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1.0 Introduction of Principles

The ventilation systems in indoor swimming pools must be designed to ensure bather comfort and at the same time prevent condensation on the building interior surface during winter months. The comfort level or better put forth, "thermal comfort level" for the bather depends on the following factors:

- Air temperature
- Temperature of the surrounding building surface area
- Relative humidity
- Air movement
- Activity level of the bather
- Water temperature

The following paper/report discusses the important considerations concerning ventilation systems for Natatoria

Since the ventilation system is the foremost energy user, and is important to environmental comfort in Natatoria's, performance it is of primary concern.

The heat energy graph below illustrates the relationship of the major heat energy users in Natatoria.
(See Figure 1)

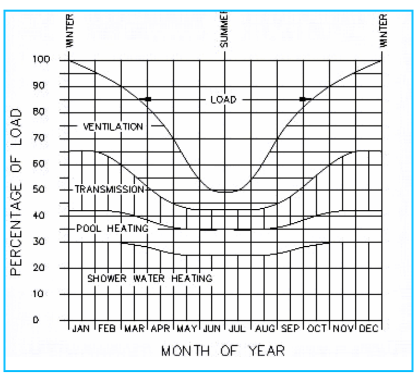


Figure 1

2.0 Climatic Data

2.1 Outside Air Condition

Winter:
Calculations corresponding to the relative outside air conditions for the selected climate zone, and determination of the insulation value of the building construction required to prevent condensation on/in walls, floors, roof and windows are made.

Summer:
Outdoor air temperature at which outdoor air can be used to dehumidify Natatoria without mechanical cooling/ dehumidification or heating, and condensation of the building interior will no longer occur on/in the building interior is roughly, 19 C /65% RH (66 F/65% RH), x = 9 g/kg. These outdoor conditions allow the ventilation system to dehumidify the indoor air with outside air.

2.2 Room Conditions

2.2.1 Indoor Swimming Hall

Air Temperature:
The indoor air temperature should be individually determined for each facility. An indoor air temperature of 29-30 C (84-86 F) is sufficient for building construction with little glass surface area. Building construction with high glass surface area may require higher indoor air temperatures around 31-32 C (88-90 F). The higher the pool water temperature, the smaller the required temperature difference between the air and pool water to maintain proper thermal comfort levels for the bather. (See Figure 2)

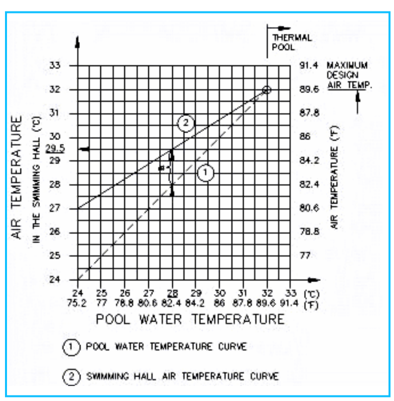


Figure 2

It should be mentioned that the closer the air temperature is to the pool water temperature, the higher the theoretical evaporation rate of the pool water into the air. However, in practice with calm water and air conditions, such as in night setback mode, this does not occur. If the air temperature is regulated at 2-3 C (3-5 F) above the pool water temperature, a layer of air saturated with water vapor will develop above the water surface. This actually limits the evaporation process, reducing the effective evaporation rate. This effect can be used in properly designed pools to reduce night time energy consumption.

Absolute Humidity:
The absolute humidity in the Natatorium should be regulated to remain on the comfort curve for unclothed persons. An absolute humidity of 15 g H20/kg Air (0.0146 lb H20/lb Air) is recommended for new, well insulated Natatoria building construction. This is the maximum design value.

Relative Humidity:
The relative humidity is dependent upon the room air temperature as follows:

- 28 C (82 F) 60% relative humidity
- 30 C (86 F) 55% relative humidity
- 32 C (90 F) 50% relative humidity

The relative humidity is adjusted throughout the year depending on the inside glass surface temperature (or other critical construction components). (See Figure 3)

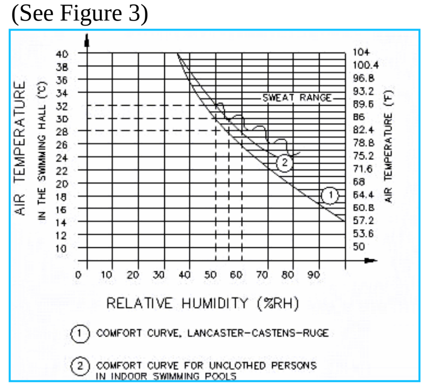


Figure 3

Ideal building construction can maintain the optimal thermal comfort conditions for the bather when the outside air temperature falls between 10-19 C (14-68 F). When the heat transfer coefficient, U-Value measured in w/m2 K (BTU/ft2 F), for the building element is too high, the absolute humidity should be reduced during winter months to avoid condensation on glass surfaces.
(See Figure 4)

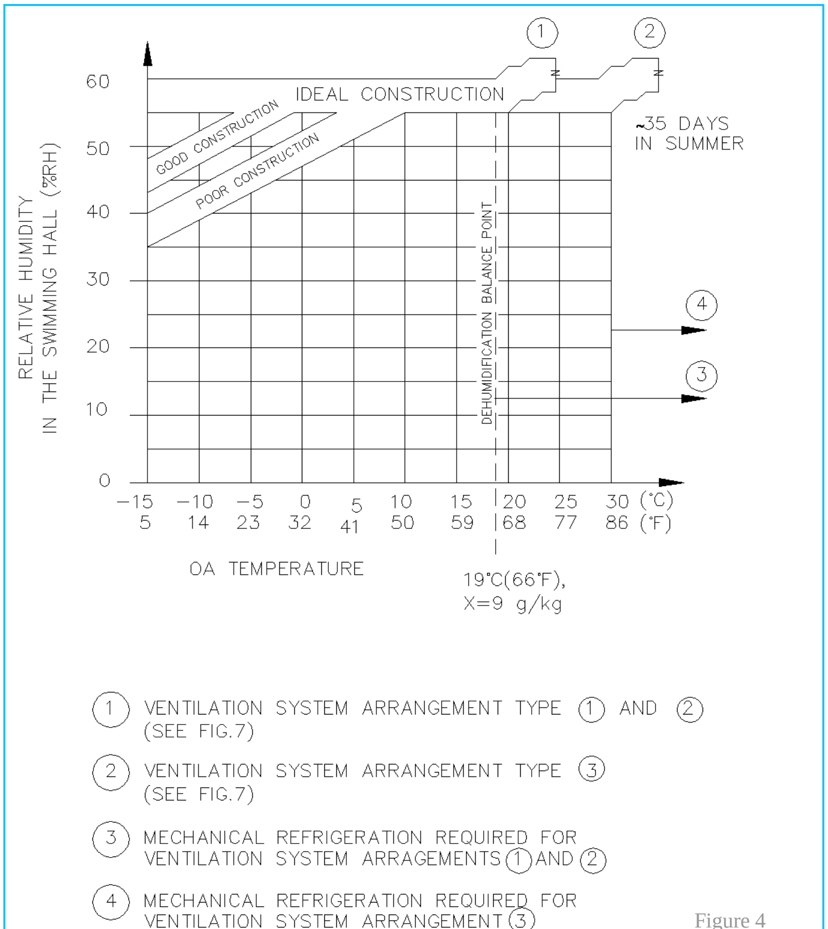


Figure 4

When the outside air temperature and relative humidity rises above 19 C/65% RH (66 F/65% RH), which corresponds to an absolute humidity of x = 9 g/kg (0.0140 lb/lb), condensation build-up on interior surfaces of the swimming hall is unlikely. This is called the dehumidification balance point. As the outside air temperature rises further condensation is not a problem, if the building ventilation system (with built-in dehumidification) is properly designed.

3.0 Evaporation

The evaporation of pool water in the Natatoria is the basis for dimensioning the ventilation, pool water heating, heat recovery and dehumidification systems, as well as for generating the energy balance for indoor swimming halls. In spite of the central significance of the evaporation rate, basic calculation methods have not yet been generally accepted in the United States.

The Department of Energy, Denver Regional Office is studying pool water evaporation rates, and has funded several studies on this subject.

The German Verein Deutcher Ingenieure Standard, VDI 2089 is the most comprehensive standard for designing heating, ventilating and domestic hot water systems for indoor pools.

Actual measurements were made on an indoor pool with a 28 C (82 F) water temperature and 30 C/50% RH (86 F/50% RH) air temperature. The following evaporation rates were measured:

Calm (Night setback)

VDI 2089	**DOE**
~75 g/h m² (0.015 lb/h ft²)	[0.020 lb/h ft²]

Average operation:

VDI 2089	**DOE**
~135 g/h m² (0.028 lb/h ft²) (low value, due to light use)	[0.055 lb/h ft²]

The usual calculations will be shown using the specific evaporation rates given in the German Standard VDI 2089.

The basis for the calculations is the pool water surface area (WSA). Evaporation from decking and seating areas are contained in the ε-value. The evaporation is strongly influenced by bather activity in the pool. The first bather in the pool has the largest influence and the evaporation rate per person falls off as more bathers enter the pool.

In calm or night setback operation a physical condition has been observed. A colder layer of air builds over the WSA limiting the evaporation rate. For example, with a water temperature of 27 C (81 F), a 27 C air layer at 100 % relative humidity (100 % saturated air) develops. This vapor layer is only a few centimeters thick. If the layer is not disturbed, the pool water evaporation rate remains low. Since warmer air can hold more water vapor then cooler air, if the water temperature is lower than the air temperature the relative humidity at the pool surface will increase toward saturation. This is similar to fog developing on cold ground on a warm spring morning. This vapor layer can exist only when the air higher above the pool remains calm.

This condition is stable when the air temperature lies 2-3 C (3-5 F) above the pool water temperature, because the stratified partial vapor pressure of the drier air at the higher temperature is greater than the saturated vapor pressure of the air near the pool surface at the lower temperature.

The evaporation energy will be drawn from the pool water and the wet surroundings. For example, the evaporation energy with 28 C (82 F) pool water temperature amounts to 675.5 Wh/kg (1,051.5 BTUH/lb). On the basis of Dalton's Law applied to evaporation, the mass flow evaporation rate can be calculated, for given air and water conditions, with the following equation:

$m_V = \varepsilon A (pS - pV)$ [g/h] (1)

where,
m_V = evaporated water quantity [g/h]
ε = empirical total evaporation rate factor [g/h m2 mbar]
A = pool water surface area, WSA [m2] (inner area of pool, not including the overflow rim/gutter)
p_S = saturated vapor pressure of air at the pool water temperature
p_V = partial vapor pressure of water in air at the room air temperature

Correct Values for the total evaporation rate factor, ε:

ε ~ 35 g/h m2 mbar	Wave pool operation in indoor swimming pools.
ε ~ 28 g/h m2 mbar	Maximum operation in public indoor non-swimming pools, used for sizing the ventilation system.
ε ~ 20 g/h m2 mbar	Maximum operation in public indoor swimming pools, used for sizing the ventilation system.
ε~ 13 g/h m2 mbar	Average pool operation in public swimming pools, used for sizing the heat recovery system and developing the energy balance.
ε~ 5 g/h m2 mbar	Calm or night setback operation with air temperatures ~ 2 C (3 F) above the pool water temperature.
ε~ 0.5 g/h m2 mbar	Covered pools, evaporation from overflow rim only.

<u>Hot Whirlpools:</u>
In addition to increased evaporation caused by strong water currents, aeration must be considered. The following equation is valid for total evaporation rates for these pools:

$m_W = \varepsilon A (pS - pV) + VA \rho (xS - x0)$ (2)

where,
ε = 11 [g/h m2 mbar]
V_A = air flow rate [m3/h]
ρ = density of air [kg/m3]
x_S = water vapor content of air leaving the pool [g/kg]
x_0 = water vapor content of the supply air [g/kg]

A diversity factor representing the time of operation per hour of the whirlpools should also be applied. Special Cases: The increase in the evaporation rate for water channels, water falls, water mushrooms, slides, water canons, bubblers, etc. must be individually calculated or their operation must be regulated, so that the total evaporation rate does not exceed the dehumidification capacity of the ventilation system.

Other Values by Example:

- Evaporation rate from slides
27 C (81 F) pool water temperature
30 C (86 F) indoor air temperature, x = 14 g/kg
m_V = 500-700 g/lm (0.47 lb/LF)

- Evaporation from hot whirlpools
m_V~ 2,000 g/m2 (0.41 g/ft2)

- Evaporation rate from water mushrooms and canons from experience these water attractions create very high water evaporation rates (must be individually calculated using known air and water temperatures)

The aforementioned mass flow evaporation rate equation incorporates the pool WSA. Now we must look at the different types of overflow rims/gutters to determine how they affect the overall pool water evaporation rate.

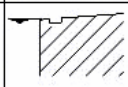
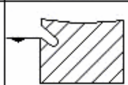
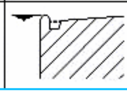
DESCRIPTION	SCHEMATIC	FACTOR
RIM/GUTTER W/ ROLL GRILLE		1
OPEN RIM/GUTTER (Tapiola Rim)		1.1
LOW-LYING WATER LINE (Wiesbaden Rim)		0.8
HIGH-LYING WATER LINE (Saint Moritz Rim) W/ ROLL GRILLE		1.2

Figure 5

Correction Factors for Different Rim / Gutter Types:
(See Figure 5)

Each rim/gutter type has an associated correction factor to be applied to the general mass flow evaporation rate equation. The corrected equation is as follows:

$m_{V,c} = f\, mV$ [g/h] (3)
where,
$m_{V,c}$ = the corrected mass flow evaporation rate [g/h] (from Eq. 1)

Special Remarks about the Total <u>Evaporation Rate Factors:</u>
It is important to recognize the differences between the total evaporation rate factors. The maximum value is used for sizing the ventilation system. The average value is used for sizing the ventilation heat recovery system and developing the energy balance. The calm or night setback value is used to determine pool water heating energy consumption during night setback with a properly designed ventilation air distribution system.

Dehumidification systems are frequently oversized when designing to the maximum total evaporation rate factor. This leads to the installation of oversized equipment, which increases energy use, causes excessive cycling of the compressor, which can lead to premature failure and allows greater fluctuations of the indoor humidity conditions.

4.0 Air Flow Rate

The supply air quantity for operation in an indoor swimming pool is calculated after considering the following criteria:

- Evaporation
- Prevention of Condensation at the Windows and Other Building Elements
- Supply Air Distribution

The required air flow rate to maintain summer humidity levels is given by the following equation:

$M_L = m_{V,c} / \rho (x_R - x_0)$ (4)

where,
m_L = supply air quantity [g/h]
$m_{V,c}$ = evaporation rate [g/h] (from Eq. 3)
x_R = absolute humidity in the room [g/kg]
x_0 = absolute humidity of the supply air [g/kg]
ρ = density of the supply air [kg/m3]

For sizing the system the following is recommended:

X_R = 15 g/kg, (with a room condition of 30 C/55% RH (86 F/55% RH)

x_0 = 9 g/kg, supply air absolute humidity

Δx = 6 g/kg, (x_R - x_0)

Air Flow across the Windows:
In addition to the airflow rate the proper air flow across the windows should be calculated.

The supply air quantity should be distributed throughout the room to ensure an even washing of the interior building surface.

The proper number of air changes for an indoor pool lies between 4-8/hour. The lower value is valid for straight forward air distribution patterns and the higher value is for more complicated floor plans and sections.

During calm or night setback periods the ventilation rate can be reduced in accordance with the falling evaporation rate. However, the air drying time should be calculated and is usually between 0.5-1 hour after the pool operation has been switched to the setback mode.

Correct Values for Air Flow across Windows:

Window height:

2 m (6.5 ft)	4 m (13 ft)	6 m (20 ft)

Air Flow Rate

per linear meter:

200 m3/h	300 m3/h	500 m3/h

per linear foot:

35 CFM	55 CFM	90 CFM

Terminal Air Velocity:

1.5-2 m/s	2-3 m/s	3-4 m/s
3-400 fpm	4-600 fpm	6-800 fpm

Minimum Outside Air Quantity:
Independent of the dehumidification system operation a minimum quantity of outside air must be provided during the operation of the swimming hall to create proper hygienic air conditions for the pool quests. The recommended outside air quantity per person for indoor pools is 50 m3/h (30 CFM) or 0.5 CFM per square foot of Natatoria. During night setback operation the outside air can be reduced. The plate heat exchanger recuperates the waste heat, and the dehumidification system controls the relative humidity in the swimming hall This is more economical than dehumidifying with cold outside air during cooler seasons.

Maximum Outside Air Quantity:
The maximum outside air quantity should be generally sized, so that dehumidification with outside air is possible down to the dehumidification balance point, 19 C/65% RH (66 F/65% RH). Ventilation units which use less than 25% outside air are generally not as effective in maintaining indoor air quality as those which allow 50 to 100% outside air operation.

5.0 Heat Recovery

In order to save energy and reduce demand loading, installation of a heat recovery system to recover the high heat content of the swimming hall exhaust air is usually economical.

Whether a new building or renovation project a variety of different heat recovery systems can be built. The following is a short comparison of several systems available:

5.1 Heat Recovery Coil

- Advantages:
  Standard air handler, simple arrangement, simple controls, heat recovery from chiller, variable speed fans.

- Disadvantage:
  Additional piping and pumps

5.2 Plate or Pipe Heat Exchanger

- Advantages:
  Direct heat transfer without additional heat transfer medium from the exhaust to outside air. Good cleaning effect, variable speed fans, increased energy savings during winter operation.

- Disadvantage:
  Outside air and exhaust air ducted back to the same location. With new buildings this can be planned for, but with renovation projects it is not always possible.

  A frost protection control system must be provided/ considered.

  High air velocities are required through the exchanger to avoid laminar flow, therefore fan energy consumption is higher.

- Material:
  Glass pipes, aluminum plates or polyethylene sheets.

5.3 Heat Pipe

- Advantages: (similar as with the plate heat exchanger)

- Disadvantages: (similar as with the plate heat exchanger)

Low temperature differences between the exhaust and outside air require a special capacity regulation controller.

5.4 Water Loop Heat Recovery Coils
(run-around heat exchanger)

- Advantages:
  The outside air and exhaust do not need to be ducted to the same location. Therefore, this system is oftentimes suitable for renovation projects.

- Disadvantages:
  Additional heat transfer medium and circulation pumps are required. The energy consumption of the pumps amounts to 2-3 percent of the yearly energy recovery. With exhaust air and non-filtered outside air the coil fin spacing must be ~ 6-8 fins per inch. Optimal performance can only be reached when the system is sized for the most frequently encountered temperature conditions (not at the design outside air temperature). Only by careful consideration of the entire system operation can a good seasonal efficiency be reached.

- Material:
  Copper coils with aluminum fins.

5.5 Built –in Refrigeration

Refrigerant compressors (built-in refrigeration) are predominantly used to dehumidify the bypass air and allow reduction of the outside and exhaust air quantity.

- Advantages:
  Allows dehumidification while at the same time reintroduces the waste heat from the condenser back into the system. The heat can be used to reheat the supply air or can be redirected to heat the pool water. Compressor operates at a high coefficient of performance (COP).

- Disadvantages:
  More expensive ventilation unit, higher maintenance costs, complex control system, can overheat pool water

5.6 Heat Wheel
(rotating heat exchanger)

Because of the humidity transfer associated with this type of heat recovery exchanger they are generally not suitable for swimming hall ventilation. However they can be used for other duty in the fitness facility.

- Advantages:
  Total energy exchanger efficiency

- Disadvantages:
  Uncontrolled humidity transfer, require adjustment of the wheel speed of rotation

5.7 Summary

Because of the dehumidification and heat recovery requirements on indoor swimming pools, the recuperative (plate) heat exchanger and built-in refrigeration offer the most energy saving system combination. This type of system is available as a packaged unit with factory wired controls and waste heat recovery piping connections. These systems can be proprietary and complicated. The simplest system should always be compared using life-cycle costing to other more complicated systems before the ventilation concept is selected. The plate frame heat exchanger type air handler may prove to be the most economical system in situations where energy cost are lower and maintenance cost generally higher. However, the standard air handler with heat recovery coil should also be considered as the base case.

5.8 Heat Recovery Systems

Heat recovery in Natatoria ventilation is practical and can save energy cost. A life-cycle cost analysis should be performed for each facility to clearly define applicable systems and their associated first cost, life-cycle cost and net savings over time. B2E has developed engineering software which calculates the water evaporation rate for any Natatoria WSA program lay-out, and the energy use per kg (lb) of evaporation for commercially available dehumidification and heat recovery ventilation equipment, and plots the energy balance diagram. This is a useful tool for comparing ventilation systems.

The decision to select one system over another cannot be made without consulting the facility owner. These systems can range from simple to complex depending on how much energy savings is desired. The simpler the system concept the fewer system components to maintain, which may offer better life-cycle cost savings than the most efficient more complex systems.

Some example heat recovery systems are:

<u>Simple System:</u>

Description: Standard air handlers with corrosion resistant construction.

Arrangement: Dehumidification and reheat w/100% outside air capability

Cooling Source: Central chiller with heat recovery bundle.

Heating Source: Central boilers

- Advantages:
  Lowest first cost, lowest maintenance cost. Allows 100% fresh air intake (very important during super chlorination of pool water), lighter air handlers, two-speed fan motors for night setback, heat recovery to any pool or air handler any time, simple controls can easily be controlled/monitored offsite via DDC LAN (BACnet compatible), will not overheat pool water, chiller does not run all the time.

- Disadvantages:
  Some additional piping and pumps for chiller, higher energy cost.

Figure 6 shows a schematic diagram of a Natatoria air handler simple type arrangement.

<u>Slightly Complex System:</u>
Description: Special Pool dehumidific-ation and heat recovery unit with plate frame heat exchanger.

Arrangement: Dehumidification and reheat w/50% outside air capability.

Cooling Source: Central chillers.

Heating Source: Central boilers.

- Advantages:
  Lower energy cost, allows 50% fresh air intake, variable speed fan motors for night setback, built-in plate frame heat exchanger for winter operation, simple controls can easily be controlled/monitored offsite via DDC LAN (BACnet compatible), does not need air handler heat recovery coil, chiller does not run all the time.

- Disadvantages:
  Higher first cost, higher maintenance cost, does not allow 100% fresh air intake, heavier air handlers, some additional piping and pumps for chiller, higher energy cost.

Figure 8 shows a schematic diagram of a Natatoria heat recovery air handler slightly complex type arrangement.

<u>Complex System:</u>

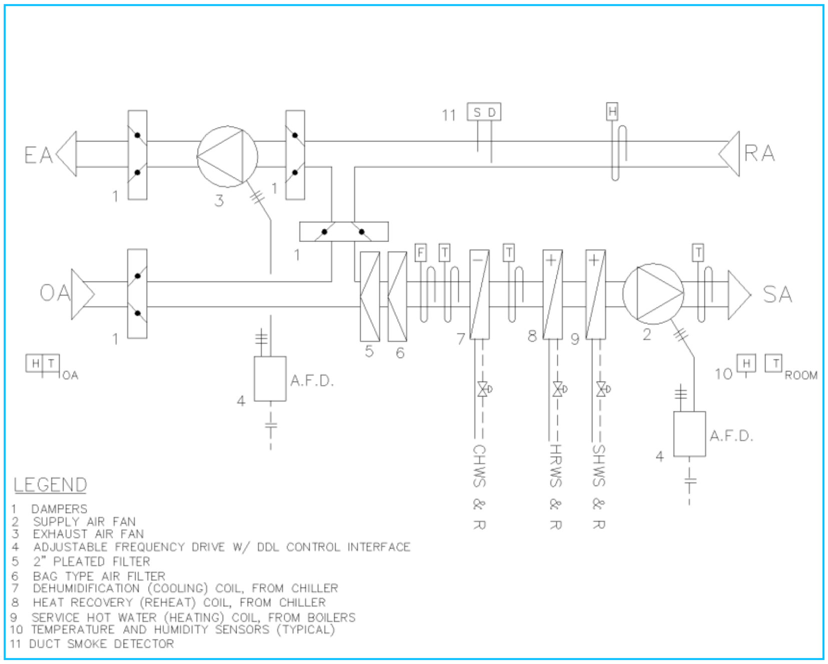
Description: Special pool dehumidific-ation and heat recovery unit with plate frame heat exchanger, and built-in refrigeration.

Arrangement: Dehumidification and reheat w/50% outside air capability.

Cooling Source: Internal compressors and refrigeration section.

Heating Source: Central boilers.

- Advantages:
  Should have lower energy cost, built-in heat recovery to air handlers, heat recovery to pools, can monitored offsite by DDC



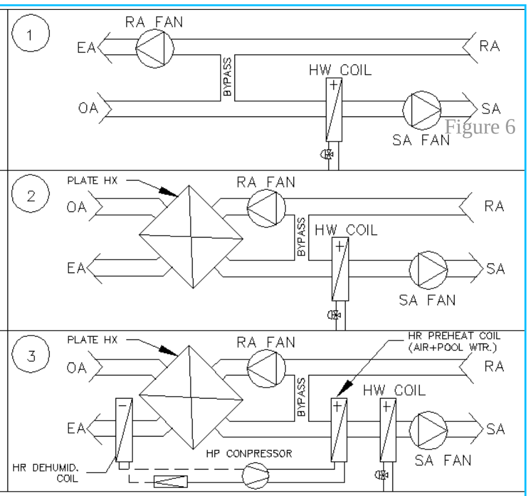
1 DEHUMIDIFICATION WITH OUTSIDE AIR/EXHAUST AIR WITHOUT HEAT RECOVERY	
2 DEHUMIDIFICATION WITH OUTSIDE AIR/EXHAUST AIR WITH HEAT RECOVERY PLATE HEAT EXCHANGER (EFFICIENCY 50%)	
3 COMBINED SYSTEM WITH RECUPERATIVE HEAT EXCHANGER (EFFICIENCY 50%) AND HEAT PUMP FOR DEHUMIDIFICATION WITH WASTE HEAT RECOVERY	

Figure 6

ECONOMIC COMPARISON: t_{OA}=41°F/80%RH, t_{SH}=86°F/55%RH, t_{PW}=81–82°F

FACTORS \ SYSTEM	1 OA/EA W/O HR	2 OA/EA W/ HR	3 COMB. SYS. REC./HP
1. ENERGY REQUIRED FOR EVAPORATOIN AND DEHUMIDIFICATION PER Kg H_2O			
HEATING (GAS) kWh/Kg H_2O	1.344	1.010	0.186
ELECTRICITY kWh/Kg H_2O	-----	0.042	0.452
TOTAL ENERGY REQUIRED GAS+ELEC.	100% 1.344 kWh	85% 1.142 kWh	48% 0.638 kWh
2. ENERGY COST PER Kg H_2O			
HEATING (GAS) \$0.035/kWh	\$4.70	\$3.54	\$0.65
ELECTRICITY \$0.05/kWh	-----	\$0.21	\$2.26
ENERGY COST \$/kg H_2O	100% \$4.70	80% \$3.75	62% \$2.91

LAN, single point warranty for air handlers with heat recovery, no central chillers or pumps.

- Disadvantages:

  Highest first cost, can have higher energy cost, higher maintenance cost, does not allow for 100% fresh air intake, heat recovery is less flexible can cause over heating of pool water, need additional condensing unit section for humid climates, controls complicated, heavier air handlers, single speed fan motors, unit repair/replacement more costly than simple unit, more maintenance, compressors run 100% of the time.

6.0 Dehumidification Energy Consumption for Different Systems

The energy consumption required to dehumidify 1 kg (2.2 lb) of water is used to compare the energy cost for different system arrangements.

- The energy required to evaporate water from the pool is constant.
- The energy transfer in the coil or heat exchanger required to preheat outside air used for dehumidification must be calculated.
- Latent heat removal by the refrigeration evaporator and use of this waste heat at the condenser to heat the outside air must be determined. Calculations are based on providing the minimum required outside air quantity per person for comparison.

The entire system is arranged, so that minimum energy consumption is achieved using heat recovery and mechanical dehumidification. With outside air temperatures above the refrigeration system balance (bivalent) point the excess heat generated at the condenser can be used economically to heat the pool water. (See Figure 7)

Example Calculation:

An energy consumption and cost comparison follows for dehumidifying 1 kg (2.2 lb) of water and providing the minimum quantity of outside air to the swimming hall.

Basis:

Outside air:
5 C/80% RH (41 F/80% RH), x = 4.5 g/kg

Indoor air:
30 C/55% RH (86 F/55% RH), x = 15 g/kg
Pool water:
27-28 C (81-83 F)

Energy consumption due to ventilator system external pressure drop is neglected.

Heating w natural gas
3.5 ¢ /kWh (η = 0.85)

Electricity
5.0 ¢ /kWh (using demand rate schedule)

The following systems are compared:

1. Dehumidification with outside air/exhaust air without heat recovery.

2. Outside air/exhaust air dehumidification with heat recovery (heat exchanger efficiency 50 %)

3. Combined system with recuperative heat exchanger (efficiency 50 %) and built-in refrigeration for dehumidification with waste heat recovery.

Figure 7 shows schematic diagrams and the necessary energy consumption and relative costs for the system comparison.

7.0 Energy Balance for the Indoor Swimming Hall

Determination of the total heating demand of and waste heat rejection by the indoor swimming hall begins by developing an exact energy balance. Installation of ventilation units with refrigeration waste heat recovery and dehumidification, unlike other ventilation units in the building strongly influence the energy consumption in the Natatoria. For this reason the swimming hall energy balance should be constructed considering the swimming hall alone. A separate energy balance can be developed for the remaining building components. The following loads should be considered:

- Heat loss or gain from through the building shell
- Outside air heating capacity of the built-in plate heat exchanger system (if used)

- Required pool water heating load, consisting of evaporation, transmission losses and preheating the fresh water intake

- Heat gain from the underwater and room lighting systems

- Heat gain from the pool water circulation pumps

- Heat gain from the fan motors in the ventilating units

- Heat gain from the refrigeration system condenser (waste heat)

All of these components are represented in the following example for an indoor swimming hall with 800 m2 (8,600 SF) WSA.

Figure 9 shows the energy balance of the indoor swimming hall during normal operation.

It can be seen that with outside air temperatures over 16-17 C (61-63 F) the mechanical refrigeration begins to cycle on and off. The waste heat from the refrigeration cycle is collected in the condenser where it is used either to heat the supply air or the pool water.

This graph does not show, however, the heat gain from underwater or room lighting systems, because they are usually not switched on during normal operation (this is generally the case for swimming halls which are designed for natural lighting).

8.0 Air Distribution

The air should be distributed in such a manner to ensure that the interior building surface temperature does not fall below the air dew point. In addition, the air velocity at the seating/standing areas should not be higher than 0.2 m/s (40 fpm). This means that optional location for introducing the air is under the windows at the floor and front of outside walls. At the same time the supply air flow pattern should be arranged to provide an even washing of the entire space and therefore an even temperature distribution.
The better the window construction is, the lower the risk of condensation build-up at the windows. If the glass and mullions are well insulated, less air flow across the windows is required which provides more available air to be used to protect other surfaces.

The return air should be divided with 50 % of the total return air removed from the low lying seating/standing areas located across from the supply air outlets. The remaining return air should be removed from the high lying ceiling space above the pool WSA. This will improve indoor air quality.

Care should be taken not to locate return air inlets in close proximity to supply air outlets. This can create short circuiting of the air from supply air ductwork directly into the return air ductwork which wastes energy and provides no protection against condensation.

Special considerations should be made for high, large volume halls in the pool area to avoid hidden problem areas where condensation can build-up.

8.0 Important Points for Proper Operation of the Ventilation System

Ventilation systems used for indoor swimming pools require careful inspection and maintenance. Careful adjustment and regular preventive maintenance are necessary and important for any mechanical system under consideration for use in indoor swimming facilities.

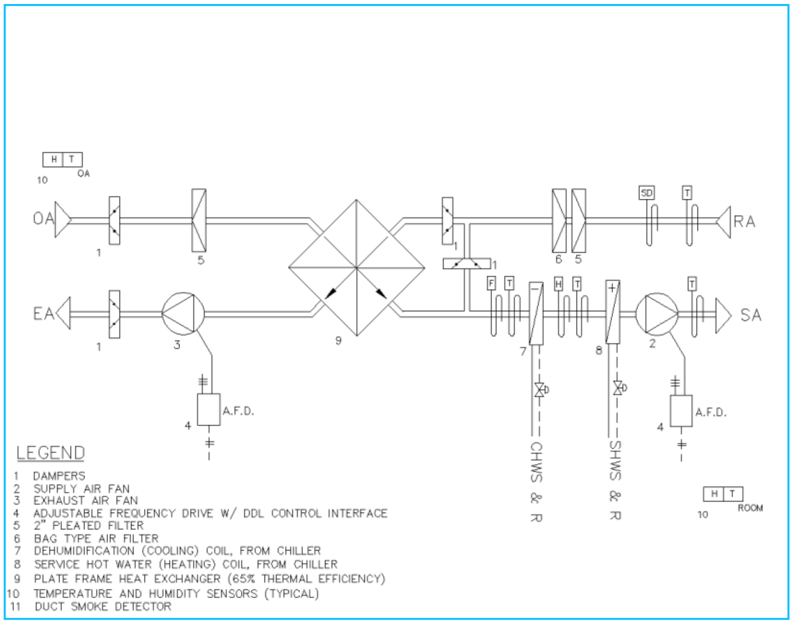
Important items for inspection and/or adjustment are:

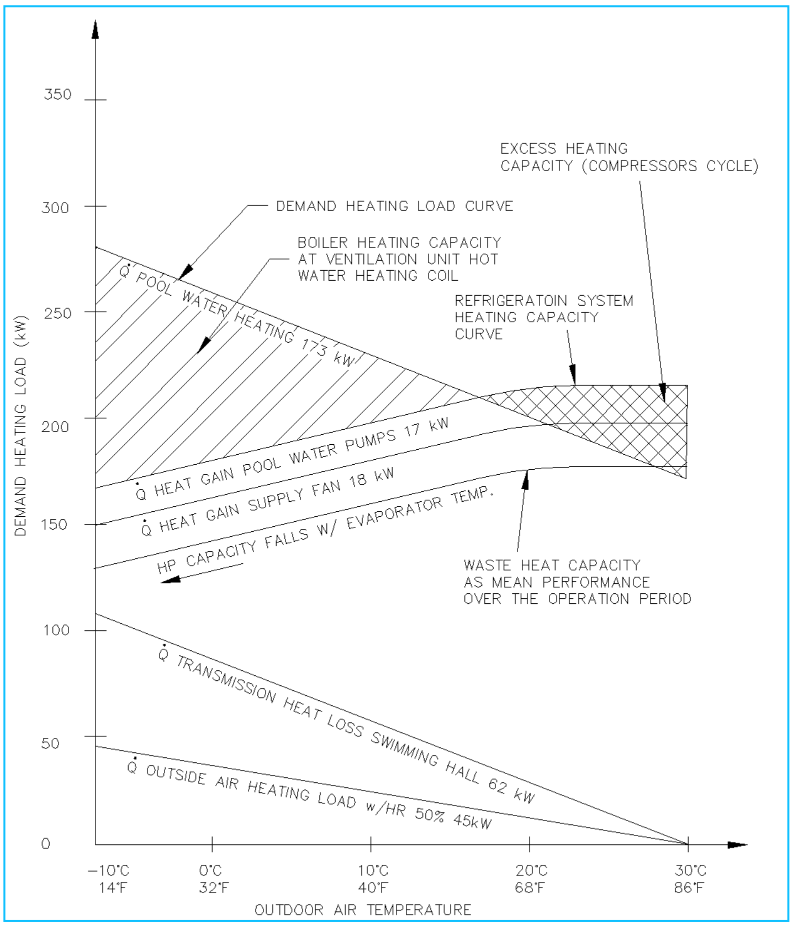
- Optimizing the indoor swimming hall temperature and relative humidity.

- Regular measurement of the outside air and exhaust air flow and the exhaust air temperature.

- Night setback operation with two speed or variable speed fan motors.

- the design protocol. This ensures proper operation of the heat recovery system.
- Cleaning the plate heat exchanger.





- Regular inspection of the unit control system which regulates air temperature and humidity.

  Fine adjustment of the set points to compensate for free heat from lighting and direct UV radiation from the sun. Most ventilation units can be provided with built-in or field supplied digital diagnostics and controls which alert the operator in the event of improper function of one or more system components.

- Air damper regulation to trim the outside air quantity down for reduced energy consumption while maintaining proper indoor air quality.

- Replacing dirty filters as required.

- Matching the total air flow to the actual operation of the swimming hall by inspecting various components of the building construction throughout the year.

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