עקרונות פיזור אויר והצגת סוגים של מפזרים
Laminaire Radial Diffuser -
& Displacement Ventilation

אנטולי ליפשיץ – אלקטרה M&E

The 19th International Annual Convention
Electricity 2018 חשמל
The Society of Electrical and Electronics Engineers in Israel

אלקטרה

עקרונות פיזור אויר והצגת סוגים של מפזרים -
Laminaire Radial Diffuser & Displacement Ventilation

1. הצגת שיטות ואפשרויות של אספקה ופיזור אויר לפי "אוורור תזוזה"
2. הצגת הניתוח הטכני / הנדסי של מפזרים
3. סקירה לגבי שיטות אספקה ופיזור אויר במטווחים סגורים
4. סיכומים והמלצות

עקרונות פיזור אויר Displacement Ventilation

1. אוורור תזוזה (DV) הוא תהליך אספקת אוויר לחדר בטמפרטורה מעט נמוכה מטמפרטורת הסביבה הרצויה ובמהירות איטית. האוויר יזרום לאורך הרצפה ויעלה על ידי קונוונציה טבעית כאשר הוא מתחמם או כאשר הוא באה במגע עם מקור חום -ציוד או אנשים. לאחר מגע עם מקור החום, האוויר בטמפרטורה מחוממת תעלה לתקרה. מטרה השיטה של "אוורור תזוזה" לשמור על תנאים הנרשם באזור של אנשים.
2. בדרך כלל קיימים שני אזורים בחדר / אולם - אזור הנשימה, שנמצא מהרצפה ועד לראש של בן אדם והאזור חם יותר- מעל גובה בן אדם , שנמצא מעל אזור הנשימה. בשיטה " אוורור תזוזה " מסופק אוויר באיכות גבוהה לאזור הנשימה. האוויר המחומם יהיה מעל גובה של 1.80-2.00 מטר מהרצפה – מעל אזור נשימה של אנשים .
3. מערכת "אוורור תזוזה" שונה ממערכות "אוורור ערבובי". באוורור ערבובי האוויר מסופק לחדר במהירות גבוהה מהתקרה וכל האוויר בחדר מעורבב יחד כדי לספק טמפרטורה אחידה. החיסרון " אוורור ערבובי" שהוא פחות חסכני – כמטפל את כל החלל ברציפות ולא רק אזור הנשימה; ולכן, שיטה קונבנציונלי של "אוורור ערבובי" פחות חסכונית ופחות נקייה .

Displacement Ventilation System

1. שיטת פיזור "תזוזה" - Displacement Ventilation System אפקטיבי בשימוש :
   - ❖ באולמות קונצרטים
   - ❖ באודיטוריום וחדרי לימוד
   - ❖ בחדרי ישיבות ומשרדים
   - ❖ בלביאים של בתי מלון ואטריום
   - ❖ באולמות תצוגה ואולמי קניות
   - ❖ במוזיאונים
   - ❖ בבתי החולים
   - ❖ בטרמינלים של שדי התעופה ותחנות רכבת
   - ❖ במטווחים סגורים – בשיטה של Radial Diffuser ו- Air Wall

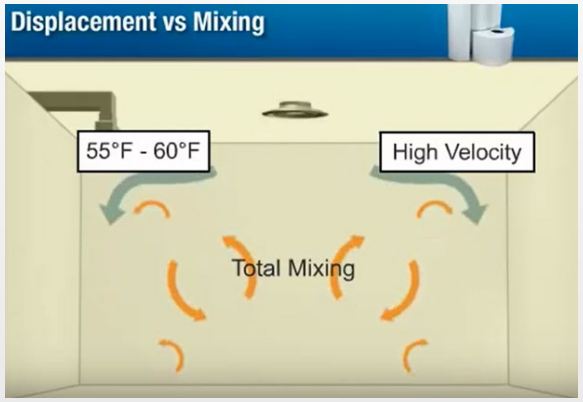
ANSI/ASHRAE Standard 62.1-2013
(Supersedes ANSI/ASHRAE Standard 62.1-2010)
Includes ANSI/ASHRAE addenda listed in Appendix J

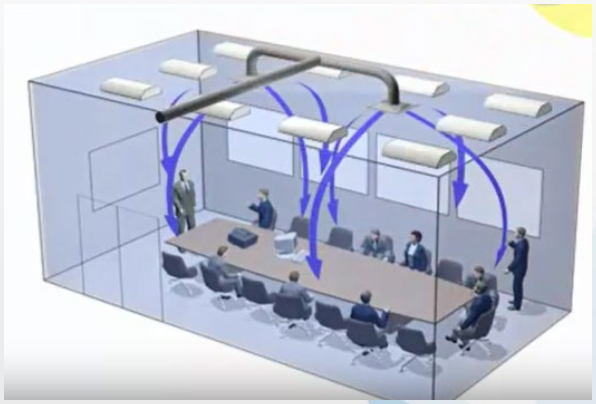
Ventilation for Acceptable Indoor Air Quality

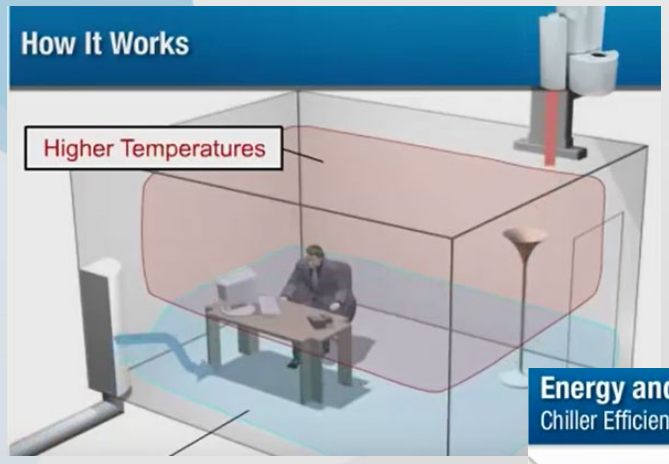
TABLE 6.2.2.2 Zone Air Distribution Effectiveness

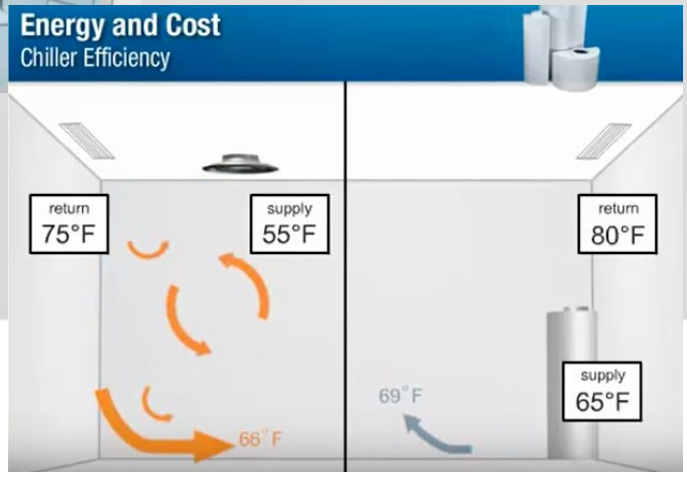
Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level	1.0
Note: For lower velocity supply air, $E_z = 0.8$.	
Floor supply of cool air and ceiling return, provided that the vertical throw is greater than 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) or more above the floor	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification, or underfloor air distribution systems where the vertical throw is less than or equal to 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return	0.8
Makeup supply drawn in near to the exhaust and/or return location	0.5

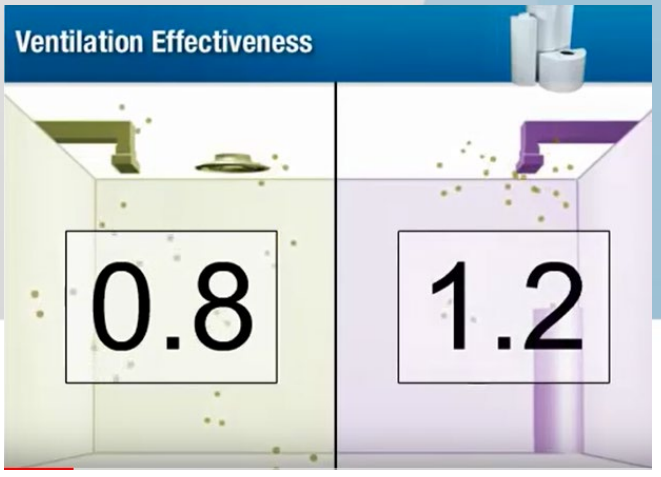
Air Distribution Options – Mixing & Displacement



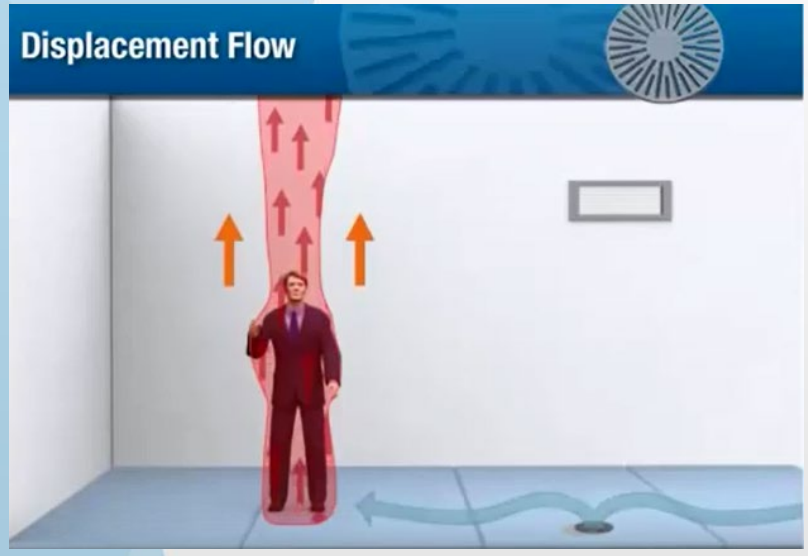




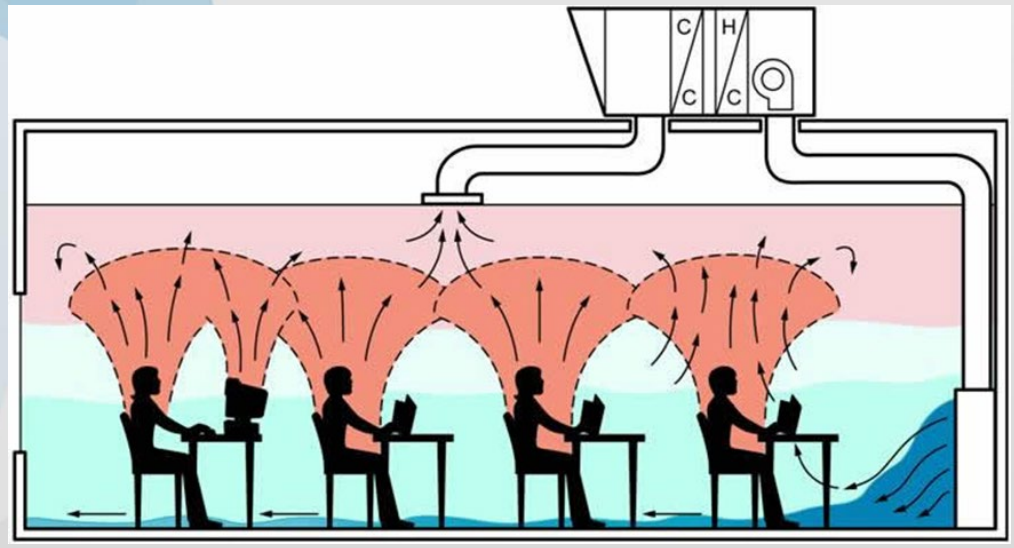


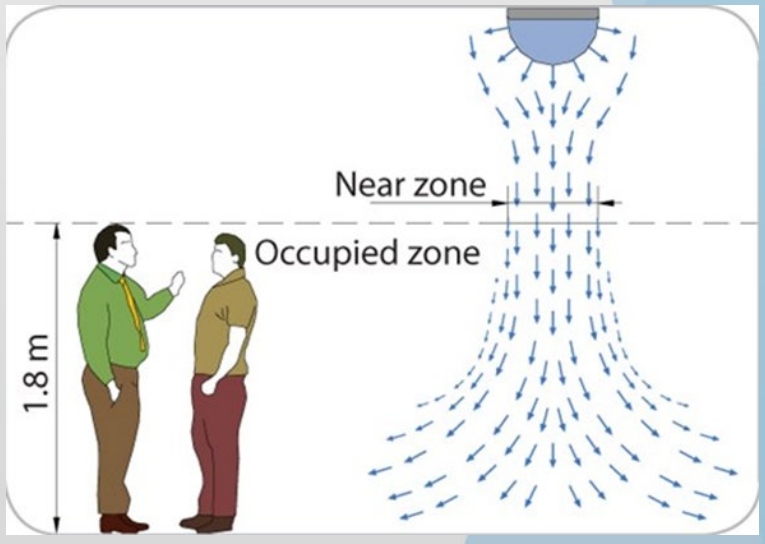


Air Distribution Options



אספקת אויר עם מפזרים ריצפתים





אספקת אויר עם מפזרים קירים

אספקת אויר עם מפזרים תקרתים

Underfloor Air Distribution (UFAD)

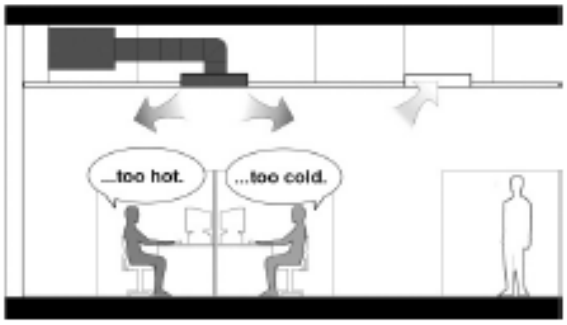


Figure 3.1 Conventional overhead air distribution system.

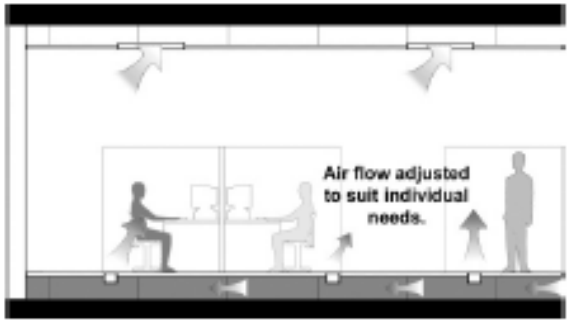


Figure 3.2 Underfloor air distribution system.

CHAPTER 1—INTRODUCTION

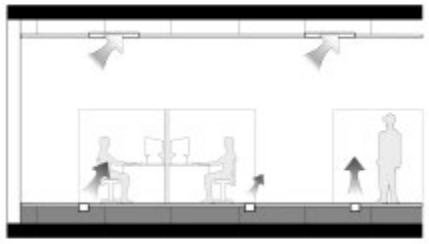


Figure 1.2 Underfloor air distribution system.

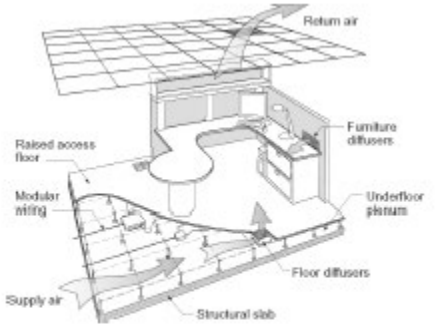


Figure 1.3 Cutaway of typical office work space showing UFAD with TAC system.

Underfloor Air Distribution (UFAD) Design Guide

Fred S. Bauman

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Underfloor Air Distribution (UFAD)

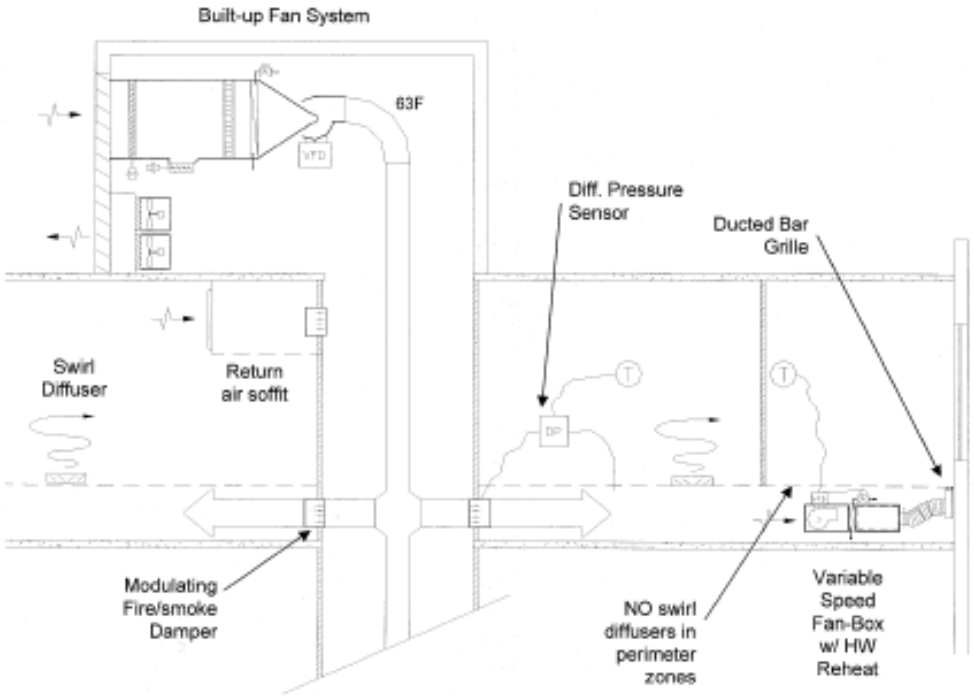


Figure 9.6 UFAD system schematic with variable-speed fan coil with reheat in perimeter.

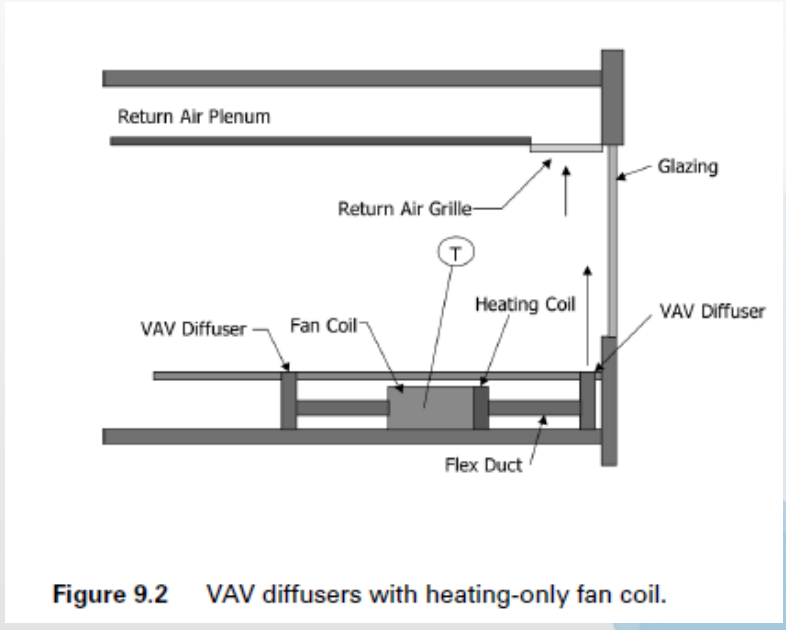


Figure 9.2 VAV diffusers with heating-only fan coil.

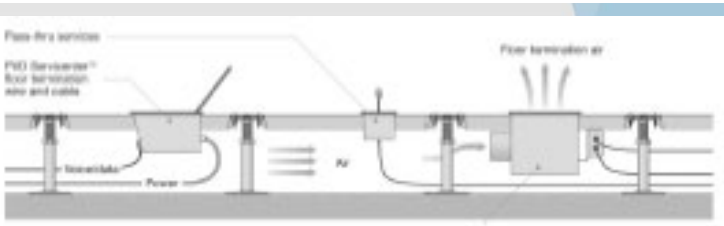
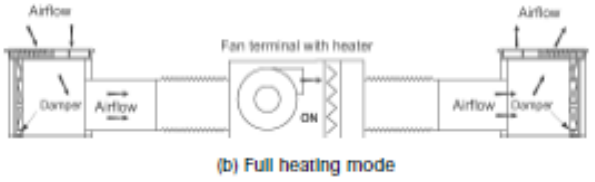


Figure 5.20 Installation of a raised floor system creates an integrated service plenum.



(b) Full heating mode

Figure 5.18 Perimeter solution using heating fan terminal with VAV

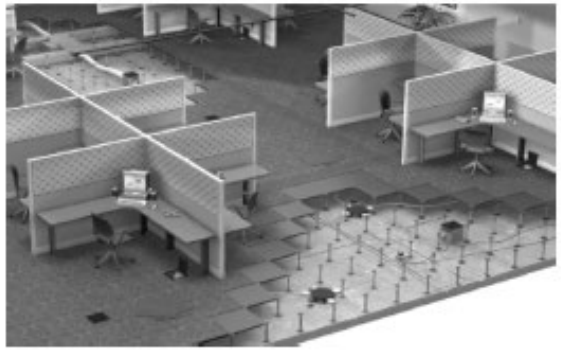
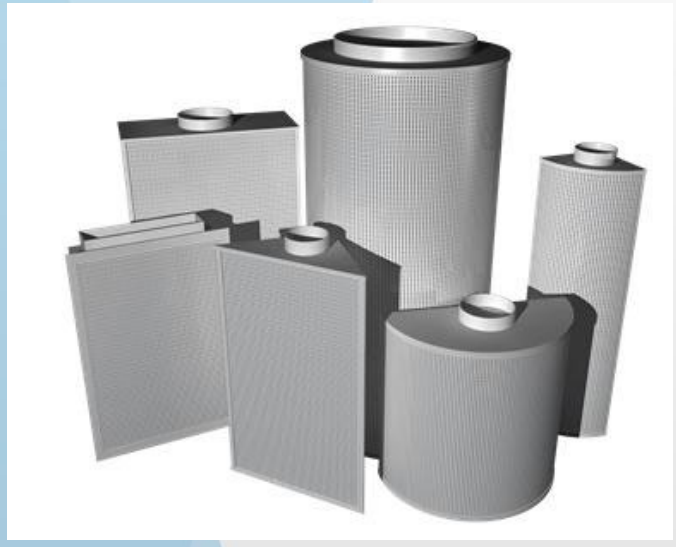
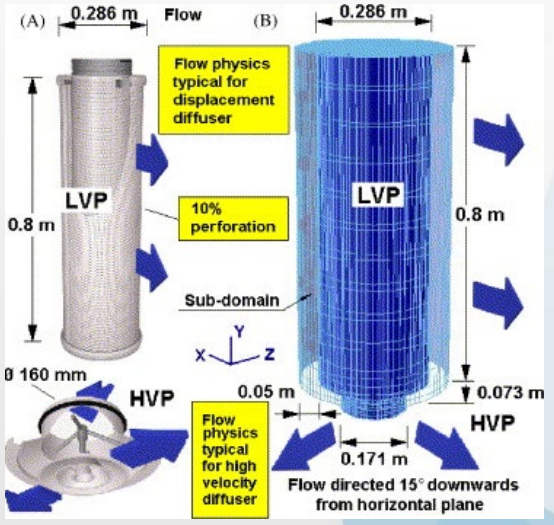
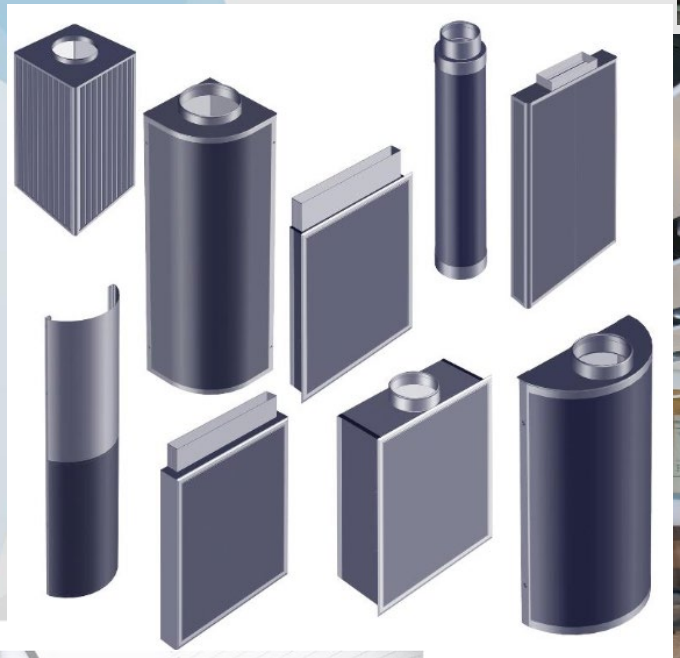


Figure 4.2 Installation of raised floor system in open plan office.

Displacement Laminaire Radial Diffuser Types





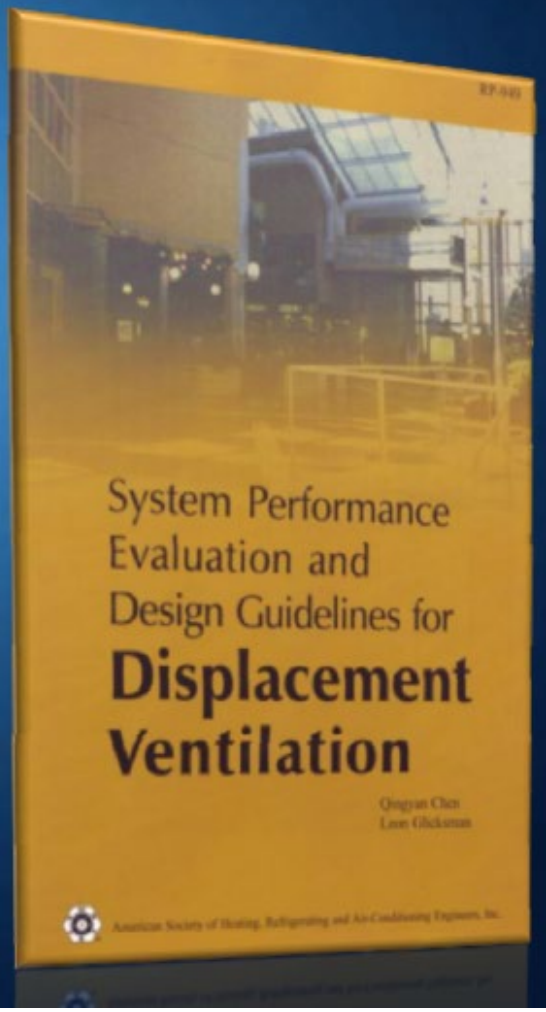


Displacement Ventilation Calc Procedure

Theory and Design Considerations

Air Volume Calculations:

- ASHRAE Design Guide
- Calculate:
  - Supply Air Volume
  - Supply Air Temperature
  - Exhaust Air Temperature
- Based on zones with ~9’ ceiling height



Displacement Characteristics

History of Displacement Systems:

- Utilized in Europe for over 30 years
- Origins in industrial facilities
- #1 choice for industrial facilities in Europe
- Applied to commercial market in the 1980's
- Becoming popular in North America

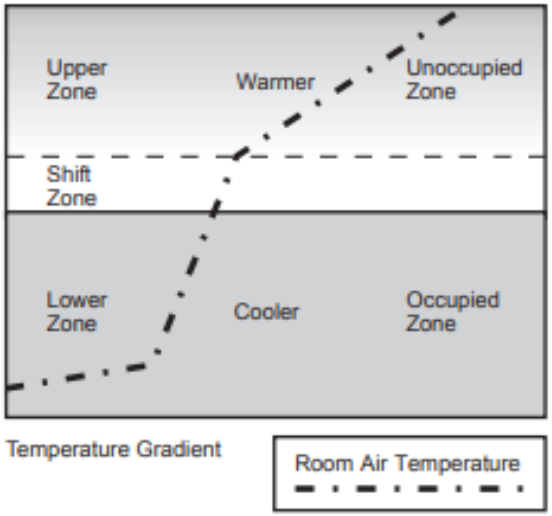
Displacement Ventilation System

Displacement Ventilation System

This solution not only has the potential for great thermal comfort, it also enables efficient use of our conditioned air. Unlike overhead air distribution, DV introduces low velocity, higher temperature supply air to the space. Some energy advantages of displacement ventilation over a totally mixed ventilation system include:

- Lower cooling energy and lower capacity demands will help maintain equal thermal conditions in the occupied zone.
- Higher temperature supply air can maximize the hours of economizer free cooling.
- Improved chiller COP due to higher EWT and higher supply air temperature.

NOTE: In displacement ventilation, the air temperature is actively controlled only in the occupied zone and supply airflow rate is adjusted to a level that makes the airborne contaminants rise above the breathing zone.

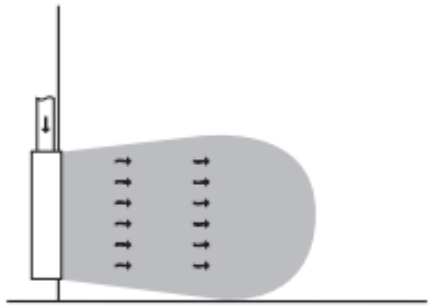


ISOTHERMAL VENTILATION

ASHRAE Standard 62.1-2010 "Ventilation for Acceptable Indoor Air Quality" table 6.2 states the ventilation effectiveness for over head mixed distribution systems is E_z = 1.0. Where fully stratified systems are assigned a value of 1.2, by comparison, 20% more effective than overhead. Better ventilation efficiency means, in addition to energy savings through a reduction in air volume, improved indoor air quality in the occupied zone is attainable.

Where:

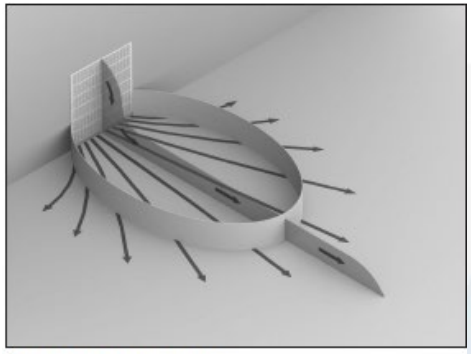
E_z = Air Change Effectiveness (Table 6.2)



Displacement Ventilation System

COOLING

With displacement ventilation, the room air temperature increases with the height in the space. As a result, the thermal conditions and air quality are actively controlled only in the occupied zone. The air temperature and contaminant level are higher in the stratified zone. Depending on the breakdown of heat gains and the height of the space, the temperature difference between the supply and exhaust air is 8 - 18°F. Since cool air is supplied directly to the occupied zone, special attention to the analysis of the adjacent zone should be taken to minimize occupant discomfort.



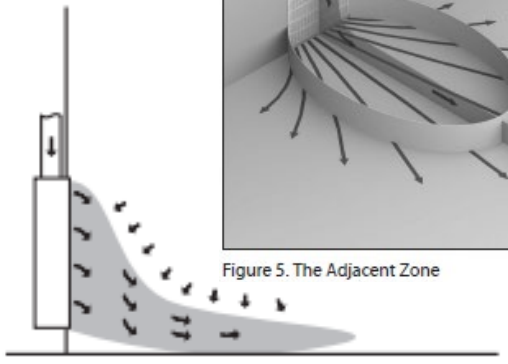


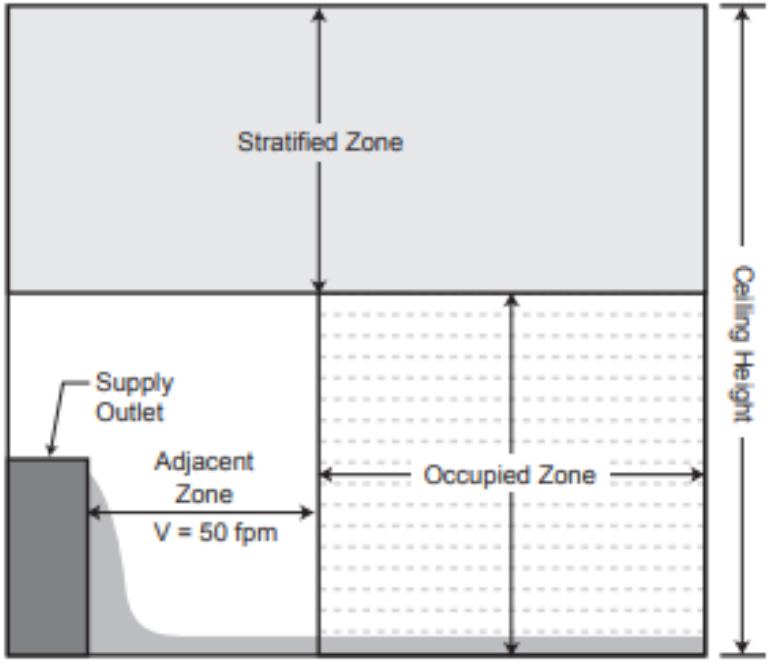
Figure 5. The Adjacent Zone

DESIGN CONDITIONS

In commercial buildings the air quality criteria is often indicated in terms of CO_2 concentrations. In other applications, it is important to determine whether the contaminants are warmer and/or lighter than room air. In both cases where the contaminant loads are high, special attention to the occupied zone height, supply airflow rate, and unit location should be analyzed.

ADJACENT ZONE

The cool supply air creates a zone in front of the supply unit where a draught might be perceived. The size of this adjacent zone depends on the properties of the supply unit, the airflow rate, and the supply air temperature. During the design process, the dimensions of the adjacent zone should be determined, the can later be used when placing objects or occupants in the space.



Displacement Diffuser's Types

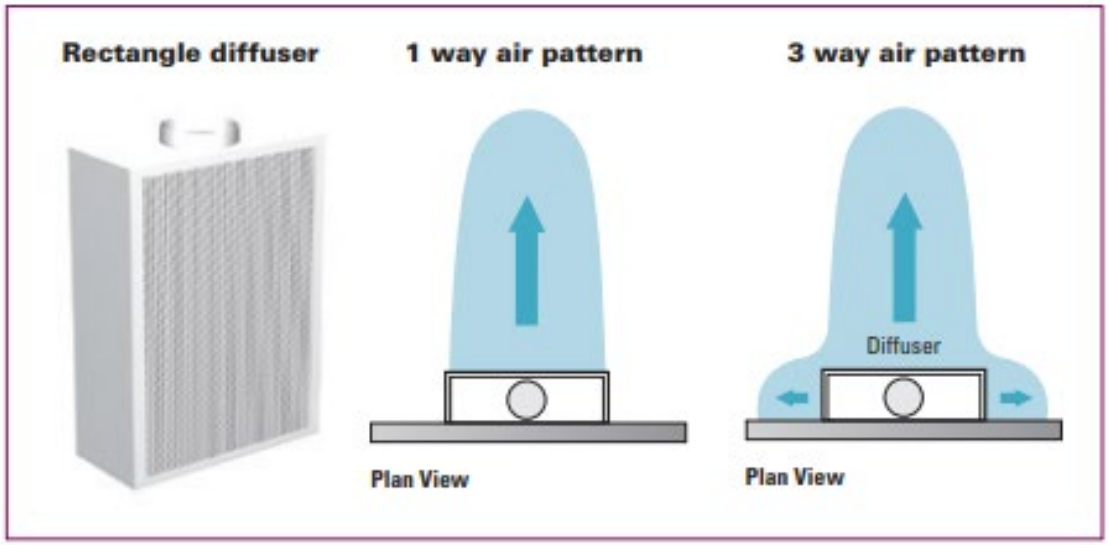


Figure 21: Rectangle diffusers

Figure 22: DF1L installed against wall

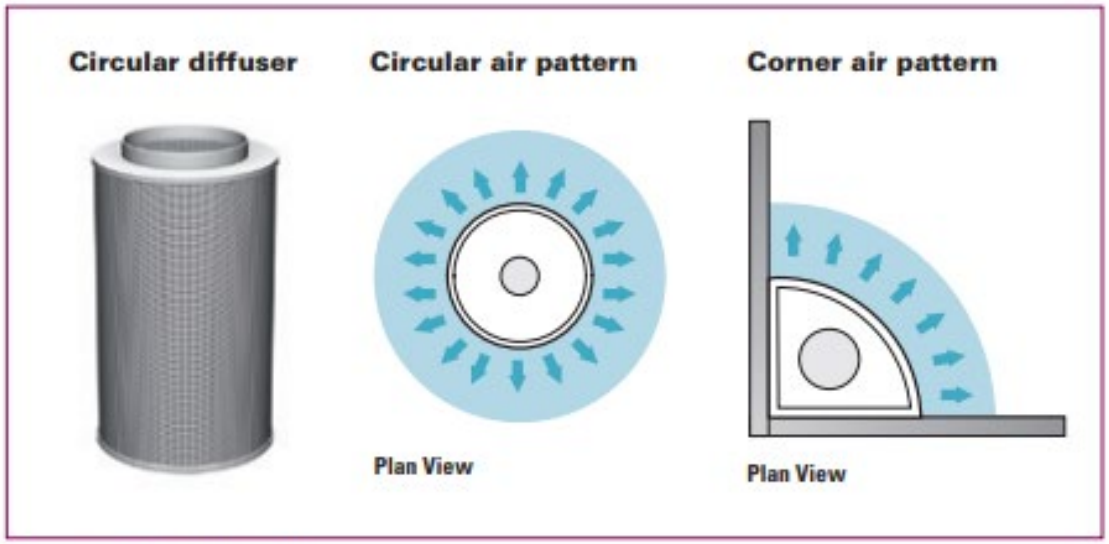
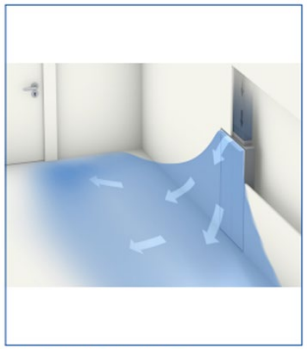
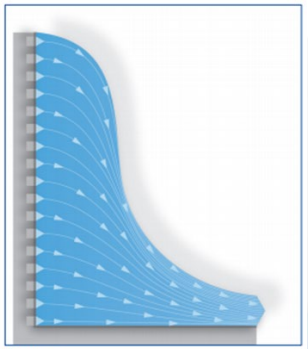


Figure 23: Circular diffusers

Figure 24: DR180 installed in free space

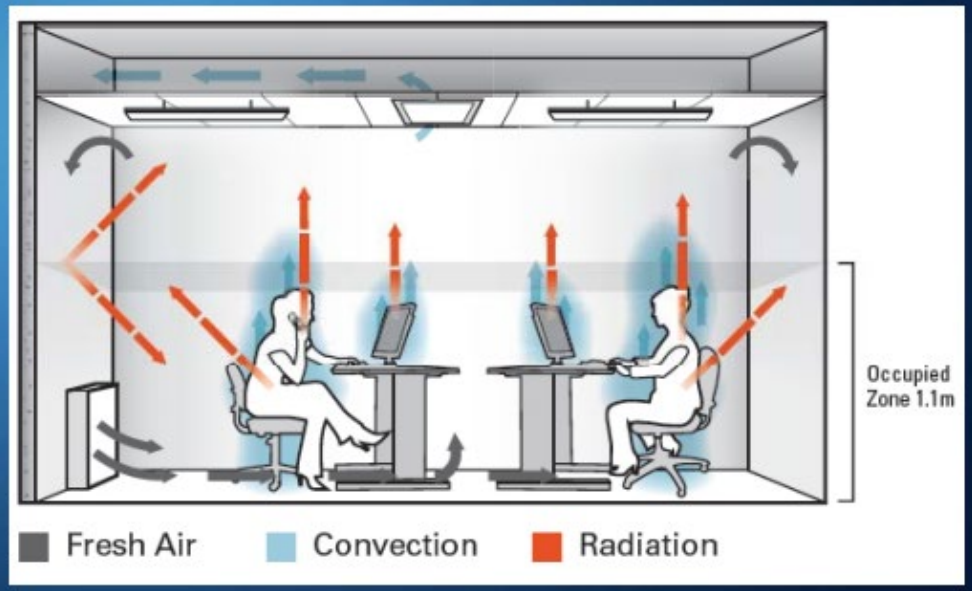
Displacement Characteristics


Three-dimensional representation


Side view

Displacement Systems:

- 65-68°F supply air
- Low velocity
- No mixing in space
- Heat sources drive air motion
- Stratified heat, contaminants
- Only conditions the occupied zone



Application	Recommended minimum supply air temperature °C	Room air °C
Auditorium	21 ... 22	24
Lobby	18 ... 22	24
Atrium	18 ... 24	24
Classroom	20 ... 22	24
Industry	14 ... 18	24
Hot and humid conditions	16 ... 18	26

Displacement Diffuser Types

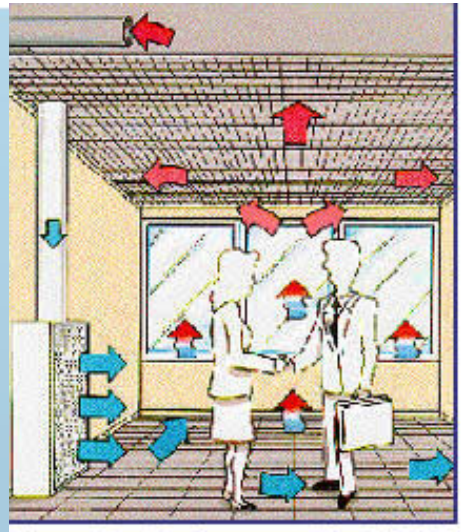
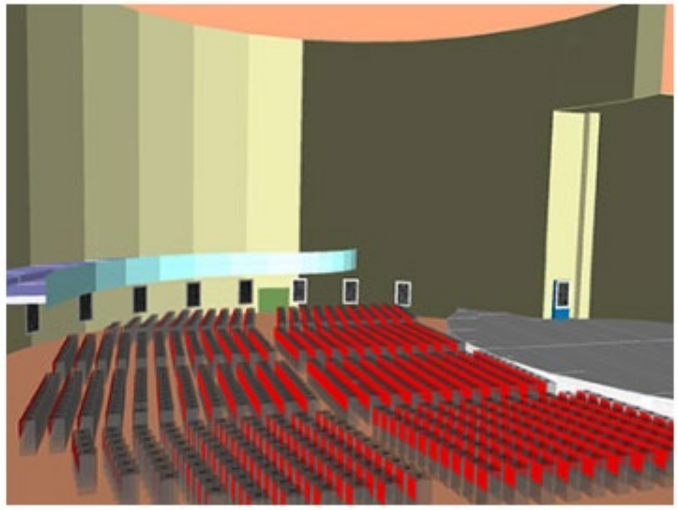
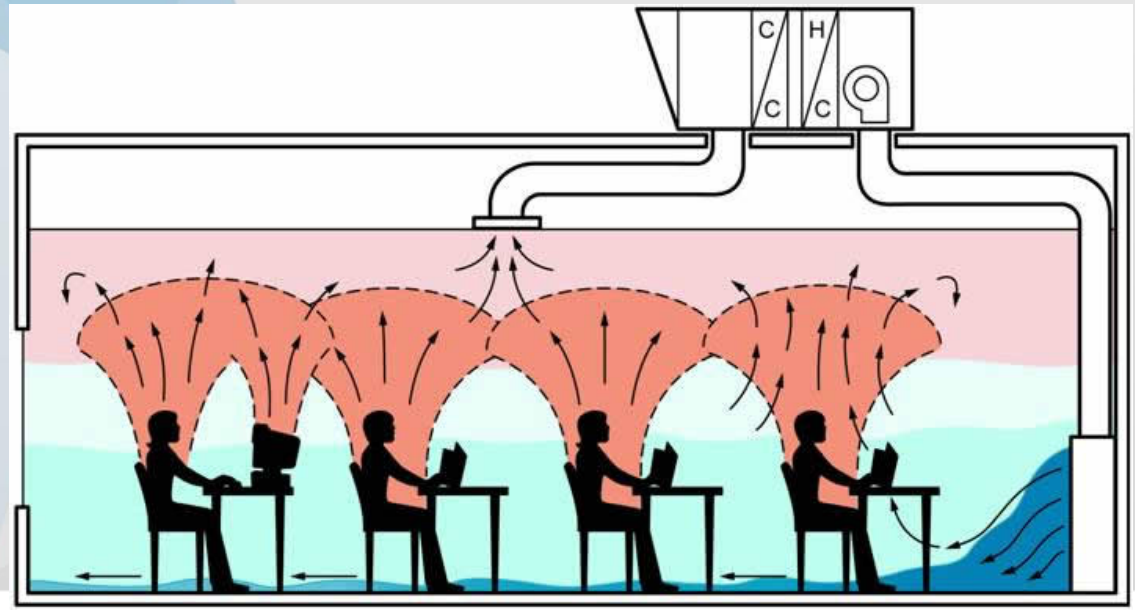
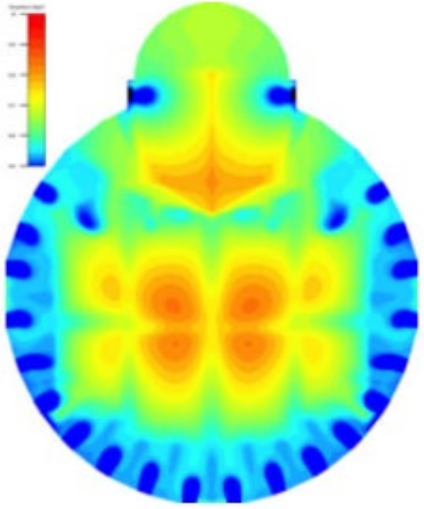


Figure 2 - Displacement Ventilation







Brisbane City Hall, Displacement Ventilation System. Halton displacement diffusers were used to supply air from the perimeter. The warm return air was extracted at the top of the auditorium ceiling.

Displacement Design Recommendations

Selection:

- Face velocity (~40 fpm)
  - Volume / 40 = Net diffuser face area
- No throw, drop, collision, etc. to consider
- Low noise
- Low pressure drop

Displacement Diffuser's – Design Example's

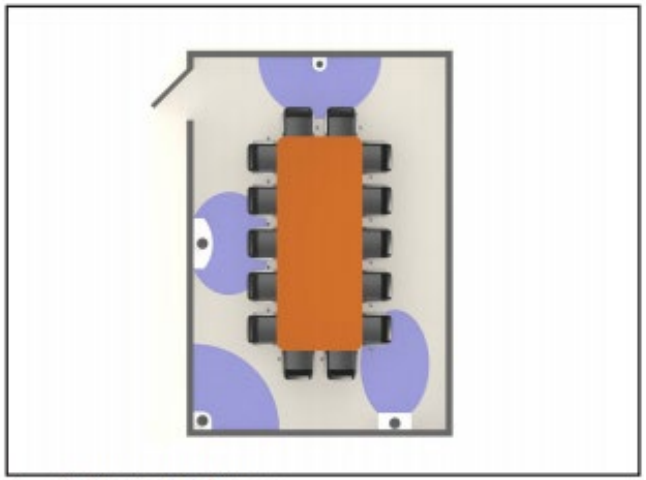


Figure 6. Standard Air Patterns

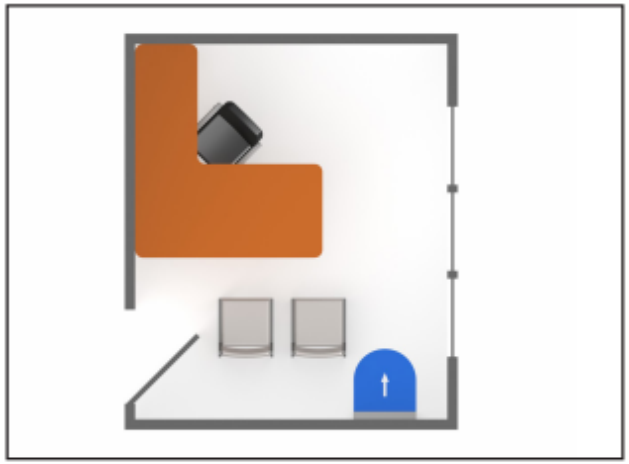


Figure 11. Design Example - Private Perimeter Office

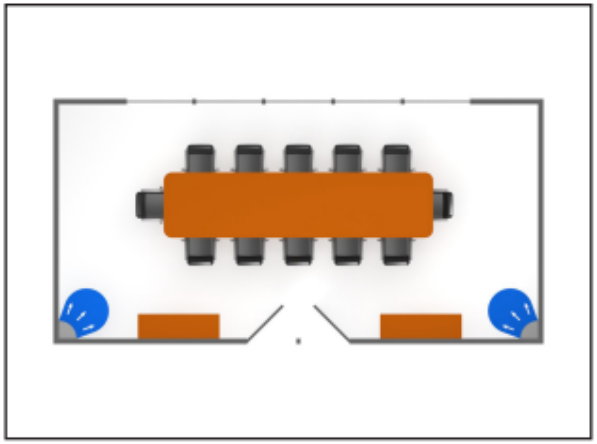


Figure 13. Design Example - Perimeter Conference Room

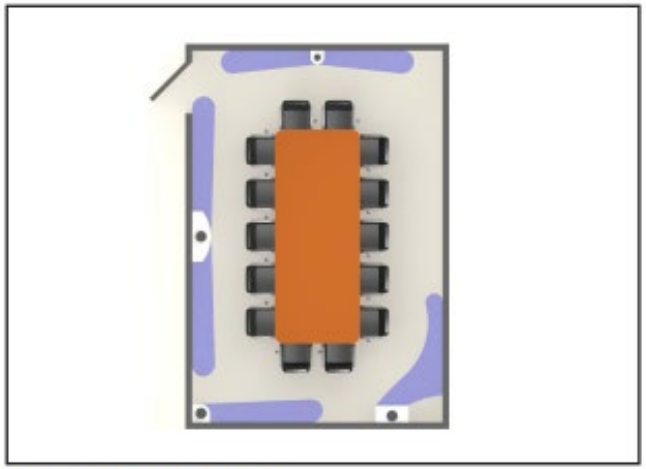


Figure 7. Adjusted Air Patterns

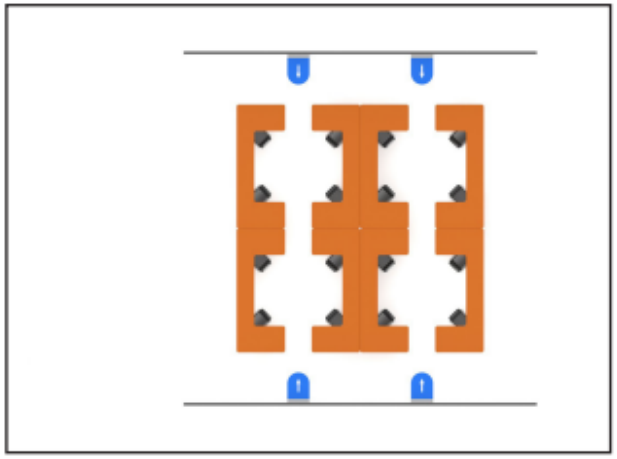


Figure 12. Design Example - Open Plan Interior Office

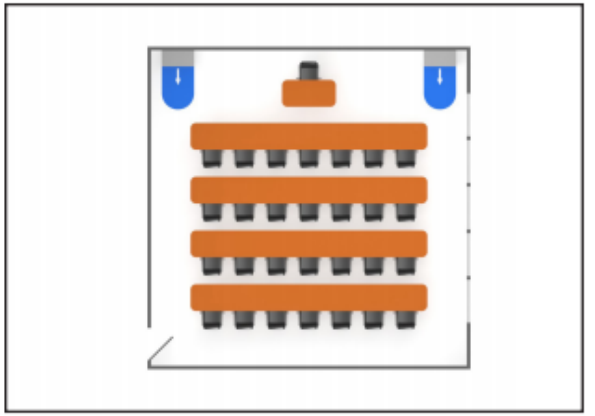
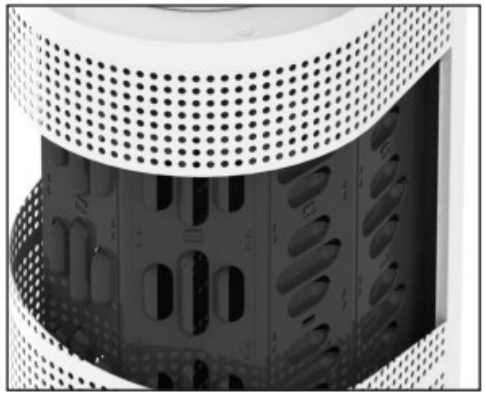
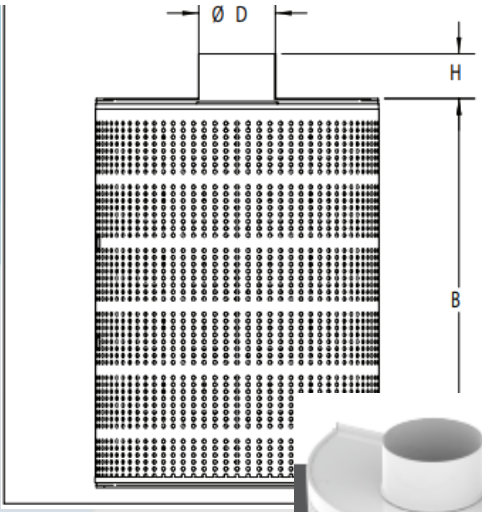
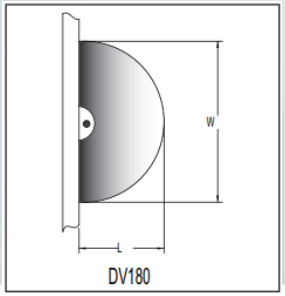


Figure 15. Design Example - Elementary School Classroom

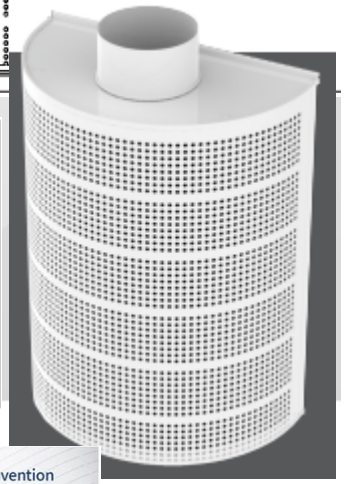
Radial Diffusers Types

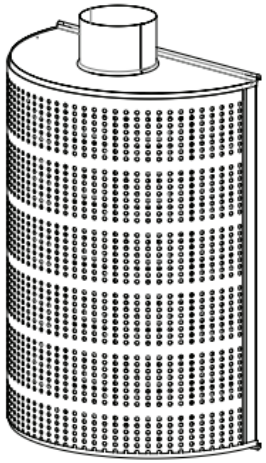


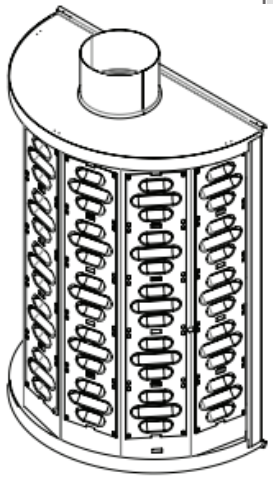




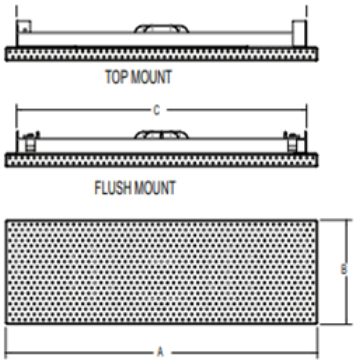
DV180

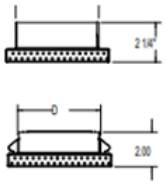


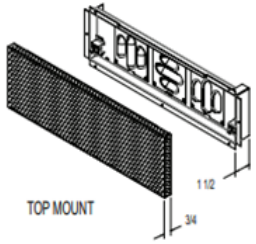


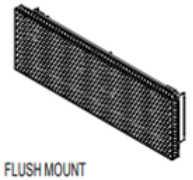


View with face removed showing integral variable air pattern controllers

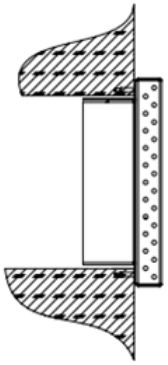


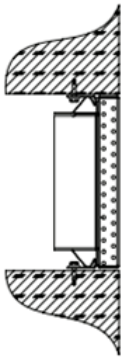





FLUSH MOUNT

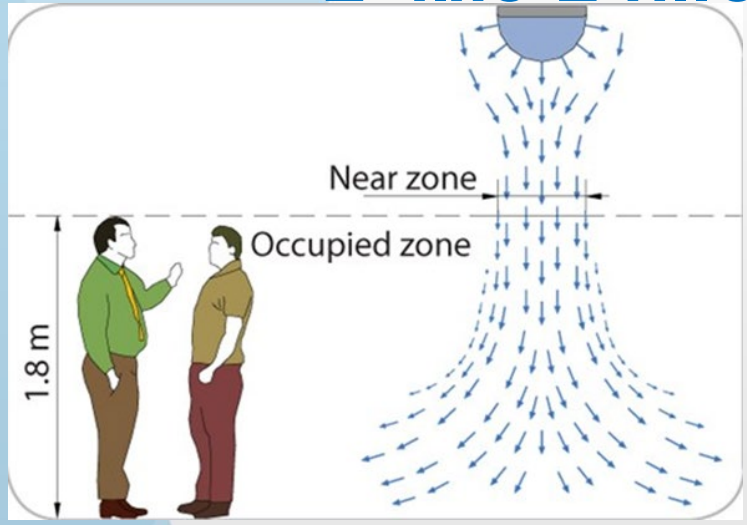
Model	Nominal Unit Size	Unit Dimensions (inches)			
		A	B	C	D
DVR1	6 x 18	6	18	16¾	4⅞
	12 x 12	12	12	10⅛	10¾
	18 x 6	18	6	4⅛	16¾
	18 x 8	18	8	6⅛	16¾
	18 x 12	18	12	10⅛	16¾
	24 x 6	24	6	4⅛	22¾
	24 x 8	24	8	6⅛	22¾
	24 x 12	24	12	10⅛	22¾
	24 x 24	24	24	22⅛	22¾
	24 x 30	24	30	28⅛	22¾
	24 x 36	24	36	34⅛	22¾
	24 x 48	24	48	46⅛	22¾
	30 x 6	30	6	4⅛	28¾
	30 x 8	30	8	6⅛	28¾
	30 x 24	30	24	22⅛	28¾
	36 x 6	36	6	4⅛	34¾
	36 x 8	36	8	6⅛	34¾
	36 x 24	36	24	22⅛	34¾
	40 x 6	40	6	4⅛	38¾
	40 x 8	40	8	6⅛	38¾
	48 x 6	48	6	4⅛	46¾
	48 x 8	48	8	6⅛	46¾
	48 x 24	48	24	22⅛	46¾
	60 x 8	60	8	6⅛	58¾

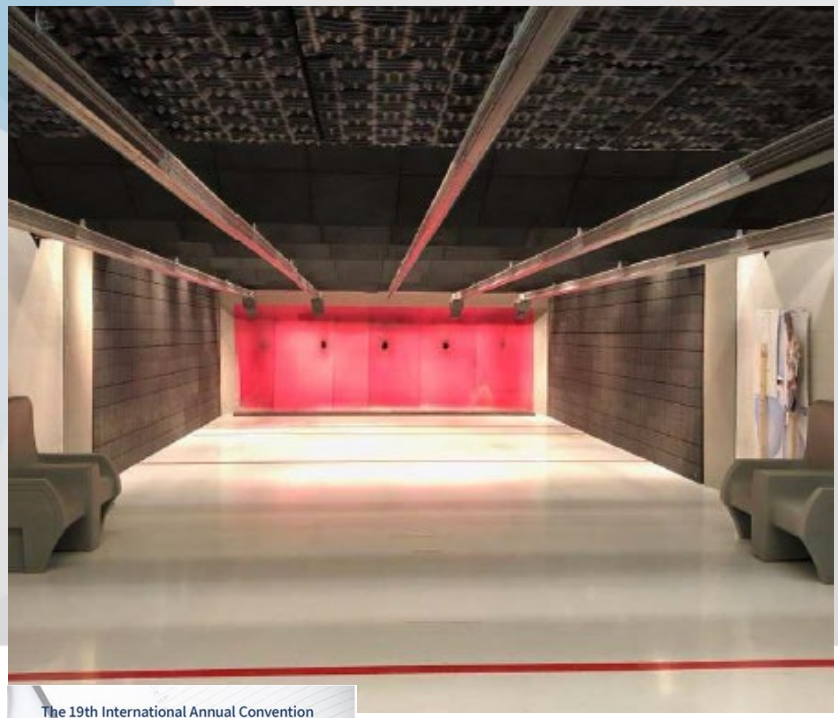

SURFACE MOUNT


FLUSH MOUNT

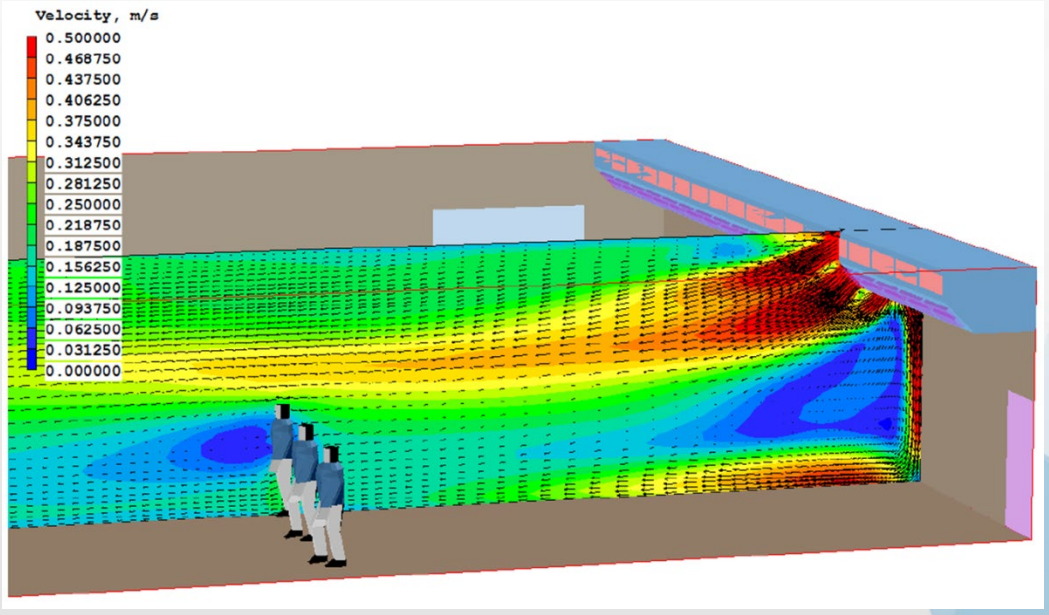
אלקטרה

במטווחים סגורים Radial Diffuser

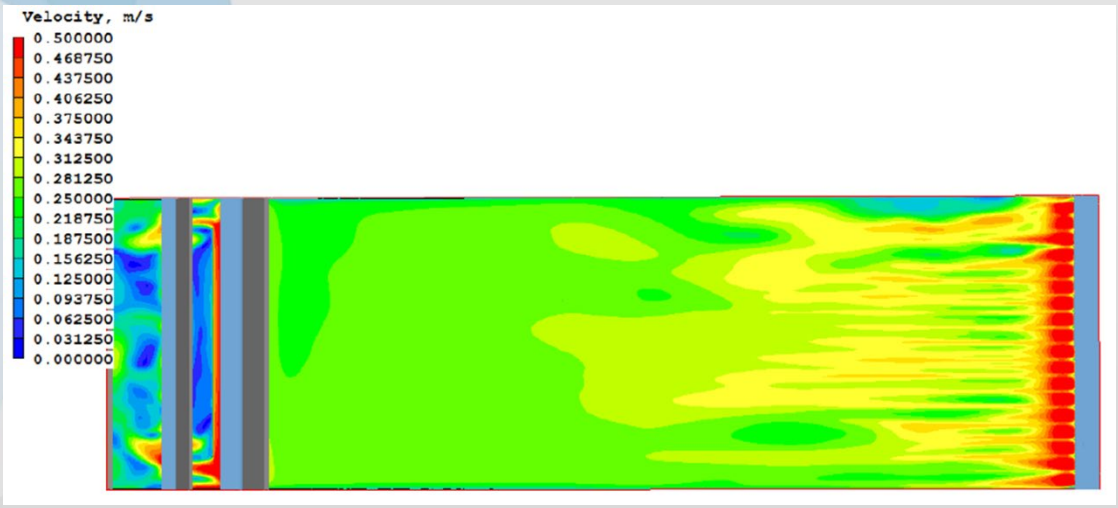




Air Supply from Radial Diffuser

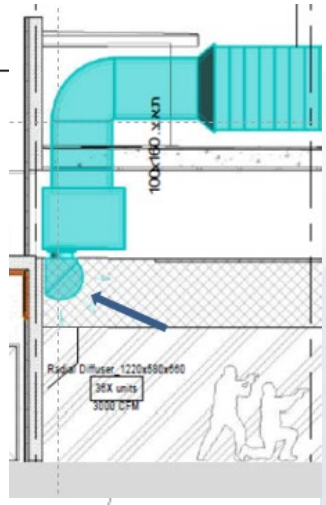


50m range - predicted velocity contours vectors on longitudinal slice 1 (close-up of firing line end)



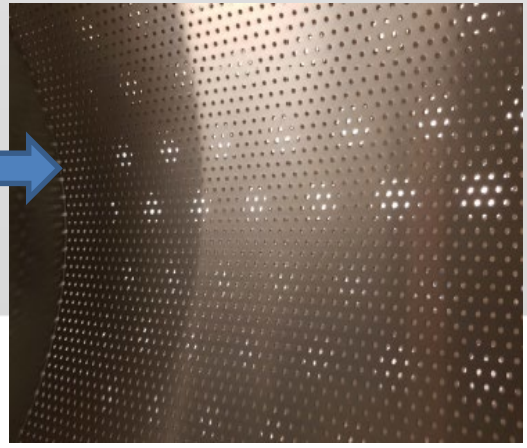
50m range - predicted velocity contours and turbulence kinetic energy contours on a horizontal slice 3.0m above the floor (velocity above, turbulence kinetic energy below)

סכמת אויר במטווחים סגורים



- בהתאם לתקן אמריקאי לתכנון מטווחים סגורים Range Design Criteria זרימת אויר מקו הירי עד לקו המתרות חייבת להיות למינארי (מהירות מומלצת בהתאם לתקן יהיה בין 0.25 מ/שניה ל-0.38 מ/שניה , מהירות מקסימלית – עד 0.51 מ/שניה , כמות אויר חוץ המינימלי חייב להיות 25% מספיקת אויר כוללת.
- כמות אויר חוץ המסופק חייב להשתנות בהתאם לריכוז גזים במטווח – עופרת , CO_2 או NO_x

Franklin Park Police – Radial Diffuser



מבט מבפנים למפזר
אספקת אויר פח
פנימי 14% מעבר
אויר – פח חיצוני –
17% מעבר אויר

מדידות 10 ו-15 מ' מקו הירי Federal Air Marshal Field office

גובה מדידה 0.5 מ'

מהירות אויר 0.54 m/s

גובה מדידה 1.5מ'

מהירות אויר 0.52 m/s

גובה מדידה 2מ'

מהירות אויר 0.54 m/s

גובה מדידה 0.5 מ'

מהירות אויר 0.44 m/s

גובה מדידה 1.5מ'

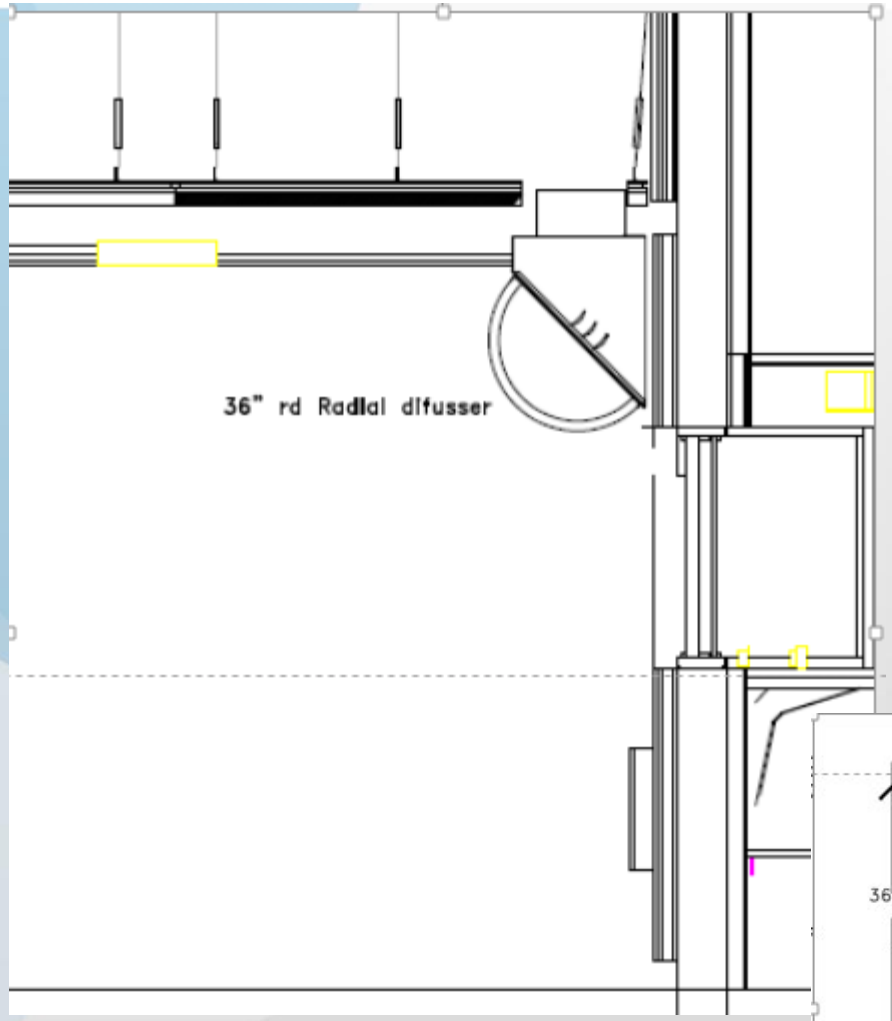
מהירות אויר 0.45 m/s

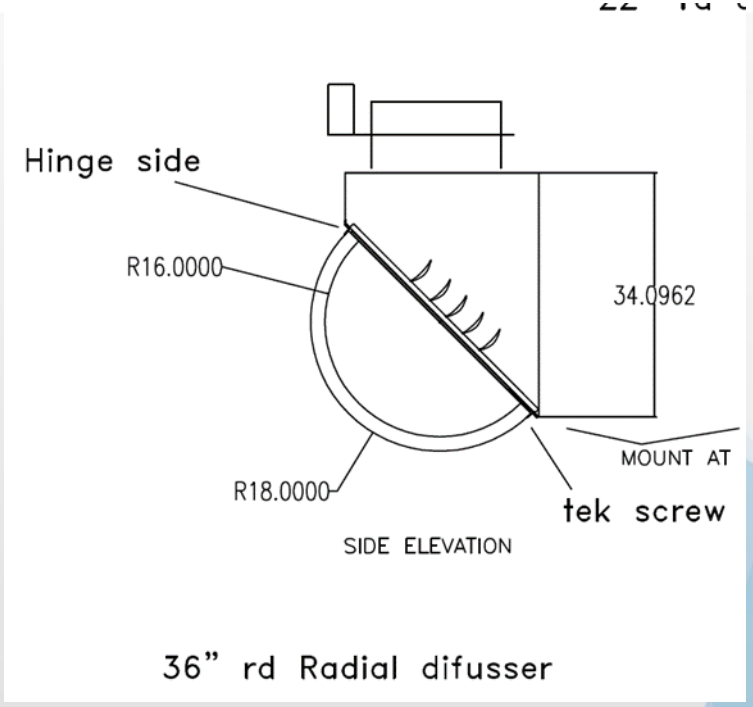
גובה מדידה 2מ'

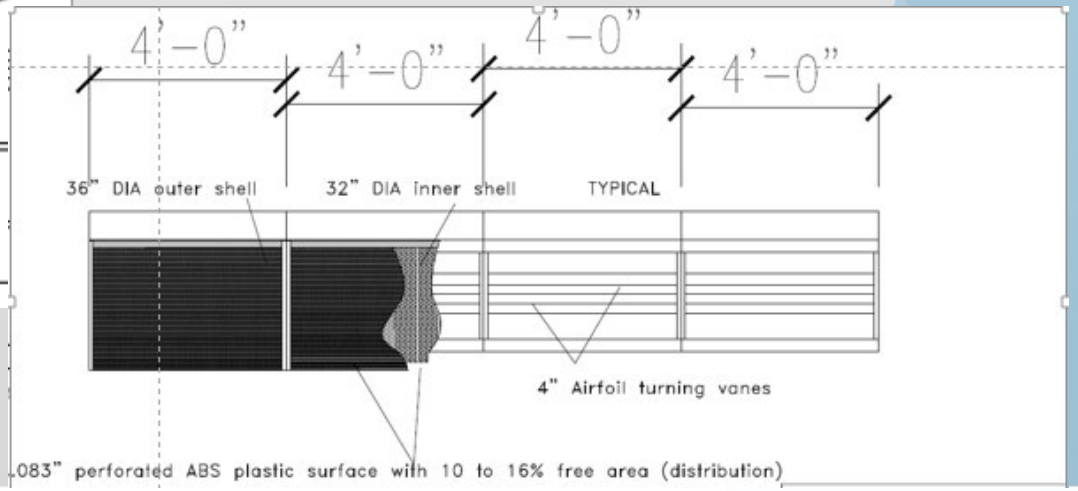
מהירות אויר 0.47 m/s

Radial Diffuser - Smoke Test

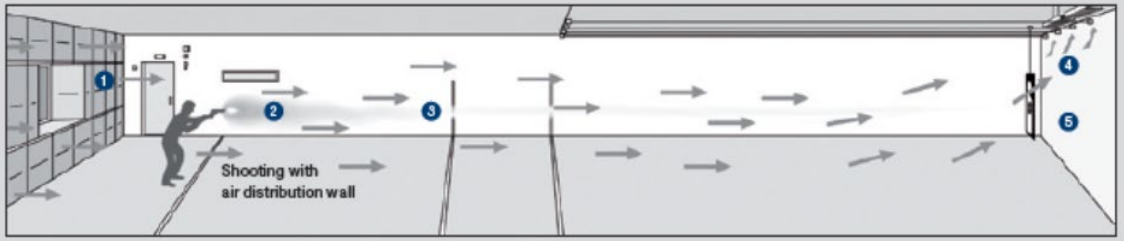
Radial Diffuser







Air Wall - KRANTZ



Functioning

The displacement outlets are positioned in a certain distance behind the firing point, to direct the supply air with low velocity (between 0.25 and 0.35 m/s) and low turbulence towards the targets.

Thus, the shooters are permanently surrounded by a flow of fresh air. The airborne pollutants that accumulate in the supply air while shooting are displaced by this air flow towards the opposite end of the room where the polluted air will be extracted.

Further to this the low supply air velocity generates a comfortable, draught-free thermal environment.

The ballistics of the projectile will not be influenced by the air flow.

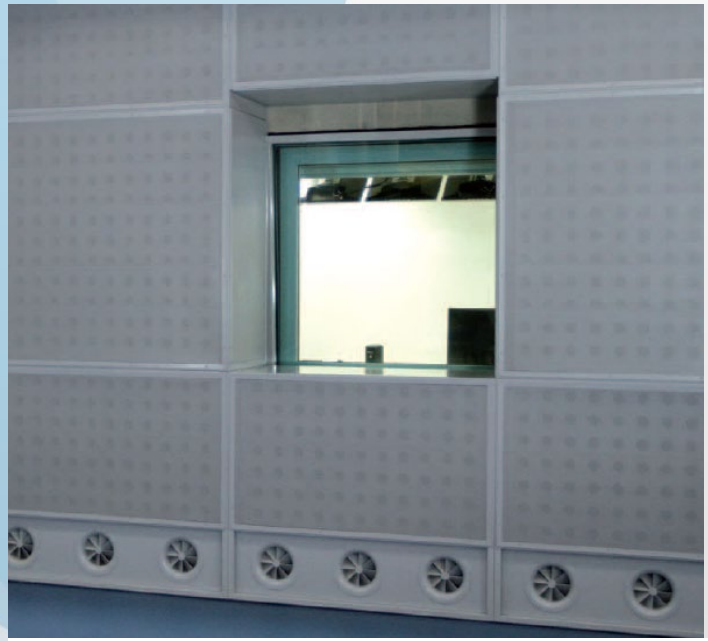
The displacement outlets are delivered in separate parts along with the necessary post-and-beam structure and connection elements for easy installation of the air distribution wall on site.

Technical data

Volume flow rate range:	depending on the room cross section and the appearance of pollutants[1)]
Discharge velocity:	0.25 – 0.35 m/s
Size:	adapted to the room cross section
Coverage:	total room cross section / room length
Type:	VA-RSA
Make:	Krantz Components

[1)] according to the type of firearm/gun and shot rate

Air Wall - STRULIK



Guidelines for the operation of enclosed shooting ranges

Criteria	National	International
Recommended airflow system	Displacement ventilation system	The planning and implementation of the supply air systems must be adapted to the guidelines of the respective country.
Recommended air speed over the room cross section	Minimum value: 0.25 m/s	
Recommended room temperature of the shooting range	approx. 18 °C	
Distance of the shooters from the supply air wall	5.0 m (2.0 m for air guns and CO_2 weapons)	
Sound pressure level of the ventilation system	in accordance with workplace regulations and the Technical Instructions on Noise Control (TA-Lärm): no specification in the guidelines of the German Shooters Association (DSB)	
Acoustic requirement with respect to the reverberation period	0.5 s in the 125 – 4000 Hz range	
Maximum pollutant concentration	Technical instructions for air quality control (TA-Luft), workplace regulations	

Structure

The individual sections are constructed from sheet steel and have several chambers to form displacement diffusers. The blades are designed to provide optimal air distribution.

Swirl diffusers fitted in the bottom chambers are designed to drive the supply air in the lower zone towards the shooters in the form of turbulent air streams. This design element guarantees the fast reduction in the temperature differences between the supply and room. The cross sectional area of any windows and doors should not be more than 15% of the total usable surface of the shooting range. If it is more, it is possible to compensate by adding inlet surfaces to the window and door frames.

Lower chamber with swirl diffusers

המלצות ומסקנות

1. שיטת פיזור "תזוזה" - Displacement Ventilation System אפקטיבי בשימוש :
   - ❖ באולמות קונצרטים
   - ❖ באודיטוריום וחדרי לימוד
   - ❖ בחדרי ישיבות ומשרדים
   - ❖ בלביאים של בתי מלון ואטומים
   - ❖ באולמות תצוגה ואולמי קניות
   - ❖ במוזיאונים
   - ❖ בבתי החולים
   - ❖ בטרמינלים של שדי התעופה ותחנות רכבת
   - ❖ במטווחים סגורים – בשיטה של Radial Diffuser ו- Air Wall

2. לפי "Ventilation for Acceptable Indoor Air Quality" ASHRAE Standard 62.1-2013 מפרטת את יעילות האוורור עבור התפלגות מעורבת מערכות הוא Ez = 1.0 .
   אספקת הרצפה של אוויר קריר וחזר תקרה, בתנאי מהירות נמוכה תזוזה אוורור משיגה יעילות האוורור עבור Displacement Ventilation מערכות מקדם Ez = 1.2
   Zone Air Distribution Effectiveness