that the relative total air movement at the 50 fpm isovel for Therma-Fuser modules is the same at 50% turndown as for fixed diffusers at 75% turndown.

High induction of room air into the supply air results in thorough mixing and temperature equalization. When heating, buoyant warm supply air is quickly mixed with the room air producing a less buoyant lower temperature mixture which is circulated throughout the occupied space due to the good air movement.



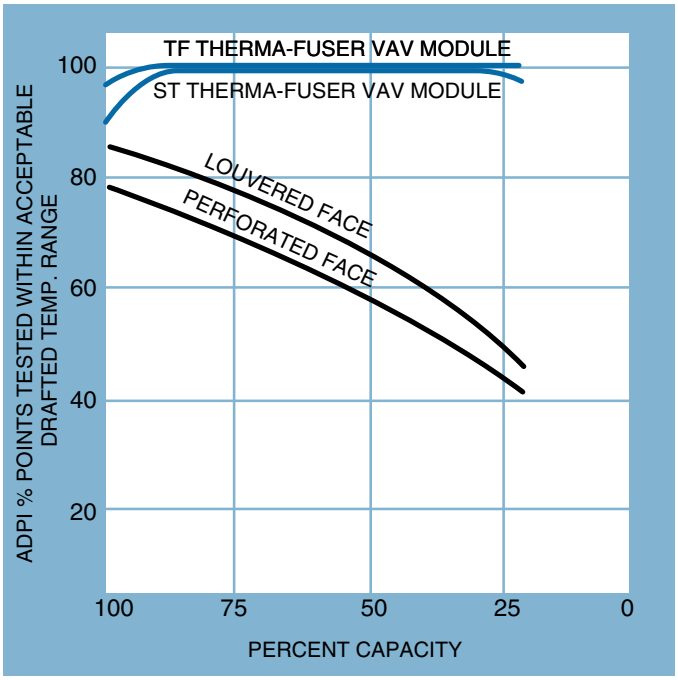
UNIFORM TEMPERATURE DISTRIBUTION

The intensive heat transfer between primary and secondary air—usually within two feet of the edge of the Therma-Fuser module—greatly reduces the temperature differential between the moving air stream and the room. This reduces the air density differential (buoyancy effect) that causes colder air to drop (cooling mode) and warmer air to rise (heating mode). Unlike fixed diffusers, the horizontal throw of air is maintained with Therma-Fuser modules as volume changes. Gentle air motion throughout the Therma-Fuser unit's area of thermal control is maintained eliminating hot or cold air pockets.

ADPI

Air Diffusion Performance Index (ADPI) is defined in the 2001 ASHRAE Fundamentals Handbook as the percentage of points measured in a room which are within both the ASHRAE temperature and velocity ranges for comfort. The ASHRAE Handbook states on page 32.17 that, *"For an office environment in cooling mode, the design goal should be an ADPI greater than 80. The ADPI should not be used as a measure of performance for heating conditions."*

The Therma-Fuser module's ability to circulate room temperature air while meeting a wide range of load requirements allows the achievement of exceptional ADPI ratings. Fixed diffusers with lower velocities under turndown conditions do not perform well at reduced loads under the ADPI criteria.



VENTILATION EFFECTIVENESS

Improved ventilation effectiveness (efficiency) is associated with reduced room air stratification. The high velocity discharge from Therma-Fuser modules produces quick mixing of primary and induced secondary air which reduces stratification. As would be expected, studies (see note 11 of *Notes and References*) have shown that if thermal load and comfort requirements (ADPI and minimum stratification) are met, full ventilation mixing occurs resulting in a high ventilation efficiency. Therma-Fuser modules achieve this at both design and turndown air flows where fixed diffusers can not.

Therma-Fuser modules consistently produce higher throws, better Coanda, higher total air movement, more even temperature, better ADPI and higher ventilation effectiveness than fixed diffusers and VAV boxes. Therma-Fuser modules are the preferred VAV terminal. Use them in your VAV systems.

Notes and References

1) Diffuser modules evaluated:

- Louvered face, 24" x 24", 10" round neck, 3 cones.
- Perforated face, 3/16" dia. holes, 24" x 24", 10" round neck, flush face, rotating pattern controllers on perforated face.
- TF-HC -10" round neck Therma-Fuser module.
- ST-HC -10" round neck Therma-Fuser module.

Except infrared imaging done with 8" neck versions of the above.

2) All tests per ASHRAE Standard 70 and ARI 880.
100% flow capacity was 450 cfm except infrared imaging at 275 cfm. Static pressure for the Therma-Fuser module maintained at 0.15" wg.

3) Isothermal air was used except for photographs of air flow using neutrally buoyant helium bubbles, temperature photographs using infrared imaging and ADPI.

4) Effective areas (A_K) calculated by dividing the primary flow rate by the discharge velocity measured at that flow rate.

5) Discharge velocities for various flows measured per manufacturer's recommendations.

6) Throw tests per ASHRAE Standard 70.

7) Photographs of air flow use neutrally buoyant helium bubbles injected at the neck of the diffuser. Bubbles carried by the air stream were side illuminated with high intensity light and photographed against a black background.

8) Room air movement calculated per 2001 ASHRAE Fundamentals Handbook, page 32.6.

9) Color temperature photographs taken of a screen in a vertical plane centered in the air stream using an infrared imaging camera.

10) ADPI testing of the Therma-Fuser modules by ETL Testing Laboratories per ASHRAE Standard 113. Other ADPI information based on 2001 ASHRAE Fundamentals Handbook, page 32.13 and ASHRAE paper No. 2258 RP-55 and 88 (Research Report) “Analysis, Evaluation and Comparison of Room Air Distribution Performance—A Summary” by Ralph Nevins and Paul Miller.

11) Ventilation efficiency study from March 1993 ASHRAE Journal, page 42 “Air Movement, Comfort and Ventilation in Partitioned Workstations” by Fred Bouman, et al.

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