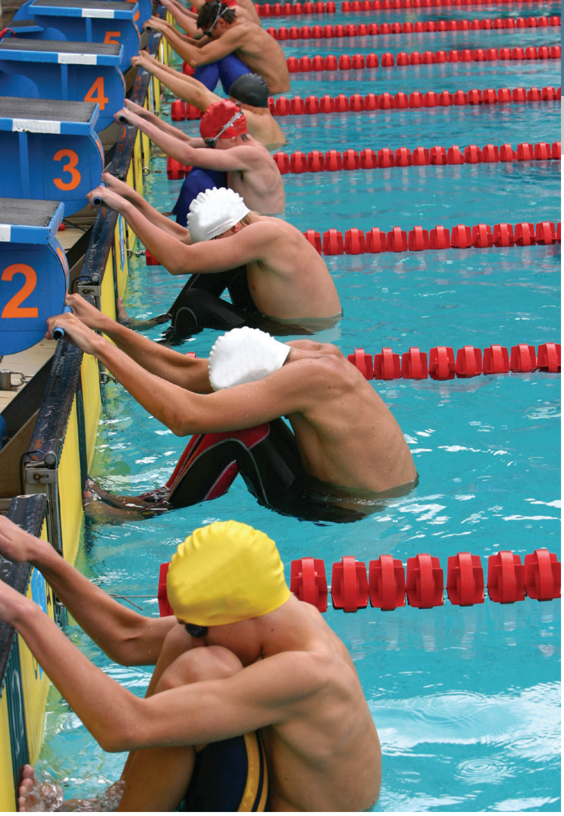


Indoor pool air handling systems must sustain healthy and durable pool spaces during all operating modes.

Special operating modes

Strategies for maintaining IAQ and saving energy when pools are unoccupied, superchlorinated, or hosting swim meets

by Gary Lochner, Innovent

Indoor aquatic facilities require continuous ventilation and effective air distribution during all operating modes. This design guide describes strategies to maintain indoor air quality and reduce energy use in these environments during special operating modes.

UNOCCUPIED MODE STRATEGIES

In a commercial office space or school classroom it is acceptable to reduce or eliminate outdoor air when rooms are unoccupied. However, due to the presence of chloramines, which are gases that form when pools are chlorinated, unoccupied strategies that work well for other types of facilities are inadequate for pool environments. Chloramines are toxic to occupants, cause corrosion, and continuously migrate from an uncovered pool into the air. Chloramine migration increases when pool activity increases but is not eliminated when the pool is unoccupied. ASHRAE 62.1 outdoor ventilation air requirements for pools are based on the expected off-gassing of chloramines, not occupancy.[1]

Similarly, evaporation from a still pool is reduced but not eliminated. ASHRAE lists pool activity factors that modify theoretical evaporation rates and defines an unoccupied pool as having an activity factor of 0.5.[2] Pool spaces have a constant internal dehumidification requirement that is not present in a typical space when unoccupied.

Pool spaces are energy-intensive spaces, with fan motors, air heating (ventilation and envelope), dehumidification, and pool water heating consuming the most energy. These energy costs can be reduced during unoccupied mode by carefully considering facility requirements during initial design of the air handling unit and air distribution, and by understanding the owner's ability to closely monitor changes in condensation, corrosion, air quality, and water chemistry. If not carefully considered during the

design and actively managed and monitored by the owner, changes in operation to reduce energy consumption during unoccupied mode can shorten the life of natatorium materials and air handling systems, and can create poor indoor air quality, out-of-balance pool-water chemistry, dissatisfied swimmers, and much greater—rather than reduced—ownership costs.

Depending on application requirements, the following strategies can reduce energy use when pools are unoccupied.

Chloramine removal and dehumidification requirements are reduced from normal operation but are not eliminated when the pool is unoccupied.

Using an automatically deployed pool cover

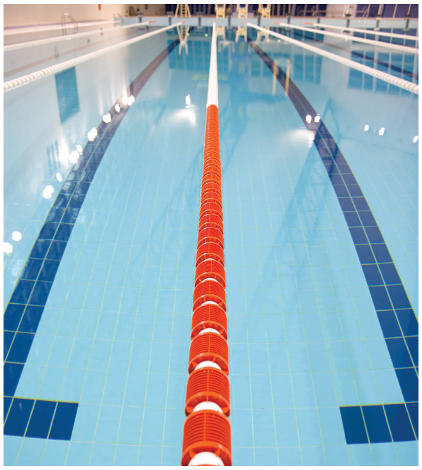
Pool covers can significantly reduce or eliminate pool water evaporation and chloramine migration. This may allow a reduced outdoor air rate, and can reduce costs for dehumidification, pool water heating, air heating, and exhaust fan motor operation.

Owners often find pool covers impractical due to high first cost and the additional maintenance requirements for deploying, removing, and then storing the cover in a suitable spot, and because their pool shape may not be well-suited for a pool cover. Also, trapping moisture and chloramines beneath the cover can have an undesirable effect on water chemistry, which could require special chemical dosing and an expensive ventilation purge operation each morning, significantly reducing energy savings.

Reducing outdoor air rate

Reducing the outdoor air rate during unoccupied mode can reduce air heating costs and help maintain relative humidity between 40-60%, the recommended range for pool spaces per the ASHRAE *HVAC Applications Handbook.*[2] A carefully considered reduction in the outdoor air rate is justified since the transfer of chloramines is reduced. A good strategy is to start by reducing the outdoor air amount to two-thirds of the normal set point and then monitor air quality, water quality, and corrosion of enclosure materials to determine the best set point for the facility.

The potential savings gained from reducing outdoor air should be weighed against the complex air distribution requirements of most pool spaces. Chloramines must still be removed continuously. Condensation prevention



When unoccupied, make sure that enough outdoor air and supply air is provided to prevent condensation, corrosion, and stratification.

on exterior surfaces and good air mixing throughout the space to prevent corrosion and stratification, especially in pools with high ceilings, is still required when pools are unoccupied. Keep in mind that a benefit of bringing in outdoor air in colder months is that it lowers space RH naturally and reduces the risk of condensation on exterior surfaces, especially glass. The cost of dehumidifying in cold months with the outdoor air introduced for IAQ is significantly lower than dehumidifying with electricity when air-to-air heat recovery is utilized.[3]

Alternative methods that reset the space RH set point down using condensation sensors or outdoor air temperature and then running compressors to reduce the space dew point are expensive and complex. Refrigeration systems dehumidify inefficiently at low RH levels, with less of the energy going to moisture removal as the RH is lowered and more going to cooling while the space requires heating. In addition, relying on a sensor rather than outdoor air with effective air distribution to reduce condensation could cause maintenance problems and very high energy costs if the sensor malfunctions.

Reducing the total supply air rate

Since fan horsepower has a cubic relationship to airflow, reducing the total supply air rate by a small percentage using variable frequency drives (VFDs) significantly reduces fan motor energy use, one of the main energy costs for a pool environment.

Care must be taken when selecting diffusers to ensure that they still have enough throw to prevent condensation and corrosion on exterior surfaces (especially glass) at the reduced rate. Outdoor ambient temperatures are coldest during nighttime hours. The combination of dry outdoor

Table 1: Minimum Ventilation Rates in Breathing Zone[1]

Occupancy Category: Sports and Entertainment	People Outdoor Air Rate		Area Outdoor Air Rate		Notes	Default Values			
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s•person	cfm/ft^2	L/s•m^2		#/1000 ft^2 or #/100 m^2	cfm/person	L/s•person	Air Class
Spectator areas	7.5	3.8	0.06	0.3	H	150	8	4.0	1
Swimming (pool & deck)	—	—	0.48	2.4	C	—			2

Notes
1 From Table 6.2.2.1, *ANSI/ASHRAE Standard 62.1-2016. Ventilation for Acceptable Indoor Air Quality.*
4 Default occupant density: The default occupant density shall be used where the actual occupant density is not known.
5 Default combined outdoor air rate (per person): Rate is based on the default occupant density.
C Rate does not allow for humidity control. "Deck area" refers to the area surrounding the pool that is capable of being wetted during pool use or when the pool is occupied. Deck area that is not expected to be wetted shall be designated as an occupancy category.
H Ventilation air for this occupancy category shall be permitted to be reduced to zero when the space is in occupied-standby mode.

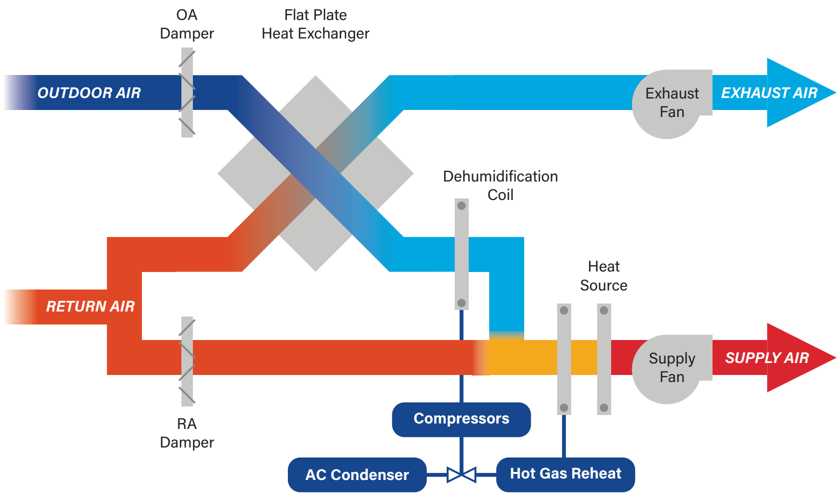


Figure 1: Exhaust air energy recovery reduces entering outdoor air sensible load. Using an air to air heat exchanger, which transfers heat from the exhaust airstream to the entering outdoor airstream, can significantly reduce energy costs. Energy efficiency varies from 45-55% for run-around coils and heat pipes to 65-75% for flat-plate heat exchangers.

air and lower evaporation from still water naturally reduces the indoor dew point, but if diffusers fail to effectively wash surfaces, condensation and corrosion will occur. The air distribution system must continue to remove chloramines and provide good mixing throughout the space to prevent stratification, as well. Any method of reducing total air movement must be scrutinized to avoid unintended effects on space pressure or the amount of fresh air provided. As a rule, if considering a total supply air rate reduction, Innovent recommends starting at 80% of the occupied total supply air rate and not reducing to below two-thirds of the occupied total supply air rate.

Shutting off outdoor air

It is **not** advisable to shut off outdoor air when the pool is unoccupied. This misguided practice puts air quality, water quality, and the building enclosure at risk, and can be far more costly than the achieved reduction in air heating cost. Chloramines still migrate to the air during unoccupied hours. Allowing chloramines to build up at the water surface and in the space exposes the enclosure to risk of corrosion, and can negatively impact air quality and water chemistry. A much better choice is to continuously remove the chloramines from the space through effective ventilation and provide efficient energy recovery on the required ventilation air, possibly combined with a carefully considered and monitored reduction in the amount of outdoor air provided. See Figure 1.

Cycling unit on and off

It is **not** advisable to cycle the air handling unit on and off. This will result in poor humidity control and can significantly shorten mechanical equipment life due to constant cycling and exposure to stagnant, humid, and corrosive air. It also increases the likelihood of corrosion and microorganism growth in the pool space. If the owner chooses to include a dedicated source capture (chloramine removal) exhaust system it should operate continuously.

The percentage of ventilation air used during purge mode can vary based on how quickly after superchlorination the owner needs the pool air and water healthy for occupants.

Resetting space temperature

It is **not** advisable to reset the space temperature down when the pool is unoccupied as this will increase pool water evaporation and the risk of condensation.

PURGE MODE STRATEGIES

Purge mode is used to ventilate a pool space after superchlorinating ("shocking the pool") to restore proper water chemistry. The superchlorination process uses about 10 times the normal amount of chlorine and results in very high amounts of chloramines in the air.

Balancing ventilation, heating, and downtime requirements

Depending on how quickly the facility owner needs to have pool air and water healthy for occupants, the percentage of ventilation air used during purge mode can be varied. For example, in a recreation center, which may have to be shut down temporarily during normal operation due to urine or fecal matter in the pool, a 100% outdoor air/exhaust air (OA/EA) purge option may be desirable to re-open the pool as quickly as possible. For most community recreation centers, a 50% OA/EA purge mode strikes a good balance between cost and downtime. For a school competition pool where superchlorination can be scheduled during unoccupied hours as part of routine maintenance, a lesser percentage of ventilation running for a longer period of time may be the right choice.

A 100% OA/EA purge option is the most effective at quickly removing extra chloramines. This was the traditional solution when the need for a purge mode was first recognized, but it has costly consequences. 100% OA/EA purge requires:

- Outdoor air intake(s) and filtration capable of full supply air volume
- Exhaust or return fan(s) capable of 100% airflow
- A significant increase in heating capability and heating cost to condition the additional fresh air

The cost of providing 100% purge capability needs to be evaluated against the need to bring the pool back into safe operating condition quickly.

The inability of many standard pool air handlers to either deliver and/or heat increased amounts of ventilation air has resulted in purge solutions based on the limitations of the pool air handler rather than the needs of the particular pool space. One solution provides 100% OA/EA for 10 minutes (or the completion of one air change). There is no evidence to suggest that the time required for off-gassing of chloramines from superchlorination is related to the time required to complete a single air change. This method would merely remove

Design a purge solution based on the needs of the space rather than on the limitations of a pool air handler.

the chloramines that had migrated to the air in the first 10 minutes. Another solution runs 100% OA/EA for 30 minutes (default), and allows the space temperature to drop to 40 °F (4.4 °C) before terminating the operation, which will cause severe condensation problems.

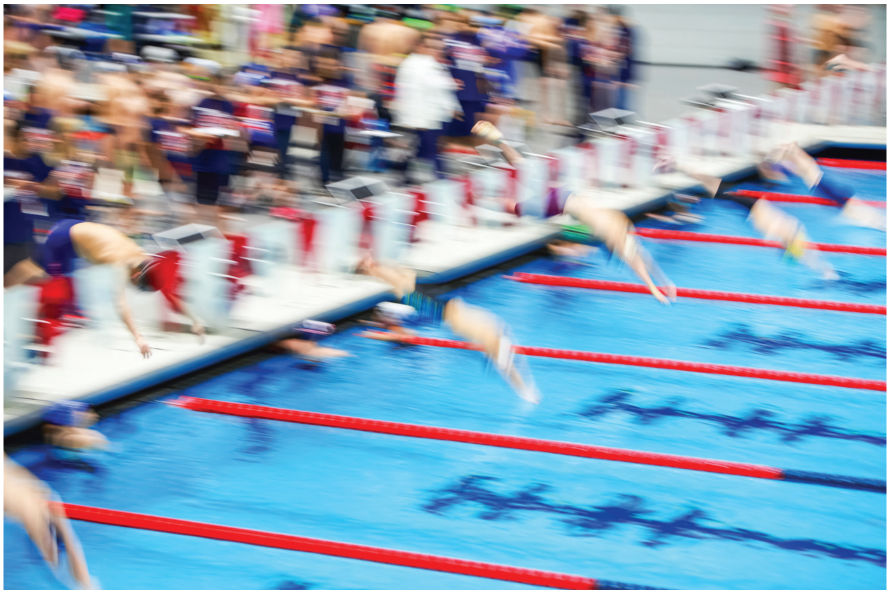
Current guidelines in the *Model Aquatic Health Code*[4] (MAHC) published by The Centers for Disease Control (CDC) recognize the need for increased ventilation after superchlorination but do not account for the differences in types of pool facilities. The CDC recommends providing twice the ASHRAE 62.1 prescribed amount of outdoor air during purge mode (this typically would result in a purge mode with 20-30% outdoor air). The MAHC states that the intent is to run the system in purge mode until the contaminant causing the odor/eye/lung problem dissipates to an acceptable level. However, the single requirement of providing twice the ASHRAE 62.1 prescribed outdoor air amount represents a one-size-fits-all approach that might result in a purge mode running for one hour in one case or eight hours in another, without consideration for the needs of the specific installation.

Recognizing the cost of heating additional outdoor air, the first-cost impact on the size of the heating system, and the limitations of many pool air handlers to provide and condition outdoor air, the CDC states that the outdoor air provided for purge mode does not need to be heated or otherwise treated. In most climates, this limits the time purge mode can run to a few minutes before adversely affecting pool space temperature and causing serious condensation problems. Providing increased ventilation in purge mode without the ability to heat the additional outdoor air compromises purge capability for most of the year.

Purge mode strategies that reduce energy and first costs, and deliver higher percentages of fresh air

There are options to reduce purge mode energy and first costs:

- Provide a 50% OA/EA purge mode. This can be an economical and effective choice, especially when provided with air-to-air energy recovery on the 50% OA/EA airflow. It may take an hour or two longer to remove the chloramines than a 100% OA/EA purge mode, but the increase to the heating plant is much smaller and the higher percentage of conditioned outdoor air may already be required if the pool is used for competitions and has a swim meet spectator space.
- Design the purge mode for a less extreme winter OA design temperature (for example, purge to 0 °F [17.8 °C] when the design temperature is –15 °F [–26.1 °C]), and prevent purge mode operation below the purge design OA temperature.



When one air handler serves both pool and spectator areas it must be designed to condition and deliver additional ventilation air during a swim meet.

MEET MODE STRATEGIES

For spectator areas, ASHRAE 62.1 requires a ventilation rate of 7.5 cfm (3.8 L/s) of outdoor air per spectator plus 0.06 cfm/ft² (0.3 L/s•m²) of spectator floor area when a swim meet is held. This requirement is in addition to the required ventilation rate for pool and deck areas (Table 1).

The best way to meet the spectator area ventilation requirement while delivering air that is cooler and more comfortable than the air delivered to the pool area is to physically separate the spectator area from the pool area and provide a dedicated air handling unit for that area. In this case, a "Meet Mode" is not required for the pool air handler. However, due to budget considerations the spectator area is typically within the pool space and a Meet Mode is required to ensure adequate ventilation for spectators.

When the pool and spectator area(s) are served by the same air handling unit, it must be designed to condition and deliver the additional ventilation air required during a swim meet. At a minimum, this will result in a greater heating requirement at winter design conditions and a greater sensible cooling requirement at summer design conditions (if the facility expects to hold swim meets during the summer). The latent load from spectators (estimated at 0.16 Btu/lb/spectator or 0.37 kJ/kg) and the outdoor air latent load at summer design conditions (which depends on climate) are added to the expected evaporation load at summer design conditions to determine the dehumidification required during Meet Mode. A pool air handling unit that optimizes the use of outdoor air for economical dehumidification for most of the year will have built-in capability to condition and deliver the additional outdoor air required for Meet Mode.

There is a school of thought that the pool evaporation rate is lower than normal during a swim meet because there is only one swimmer per lane in the pool for short bursts and, therefore, the activity factor is lower. However, this reduction in evaporation load is offset by there being many more people than normal on the pool deck. The sensible and latent load from swimmers is usually ignored because they are in the water and water-cooled. If most of the swimmers and coaches are on the deck during a meet, their latent and sensible loads cannot be ignored. To be conservative, Innovent recommends designing without reducing the activity factor during Meet Mode.

For facilities hosting large competitions it may be advisable to calculate ventilation rates by zone, adding them together as follows:

- Pool and deck areas: 0.48 cfm/ft² (2.4 L/s•m²)
- People on the deck (swimmers and coaches): 7.5 cfm/person (3.8 L/s•person)
- Spectators: 7.5 cfm/person (3.8 L/s•person)
- Add additional outdoor air to meet air distribution requirements and to account for pool height and activity factor.[5]

SUMMARY

Indoor pool air handling systems must sustain healthy and durable pool spaces during all operating modes. The strategies presented here will help optimize energy use during special operating modes without sacrificing indoor air quality.

About the author

Gary Lochner is Senior Director, Application Engineering, Sales at Innovent. He holds a Mechanical Engineering Degree with heat transfer emphasis from the University of Minnesota. His background includes technical and leadership positions at a major HVAC manufacturer and a succession of roles at Heatex and Innovent. For nearly twenty-five years Gary has helped design over 1000 HVAC units serving indoor aquatic facilities, ranging from high school pools to community rec centers to major water parks. Gary has spoken on design considerations for these spaces at many ASHRAE chapter meetings. This broad experience has uniquely equipped him with a deep understanding of the many complex factors at play in natatoriums.

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Chloramines & Pool Operation
Website from The Centers for Disease Control and Prevention
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