Underfloor Air Distribution Systems

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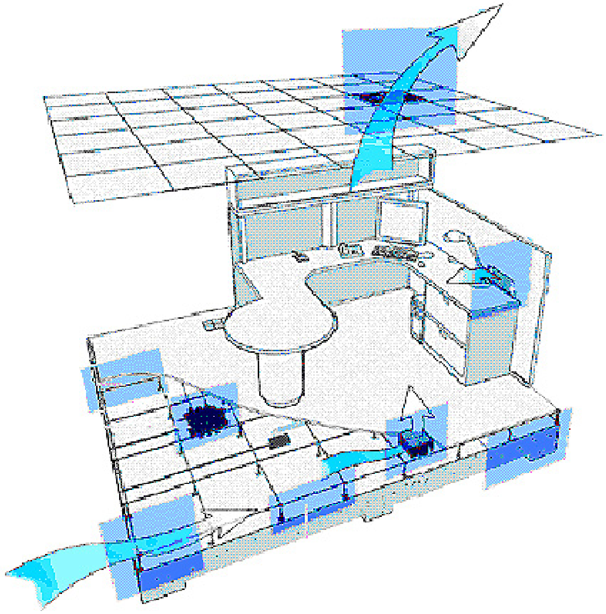
York International

- Why use Underfloor Air?
- What is Underfloor Air Distribution (UFAD)?
- How Does it Work?
- Features and Benefits
- Lessons Learned

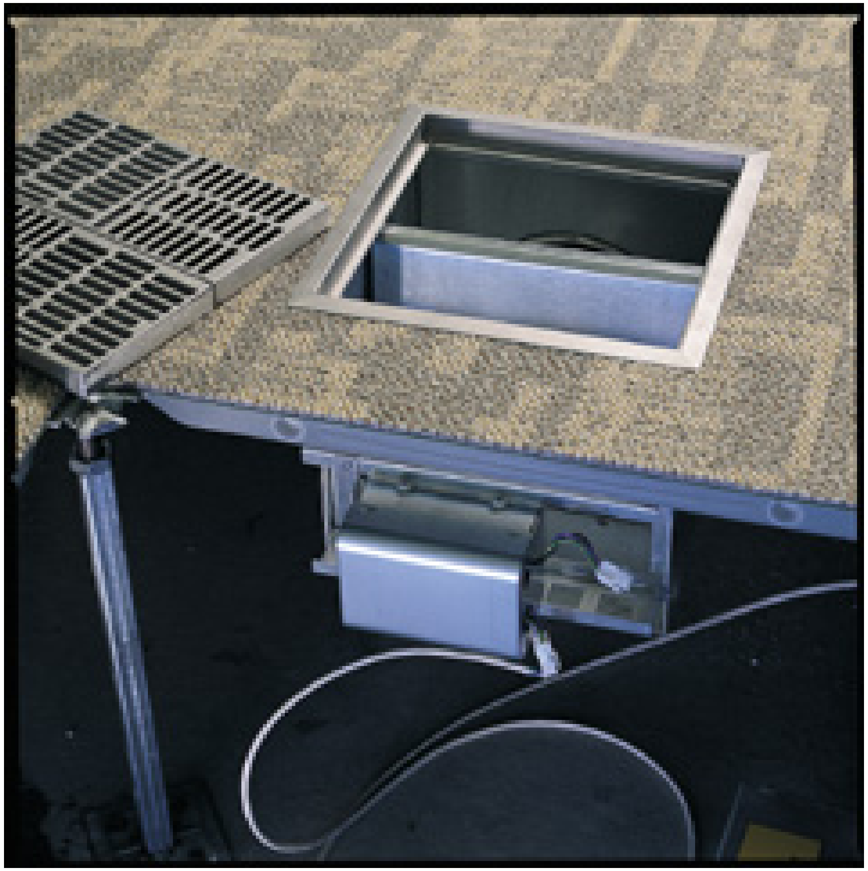
Potential UFAD Benefits

- Improved occupant comfort, productivity and health
- Improved ventilation efficiency and indoor air quality
- Reduced energy use
- Reduced life-cycle building costs
- Improved flexibility for building services
- Reduced floor-to-floor height in new construction



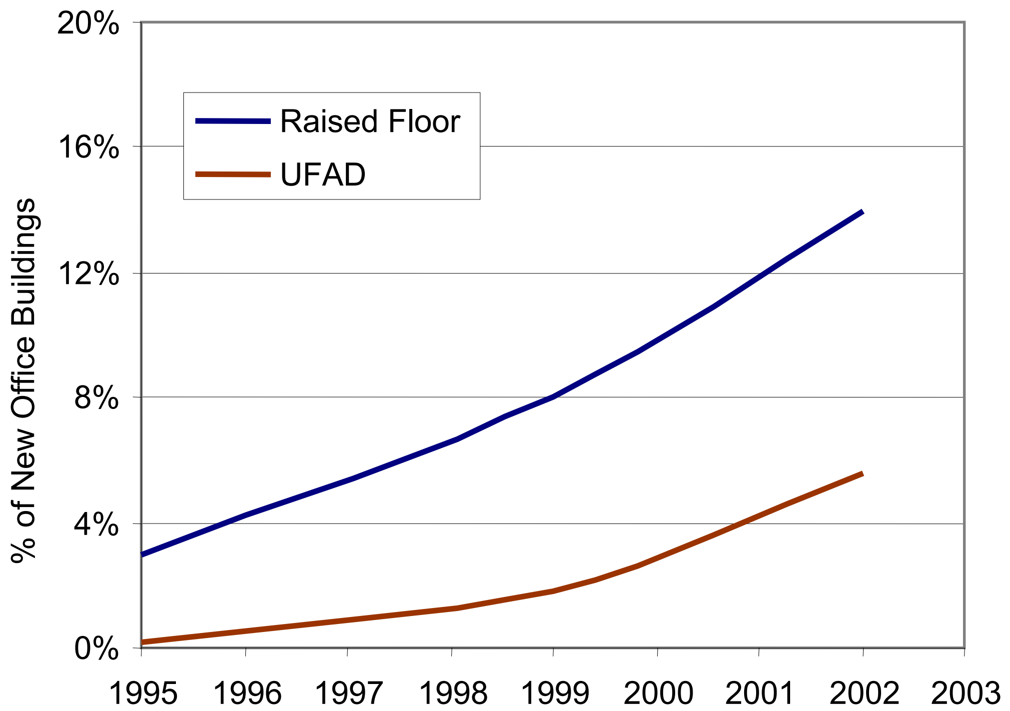
What is Underfloor Air Distribution?

"Instead of air being introduced through a ducted overhead system, air is distributed via the plenum space under a raised access floor system and introduced through a series of diffusers which are installed in the raised floor panels."



Raised floor and UFAD adoption

- 1995: Less than 3% of new office buildings had raised floors, UFAD a "fringe" element
- 1999: 8% of new offices used raised floors, 20-25% of these with UFAD systems.
- 2002: 12% -15% have raised floors, ~ 40% of these with UFAD systems.

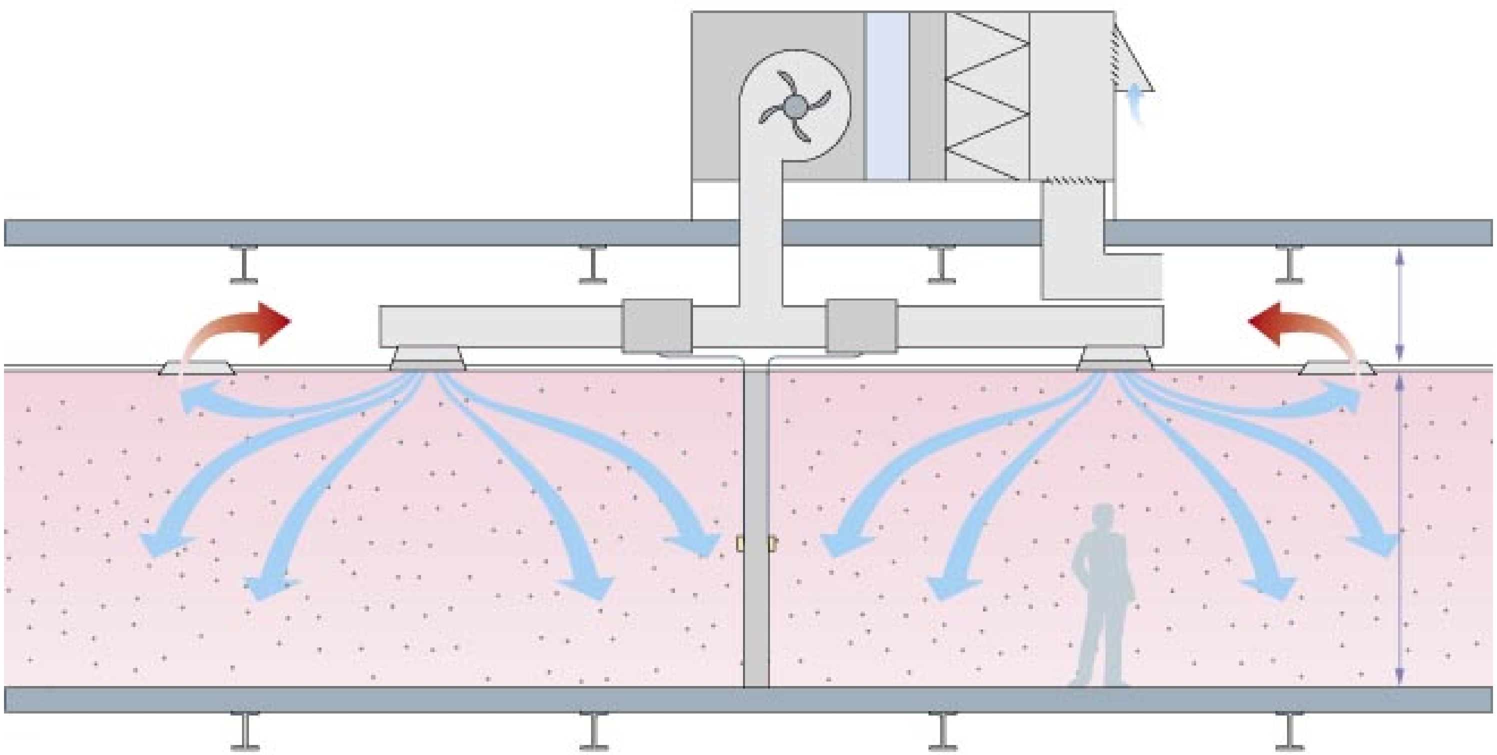


Underfloor vs. Conventional Air Distribution System Design Issues

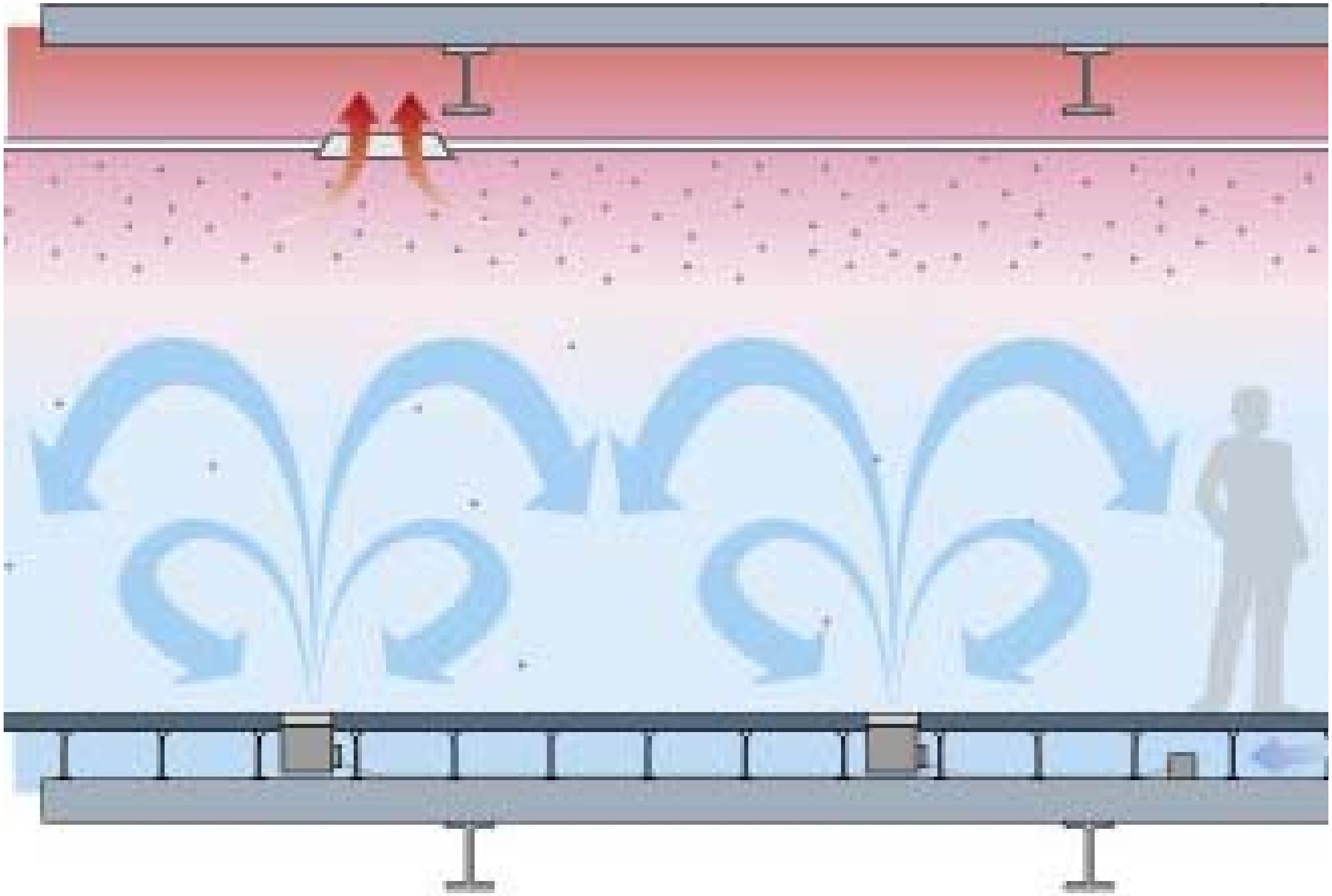
- Underfloor air supply plenum
- Air supplied into occupied zone near floor level
- Higher supply air temperatures (for cooling)
- Allows for occupant control
- Properly controlled stratification leads to reduced energy use while maintaining comfort
- Reduced space sensible heat load
- Perimeter zone solutions are critical
- Access floor improves flexibility and re-configurability

How Does it Work?

Overhead Air Distribution System



Underfloor Air Distribution System



Types of Diffusers

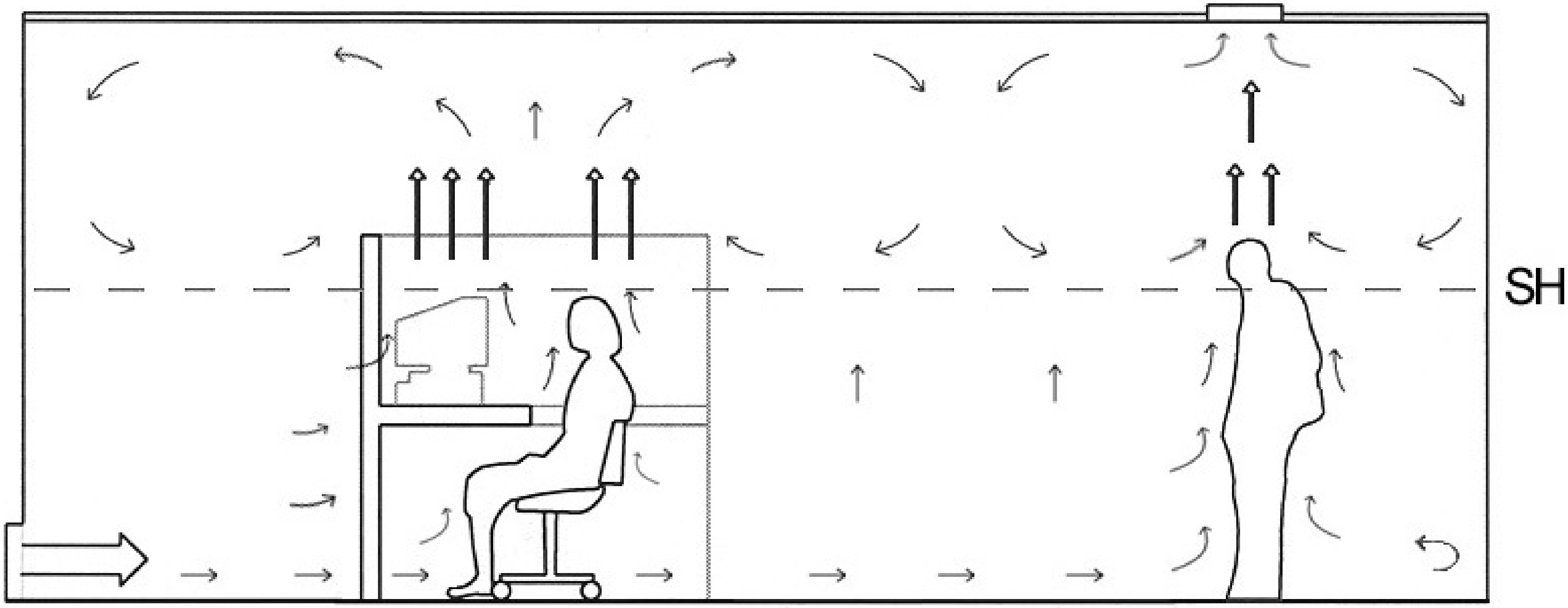
Motorized Diffusers

– Operates a damper via thermostatic controls

Swirls Diffusers

– Air Flow is manually controlled at each diffuser

Displacement Ventilation System



Minimize mixing in occupied zone

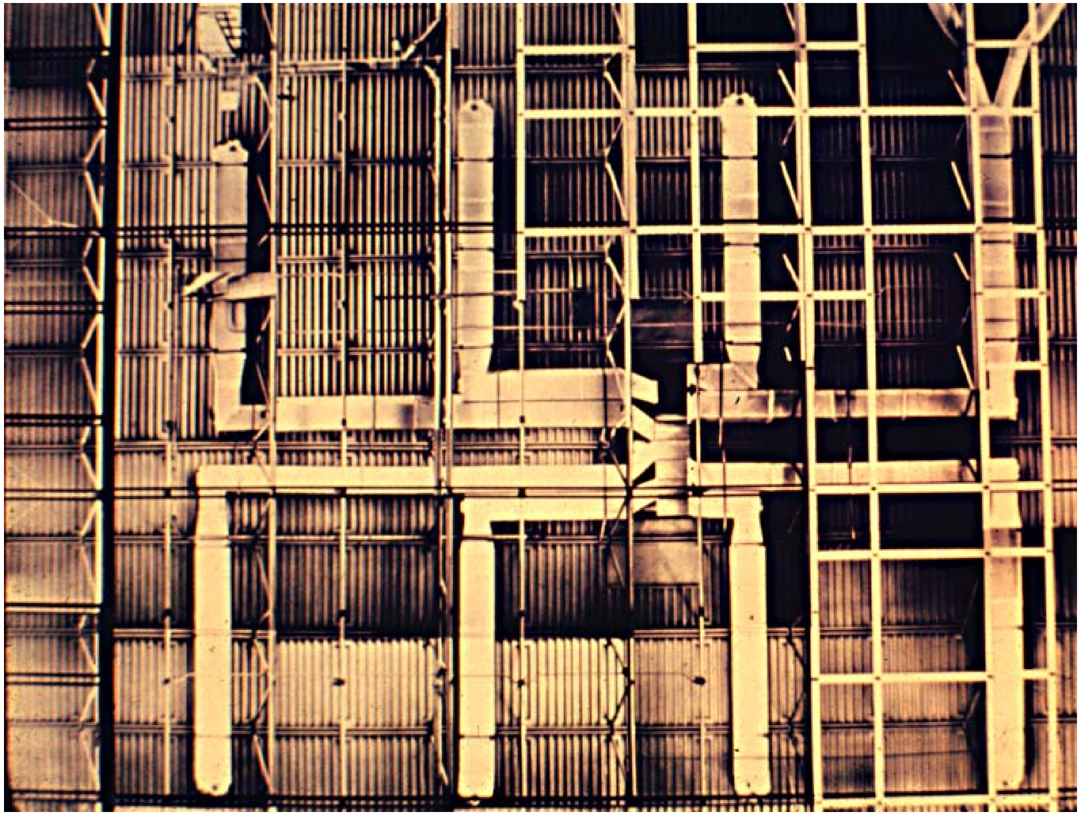
Cost Issues-Raised Access Floor and Diffusers

In most cases the additional cost the raised access floor and diffusers will be offset by the realized saving related to other trades such as HVAC, Power, Voice, and Cabling.

HVAC Cost Savings

Duct Work Cost

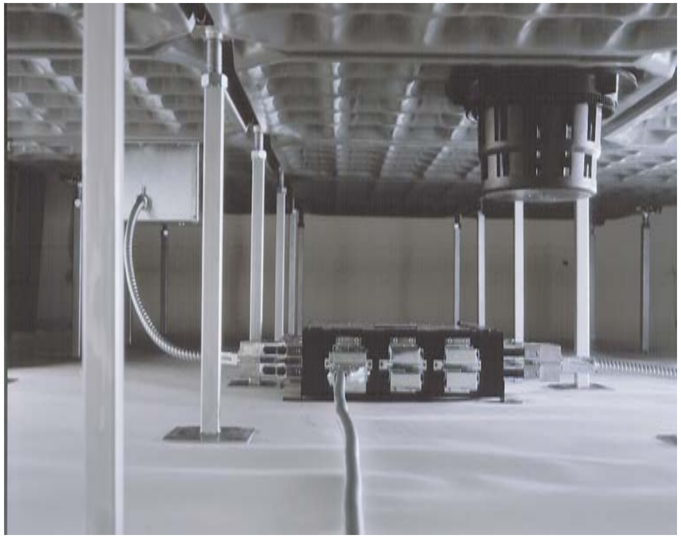
- Sheet Metal
- Fabrication
- Installation
- Majority Eliminated



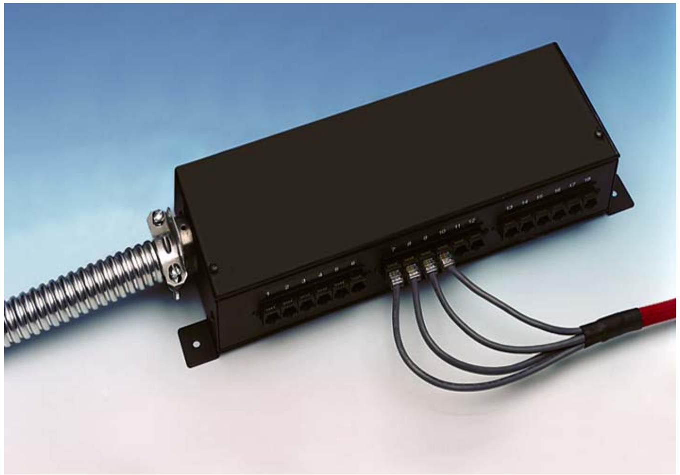
Overhead HVAC Ductwork

Power Savings

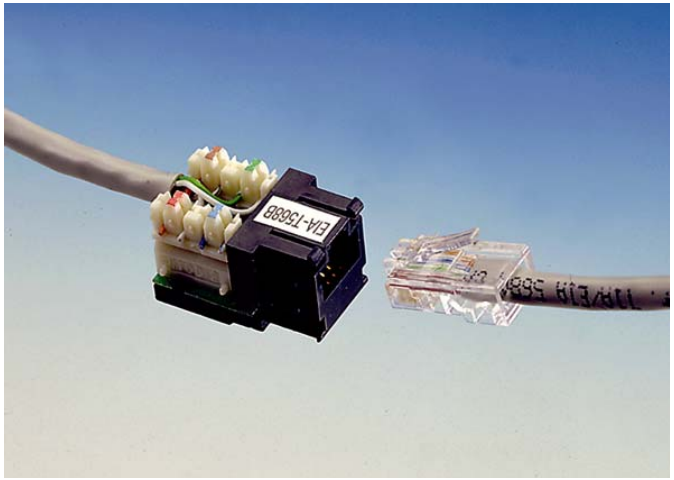
- Power supplies are place under the raised floor.
- “Plug & Play Power Controls make for faster installation.



Voice and Cabling Savings



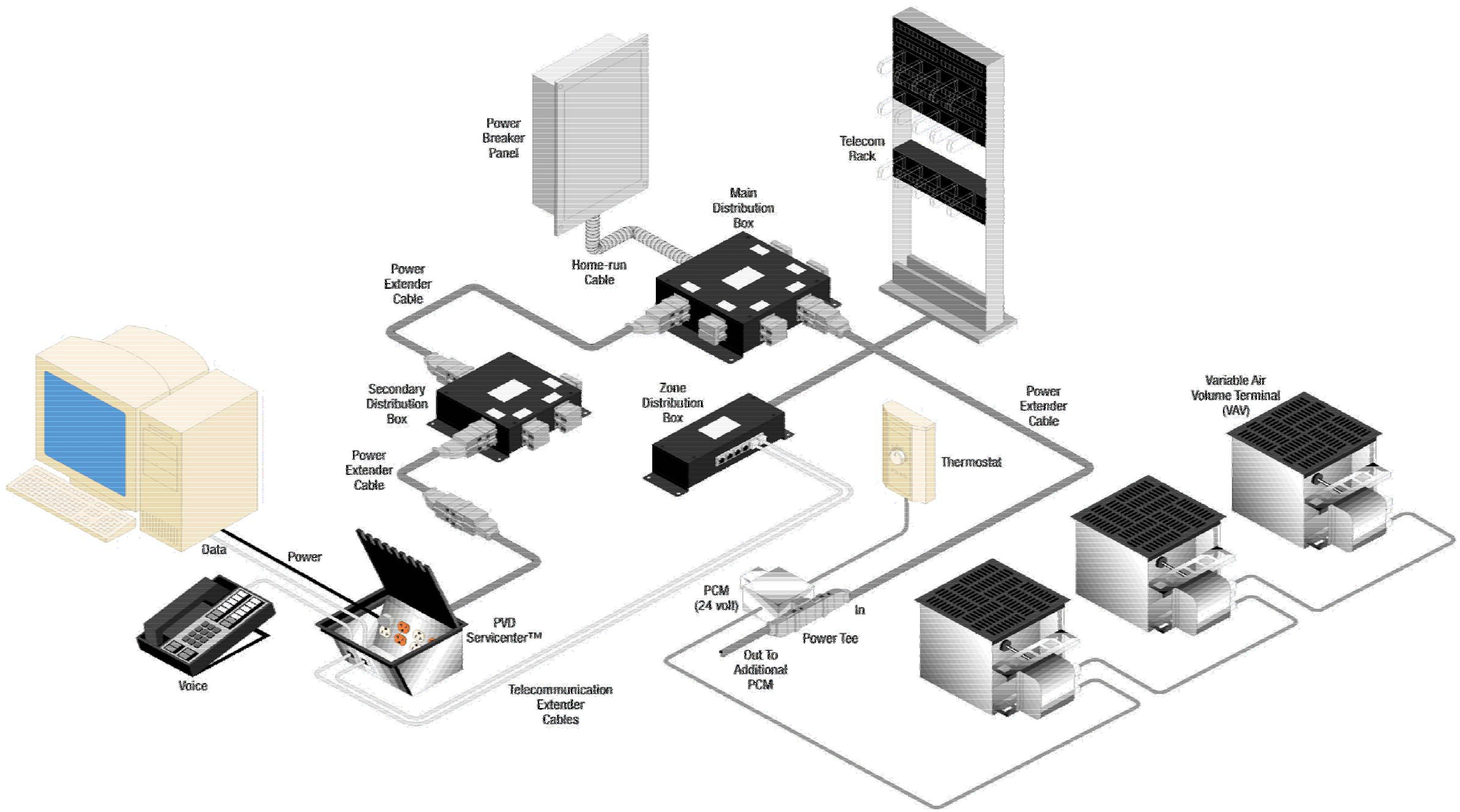
“Plug & Play” Voice and Cabling Systems are easily installed under the raised floor.



Voice and Cabling Savings

Difficult and costly overhead installations are eliminated.

State of the Art Integrated System


Power Breaker Panel
Telecom Rack
Main Distribution Box
Home-run Cable
Power Extender Cable
Secondary Distribution Box
Zone Distribution Box
Power Extender Cable
Variable Air Volume Terminal (VAV)
Power Extender Cable
Thermostat
Data
Power
PCM (24 volt)
In
Power Tee
Out To Additional PCM
PVD Servicenter™
Voice
Telecommunication Extender Cables

Underfloor Air Distribution Benefits

Flexibility to make changes

- Improved indoor environmental quality
- Energy savings
- Reduced lifecycle cost of building

Flexibility

*The entire under floor space is a plenum

*Conditioned air available *anywhere*

*Add terminals in minutes

*"Plug & Play" power and controls

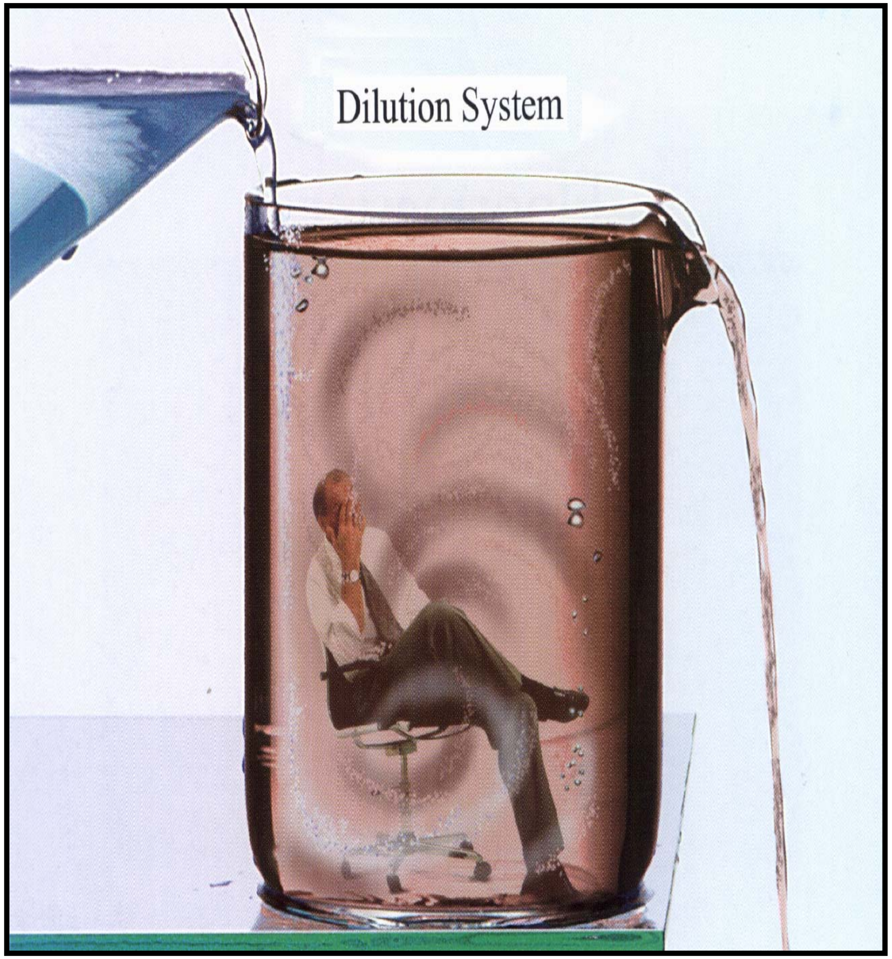
*Re-zone & add zones in minutes

*Reconfigure HVAC easier than furniture

IAQ with Conventional Overhead Air Distribution

All the supply air is injected, high in the space, at a velocity designed to create mixing within the room. Then some of the mixed air is drawn off, usually at ceiling level, as return or exhaust air.

Thus pollutants and germs must be disseminated throughout the room, they are actively spread and shared between all room occupants.

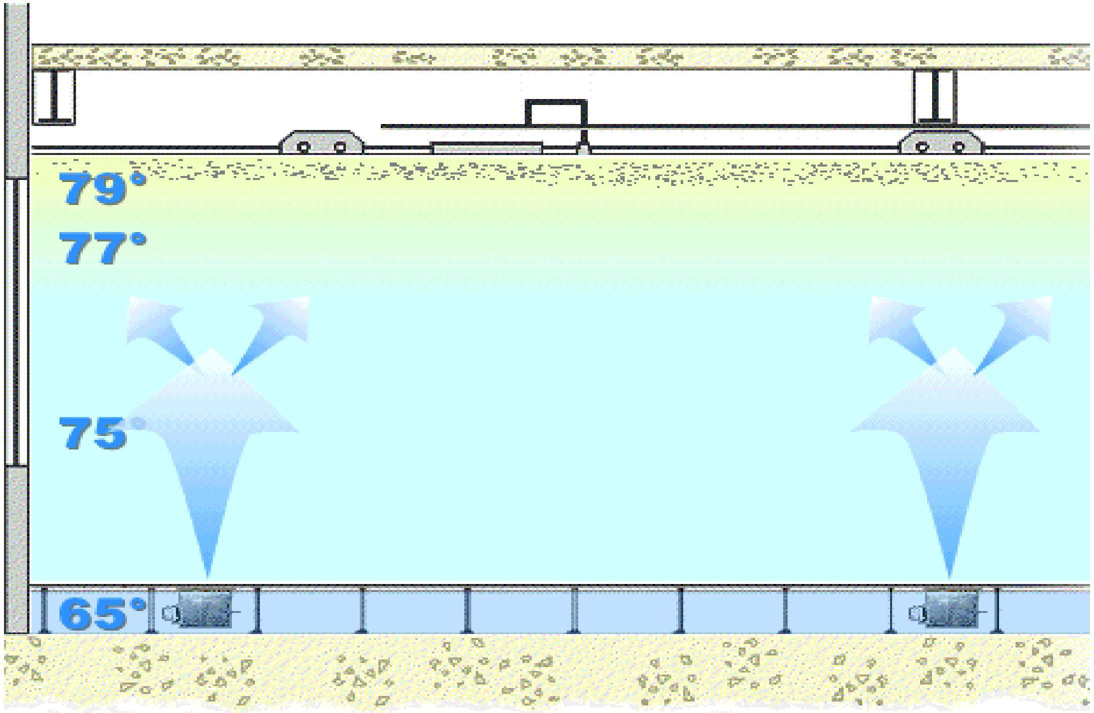


Improved Indoor Air Quality

*Occupant gets first use of conditioned air

*Convection enhanced ventilation (CEV) cools and ventilates people first

*Single pass of air pushes pollutants up to ceiling



IAQ with Underfloor Air Distribution

UFAD stratifies the air and prevents mixing. Pollutants are carried upwards, in thermal plumes, out of reach of occupants. Concentrated pollutants are removed via exhaust at highest points in room. Occupants located in clean zone constantly breathe uncontaminated air.

No sharing of pollutants and germs between room occupants.

Indoor Air Quality

- Traditional approach
  - Provide uniform ventilation throughout space
- Underfloor approach
  - Fresh air is delivered closer to the occupants
  - Floor-to-ceiling air flow pattern provides improved IAQ in occupied zone (up to 6 ft [1.8 m])
  - Local air supply improves air motion, preventing sensation of stagnant air (associated w/ poor IAQ)

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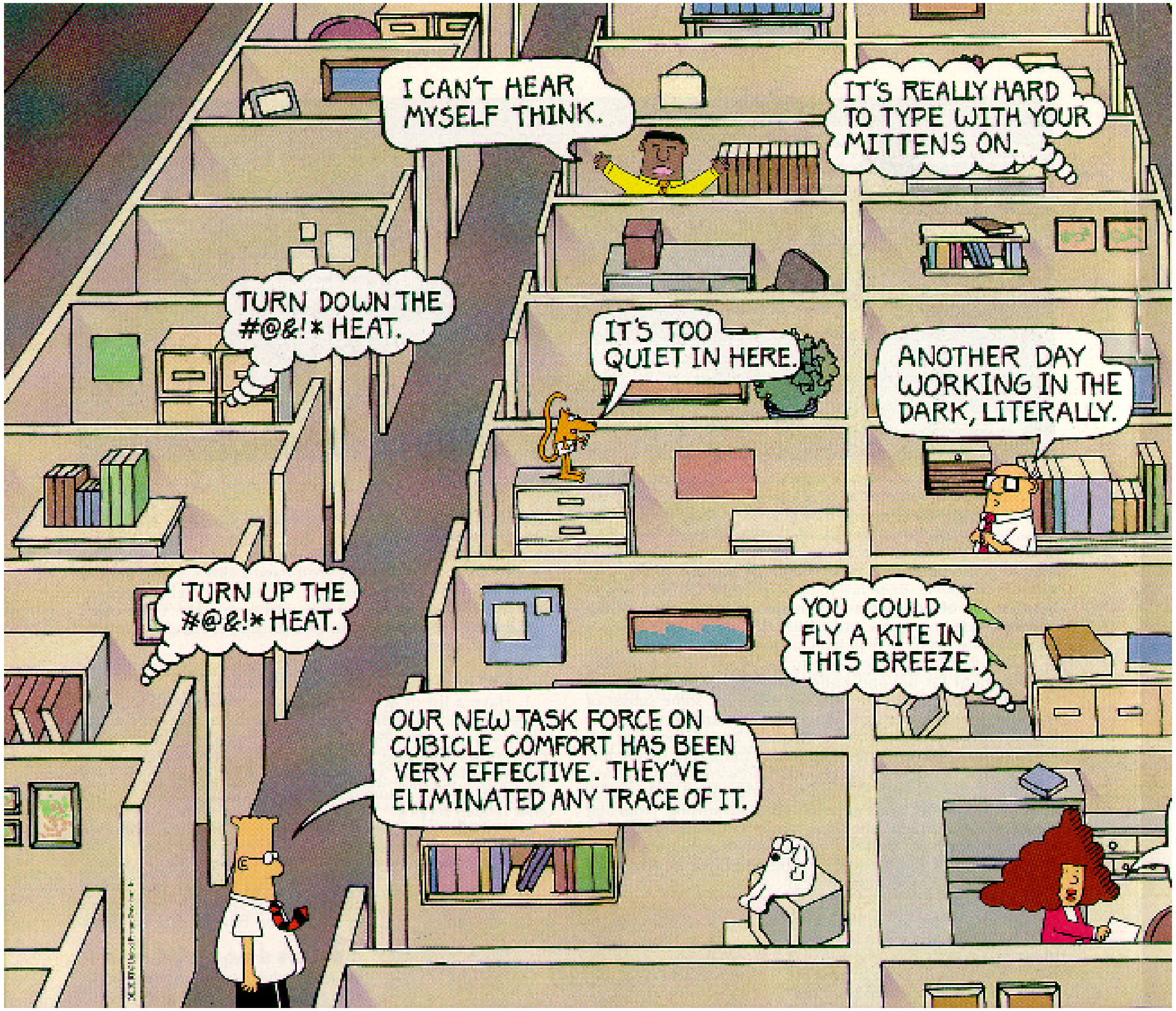
Energy Efficiency and Renewable Energy

Thermal Comfort

Variations in Individual Preferences

- Clothing
- Activity level
- Body weight & size
- Personal preferences



Thermal Comfort

- Traditional approach
  - Satisfy up to 80% of building occupants
- Underfloor approach
  - Allow personal control of the local thermal environment – satisfy up to 100% of occupants – reduce occupant complaints

Energy Savings

20% - 30% total energy savings vs. overhead HVAC system

*Reduced fan horsepower and energy consumption due to very low differential static pressure (0.05” vs. 1.5-2.0” typical for overhead supply air systems)

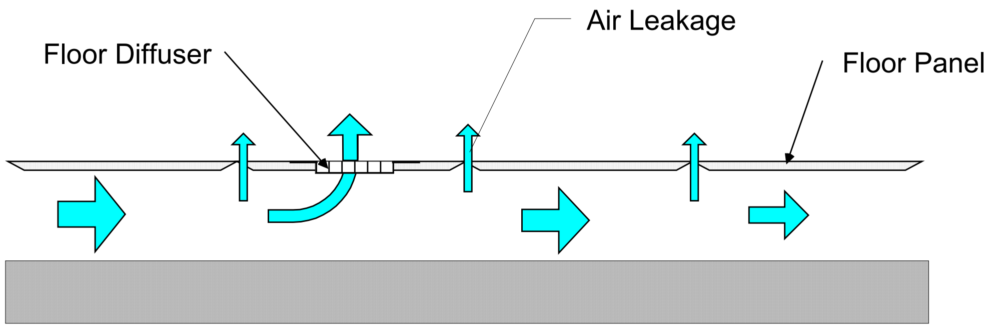
*More hours of free cooling since air is delivered at 63^0F- 65^0F vs. 55^0F for overhead systems

Reduced Fan Power

- Underfloor plenum is the primary air distribution route
- UFAD systems use less ductwork than OH systems
- Primary fan pressure reduced 1/2 to 1 in. H_2O, a reduction of about 25%
- Substantial energy savings on primary fan power possible, however this may be offset by fan-powered boxes or terminals

Plenum Air Leakage

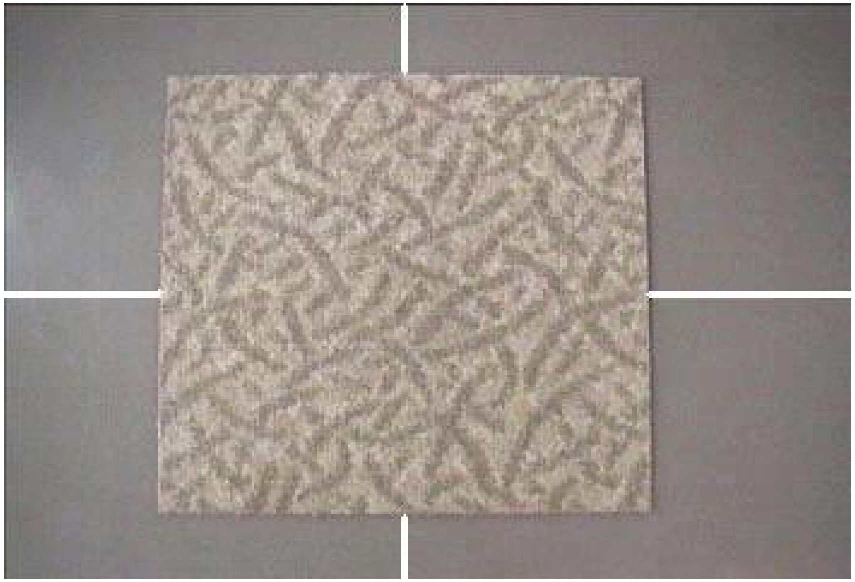
- Air leakage from a pressurized plenum may impact energy use and can impair system performance if not accounted for.



- Types of leakage
  - Leakage between floor panels
  - Leakage due to poor sealing and construction

Carpet Tile Configurations

Aligned



Offset

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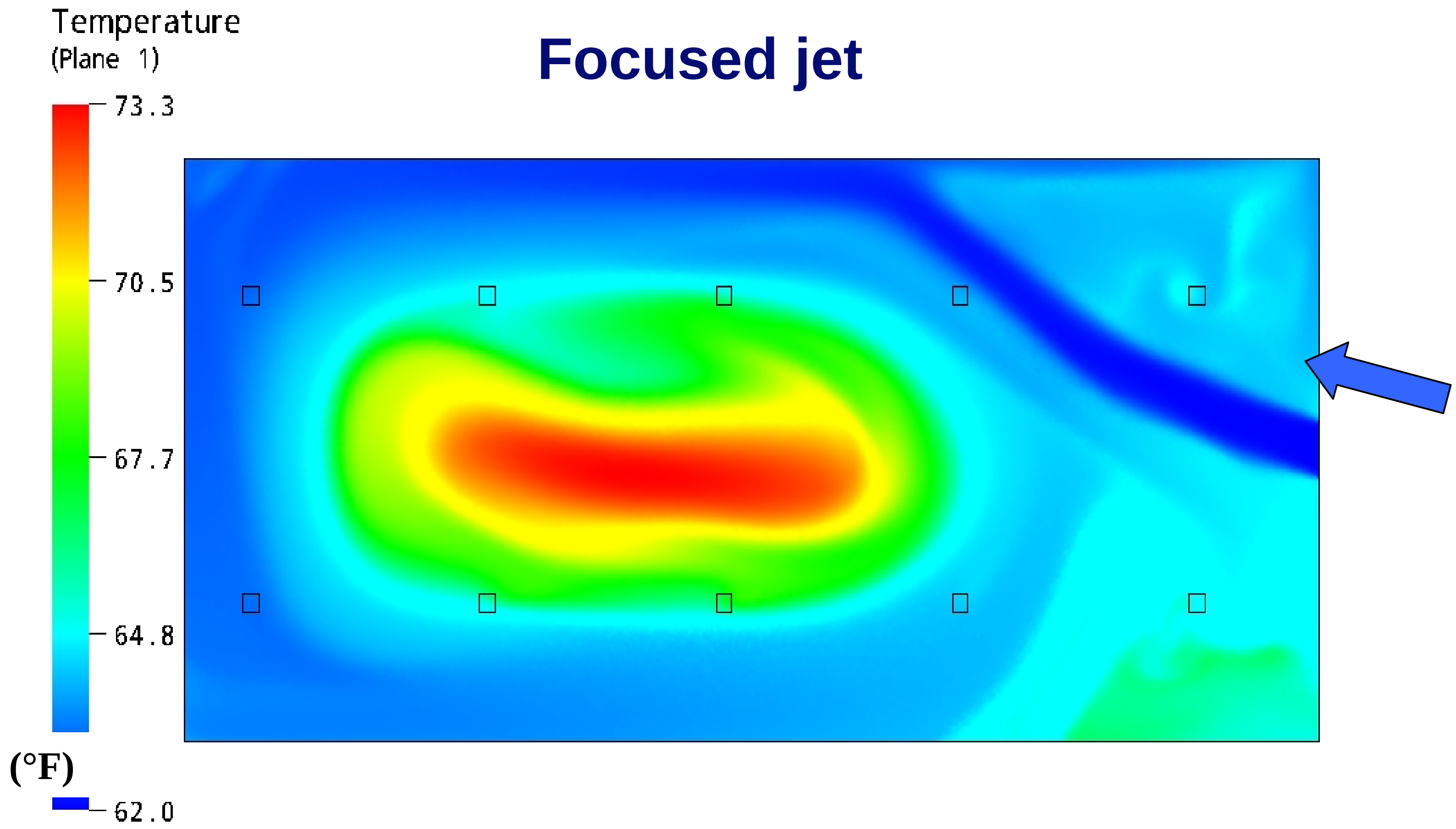
Plenum Air Temperature – CFD Model



LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas:

Sustainable site planning
Safeguarding water and water efficiency
Energy efficiency and renewable energy
Conservation of materials and resources
Indoor environmental quality

Summary of Potential LEED Points

Optimized energy performance	1 – 4 points
Recycled content	1 – 2 points
Regional materials	1 point
Carbon dioxide monitoring	1 point
Increased ventilation effectiveness	1 point
Construction IAQ Management Plan	1 point
Controllability of systems	1 point
Thermal comfort	1 – 2 points
Low-emitting materials	1 point
Daylight and views	1 – 2 points
Potential Contribution	**10 – 16 points**

Potential LEED points with UFAD

- Energy & Atmosphere
  - **Optimized energy performance** – reduce building energy use below levels specified in ASHRAE Standard 90.1 (1-10 pts)
- Indoor Environmental Quality
  - **Improved ventilation effectiveness** – performance of UFAD system results in ventilation effectiveness greater than 0.9 (average for overhead mixing systems), as measured according to ASHRAE Standard 129-1997 (1 pt)
  - **Controllability of systems** – provide individual control of thermal, ventilation, and lighting systems to support improved occupant comfort, health, and productivity (1-2 pts)

Case Study: MIT Stata Center - Cambridge

M.I.T.'s Ray and Maria Stata Center, a 730,000-square-foot complex devoted to computer science.

The meandering main corridor, with its bright red, blue and yellow walls, is known as "student street."

Liberty View Elementary School – Oathe, KS

Olathe, Kansas
(near Overland Park)
78,000SF Elementary School

Blue Valley Elementary School # 19

DDVAV .vs. FlexSys

Values were calculated on 55,800 sq. ft. (Athletic / Kitchen wing not included).

	Dual Duct	FlexSys	SAVINGS
AHU 1,2,3	$44,000	$44,000	
Labor @ $5,000 each AHU	$15,000	$15,000	
Boilers 1,2,3, installed	$75,000	$75,000	
Chillers, air cooled scroll	$94,824	$94,824	
Sheet Metal - dual duct sys (*$7.15/sq ft*)	$399,000	$60,000	**$339,000**
MIT / MFT w/controls & floor grilles installed	- - - -	$118,955	($118,955)
DDC Controls (*52 dual duct units*)	$30,200	- - - -	**$30,200**
Test & Balance	$40,000	$10,000	**$30,000**
Tate floor (*38,000 sq ft*)	- - - -	$202,650	($202,650)
Electrical: Floor recept., wire, & cable	- - - -	$10,200	($10,200)
Electrical: Wall recept., wire, & cable	$66,629	$39,978	**$26,651**
Electrical: Labor	$179,854	$119,783	**$60,071**
G.C. cost for electrical	$50,000	- - - -	**$50,000**
G.C. cost for AS IS walls & penthouse	$194,921	- - - -	**$194,921**
G.C. cost for proposed Low walls & basement	- - - -	$147,765	($147,765)
Data Cable installed classrooms (150 drops)	$30,000	$17,000	**$13,000**
Hot Water System/ w/labor		$30,000	($30,000)
	$1,219,428	$985,155	**$234,273**

Operating Savings assumptions:	(CMR) 6% Job Expense	$14,056
1. 65° Air Temp = 17% to 30% chiller savings	(CMR) 7% Overhead	$16,399
2. ASHRAE 62 Ventilation Effectiveness: Ve = 1.2 vs 0.8	(CMR) 8% Profit	$18,742
		$283,471

	Dual Duct	FlexSys	SAVINGS
Predicted Annual operating cost: HVAC	$43,500	$30,451	**$13,049**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In Summary:

- Underfloor air distribution is the next generation in air conditioning systems.
- Provide significantly better indoor air quality.
- Provides a medium for easier installation of other trades.
- Enhances a buildings ability to change and adapt to its own needs and requirements.
- Reduces operating cost and reduces a buildings lifecycle cost.

- ***University of California at Berkeley*** - Center for the Built Environment www.cbe.berkeley.edu/underfloorair
- ***Carnegie Mellon University*** - Center for Building Performance & Diagnostics www.arc.cmu.edu/cbpd
- ***Center for Renewable Energy & Sustainable Design*** www.crest.org
- ***Rocky Mountain Institute*** www.rmi.org
- ***U.S. Green Building Council*** www.usgbc.com
- ***General Services Administration*** www.gsa.gov

Thank You!