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Ultraviolet Water Treatment for Recreational Water Facilities (RWFs)

With the ever-growing emphasis on physical fitness, spas and personal training, local recreational water facilities continue to be a wise choice, even for the rehab niche. How much thought do you actually believe your fitness or rehab swimmers give to the quality of water that they are about to jump into? If they are like most, probably not much more than a quick verification to confirm that the water is clear. However, if you operate an RWF, your thoughts weigh heavily on what lurks below the surface.

It is well documented that **Recreational Water Illness (RWI)** is on the rise. RWIs are spread by ingesting, breathing, or having contact with contaminated water from swimming pools, spas, lakes, rivers or oceans. RWIs can cause a variety of symptoms including intestinal, skin, ear, eye, respiratory, and neurological infections. The most commonly reported RWI is diarrhea that is typically caused by one or more of the following: ❶ parasites including Cryptosporidium and Giardia, ❷ bacteria such as Shigella, and E. coli O157:H7, or ❸ viruses such as noro-virus. Children, pregnant women, and people with compromised immune systems can suffer from more severe illness if infected with these germs. In some individuals with weakened immune systems it has been reported that Cryptosporidium can be life threatening.

Why is RWI on the rise?

- The emergence of more chlorine resistance germs
- More splash parks in local communities
- Families staying closer to home due to the current economic climate that is causing an increase to local splash parks
- Poor pool maintenance at RWFs

This article will clarify the differences in available UV technology and help define a few steps operators can take to greatly enhance the safety and water quality of any RWF.

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The first step is defining a Recreational Water Facility. **A RWF is any commercial or public pool, spa or splash park.** It is made up of water, filtration, biocide chemicals, a recirculation system and people…at times a lot of people. Think of a pool as an incubator, especially a jacuzzi. If left untreated or poorly maintained, bacteria will grow and multiply within hours. The water will eventually get cloudy and soon the RWF will have to close down until the water quality issue is back within acceptable norms as stipulated by the local Health Department.

Regulations

Chlorine continues to be the disinfectant of choice for RWFs. It is inexpensive and does a good job of killing most microorganisms and pathogens. It provides a residual that continues to protect the pool from contamination. Unfortunately, the world we live in is always changing. Chlorine is no longer a practical stand-alone disinfectant, nor is it a safe, environmentally friendly answer. Furthermore, studies have shown that there is an increase of more chlorine resistant microorganisms migrating into our water systems, including RWFs. This is why it is important for RWFs to take the initiative in their water treatment process by adapting a multi-barrier approach to water disinfection.

UV disinfection equipment has been installed on swimming pools with great success for decades with little to no regulation overseeing the recreational water industry. UV equipment in combination with chlorine disinfection provides a safe and effective multi-barrier approach for RWF water treatment program. More recently, however, regulations have caught up with the industry, especially as more news about cryptosporidium spreads across the US.

Today, NSF 50 is the primary self-regulating body governing the RWI. NSF 50 certified UV equipment assures that the equipment has been tested and meets the safety criteria set forth by the organization and the industry as a standard. For more information on the certification process please go to www.nsf.org.

Third party vioassay validation (DVGW / USEPA) is a more stringent validation procedure than NSF-50. Third party bioassay validation certification is on the rise at RWFs, especially in commercial and municipal splash parks. The reason for this trend is simple. One is more likely to accidentally ingest a mouthful of water from a splash park than from a pool. As a result, more municipalities and city regulators require the water at RWF locations to be treated to drinking water standards that include the use of UV to protect against RWIs. A third party bioassay validated system has been challenged in multiple scenarios to ensure that the UV unit performs per the manufacturer's claims. Since validated systems are costly to certify, one will typically pay significantly more for a validated system than a non-validated system.

Average UV Dose Required for Inactivation (mJ/cm2)

Pathogen	1-Log	2-Log	3-Log	4-Log
Cryptosporidium parvum oocysts	1.3	2.5	4.3	5.7
Giardia lamblia cysts	0.3	0.7	1.3	1.7
Vibrio cholerae	0.8	1.4	2.2	2.9
Shigella dysenteriae	0.5	1.2	2	3
Escherichia coli 0 157:H7	1.5	2.8	4.1	5.6
Salmonella typhi	1.8 - 2.7	4.1 - 4.8	5.5 - 6.4	7.1 - 8.2
Shigella sonnel	3.2	4.9	6.5	8.2
Salmonella enteritidis	5	7	9	10
Hepatitis A virus	4.1 - 5.5	8.2 - 13.7	12.3 - 22	16.4 - 29.6
Poliovirus Type I	4.1 - 6	8.7 - 14	14.2 - 23	21.5 - 30
Coxsackle B5 virus	6.9	13.7	20.6	30
Rotavirus SA 11	7.1 - 9.1	14.8 - 19 2	3 - 25	36

UV Technology

UV technology is a well-established method of providing a non-chemical form of disinfection to water systems. It has been used in commercial and industrial applications since the early 1900s.

A UV unit produces either a wide spectral output (medium pressure systems) or narrow spectral output (low pressure systems) of UV light, typically in the 200-350 nm range. Exposure to this UV output is lethal to most microorganisms. Virtually all UV systems that are installed in commercial and industrial applications are designed to produce a minimum UV dose of 30 mJ/cm2 at the end of a unit's lamp life. Upon exposure to the UV lamps, a microorganism's DNA is altered and as a result, becomes non-viable. It basically dies shortly after exposure to UV.

Most microorganisms are killed with a UV dose of ≤10 mJ/cm2. Please refer to the chart (below left) for additional information on some of the most common microorganisms found in drinking water systems.

Low Pressure vs. Medium Pressure UV Systems

There are two schools of thought and technologies available for RFW facilities. One group utilizes low-pressure UV systems. The second group prefers medium pressure UV systems. Both technologies work equally well at killing cryptosporidium and reducing monochloramines from a RWF. The noise and confusion you hear in the background, typically comes from the manufacturer or manufacturer's representative pushing one technology over the other technology. An unbiased review of both technologies is noted below.

A **low pressure UV system** is generally made up of multiple UV lamps within a reactor chamber. Virtually all of its UV lamp output (95%) is produced at a wavelength of 254 nm.

Key Advantages of Low Pressure Systems

- Easily kills cryptosporidium, giardia and other microorganisms
- Very effective at reducing monochloramines
- Low operating cost
- Lower total cost of ownership than medium pressure systems

Disadvantages of Low Pressure Systems

- Tends to have a larger footprint than medium pressure systems
- Not effective at reducing dichlorimines or trichlorimines as medium pressure systems

Keep in mind, however, if monochloramines are absent from the water it will be difficult to produce dichlorimines or trichlorimines

A **medium pressure UV system** can be configured into a single or multiple lamp configuration. System design is dependent on flow rate and UV dose. Each UV lamp produces a wide range of UV output, typically in the 220 nm to 350 nm wavelength.

Key Advantages of Medium Pressure Systems

- Easily kills cryptosporidium, giardia and other microorganisms
- Very effective at reducing monochloramines, dichlorimines, and trichlorimines
- Small footprint
- Ideal for retrofitting into an existing pump room with limited space

Disadvantages of Medium Pressure Systems

- UV output is not as efficiently delivered as low-pressure systems
- Consumes significantly more power than low-pressure systems
- Total cost of ownership is much higher than low-pressure systems especially in the 600-1,000 gpm flow rate range

TECH TIP: A CASE STUDY

In 2009, an inquiry was submitted for a national theme park's RWF. The client specified a UV system to control cryptosporidium for their new outdoor splash park. The flow rate was 710 gpm. The cost of electricity was $0.12 per KWH. Listed below is a summary of power consumption for the proposed equipment. As you can see, the low-pressure system provides a quick payback compared to the two medium pressure systems, even though it incorporates more UV lamps.

Technology	No of UV Lamps	Power	Annual Power Cost	5-Year Power Cost	10-Year Power Cost	15-Year Power Cost	20-Year Power Cost
LP System	6	1.5 KWH	$1,577	$7,884	$15,768	$23,652	$31,536
MP System #1	2	4.0 KWH	$4,205	$21,024	$42,048	$63,072	$84,096
MP System #2	4	7.8 KWH	$8,199	$40,997	$81,994	$122,990	$163,987

Applications

For RWFs there are two applications that are usually considered when one decides to install a UV system. One application calls for disinfection for the treatment of chlorine resistant microorganisms. The other application calls for the reduction of chloramines.

Cryptosporidium

One of the driving factors causing more RWFs to incorporate UV into their facility is the increasing need to treat cryptosporidium. Cryptosporidium is a cyst that is resistant to chlorine, even at high dose levels. UV, however, easily kills cryptosporidium. As outlined in the earlier dosage chart, cryptosporidium can easily be killed with a UV dose of ≤10 mJ/cm2.

For disinfection applications in splash parks and outdoor pools, chloramines reduction is generally not as important as providing treated water for the control of RWIs. In this case, either a UV dose of 30 or 40 mJ/cm2 is more than adequate. There is a trend emerging that outdoor facilities will require a minimum UV dose of 40 mJ/cm2 in the future.

The best treatment for a RWF today incorporates a multi-barrier approach. Utilizing chlorine, filtration and UV will enhance the quality of the water and ensure the safety of a RWFs swimmer.

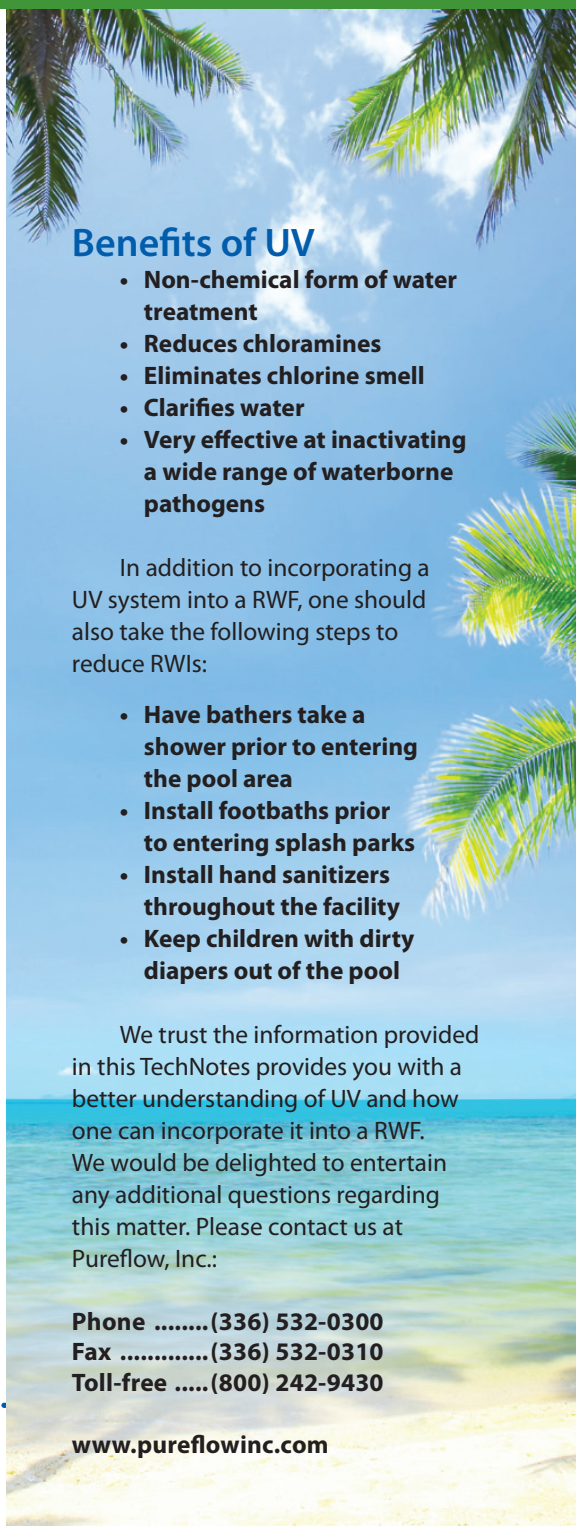
Chloramines Reduction

Another benefit of incorporating UV into a RWF is its unique ability to reduce chloramines in either an indoor or outdoor facility. Have you ever walked into an indoor swimming pool only to be overwhelmed by that strong chlorine smell? You know the feeling. Your eyes begin to burn, they become bloodshot and it can be difficult to breath. That chlorine smell is not really chlorine, but the off gassing of chloramines. In either case, a properly sized UV system can easily eliminate that smell and burning sensation.

Chloramines are produced by any combination of factors. The more common methods of chloramines formulation involve heavy bather load, sweat and urine.

Generally speaking, UV sizing for a RWF is going to be site and application specific. For chloramines reduction applications, the required UV dose is 60 mJ/cm2. With this dosage, one will immediately notice a reduction in that chlorine smell within the initial 24-48 hours of operation after the installation and operation of the UV system.

This was the case for the **Jamerson Family YMCA in Lynchburg, VA**. The local members who used the indoor competition pool were challenged with a strong chloramines odor. Pureflow was able to eliminate the chloramines smell by installing an Aquafine MPR Series UV unit on the recirculation line to the pool. During the initial 24 hours of operation with the UV unit on, the combined chlorine level (chloramines) decreased from 0.6-0.8 ppm to 0.1 ppm. After 48 hour operation, the combined chlorine level held steady at 0 ppm, and it remains at 0 ppm. Competition pool swimmers noticed an immediate improvement in air quality within the pool area shortly after the medium pressure UV unit became operational.



Benefits of UV

- **Non-chemical form of water treatment**
- **Reduces chloramines**
- **Eliminates chlorine smell**
- **Clarifies water**
- **Very effective at inactivating a wide range of waterborne pathogens**

In addition to incorporating a UV system into a RWF, one should also take the following steps to reduce RWIs:

- **Have bathers take a shower prior to entering the pool area**
- **Install footbaths prior to entering splash parks**
- **Install hand sanitizers throughout the facility**
- **Keep children with dirty diapers out of the pool**

We trust the information provided in this TechNotes provides you with a better understanding of UV and how one can incorporate it into a RWF. We would be delighted to entertain any additional questions regarding this matter. Please contact us at Pureflow, Inc.:

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- George Washington

"No one is wise or safe, but they that are honest."

- Sir Walter Raleigh

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