Innovations in Action

ADVANCED COOLING TECHNOLOGIES, INC.

ENERGY RECOVERY SYSTEMS

ACT-HP-WAHX WRAP-AROUND HEAT PIPE HEAT EXCHANGERS

Highly Recommended for Dedicated Outside Air System Installations

Limited Lifetime Warranty

Start Saving Energy Today:

- Quick return on investment (under 2 years) from energy savings
- Enhanced dehumidification by pre-cooling incoming airstreams
- Totally passive, no moving parts or system maintenance
- Installing an ACT-HP-WAHX may result in the choice of a smaller AHU
- Eliminates typical overcooling to dehumidify, plus free passive reheating of the buildings entering airstream

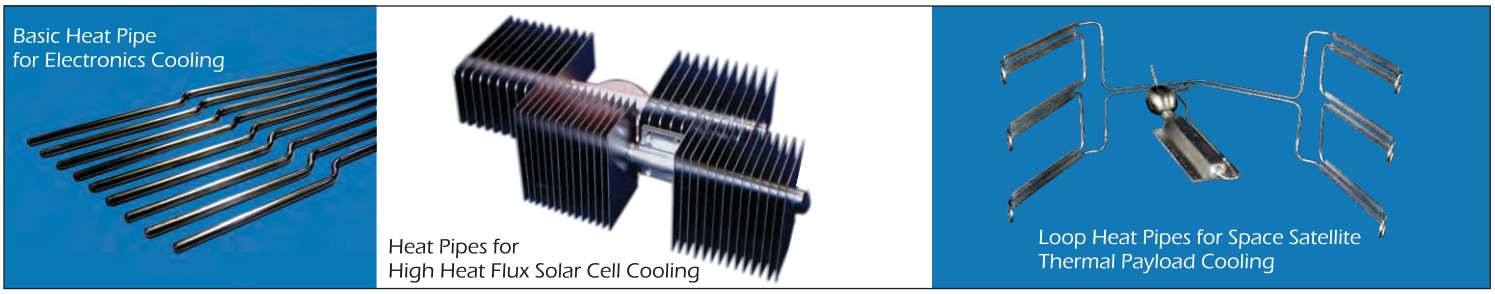
US DEPARTMENT OF ENERGY CITES HEAT PIPES AS..."UNDER UTILIZED" AND A VIABLE ENERGY SAVING TECHNOLOGY FOR HVAC SYSTEMS.

Application & Specification Guide

ACT Energy Recovery Systems

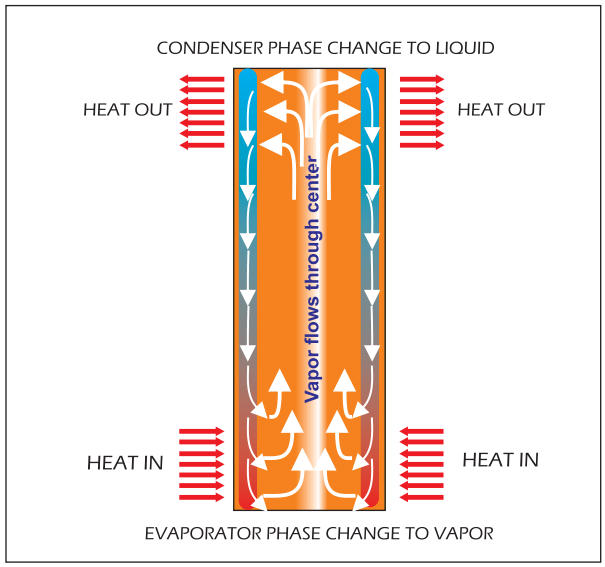
ACT's Heat Pipe Core Thermal Competence

Thermal Expertise From Electronics to Space Flight



Heat pipes are a proven heat transfer technology with highly dependable operational performance in diverse applications including HVAC, industrial electronics, military and aerospace. ACT has over 200 years of accumulated engineering experience in the design, testing and manufacturing of heat pipes.

ACT-HP-WAHX Wrap-Around Heat Pipe Heat Exchangers Utilize High Performance Heat Pipes Thousand Times Better Conductor Than Copper



Heat Pipe Operating Principle:

Heat pipes function by absorbing heat at the evaporator end of the cylinder, boiling and converting the fluid to vapor. The vapor travels to the condenser end, rejects the heat, and condenses to liquid. The condensed liquid flows back to the evaporator, aided by gravity.

This phase change cycle continues as long as there is heat (warm outside air) at the evaporator end of the heat pipe. This process occurs passively (no external electrical energy required).

ACT-HP-WAHX Wrap-Around Heat Pipe Heat Exchanger Installation

The ACT Wrap-Around Heat Pipe Heat Exchanger system has three basic components: a pre-cool coil, a re-heat coil, and heat pipes connecting the coils. The two heat pipe coils are designed to be installed around the existing cooling coil (chilled water or DX). The Wrap-Around system, in most cases, does not require duct rerouting. Larger systems may require on site installation by an ACT factory technician. Typical retrofits utilize existing space and offer immediate savings by pre-cooling the incoming airstream and transferring the heat to re-heat the outlet airstream to the building.

In addition to passive pre-cooling and re-heating there may be some design days that require an active control system to limit the amount of re-heat supplied by the heat pipe heat exchanger system. This is accomplished with solenoid valves that when closed can stop the fluid circulation between the pre-cool and re-heat coils. These active systems are typically controlled by the AHU's local controller or the building's automation and control system.

Optimize Your Energy Efficiency With ACT Heat Pipe Heat Exchangers

HP-WAHXs are used to change the performance of the active cooling coil (chilled water or DX). In air conditioning and dehumidification applications, especially where the amount of outside air is relatively high (20% or more) for ventilation and indoor air quality purposes, the cooling coil must lower the temperature of the air and also condense out excess moisture. Reducing the temperature of the air is called sensible cooling and condensing moisture is called latent cooling.

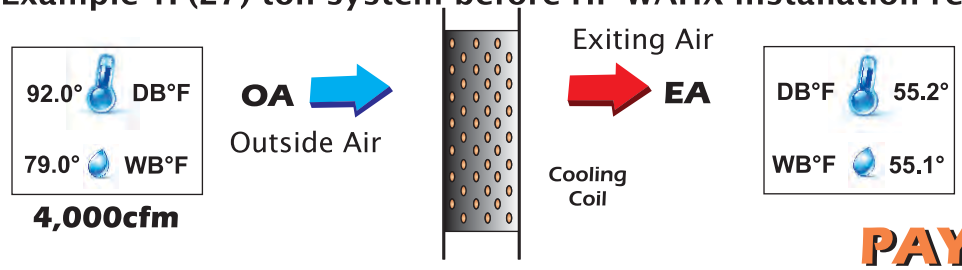
As air passes through the cooling coil, the temperature reduces to the dew point (sensible only cooling). Once the dew point is met, moisture begins to condense and the temperature continues to reduce (latent and sensible cooling). In a HP-WAHX installation, the cold air coming off of the cooling coil reduces the temperature of the heat pipes. The cooler heat pipes absorb heat from the incoming warm air stream pre-cooling it prior to reaching the cooling coil. The sensible cooling performed by the HP-WAHX reduces the initial sensible cooling load on the cooling coil allowing it to more quickly reach the dew point. The cooling coil can now use more of its capacity to remove latent heat (moisture) and achieve a lower discharge temperature. Essentially, the HP-WAHX is changing the sensible heat ratio of the cooling coil to enhance latent heat or moisture removal.

The lower temperature discharge air holds less absolute moisture (grains of water/pound of air). Therefore, when it is warmed back up to room temperature, the result will be a lower relative humidity in the conditioned space. The warm-up process is partially by the free, passive re-heat from the HP-WAHX coil. The design of the HP-WAHX can be tailored (number of rows, fin pitch, etc.) to achieve the desired amount of enhanced dehumidification.

Increased Dehumidification Performance and Enhanced AHU Porformance Example

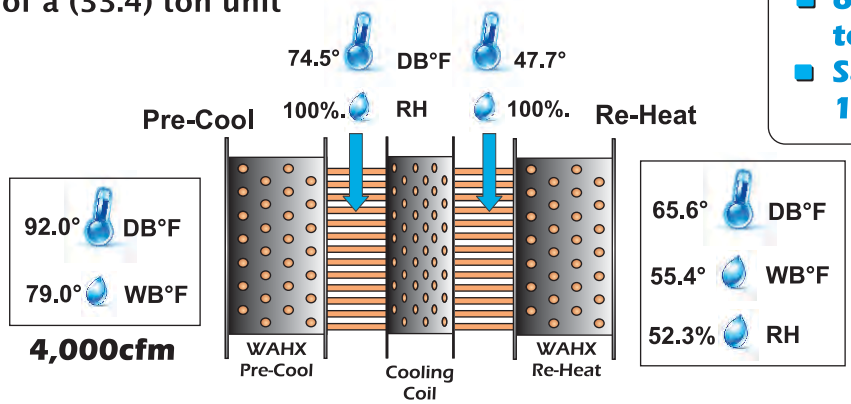
Without Heat Pipe HX

Example 1. (27) ton system before HP-WAHX installation removes 158 pounds of H_2O



With Heat Pipe HX

Example 2. Same (27) ton system after the installation of a 4-Row HP-WAHX now has the latent capacity (196 pounds H_2O) of a (33.4) ton unit



PAYBACK PERIOD IN UNDER ONE YEAR

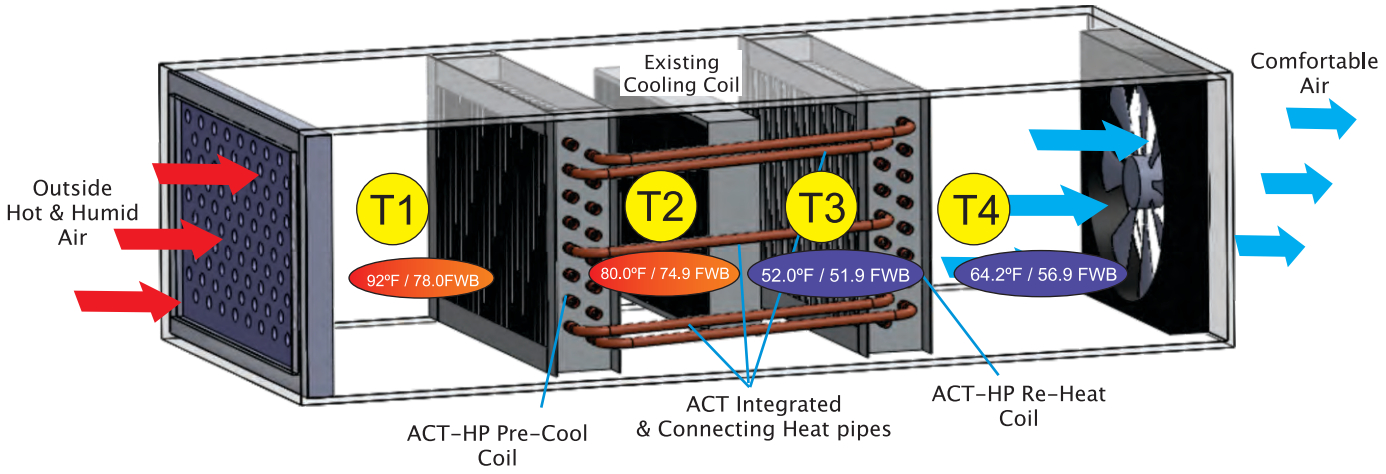
- **Increased Dehumidification by 25%**
- **6.4 Tons of Increased Latent Capacity to 196 Pounds of H_2O**
- **Saves 74,000 Btu/hr or 193,000 kWh/yr**

ACT Energy Recovery Systems

ACT-HP-WAHX Engineering Schedule Example

TYPICAL ENERGY RECOVERY MODULE SCHEDULE					
UNIT MARK	AIRFLOW CFM SUPPLY AIR CFM	SUMMER DESIGN CONDITION T1 (OUTDOOR) FDB/FWB	T2 FDB/FWB	T3 FDB/FWB	T4 FDB/FWB
DOAS	4200	92.0/78.0	80.0/74.9	52.0/51.9	64.2/56.9

Air Handler, Dedicated Outside Air System (DOAS) Air Flow Diagram (4,200 CFM)



Wrap-Around HX Temperature Transfer Effectiveness

$$\text{Effectiveness} = \frac{T4 - T3}{T1 - T3} = \frac{64.2°F - 52.0°F}{92.0°F - 52.0°F} = \frac{12.2°F}{40.0°F} = 31\%$$ (From this calculation, Δ T (°F)= 12.2°F)

Calculate Face Area & Velocity

Fin Height = 40 inches Fin Length = 40 inches

Face Area = 40"x 40"/144sq.in. = 11.1 sq.ft.

$$\text{Face Velocity} = \frac{4200 \text{ cfm}}{11.1 \text{ sqft}} = 378 \text{ fpm}$$

Select Heat Pipe Rows WAHX From (Figure 1)

Effectiveness = 31% and Face Velocity at 378 fpm
Result: 2 ROWS will meet the requirement.

WAHX Pressure Drop From (Figure 2)

Face Velocity at 378 fpm and 2 ROW WAHX

Results: Δ P = 0.10 single coil x 2 coils per WAHX system = 0.20 inH_2O for complete WAHX

Estimated Btu/hr. Savings converted to electric Utility Cost

Q = (1.085 x airflow rate (CFM)) x Δ T (°F) = Btu/hr

Q = (1.085 x 4200) x 12.2 = 55,600 Btu/hr

Convert Btu/hr to Watts = 1W = 3.412 Btu/hr

55,600/3.412 = 16,295 Watts = 16.3kW/hr x 24h/day = 391.2kWh/day x $0.15/kWh = $58.80/day

Annual Savings = $58.80 x 365 days = $21,460

ACT HP-WAHX Exchanger Performance & Solution Examples

Figure 1: Temperature Effectiveness (%) vs. Face Velocity (FPM)

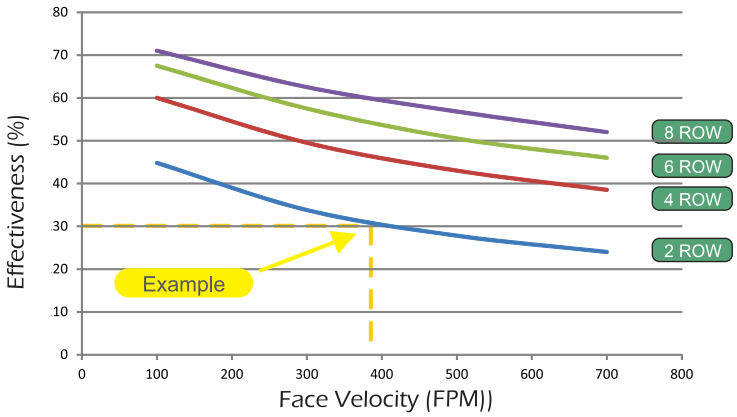
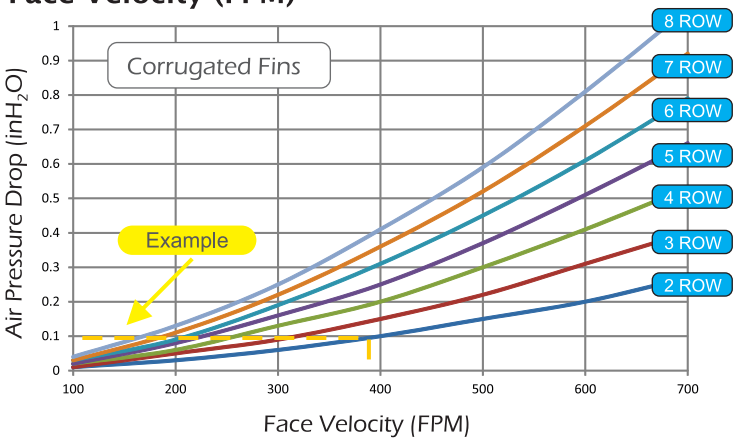
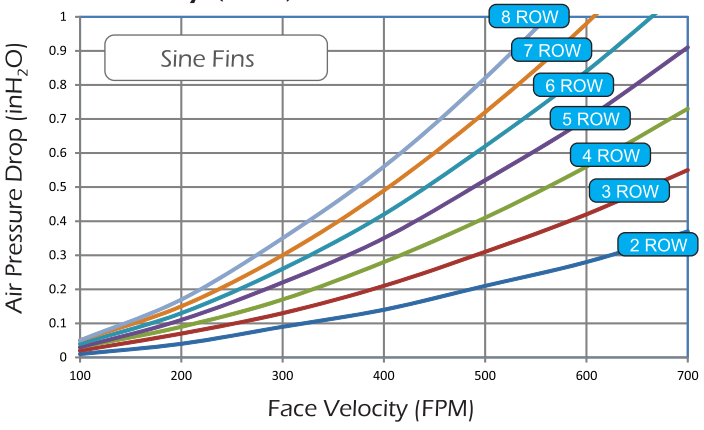


Figure 2: Air Pressure Drop vs Face Velocity (FPM)



(All examples are: 12 fins per inch, ½" heat pipes, aluminum fins .006" thickness)

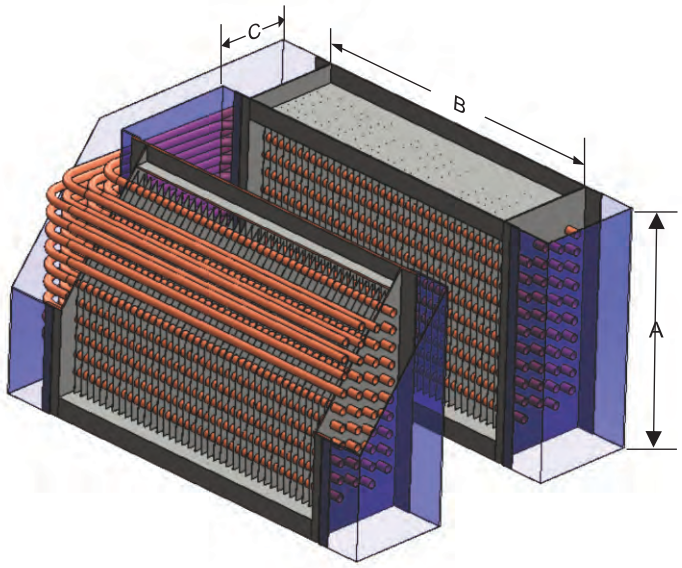
Figure 3: Air Pressure Drop vs Face Velocity (FPM)



(All examples are: 12 fins per inch, ½" heat pipes, aluminum fins .006" thickness)

Note: When performance is slightly less then required, a Sine Fin Pattern can often meet the Effectiveness requirement at a slightly higher Δ P versus adding another row of heat pipes.

Design & Construction



The ACT-HP-WAHX system features individual heat pipe circuits for a high degree of reliability. The configurations are typically called out by the number of rows. The higher the number of rows the greater the level of energy transfer.

ACT Heat Pipe Heat Exchangers are typically designed in two to eight row configurations. Each individual circuit is designed and tested to verify its engineered transport capacity. This is done through stringent testing of the individual core "U" shaped heat pipe circuit. ACT has selected (R-134a) as the working fluid due to its beneficial pressure and thermal transfer characteristics. Additionally, the proper charge of working fluid, the thermosyphon installation angle and the circuit tube diameter are all selected to create an efficient, effective thermal transfer system.

The heat pipe heat exchanger height (A) and length (B) are dictated by the installation. Widths (C) are standard depending on the number of rows.

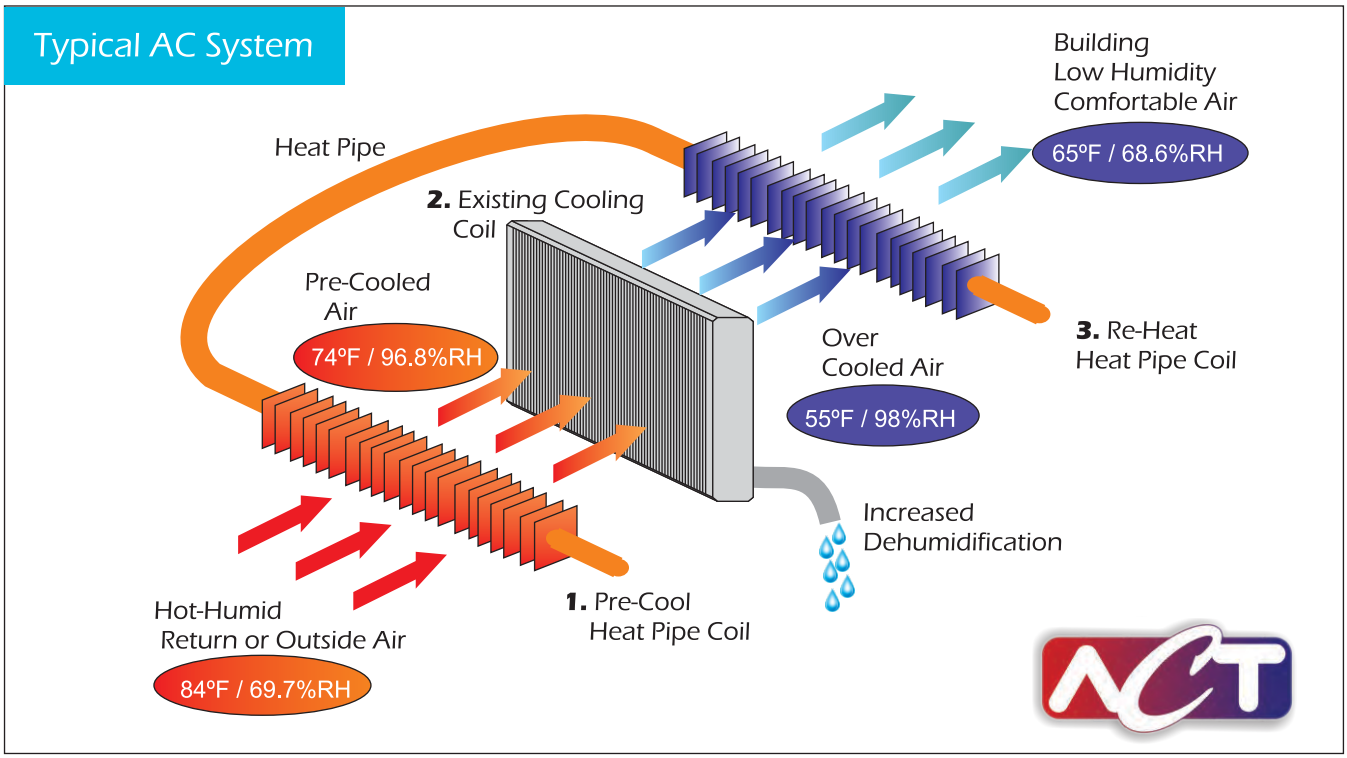
ACT-HP-WAHX Widths

2 ROW	3 ROW	4 ROW	5 ROW	6 ROW	7 ROW	8 ROW
3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.

Note: Since there is a pre-cool and re-heat coil, the required space around the cooling coil is estimated by the number of rows plus additional clearance for inspection and cleaning.

ACT Energy Recovery Systems

ACT-HP-WAHX Wrap-Around Heat Pipe System Basics



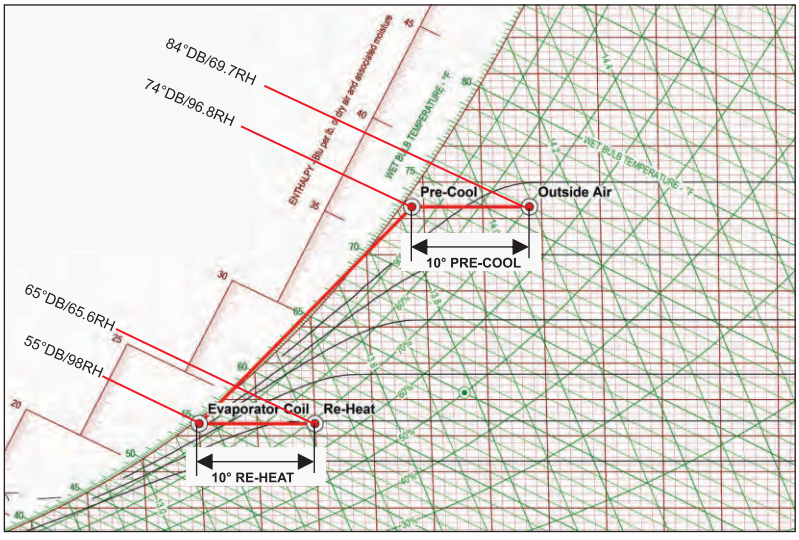
Wrap-Around System Enhanced Dehumidification Function

The ACT-HP-WAHX HVAC heat pipe system performs two major beneficial functions: Increased levels of dehumidification and reduced energy costs.

Application Example:

Step 1. Incoming return or outside 84°FDB/69.7%RH air is pre-cooled to 74°FDB/ 96.8%RH by the pre-cool heat pipe coil.

Step 2. The pre-cooled air flows through the existing AC evaporator cooling coil at 55°FDB / 98%RH . By adding a pre-cool heat pipe coil, the system now functions more efficiently and can perform higher levels of latent cooling and increased dehumidification. Often times a smaller capacity AC system can be chosen due to the increased cooling performance from the pre-cool coil.



Psychrometric chart illustrates the HVAC benefits of a ACT-HP-WA System

Step 3. The air leaving the existing AC evaporator coil is in an over cooled state and requires re-heat. Fort this example, the re-heat heat pipe coil is sized to bring the entering building air to a more comfortable range of 65°FDB / 68.6%RH. ASHRAE standards describe many instances for the requirement of humidity control . Since the building air now has low levels of humidity and more comfort, thermostat temperatures can be set higher, saving even more energy.

The addition of the ACT-HP-WAHX Wrap-Around System can effectively increase the dehumidification performance of any HVAC system. Thousands of dollars can be saved by eliminating the need for electricity or gas to reheat the over cooled air.

ACT-HP-WAHX Wrap-Around Heat Pipe Heat Exchanger Series Mechanical Specifications

The ACT Wrap-Around Heat Pipe Heat Exchanger (WAHX) shall be part number series ACT-HP-WAHX as manufactured by Advanced Cooling Technologies, Inc. The WAHX shall provide pre-cooling to the incoming return/direct outside airstreams and wrap-around the cooling coil via interconnected copper tubes to then provide reheat to the entering building air. The WAHX shall be labeled for direction of airflow, noting Pre-Cool air and Re-Heat air entering building air direction. The WAHX shall be a passive device, requiring no other means for heat transfer, and shall be capable of operating at temperatures ranging from -40°F minimum to 120°F maximum.

Wrap-Around Heat Pipe Heat Exchanger coil performance shall be rated in accordance with applicable AHRI testing procedures. Manufacturers of alternate equipment must be approved to bid via addendum, in writing by the specifying engineer, at least two weeks prior to bid time in order for their bid to be accepted by the contractor. If the equipment is not pre-approved then under no circumstances shall the contractor invest time or money in receiving submittals or considering the equipment.

Wrap-Around Heat Pipe Heat Exchanger shall be installed within 1/8 inch level both coil to coil and coil end-to-end.

Costs associated with dimensional, performance, or other deviations from the specified equipment, including engineering costs to evaluate such deviations, shall be paid by the contractor.

The manufacturer must have a quality management system in place, equal to the quality management system in accordance with ISO-9001-2008, for the design, manufacture, and service of heat exchangers. The manufacturer must also have a net worth greater than five times the value of the equipment being bid and must have been a manufacturer of heat pipes and heat pipe assemblies for at least five years prior to bid time. The Wrap-Around Heat Pipe Heat Exchanger System must be manufactured in the United States of America.

DESIGN AND CONSTRUCTION FEATURES

1. Wrap-Around Dehumidification Heat Pipe Heat Exchanger System

Heat pipes shall be 1/2-inch outer diameter, seamless, internally rifled copper tubes. The finned tube coils shall have aluminum fins, .006" minimum thickness, with enhancement (corrugated wave, sine wave, or louvered) to meet the performance and pressure drop requirements. Fin density shall be determined by the required system performance. Heat pipes shall be a maximum of 1.250 inches on center in the face and shall be 1.08 inches on center row-to-row Heat pipes shall be individually processed, individually charged, and hermetically sealed. Wrap-Around Heat Pipe Heat Exchanger System shall be installed as shown on the manufacturer's submittal drawings.

2. Protective Wrap-Around Dehumidification Heat Pipe System Enclosure and Drain Pans

The heat exchanger frame shall be fabricated from minimum 16-gauge galvanized steel. The WAHX shall be supplied with a minimum of 1.50 -inch wide flanges on all sides, both front and back. End cover plates shall be provided to protect the heat pipe ends from installation damage. End plates shall be fabricated from minimum 16-gauge galvanized steel.

Intermediate wrap-around heat pipe supports and lifting points shall be furnished as required. Drain pans are recommended under all coils and are not included with the WAHX.

3. Working Fluid

Wrap-Around Dehumidification Heat Pipe Heat Exchanger System working fluid refrigerant shall be selected on the basis of heat pipe operating temperature and compatibility with heat pipe tube material. Heat pipe heat exchanger refrigerant used shall be classed as Group 1 in the American National Standard Safety Code for Mechanical Refrigeration.

4. Active Re-Heat Circuitry

Some design days may require an active control circuit on the amount of re-heat provided by the heat pipe heat exchanger system. This is accomplished with solenoid valve circuitry which effectively stops the transfer of energy between the heat pipe coils. These active systems are typically controlled by the building automation and control system. ACT will provide individual, normally open, 12V or 24V solenoid circuit control landed to a marshaling cabinet for connection to the AHU local controller or to the building automation & control system.

5. Protective Coating (When Specified)

E-Coat to protect against corrosion. Coating to be factory applied as one unit after final fabrication.

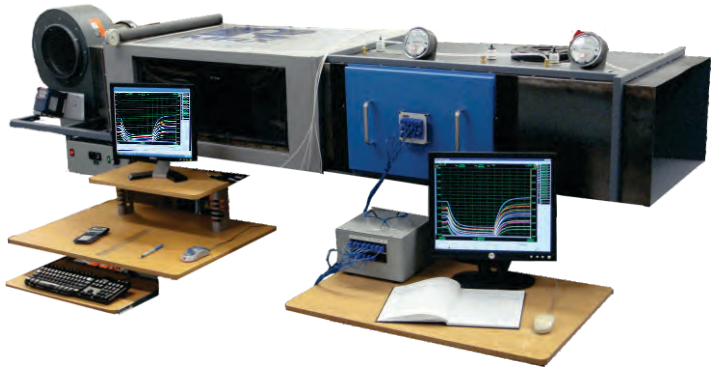
Other Energy Recovery Products:

ACT-HP-ERS/A-A Heat Pipe Air-to-Air Heat Exchanger Systems

ACT-HP-ERS/A-A is a counterflow heat exchanger-energy recovery system features ACT's high performance, high reliability heat pipes. Save energy by pre-cooling or pre-heating your incoming building supply air. ACT-HP-ERS/A-A Heat Pipe Air-to-Air Heat Exchangers can be fitted to new or existing HVAC system. Systems are sealed to prevent cross contamination of the side-by-side airstreams. Qualify for LEED and High Performance Building points with installation payback periods between 1-2 years.

Climate Test Chamber Thermal Performance Testing

ACT's Climate Test Chamber provides thermal performance testing of Wrap-Around Dehumidification and Air-to-Air Heat Pipe Heat Exchangers per AHRI specified test conditions.



General Specification:

- Heat Pipe Material:	Copper or Aluminum
- Fins	Copper or Aluminum
- Protective Coating:	Specified by application
	Heresite, E-Coat, Iridite, Tin plate
	Hot Dip Galvanized, Nickel plate
- System Working Fluid:	R-134a
- Operating Temperatures:	Specified by design

Heat Pipe Systems Provide Benefits to help meet or Achieve:

- ASHRAE Standard 621 Ventilation for Acceptable Indoor air Quality
- ASHRAE Standard 901 Energy Standard for Buildings Except Low Rise Residential Buildings
- ASHRAE 1891 Standard for the Design of High-Performance green Buildings
- Energy Policy Act 2005: Green Building Performance
- LEED Points possible for; Energy and Atmosphere, Indoor Environmental Air Quality, Innovation in design
- ISO 5000: Energy Management Standard: public and private sector organizations with management strategies to increase energy efficiency, reduce costs and improve energy performance.

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