Evaporative Cooling Systems

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ELI

Energy Labs Inc

Product Description

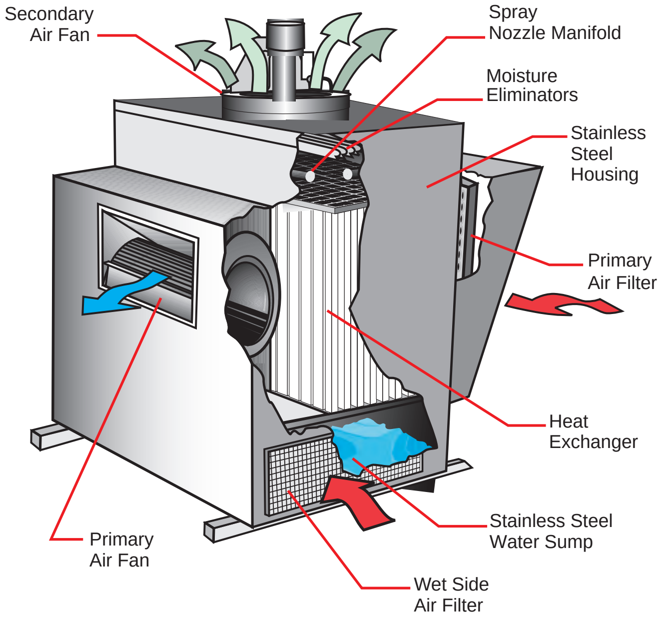
Evaporative cooling has gained rapid acceptance because the process relies on the evaporation of water to produce significant cooling with extremely low energy consumption and no use of CFC's.

Even with all the sophisticated technology available, evaporation is still one of the simplest methods of cooling air, and the principle of evaporative cooling remains a cost-effective method for environmental control.

Energy Labs Evaporative Cooling Sytems are available in three different configurations: Indirect, Direct and Supercool.

Indirect Evaporative Cooling

Indirect evaporative cooling sensibly cools the air with use of an air-to-air heat exchanger. The recirculating pump supplies water to spray nozzles which moisten the interior wall of the heat exchanger. The wet-side exhaust fan draws the secondary air through the wetted interior of the heat-exchanger tubes, causing evaporation, which cools the surface of the tubes. These tubes then sensibly cool the primary air stream on the exterior side of the tubes.



Indirect Cooling

Direct Evaporative Cooling

The second stage of cooling can be provided by direct evaporative media. The media provides a durable, highly wettable, extended surface with low air-pressure drop. It is self-cleaning and consistent in performance. Adding a direct evaporative stage to the indirect cooling process causes further reduction in dry-bulb temperature. As a result, leaving air temperatures of 55° to 65° are attained. This compares favorably with mechanical refrigeration systems.

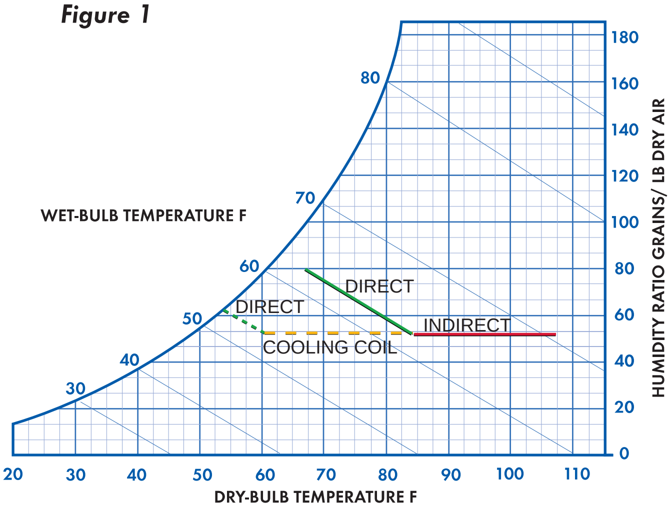
See figure 1 for a psychometric chart.

Indirect / Direct / Refrigeration

Some circumstances require an additional stage of cooling. Refrigeration operates when the first two stages of indirect and direct evaporative cooling cannot achieve the required supply-air temperature.

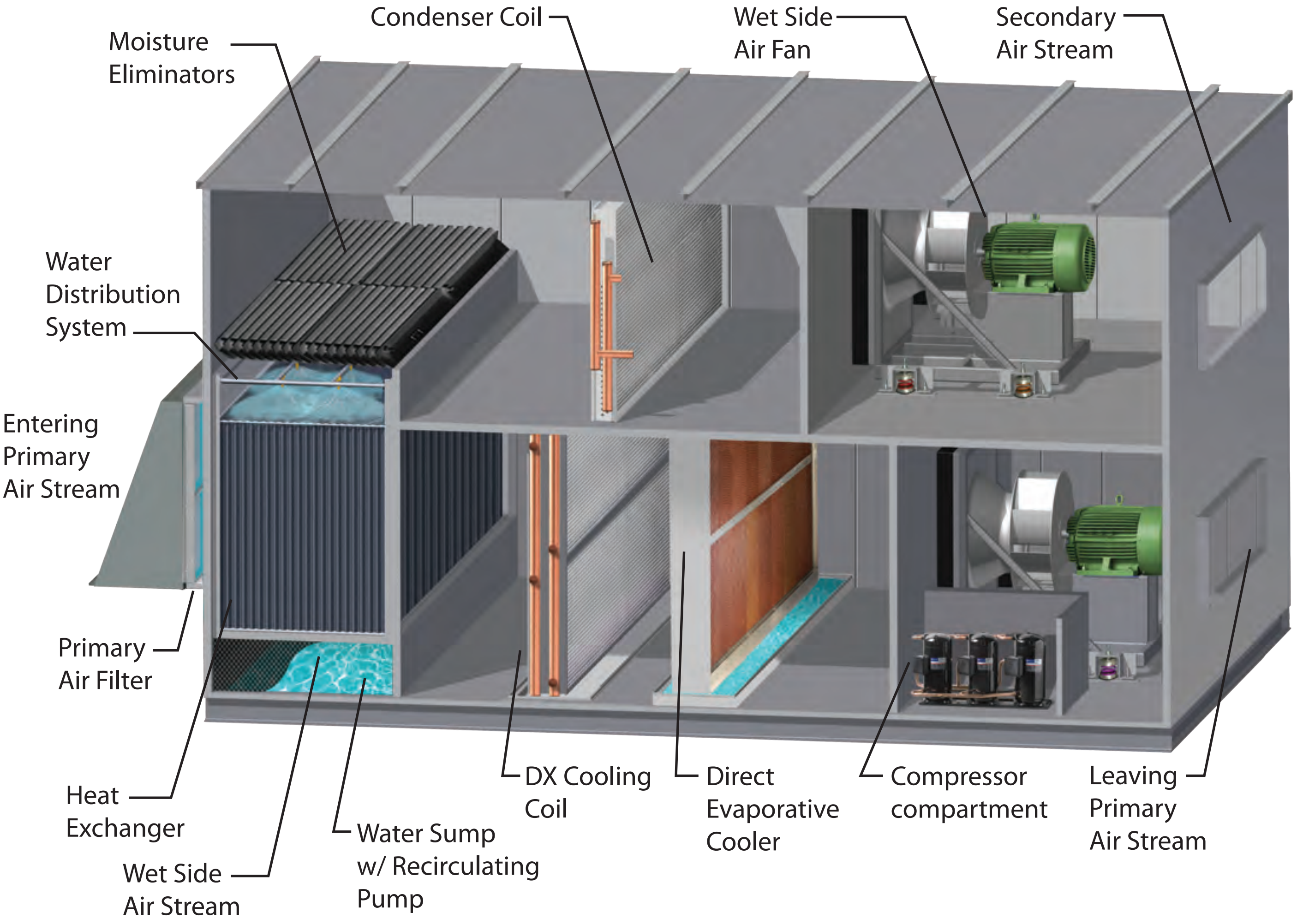
The hours of refrigeration operation will usually be less than 20% of the total system operating hours. One of the unique advantages of this system is the ability to humidify and cool. The direct stage is also utilized to humidify the air during winter when the addition of humidity is necessary to maintain the comfort level of the space.

Figure 1



Supercool System

Energy Labs has developed and patented a system which can provide the third stage of refrigerated cooling as a complete factory-packaged system. By locating the condenser coil in the wet-side air stream, this system takes advantage of lower air temperatures to reduce the condensing temperature. This, in turn, further reduces compressor size and power consumption and extends the normal operating life.



Supercool System

Unit Base & Casing

The unit base is constructed of fully welded, 4" high minimum structural-steel channel. Unit casing is 18-gauge 304 stainless-steel panels with a 16-gauge 304 stainless-steel water sump. Hinged access doors with continuous stainless-steel hinges are provided for access to the water distribution system. The unit casing is insulated with a minimum of 1" thick, 1.5 lb. density, NFPA approved acoustical fiberglass insulation.

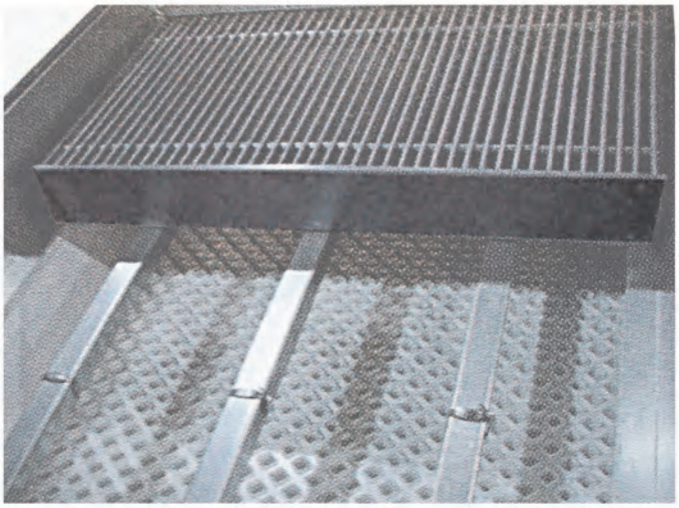
Water Distribution Pump

Energy Labs Indirect / Direct evaporative cooling units use an end-suction, base-mounted circulating pump. Each pump has a cast-iron volute and seal plate, and the pump impeller is made of reinforced fiberglass. The motor is close coupled with stainless-steel shaft and permanently grease lubricated bearings. The pump is designed for continuous operation to ensure a long life. Each pump is protected against low-water level in the sump with a low-water cut-off safety switch.

Heat Exchanger

Energy Labs exclusive air-to-air heat exchanger is factory fabricated using non-corrosive, High Impact Polymer tubes. The use of heavy duty, flame resistant, non-corrosive, polymer heat exchanger tube sheets and air baffles also contributes to low maintenance and long heat exchanger life.

Heat exchanger will meet the NFPA 90A for flamespread and smoke requirement.



Water Circulating System

The water distribution system consists of schedule 80 PVC piping for the water distribution manifold, with brass nozzles designed to provide uniform distribution of water over the entire heat exchanger. The water distribution nozzles are protected by a cleanable, in-line, 304 stainless-steel strainer. Copper distribution piping is available as an option.

Rain Hood and Filter Section

The rain hood or outside air louver and filter racks are constructed from 16-gauge 304 stainless-steel. Side access or face-loading designs are available, filter sections are designed to accept frames for different filter types, to accomodate a variety of applications.

Wet-Side Fan

Wet-side fan housings are constructed of 14-gauge 304 stainless steel. Fan blades are made of industrial quality polymer with a cast-aluminum hub. Fans are statically and dynamically balanced. This construction ensures long life within the wet environment to which the fans are exposed. Wet-side fan motors are TEAO or TENV.

Direct Evaporative Section

Energy Labs direct evaporative cooling media is CELdek ® or GLASdek ®. The media is made from treated cellulose paper or glass fibers to meet specific job requirements and provide maximum evaporation.

Controls and Wiring

Energy Labs U.L. 508 listed single-source power panels include NEMA 4 enclosure with main disconnects, all necessary starters, relays, HOA switches, and control transformers for complete electrical control of the unit.

A control system for automatic operation of indirect/direct evaporative cooling units is also available. Other options include automatic flushing of the unit sump for cleaning, maintenance and freeze protection.

Selection Process

Two values must be determined for every selection.

- Leaving air temperature from the heat exchanger.
- Air-pressure drop through the Heat Exchanger.

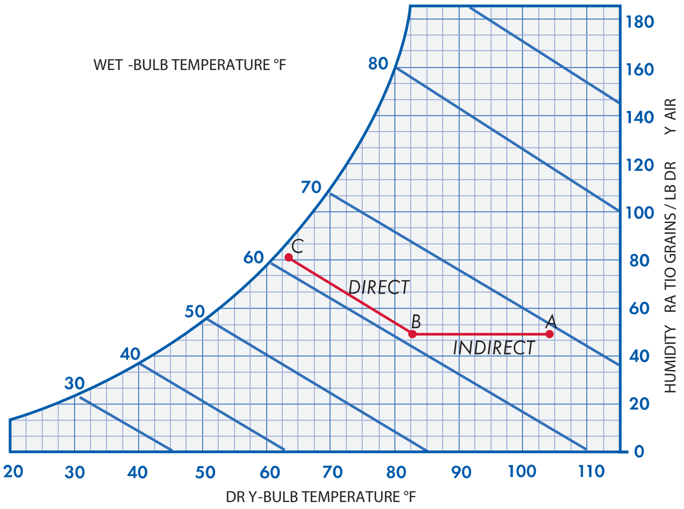
Selection example:

Project: A bakery in Barstow, CA.

Application: Indirect / Direct space cooling and make-up air system

Ambient design: 104°F DB / 69°F WB

Supply airflow: 9000 CFM



Step 1

From Table 1 for a 9000 CFM unit, the face area of the heat exchanger is 24 ft^2. Therefore, the velocity of air through the heat exchanger is 375 ft./min.

Step 2

From Curve 1 on page 7 at a velocity of 375 ft./min., the indirect heat exchanger efficiency (EFFI) is 66.5%.

Step 3

Use Equation 1 to determine the indirect Heat Exchanger leaving-air temperature.

Step 4

From the psychometric chart obtain the wet-bulb temperature of the air leaving the heat exchanger. Leaving air is 80.7°F DB/61.9°F WB, condition B on the psychometric chart.

Table 1

MODEL	NOMINAL CFM	HEAT EXCHANGER		FACE AREA
		QTY	H x W	Ft^2
I-30	3000	1	24X48	8.0
I-45	4500	1	36X48	12.0
I-60	6000	1	36X60	15.0
I-70	7000	1	36X72	18.0
I-80	8000	1	36X84	21.0
I-90	9000	2	36X48	24.0
I-120	12000	2	36X60	30.0
I-140	14000	2	36X72	36.0
I-160	16000	2	36X84	42.0
I-60	6000	1	48X48	16.0
I-80	8000	1	48X60	20.0
I-95	9500	1	48X72	24.0
I-110	11000	1	48X84	28.0
I-120	12000	2	48X48	32.0
I-160	16000	2	48X60	40.0
I-190	19000	2	48X72	48.0
I-220	22000	2	48X84	56.0

⬜	24" height Heat Exchanger
🟩	36" height Heat Exchanger
🟨	48" height Heat Exchanger

Use equation 2 to determine the direct leaving air-temperature. Point C on psychometric chart.

EQUATION 1

Tl = Tedb-(Tedb-Tewb) X EFFI

TI : The dry-bulb temperature of air leaving the indirect heat exchanger

Tedb: The dry-bulb temperature of air entering the indirect heat exchanger

Tewb: The wet-bulb temperature air entering the wet side

EFFI: The efficiency of the indirect heat exchanger from curve 1

TI : 104-[(104-69) x 0.665]

TI : 80.7 °F

EQUATION 2

Td = TI-(TI - TIWb) x Effd

Effd= The efficiency of direct evaporative media from curve 2

Td: The dry-bulb temperature of air leaving the direct section

TI: The dry-bulb temperature of air leaving the indirect section

TI wb: The wet-bulb temperature of air leaving the indirect section

Td= 80.7-[(80.7-61.9) X 0.90]

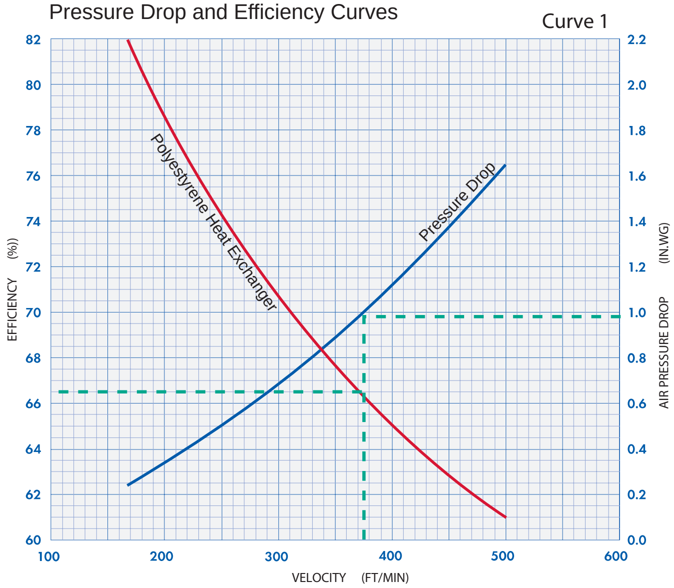
Td= 63.9°F

NOTE: 12" Direct media used in example.

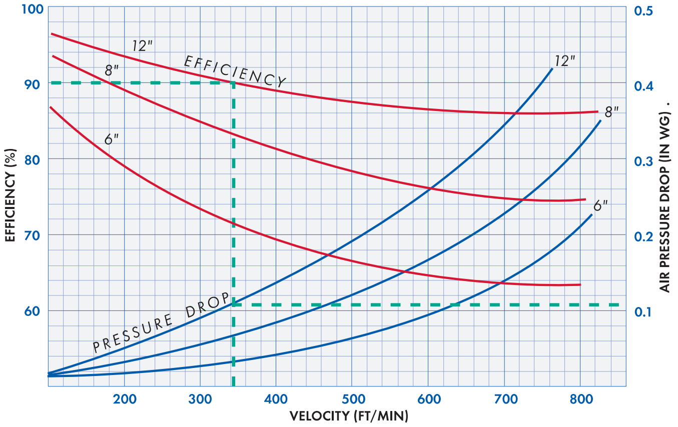
Effects of Air Density

Efficiency and pressure drop of Heat Exchanger is dependent on air density changes. Use following equations to calculate efficiency and pressure drop at higher elevations.

Indirect Evaporative Heat Exchanger
Pressure Drop and Efficiency Curves



Direct Evaporative Media
Pressure Drop and Efficiency Curves



Eff= Es+(ds - d) X K1

Eff: Efficiency at higher elevation, percent %
Es: Effciency at sea level, percent %
ds: Density of air at sea level 0.0725 lbm/ft3
d: Density of air at higher elevation lbm/ft3
K1: Constant 344.6

P= Ps - (ds - d) x K2
p: Pressure drop at higher elevation In. Wg.
Ps: Pressure drop at sea level In. Wg.
K2: Constant 12.31

Step 5

From curve 1 at air velocity of 375 ft./min., the pressure drop through the heat exchanger is 1.0" (Note that this pressure drop represents only the loss through the indirect heat exchanger). Add the pressure drop through dirty filters (which typically ranges from 0.5 to 0.7 in.) to obtain the total pressure drop through the unit.

Step 6

From Curve 2 at the air velocity of 375 ft./min., the direct evaporative efficiency (Effd) for 12" media is 90%.

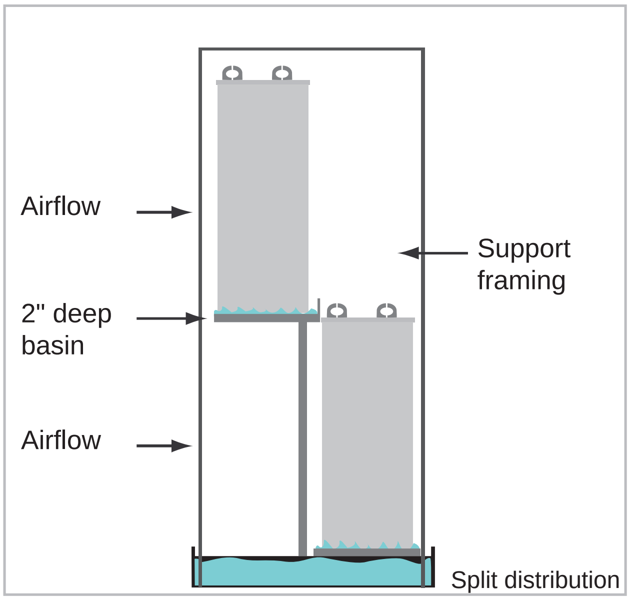
Since direct evaporative cooling is an adiabatic process, the wet-bulb temperature remains constant. From Curve 2 at air velocity of 375 ft/min., the pressure drop through the direct evaporative section for a 12" thick media is 0.11 in.Wg. Add pressure drop through the indirect heat exchanger and dirty filters to obtain the total pressure drop through the unit.

If the addition of moisture to the supply-air stream is not desired, a supplemental cooling coil may be added in lieu of the direct evaporative cooling section.

During high ambient dry-bulb conditions, a third stage of refrigeration could be added to provide the required supply-air temperature. At reduced ambient conditions, either one or both of the evaporative stages will satisfy the required supply air temperature.

Humidification Control

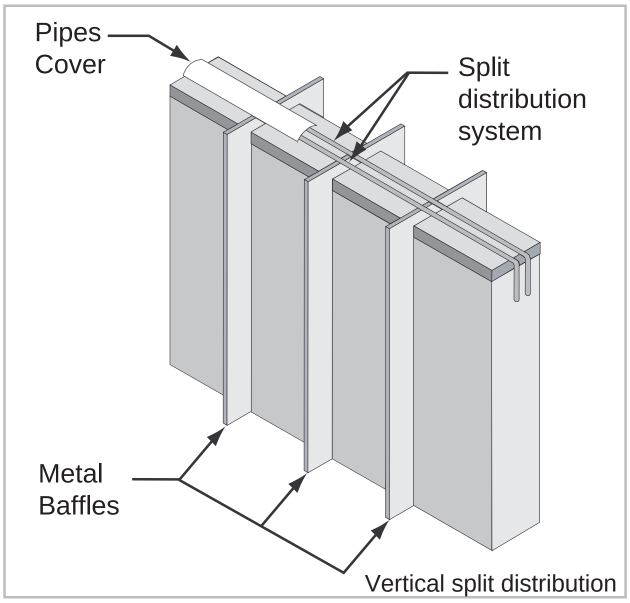
Staged systems can be very hard on the media. Once the humidity demand is met, the water supply is turned off. If the on and off point are set too close, the water will turn on to partially wet the pads then quickly turned off. After hundreds of these on/off cycles per day, the pads build up with minerals which may cause them to become heavy and collapse. The following are three ways to circumvent this problem.



Split distribution

Split Distribution

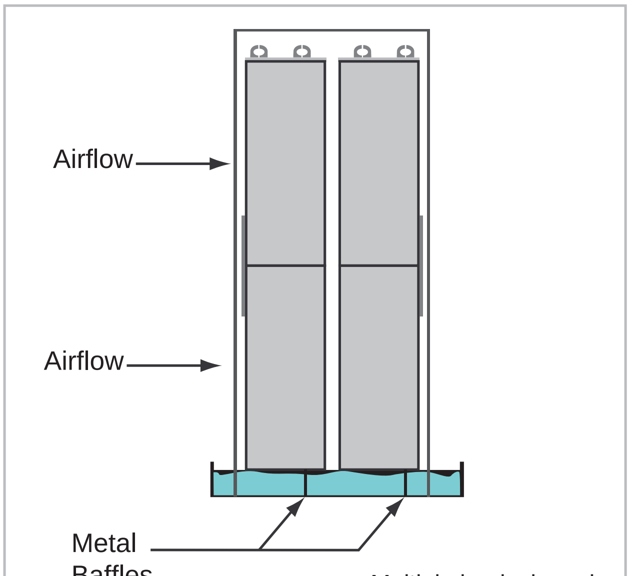
Designing the system with shorter pads using the split distribution system allows the water to drain out the bottom of the pad after traveling a shorter distance. In tall-pad systems, the drain water may come quite concentrated with minerals, due to evaporation during the time it travels from top to bottom of the pad. In some cases, the water may completely evaporate before it reaches the bottom. Both of these conditions should be avoided, as they severely shorten the service life of the media. For staged systems, the CELdek or GLASdek should have a separate water distribution system at least every six feet of height.



Vertical split distribution

Vertically Split Distribution

Vertical split banks are used for applications requiring exact humidity or temperature control. Commonly, water is supplied to every other pad along a bank of media using separate distribution headers. As the demand for humidification increases, the rest of the pads are supplied with water as well.



Multiple banks in series

Multiple Banks in series

Usually the media is installed two or three banks deep in the airflow direction. The media is either four or six inches deep, depending on the required evaporative efficiencies of media.

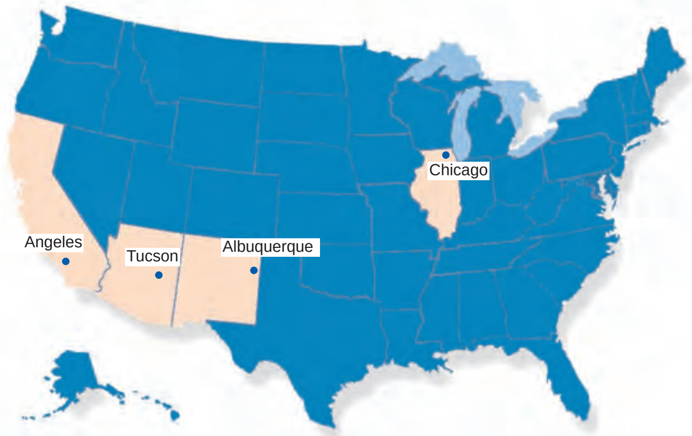
Each bank may or may not be vertically split.

Geographical Differences

The ASHRAE 1993 Fundamentals Handbook, chapter 24, shows design dry-bulb conditions on a 1%, 2.5%, and 5% basis for most major U.S. cities. An examination of these conditions shows that the 1% mean coincident wet-bulb temperature in the western states ranges from 59°F to 73°F Evaluating two-stage evaporative system operation at these conditions shows leaving-air temperatures ranging from 52° to 70°F. These areas are excellent for application of two and three stage systems and will show significant energy reduction with little or no refrigeration required.

An evaluation of weather data and hours of cooling shows that the vast majority of operational hours are at reduced or partial load conditions where the ambient dry-bulb and wet-bulb temperatures are lower than design. The resultant supply-air temperature of the two-stage evaporative system is also lower. At these conditions the need for refrigeration is eliminated or greatly reduced.

Independent computer studies evaluating the operation of systems in the following geographical areas show that the two-stage evaporative system will accomplish certain percentages of the total annual ton hours.



% Ton hours of cooling replaced by two stage system

Albuquerque	69%
Chicago	42%
Los Angeles	54%
Tucson	63%

Evaporation Rate

Water flow over the pad is determined by top surface area, regardless of height. For good wetting and flushing, a range of 1.0 to 1.5 gallons per minute per square foot of top surface area is recommended. Thus, regardless of the volume of water supplied at the top, at least 1.0 GPM per square foot of top surface area should drain at the bottom.

The following equation estimates the rate of water evaporation. For exact values use the psychometric

GWE: CFM (EDBT-LDBT)/10,000

GWE: Gallons of water evaporated/hr

EDBT : Entering dry-bulb temperature

LDBT : Leaving dry-bulb temperature

Cost Effectiveness

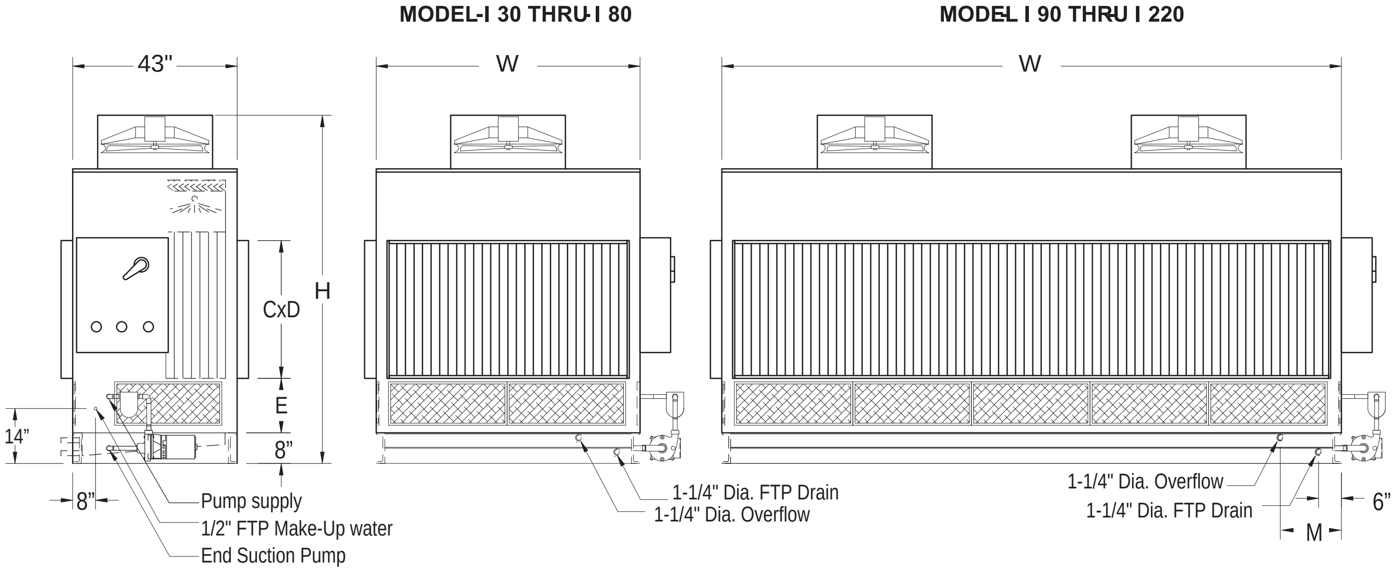
When comparing the initial cost of a conventional system to evaporative two and three-stage systems, the cost increase to incorporate the evaporative system can be offset by decrease in cost of conventional refrigeration, as well as a decrease required in first cost of the electrical power service.

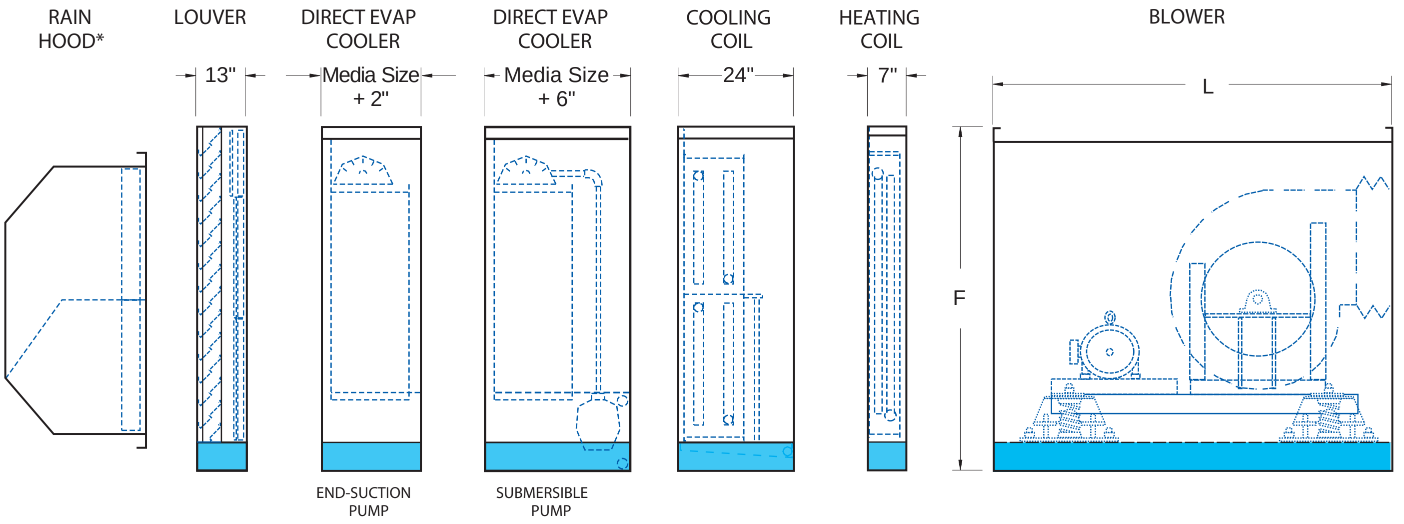
Maintenance

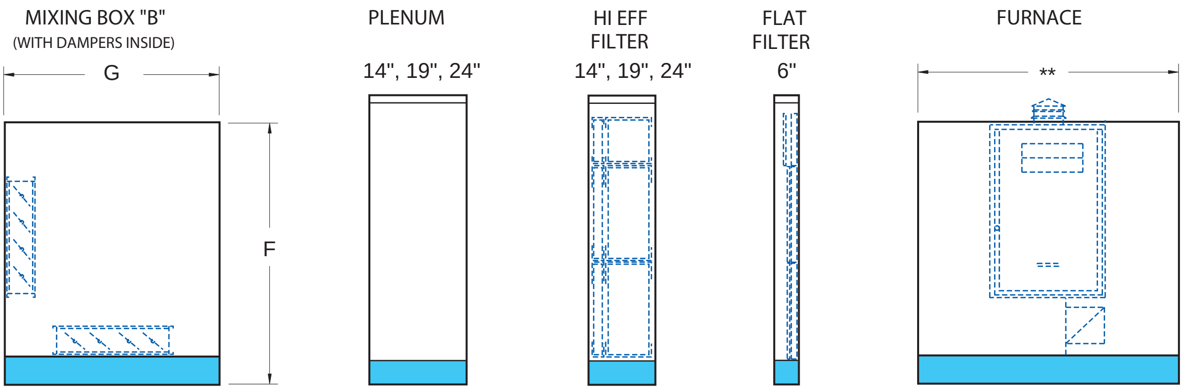
Equipment that utilizes water will require regular preventive maintenance. The need for treatment would only apply to those areas where the make-up water has high concentrations of dissolved solids.

The primary maintenance requirements for an evaporative cooling system are cleaning and flushing of water sumps on a scheduled basis. In areas where algae is prevalent, simple algaecide conditioning may be required. As an alternative, Energy Labs offers an automatic flush cycle, which minimizes the need for chemical water treatment.

Unit Drawings







* Rain hood and filters should be provided on inlet of all indirect units.
** Section length with gas furnace vary from brand to brand, contact your sales representative.
19" plenum with access door should be provided between heat exchanger and coil section.

Indirect Evaporative Cooling Data

		Heat Exhachanger		Face Area	Prefilter				Wet Side Filter				Max Coil	Direct Section	Wet Side Fan			Pump
Model	Nominal CFM	QTY	H x W	SQ FT	QTY	SIZE	QTY	SIZE	QTY	SIZE	QTY	SIZE	HxW	HxW	QTY	SIZE	HP	HP
I-30	3000	1	24x48	8.0	2	24x24	-	-	2	11-3/4 x 28	2	11-3/4 x 24	24x36	24x48	1	24	1/2	1/2
I-45	4500	1	36x48	12.0	2	24x24	2	24x12	2	11-3/4 x 28	2	11-3/4 x 24	36x36	36x48	1	24	1/2	1/2
I-60	6000	1	36x60	15.0	3	20x20	3	16x20	2	11-3/4 x 28	2	11-3/4 x 30	36x48	36x60	1	30	3/4	1/2
I-70	7000	1	36x72	18.0	3	24x24	3	24x12	2	11-3/4 x 28	2	11-3/4 x 37-1/2	36x60	36x72	1	30	3/4	1/2
I-80	8000	1	36x84	21.0	2	24x20	6	20x20	2	11-3/4 x 28	3	11-3/4 x 28-1/2	36x72	36x84	1	30	1.0	1/2
I-90	9000	2	36x48	24.0	4	24x24	4	24x12	2	11-3/4 x 28	4	11-3/4 x 24-3/4	36x84	36x96	2	24	1/2	3/4
I-120	12000	2	36x60	30.0	5	24x24	5	24x12	2	11-3/4 x 28	4	11-3/4 x 31	36x108	36x120	2	30	3/4	3/4
I-140	14000	2	36x72	36.0	6	24x24	6	24x12	2	11-3/4 x 28	5	11-3/4 x 31	36x132	36x144	2	30	3/4	3/4
I-160	16000	2	36x84	42.0	4	24x20	12	20x20	2	11-3/4 x 28	5	11-3/4 x 35	36x156	36x168	2	30	1.0	3/4
I-60	6000	1	48x48	16.0	4	24x24	-	-	2	11-3/4 x 28	2	11-3/4 x 24	48x36	48x48	1	30	3/4	1/2
I-80	8000	1	48x60	20.0	4	24x24	2	24x12	2	11-3/4 x 28	2	11-3/4 x 30	48x48	48x60	1	30	1.0	1/2
I-95	9500	1	48x72	24.0	6	24x24	-	-	2	11-3/4 x 28	2	11-3/4 x 37-1/2	48x60	48x72	2	24	1/2	3/4
I-110	11000	1	48x84	28.0	6	24x24	2	24x12	2	11-3/4 x 28	3	11-3/4 x 28-1/2	48x72	48x84	2	30	3/4	3/4
I-120	12000	2	48x48	32.0	8	24x24	-	-	2	11-3/4 x 28	4	11-3/4 x 24-3/4	48x84	48x96	2	30	3/4	3/4
I-160	16000	2	48x60	40.0	10	24x24	-	-	2	11-3/4 x 28	4	11-3/4 x 31	48x108	48x120	2	30	1.0	3/4
I-190	19000	2	48x72	48.0	12	24x24	-	-	2	11-3/4 x 28	5	11-3/4 x 31	48x132	48x144	2	30	1.0	3/4
I-220	22000	2	48x84	56.0	12	24x24	4	24x12	2	11-3/4 x 28	5	11-3/4 x 35	48x156	48x168	2	30	1-1/2	3/4

Dimensions and Weights

												L Dimension			Weights (LB)				
															Indirect Section		Direct Section		Hood
Model	C	D	E	F	G	H	J	K	M	W	Max DWDI Fan	Motor on Side	Motor Behind	Max Motor Frame	Shipping	Operating	Shipping	Operating	Qty
I-30	24	50-3/4	22-1/4	60	24	84	13	32	24	55	135	50	66	256T	956	1139	135	258	1
I-45	36	50-3/4	22-1/4	72	30	96	19	32	36	55	165	56	74	286T	1080	1263	168	293	1
I-60	36	63-1/2	22-1/4	72	30	96	19	43	36	68	182	58	76	284T	1239	1468	207	361	1
I-70	36	78-1/4	22-1/4	72	30	96	25	38	36	83	182	58	76	284T	1440	1723	250	436	1
I-80	36	89	22-1/4	72	30	96	25	42	36	93	222	68	86	324T	1581	1902	282	494	1
I-90	36	102-1/2	22-1/4	72	30	96	25	48	40	107	245	77	90	324T	1902	2272	321	564	1
I-120	36	128	22-1/4	72	30	96	25	64	36	132	270	70	94	326T	2196	2658	396	697	1
I-140	36	158	22-1/4	72	30	96	25	76	36	162	270	70	94	326T	2589	3159	485	854	2
I-160	36	179	22-1/4	72	30	96	25	86	40	183	270	70	94	326T	2865	351 1	547	964	2
I-60	48	50-3/4	22-1/4	84	30	108	19	43	48	55	182	58	76	284T	1236	1419	203	328	1
I-80	48	63-1/2	22-1/4	84	30	108	25	82	48	68	222	68	86	324T	1397	1626	249	402	1
I-95	48	78-1/4	22-1/4	84	30	108	25	48	48	83	245	70	90	324T	1762	1044	302	489	1
I-110	48	89	22-1/4	84	30	108	25	60	48	93	270	70	94	326T	1882	2203	340	552	1
I-120	48	102-1/2	22-1/4	84	30	108	25	64	48	107	270	70	94	326T	2067	2437	388	631	1
I-160	48	128	22-1/4	84	30	108	25	86	48	132	300	76	102	364T	2456	2918	480	780	1
I-190	48	158	22-1/4	84	36	108	31	83	48	162	330	80	106	365T	2923	3493	586	958	2
I-220	48	179	22-1/4	84	36	108	31	96	48	183	330	80	106	365T	3290	3963	662	1079	2

⬜	Cabinet dimension for 24" height Heat Exchanger
🟩	Cabinet dimension for 36" height Heat Exchanger
🟨	Cabinet dimension for 48" height Heat Exchanger

Heat Exchanger material

🟦 High Impact Polystyrene (ETL Approved)

Energy Labs Products

Custom Air Handling Units

Capacities from 500 to 200,000 CFM; With Chilled water
Glycol
DX
Hot water
Steam coils

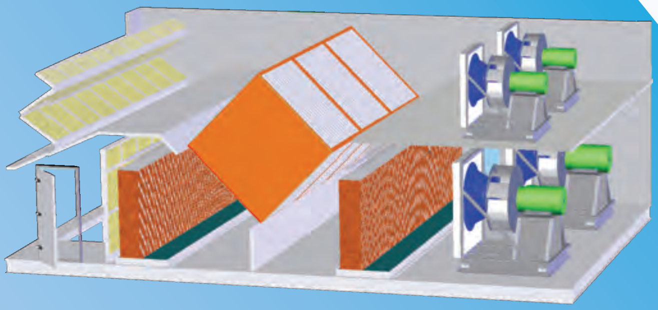
Thermal Break construction
Hi Efficiency injected foam panels.
Capacities from 500 to 200,000 CFM.

Indirect / Direct Evaporative Cooling Systems

Capacities from 2,000 to 100,000 CFM.
304 stainless-steel housing.
High efficiency air to air heat exchanger.

Energy Recovery Systems

With Heat Exchangers or Heat Wheels.



Custom Air Cooled DX Units

Air cooled condensing units are available from 15 to 300 tons.
Integrated controls.
R410a and R134a refrigerants.
Copeland Scroll
and screw compressors.

Custom Evap. Condensing Units

Available from 50 to 300 tons.
Integrated controls.
R410a and R134a refrigerants.
Copeland Scroll and screw compressors.

B-Evap-0112

For more information including detailed product specifications, and specific requirements for special applications, please contact your local sales representative.

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