DEHUMIDIFICATION THAT WORKS

Engineering Guide
ClimatePak® VHR

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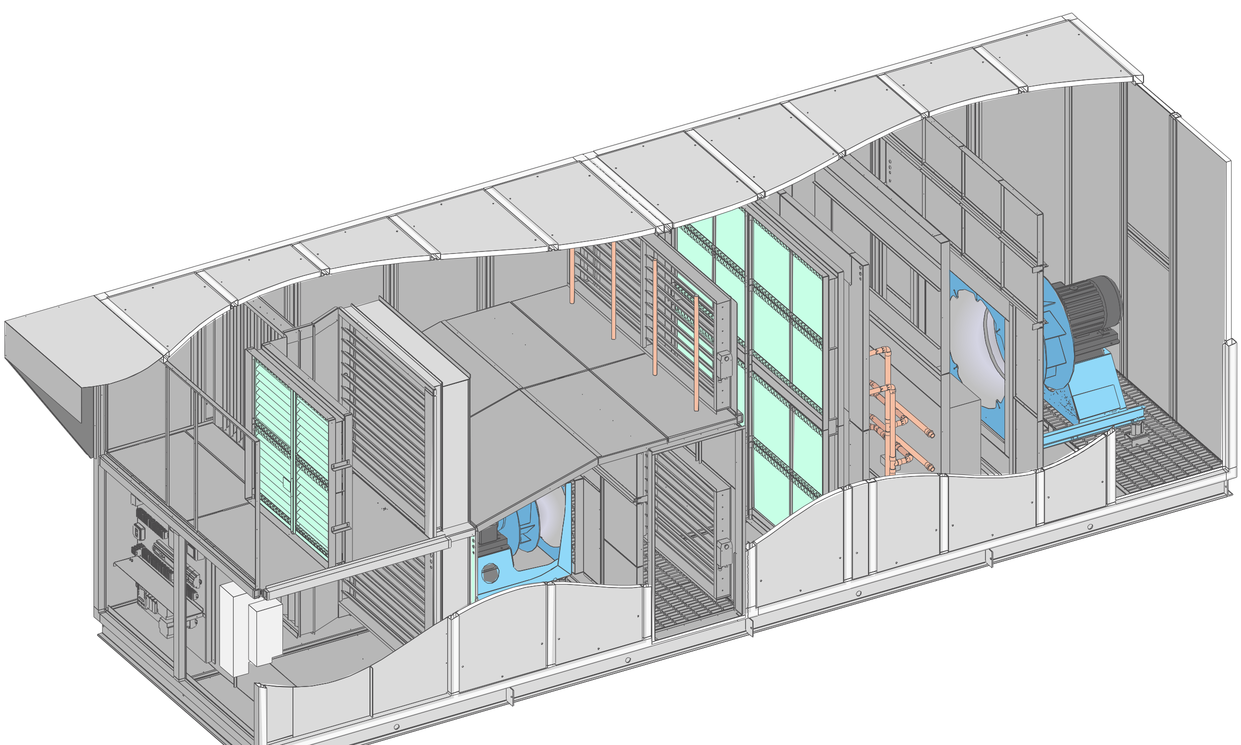

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3491 Industrial Drive
York, Pennsylvania 17402 USA
800-959-7725 Fax 717-757-5085
 DOC# EGW04-VHR-EG-20160816

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SECTION I: INDOOR POOL APPLICATION

Introduction

Creating an Ideal Environment for Indoor Pool Facilities

Indoor pool facilities are unlike any other structure in design, construction and maintenance requirements. Humidity, air and water temperatures are especially difficult to control, and improper management usually results in an uncomfortable environment, excessive operating costs and possibly serious structural damage. Effectively controlling these special conditions requires control hardware and control sequences specially engineered for large commercial indoor pool applications. The ClimatePak® System utilizes an environmental control package designed to meet all special needs of the indoor pool environment, while reducing energy usage and building maintenance costs.

Operating Cost

Energy consumption is a direct function of the variables necessary to satisfy the occupant and protect the facility. These variables include space heating and cooling, water heating, humidity removal and ventilation. Maintaining ideal and precise environmental conditions has a fairly high cost of operation. A majority of the indoor pools, regardless of geographic location, require water and space heating 70% to 90% of the year.

Application

Moisture Loads

An indoor swimming pool produces large quantities of water vapor through evaporation, which accounts for roughly 95% of the pool water heat loss, making the water colder. This excessive humidity will form damaging condensation unless removed from the building. In the past, the method of removing this water vapor was by ventilating an otherwise energy efficient building, exhausting the humid air and the energy it contained. Additional energy was used to bring in and heat the make-up air and to heat the pool water.

More cost effective technologies offer an alternative method adding heat exchangers and mechanical heat recovery systems with many useful options. The ideal solution to removing the water vapor from the pool area is to convert the latent (wet) heat contained in the moist air back into sensible (dry) heat, placing it back into the pool water and air.

Effects of Moisture

Excess humidity in natatorium structures may be readily apparent as condensation on cool surfaces such as windows and outside doors, the growth of mildew or mold, and, when coupled with poor pool chemistry, the accelerated corrosion of metals. In its less obvious forms, moisture may penetrate walls and ceilings and cause rot that becomes noticeable only when large scale structural failure occurs. Humidity levels are also a major factor in the comfort of pool users.

Indoor Air Quality

Pools and water parks with water features have a higher evaporation rate than a standard pool because of the increased water surface area. Chloramines (See *Pool Water Chemistry* on the next page), which are present in the water, become more concentrated in the air as the "water to air" interactions increase, affecting the indoor air quality. A strong "chlorine" odor is an indicator of poor pool water chemistry, and is generally offensive to the occupants. Higher levels of chloramines can cause skin/eye irritation and respiratory problems commonly known as "lifeguard lung". Most poolrooms are designed with a minimum ventilation rate to dilute the airborne pollutants generated from the chemical interactions in the pool water. Typically these rates are based on ASHRAE standard 62.1 and dictated by local codes at about 0.5 CFM per square foot of pool and deck area, but depending on the pool water chemistry the ventilation rate may not always be adequate for good poolroom indoor air quality.

However, increasing ventilation rates can significantly add to the cost of operation. Energy conservation strategies, such as heat recovery, airflow measurement, and CO2 based ventilation control help control costs while improving indoor air quality. Depending on the geographic location and season of the year, treating the outside air has a direct effect on energy consumption. Some facilities prefer higher than minimum ventilation rates, up to 100% of OA, to maximize indoor air quality, but the cost of treating this air can be significant.

Occupant Comfort

Occupant comfort in a natatorium is easy to understand. If you ever swam in an outdoor pool on a cold, windy day or exited a pool in a dry, desert location you will probably notice an immediate chill. The opposite is true where high humidity is not adequately controlled either through ventilation or by mechanical means. The moisture level can reach such a state where it is oppressive or stuffy. Common complaints are difficulty in breathing and the room being perceived to be warmer than the actual dry bulb temperature would suggest.

Regardless of the source of discomfort, users will not enjoy the facility if water/air temperatures and humidity levels are not within a narrow range. Ideal water temperature is around 82°F with the air temperature about 2°F higher to prevent chilling when exiting the pool and to minimize evaporation from the pool surface. Here are some recommended temperatures for poolrooms, which can be adjusted to meet specific needs of bathers. In general, "active" poolrooms are maintained at lower temperature ranges so the users don't overheat, warmer temperatures are more common for seniors or children or less active pools.

The desirable humidity range is generally between 50 and 60% (see Table 1-1). Greater than 60% creates a sticky feeling and/or difficult breathing. Low humidity results in evaporative cooling on the bather's skin, resulting in a chill. Poor air movement caused by improper duct placement within the poolroom will also lead to occupant discomfort. Excessive supply air blowing on bathers can create drafts, while uneven air distribution may create stagnant zones within the space.

Table 1-1. Typical Pool Water & Air Temperature Set-Points

POOL TYPE	WATER TEMP (°F)	AIR TEMP (°F)	ROOM RH %
Recreational Pool	80 to 85	Water Temp + 2	55 to 60
Therapy Pool	86 to 92	86[1]	55 to 60
Whirlpools	99 to 104	86[1]	55 to 60

[1] Normally max 86°F to minimize overheating of occupants

Pool Water Chemistry

Proper water chemistry (Table 1-2) in swimming pools is critical for the health of the bathers and the condition of the enclosure and components. An enclosure with poor water chemistry has a noticeable “chlorine” smell, which is an indication of high chloramine levels in the air. Not only does this have an effect on the water, but it affects the bathers and the air they breathe.

Table 1-2. Recommended Pool Water Chemistry

	POOL			SPA		
	IDEAL	MIN	MAX	IDEAL	MIN	MAX
Total Chlorine (ppm)	1.0 - 3.0	1	3	3.0 - 5.0	1	10
Free Chlorine (ppm)	1.0 - 3.0	1	3	3.0 - 5.0	1	10
Combined Chlorine (ppm)	0	0	0.3	0	0	0.3
Bromine (ppm) if applicable	2.0 - 4.0	2	4	3.0 - 5.0	2	10
pH	7.4 - 7.6	7.2	7.8	7.4 - 7.6	7.2	7.8
Total Alkalinity (ppm)	80 - 100	80	180	80 - 100	60	180
TDS (ppm)	1000 - 2000	300	3000	1000 - 2000	300	3000
Calcium Hardness (ppm)	200 - 400	150	1000	200 - 400	150	1000
Calcium Acid (ppm)	30 - 50	10	100	30 - 50	10	100

Dehumidification/ventilation equipment is not designed to remedy the effects of poor pool chemistry, but is designed to deliver prescribed ventilation to manage smaller amounts of pollutants generated from normal pool activity. Pool water chemistry is a part of daily maintenance and it is recommended that the users follow the current National Spa and Pool Institute standards. For more information, see the PoolPak® Educational Library article *Indoor Pool Water Chemistry*.

Equipment Choices

Overview

There are several methods for controlling humidity, temperature and ventilation in poolrooms. Each method offers some level of control, but there can be significant differences in first cost and operating cost of each method. Geographic location, degree of comfort, unit cost and operational cost must be evaluated in the selection of the correct system.

Ventilation with Heating

- Moisture removal is accomplished through dilution with dryer outside air
- High cost of operation (air reheating)
- Lowest first cost
- No opportunity to recover energy in the exhaust airstream
- No opportunity to recover energy into the pool water
- No integral cooling capability
- Summer space conditions can be unbearably hot and humid

Ventilation with Heating and Energy Recovery (VHR)

- Moisture removal is accomplished through dilution with dryer outside air
- Significant heat recovery from exhaust air stream
- Cost-effective method but with modest operating cost
- Performance limitations in humid areas or during summer peaks
- No opportunity to recover energy into the pool water
- No integral cooling capability

Mechanical Dehumidification

- Moisture removal is accomplished through mechanical refrigeration
- Significant heat recovery using "heat pump" technology
- Recovers the most energy from the exhaust airstream
- Offers an opportunity to recover energy into the supply airstream
- Offers an opportunity to recover energy into the pool water
- Higher first cost with lower operating cost
- No performance limitations based on location
- Tightest control of setpoint conditions
- Integral cooling capability
- Can be integrated to include appropriate ventilation strategies

Hybrids

- Combines various technologies to increase efficiency and capability
- Utilizes ventilation as primary dehumidification method
- Switches to heat pump method when conditions require better environmental control

Other Technologies

Desiccant technology can be adapted to provide super dry air which is injected into the poolroom to dilute the moisture load. The regeneration phase of the desiccant is typically driven by waste heat from refrigeration cycle or other fossil fuel.

Wheels are sometimes considered because of their wide acceptance as heat recovery devices. Latent or Enthalpy wheels are not suitable for pools, but sensible wheels may have application.

Room Air Distribution

All PoolPak® models provide continuous air recirculation, and with a good air distribution system, will promote uniform space conditions. To remove the required moisture and maintain controlled conditions, it is essential that there be adequate air movement and distribution in the natatorium. The unit must remove the humid air from the pool area and discharge the dehumidified air back into it. The supply air should be distributed over areas subject to condensation (windows, outside walls, support trusses, skylights, etc.).

Air-Side Design

The supply air volume and external static pressure capability of the fan is given for each model in the Performance Section. It is recommended that an experienced engineering or mechanical contracting firm do the design, sizing and layout of the duct system.

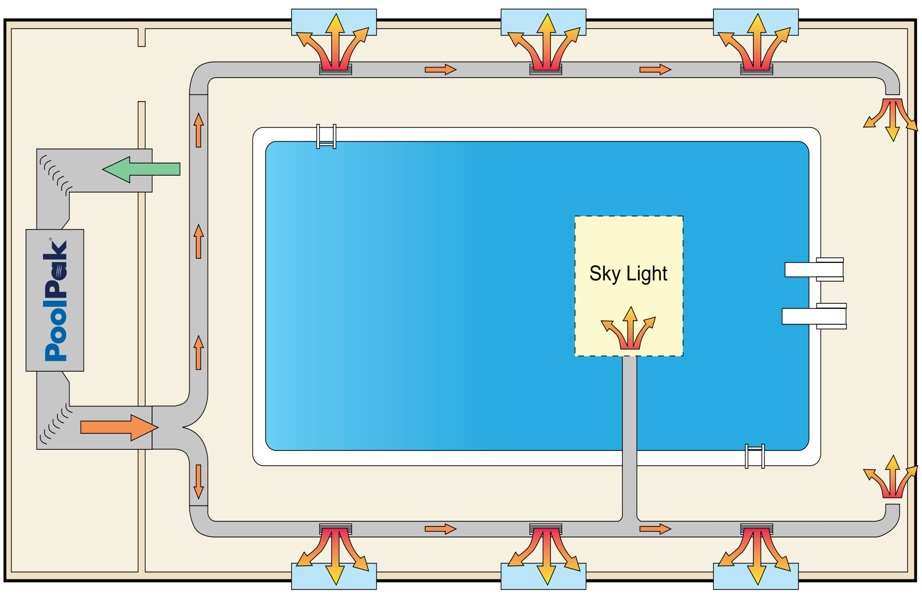
The recommended volume of supply air should provide three to eight air changes an hour. However, in larger waterparks or spaces with high sensible heat gain, higher airflows may be appropriate. Lower air volumes require more care to avoid short cycling the air between the return and supply, air stratification and pockets of high humidity.

The most even control of space conditions occurs with proper air distribution and a proper air flow rate. This provides space control without excessive loading and unloading of refrigerant-based dehumidification equipment.

SUPPLY AIR

After dehumidification, dry air is supplied back to the room. Supply air should be distributed from ducting around the perimeter (see Figure 1-1) of the space. The two options for perimeter supply air distribution are overhead (see Figure 1-2) or below grade (see Figure 1-3).

Figure 1-1. Perimeter Air Distribution



The warm, dry air should be directed over outside walls, windows and other surfaces susceptible to condensation. Supply ducts should be as short and with as few turns as possible. Use turning vanes to minimize air noise and static pressure drop.

Recommended maximum supply duct air velocity is 1000 FPM. The recommended velocity from diffusers is 300 to 500 FPM. Air velocities in ducts should be kept as low as is reasonable to avoid excessive noise in the ducts. In multiple unit installations, supply air from each unit may go into a common supply duct or into a plenum. The duct should be attached with a flexible connection to minimize vibration transmission.

RETURN AIR

The unit will operate most efficiently in a natatorium where the supply and return openings are placed diagonally opposite each other. All ducting should be done in accordance with acceptable practices. Return air ducts in the section just prior to entering the unit return air opening and elbows in both the return and supply air ducts must comply with the guidelines set forth in SMACNA HVAC Duct Construction Standards Metal and Flexible – Third Edition, Chapter 4.

DUCTWORK DESIGN

All supply and return duct work to the unit should be installed such that no condensate occurs on the duct work. Duct turns and transitions must be made carefully to keep friction losses to a minimum. Duct elbows should contain

Figure 1-2. Overhead Air Distribution

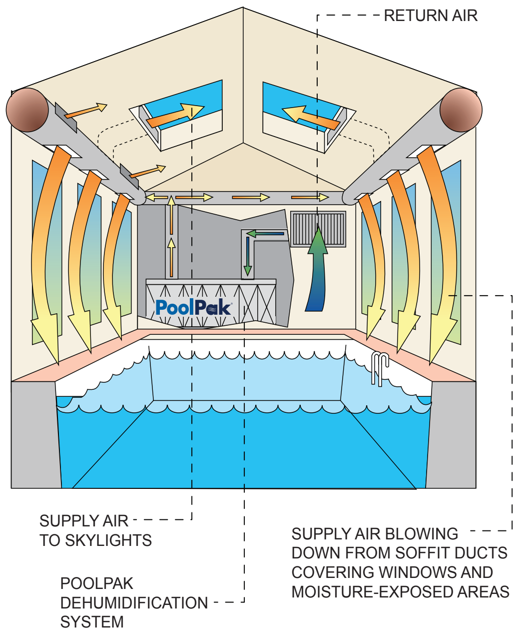
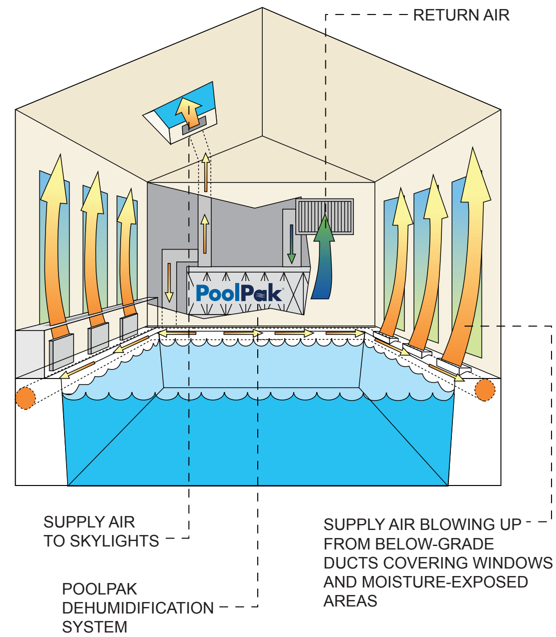


Figure 1-3. Below Grade Air Distribution



splitters or turning vanes and avoid short radius fittings. Duct work that is connected to the fan discharge should run in a straight line with proper transitions, and minimum distances to elbows as recommended by SMACNA and should not be reduced in cross-sectional area. Never deadhead the fan discharge into the flat side of a plenum.

Duct work attached to the ClimatePak® unit return air connection must be done in accordance with SMACNA recommended standards and /or generally accepted industry practice.

Supply and return duct work should have all seams sealed before applying insulation to the exterior of the duct work. The insulation's seams must be sealed, wrapped, and mastic coated. Use of pre-insulated duct work (interior) is acceptable if it meets local codes; however, all seams must be sealed prior to startup.

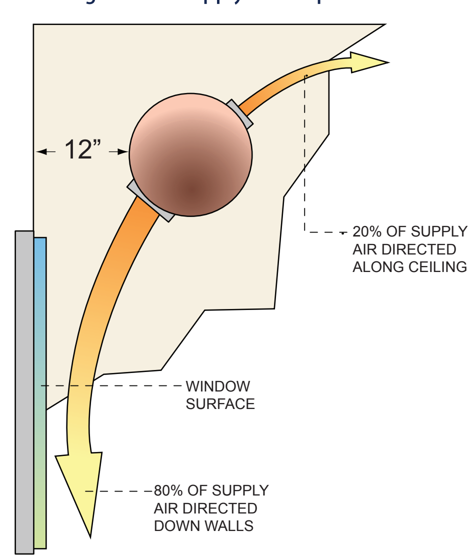
AIR DISTRIBUTION

Supply outlets and return grilles should be carefully placed to avoid short-circuiting in the space. Short-circuiting creates stagnant areas where humidity and temperatures may build up to undesirable levels, reducing the effectiveness of the ClimatePak® system. Return grilles can be placed high in the space to reduce return ductwork, however removal of chloramines from the occupied area has become much more of a design consideration and so low returns are favored by poolroom designers.

Supply air should be directed 45 degrees up and down (most of the air will be directed downward) toward exterior walls, windows, skylights, and other areas where stagnant conditions could cause humidity buildup and condensation problems or drafts (see Figure 1-4). The end result of the supply air ducts is to wash the surfaces of the pool room that are prone to condensation with the warm, dry supply air.

Diffusers for supply ducts located overhead (as opposed to under the deck) must be sized such that the supply air will be thrown all the way to the deck and wash the entire wall surface from supply duct to the floor.

Figure 1-4. Supply Air Proportions



As a rule, directing the supply air at or across the pool surface increases the evaporation rate. To control the buildup of chloramines at the surface of the pool, some air may be directed at the pool surface. Supply outlets should not discharge directly onto surfaces where drafts may be created that will blow on swimmers walking along the edges of the pool. Spectators should have supply air directed toward their faces.

AIR CONNECTIONS TO CLIMATEPAK®

ClimatePak® outside air intake and exhaust air openings may have rain hoods if the unit is mounted outdoors. Rain hood locations are illustrated on the unit arrangement drawings. The intake and exhaust should be screened to prevent the entrance of foreign matter and arranged to avoid recirculation of exhaust and outside air. Also, when auxiliary gas heat is selected (in an outside installation), a combustion air louver or rain hood is provided.

Supply, return, outside, and exhaust air ductwork connections over 5 feet long must be supported to avoid damage to unit. Short, flexible connections of rubber or canvas can be made between the return duct and the unit to eliminate vibration transmission through the duct.

PoolPak® International does not recommend the use of equipment rooms or locker rooms as return or supply air plenums due to the potential of corrosion for components installed in the room. The return air duct should always connect the pool enclosure to the return air connection of the ClimatePak® unit(s).

OTHER AIR-SIDE CONSIDERATIONS

A duct heater (hot water coil, electric, or gas) may be installed in the supply duct to provide auxiliary space heating. Be sure that the additional air pressure drop across the heater is accounted for in the unit fan selection. These heating components must be designed for use in swimming pool environments.

Maintain the poolroom at a slightly negative pressure. This will minimize moisture and chemical odor migration to other spaces. The exhaust fan should be sized for about 5-10% greater CFM than the amount of outside air being introduced into the space. Ducts can be fabric, aluminum, PVC, or galvanized steel. Even though “dry air” is being supplied back to the pool, do not use duct board or similar materials. If the ClimatePak® unit is installed in an area that is below the natatorium’s dew point temperature, the ducts may require insulation, pitching and drainage.

Continuous vapor barriers are required between the poolroom and all other interior and exterior spaces because of the high dewpoint in the poolroom all the time. Care must be taken during design and installation to avoid gaps in the vapor barriers or building damage may result. For more information, see the PoolPak® Educational Library articles *Efflorescence, What Causes It and How Do You Remove It?* and *Vapor Barriers In Natatoriums*.

Windows and exterior doors must be selected with adequate thermal insulation (including thermal breaks) to minimize condensation on their interior surfaces even if the supply air is directed across these components. Doors and windows must also have as low an air leakage as possible. Although the space will be maintained at a slightly negative pressure, cold air leaking into the space from poorly sealed openings will negate all of the effects of good thermal insulation.

SECTION II: PRINCIPLES, FUNCTIONS AND FEATURES

Outside Air Dehumidification System

Moisture removal through dilution with outside air can be very effective. If Outside air has less moisture in it than pool hall, mixing the OA with pool hall air can reduce overall humidity. OA brought in to manage the humidity must be heated up to the pool hall temp to make it comfortable for bathers. To make room for this incoming air, the air already in the pool hall must be extracted.

The conventional heating and ventilation units are constant volume (once through) system that delivers a 100% of OA. A 100% of the pool hall air is exhausted to make room for the OA. When water is evaporated from the surface of the pool, heat is taken from the remaining water in the form of water vapor. A mechanical dehumidification system through a vapor compression cycle recovers and recycles this energy. A heating and ventilation unit exhausts and loss the heat with the escaping vapor. It is important to know that evaporation increases as the indoor dew point decreases and large quantity of low temp OA decreases the dew point of the room. OA quantity shall be minimized to avoid increased evaporation, which increases pool heating requirement.

The ClimatePak® relies on a sophisticated control system along with air measuring stations and air management system to maintain setpoint conditions through dilution with outside air. The ClimatePak® dramatically reduces energy costs by ensuring that the incoming outside air is monitored and controlled to the minimum consistent for avoiding condensation while recovering the waste heat from the exhaust air through its integral heat pipe and bypass damper heat recovery system. The ClimatePak® automatically performs the following functions:

- Dehumidification/Humidity Control
- Natatorium Space Heating with Auxiliary Heat
- Proper Ventilation
- Recovery of Reusable Heat from the Exhaust Air Stream
- Optional Natatorium Space Cooling
- Wall Condensate Prevention

A ClimatePak® (VHR) unit, with the outside air dryness and quantity matched correctly to the evaporation rate of the pool water, will efficiently maintain the pool air at relative humidity levels between 50 and 60%. However, there are times in all but the driest climate areas where the outside air humidity rises to levels such that the air will not provide enough dehumidification to completely meet desired conditions. In case such as these, operable windows, louvers, and/or supplemental exhaust fans are used to augment the ClimatePak® unit's airflow.

ClimatePak® VHR Operation

The primary function of the ClimatePak® VHR unit is to provide environmental control of an enclosed space through the use of dry outside air, heat pipe technology, and a sophisticated control system. Valuable heat in the return air (RA) air stream coming from a warm, humid enclosed space (such as an indoor swimming pool) is recovered for reuse. This return air is either exhausted (exhaust air- EA) or becomes recirculation air, is re-mixed with the pre-heated fresh outside air (OA), filtered and becomes usable supply air (SA) to the space thereby completing the cycle.

Air Management Operation

Dry outside air in the winter months for example, can at times be very dry. While high humidity is a problem with occupant comfort and protecting the building enclosure, poolroom humidity that is too low is also a problem. The pool evaporation rate will increase as the humidity drops which increase the cost of heating the pool water. Comfort becomes an issue as well because of the added evaporation from the bathers skin makes them feel colder than the actual water or air temperatures should make them feel.

The ClimatePak® measures the space humidity levels and can reduce outside air to match the dehumidification airflow as required for the space. The reduction in unnecessary outside air reduces the air heating load and fan energy, while controlling space humidity to desired levels. The Variable Frequency Drives (VFD) change the supply and exhaust fan volumes as needed based on operator adjustable setpoints, while maintaining desired room pressure.

Another design issue with poolrooms is containing the poolroom smell within the poolroom enclosure so it does not infiltrate to other spaces. The best way to control odors is to keep the poolroom enclosure under a slight negative pressure relative to the other spaces. One approach requires that the exhaust air fan be slightly larger than the supply fan. While this simple approach works well for most situations, there are times when wind pressure, open doors, or system deficiencies will compromise the pressurization strategy.

Another approach is to measure and control airflows using the pressure differential between the spaces. This approach has some limitations. Pressure control only work wells when you have tight spaces. Wind pressure on the building and open doors can contribute to a loss of room "tightness" which will signal a change to the fan supply and exhaust rates. Also finding a representative pressure for inside ad outside of the building is extremely difficult. The pressure differential measurement approach lacks the realtime airflow readings which could lead to over or under control of system airflow rates.

The ClimatePak® VHR is equipped with active airflow monitoring and control; a combination of digital airflow measuring stations and software controlling the fans to assure proper airflows and room pressure. As before, the Variable Frequency Drives (VFD'S) change the supply and exhaust fan volumes as needed based on operator adjustable setpoints. One of the advantages of this approach is that the airflows can be modulated to control differential airflow volumes while managing outside air to control humidity.

Vertical Heat Pipe Energy Recovery Operation

The ClimatePak® Ventilation and Heat Recovery (VHR) product provides a passive method of recovering wasted heat from the exhaust air stream. The passive energy recovery system is a closed thermo-siphon refrigerant cycle which efficiently exchanges heat without the need for pumps or compressors. The temperature difference between the two air streams is the engine that powers the system.

HOW IT WORKS:

Exhaust air is blown through the lower portion of the heat pipe coil where the cooler liquid refrigerant is "boiled" by the warmer exhaust air (This section of the heat pipe is referred to as the evaporator region). Vaporized refrigerant migrates up through the heat pipe into the upper portion where colder outside (ventilation) air cools the refrigerant vapor, condensing it to a liquid, in the process releasing reclaimed heat into the air (This section of the heat pipe is referred to as the condensing region. The heat pipe coils are stacked in a near vertical arrangement where gravity moves the refrigerant back to the starting position where the process continues. The arrangement raises the heat transfer efficiency because the refrigerant is returned to the evaporator section quicker because of the gravity.

As described before, the ventilation air heating load for a poolroom is significant, and so transferring much of the wasted exhaust air heat back into the outside air greatly reduces the cost of heating the outside air.

HEAT PIPE DAMPER CONTROL:

WINTER Heat Recovery

The warm exhaust air is filtered before entering the heat recovery section of the heat pipe coil and exhausted through the heat recovery damper bank. The liquid refrigerant in the sealed heat pipe is vaporized and migrates vertically up to the heat reclaim section of the heat pipe coil. The cooled exhaust air is then dumped to the outside.

The cold outside air enters through the heat recovery damper bank and is filtered before entering the heat reclaim section of the heat pipe coil. The refrigerant gas in the sealed heat pipe is condensed and drains vertically down to the heat recovery section of the heat pipe coil. The warmed outside air is then mixed with the poolroom return air in the unit.

Damper Positions:

- Exhaust Air Heat Pipe Recovery Section Damper is open.
- Exhaust Air Bypass Damper is closed.
- Recovery Air Heat Pipe Recovery Section Damper is open.
- Recovery Air Bypass Damper is closed.

WINTER Defrost
The warm exhaust air is filtered before entering the heat recovery section of the heat pipe coil and exhausted through the heat recovery damper bank. The liquid refrigerant in the sealed heat pipe is vaporized and migrates vertically up to the heat reclaim section of the heat pipe coil. The cooled exhaust air is then dumped to the outside.

The cold outside air enters through the heat recovery damper bank and bypasses the heat reclaim section of the heat pipe coil to melt any accumulated frost on the heat reclaim coil. The refrigerant gas in the sealed heat pipe is condensed and drains vertically down to the heat recovery section of the heat pipe coil. The cold outside air is not tempered with the heat pipe and is then mixed with the poolroom return air in the unit.

Damper Positions:

- Exhaust Air Heat Pipe Recovery Section Damper is open.
- Exhaust Air Bypass Damper is closed.
- Recovery Air Heat Pipe Recovery Section Damper is closed.
- Recovery Air Bypass Damper is open.

Summer Bypass
The warm exhaust air is filtered before entering the heat recovery section of the heat pipe coil and exhausted through the heat recovery damper bank. The liquid refrigerant in the sealed heat pipe does not vaporized or migrate vertically up to the heat reclaim section of the heat pipe coil because the heat reclaim section is warmer than the recovery section. The untreated exhaust air is then dumped to the outside.

The warm outside air enters through the heat recovery damper bank and bypasses the heat reclaim section of the heat pipe coil. The refrigerant gas in the sealed heat pipe does not condense or circulate down to the heat recovery section of the heat pipe coil. The untreated outside air is then mixed with the heat reclaim coil bypass air in the heat reclaim coil bypass air section. There is no recirculated air being mixed with the outside air.

Damper Positions

- Exhaust Air Heat Pipe Recovery Section Damper is open.
- Exhaust Air Bypass Damper is open.
- Recovery Air Heat Pipe Recovery Section Damper is closed.
- Recovery Air Bypass Damper is open.

ICCVHR Control Functions

Overview

The ClimatePak® is controlled by the Instant Control Center (ICCVHR), a microprocessor-based system that incorporates all of the functions necessary to maintain correct natatorium space temperature and humidity. The ClimatePak® controls automatically operate the dehumidification, heating, cooling economizer and heat recovery system in response to the natatorium requirement while adjusting unit outputs to maintain building conditions. The ClimatePak® controls are capable of providing proportional control of dehumidification and cooling by modulating open or close the outside air damper and exhaust fan speed as necessary.

All ClimatePak® operating and logic controls are factory mounted and wired. The control sequences are designed specifically to control swimming pool environmental conditions. The following is a brief description of the control functions available with the ICC Control System. For more detail or finding this information in the controller, see the VHR installation and Operation Manual (IOM).

Air Flow Monitoring and Control

The best way to control building pressure is by measuring and controlling airflow rates. The ClimatePak® system employs active airflow monitoring and control. Factory mounted VFD on the supply and exhaust fan to modulate airflow. The controller receives feedback from fan inlet measuring stations and outdoor air measuring stations to continuously monitor the outside air, exhaust air and supply airflow.

By tracking the airflow rate of the exhaust fan and outdoor air intake, a consistent building pressure can be maintained. See Figure 2-2 for reference. The ICC controller takes the outside air flow measurement and controls the speed of the exhaust fan. This control maintains a constant return airflow to supply airflow differential whether the system is operating at the minimum outdoor airflow or maximum outdoor airflow rate. Factory mounted and calibrated airflow measuring stations and control system provide another benefit which is that it can deliver precisely the airflow needed for balancing the dehumidification system which saves time. The air flow measuring system allows for easy and accurate verification and documentation for the amounts of air coming into and out of the building.

To determine the desired airflow rates, the controller must be programmed with setpoints for the desired supply air flow, the desired return airflow, the minimum outdoor airflow and, minimum mixed air temperature allowed. During minimum outdoor air ventilation, the controller controls the outside air and recirculation damper to maintain the minimum ventilation air requirement. During economizer mode or if maximum dehumidification is required, the controller modulates the outside air flow and exhaust airflow to maintain space conditions.

Humidity Control

The primary function of the ICC control system is humidity control. The ICC control system accomplishes humidity control by using the outside air or chilled water coil.

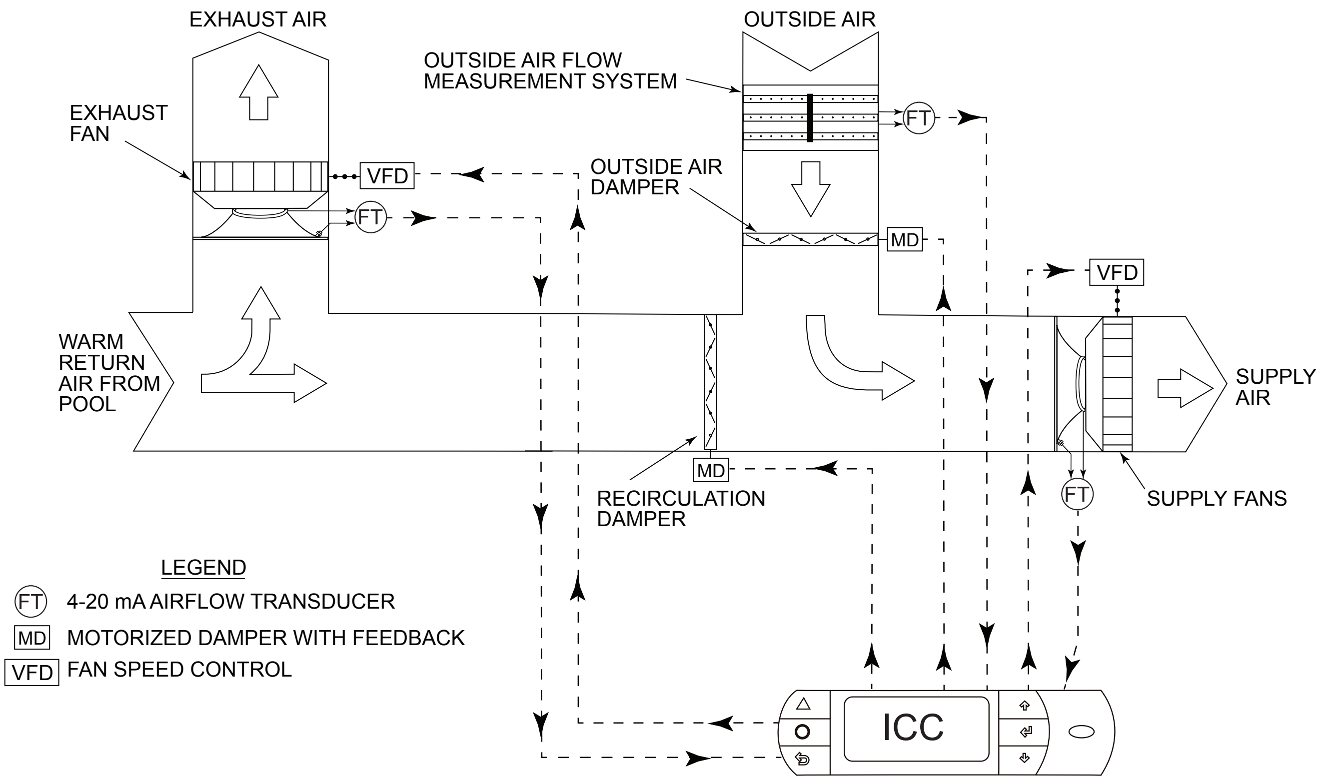
DEHUMIDIFICATION WITH OUTSIDE AIR

Dehumidification is dependent on the outside air condition in relation to the natatorium space condition. Control algorithms in the unit control system monitor the difference and the rate of change in the difference between the natatorium space dew point, space dew point set point and outside air dew point to calculate and deliver the correct amount of outside air to maintain the desired space dew point.

DEHUMIDIFICATION WITH CHILLED WATER COIL

When active, the capacity of the chilled water coil will be controlled by a three way valve in response to the output of the control loops for the return air dew point. If the return air temperature or dew point continues to rise, the control valve will continue to open. If the dew point control routine continues to request chilled water coil operation and the dry bulb control routine begins to request heating, the chilled water coil will remain active and the hot water coil control valve will be opened as required by the heating need.

Figure 2-2. Active Airflow Control with Direct OA Measurement Schematic



Fan Control

By comparing airflow and temperatures the ICC control logic will select the optimum airflow rate for the conditions. Each fan is controlled by a Variable Frequency Drive (VFD) providing the ability to reduce the air quantities without compromising indoor conditions. During unoccupied periods outside air can be greatly reduced, saving the cost of conditioning the outside air as well as unnecessary exhaust fan energy. During unoccupied periods, the supply air quantity may also be reduced further saving fan energy, but reducing supply air too much can create condensation problems in stagnant zones. A standard feature by PoolPak® is the Cold surface sensor which provides a reliable method of protecting cold walls and windows from condensation.

Cold Surface Temperature Humidity Reset

The ICC controller system includes a sensor that measures the temperature of the coldest surface in the pool enclosure usually an exterior window or door frame. When the temperature of this surface approaches the dewpoint temperature of the space, the controller lowers the humidity setpoint to activate dehumidification. This function helps to prevent condensation on the cold surface. Typical locations for this condensate prevention surface temperature sensor are north facing exterior walls, windows, window/door frames, and skylights.

Space Heating

The ClimatePak® VHR unit contains a heat recovery system that allows heat to be transferred from the exhaust air stream to the outside air stream. The heat recovery is enabled when space heating is required. If additional heating is needed, the ICC controller then turns on the auxiliary heat system. The ClimatePak® automatically controls the output of the optional factory-installed auxiliary air-heating system which can be hot water, electric or gas.

Space Cooling

The unit provides space cooling in one of two ways. If the outside air conditions are suitable, the unit can use this to cool the space. If equipped with an auxiliary cooling system, the unit can activate it to cool the space as needed.

Occupied/Unoccupied Control Mode

The ClimatePak® VHR unit time clock allows 7-day, 24 hour scheduling of operational control for both occupied and unoccupied times during the year. During unoccupied times, if the dehumidification load diminished, the OA damper will go to the close position until either a cooling or dehumidification need arises and OA can be use to satisfy the needs. The unit is configured to reduce the amount of air supplied to the space during unoccupied period to save energy (Night Fan Setback). During occupied times, the ClimatePak® VHR unit will deliver outside at the amount required to satisfy the condition but never less than the minimum OA set point. The high limit for the maximum outside in percentage is determined by the capability of the unit.

Purge Mode

The ClimatePak® VHR unit has a purge cycle to bring in the maximum amount of outside air for which it is capable. The purge cycle is programmable by the owner as necessary to ventilate the natatorium after shocking the pool. Unit control provides completely automatic operation by controlling the supply and exhaust fan and by opening the outside air damper for the programmed time intervals.

Event Mode

The event mode changes the ventilation air quantity to meet the demands of an event or situation where additional outside air is needed. The schedule can store up to 14 unique events per week, which are user adjustable at the remote user interface (RUI). During a scheduled event, the minimum outside air set point is raised to a value higher than the minimum damper set point. For each event, the screen shows the day of the week, the hour in 24-hour format, the minute, and the event type.

CO2 Based Demand Ventilation (Optional)

The amount of outside air ventilation is controlled by the PoolPak unit based on the CO2 level sensors in the return air stream.

Features and Options

Standard Factory Mounted Features

- Direct drive plenum fans
- Variable frequency drives
- Two inch, double wall, foam insulated panels
- Airflow monitoring (transducers located on fans and outside air)
- Passive heat pipe heat recovery coil
- Supply air configuration: all sides available
- Dampers: Outside air, recirculation air, heat pipe inlet face dampers, heat pipe outlet face damper, heat pipe inlet bypass damper, heat pipe outlet bypass damper
- Gravity relief dampers on exhaust
- Filters and filter rack (outside, exhaust heat pipe and supply)
- Weatherproofing for outdoor installation
- Temperature (T) and humidity sensors:
  - Return air, T and H
  - Heat pipe Fin, T
  - Supply air, T and H
  - Outside air, T and H

PoolPak®

Standard Factory Supplied, Field Installed Features

- Cold surface temperature sensor, T
- Remote interface Unit (RIU)

Optional Factory Mounted Features

- Integral hot water coil and valve
- Integral or attached module indirect-fired gas furnace – **Contact factory for availability**
- Integral chilled water coil and valve
- Integral DX evaporator coil – **Contact factory for availability**
- Building automation system connection (Lonworks, Modbus, or BACnet)
- Virtual-Tech® Plus VHR – wireless remote access package for factory monitoring only
- Freeze protection
- Return Air CO2 level sensor

Optional Field Installed Features

- Remote air-cooled condensing unit and associated refrigerant piping
- Building Automation System external components and wiring
- Remote exhaust fan

Selection

The selection process for a Climatepak® VHR unit utilizes computer software to determine the dehumidification load and provides analysis of unit performance based on the outdoor air conditions. Outside and exhaust airflow is matched to the dehumidification requirement and the aux heating coil is selected to meet the heating requirement. Additional sensible cooling may be added if needed.

The basic data that is needed in order to calculate a load includes:

- Indoor dry bulb temperature
- Indoor relative humidity
- Job location or design summer/winter outside air temperatures
- Room Volume (cu ft)
- Total wet surface area of the pool room (sq ft)
- Total dry surface area of the pool room (sq ft)
- Spectator count
- Pool temperature
- Pool Usage
- Pool type (swimming pool, wave pool, therapy, and others)

A climate analysis can be part of the selection output. See the following sections for an example of such an analysis. Contact your exclusive PoolPak® Sales representative for selection assistance.

Example of VHR Climate Analysis

VHR Climate Analysis indicates the suitability for the outside air to meet certain space conditions using TMY bin data. This analysis evaluates the room conditions at various temperatures and relative humidity to determine an acceptable range of operating conditions.

The following is an example of such an analysis for a pool room located near Boston, MA using the desired room condition and two alternative space conditions (Case 1 & Case 2). Note the change in psychrometric properties of the air and evaporation load.

Assumptions: Activity factors constant, no sensible heat gain in the structure.

Table 2-2. Example Case Design Summary

PARAMETERS	DESIRED	CASE 1	CASE 2
Air Temp °F	84	86	84
Air RH %	50	50	55
Wet Bulb °F	69.9	71.6	71.6
Humidity Ratio #W/#A	0.013	0.013	0.014
Dew Point °F	63.4	65.2	66.1
Load # H20 / Hour	156	144	138

At Desired Conditions 84/50% RH

At maximum outside airflow (based on 8 Air Changes) there are 1426 hours where conditions exceed 84/50%.

Table 2-3. Accumulated Hours Where Desired Conditions Not Met

OUTSIDE AIR WEATHER BIN CONDITIONS				POOLROOM CONDITIONS		
HOUR	DB F	WB F	H RATIO	CFM OA	DB F	CUMULATIVE HOURS DESIGN NOT MET
7	92	69.4	0.010	15,300	90	7
107	87	69.7	0.012	15,600	86	114
218	82	67.9	0.011	15,600	84	332
387	77	65.7	0.011	15,600	84	719
707	72	63.8	0.011	15,600	84	1426
873	67	60.6	0.010	12,975	84	
793	62	56.7	0.009	8,852	84	
816	57	52.3	0.007	6,599	84	
640	52	47.5	0.006	5,263	84	
689	47	42.1	0.005	4,536	84	
883	42	37.8	0.004	4,536	84	
777	37	33.1	0.003	4,536	84	
780	32	28.4	0.002	4,536	84	
512	27	23.3	0.002	4,536	84	
315	22	18.4	0.001	4,536	84	

At Case 1 Conditions 86/50% RH

At maximum outside airflow (based on 8 Air Changes) there are 322 hours where conditions exceed 86/50%.

Table 2-4. Accumulated Hours Where Case 1 Conditions Not Met

OUTSIDE AIR WEATHER BIN CONDITIONS				POOLROOM CONDITIONS		
HOUR	DB F	WB F	H RATIO	CFM OA	DB F	CUMULATIVE HOURS DESIGN NOT MET
7	92	69.4	0.010	10,292	89	7
107	87	69.7	0.012	15,600	87	114
218	82	67.9	0.011	15,600	86	332
387	77	65.7	0.011	13,422	86	
707	72	63.8	0.011	12,530	86	
873	67	60.6	0.010	6,726	86	
793	62	56.7	0.009	5,252	86	
816	57	52.3	0.007	4,536	86	
640	52	47.5	0.006	4,536	86	
689	47	42.1	0.005	4,536	86	
883	42	37.8	0.004	4,536	86	
777	37	33.1	0.003	4,536	86	
780	32	28.4	0.002	4,536	86	
512	27	23.3	0.002	4,536	86	
315	22	18.7	0.001	4,536	86	

At Case 2 Conditions 84/55%RH

At maximum outside airflow (based on 8 Air Changes) there are 0 hours where conditions exceed 84/55%.

Table 2-5. Accumulated Hours Where Case 2 Conditions Not Met

OUTSIDE AIR WEATHER BIN CONDITIONS				POOLROOM CONDITIONS		
HOUR	DB F	WB F	H RATIO	CFM OA	DB F	CUMULATIVE HOURS DESIGN NOT MET
7	92	69.4	0.010	8,654	87	0
107	87	69.7	0.012	14,194	86	
218	82	67.9	0.011	12,927	84	
387	77	65.7	0.011	10,881	84	
707	72	63.8	0.011	10,263	84	
873	67	60.6	0.010	5,906	84	
793	62	56.7	0.009	4,698	84	
816	57	52.3	0.007	4,536	84	
640	52	47.5	0.006	4,536	84	
689	47	42.1	0.005	4,536	84	
883	42	37.8	0.004	4,536	84	
777	37	33.1	0.003	4,536	84	
780	32	28.4	0.002	4,536	84	
512	27	23.3	0.002	4,536	84	
315	22	18.7	0.001	4,536	84	

Conclusion

1. There are 1,423 hours when the condition will not be at the desired 84-50% level.
2. Case 1 shows the unmet dehumidification hour is reduced to 322 hours if the set point is at 86-50% rather than 84-50%.
3. Case 2 shows 0 unmet dehumidification hours at 84-55%. The room humidity level is expected to be at 84-55% level rather than 84-50% level.
4. The example shows the practical compromises for air changes and an acceptable range of conditions

Summary of Pool Room Analysis

Assumptions: Activity factors constant, no sensible heat gain in the structure

Table 2-6. Summary of Pool Room Analysis for Boston, MA

PARAMETERS	DESIRED	CASE 1	CASE 2
Air Temp °F	84	86	84
Air RH %	50	50	55
Wet Bulb °F	69.9	71.6	71.6
Humidity Ratio #W/#A	0.013	0.013	0.014
Dew Point °F	63.4	65.2	66.1
Load #H20/Hour	156	144	138
Indoor Temperature	90+	89+	87+
Hours of Partial Dehumidification	1426	332	0

PoolPak

SECTION III: SIZING AND PERFORMANCE

Sizing

Unit Dimensions and Weights

Figure 3-1. VHR Dimensional Isometric View

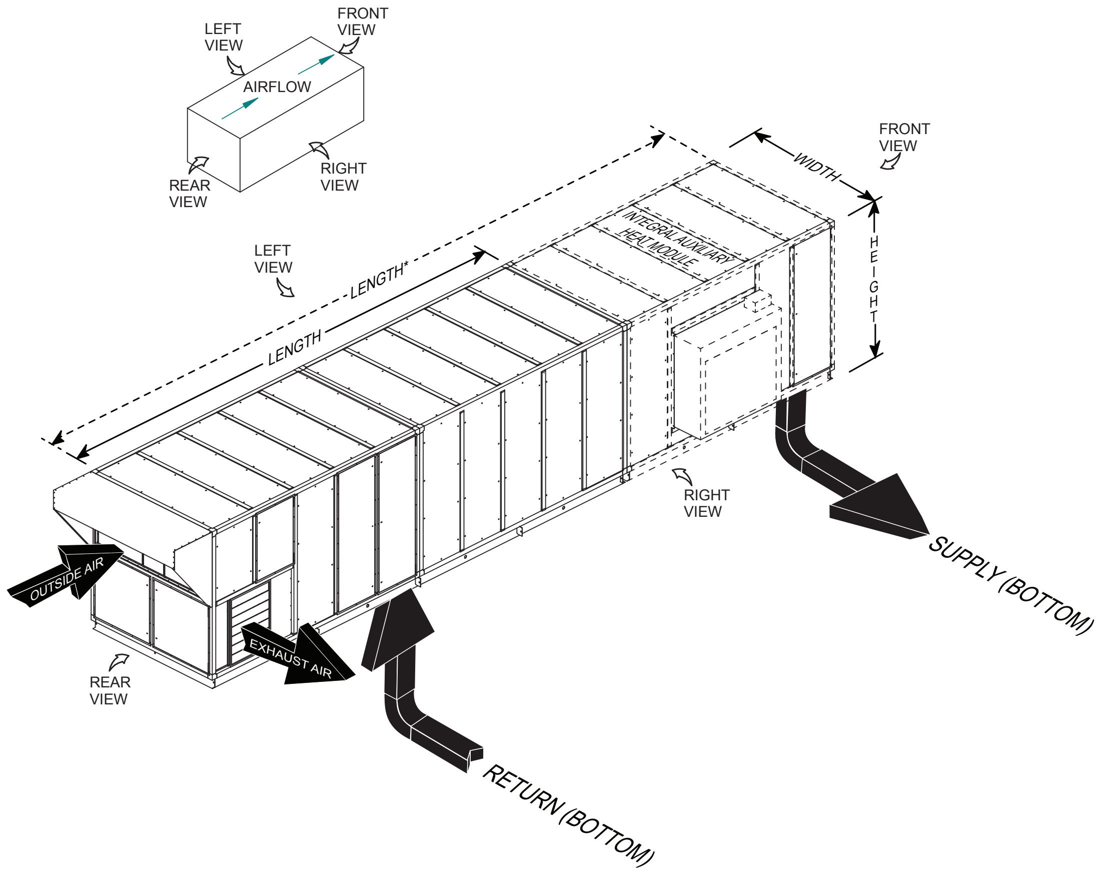


Table 3-1. VHR Dimensions and Weights

MODEL	BASE UNIT (INCHES, LBS)				W/ GAS FURN MODULE	
	WIDTH	HEIGHT	LENGTH	WEIGHT[1]	LENGTH	WEIGHT[2]
VHR 015	67.8	94.2	264.1	6,400	331.5	7,800
VHR 020	96	102	328.7	8,000	438.7	13,000
VHR 030	96	114	328.7	10,800	468.7	15,000
VHR 040	102	138	458	13,800	Contact Factory	
VHR 050	132	138	458	16,400		

[1] Weight is approximate and includes largest heat pipe, 2-row hot water coil & typical fans/motors.

[2] Weight including gas furnace module is approximate, contact factory.

ClimatePak® VHR Product Drawings

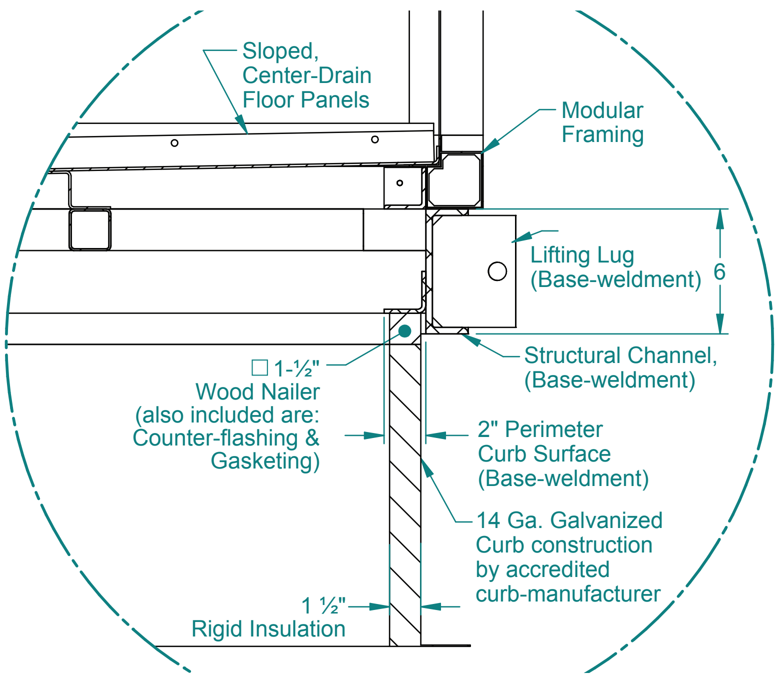
ClimatePak® generic product drawings are available on the PoolPak® website in the *Product Library*.

Curb Sizing

For rooftop mounting the VHR unit where a PoolPak curb is not purchased, PoolPak recommends the curb manufacturer refer to the selected-unit-specific product drawings to mate the curb to the VHR curb pocket max dimensions at acceptable design tolerances.

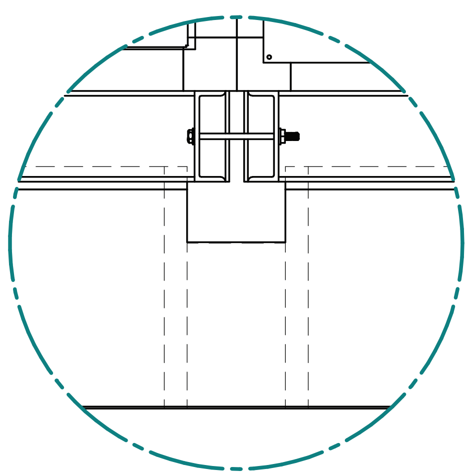
For VHR models, the curb pocket is flush with the bottom of the unit while providing an overhang angle for an extra drip edge to prevent water infiltration through the base. See Figure 3-2 for VHR base/curb cross section.

Figure 3-2. VHR base/curb cross section



For curb-mounted VHR units shipped split or with an attached auxiliary heat module, a weather tight notch must be provided between the unit sections. Additional instructions will be provided. See Figure 3-3 for an illustration.

Figure 3-3. VHR curb notch detail



Performance

ClimatePak® VHR Performance Summary

Table 3-2. VHR Unit Performance Summary

MODEL	MOISTURE REMOVAL CAPACITY (LBS/HR)	MAXIMUM OUTSIDE AIR (CFM)	MAXIMUM SUPPLY AIR (CFM)
VHR 015	162	9,000	15,000
VHR 020	360	20,000	21,000
VHR 030	540	30,000	34,000
VHR 040	720	40,000	40,000
VHR 050	900	50,000	50,000

[1] Moisture removal based on average OA dew point of 60F and space conditions of 84F, 60% RH

VHR Heat Pipe Performance

Table 3-2. VHR Unit Performance

VHR MODEL	HEAT PIPE GRADE	CFM	LEAVING AIR TEMP (DB °F/WB °F)		HEAT CAPACITY[1] (MBH)	ENERGY RECOVERY CAPACITY (%)
			EXHAUST AIR	OUTSIDE AIR		
VHR 015	C (80″ x 37.5″)	5,200	56.6 / 56.6	46.1 / 29.5	225	51.4
VHR 020	C (80″ x 37.5″)	5,200	56.6 / 56.6	46.1 / 29.5	225	51.4
	D (80″ x 50″)	7,000	56.7 / 56.7	45.7 / 29.2	300	50.9
VHR 030	D (80″ x 50″)	7,000	56.7 / 56.7	45.7 / 29.2	300	50
	F (97″ x 51″)	8,600	57.5 / 57.5	45.3 / 29.0	365	50.4
VHR 040	E (80″ x 60″)	8,300	56.4 / 56.4	46.0 / 29.4	225	51.4
	G (80″ x 80″)	11,000	56.5 / 56.5	45.9 / 29.3	474	51.2
VHR 050	G (80″ x 80″)	11,000	56.7 / 56.7	45.7 / 29.2	474	51.2
	L (80″ x 100″)	14,000	56.7 / 56.7	45.7 / 29.2	600	50.9
	D (80″ x 120″)	16,500	56.4 / 56.4	46.0 / 29.4	718	51.3

[1] Heat capacity based on space conditions of 84F, 60% RH and design OA climate of Boston, MA (entering outside air temp 6°F DB, 2°F WB)

Hot Water Coil Performance

Table 3-4. Hot Water Coil Performance

VHR MODEL	1 ROW HOT WATER COIL		
	AIRFLOW RATE (CFM)	FLOW RATE RANGE (GPM)	HEAT CAPACITY RANGE (MBH)
VHR 015	8,000 - 12,000	5 - 25	152 - 263
	12,000 - 15,000	10 - 30	250 - 381
VHR 020	10,000 - 13,500	10 - 30	225 - 349
	13,501 - 16,500	10 - 40	258 - 431
	16,501 - 20,000	15 - 45	342 - 508
VHR 030	20,000 - 25,000	20 - 60	451 - 676
	25,001 - 30,000	20 - 60	505 - 781
	25,000 - 30,000	20 - 60	517 - 911
VHR 040	30,000 - 35,000	20 - 80	514 - 902
	35,001 - 40,000	30 - 90	709 - 1,087
VHR 050	40,000 - 45,000	30 - 90	737 -1,087
	45,001 - 50,000	30 - 90	857 - 1,300

VHR MODEL	2 ROW HOT WATER COIL		
	AIRFLOW RATE (CFM)	FLOW RATE RANGE (GPM)	HEAT CAPACITY RANGE (MBH)
VHR 015	8,000 - 12,000	20 - 50	370 - 556
	12,000 - 15,000	20 - 50	455 - 654
VHR 020	10,000 - 13,500	20 - 40	432 - 595
	13,501 - 16,500	20 - 50	510 - 727
	16,501 - 20,000	30 - 60	663 - 869
VHR 030	20,000 - 25,000	40 - 80	865 - 1,148
	25,001 - 30,000	50 - 90	1,070 - 1,359
	25,000 - 30,000	50 - 90	1,098 - 1,402
VHR 040	30,000 - 35,000	50 - 90	1,085 - 1,483
	35,001 - 40,000	60 - 100	1,377 - 1,694
VHR 050	40,000 - 45,000	60 - 100	1,451 - 1,784
	45,001 - 50,000	60 - 100	1,665 - 2,075

Note:
Entering Air Temperature - 80°F; Entering Water Temperature - 180°F; Max Working Pressure - 125 psi; Capacity is a function of Airflow

ClimatePak® Auxiliary Gas Furnace Option

Contact Factory for availability and sizing of the integral gas furnace option.

Table 3-5. VHR Gas Furnace Option

FURNACE TYPE	INPUT MBH	OUTPUT MBH	VHR MODEL (SUPPLY AIRFLOW IN KCFM)							
			VHR 015		VHR 020		VHR 030		VHR 040/050	
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
SINGLE FURNACE	350	280	8.0	12.0	–	–	–	–	–	–
	400	320	8.0	14.0	–	–	–	–	–	–
DUAL FURNACE	450	360	8.0	15.0	15.0	16.0	–	–	–	–
	500	400	8.0	15.0	15.0	18.0	–	–	–	–
	600	480	8.0	15.0	15.0	21.0	21.0	22.0	–	–
	700	560	8.0	15.0	15.0	21.0	21.0	24.0	–	–
	800	640	8.0	15.0	15.0	21.0	21.0	28.0	–	–
DRUM FURNACE	937	750	–	–	15.0	21.0	21.0	30.0	Contact	
	1060	850	–	–	15.0	21.0	21.0	34.0	–	–
	1250	1000	–	–	15.0	21.0	21.0	34.0	Factory	
	1560	1250	–	–	15.0	21.0	21.0	34.0	–	–

[1] Actual CFM allowed is determined by the cabinet size and model chosen

Chilled Water Coil Performance

Chilled water coil option for auxiliary air cooling is available. Performance varies depending on outside air conditions, space conditions, airflow rates, and chilled water temperature and flow rate. Contact PoolPak factory for selection and performance of the chilled water coil option.

Direct Expansion (DX) Coil Performance

Direct expansion coil option for auxiliary air cooling is available. Performance varies depending on outside air conditions, space conditions, and airflow rates. Contact PoolPak factory for selection and performance of this option.

VHR INSTALLATION AND OPERATION

The Installation, Operation and Maintenance (IOM) manual is a companion document to the Engineering Guide. The IOM includes a detailed description of installation and operation details, controls and sequence information, and wiring and connection diagrams.

This document is available as a download from the *Product Library* section of the PoolPak website.