ADVANCED COOLING TECHNOLOGIES

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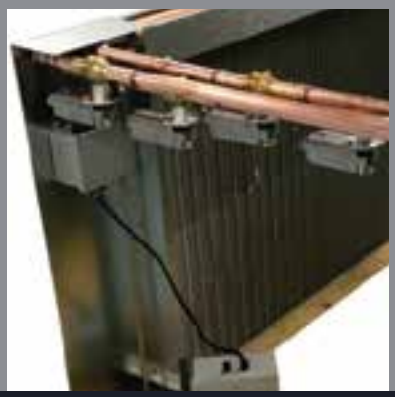
ENERGY RECOVERY HEAT PIPE HEAT EXCHANGERS



®Conforms to UL STD 207

SA44069

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 Devices, 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 diverse product portfolio enhances our ability to meet our customers' performance, cost and reliability requirements. ACT is the only U.S.-based Heat Pipe manufacturer that routinely ships Heat Pipe products for terrestrial, spacecraft, and high temperature applications.

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.

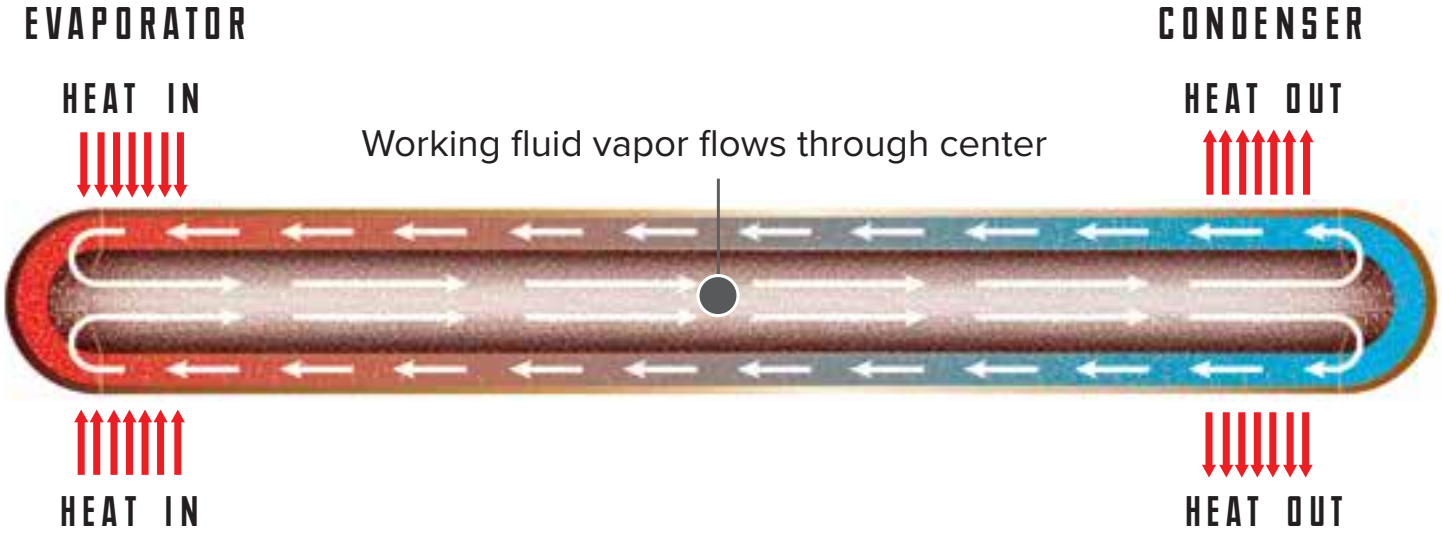
TABLE OF CONTENTS

HVAC HEAT PIPE OPERATION

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.

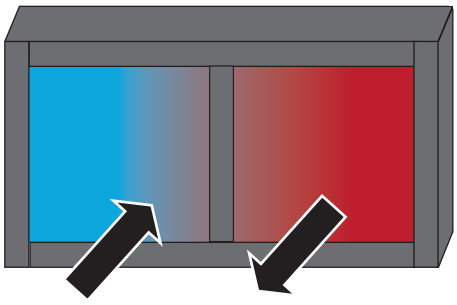
The phase change cycle continues as long as there is heat (warm outside air) at the evaporator end of the heat pipe. This heat transfer process occurs passively (no external electrical energy input required).



ACT HVAC ENERGY RECOVERY SYSTEMS

ACT ENERGY RECOVERY TYPES

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



PASSIVE AIR-TO-AIR HEAT PIPE HEAT EXCHANGER
(HP-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

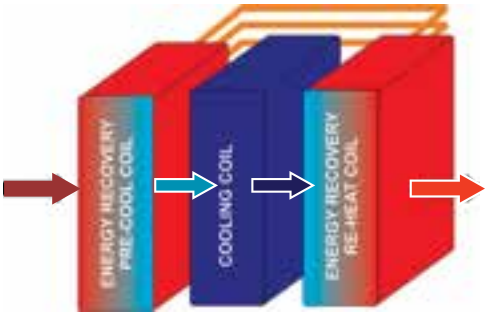
OPTIONS

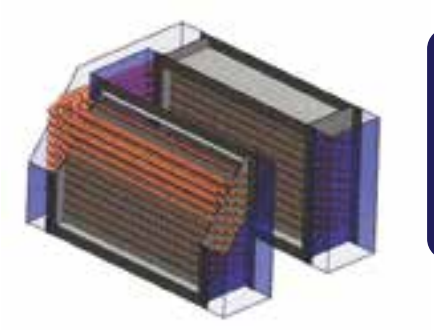
- Up to 1” diameter coil tubes (copper or aluminum)
- Stainless steel casing
- Multiple fin types & materials
- Controllable (active or passive)
- Corrosion coating (E-Coat or Heresite)

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 it's 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.





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 36" 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 controled, 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.

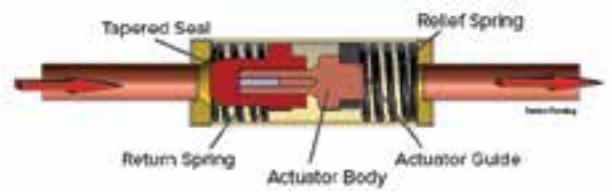
SPLIT LOOP THERMOSYPHON WITH 100% REHEAT CONTROL WRAP-AROUND (ACT-SLT)

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.

HP-WAHX WITH CONTROL

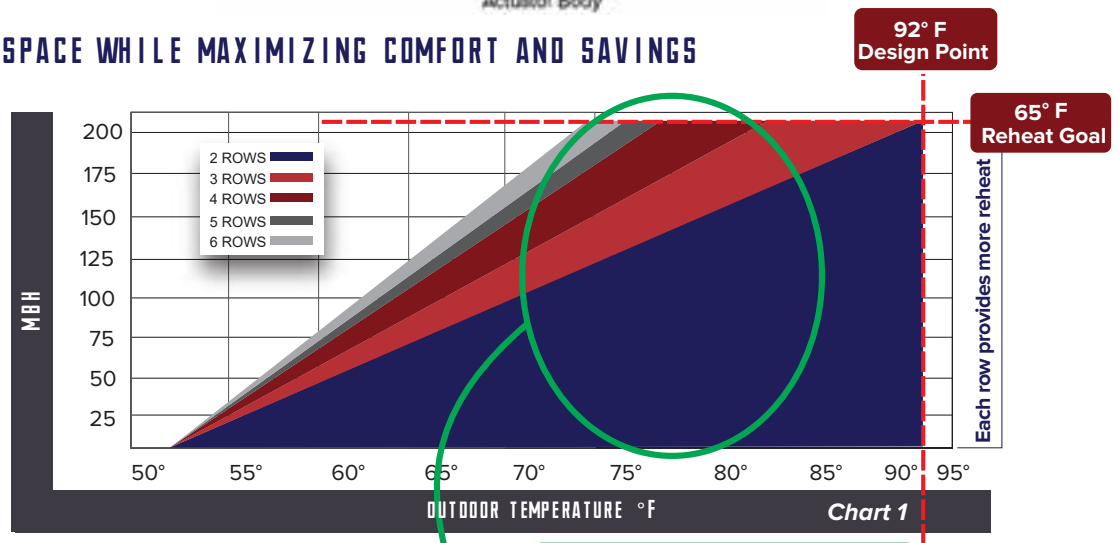
PASSIVE THERMAL CONTROL VALVE (ACT-TPV)

For applications that do not require a variable discharge temperature, ACT's passive thermal control valve can be used to maximize energy savings while preventing overheating of the air delivered to the space. For example, if the design point specification results in a selection of a two row WAHX, the WAHX can be designed with two rows that are uncontrolled with an additional two rows with ACT's passive thermal control valves. When the system is operating below the maximum design point, all four rows can be operational, increasing energy savings. When the temperature rises towards the maximum design point, ACT's passive thermal control valves will begin to automatically close, preventing overheating of the conditioned air.

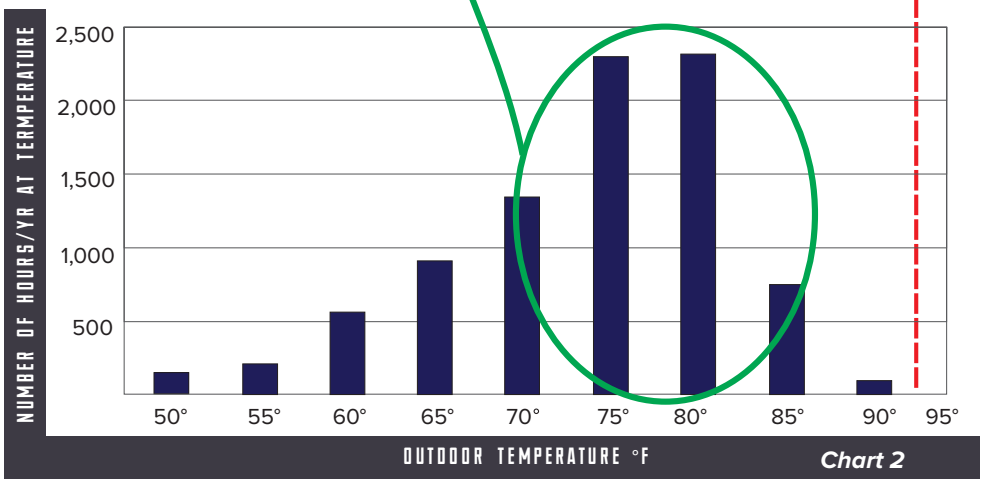


AVOID OVER-HEATING THE SPACE WHILE MAXIMIZING COMFORT AND SAVINGS

HP-WAHX Performance
Meeting reheat and design point targets with additional rows



FORT LAUDERDALE, FLORIDA
ANNUAL BIN TEMPERATURE DATA



TECHNICAL PARAMETERS UTILIZED:

Annual Data *- Running Hours 24 Hrs/Day 7 Days/Week (Note: Temperatures below 57.5° F are not calculated).*

System Assumptions: 17,500 CFM system, operating in Fort Lauderdale Florida, Cooling Coil at 55° FDB/54.9°FWB.

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 18-24months
- **No Cross Contamination of airstreams**
- **Passive System**
  - 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

FEATURES

- 1/2” rifled copper tubes for enhanced thermal performance
- Aluminum fins (8-14 Fpi)
- Galvanized steal 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 HP-AAHX WORK?

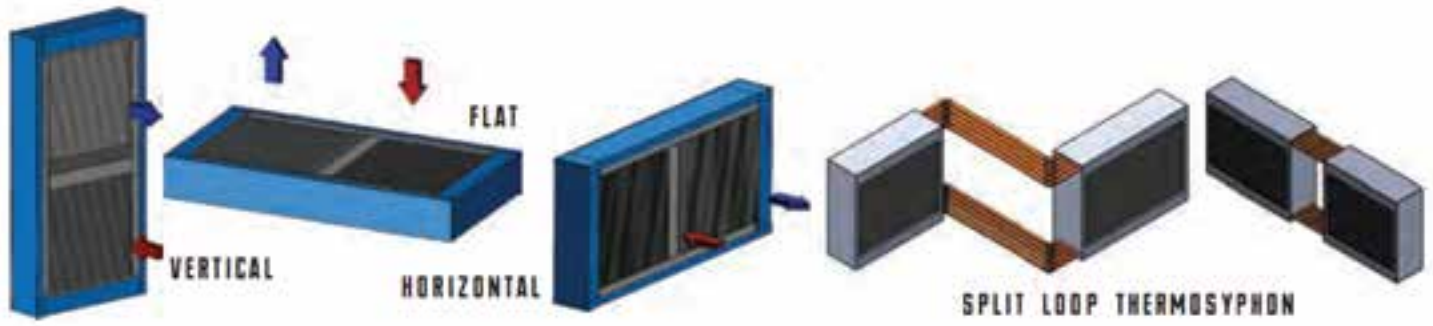
AAHX is a heat exchanger that uses a series of heat pipes to transfer energy between the outgoing exhaust air stream and the incoming air stream. The cool (summer) or warm (winter) air leaving the building is used to pre-cool or pre-heat the incoming outside air.

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 tonnage load capacity

HP-AAHX INSTALLATION OPTIONS

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

TILT AIR-TO-AIR HEAT PIPE HEAT EXCHANGERS

CONTROL HP-AAHX FUNCTION BY TILTING

Tilting the HP-AAHX will transfer operation from summer to winter by assuring the warm air stream is lower than the cold air stream, allowing the refrigerant liquid to flow by gravity back to the evaporator back from the condenser. Features included: steel housing, integratable flex duct, dual contacts, heavy duty actuator, and simple AHU installation.

AIR-TIGHT SEAL
NO BYPASS

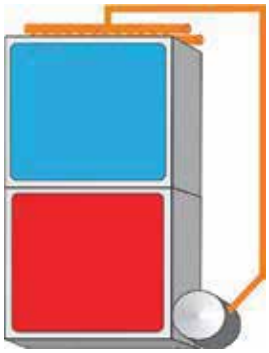
HEAVY DUTY TILT
ACTUATOR AND
POSITION SWITCHES

ROBUST DESIGN

PUMPED AIR-TO-AIR HEAT PIPE HEAT EXCHANGERS

ENERGY RECOVERY - PUMPED SYSTEM, VERTICAL INSTALLATION

- Summer/Winter Energy Recovery (pump operates for one season; passive operation for other season)
- System can be split between ducts up to 30'+
- Low pressure drop
- Sizes up to 25,000 CFM+
- Positive Recovery Efficiency Ratio (RER)
- Low RPM pump configuration for longlife



ONLINE SELECTION TOOLS

The WAHX and AAHX Selection Tools are intended to provide the designer with the capability to perform a preliminary design selection and to evaluate performance at various design conditions. It is also intended to be a tool to communicate engineering requirements and design targets to ACT for additional calculations and/or for preparing a quotation.

The WAHX and AAHX Selection Tool can be set to English or Metric units. Multiple input varibles can be selected from CFMs to DB/WB combinations for incoming Air, Active Coil and Supply Air, to mention a few.

There are two useful output options for each Selection Tool. One is “Print to PDF,” which will capture the on-screen data in a savable format. The other is “Submit to ACT” which will capture the screen data, including the product information, contact information and any notes the user enters, and sends it to an ACT engineer for further assistance or quotation.

FREE ONLINE TOOLS

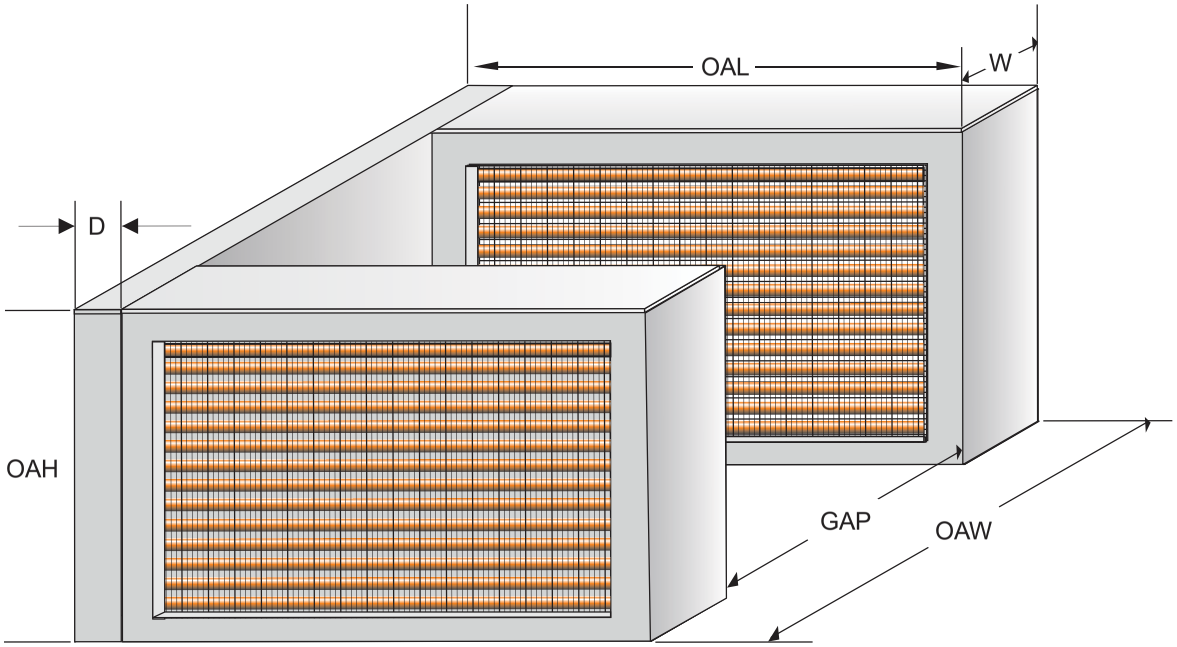
- EASY TO USE
- NO PASSWORD REQUIRED

WAHX SELECTION TOOL

www.1-ACT.com/HVAC/WAHX

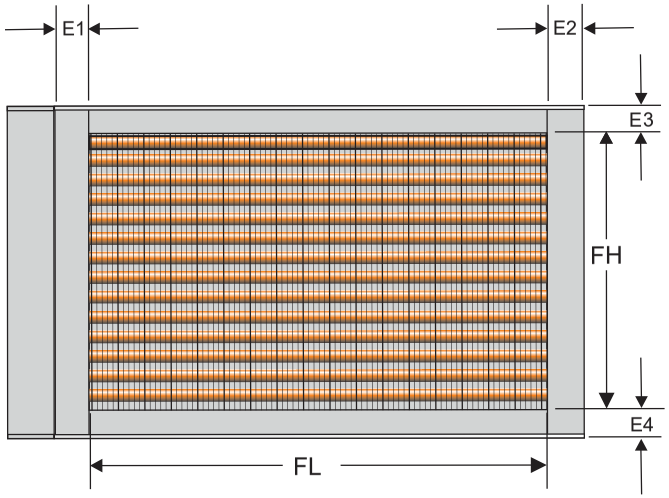
AAHX SELECTION TOOL

www.1-ACT.com/HVAC/AAHX



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

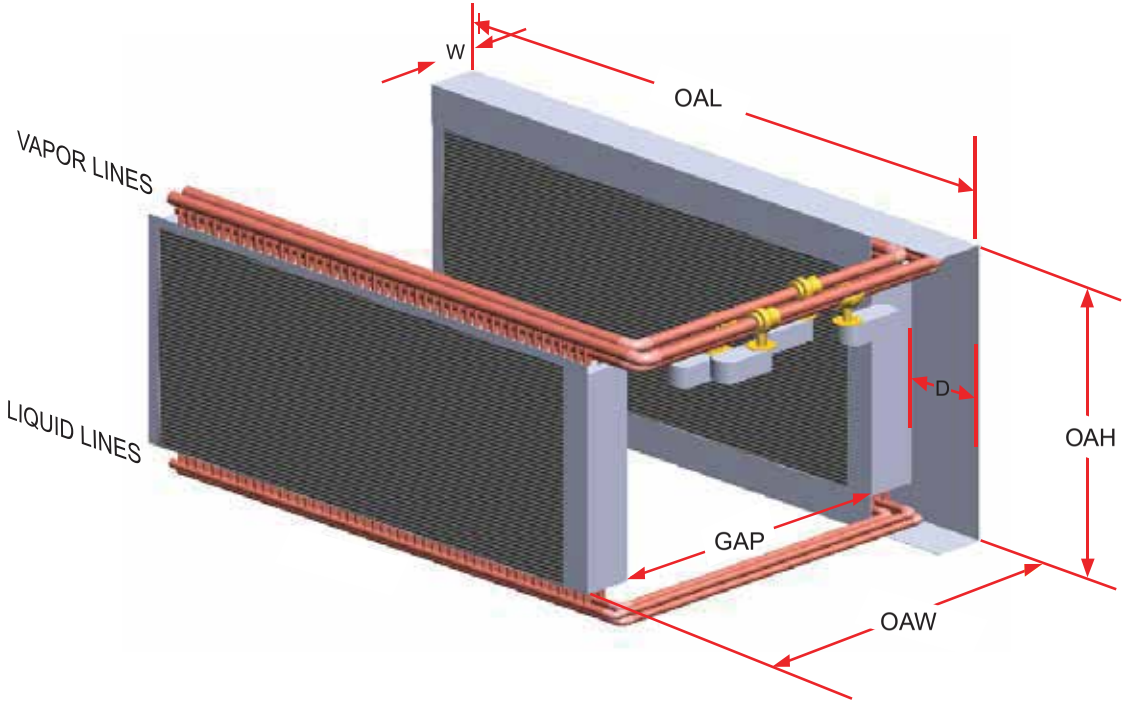
Energy Recovery Coil Side View



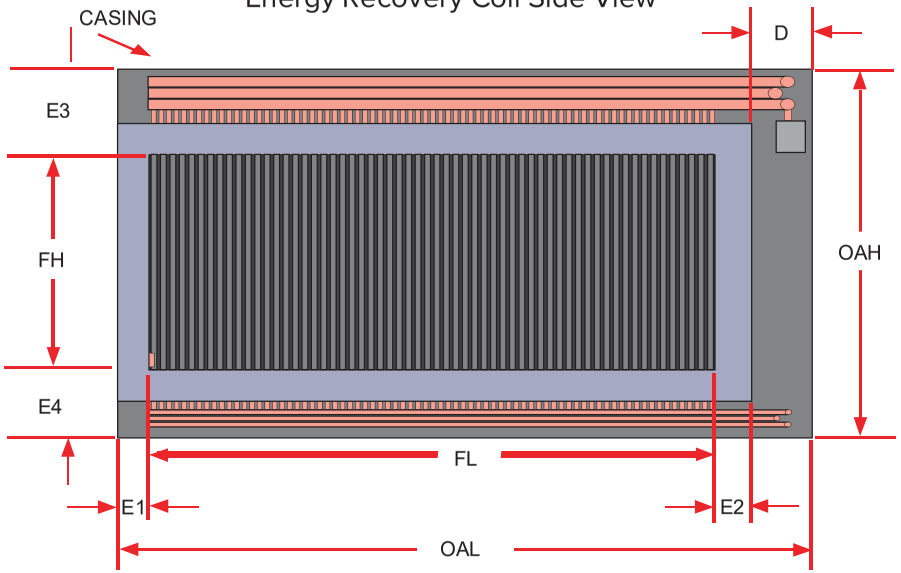
(D) RETURN TUBE DEPTH TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
D	2.0”	2.0”	2.75”	2.75”	3.5”	3.5”	4.25”	4.25”	5.0”	5.0”

(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”

Note: Drawings are not to scale



Energy Recovery Coil Side View



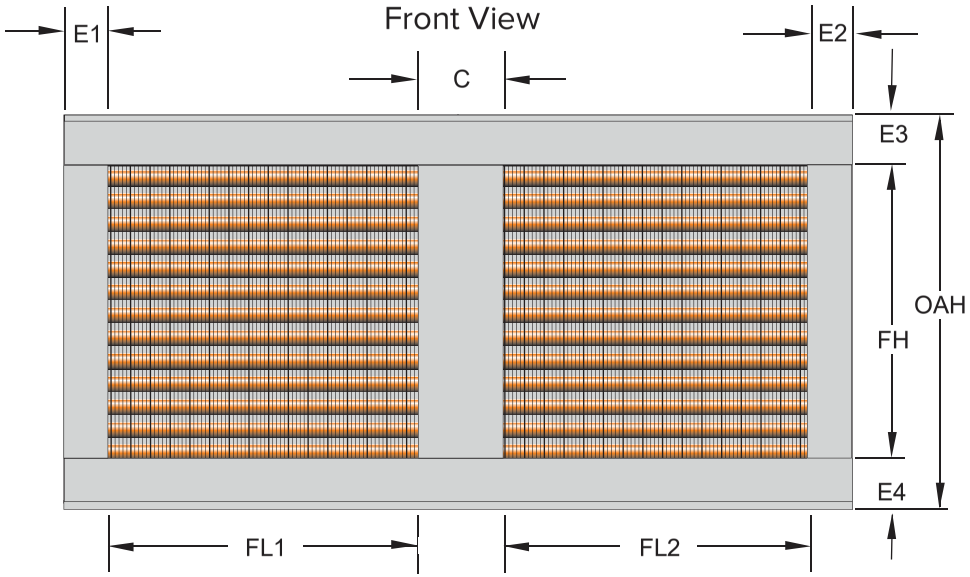
Note: Drawings are not to scale

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”

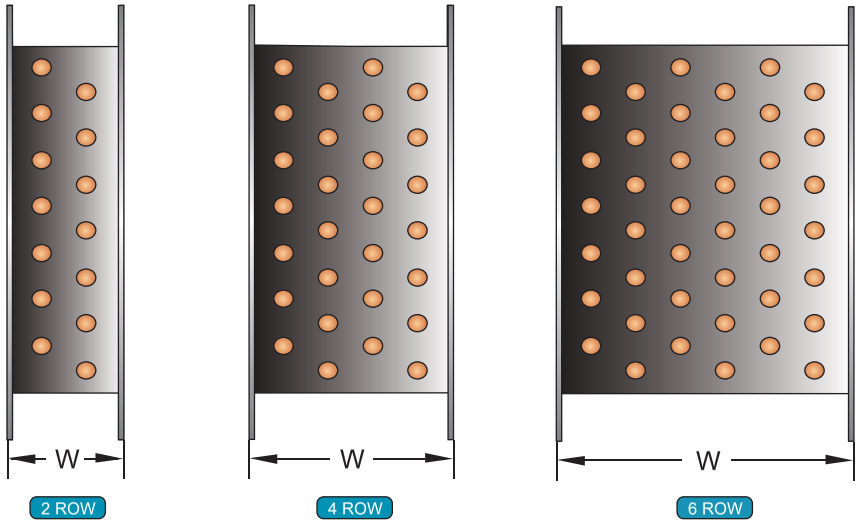
(W) COIL WIDTH TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
W	3.0”	4.0”	5.0”	6.0”	7.0”	8.0”	9.0”	10.0”	11.0”	12.0”



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

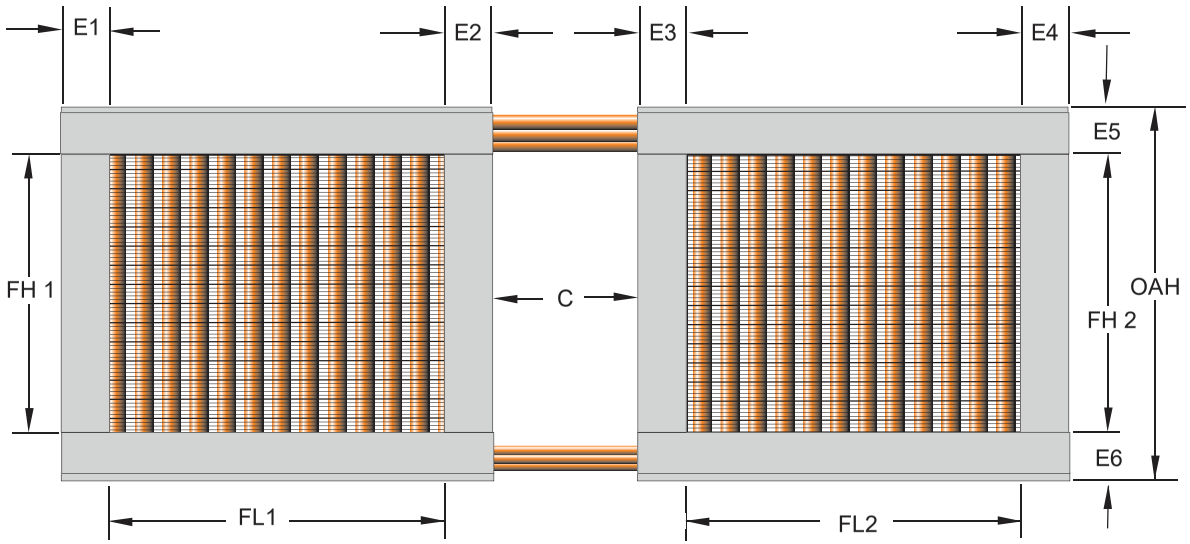
SIDE VIEW DIMENSION TABLE BY NUMBER OF ROWS										
Rows	1	2	3	4	5	6	7	8	9	10
W	2.0”	3.0”	4.0”	5.5”	6.5”	7.5”	8.5”	9.5”	11.0”	12.0”

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



Note: Drawings are not to scale

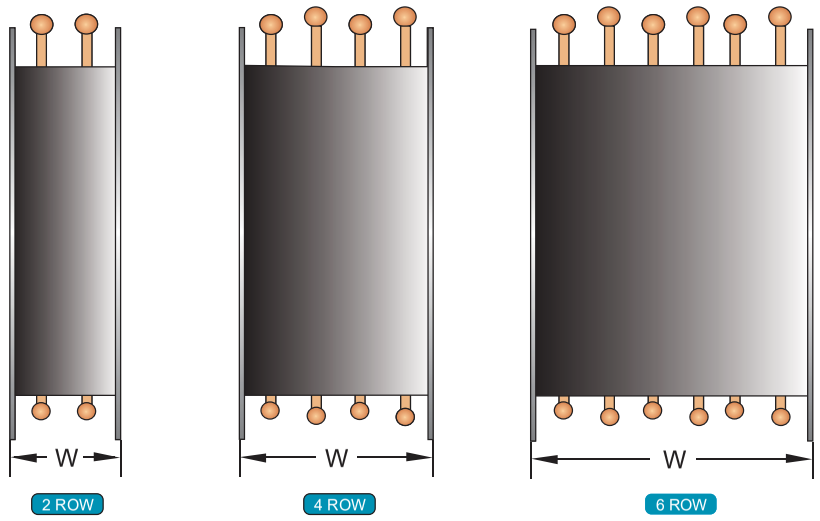
Front View



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 can not 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

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

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

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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