

# Splash & Spray

Community Water-Play In Action!

## Hot Industry Trends

Spray Parks – how to avoid costly mistakes

## Navigating the Waters

Making an RFP/RFQ work for your municipal waterpark

## Community Treasures Unveiled

Splash! La Mirada Regional Aquatics Center





# E = Efficiency

**With proper consideration to humidity, evaporation and ventilation, an aquatic center can achieve energy efficiency.**

My introduction to the waterpark industry involved a roof that was saturated and sagging with water dripping throughout the facility. Not only was the facility lacking energy efficiency, but not enough consideration was given to the energy design and so the building's structure was comprised. A better method of ventilation rate modulation is required, along with a control system that provides feedback from multiple sensors throughout the aquatic center. This will help a facility achieve energy efficiency and ensure that the waterpark is never exposed to excessive humidity which leads to excessive condensation on the surface and within the building structure.

## **Waterpark Efficiency Introduction**

The primary function of the waterpark ventilation system is to maintain proper air quality. Proper air quality provides a comfortable and safe environment for occupants and protects the building structure. The key characteristics of waterpark air quality are temperature, humidity and chloramines levels.

Evaporation from the pools and water features drives the humidity in the waterpark. Humidity drives the ventilation rate to maintain air quality. Therefore, evaporation and humidity drive the majority of the waterpark thermal energy needs. To optimize waterpark energy efficiency:

**By Ed Kiser, P.E.**

Indoor pools and water features add significant humidity to the air through evaporation.

1. Limit evaporation as much as possible
2. Optimal ventilation equipment and air distribution design
3. Control system that can react to system changes

### Waterpark Design conditions

Air temperatures are usually set at approximately 86oF with 84oF average pool water temperatures. ASHRAE recommends maintaining between 50% to 60% relative humidity for indoor pool facilities.

*“Fluctuations in relative humidity outside the 40 to 60% range can increase levels of bacteria, viruses, fungi and other factors that reduce air quality. For swimmers, 50 to 60% Rh is most comfortable. High relative humidity levels are destructive to building components. Mold and mildew can attack wall, floor and ceiling coverings, and condensation can degrade many building materials. In the worst case, the roof could collapse due to corrosion from water condensing on the structure.”*

2007 ASHRAE Applications Manual page 4.6

### Waterpark Evaporation

Indoor pools and water features add significant humidity to the air through evaporation. There are three primary drivers of evaporation in a waterpark:

1. Air to Water Surface Area
2. Air Velocity relative to the Water Surface
3. Difference of Water Saturation Pressures

Many of the water features in waterparks increase both the air to water surface area and the relative velocity



Aquatic centers face differing evaporation levels depending on the occupancy.

between the water and air surfaces. Swimmers also increase each through splashing the water and carrying it out of the pool with them. Therefore, the total evaporation within the aquatic center varies with the occupancy (fully occupied, partially occupied, unoccupied, etc...).

Simple methods to reduce evaporation:

- A. Reduce water temperature as much as possible (unoccupied opportunities)
- B. Cover unoccupied pools
- C. Minimize(eliminate) water feature flows/spraying during unoccupied hours

### The Weather Variable

In most facilities, the only means to control building humidity is through the introduction of outside air. The ventilation system can heat the air, but typically it cannot remove humidity. Therefore, the ventilation system’s ability to dehumidify is dependent on the outdoor humidity. Unfortunately, weather conditions are variable with changing humidity ratios from season to season, day to day, and even hour to hour.

The maximum waterpark humidity ratio is 115 grain/lb (86oF/60% RH). Subtracting the indoor humidity ratio from the outdoor humidity ratio gives the Humidity Ratio Difference (amount of moisture the air can absorb before reaching the maximum

**TABLE 1**  
**Example Midwest weather conditions (600 feet elevation)**

WEATHER EXAMPLE	OUTDOOR WEATHER CONDITIONS			WATERPARK MAXIMUM CONDITIONS			HUMIDITY RATIO DIFFERENCE (gr/lb <sub>a</sub> )
	DRY BULB TEMP (°F)	RELATIVE HUMIDITY (%RH)	HUMIDITY RATIO (gr/lb <sub>a</sub> )	DRY BULB TEMP (°F)	RELATIVE HUMIDITY (%RH)	HUMIDITY RATIO (gr/lb <sub>a</sub> )	
Design Winter Day	0	90%	5	86	60%	115	110
Average Winter Day	32	90%	24	86	60%	115	91
Average Spring Day	55	80%	53	86	60%	115	63
Average Summer Day	80	60%	95	86	60%	115	21
Design Evaporation Day	85	67%	125	86	60%	115	-10

**All waterparks are different, and therefore, will have different evaporation rates and ventilation needs.**

humidity ratio). As you can see, the amount of moisture the supply air can absorb changes drastically with the weather.

### Ventilation Rate Requirements

To maintain a constant humidity in the building, a ventilation system must react to the weather and occupancy variables. Weather conditions will change the amount of moisture that the ventilation air can absorb. Occupancy changes the

rate of evaporation, and thus, the rate at which humidity is added to the air. If the ventilation does not react to changes, one of two things will happen:

1. The ventilation system will over ventilate the space and lower the building humidity below the required conditions. This lower humidity will actually increase the evaporation in the waterpark. Operating at lower humidity consumes more energy to heat the additional air and evaporate the additional water.
2. The ventilation system will under ventilate the space and raise the building humidity above the required conditions. This higher humidity can cause condensation and building structure deterioration, and lower the air quality for the waterpark occupants.

A common scenario is a ventilation system with fixed air exchange somewhere in the middle. Such a ventilation system would waste energy during hours of cooler weather / lower waterpark occupancy, and create humidity problems during hours of warm humid weather / higher waterpark occupancy.

### Ventilation Rate Example Calculations

Example evaporation calculations on a 40,000ft<sup>2</sup> waterpark illustrate how these variables affect the total amount of ventilation required to maintain an average space condition of 86oF / 55% RH. All waterparks are different, and therefore, will have different evaporation rates and ventilation needs. However, the ventilation needs of all waterparks change proportionally with the variables similar to the example below.

Assuming occupied conditions for all weather examples, you can see how much warmer weather decreases the ability of the ventilation system air to remove moisture from the facility. Therefore, more outside air must be supplied to the space to maintain the building humidity.

Additionally, once the outdoor air exceeds the threshold humidity ratio, the ventilation system can

no longer maintain the building humidity set point. Without mechanical cooling, the facility must deal with higher humidity during these humid days.

Holding the weather constant at our average winter day conditions, it is clear that occupancy significantly changes the ventilation needs throughout every day. This calculation shows that unoccupied (night) ventilation is roughly one third that of the normally occupied condition. The ventilation system must continuously monitor the building conditions and react to them to take advantage of this opportunity.

### HVAC Airflow design

Supply air should be designed velocity independent. That will allow the HVAC units to slow down with Variable Frequency Drives (VFDs) without compromising the air distribution to the ground level. Systems designed to throw air to the ground with velocity are forced to maintain a constant fan speed or compromise the air distribution to the ground level.

Exhaust air collection should be done at the pool level(s). This will remove humidity and airborne contaminants at the source to increase air quality and provide more uniform building conditions.

In a high exhaust ventilation system, we have discovered that during occupied hours the humidity is much higher at the floor than at the high unit exhaust location. Even with large ceiling circulation fans, the humidity does not completely mix with the fresh air and exit the building through the high points exhaust. This creates areas of high humidity around the pools, and can also create areas of higher chloramine levels around the pool.

Ventilation requires a great deal of electricity and natural gas (or some other thermal source) to move and heat air. To be effective using that energy, the air must be delivered to the waterpark at ground level to increase the air turnover where it is needed. Waterparks do not want to consume energy to increase the air turnover near the building ceiling where there are no people and less pool contaminants.



The right ventilation system will allow an aquatic center to conserve energy.

## Hot water heating coils

Hot water air handling units have several operational advantages over direct gas fired air handling units.

1. Turndown: We have established the need for the ventilation system to modulate airflow considerably as conditions change. Hot water heating allows for unlimited turndown of heating and unlimited turn-down of airflow to meet the building need. Direct fire gas burners, however, have limited heating turn-down ratio. Additionally, the airflow over a burner must be maintained to ensure good combustion. Therefore, the airflow turndown is also limited with direct fire gas burners.
2. Humidity: Maintaining the waterpark humidity is the primary driver for the ventilation rate. Hot water heating adds only sensible heat (temperature) to the supply air. Direct fire gas burners add both sensible heat (temperature) and latent heat (humidity) to the supply air as a result of the products of combustion entering the air stream. Therefore, a direct fire gas system has to

supply more total air to a waterpark to provide the same humidity set point. The additional supply air requires more fan electricity and burner natural gas.

3. Heat Recovery Integration: Waterpark resorts have multiple opportunities for heat recovery. That heat can be converted to hot water and supplemented to the waterpark heating system to offset the heating fuel use.

## Building Control System

A global building control system is required to operate the ventilation system properly. There are too many variables that change by the hour to try to operate a waterpark ventilation system manually. Manual control will lead to over and under ventilation of the facility, which will lead to problems.

The control system needs multiple building sensors (temperature, humidity, etc...) located throughout the occupied waterpark areas to make operation decisions. Simple exhaust air sensors give an average reading of the entire aquatic center, and are not representative of the multiple

conditions where the occupants reside. To optimize the ventilation system, the control system needs optimum feedback.

The control system can also archive all operating data. This allows for easy trouble shooting and identification of opportunities.

Energy efficiency in a waterpark is not easy. It requires much more than efficient equipment and a well designed system. Waterpark systems need continuous monitoring and control capabilities to react to the always-changing waterpark conditions. The results are energy efficiency as well as improved air quality, guest comfort and long term protection of the facility structure. **S&S**

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**TABLE 2**  
**Occupied 40,000ft<sup>2</sup> waterpark example ventilation requirements**

WEATHER EXAMPLE	OUTDOOR WEATHER CONDITIONS			WATERPARK SPACE CONDITIONS			VENTILATION	
	DRY BULB TEMP (°F)	RELATIVE HUMIDITY (%RH)	HUMIDITY RATIO (gr/lb <sub>a</sub> )	DRY BULB TEMP (°F)	RELATIVE HUMIDITY (%RH)	HUMIDITY RATIO (gr/lb <sub>a</sub> )	TOTAL FLOW (scfm)	SPECIFIC FLOW (scfm/ft <sup>2</sup> )
Design Winter Day	0	90%	5	86	55%	105	68,552	1.7
Average Winter Day	32	90%	24	86	55%	105	78,408	2.0
Average Spring Day	55	80%	53	86	55%	105	106,088	2.7
Average Summer Day	80	60%	95	86	58%	112	242,469	6.1
Design Evaporation Day	85	67%	125	86	70%	136	251,758	6.3

**TABLE 3**  
**40,000ft<sup>2</sup> waterpark example ventilation requirements through different occupancy conditions**

OCCUPANCY	WEATHER CONDITIONS			WATERPARK SPACE CONDITIONS			VENTILATION	
	DRY BULB TEMP (°F)	RELATIVE HUMIDITY (%RH)	HUMIDITY RATIO (gr/lb <sub>a</sub> )	DRY BULB TEMP (°F)	RELATIVE HUMIDITY (%RH)	HUMIDITY RATIO (gr/lb <sub>a</sub> )	TOTAL FLOW (scfm)	SPECIFIC FLOW (scfm/ft <sup>2</sup> )
Unoccupied Night	32	90%	24	86	55%	105	26,953	0.7
Low Occupancy Weekday	32	90%	24	86	55%	105	49,005	1.2
Normal Occupancy Weekend	32	90%	24	86	55%	105	78,408	2.0