100% Outside Air Systems & Active & Passive Chilled Beams

Presented by: Dan Hahne
(Varitec: Director of High-Performance HVAC Solutions)

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PREMIER PERFORMANCE THROUGH EDUCATION, DESIGN & INNOVATION

Introduction

Education:

- University of Arizona – Chemical Engineering
  - 1974 thru 1976
- University College London – BFA Degree (Sculpture)
  - 1978 thru 1983
- Boston University – MFA Degree (Sculpture)
  - 1983 thru 1985

Industry:

- **Norman S. Wright SW:** Estimator/Sales
  - 1985 thru 1999
- **Air Specialty Products/ThermAir Systems:** Outside Sales
  - 2000 thru 2008
- **Air Specialty Products/ThermAir Systems:** Engineering Sales
  - 2009 thru 2016
- **Varitec Solutions:**
  - Senior Sales Engineer
    - 2016 - 2022
  - Director of High-Performance HVAC Solutions/Educator
    - 2022 thru present

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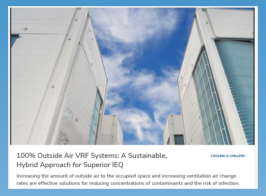
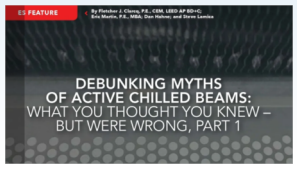
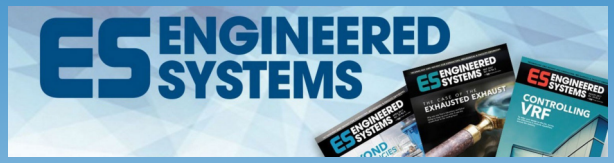
Introduction

Publications:







- **July 2022: 100% Outside Air VRF Systems: A Sustainable, Hybrid Approach for Superior IEQ**
  - Dan Hahne
- **October 2021: Health Care Design: Beyond Code Minimum – Creating Healthier, More Efficient Environments**
  - (Co-Authored with Fletcher Clarcq P.E.)
- **June 2021: Health Care Design: ANSI/ASHRAE/ASHE Standard 170, and Beyond**
  - (Co-Authored with Fletcher Clarcq P.E.)
- **November 2019: Debunking the Myths of Active Chilled Beams: What You Thought You Knew But Were Wrong**
  - (Co-Authored with Eric Martin P.E., Fletcher Clarcq P.E. Steven Lamica, Engineer (Dadanco))
- **October 2019: Debunking the Myths of Active Chilled Beams: The Drip Test**
  - (Co-Authored with Eric Martin P.E., Fletcher Clarcq P.E. Steven Lamica, Engineer (Dadanco))

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VARITEC:
The HVAC System Solution Resource

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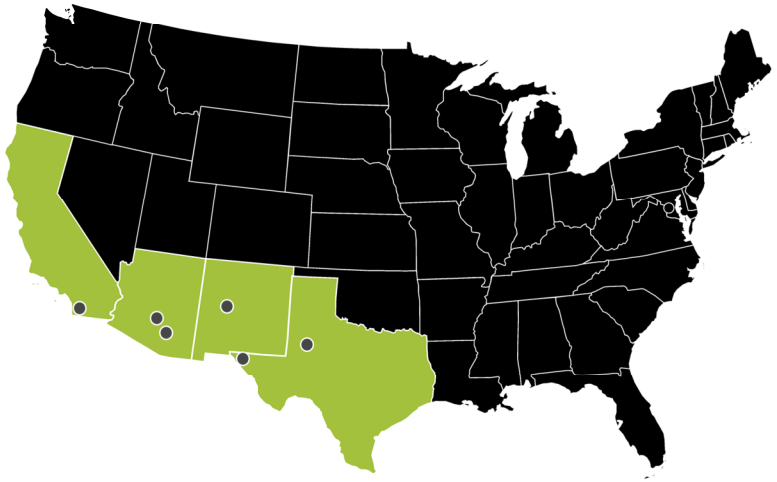
Varitec: The HVAC System Solution

SERVING THE SOUTHWEST
FOR OVER 45 YEARS



Arizona | New Mexico | West Texas | San Diego

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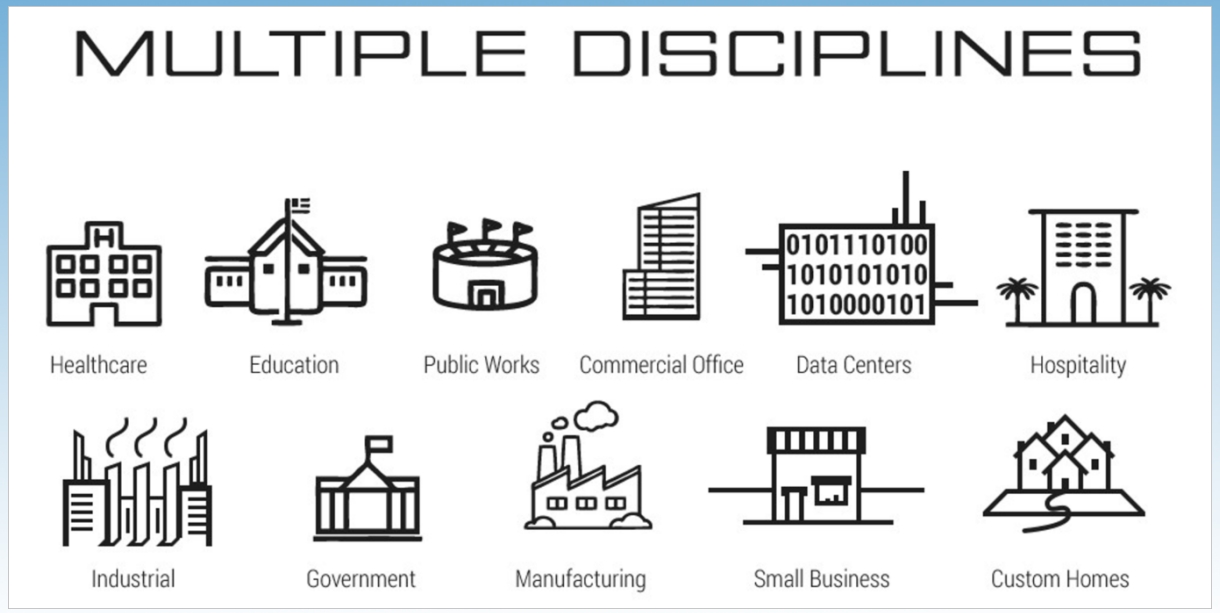
Varitec: The HVAC System Solution



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Varitec: The HVAC System Solution

System Solutions:

- Mixed Air VAV Systems
- Variable Refrigerant Systems
- Underfloor Air Systems
- 100% OSA Systems
  - DOAS Technology
  - Active Chilled Beams
  - Passive Hydronic Cooling & Heating Systems
- Humidity “Control”
- Package Central Plants for Air & Water Cooled Designs
- Cloud Based Controls

NORTEK™

VARITEC™ CONTROLS & SERVICE SOLUTIONS

KRUEGER Excellence in Air Distribution

MARLEY® SPX® COOLING TECHNOLOGIES

DAIKIN

driSteem™

KMC® CONTROLS

TURNTIDE®

ANNEXAIR

DADANCO feel the difference™

BRAINBOX AI

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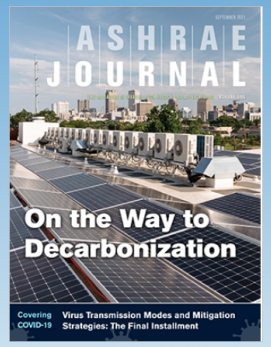
Ventilation: The OSA Challenge

ASHRAE Journal September 2021



- **Recent Development for Standard 90.1;**
  - "…the **U.S. Department of Energy (DOE)** issued a determination that **ANSI/ASHRAE/IES Standard 90.1-2019** for buildings except low-Rise Residential Buildings, improves energy efficiency in commercial buildings…The **final determination** makes the 2019 version of the standard the reference energy-efficiency standard…"

What's Next for Standard 90.1

ATLANTA–In late July, the U.S. Department of Energy (DOE) issued a determination that ANSI/ASHRAE/IES Standard 90.1-2019, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, improves energy efficiency in commercial buildings compared to the 2016 standard.

The final determination makes the 2019 version of the standard the reference energy-efficiency standard for buildings other than low-rise residential buildings, said Standing Standard Project Committee 90.1 Chair Don Brundage, P.E., Member ASHRAE; Co-Vice Chair Thomas Culp, Ph.D., Member ASHRAE; and special status as the model energy code for buildings within the 90.1 scope."

Now What?

DOE analysis shows the updated standard could cause national savings in commercial buildings of about 4.7% site energy, 4.3% source energy and 4.3% energy cost. States and other jurisdictions are now required to review their commercial building code regarding energy efficiency and update their codes to meet or exceed Standard 90.1-2019. Each state or jurisdiction has their own process for considering updates

US Department of Energy

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Shaping The Future Of HVAC

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VARITEC™
TECHNICAL INSTITUTE

(New Horizons Launch, January 9, 2006)

Mission:

To provide an educational platform for continued learning in the HVAC industry with a focus on high performance buildings and innovative technologies for a better built environment.

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Varitec Technical Institute

May 12th: Varitec Sustainability Symposium

- Why Buildings Matter

June 15th: Refrigerants: A Global Imperative

July 13th: 100% Outside Air Systems

- Part 1: Variable Refrigerant Systems

September 28th: 100% Outside Air Systems

- Part 2: Active & Passive Chilled Beams

October 26th: 100 Outside Air Systems

- Part 3: Passive Radiant Heating & Cooling Systems

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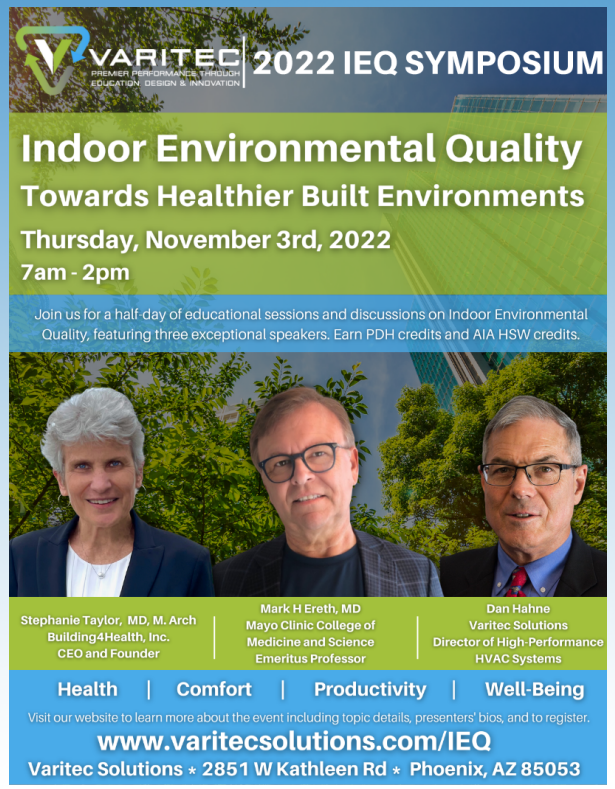

Varitec Presents:
Indoor Environmental Quality (IEQ) : Towards Healthier Built Environments Symposium

Date: November 3rd, 2022
Speakers:

- Dr. Stephanie Taylor (B4H Group)
- Dr. Mark Ereth, MD (Mayo Clinic)
- Dan Hahne (Varitec)

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TODAY'S AGENDA

- Review: ASHRAE, CDC & EPA:
  - Air Quality Statements
- HVAC Fundamentals & Heat Transfer
- Conventional Mixed Air Systems
- Passive & Active Chilled Beams:
  - Two Design Strategies
- Chilled Beam: Product Portfolio
- Air Handler Units: (DOAS)
- Innovative Design Concept for Enhanced Efficiency
- Review

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ASHRAE, CDC & EPA: Air Quality Statements

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ASHRAE, CDC & EPA: Air Quality Statements

CDC Website Subsequent Statement

- *"When indoors, **ventilation mitigation strategies** can help reduce viral particle concentration."*
- *"Open outdoor air damper beyond minimum settings to reduce or **eliminate HVAC air recirculation**."*

EPA: Introduction to Indoor Air Quality

- **Primary Causes of Indoor Air Quality Problems:**
  - "Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources…"
- ***"An important approach to lowering the concentrations of indoor air pollutants… the amount of outdoor air coming indoors.."***

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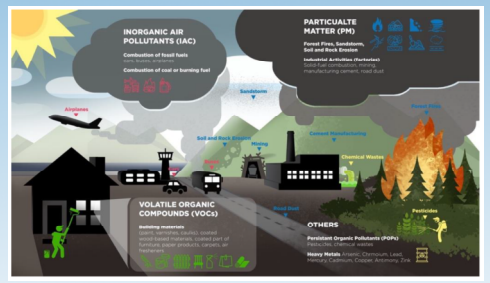
ASHRAE, CDC & EPA: Air Quality Statements

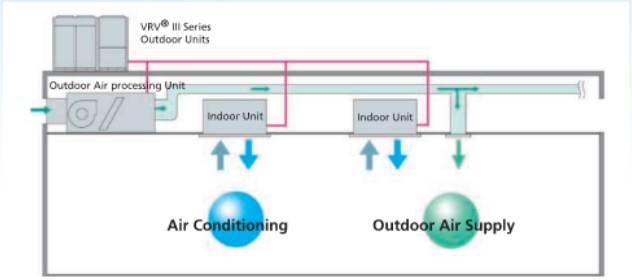
Environmental Protection Agency (EPA):

- **Outdoor Air and Indoor Contaminants: Comparison**

Indoor Air Pollutant

- Asbestos
- Biological Pollutants
- Carbon Monoxide
- Cook Stoves
- Formaldehyde/Pressed Wood Products
- Lead
- Nitrogen Dioxide
- Pesticides
- Radon
- Particulate Matter (PM)
- Volatile Organic Compounds
- Wood Smoke





Outdoor Air Pollutant

- Carbon Monoxide
- Lead
- Nitrogen Dioxide
- Ozone
- Particulate Matter (PM):Various Sizes
- Sulfur Dioxide)

(Note: Outdoor air contains other pollutants not regularly monitored by the EPA)

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ASHRAE, CDC & EPA: Air Quality Statements

Environmental Protection Agency (EPA):

- *"EPA studies of human exposure to air pollutants indicate the **indoor levels of pollutants may be two to five times –** and occasionally more than 100 times **– higher than outdoor levels."***

(By: Robert E. Stumm, P.E.)

ASHRAE Journal: June 2022

"Of particular interest are several studies providing substantial evidence of **acute exposure to CO_2 at levels as low as 1,000 ppm** inducing significant reductions in cognition and decision-making abilities…"

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HVAC Fundamentals
&
Heat Transfer

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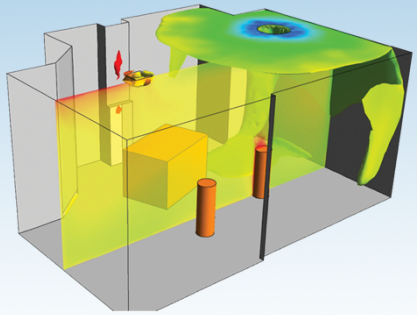
HVAC Fundamentals & Heat Transfer

HVAC Engineering Purpose: Maintain Space Conditions

- Understand the laws of physics to effectively move **ENERGY** (load) from point A to point B
- **Conventional Approach:** Calculate a buildings **ENERGY** ("total" load) and design HVAC system to transfer the load from Point A to Point B



(Mixed-Air Environment)

Heat Energy

- **Energy Present in Sample of Air**

HVAC Systems: Conventional Approach

- **Air is the heat transfer medium**

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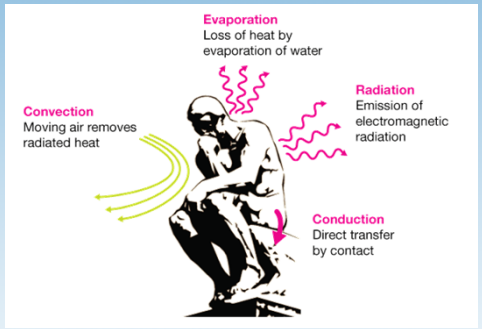
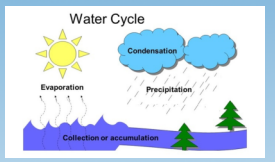
HVAC Fundamentals & Heat Transfer

HVAC Engineering: Move Energy - Heat Transfer

- Heat Transfer Methods: Naturally, Mechanically

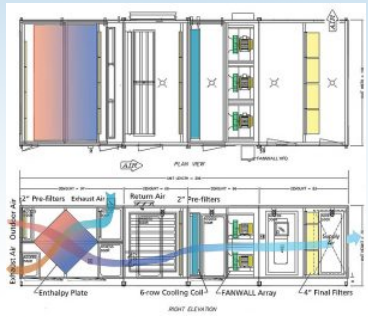




- Naturally: Principles of imbalance and equilibrium (towards steady state)
  - Energy moves from high energy state to a low energy state

Mechanically:

- Applying energy (motors) to move energy
- Mechanically force heat transfer
- Energy is required



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HVAC Fundamentals & Heat Transfer

HVAC Engineering: Move Energy - Heat Transfer

HVAC Systems: Purpose

- **To Maintain Thermal Comfort:**
  - Maintain Energy Levels in a Building
    - Cooling: Remove energy gained
    - Heating: Add energy lost
- **To Maintain Indoor Air Quality:**
  - Buildings to be properly ventilated to maintain a healthy environment
- **Energy to be Transferred = Total Energy Load:**
  - **Total Energy (Load) = Sensible Energy + Latent Energy**

- **(1) ton of energy (load) = 12,000 BTUs total energy**

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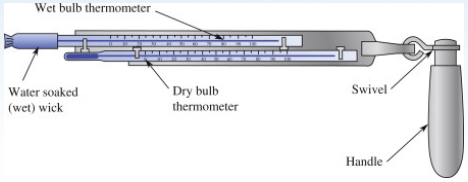
HVAC Fundamentals & Heat Transfer

HVAC Engineering: Move Energy - Heat Transfer

- **SENSIBLE HEAT ENERGY: Energy a person "SENSES"**
  - **Sensible energy (heat) is the energy measured as Temperature displayed on a thermostat**
  - Sensible heat is measured as **"Dry Bulb (DB)"** temperature: Fahrenheit (F)



(Sling Psychrometer)

LATENT HEAT ENERGY: Humidity (water vapor)

- **Latent energy is the energy required to maintain water in a vapor phase (gas)**
- Latent Heat is measured as **"Wet Bulb (WB)"** Temperature: Fahrenheit (F)

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HVAC Fundamentals & Heat Transfer

HVAC Designs: Moving Energy - Heat Transfer

Sensible vs Latent Cooling: Sources

Sensible Heat Loads:

- Energy used to remove heat from occupied zone
- Heat sources:
  - Internal heat loads
  - Plug loads
  - Solar gain

Latent Heat Loads:

- Energy to remove moisture
- Moisture sources:
  - Occupants
  - Humidity infiltration

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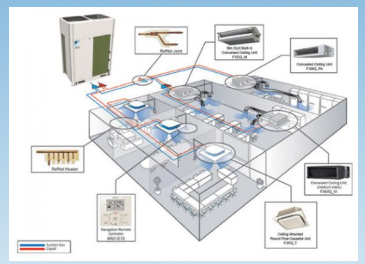
Conventional Mixed Air Systems

Conventional Mixed Air Systems

Heat Transfer and "Heat Transfer Mediums":

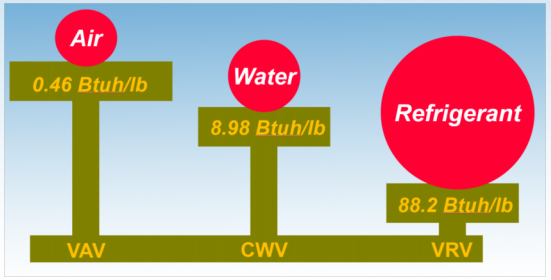
Heat Transfer Medium:

- That by which energy is transported: Solids or Fluids



Heat Transfer Fluid: Definition

- "**..heat transfer fluid is a gas or liquid** that takes part in heat transfer by serving as an intermediary in cooling on one side of a process (i.e. a building), transporting and storing thermal energy and heating on another side of a process". (i.e. outdoors) (Wikipedia)



HVAC: Heat Transfer Mediums

- **Air: (0.46 BTUs/LB (Dry Air))**
- **Water: (8.98 BTUs/LB (Water))**
- **Refrigerant: (88.2 BTUs/LB (Refrigerant))**

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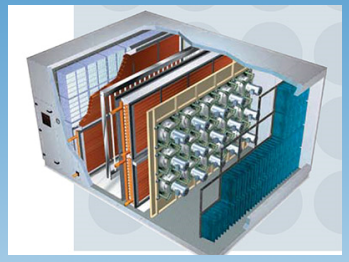
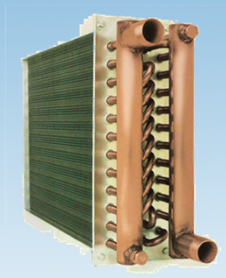
Conventional Mixed Air Systems

Heat Transfer Medium: All-Air Systems

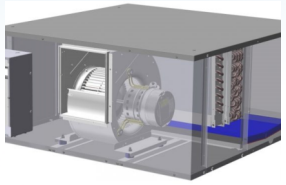


- **A large volume of air** is needed to move energy from or to a building to maintain space setpoint conditions



- **Total Load:**
  - **Sensible load** (energy required to remove or add heat to the airstream) **+ latent load** (energy required to remove moisture from the airstream)
  - **Total load: Present at an AHU cooling coil**

- **Fan motor horsepower required to overcome system resistance**



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Conventional Mixed Air Systems

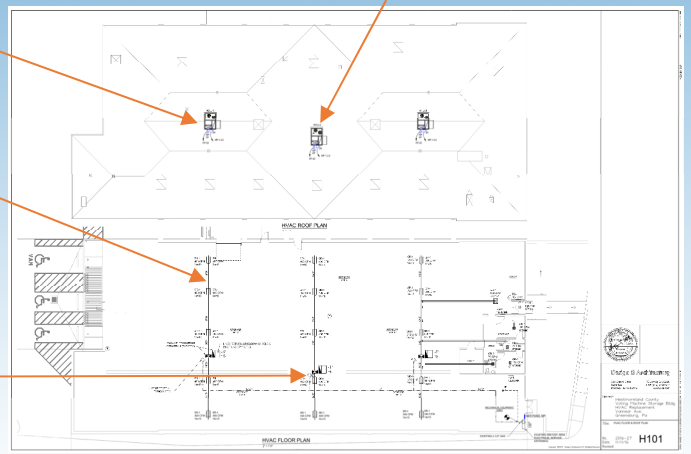
All-Air Systems: Ducted Package Rooftop System

Package Rooftop Heat Pumps:
- Total load seen at heat pump coil

Supply Duct:
- Conditioned cool, filtrated air (~55F) supplied to building

Return Air Duct:
- Warm return air (~78-82F) returned to rooftop AHU

% of Outside Air:
- Brought in at rooftop unit



A lot of duct is required to move a lot of air!!!

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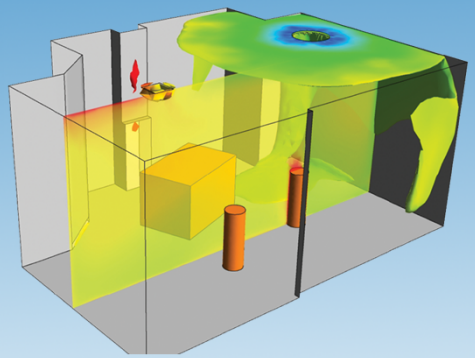
Conventional Mixed Air Systems

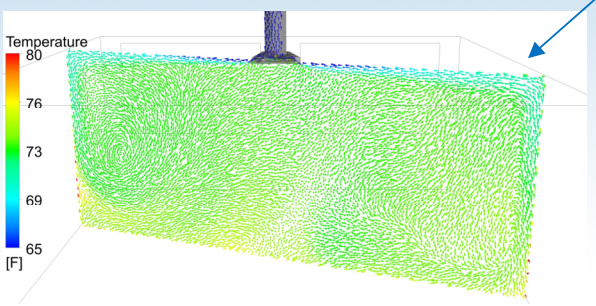
All-Air Systems: Mixed-Air Environments

- Conventional Approach: All-Air System
- Condition the cubic volume of space



~75F (+/-2F) DB @ 50% RH (Cooling):
Room Dew Point: 55.13F @ 1100ft elevation

Uniform thermal profile



How:

- **55°F Supply Air (cooling)**
- Diffusers-High discharge velocity **(150 FPM)**
- Mix the entire cubic volume of space for uniform temperature profile (+/- 2F)
- **20F delta T** to satisfy the space load

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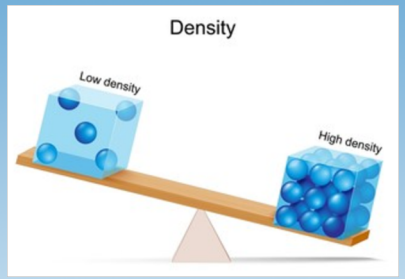
HVAC Fundamentals & Heat Transfer

Heat Transfer Mediums: A More Efficient Option

Use Chilled Water to Move Energy in Lieu of Air

Why? Water is More Dense Than Air



- **Specific Heat:** Heat required to raise the temperature of the unit mass of a given substance by a given amount (usually one degree).
- **Water has 4.23 times** the specific heat capacity than air
  - It takes **less water to move the same amount of energy** than it does air.
  - **Less water than air, less pump horsepower than fan horsepower**

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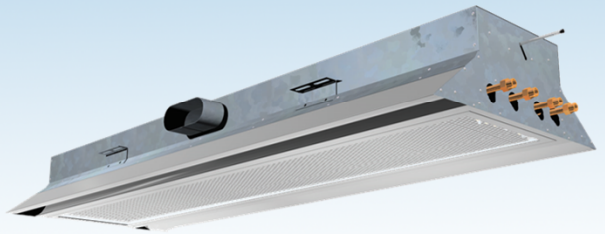
Chilled Beams:
Concept, Operation & Design



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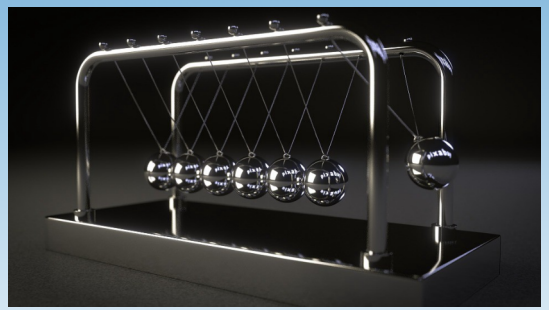
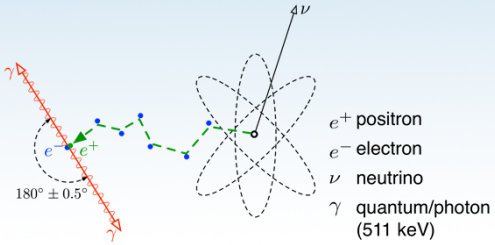
Chilled Beams: Concept, Operation & Design

Increase System Efficiency: A Solution

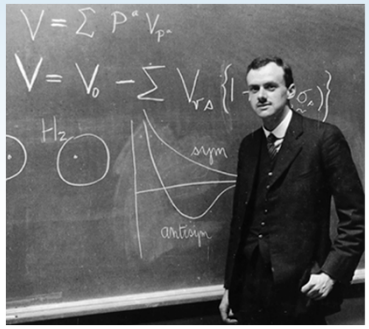
Laws of Physics & Energy



- Apply physical properties **to assume some of the work** required to move energy from inside a building to outdoors
- Efficiency, output in relation to input, for work to be done



(Paul Dirac)



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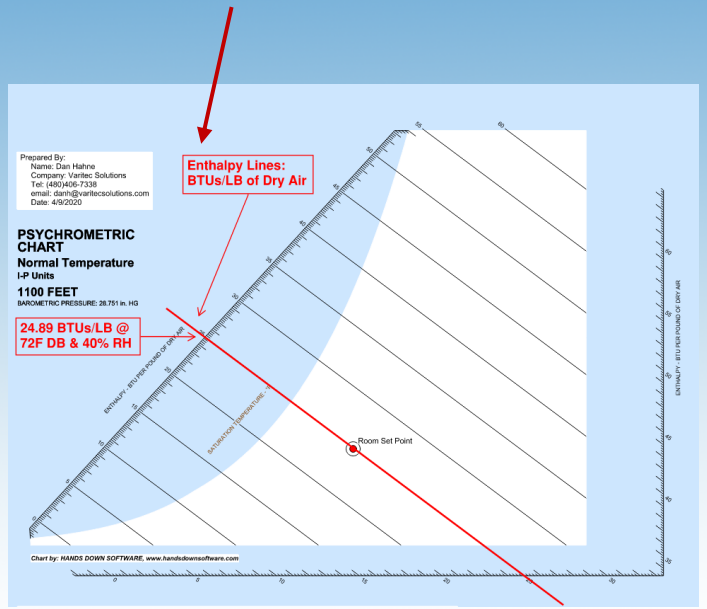
Chilled Beams: Operation & Design

Total Energy (Enthalpy) = Sensible Energy + Latent Energy

REMEMBER:

- **Sensible energy: The energy that moves air molecules** measured by the dry bulb temperature at the thermostat
  - Load Source: People, equipment, windows, solar gain
- **Latent Energy:** The energy required to maintain water in a vapor state
  - Load Source: Respiration, perspiration, evaporation, infiltration



Chilled Beams: Operation & Design

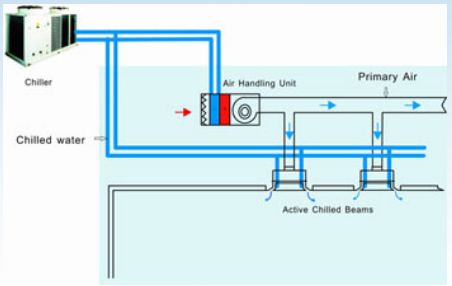
100% Outside Air Systems (OSA)

To Increase System Efficiency:

- **Decoupled Hydronic Systems**

Why?

- **Water** is more dense than air
- **Water** is a more efficient heat transfer medium than air
  - 4.23x more specific heat capacity **(4-6F vs 20F delta T)** to maintain space setpoint conditions
  - **Less horse power** to move the same amount of energy using water than air



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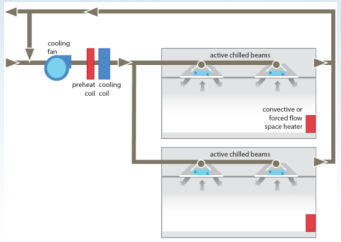
Chilled Beams: Operation & Design

Chilled Beam Technology:

- **DECOUPLE** the **Total Load**
- **Sensible load:** Designed to meet the **energy load in the occupied zone**
- **Latent load:** Latent cooling is achieved by the outside air component. **The lower supply air dew point; greater humidity control**
  - **Total Air Flow Reduced**

Chilled & hot water piped locally to each zone

Ductwork Significantly Reduced



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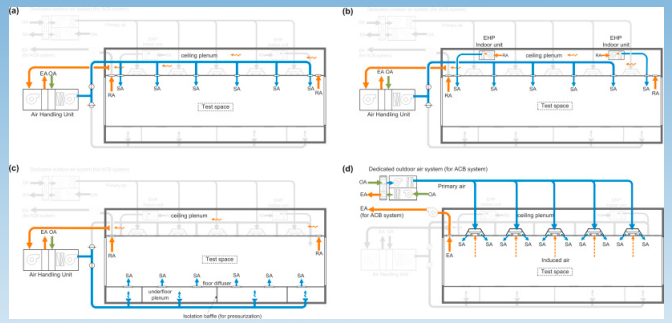
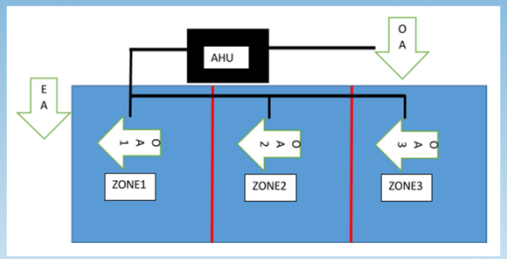
Chilled Beams: Operation & Design

100% Outside Air Systems (OSA)

- **Greater System Efficiency (Reduced System Horsepower)**





- **No Return Air to Air Handler**

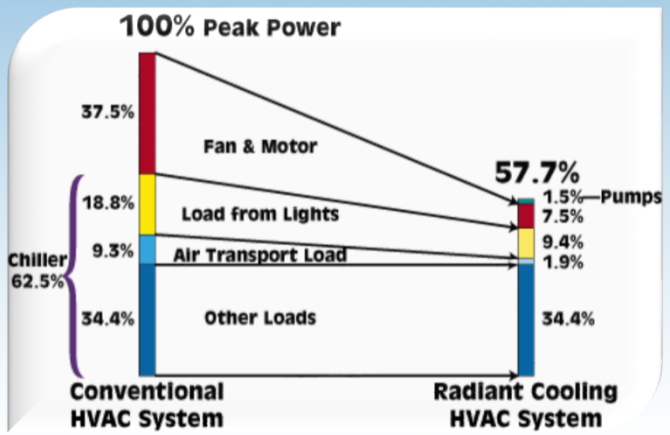
- Design air flow as close to ventilation air requirements
- 50-70% less air flow required compared to mixed air: (e.g. VAV)
- **Reduced System Horsepower = Energy Savings**
- Volume of OSA supplied is exhausted from a building to maintain positive building pressure

Chilled Beams: Operation & Design

Chilled Beam Technology:

- **Move Sensible Energy to the Chilled Water Loop**

- **Less horsepower to move water than air**
- Hydronic systems can reduce energy by 30-40% due to reduced horsepower
- **Passive hydronic systems:** Potential for enhanced efficiency in dry climates resulting in extended economizer hours



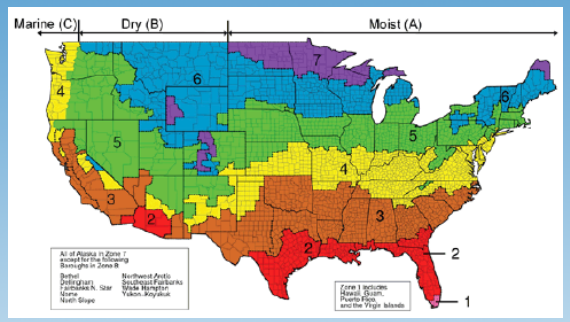
Chilled Beams: Operation & Design

100% Outside Air Systems (OSA)

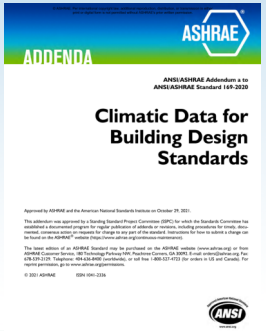
Review Regional Climate Data

Design HVAC System to the Region:

- **ASHRAE Climate Map:**
- **Southwestern Region**
  - **Hot Dry Climate:** Decoupled hydronic systems are ideal**:**
    - Coolest times of year, driest ties of year
    - **Arizona Monsoon:**
      - Humidity needs to be carefully assessed (70F Dew Point or greater)



ASHRAE Standard 169: Climate Zones



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Passive & Active Chilled Beams: Two Design Strategies

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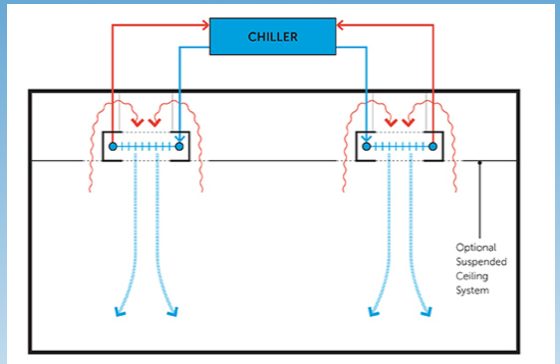
Chilled Beams: Operation & Design

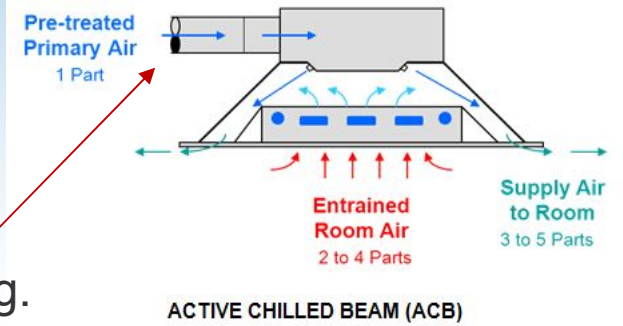
Passive Chilled Beams

- Designed to meet sensible cooling loads of the conditioned space
- **Ventilation is decoupled from the beam.**



Active Chilled Beams

- Designed to satisfy the sensible cooling and heating loads of the conditioned space
- Ventilation is direct coupled to the beam
- Air inlet static pressure: 0.2 to 0.6” w.g.

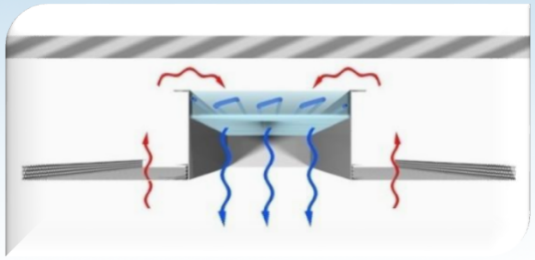


ACTIVE CHILLED BEAM (ACB)

Active & Passive Beams: Two Design Strategies

Passive Chilled Beams:

- **Cooling only devices:** Coils suspended from ceiling deck
- Warm upper level room air is cooled via conduction at beam cooling coil
- Cool air falls to the occupied zone



- Entering chilled water temperature: 57-60F: 2-3F above space dew point
- Convection drives the air
- **300 BTUs/Linear foot of beam**
- Beam locations – Thermal comfort

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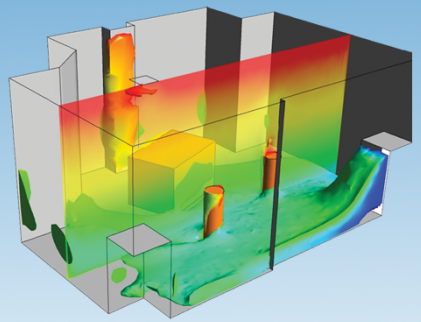
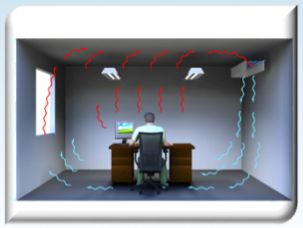
Active & Passive Beams: Two Design Strategies

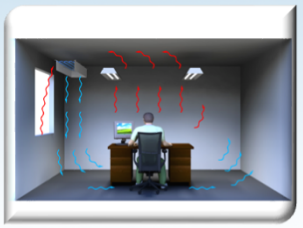
Passive Chilled Beams: Airside Component

Thermally Stratified Environment

- Conditioned space in the occupied zone
- Thermal profile throughout the height of a room
- Increase temperature difference between passive beam cooling coil and ambient air
- Convection drives airflow, not fan energy







Displacement Ventilation

- Air decoupled from passive beam
- Low velocity air supplied by air diffusers

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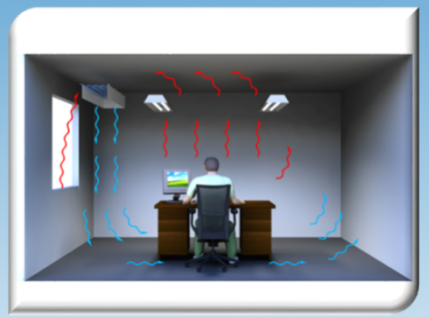
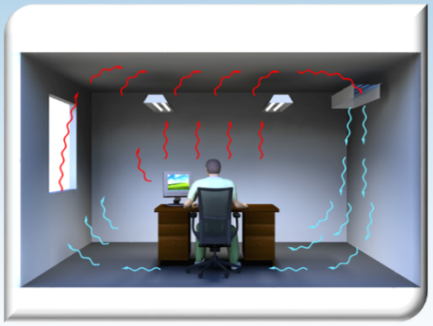
Active & Passive Beams: Two Design Strategies

Passive Chilled Beams: Airside Component

- **Airside Component:**
- Stratified thermal gradient throughout the room



- **Displacement ventilation**
  - Low in wall
  - Ceiling mounted
  - Underfloor air systems



Passive Beam Placement:

- Away from Sedentary Occupants

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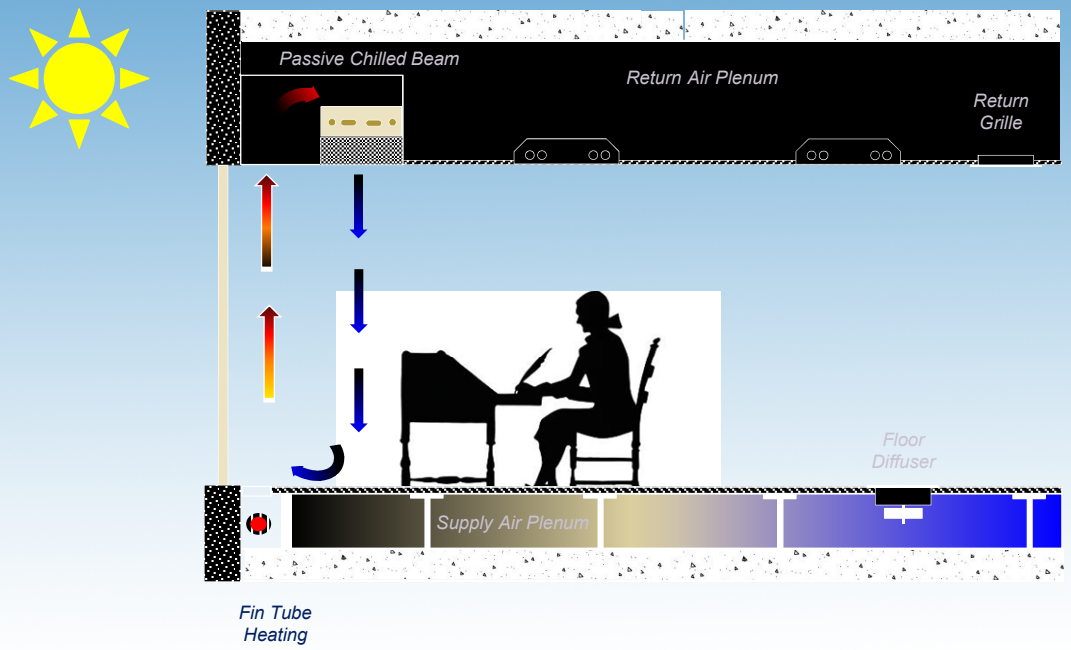
Active & Passive Beams: Two Design Strategies



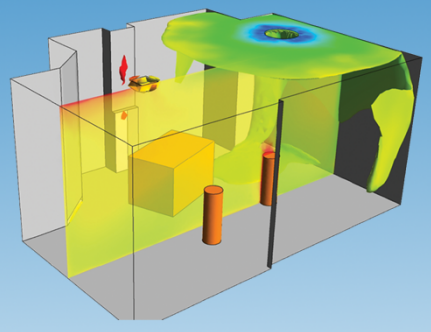
Hybrid Systems:

- Passive beams with underfloor air systems

Active & Passive Beams: Two Design Strategies

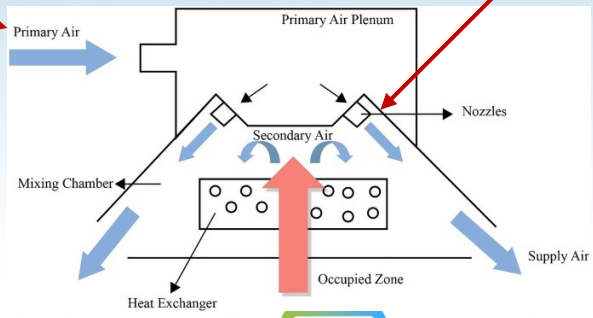
Active Chilled Beams:

- **The Airside Component**
  - **Thoroughly Mixed air environment**



- **OSA supplied for ventilation**
- **55 – 60F primary (OSA) air**
  - Upper plenum primary air
  - Lower plenum coil & induced air
- **1200+ BTU per lineal foot**

- High velocity supply air induces room air through the coil



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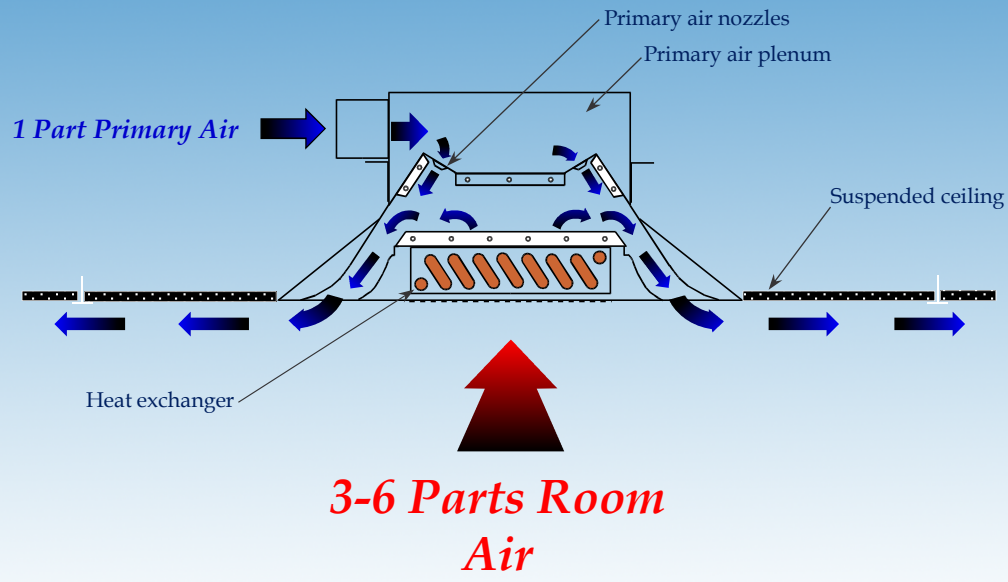
Active & Passive Beams: Two Design Strategies

Active Chilled Beams:

- Ceiling mounted



3-6 Parts Room Air

Higher Room Air to Outside Air Induction Ratios = Greater Efficiency

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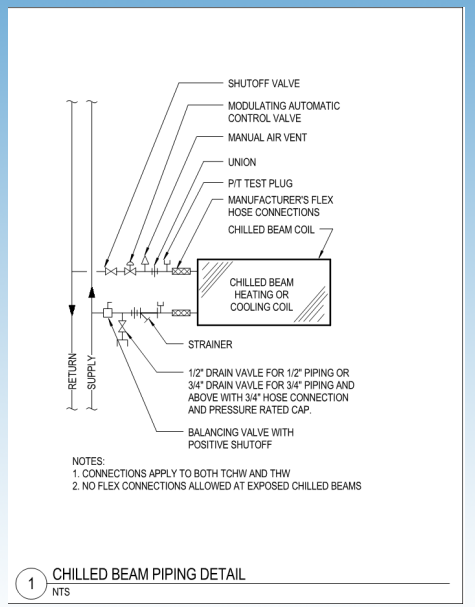
Chilled Beams: Theory & System Design

Chilled Water Piping Design:

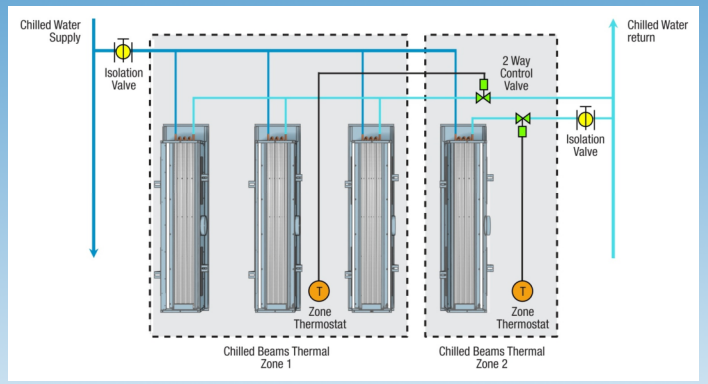
- **Design to meet the sensible loads in the space**
- **Cooling: (Active & Passive Systems)**
  - Higher **CHSW supply temperature, 56-65F (2-3F above space dew point)**
  - Condensation control
- **Heating: (Active Systems)**
  - Lower HSW supply temperature possible, generally 100-120F
  - 2-pipe heating
  - 4-pipe heating



Chilled Beams: Theory & System Design

Water Side Design Considerations:

- Zone control: **Pipe beams in parallel**
- **Entering water temperature 2-3F above dew point**
- **Water flow rate:**
  - Minimum: 0.6 GPM
  - Maximum: 2.0 GPM
- Control chilled water supply temperature to each zone



- Coil Head Pressure: 2-10FT

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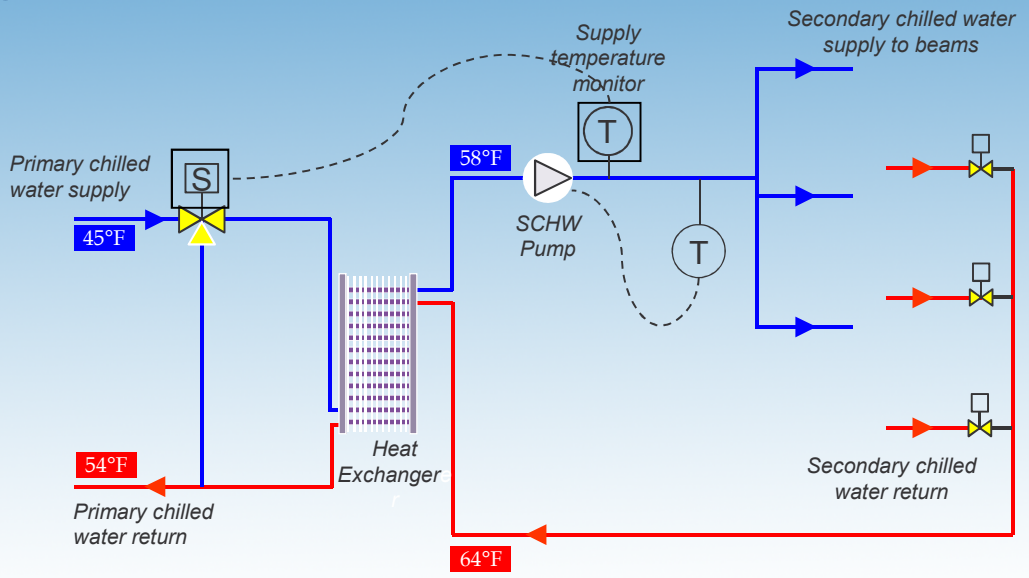
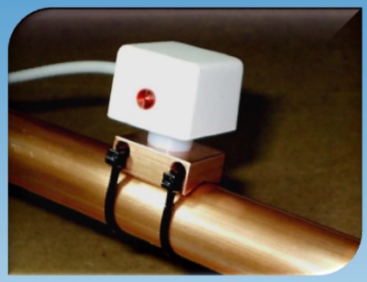
Chilled Beams: Theory & System Design

Zone Piping: Secondary Chilled Water Loop



Chilled Beams: Theory & System Design

Humidity Control:



- **CHWS Temperature higher than dew point**
- Tight building envelope
- **Airside to meet 100% of worst case latent load**
  - Infiltration
  - Maximum occupancy
  - Other sources of moisture
  - Beams selected for performance range
- **Control Strategies: Water Temperature Reset**
  - RH sensor
  - Automatic zone shut off valve
  - Water temperature reset: 3-way valve

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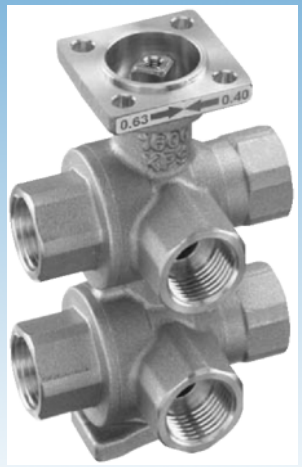
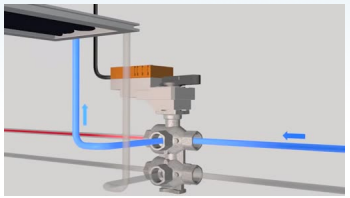
Chilled Beams: Theory & System Design

Waterside Control: 6-Way Valves

- Variable water flow
  - Pressure independent control
- Two position valves or modulating valves
- 6-way valves can be used to **convert 4 pipe into 2 pipe chilled beams**
- Reschedule or shut off SCHW only if primary moisture content cannot reduced





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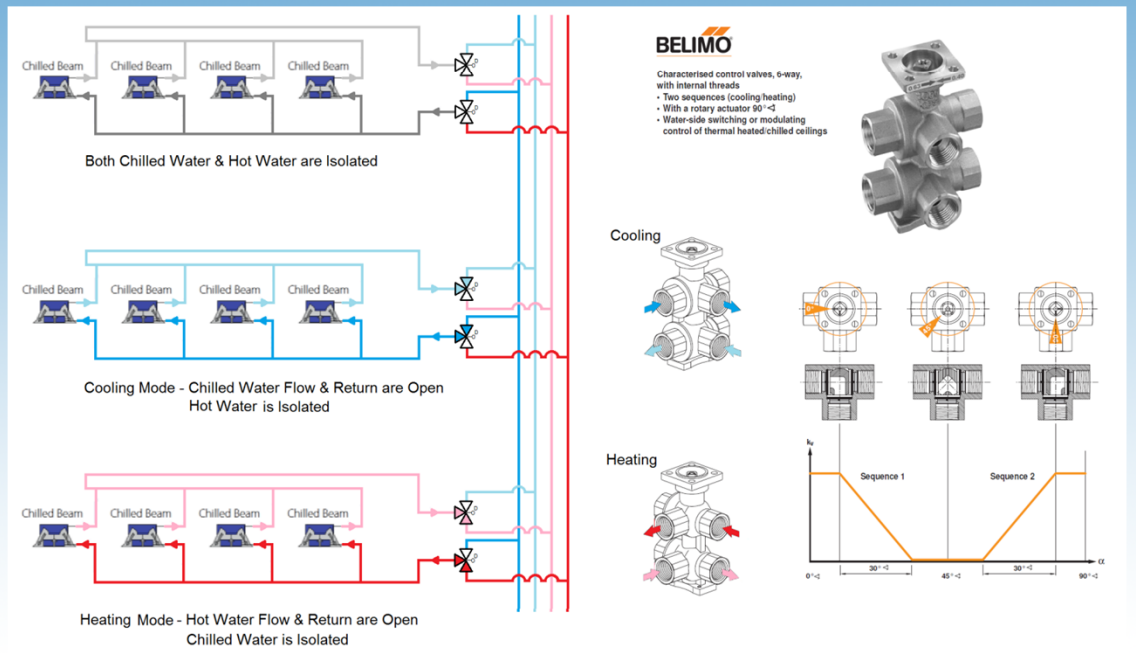
Chilled Beams: Theory & System Design

Belimo: 6-way valve:



Chilled Beam: Product Portfolio

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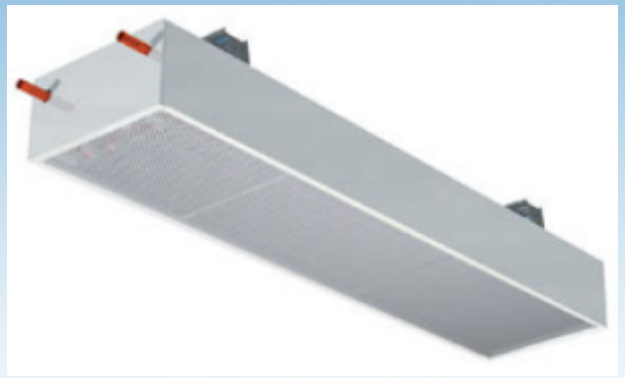
Chilled Beam: Product Portfolio

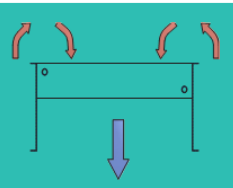
Dadanco: Passive Chilled Beams



PASSIVE

PASSIVE BEAMS

Passive chilled beams utilize natural convection in order to provide sensible cooling without the use of any forced air. Passive chilled beams are extremely energy efficient and virtually silent, however they provide much less sensible cooling than an active beam of the same size. Separate systems are needed to provide heating and ventilation. Recessed passive beams can be concealed above perforated ceiling tiles, or exposed passive beams can be used in open ceilings.



PERFORMANCE CHARACTERISTICS

LENGTH	TYPICAL CAPACITY	WATER FLOW RATE
4'-10'	UP TO 500 BTU/FT	0.5-2.5 GPM

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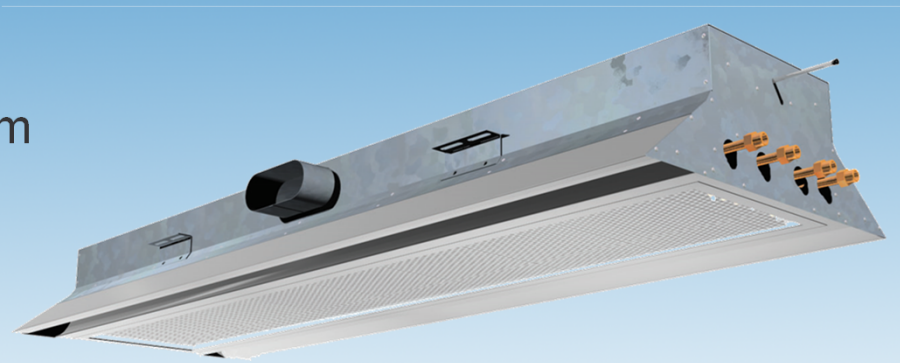
Introduction to Dadanco

Active Chilled Beams:

Dadanco: Model ACB-40



- Induction of secondary air from room
- 1 or 2-way discharge
- 2-Pipe or 4-Pipe
- 2’ wide
- 2’ - 10’ lengths
- Cooling capacity up to 1500 BTUH per LF
- Up to 35 CFM/FT primary air capacity

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Chilled Beam: Product Portfolio

Active Chilled Beams:

- Ceiling mounted

Wings and Casings:

- Coanda
- Ensures horizontal pattern and throw

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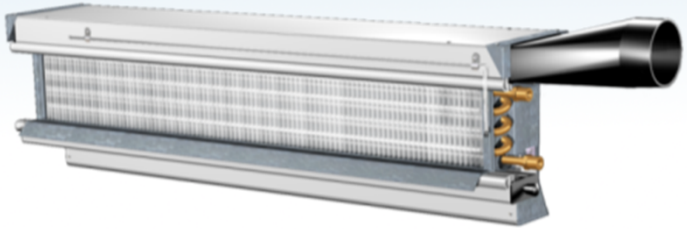
Chilled Beam: Product Portfolio

Active Chilled Beams:

Dadanco Model: ACB 30/35 Concealed

- Induction of secondary air from return air plenum
- 1 or 2-way discharge *(grille dependent)*
- 2-Pipe or 4-Pipe
- 7” wide *(12” wide grille typical)*
- 2’, 3’, 4’ 5’ or 6’ length
- Vertical coil with condensate drain pan
- Cooling capacity up to 1200 BTUH per LF
- Up to 35 CFM/ft primary air capacity
- Perimeter applications



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Chilled Beam: Product Portfolio

Active Chilled Beams:
Dadanco Model: ACB 30/35

- Plenum Mount
- Concealed

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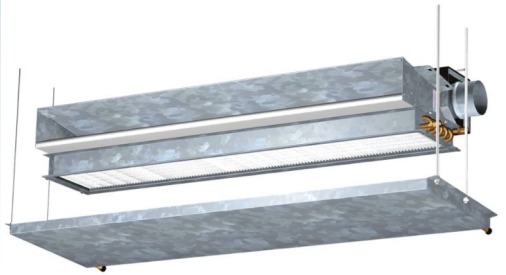
Chilled Beam: Product Portfolio

Active Chilled Beams:

Dadanco Model ACB 10 (Bulkhead)

- Horizontal discharge
- 2-Pipe or 4-Pipe
- 2’, 3’, 4’ 5’ or 6’ length
- With auxiliary condensate drain pan
- Cooling capacity up to 1200 BTUH per LF
- Up to 20 CFM/ft primary air capacity
- Hotels, dorms, atriums and lobbies



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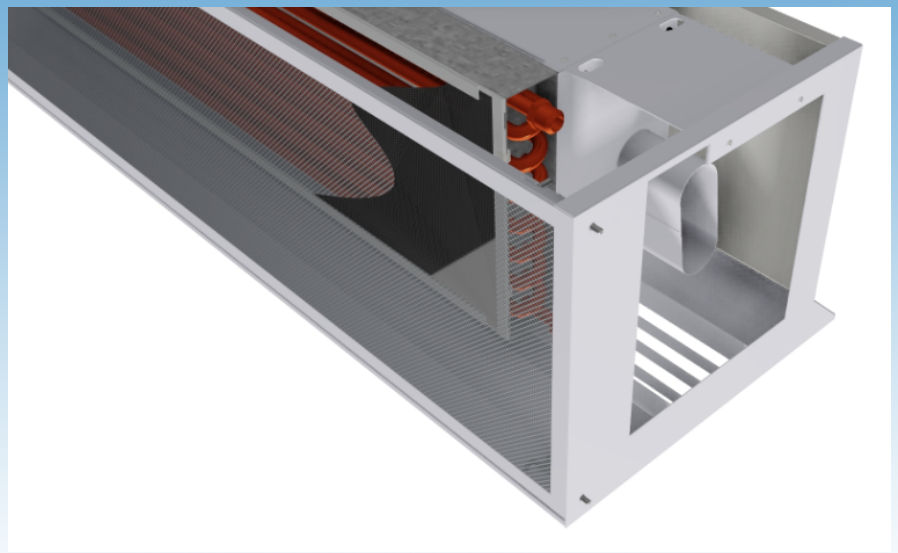
Chilled Beam: Product Portfolio



Custom Chilled Beam Capability

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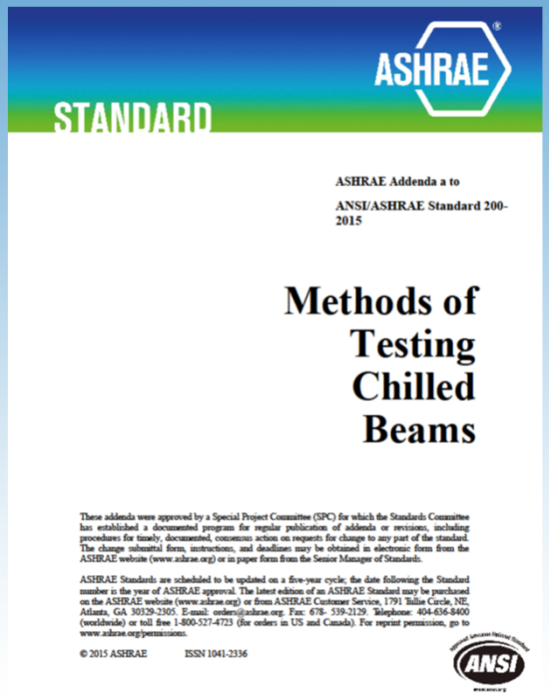
Chilled Beam: Product Portfolio

Performance Data

- **ASHRAE Standard SPC-200**
  - ASHRAE TC5.3 CB subcommittee
  - AHRI rating program
- Currently tested to:
  - DIN14037 – heated ceilings
  - DIN14240 – chilled ceilings
  - DIN15116 – active beams
  - DIN14518 – passive beams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STANDARD

ASHRAE Addenda a to

ANSI/ASHRAE Standard 200-2015

Methods of Testing Chilled Beams

These addenda were approved by a Special Project Committee (SPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards.

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Air Handler Units: (DOAS)

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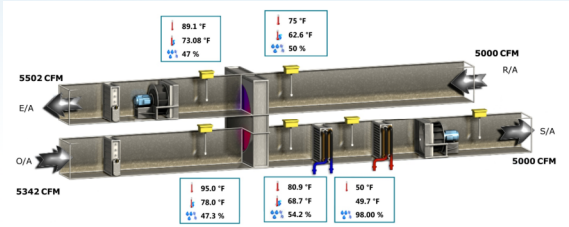
Air Handler Layouts (DOAS Units)

Air Handlers – Dedicated OSA Units (DOAS)

- **Design considerations**
  - Heat Recovery
  - Chilled & hot water coils
  - Filtration
  - Meet ventilation requirements
  - Design to satisfy peak latent load
  - Supplemental cooling if required
  - Package DX 100% OSA an option for smaller buildings
    - Semi-custom
    - Custom



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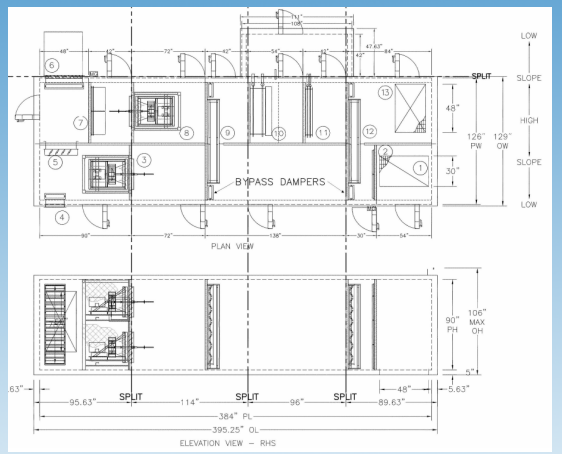
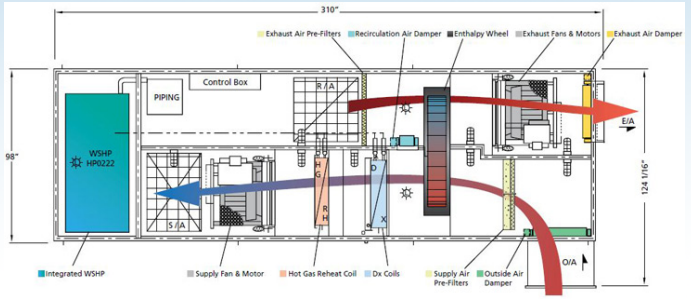
Air Handler Layouts (DOAS Units)

The Airside Component:
(100% Dedicated OSA Units)

- **Active Systems (Active Chilled Beams)**
  - 55F to 62F supply air temperature
  - Higher static pressure
  - Energy Recovery

- **Passive Systems (Passive Chilled Beams)**
  - Stratified air environments
  - 62F to 68F air temperature supply air
  - Latent load removed at the air handler
  - Energy Recovery
  - Sensible wheel for reheat





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Air Handler Layouts (DOAS Units)

The Airside Component:

Design considerations

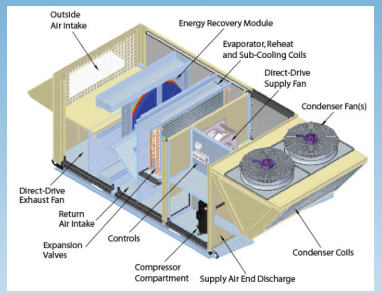
- **Active chilled beams**
  - Dual tunnel
  - Fan wall configuration
  - Enthalpy Heat Recovery
  - Sensible Heat Recovery

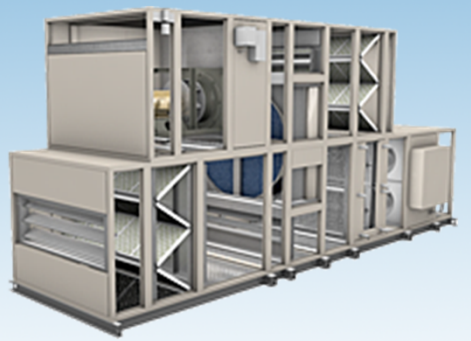
- **Passive beams:**
  - Displacement Ventilation
  - Warmer SAT without reheat
  - Side Stream Bypass Casing Design

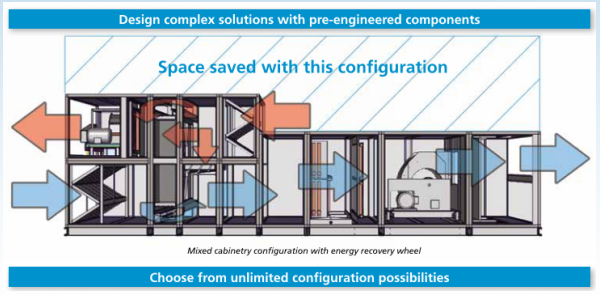
Air Handler Layouts (DOAS Units)

Air Handlers – 100% OSA Units

- **Configurations**
  - Semi-custom Layouts
  - Custom AHU Configurations







- **Configurations**
  - Chilled water
  - Package DX (variable speed compressors)
  - Desiccant dehumidification

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Air-Cooled Chiller Technology

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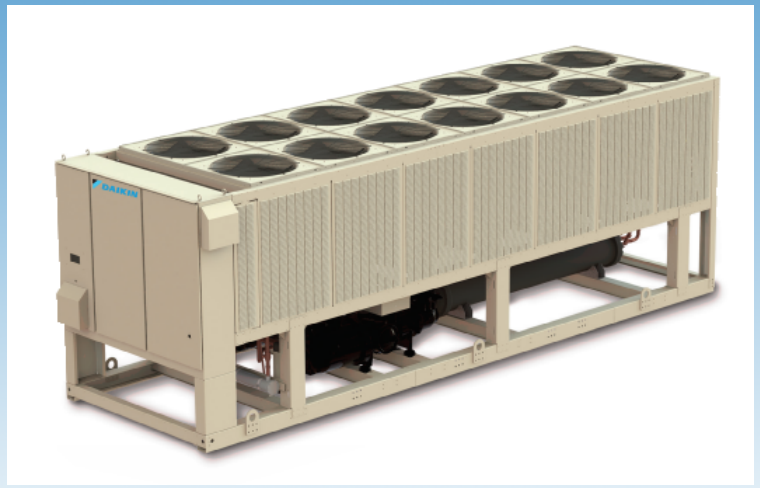
Air Cooled Chiller Technology

Daikin – Air Cooled Chillers

- Pathfinder – 165 to 550 tons
- Variable volume compressor ratio design for efficiency
- Quiet operation using single rotor design and built in muffler
- Restore cooling in 35 seconds
- Can reach full capacity in less than 4 minutes
- LWT up to 65F



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Air Cooled Chiller Technology

Daikin Model AWV18A 200 Ton Air Cooled Chiller Performance

- 115F degree ambient
- Chilled Water:
  - EWT: 54F
  - LWT: 44F

PATHFINDER® Air-Cooled Screw Chiller DAIKIN

Unit Performance

Design			
Capacity	Input Power	Efficiency	IPLV.IP*
200.0 ton	298.5 kW	8.000 EER	21.30 EER

Performance Points rated at AHRI Ambient Relief

	Unit						Evaporator				Condenser	
Point #	% Load	Capacity ton	Input Power kW	Efficiency EER	Economizer Status #1; #2	Compressor RPS #1; #2	Fluid Flow gpm	Pressure Drop ft H_2O	Entering Fluid Temperature °F	Leaving Fluid Temperature °F	Ambient Air Temperature °F	Altitude ft
1	100.0	200.0	298.5	8.000	N/A	84; 54	477.5	13.2	54.00	44.00	115.0	1100
2	75.0	150.0	133.1	13.50	N/A	52; 35	477.5	13.2	51.50	44.00	92.5	1100
3	50.0	100.0	54.60	22.00	N/A	32; 22	477.5	13.2	49.00	44.00	70.0	1100
4	25.0	50.00	20.00	29.90	N/A	26	477.5	13.2	46.50	44.00	55.0	1100

** IPLV reflects AHRI standard rating conditions and may change with user defined conditions due to AWV product optimized configurability.*

Daikin Model: AWV018A (18 Condenser Fans)

- DC inverter duty condenser fans
- Chiller Efficiency (EER): 10.60 Btu/W.h
- Chiller Part Load Efficiency: IPLV = 21.30 Btu/W.h
- More air increases chiller efficiency

DAIKIN

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PREMIER PERFORMANCE THROUGH EDUCATION, DESIGN & INNOVATION

Air Cooled Chiller Technology

Daikin Model AWV18A 200 Ton Air Cooled Chiller Performance

- 115F degree ambient
- Chilled Water:
  - EWT: 65F
  - LWT: 55F

PATHFINDER® Packaged Air-Cooled Screw Chiller DAIKIN

Unit Performance

Design			
Capacity	Input Power	Efficiency (EER)	IPLV.IP* (EER)
190.5 ton	215.1 kW	10.60 Btu/W.h	22.20 Btu/W.h

Performance Points rated at AHRI Ambient Relief

Unit							Evaporator				Condenser	
Point #	% Load	Capacity ton	Input Power kW	Efficiency (EER) Btu/W.h	Economizer Status #1; #2	Compressor RPS #1; #2	Fluid Flow gpm	Pressure Drop ft H_2O	Entering Fluid Temperature °F	Leaving Fluid Temperature °F	Ambient Air Temperature °F	Altitude ft
1	100.0	190.5	215.1	10.60	On; On	47; 42	456.1	12.1	65.00	55.00	115.0	1100
2	75.0	142.9	102.0	16.80	On; Off	33; 31	456.1	12.1	62.50	55.00	92.5	1100
3	50.0	95.30	42.90	26.70	Off; Off	22; 20	456.1	12.1	60.00	55.00	70.0	1100
4	25.0	47.60	18.80	30.40	Off; Off	20	456.1	12.1	57.50	55.00	55.0	1100

** IPLV reflects AHRI standard rating conditions and may change with user defined conditions due to AWV product optimized configurability.*

Daikin Model: AWV018A (18 Condenser Fans)

DAIKIN

- DC inverter duty condenser fans
- Chiller Efficiency (EER): 10.60 Btu/W.h
  - Chiller Part Load Efficiency: IPLV = 22.20 Btu/W.h
- More air increases chiller efficiency

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100% Outside Air Systems
&
Active & Passive Chilled Beams

Review

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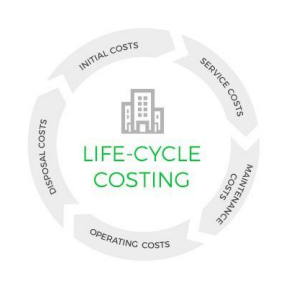
Active & Passive Chilled Beams & 100% OSA Systems

Benefits of Active & Passive Chilled Beam Systems



Energy Efficiency:

- Reduced system horsepower.
- Free cooling. (Displacement systems deliver higher supply air temperatures)
- Increased operating efficiency: Sensible load shifted to chilled water loop

Smaller Mechanical System:

- Lower floor-to-floor heights
- Smaller risers – increased tenant floor space

Reduced Maintenance:

- No moving parts or filters
- No motor or electrical connection
- Improved life cycle costs

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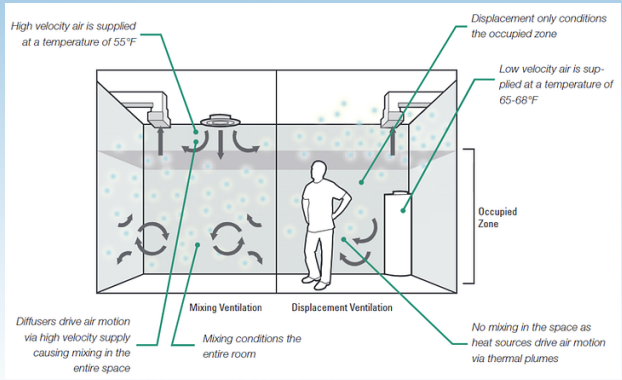
PREMIER PERFORMANCE THROUGH EDUCATION, DESIGN & INNOVATION

Active & Passive Chilled Beams & 100% OSA Systems

Silent mechanical system

- Water side of system has low noise
- Smaller air side system - less noise



Improved indoor air quality (IAQ)

- 100% DOAS have no return air path
- Displacement ventilation is recognized by ASHRAE to provide 1.2 ventilation effectiveness
- Single pass of clean air across the breathing zone

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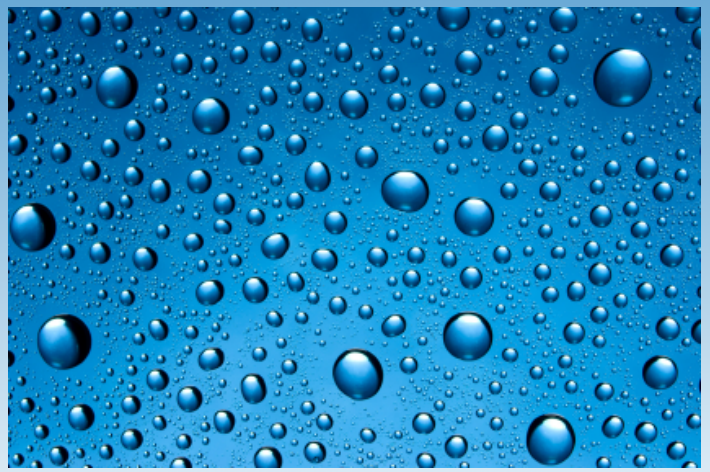
Active & Passive Chilled Beams & 100% OSA Systems

Potential for higher first cost

- Chiller required
- Additional plumbing
- Additional costs associated with tighter envelopes



PROPER BUILDING HUMIDITY CONTROL

- Condensation is a slow process
- Transient spike in humidity can be tolerated

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Questions?

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Thank you.

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