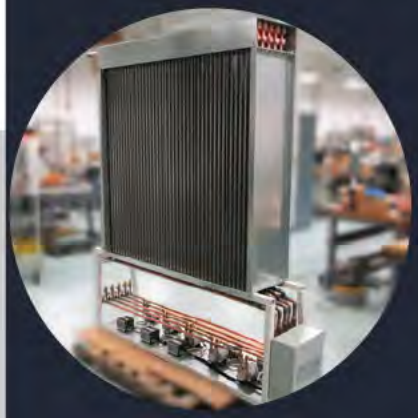
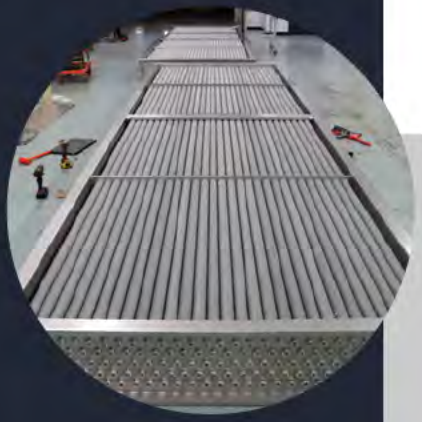
ENERGY RECOVERY SOLUTIONS





HEAT PIPE HEAT EXCHANGERS

NEW CONSTRUCTION | RETROFIT | FACTORY INSTALL

TYPICAL PAYBACK 2 YEARS

HVAC PRODUCT & DESIGN GUIDE

THERMAL MANAGEMENT EXPERTS

ADVANCED COOLING TECHNOLOGIES, INC. IS A PREMIER THERMAL MANAGEMENT SOLUTIONS COMPANY.

We serve our customers' thermal management and energy recovery needs in diverse Markets including Defense, Aerospace, Electronics, HVAC, Medical, Enclosure Cooling and Calibration Equipment. We specialize in providing performance and cost optimized thermal management technologies and solutions that meet the unique needs of each customer.

Our HVAC Wrap-Around and Air-to-Air Heat Pipe Heat Exchanger products are in operation throughout the world, improving the energy efficiency of building HVAC systems and industrial processes.

ACT is strongly committed to our customers, employees, and community. Innovation, Teamwork and Customer Care are the core values that drive the continuous growth of our company.

ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

®Conforms to UL STD 207

SA44069

TABLE OF CONTENTS

ACT'S ENERGY RECOVERY SOLUTIONS OFFER

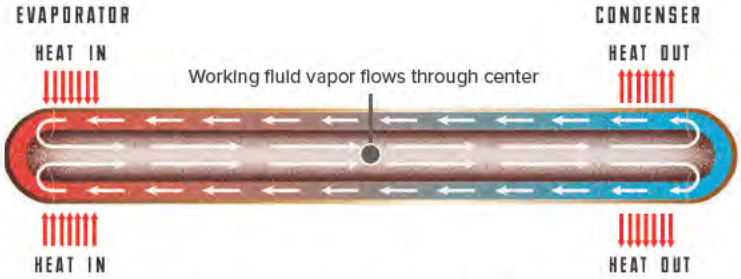
ZERO CROSS-AIR CONTAMINATION

> **Great customer service support from top down, from inside applications engineer to regional sales manager, and great product offerings.**
>
> *- Norman S. Wright, Hawaii*

ACT ENERGY RECOVERY TYPES

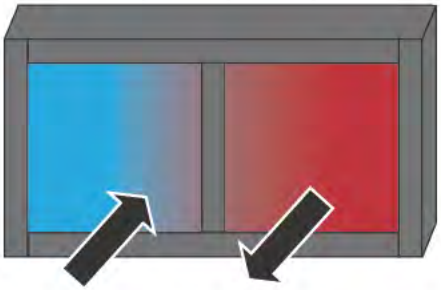
HVAC HEAT PIPE OPERATING PRINCIPLE

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. During installation, the evaporator must always be lower than the condenser.



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

ACT ENERGY RECOVERY TYPES



AIR-TO-AIR HEAT PIPE HEAT EXCHANGER
(HP-AAHX)

WRAP-AROUND HEAT PIPE HEAT EXCHANGER
(HP-WAHX)

APPLICATION SPOTLIGHT

PUMP-ASSISTED SPLIT LOOP THERMOSYPHON AAHX

- Compatible with large systems or long distance
- Energy efficient
- Optional temperature control (without the need for bypass dampers)
- Compact packaging
- Design flexibility
- High reliability, low maintenance needs

AHR EXPO
INNOVATION AWARDS
2021
WINNER

AIR-TO-AIR HEAT PIPE HEAT EXCHANGERS (HP-AAHX)

IDEAL APPLICATIONS

Where there is a ducted exhaust stream, especially when no cross-air contamination is required.

Hospitals & Healthcare Facilities
Universities
Condos/Hotels
Government Facilities Labs
Theaters
Fitness Centers
Food & Restaurant Facilities

BENEFITS

- **Energy Savings:** Payback periods generally 18-24 months
- **No Cross Contamination of airstreams**
- **Passive System Options**
  - No maintenance
  - No moving parts
- **Configuration**
  - Any height or length (not round)
  - Splittable
  - Exhaust and supply can be different lengths and CFMs
  - Only 2" to 15" in depth, requiring minimal AHU space

UP TO
40%
ENERGY SAVINGS

FEATURES

- 1/2" rifled copper tubes for enhanced thermal performance
- Aluminum fins (8-14 Fpi)
- Galvanized steel casing
- Factory installation, field installation or AHU manufacturer installation
- R-134a or R410A refrigerants
- Up to 10 Rows

OPTIONS

- Up to 1" diameter coil tubes (copper or aluminum)
- Stainless steal casing
- Multiple fin types & materials
- Controllable
- Corrosion coating (E-Coat or Heresite)
- Tilt option for summer/winter energy capture
- Pumped systems for vertical installation

AIR-TO-AIR HEAT PIPE HEAT EXCHANGERS (HP-AAHX)

HOW DOES PASSIVE AAHX ENERGY RECOVERY WORK?

AAHX is a heat exchanger that uses a series of heat pipes to transfer energy between the outgoing exhaust air stream and the incoming air stream. The cool (summer) or warm (winter) air leaving the building is used to pre-cool or pre-heat the incoming outside air.

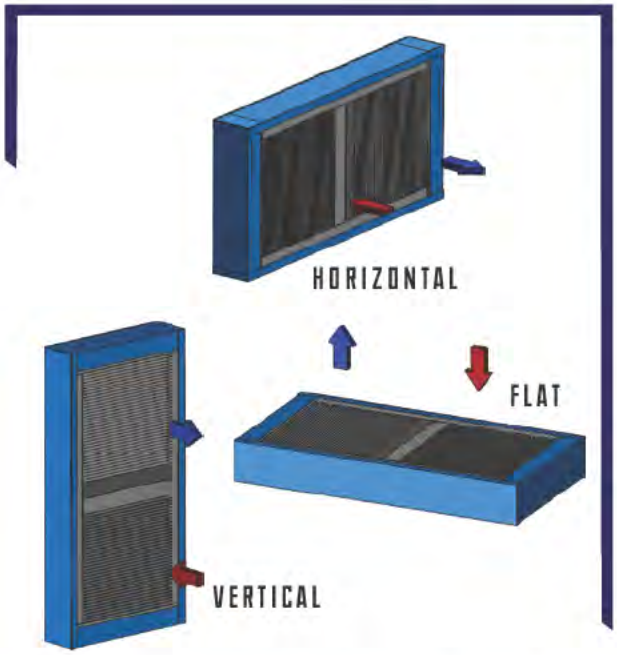
HP-AAHX SELECTION TOOL

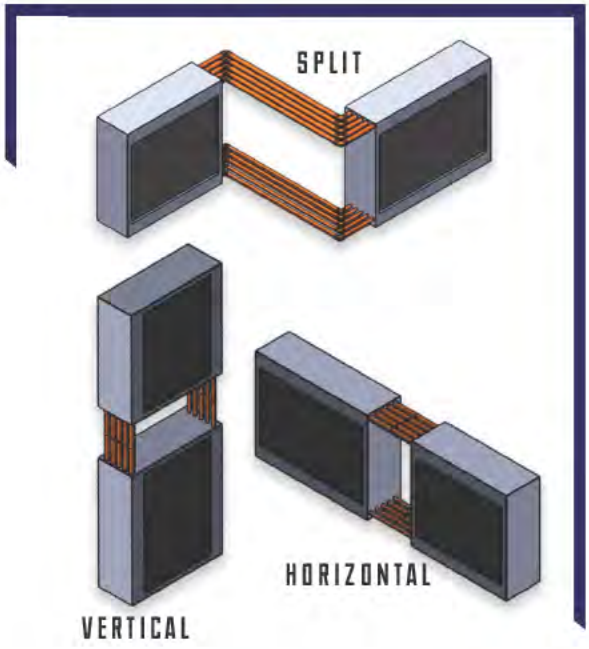
EXAMPLE OF POTENTIAL ENERGY SAVINGS

- Pre-cool and pre-heat with up to 75% effectiveness
- During summer operation with 75° exhaust air, the HP-AAHX can pre-cool entering 95° outside air down to 80°, saving on cooling tonnage load capacity
- During winter operation with 70° exhaust air, the HP-AAHX can pre-heat entering 0° outside air up to 52°, saving on heating costs

HP-AAHX CONFIGURATIONS

HP-AAHX can be oriented to match the AHU or duct work aspect ratio.





PIPE TO PIPE CONNECTION: EVERY ROW EVERY PIPE

- Any Coil Dimensions
- Stackable
- Controllable

SPLIT LOOP THERMOSYPHON: 2 PIPES PER ROW

- Any Length Coil
- Max 36" Fin Height
- Stackable
- Controllable

PUMP-ASSISTED SPLIT LOOP THERMOSYPHON HPHX

The Pump-Assisted Split Loop Thermosyphon (SLT) Heat Exchanger offers the highest levels of energy recovery and cost savings year-round for split airstreams, enabling installation into applications without side-by-side ducting. The pump-assisted, split loop design provides unprecedented installation flexibility. Estimations show possible annual operational savings in the $100's of thousands while keeping incoming air clean!

PUMP-ASSISTED SPLIT LOOP THERMOSYPHON AAHX

- Compatible with large systems or long distances
- Energy efficient
- Optional temperature control (without the need for bypass dampers)
- Compact packaging
- Design flexibility
- High reliability, low maintenance needs
- Controllable performance

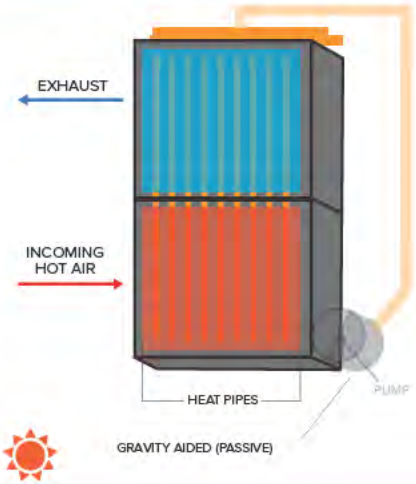
AHR EXPO INNOVATION AWARDS 2021 WINNER

If a completely passive solution is not possible for all-season recovery, then this solution offers the next best thing!

PUMP-ASSISTED SPLIT LOOP

ENERGY RECOVERY HEAT EXCHANGER

SUMMER SEASON
PASSIVE HEAT PIPE OPERATION

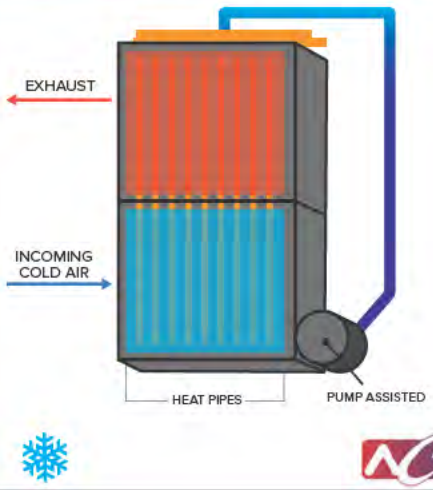


ENERGY RECOVERY

NO CROSS-AIR CONTAMINATION

ENERGY COST SAVINGS

WINTER SEASON
PUMPED TWO-PHASE OPERATION



PUMP ASSISTED AIR-TO-AIR HEAT PIPE HEAT EXCHANGERS (HP-AAHX)

PUMP ASSISTED AIR-TO-AIR HEAT PIPE HEAT EXCHANGER

This Pump Assisted AAHX recovers energy from either the exhaust or supply air stream during all seasons, allowing AHUs to consume less energy. Combining traditional air-to-air heat pipe technology and pumped two-phase systems takes advantage of both operational modes. It's the combination of passive operation for at least half of the year and very minimal energy consumption during active operation for the other half of the year that enables such high overall energy recovery from this product.

PUMP ASSISTED AAHX PERFORMANCE & PAYBACK:

LEHIGH UNIVERSITY INSTALLATION CASE STUDY

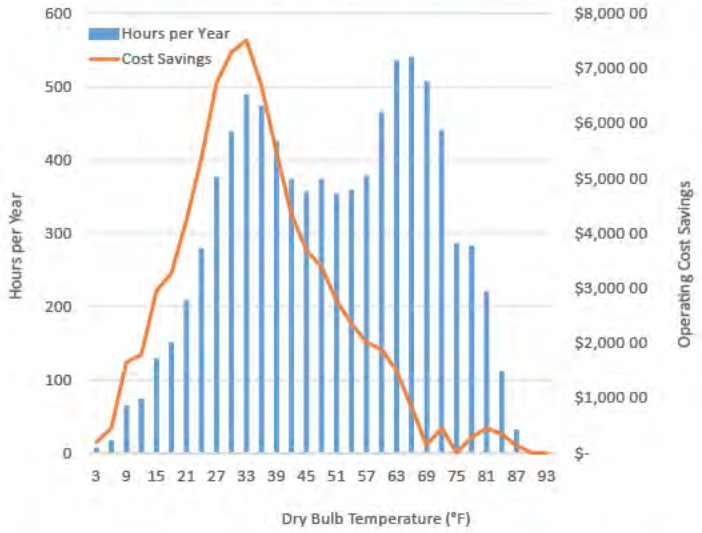
SPECIFICATIONS USING BETHLEHEM, PA WEATHER DATA

- Natural gas heating: $0.05/kWh
- Electric costs: $0.12/k ENERGY RECOVERY UNIT
- Cooling COP: 3

PROJECT HIGHLIGHTS

- Retro-fit To Replace Energy Wheel
- Payback Estimated At 2 Years
- Provided a Low Maintenance Solution

EXPECTED PAYBACK PERIOD



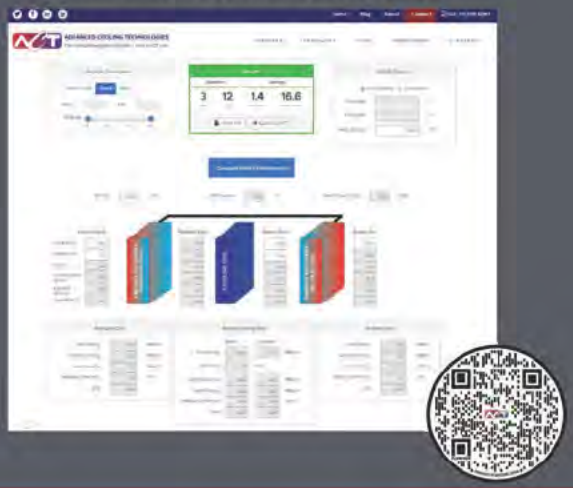
TOTAL OPERATING COST SAVINGS OF $78,215/YEAR

FREE ONLINE TOOLS

-EASY TO USE
-NO PASSWORD REQUIRED

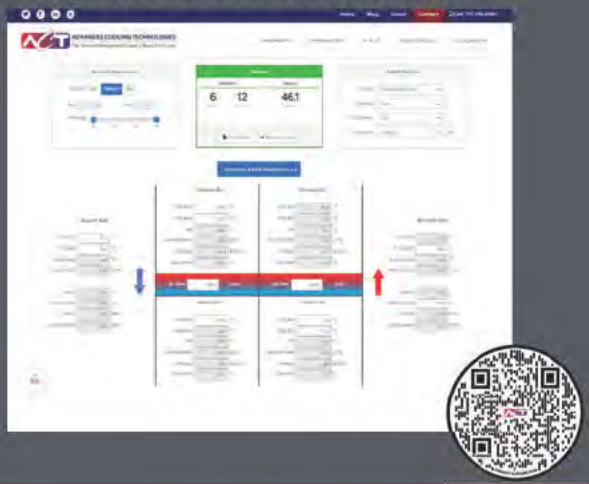
WAHX SELECTION TOOL

www.1-ACT.com/HVAC/WAHX



AAHX SELECTION TOOL

www.1-ACT.com/HVAC/AAHX



WRAP-AROUND HEAT PIPE HEAT EXCHANGER (HP-WAHX)

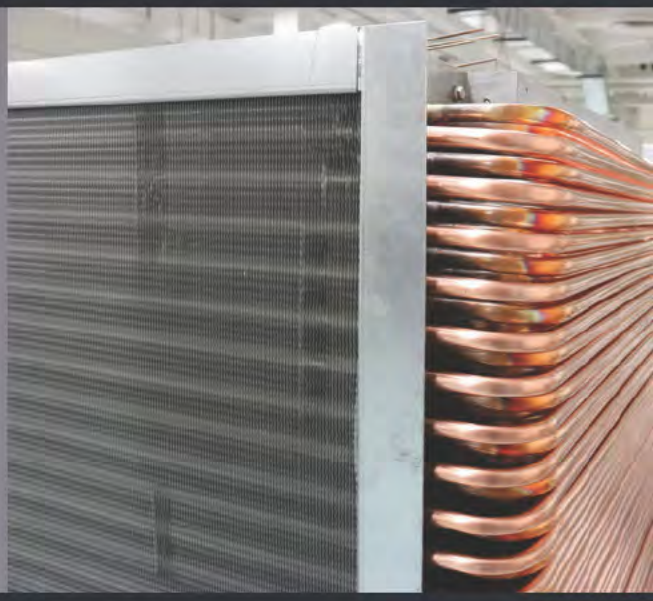
IDEAL APPLICATIONS

Dedicated outside air facilities with >70% outside air and areas with high-variable heat loads such as:

- **Universities**
- **Hospitals, Labs**
- **Condos/Hotels**
- **Government Facilities**
- **Convention Centers**
- **Prisons**
- **Food & Restaurant Facilities**

BENEFITS

- **Energy Savings**
  - Free pre-cooling (lower tonnage AHU systems)
  - Free re-heat (no electric, steam or hot water cost)
- **Passive System**
  - No maintenance
  - No moving parts (except for control valves when applied)
- **Enhanced Dehumidification**
  - Lower entering air conditions (ex: 95° to 85°)
  - Lower cooling coil discharge temperature
- Neutral Air Discharge (free re-heat)
- Conforms to UL Standard 207 for heat pipe based HVAC system
- Lower static pressure vs. other energy recovery systems

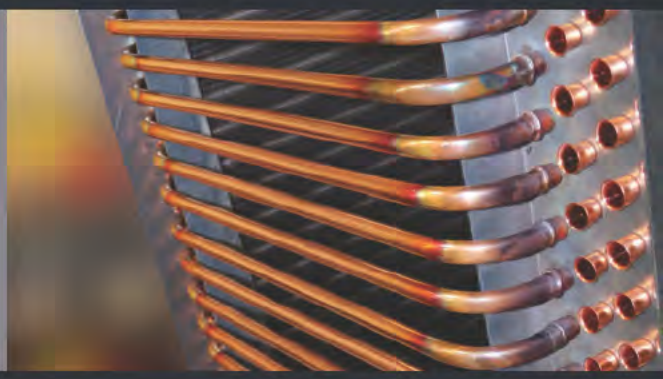


FEATURES

- 1/2" rifled copper tubes for enhanced thermal performance
- Aluminum fins (8-14 Fpi)
- Galvanized steel casing
- Factory installation, field installation or AHU manufacturer installation
- R-134a or R410A refrigerants
- Up to 10 Rows

OPTIONS

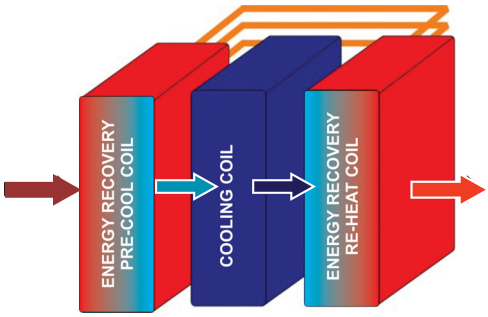
- Up to 1" diameter coil tubes (copper or aluminum)
- Stainless steel casing
- Multiple fin types & materials
- Controllable (active or passive)
- Corrosion coating (E-Coat or Heresite)

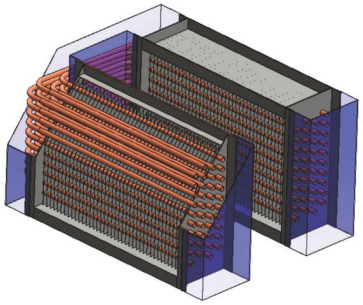


WRAP-AROUND HEAT PIPE HEAT EXCHANGER (HP-WAHX)

HOW DOES HP-WAHX WORK?

In order to condition air in hot, humid environments, the AHU must reduce its temperature well below room temperature to remove all moisture and then reheat the air to a comfortable temperature. A WAHX is comprised of two coils connected by integrated heat pipes that “wrap” around the active cooling coil. The initial pre-cool coil collects heat, pre-cooling the air. The heat pipes passively transport heat around the active cooling coil to the second reheat coil which raises the temperature coming off the cooling coil. Energy dollars are saved in the precool dehumidification and reheat stages.





HP-WAHX SELECTION TOOL

Every HP -WAHX is custom engineered for each project to yield the best ratio of cost versus performance. Typical system payback is under two years.

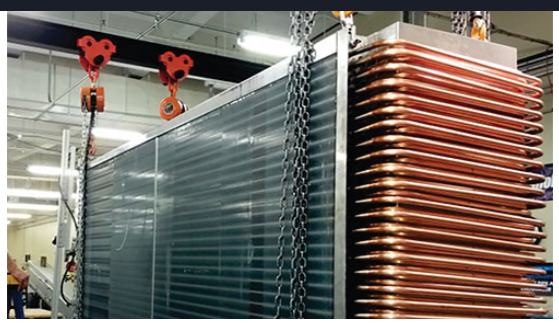
OUTSIDE AIR	DELTA T °	HEAT PIPE PRE-COOL		COOLING COIL	DELTA T °	HEAT PIPE RE-HEAT
102°/77.8°	15.6°	86.4°/73.7°		52.5°/52.4°	15.6°	68.0°/58.6°
92°/77.7°	15.2°	76.8°/69.4°		52.5°/52.4°	15.2°	67.6°/58.5°
82°/68.8°	11.3°	70.7°/65.2°		52.5°/52.4°	11.3°	63.8°/57.0°
72°/63.7°	7.5°	64.5°/61.0°		52.5°/52.4°	7.5°	60.0°/55.5°
62°/56.4°	3.6°	58.4°/55.0°		52.5°/52.4°	3.6°	56.1°/54.0°
52°/52.4°	0.0°	52.5°/52.4°		52.5°/52.4°	0.0°	52.5°/52.4°

Example:
AHU: 20,000 CFM
4 Rows of Heat Pipes
12 Fins per inch

Heat transfer is always balanced. As the outside air temperatures decrease, so does the heat transfer.

HP-WAHX CONFIGURATIONS

PIPE TO PIPE CONNECTION: EVERY ROW EVERY PIPE



- Any Coil Dimensions
- Stackable
- Controllable

SPLIT LOOP THERMOSYPHON: 2 PIPES PER ROW

- Any Length Coil
- Max 37.5” Fin Height
- Stackable
- Controllable

HP-WAHX WITH CONTROL

CONSIDER ACT'S CONTROL VALVES FOR OPTIMIZED HP-WAHX ENERGY PERFORMANCE

In order to capture and transfer even more energy, ACT's control valve options optimize the ability of the HP-WAHX to operate over a wider temperature range and increase the energy savings have a wider range of energy savings operation at lower entering air temperatures. ACT control valve options permit additional heat pipe rows, resulting in higher capacity HP-WAHX systems with the capability of stopping the heat pipes refrigerant flow in selected rows to maintain a specified discharge temperature. HP-WAHX with control maximizes energy savings as the outside air temperature fluctuates.

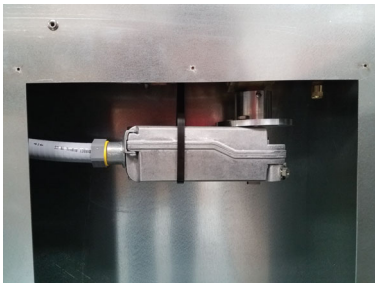
ACTIVE THERMAL CONTROL VALVE (ACT-TAV)

For applications that have variable discharge temperature requirements, ACT's active thermal control valve can be added to each of the heat pipe connecting tubes to adjust the amount of precooling and reheating necessary to meet the demand of the space being conditioned. The valves can be bundled and controlled, usually in stages of 10 to 25% each, to achieve the level of temperature control that is desired. Typically, ACT bundles the electrical wires into a local electrical panel that interfaces with the Building Management System (BMS).

The classical application is an auditorium that has long periods of unoccupancy followed by short periods of occupancy. When unoccupied, the WAHX can supply dehumidified, neutral (65-70°F) air to the space. When the space is occupied, the WAHX capacity can be reduced, usually in stages, such that the air handler can deliver dehumidified, cooler air to offset the additional cooling load of the occupants.

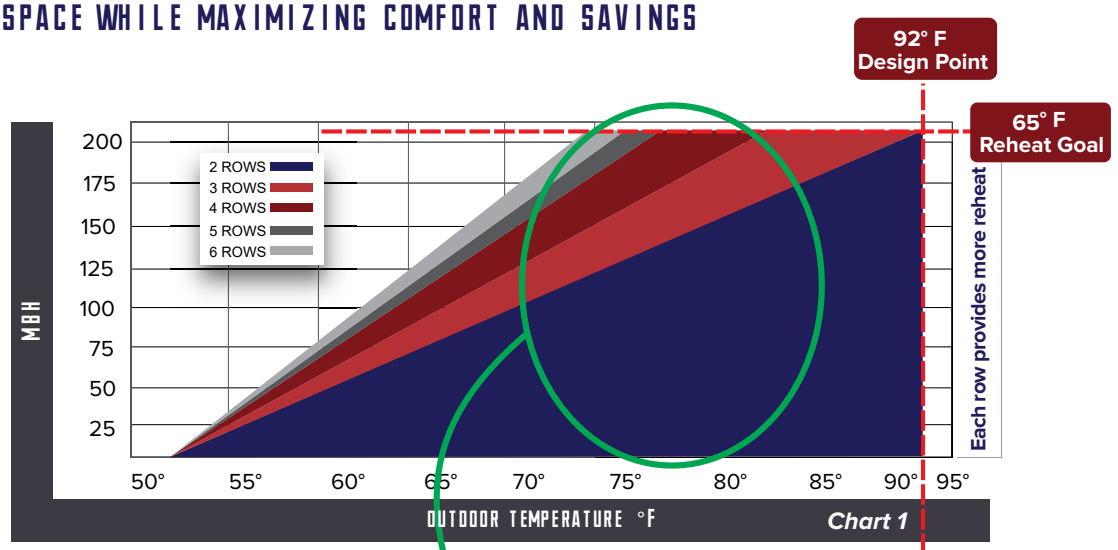
SPLIT LOOP THERMOSYPHON WITH 100% REHEAT CONTROL WRAP-AROUND (ACT-SLT)

The split loop thermosyphon wrap around heat pipe can also be controlled as described above for ACT's active and passive controlled pipe-to-pipe wrap around heat pipes. In the SLT case, one valve is added to the vapor connecting tube for each row of the coil. These valves are typically controlled by the Building Management System (BMS). They can be used for variable air discharge air applications and/or to maximize savings while preventing overheating of the conditioned air. The controlled SLT is often more cost effective for higher flow rate, larger coil sizes. ACT can evaluate your application and recommend the most cost-effective solution.

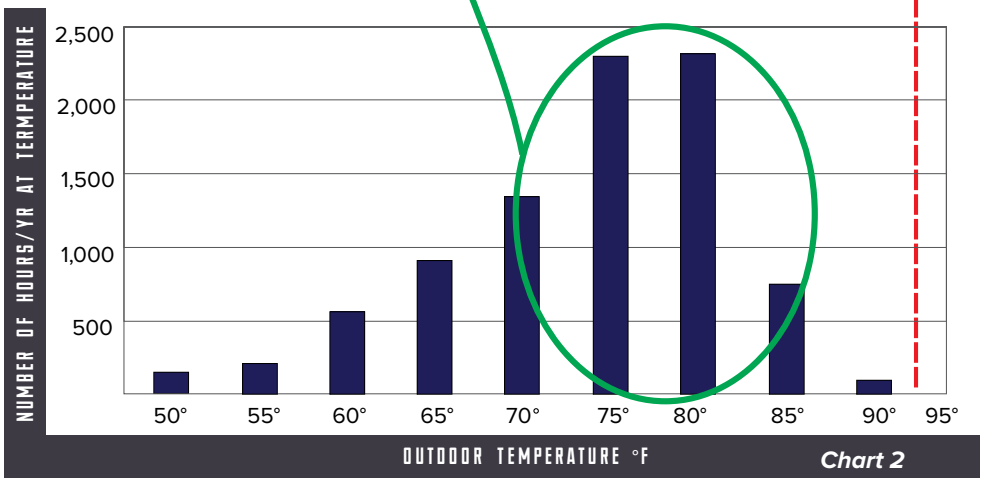


AVOID OVER-HEATING THE SPACE WHILE MAXIMIZING COMFORT AND SAVINGS

HP-WAHX Performance Meeting reheat and design point targets with additional rows even during part load conditions.



FORT LAUDERDALE, FLORIDA
ANNUAL BIN TEMPERATURE DATA



CASE STUDY

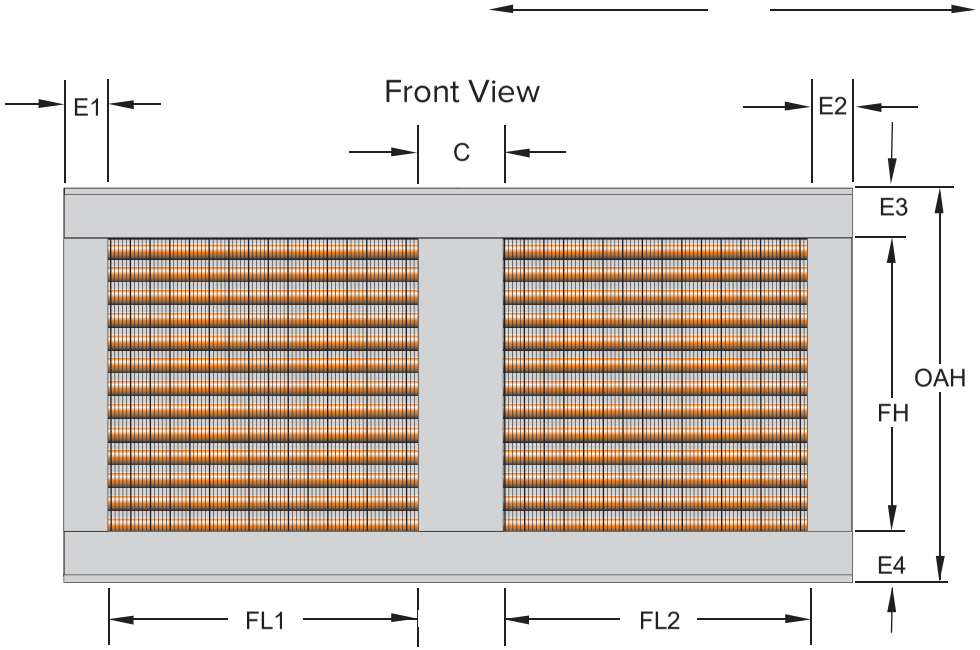
TECHNICAL PARAMETERS UTILIZED:

Annual Data

Running Hours 24 Hrs/Day 7 Days/Week
(Note: Temperatures below 57° F are not calculated)

System Assumptions: 17,500 CFM system, operating in

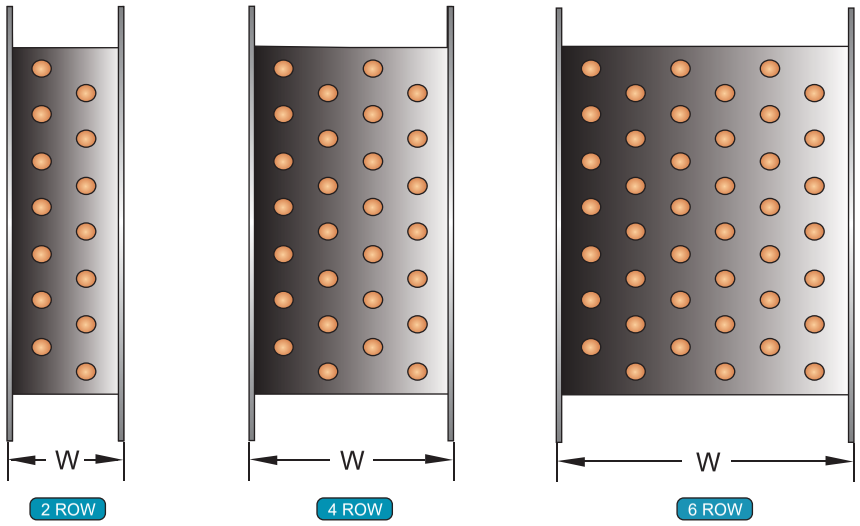
Fort Lauderdale Florida, Cooling Coil at 55° FDB 54.9° FWB.



FRONT VIEW DIMENSION TABLE	
FH: Fin Height	Fin Height MUST be in multiples of 1.25”
FL1: Fin Length	Optional
FL2: Fin Length	Optional
C: Center Divider Width	Typically 4.0” or as specified
E1 – E2: Side Flange	Minimum of 2.0” or as specified
E3 – E4: Top – Bottom Flange	Minimum of 2.0” or as specified

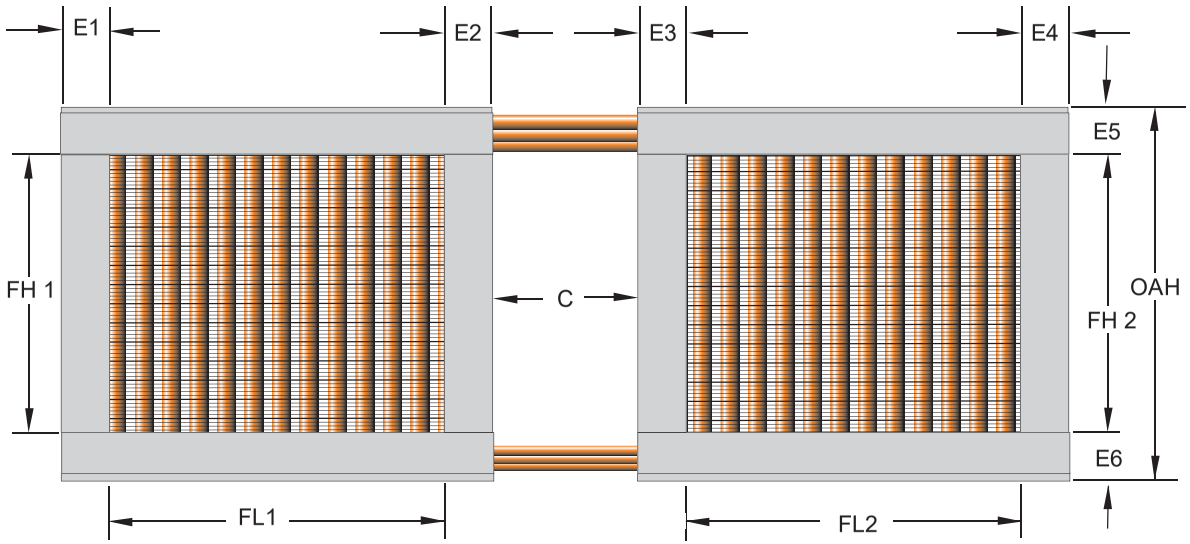
SIDE VIEW DIMENSION TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
W	2.0”	3.0”	4.0”	5.5”	6.5”	7.5”	8.5”	9.5”	11.0”	12.0”

Side View Examples: 2 - 4 - 6 Row Heat Pipe Heat Exchangers



Note: Drawings are not to scale

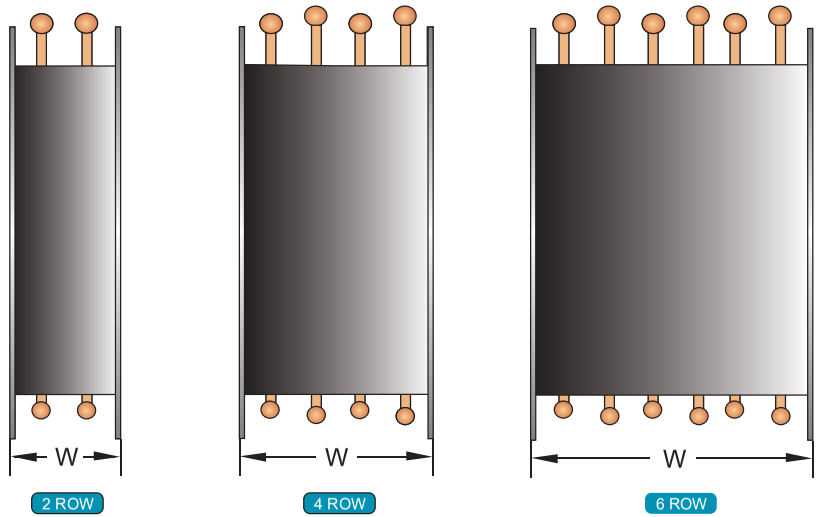
Front View



FRONT VIEW DIMENSION TABLE	
FH 1 & 2: Fin Height Maximum MUST Stack AAHX over 37.5”	Fin Height Optional
FL1: Fin Length	Fin Length Optional, must be in multiples of 1.25”
FL2: Fin Length	Fin Length Optional, must be in multiples of 1.25”
C: Center Divider Width	Typically >4.0” or as specified
E1, E2, E3, E4: Side Flanges	Minimum of 1.5” or as specified
E5: Top Flange	Minimum of 4.5” or as specified
E6: Bottom Flange	Minimum of 4.0” or as specified

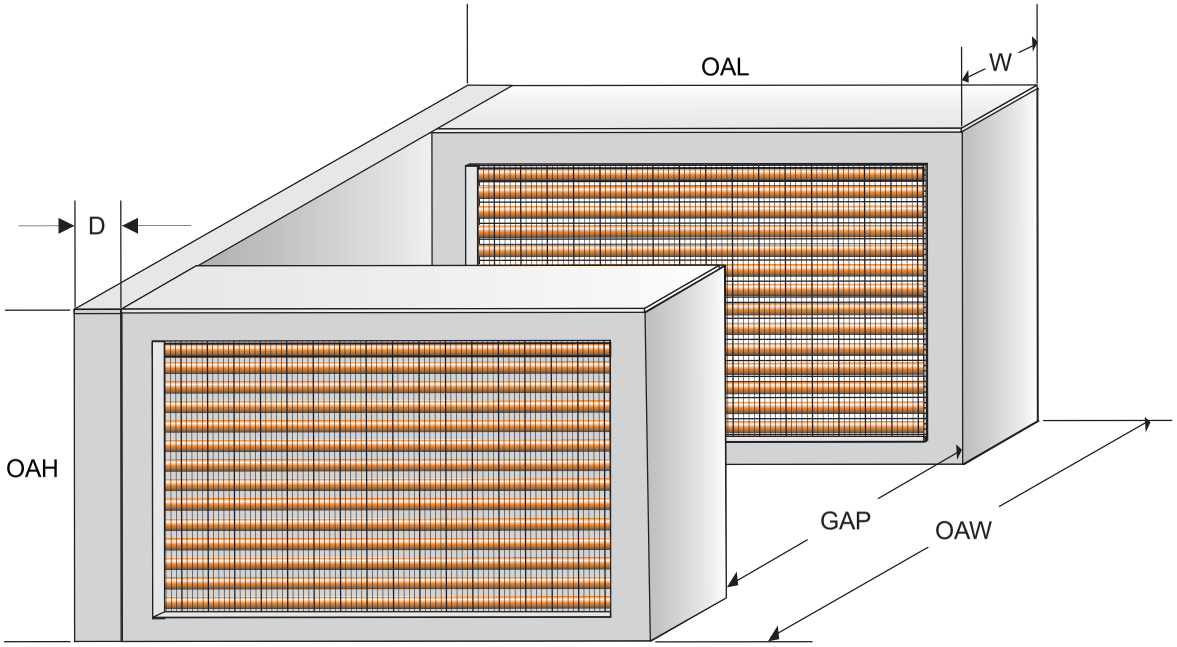
Note: HP-AAHX Split Loop Thermosyphon Systems cannot exceed 37.5” in Fin Height. Units can be stacked.

Side View Examples: 2 - 4 - 6 Row Heat Pipe Heat Exchangers



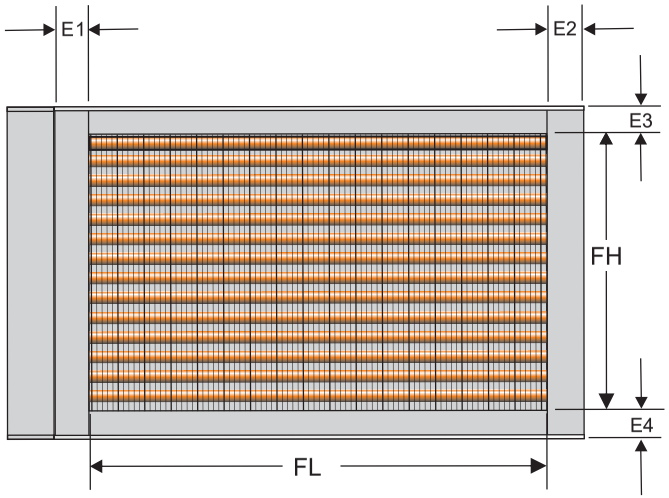
SIDE VIEW DIMENSION TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
W	3.0”	4.0”	5.0”	6.0”	7.0”	8.0”	9.0”	10.0”	11.0”	12.0”

Note: Drawings are not to scale



FRONT VIEW DIMENSION TABLE	
OAH: Total Height	Optional
OAL: Total Length	Optional
OAW: Total Coil Spacing	Optional
GAP	Optional
FH: Fin Height	Fin Height MUST be in multiplies of 1.25”
FL: Fin Length	Optional
E1 – E2: Side Flange	Minimum of 2.0” or as specified
E3 – E4: Top – Bottom Flange	Minimum of 1.5” or as specified
W: Coil Width	See table for minimum or as specified
D: Return Tube Depth	See table for minimum or as specified

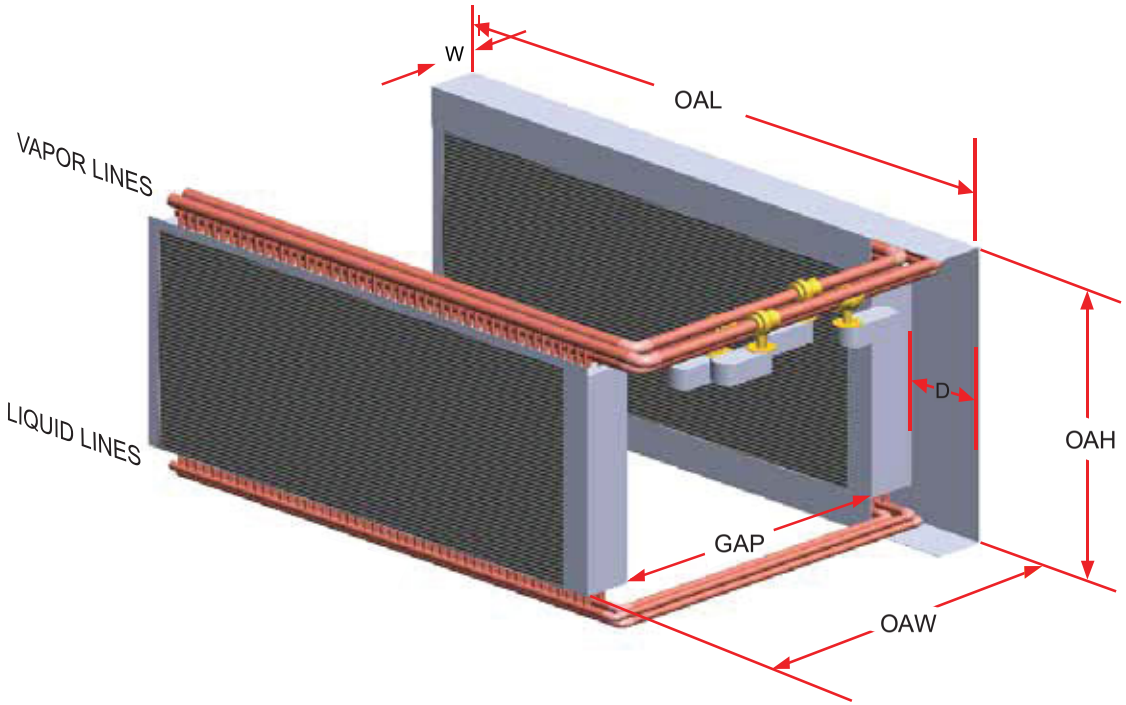
Energy Recovery Coil Side View



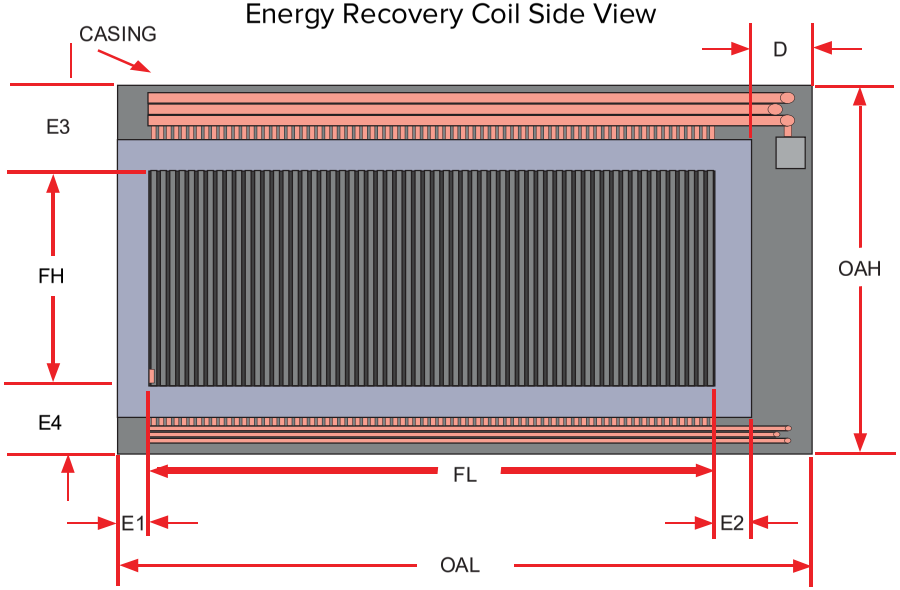
Note: Drawings are not to scale

(D) RETURN TUBE DEPTH TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
D	2.0”	2.0”	2.75”	2.75”	3.5”	3.5”	4.25”	4.25”	5.0”	5.0”

(W) COIL WIDTH TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
W	1.5”	3.0”	4.0”	5.0”	6.0”	7.0”	8.0”	9.25”	10.5”	11.5”



Energy Recovery Coil Side View



Note: Drawings are not to scale

FRONT VIEW DIMENSION TABLE	
OAH: Total Height	FH + 8.50”
OAL: Total Length	Optional
OAW: Total Coil Spacing	Optional
GAP	Optional
FH: Fin Height, *Max. 37.5”	Optional
FL: Fin Length	MUST be in multiples of 1.25”
E1 – E2: Side Flange	Minimum of 1.50” or as specified
E3: Top Flange	Minimum of 4.50” or as specified
E4: Bottom of Flange	Minimum of 4.00”
W: Coil Width	See table for minimum or as specified
D: Return Tube Depth	See table for minimum or as specified

**Note: Fin Height over 37.5” must be stacked*

(D) RETURN TUBE DEPTH TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
No Control D	2.0”	4.0”	5.0”	7.0”	8.0”	9.0”	10.0”	11.0”	12.0”	14.0”
With Control D	4.0”	6.0”	7.75”	9.75”	11.5”	13.5”	15.25”	17.25”	20.25”	22.5”

(W) COIL WIDTH TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
W	3.0”	4.0”	5.0”	6.0”	7.0”	8.0”	9.0”	10.0”	11.0”	12.0”

ADVANCED COOLING TECHNOLOGIES
1046 New Holland Avenue
Lancaster, PA 17601, USA

Phone: 717.295.6061
Email: Solutions@1-ACT.com

ISO 9001 & AS9100 Certified
ITAR Registered

MARKETS

Avionics/Aircraft
Electronics Cooling
Enclosure Cooling
Energy
HVAC Energy Recovery
Materials Process
Medical Industry
Military
Photonics
Power Electronics
Spacecraft Thermal Control
Temperature Calibration & Control
Transportation

PRODUCTS

Heat Pipes for Thermal Management
HVAC Heat Pipe Heat Exchangers
ICE-Lok™ (Isothermal Card Edge wedgelock)
Isothermal Furnace Liners (IFLs)
Liquid Cold Plates
Loop Thermosyphon
Pumped Two-Phase Cooling (P2P)
Phase Change Material (PCM) Heat Sinks
Spacecraft Thermal Control
Sealed Enclosure Coolers

RESEARCH & DEVELOPMENT

THERMAL TECHNICAL SERVICES

www.1-ACT.com/HVAC