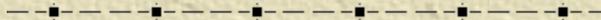
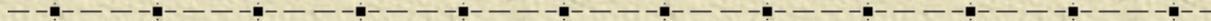


Energy Recovery Systems



Agenda

- **ARI 1060-2000**
- **Market drivers for the technology**
- **ASHRAE Standards/**
- **ARI Guideline V**
- **Energy Recovery Technology**
- **Applying Energy Recovery**

ARI Standard 1060-2000

✦ New standard for energy recovery components

✦ Performance test for

✦ summer & winter conditions

◆ Summer O.A. - 95/78 E.A. - 75/63

◆ Winter O.A. - 35/33 E.A. - 70/58

ARI Standard 1060-2000

- ◆ Performance Requirements
 - ◆ Sensible Effectiveness
 - ◆ Latent Effectiveness
 - ◆ Total Effectiveness
 - ◆ Net Effectiveness
 - ◆ Cross Leakage
 - ◆ Pressure Drop

- ◆ ARI Certification Program started in 1Q 2001

Customer Considerations

- ◆ IAQ issues and problems
- ◆ Codes
- ◆ Energy penalty to ventilate
- ◆ Use for entire space control
- ◆ Liability

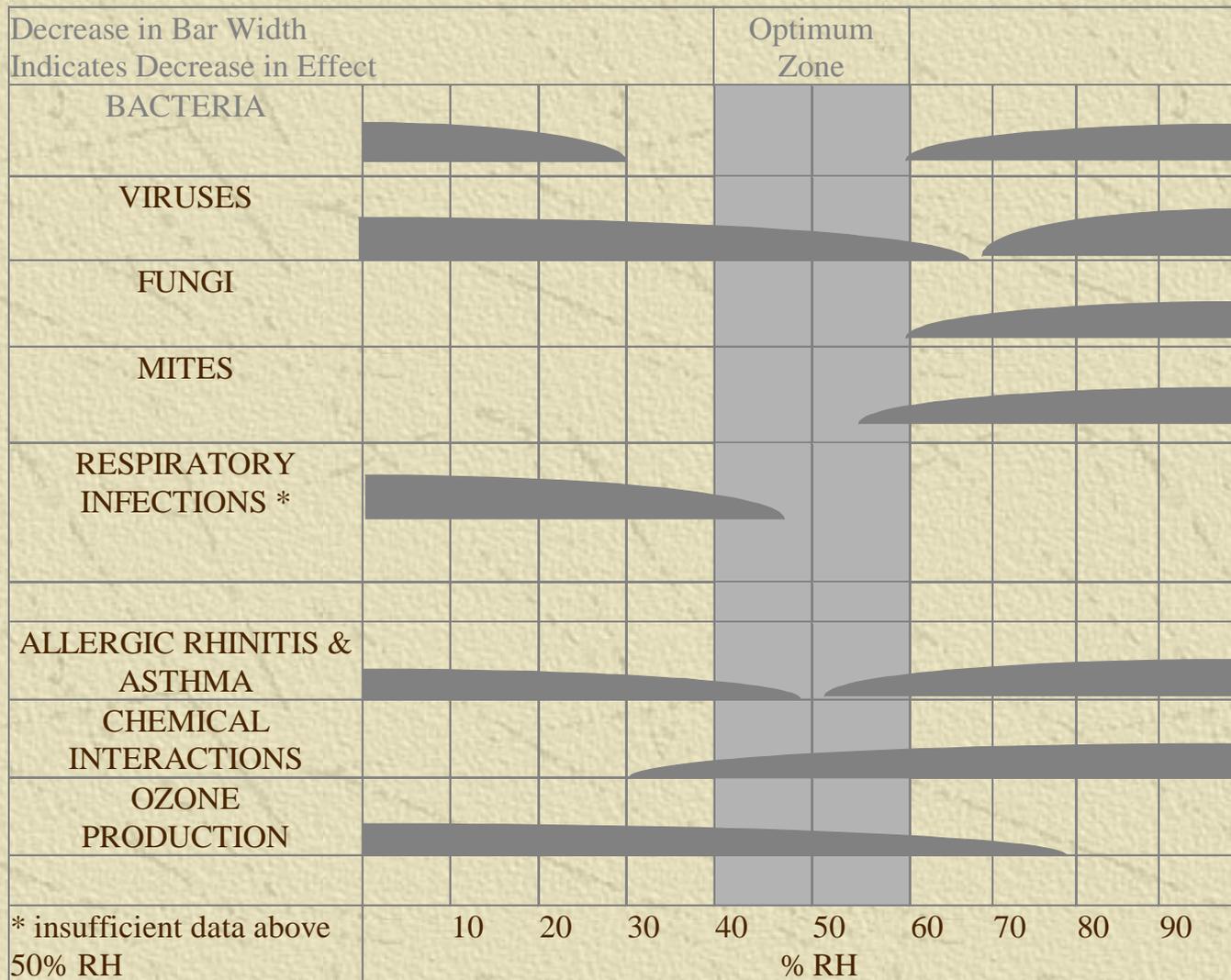
Indoor Air Quality

✦ Pollutant Issues

- ◆ Microorganisms
- ◆ Chemical Pollutants (off-gassing)
- ◆ Pollutants generated from combustion
- ◆ Particulates

✦ Temperature, humidity, and air distribution are an integral part of IAQ

Humidity- Optimum Zone



CODES AND STANDARDS

- ◆ UNIFORM BUILDING CODE
- ◆ INTERNATIONAL MECHANICAL CODE
- ◆ LOCAL CODES
- ◆ ASHRAE 90.1
- ◆ ASHRAE 84-91

✦ **ASHRAE STANDARD 62-99**

VENTILATION FOR ACCEPTABLE
INDOOR AIR QUALITY

Standard 90.1-1999/2001

- ✦ Developed with participation from many building and construction organizations including:
 - ✦ American Institute of Architects (AIA)
 - ✦ Building Owners and Managers Association (BOMA)
 - ✦ North American Insulation Manufacturer's Association (NAIMA)
 - ✦ Air-Conditioning and Refrigeration Institute (ARI)
 - ✦ Gas Appliance Manufacturers Association (GAMA)

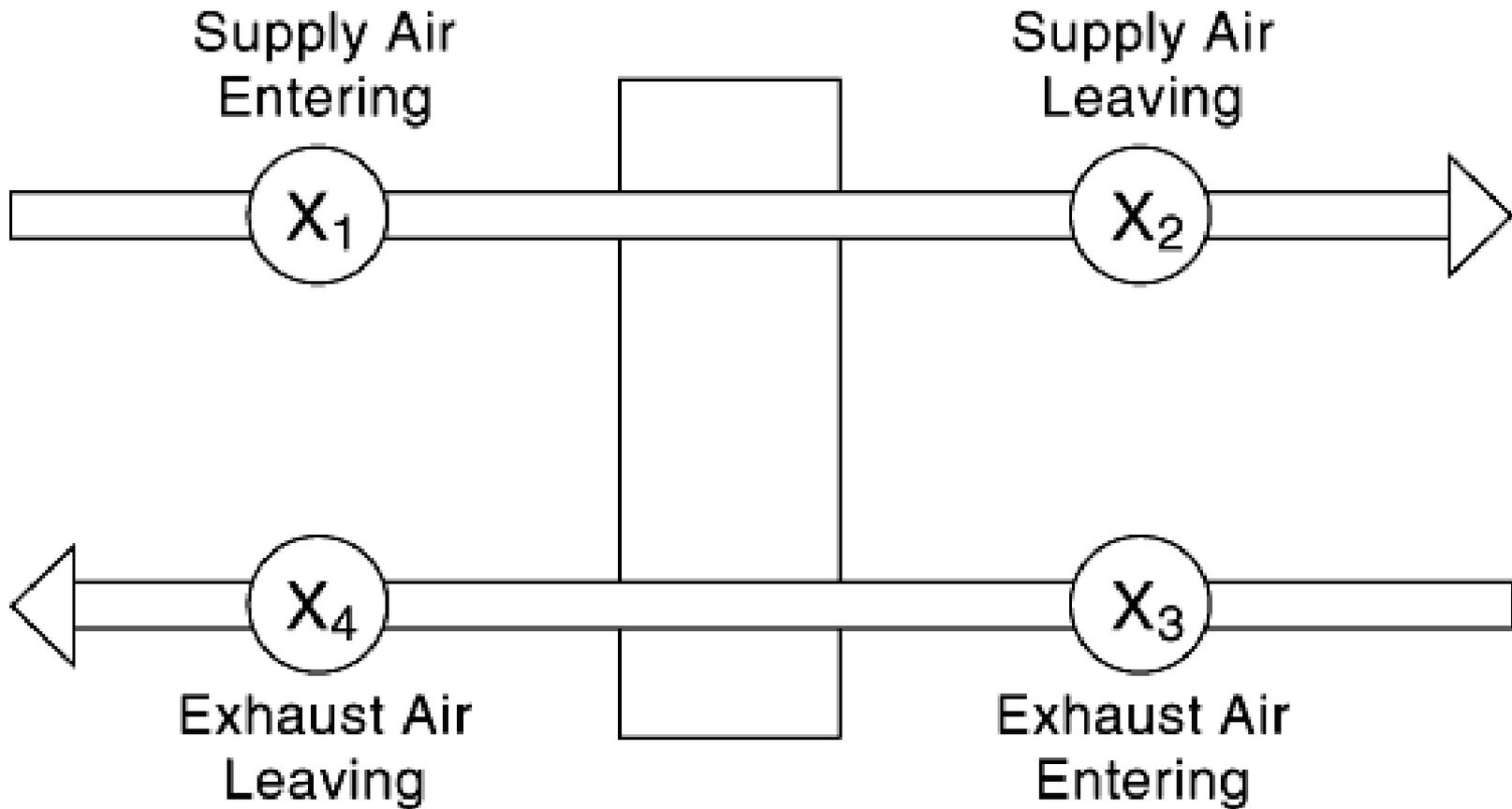
ASHRAE Standard 90.1

- ✦ 10 year review period, over - ASHRAE approved Standard 90.1-1999 in Oct/99
- ✦ New requirement for energy recovery in the standard. (Section 6)
 - ◆ **Systems with 5000cfm or greater with a minimum of 70% outside air MUST have a energy recovery system with at least 50% effectiveness.**

ASHRAE Standard 90.1

- ✦ All equipment must start to meet these standards as they are implemented in the states code.
- ✦ Energy recovery products will help make systems that are not energy efficient meet the higher energy efficient ratios.
- ✦ Recovery Energy Ratio (RER) Guideline V is being released showing the benefits of energy recovery tied into heating and cooling systems.

ASHRAE 84-91



ASHRAE 62-99 Addendum Y

- ◆ **Has 4 classifications of air (Class 1 thru 4)**
- ◆ **Allows up to 10% re circulated air from using Energy Recovery from class 2 and 5% for class 3 back to class 1**
- ◆ **ARI data show the actual transfer to be less then what addendum Y allows**
- ◆ **Brakes down the classes of air by different space types and gives the classification of that air**

Guideline V

- ✦ Industry developed with input from all major players in North America
- ✦ Purpose: *To establish a method of calculating the energy efficiency of applied Energy Recovery Ventilation components and of heating, ventilating, and/or air-conditioning systems utilizing such components at selected operating conditions*

2003
GUIDELINE for

CALCULATING
THE EFFICIENCY
OF ENERGY
RECOVERY
VENTILATION
AND ITS EFFECT
ON EFFICIENCY
AND SIZING OF
BUILDING HVAC
SYSTEMS



Guideline V

Guideline V - Definitions

- ✦ COP – Co-efficient of Performance (watts/watt; output/input)
- ✦ EER – Energy Efficiency Ratio - cooling capacity in Btu/h to the power input values in watts at any given set of Rating Conditions expressed in Btu/(W·h)
- ✦ CEF – Combined Efficiency - efficiency of a system incorporating an ERV component with a unitary packaged air conditioner, heat pump, etc. Units vary according to the application. CEF may be expressed in Btu/(W·h) or in W/W. CEF can be defined on a comparable basis to existing EER and COP ratings

$$\text{CEF}_{\text{cooling}} = \frac{\text{AAHX net cooling capacity} + \text{unitary net cooling capacity}}{\text{AAHX electric power consumption} + \text{unitary electric power consumption}}$$

Guideline V - Definitions

✦ RER – Recovery Efficiency Ratio – efficiency of the energy recovery component in recovering energy from the exhaust air-stream is defined as the energy recovered divided by the energy expended in the recovery process. Units vary according to the application. For Combined Efficiency with EER, the RER is expressed in Btu/(W·h). For Combined Efficiency with COP, the RER is expressed in W/W

$$\text{RER} = \frac{\text{Net conditioning energy recovered}}{\text{Total electric power consumed}}$$

$$\text{RER}_{\text{Total}} = \frac{\epsilon_{\text{net total}} \dot{m}_{\text{min}} (h_1 - h_3)}{P_{\text{wr}_{\text{blwr}}} + P_{\text{wr}_{\text{comp}}}}$$

What is the end result?

- ✦ RER ratio's that can be as high as 120 – the recovered energy can be very substantial while the energy used is relatively small
- ✦ CEF ratio's that increased by more than 30% over nominal EER ratio's

Energy Recovery makes good CENTS!!

ENERGY COST TO VENTILATE

- ◆ **Majority of the buildings ventilating at only 5 cfm/person or less**
- ◆ **Following ASHRAE 62-99 increases your O.A. ventilation rate by 3 to 4 times**
- ◆ **There are cost effective solutions for these types of buildings**

Energy Recovery Technology

- ✦ **Technology has been around for several decades**
- ✦ **Over 50 manufacturers of equipment today**
- ✦ **Fastest growing technology in the HVAC market**
 - ◆ **Downsize heating and cooling equipment**
 - ◆ **Downsize heating and cooling loads**
 - ◆ **Reduce peak demand**
 - ◆ **Bring in more outside air**
- ✦ **Three technologies applied:**
 - Heatpipe, Plate, Enthalpy Wheel**
 - ◆ **Wrap around heat pipe and run around plates (Neutral Air)**
 - ◆ **Dual technology units (Neutral Air)**

Energy Recovery Systems

✦ Two airstream

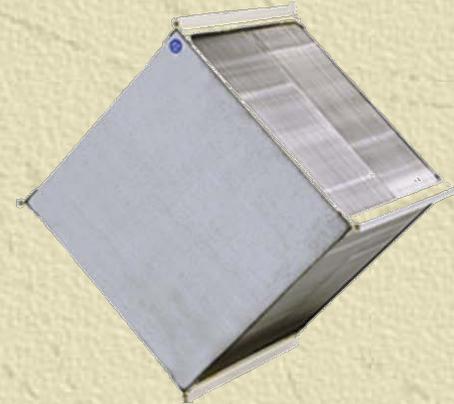
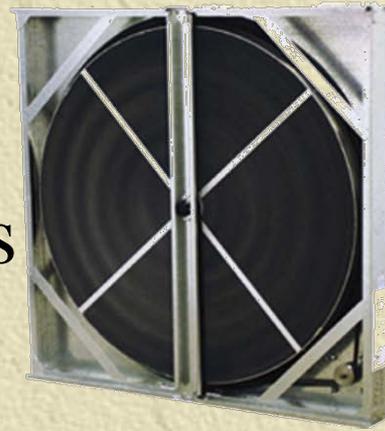
- ◆ Single plate, pipe, or wheel
- ◆ Wheel with a pipe or plate
- ◆ Wheel with a wheel

✦ Single airstream

- ◆ Pipe combined with a cooling coil
- ◆ Plate combined with cooling coil
- ◆ Regenerative wheel, for deep dehumidification processes

Heat Recovery

- ✦ Hydronic Run-around Loop
- ✦ Heat Wheel
- ✦ Heat Pipes
- ✦ Plate Heat Exchangers



Sensible Plate Heat Exchanger

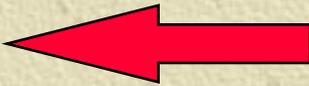
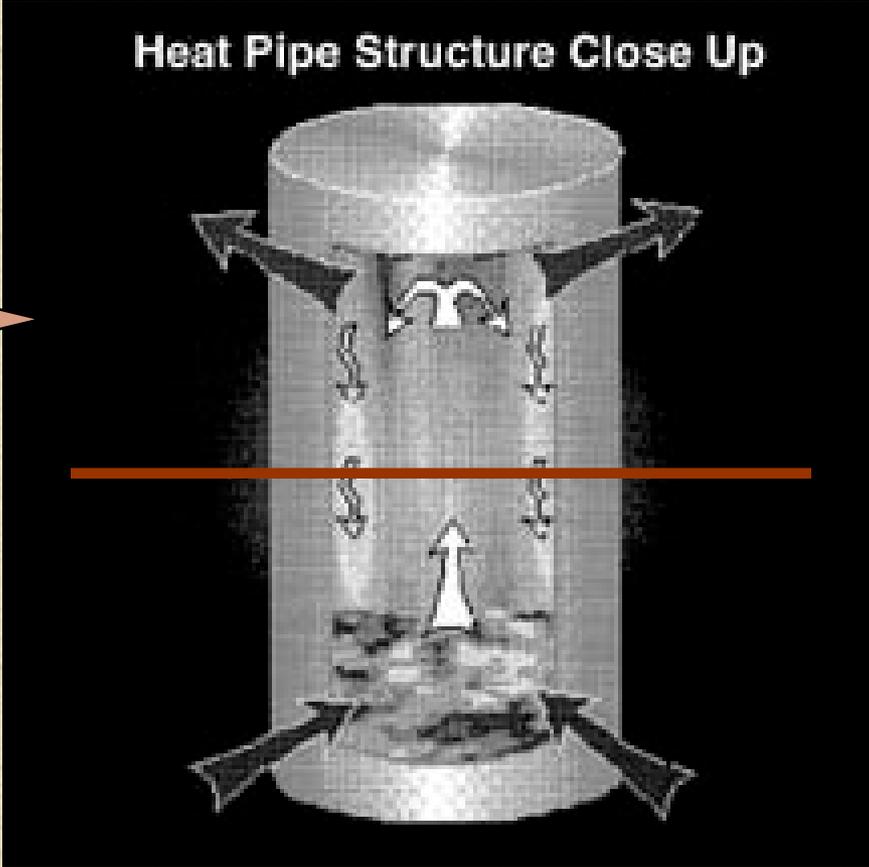
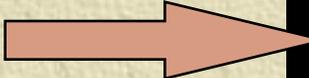
- ✦ Sensible energy transfer, no moisture transfer
- ✦ Energy transferred by surface wall of plates
- ✦ Available in plastic and Aluminum
- ✦ Low exhaust air transfer (0.05%)
- ✦ Sensible Effectiveness 55 - 65%
- ✦ Cross flow
- ✦ Defrost required once outdoor air temp falls below (23° F) - depending on exhaust air relative humidity

HEATPIPES

- ◆ **Sensible Energy transfer**
- ◆ **Closed loop system with a refrigerant charged to transfer energy**
- ◆ **Passive condenser and Evaporator**
- ◆ **40 - 55% Effectiveness**
- ◆ **Low Exhaust air transfer**
- ◆ **All one piece aluminum with integral fins or copper tube with aluminum fins**
- ◆ **Defrost required once outdoor air temp falls below 23°F - depending on exhaust air relative humidity**

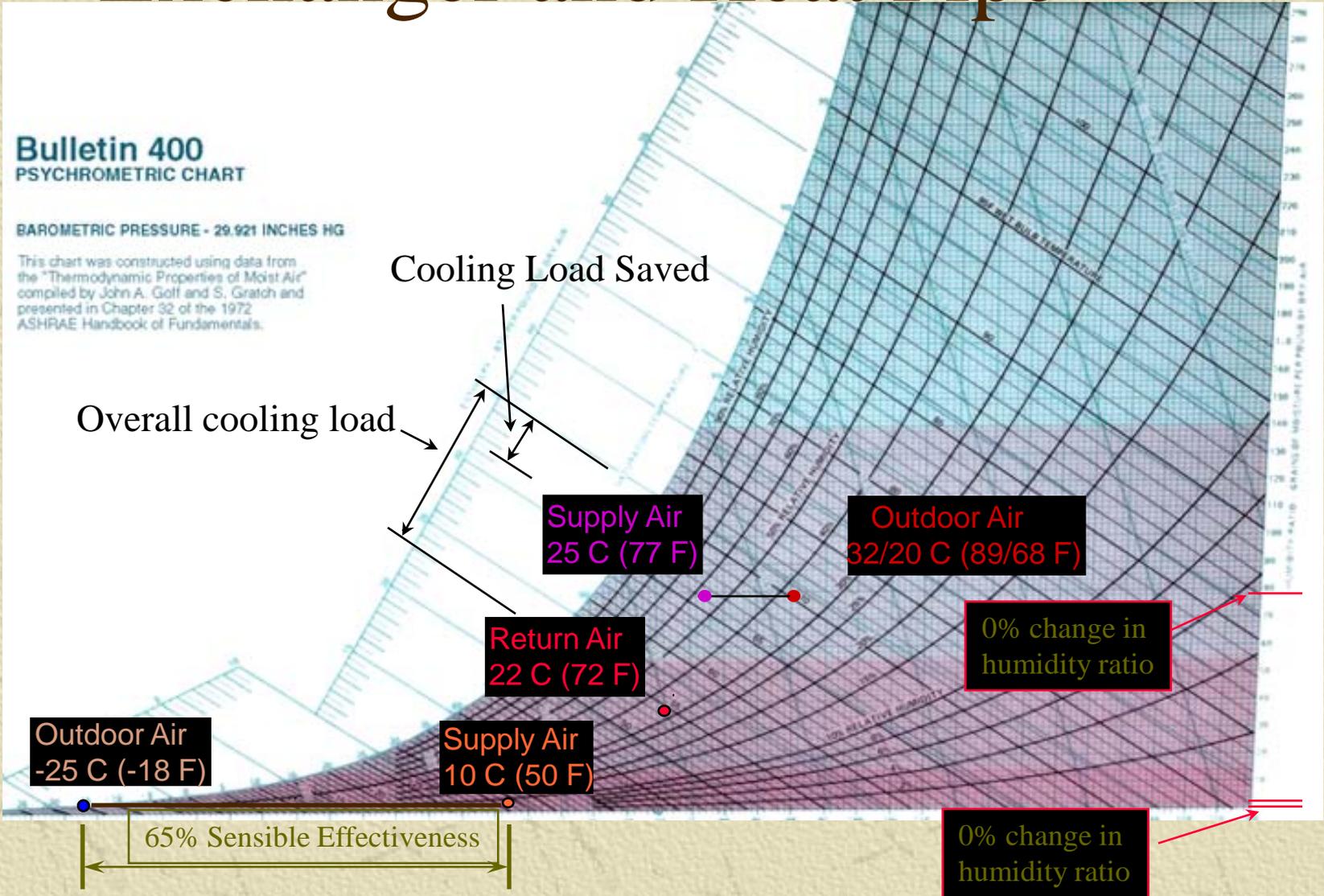
HeatPipe Technology

Outdoor Air
Condenser



Exhaust Air
Evaporator

Psychrometrics for Plate Exchanger and Heat Pipe



ERV's Enthalpy Wheels

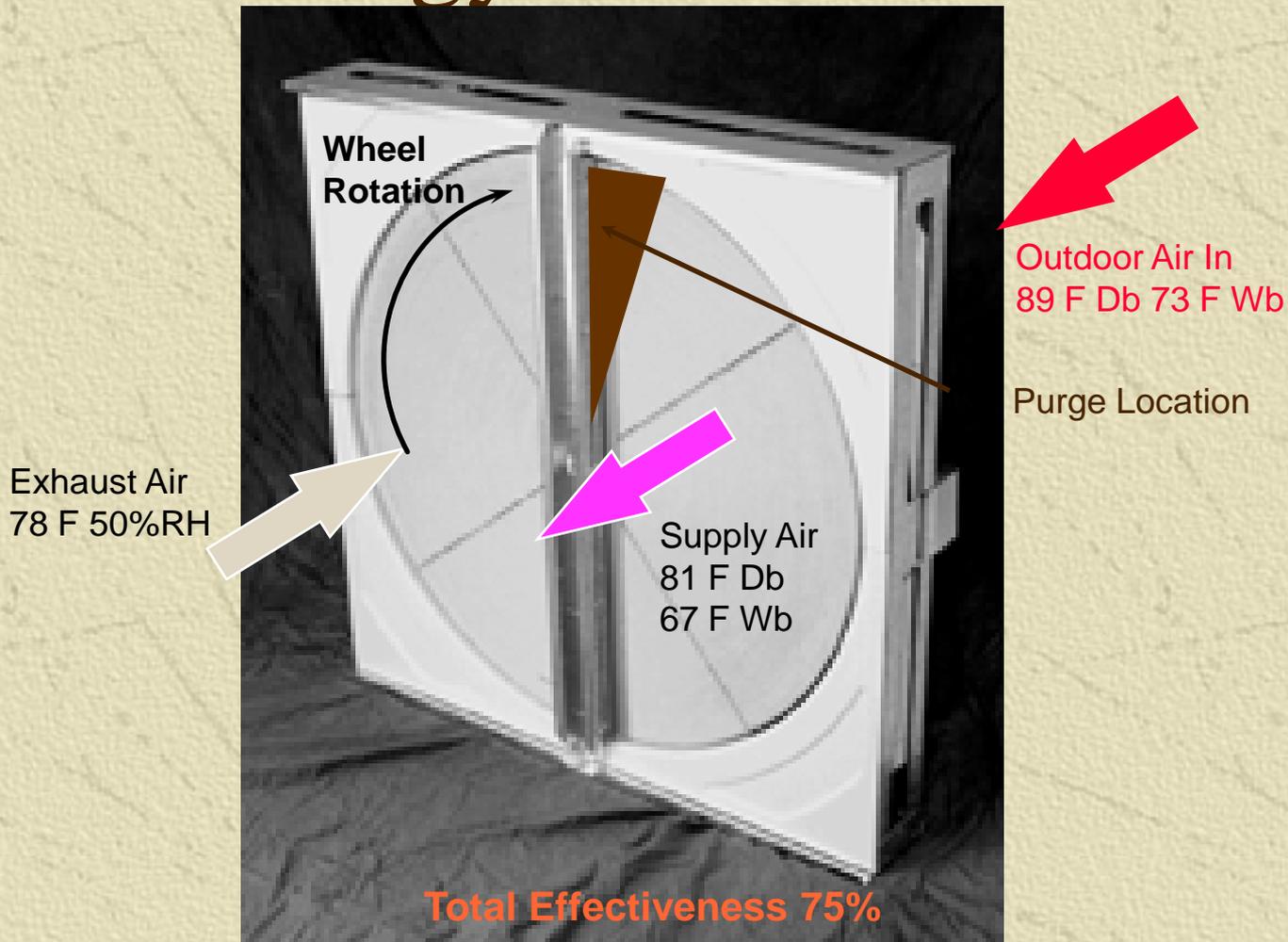
- ◆ Rotating Enthalpy wheel
- ◆ Total (sensible & latent) 65 - 80% Effectiveness
- ◆ Sensible energy transferred by mass of wheel, latent by the desiccant on the surface of the wheel
- ◆ Carry over possible with rotating wheel
- ◆ Many recent advancements with wheel technology, especially with desiccants
- ◆ Defrost required once outdoor air temp falls below -16°C (4°F) - depending on exhaust air relative humidity

ERV's Enthalpy Wheels

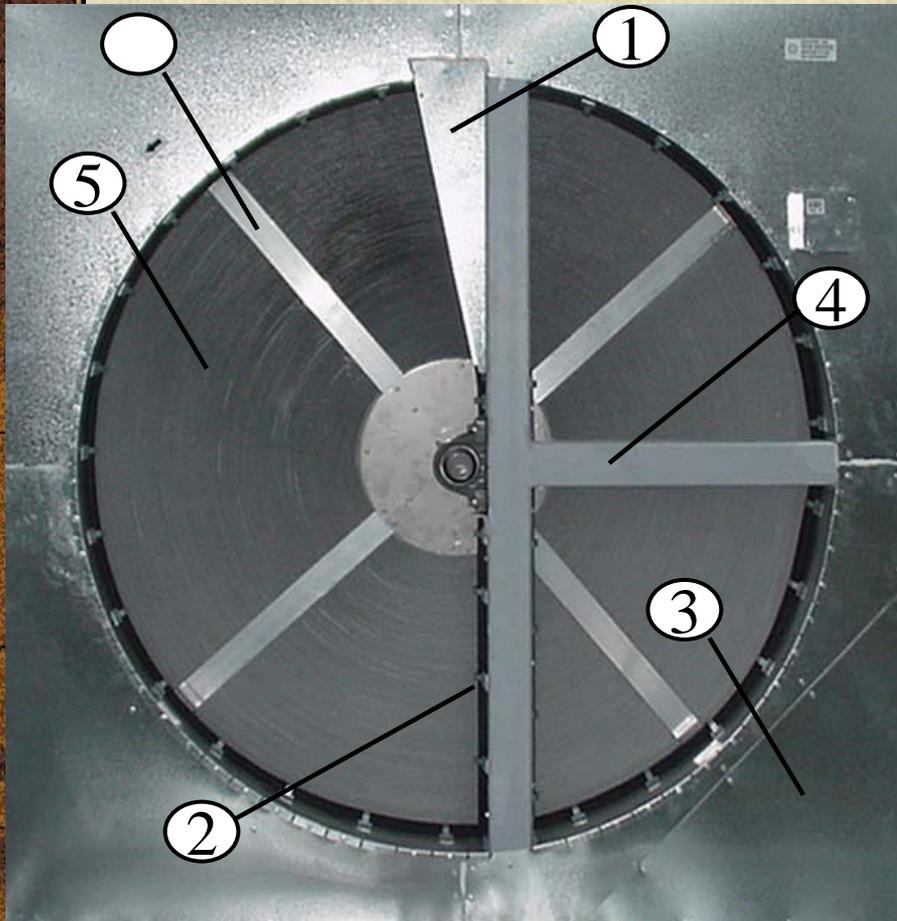
✦ Features and Benefits:

- Latent and Sensible Energy Transfer
- Silica Gel and Molecular Sieve Desiccants
- ✦ High Effectiveness from 65% to 80%
- Self Cleaning
- Purge Available to Limit Carryover
- Complies with NFPA-90 for Flame Spread

ENTHALPY WHEELS - Total Energy Transfer



ENTHALPY WHEEL - PURGE SECTION



- Purge section can limit the cross contamination to less than .04% under appropriate design conditions

- Purge section is field adjustable from 3 to 15 degrees

- Allows Enthalpy wheel's to be used in applications where very low cross contamination is required

1. Standard purge

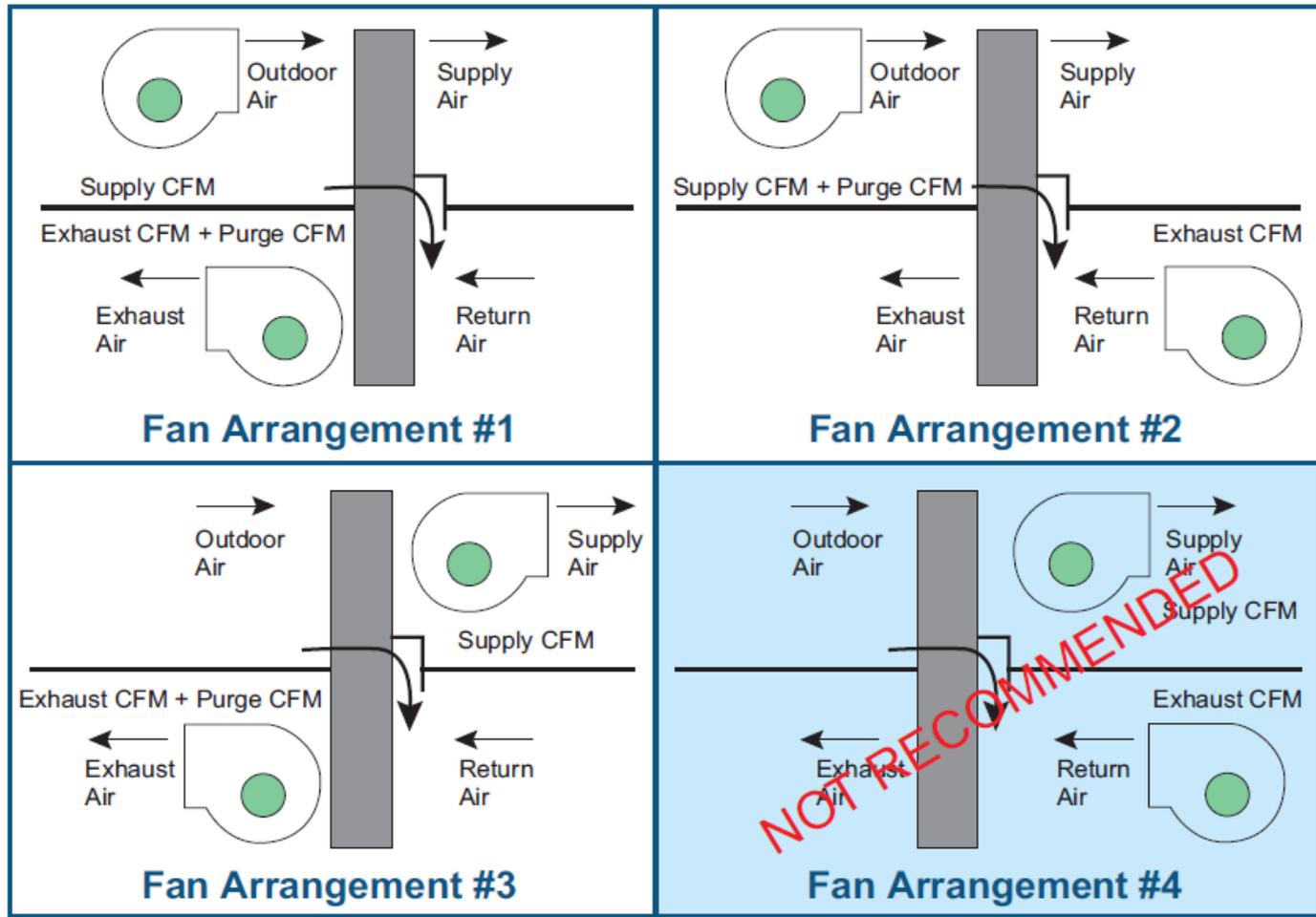
2. Labyrinth Seals

3. Drive access

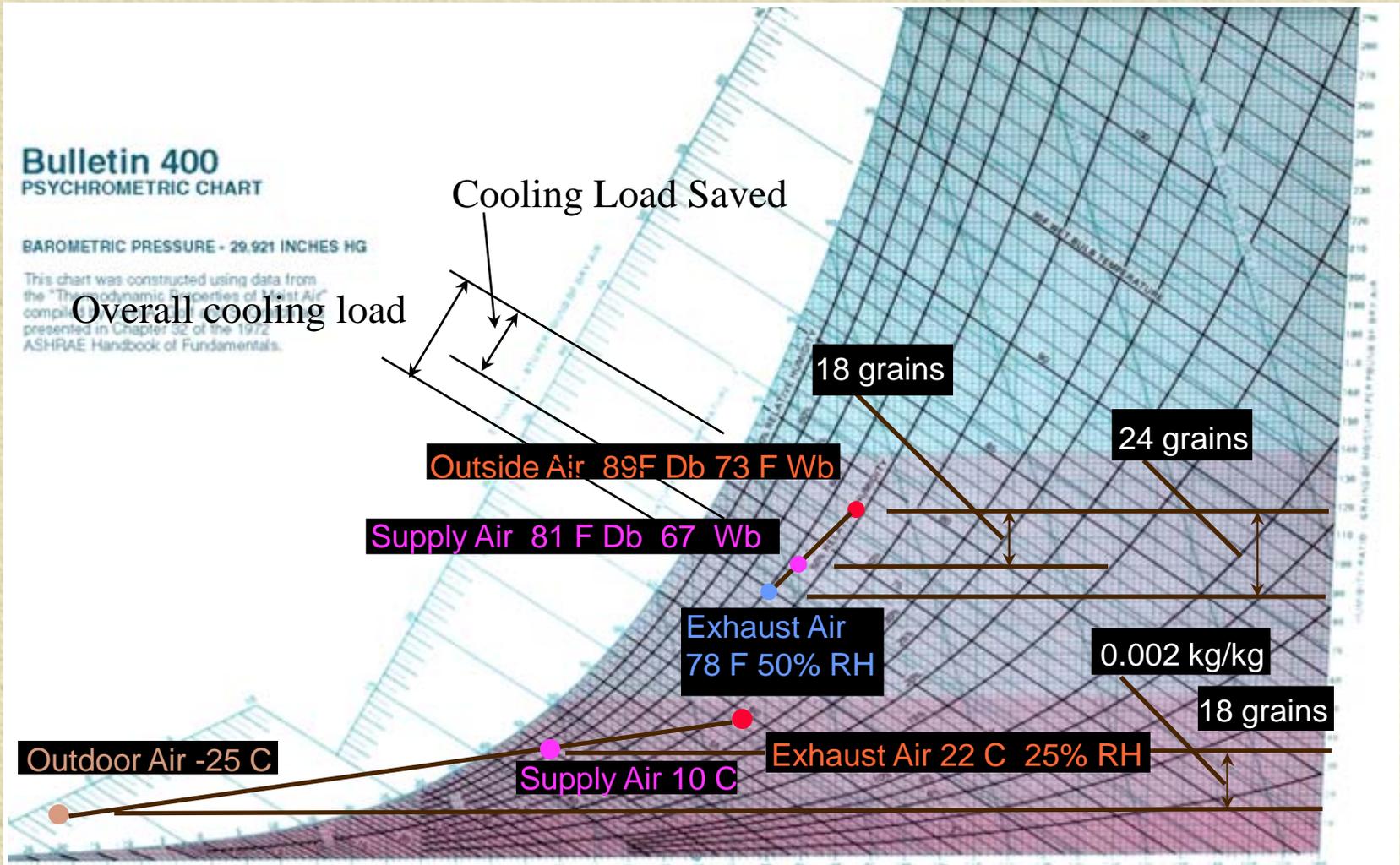
4. Structural frame work

5. Segmented Wheel

MINIMIZE CROSS CONTAMINATION



Psychrometrics for Enthalpy Wheel



120" Heat Wheel



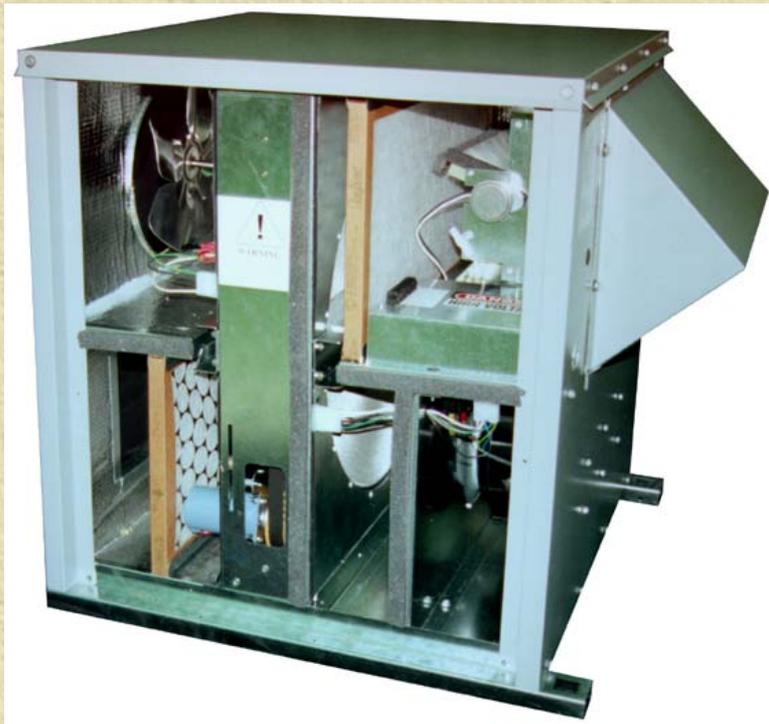
Controlling Humidity

- ◆ The best way to control humidity is to get air down to saturation and have some type of reheat (Neutral Air)
- ◆ The next best way is to pre-condition the air and have some other component do the cooling and heating.

Conventional Equipment

- ◆ Typical packaged DX equipment has to be up sized for maximum outside air load.
- ◆ This works when temperature and humidity are at the peak, but causes problems when at normal conditions.
- ◆ Poor humidity control and maintenance problems caused by short cycling at nominal conditions.

Pre Conditioner PRODUCTS

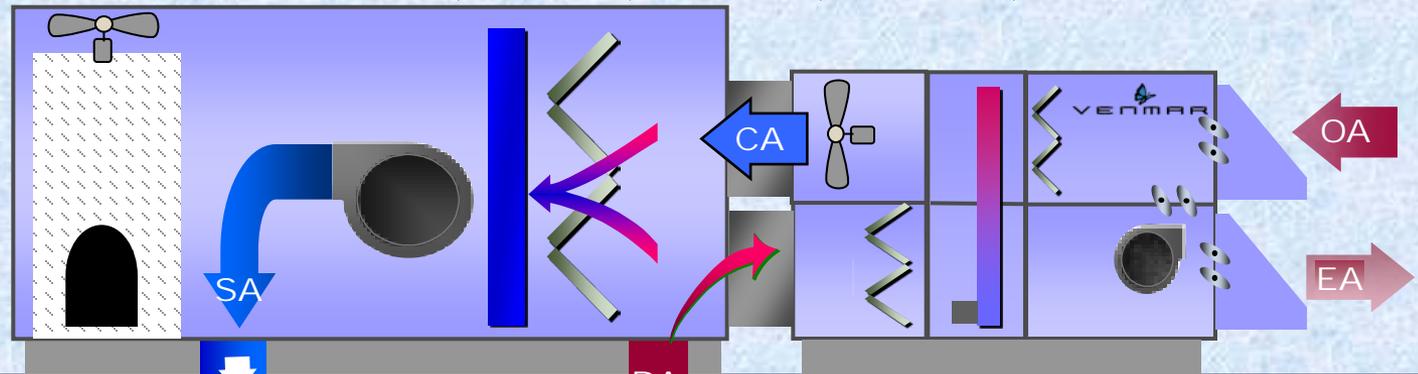


- ◆ **Energy recovery wheel with up to 75% effectiveness**
- ◆ **Easy to install. No additional roof penetrations required.**
- ◆ **Axial supply fan & backward incline exhaust fan.**
- ◆ **Aluminum wheel with Total enthalpy wheel**
- ◆ **Defrost available.**

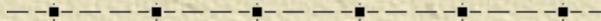
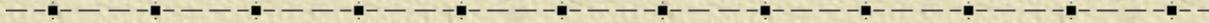
TYPICAL INSTALLATION



Rooftop Mixed-Air Outdoor Air System w/Pre-Conditioner 350, 750, 1100, 1500, 3000



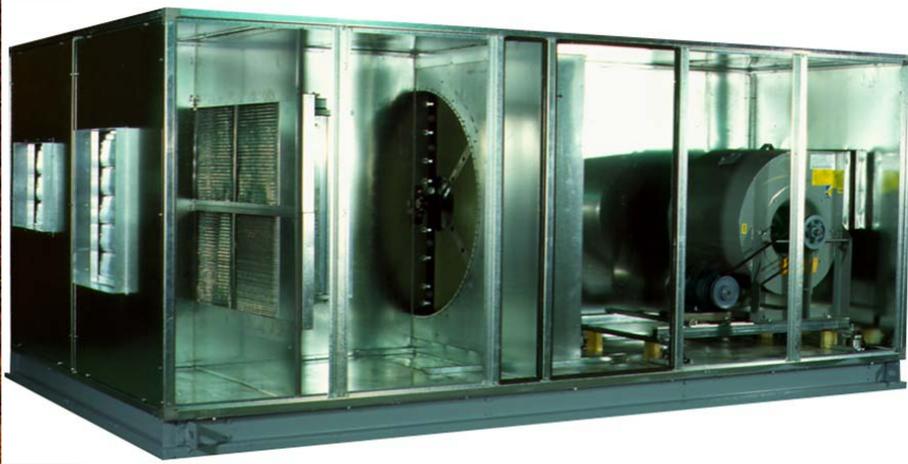
Roof Mounted Energy Recovery Units Used With Heat Pumps



Integrated Systems

- ◆ **Integrated energy recovery system with cooling coils and/or heating coils, gas burners, or electric heat, RA with integrated condensing for single piece equipment that will do the Heating, Ventilation, and Air Conditioning for desired leaving air temperature.**
- ✦ **Integrated Air cooled offering up to 130 tons**
- ✦ **Integrated WSHP offering up to 60 tons**
- ✦ **Up to 40:1 high turndown gas heat**
- ✦ **Specified performance**

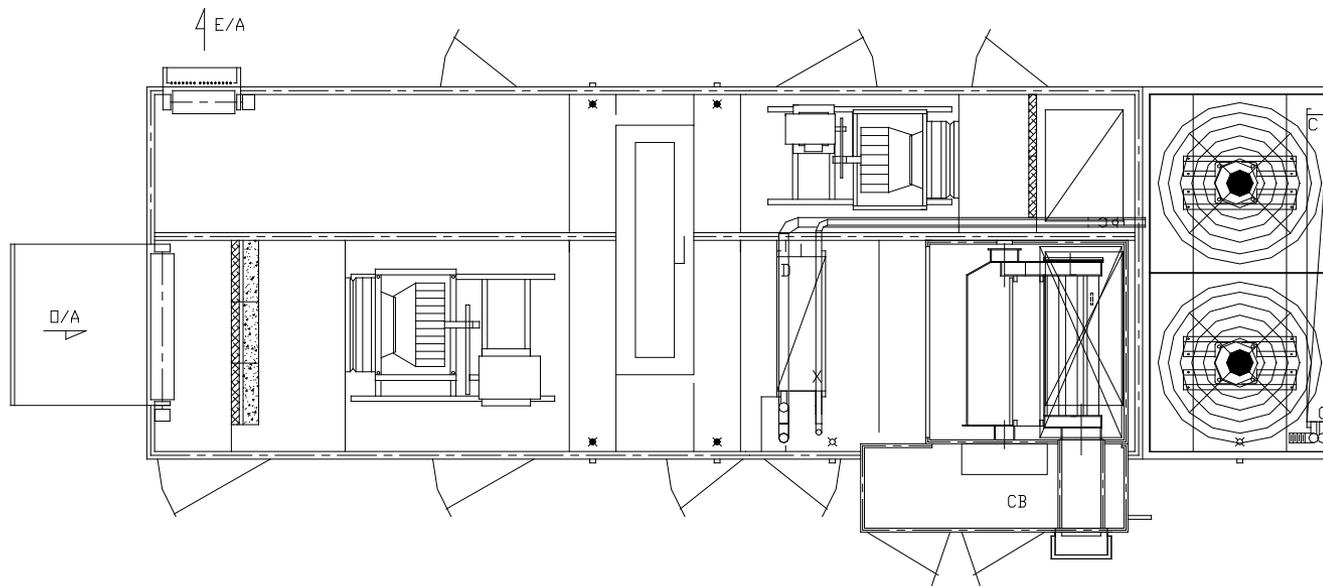
ENERGYPACK Product



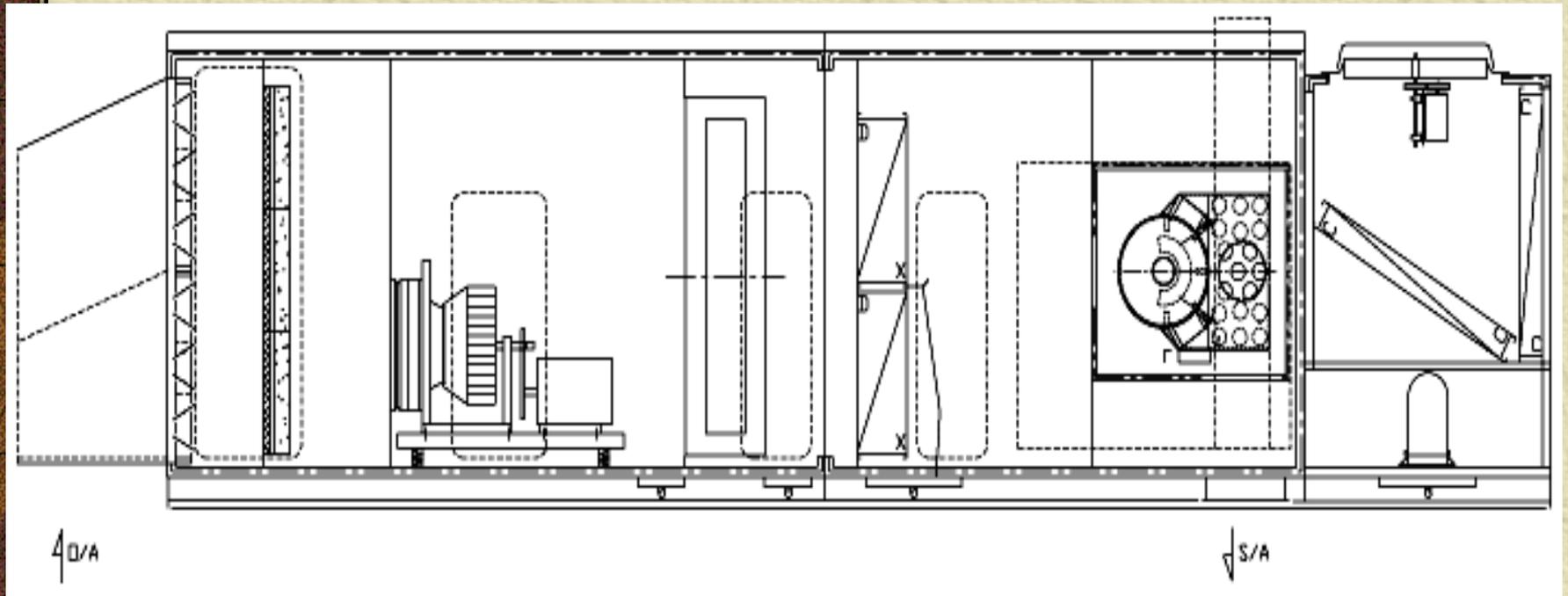
- ◆ Energy Recovery wheel, Plate and Heat pipes
- ◆ Airflow range of 1500-40,000 cfm
- Cabinet Size flexibility
- ◆ Fan and Blower flexibility

- ◆ Hot water and steam heating coils
- ◆ DX cooling coils
 - ◆ 1. remote condenser
 - ◆ 2. integrated condenser
- ◆ Chilled water coils
- ◆ WSHP
- ◆ Gas fired heating (high turndown up to 40 :1)
- ◆ Enthalpy Controllers
- ◆ Filter options
- ◆ Dampers/hoods
- ◆ Defrost strategies
- ◆ Full DDC Controls.

Integrated System



Integrated System

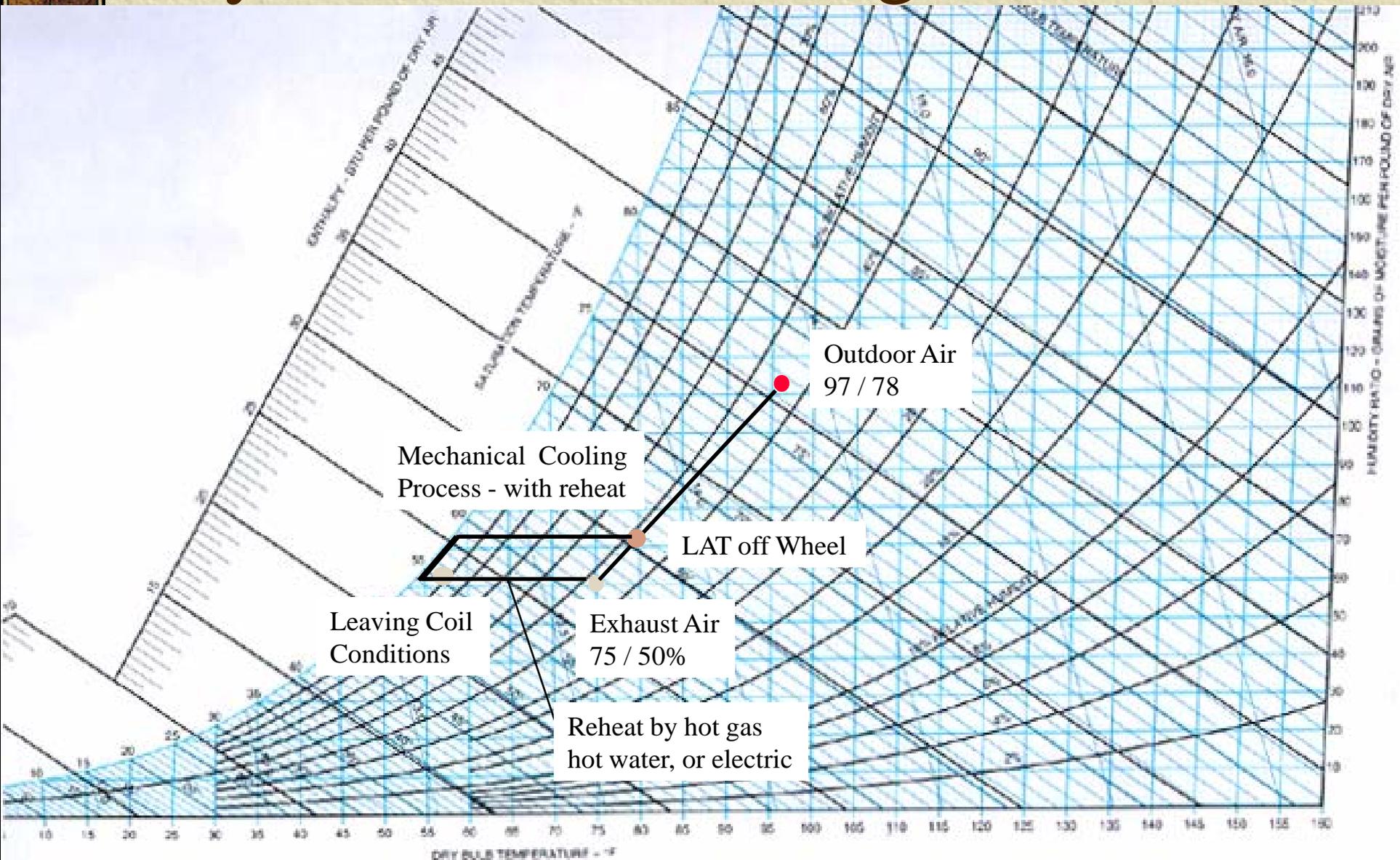


Integrated System

- ◆ **Performance similar to coupled**
- ◆ **Psychrometrics similar as coupled system**
- ◆ **Benefits of an integrated system:**
 - ◆ **No need for split system equipment**
 - additions one system does all**



Psychrometrics - Integrated



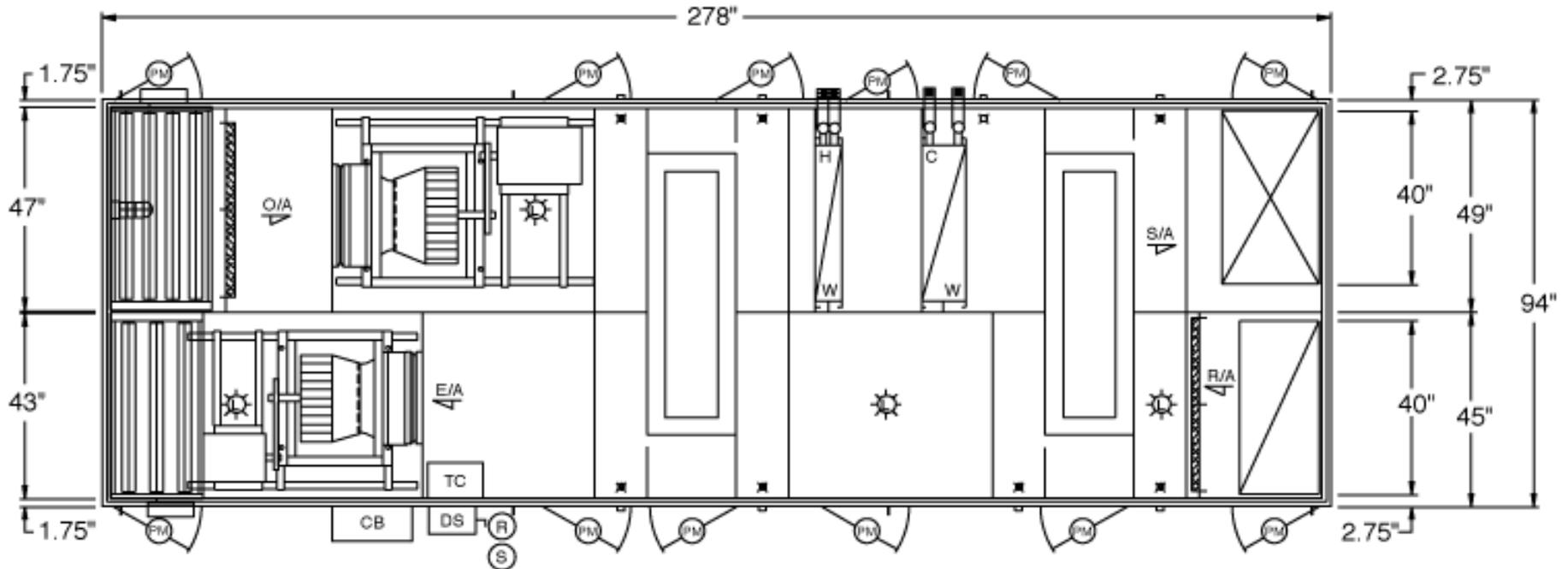
DOAS

Dedicated Outside Air Systems

- ◆ Used to provide neutral air to the building
- ◆ Provide temperature, humidity and airflow sensing capabilities tied into the DDC for monitoring and control
- ◆ Allows the room space to only have to do the sensible heating and cooling

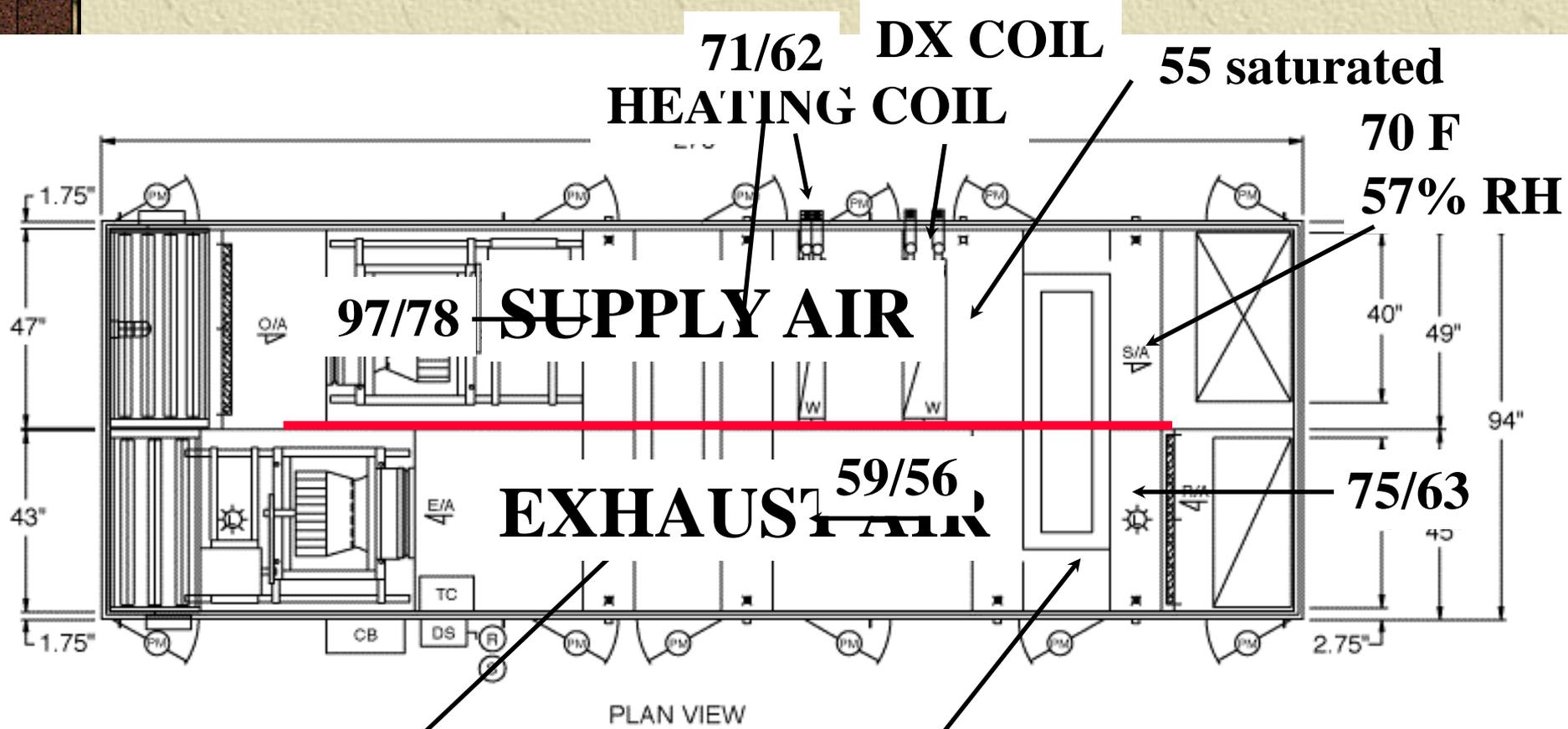
Dual/Combination Heat Exchangers

ENERGY RECOVERY VENTILATOR ROOFPACK E (MODEL 9322)



PLAN VIEW

Dual Wheel System

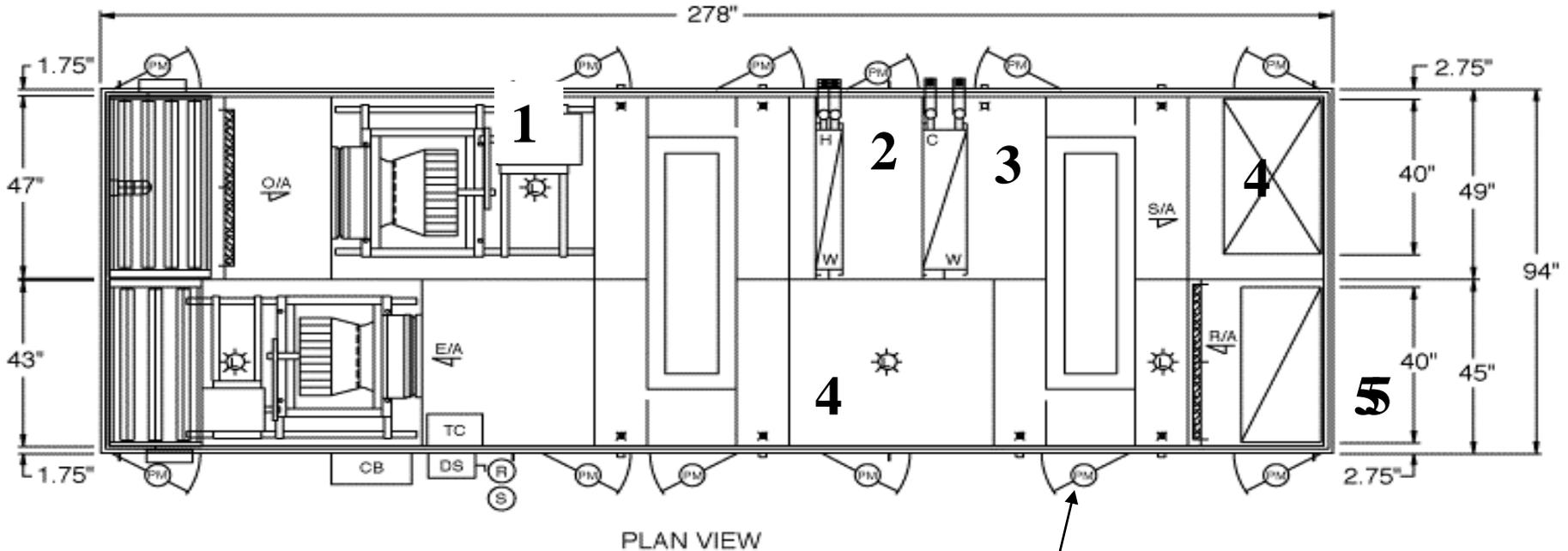


Total Energy Wheel

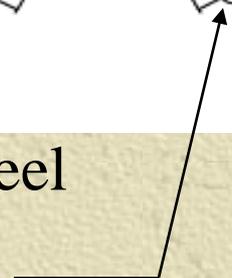
Sensible Wheel

CustomPack dual heat exchangers

ENERGY RECOVERY VENTILATOR ROOFPACK E (MODEL 9322)

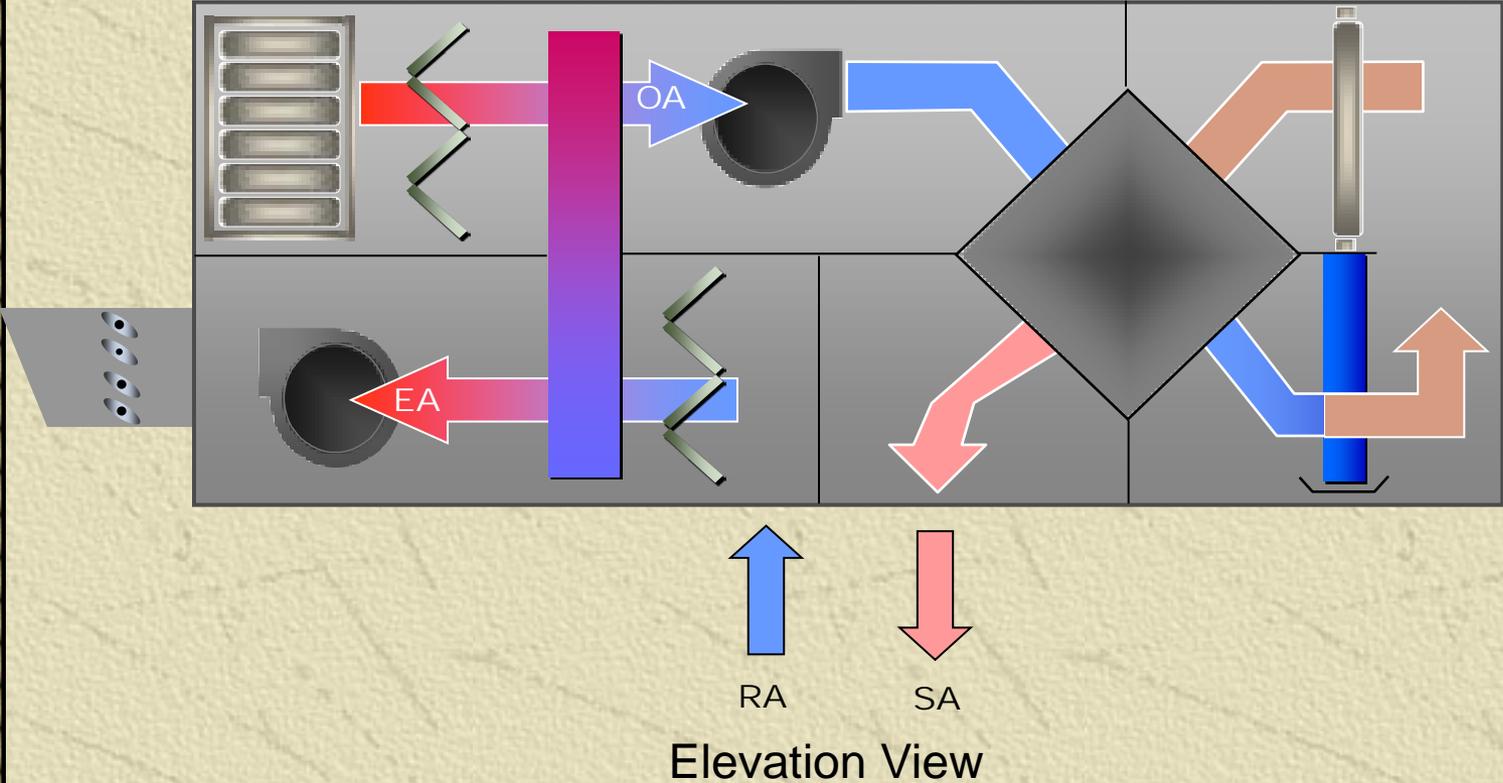


Total energy wheel + sensible wheel
 Total energy wheel + heat pipe



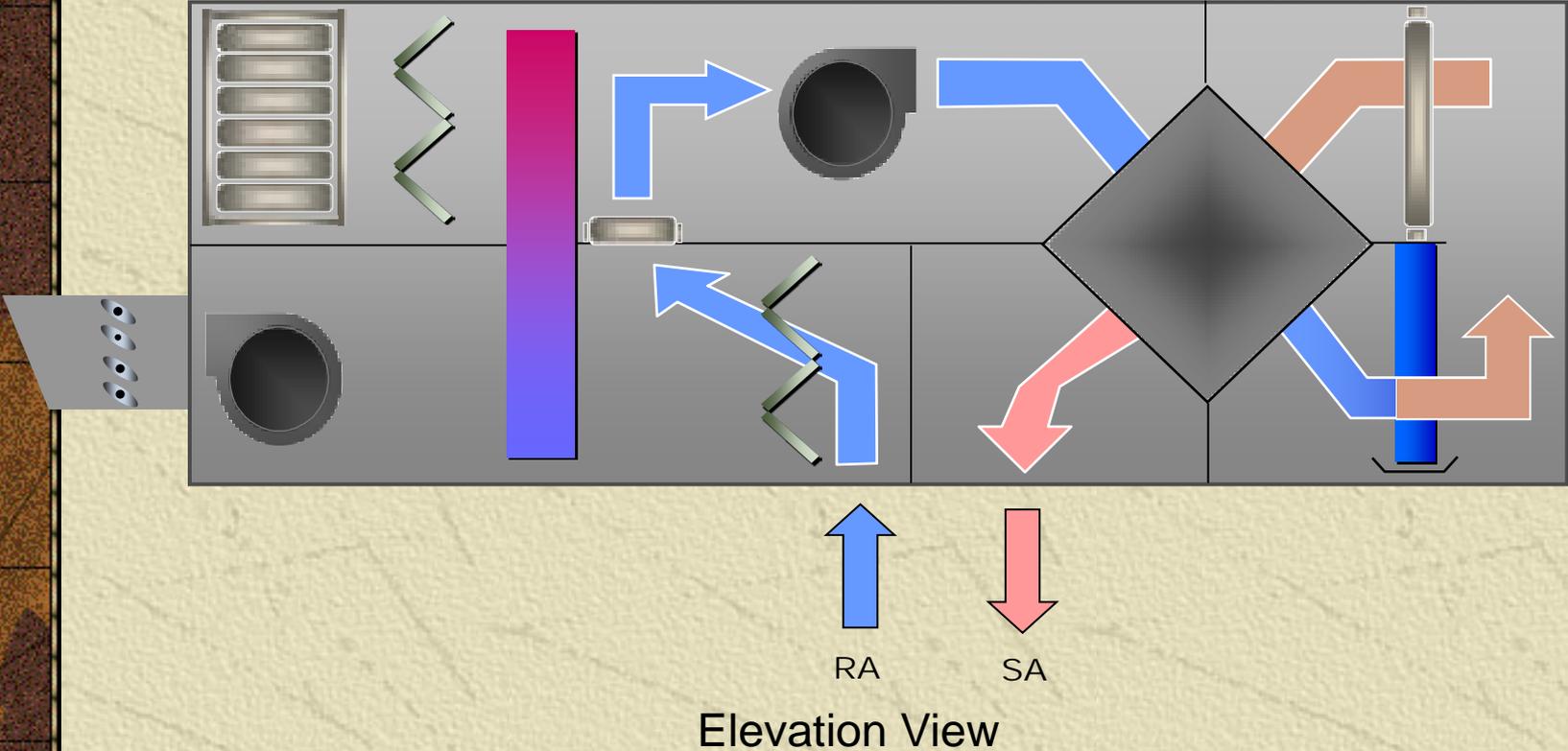
Dual Heat Exchangers

Wheel + Alpha Plate



Dual Heat Exchangers

Wheel + Alpha Plate (with recirculation damper)



Applying - HRV & ERV

✦ PLATE & HEATPIPES

- ◆ In applications where removal or moisture is required
- ◆ lowest first cost compared to ERV (plate heat exchanger)
- ◆ if source ventilator - requires very low levels of cross leakage
- ◆ for very cold climates (design temperatures below -30C (-23F))
- ◆ for high temperature applications up to 450 F (heat pipe)

✦ ENTHALPY WHEELS

- ◆ in applications where maintaining indoor RH levels is very important
- ◆ locations where hot & humid summer design conditions exist
- ◆ in climates where free cooling seasons are long
- ◆ applications that require humidification in the winter
- ◆ if source ventilator - requires very low levels of cross leakage it can be accomplished by using the purge section