

Spas, Hot Tubs, and Whirlpool Bathtubs: A Guide for Disease Prevention

by **Matthew R. Freije**

Copyright © 2000, by Matthew R. Freije

ISBN 1-930488-09-2

All rights reserved. No part of this publication, neither the printed copy nor the electronic file, in whole or in part, may be reproduced or transmitted in any form or by any means, electronic or mechanical, including transmittal by e-mail, by file transfer protocol (FTP), through access to a network, by photocopying, by recording, or by any information storage and retrieval system, without written permission from HC Information Resources Inc.

Published by:

HC Information Resources Inc.

PO Box 2109

Fallbrook CA 92088-2109, USA

Tel: 1-800-801-8050 (USA and Canada) or +1-760-451-1020

Fax: 1-800-290-1967 (USA and Canada) or +1-619-839-3166

hcinfo@hcinfo.com

<http://hcinfo.com>

For information on translations, foreign rights, a printed version, or a multi-user license, or for other sales inquiries, contact HC Information Resources at the above location. To be added to our mailing list, register at our Web site or send an e-mail message.

Acknowledgments

The time and expertise of Charles Gerba, Jon Howarth, Alison Osinski, John Rohwer, Robert Romaine, and Michael Silveri, who provided a technical review of the manuscript, are greatly appreciated. Many thanks also to Michelle Kienholz for excellence in copy editing.

Warning and Disclaimer

This report is designed to provide information about the subject matter covered. It is sold with the understanding that the publisher, author, and advisors are not rendering legal, medical, engineering, or other professional services. If such expert assistance is required, the services of a competent professional should be sought. Neither the author nor the publisher endorses or recommends any of the resources mentioned in this report; nor does either guarantee the accuracy, completeness, usefulness, or effectiveness of the material provided. The author and publisher shall not be liable for damages in an amount greater than the purchase price of this report, or in any event for incidental or consequential damages caused or alleged to be caused, directly or indirectly, by the use of any information disclosed in this report, including the use of any recommendations, methods, products, services, instructions, or ideas.

About the author

Matthew R. Freije earned a degree in mechanical engineering from Purdue University. He reviews published research and screens marketed products and services to provide practical solutions to water problems. His book *Legionellae Control in Health Care Facilities: A Guide for Minimizing Risk*, a 1997 award finalist, has been fully reviewed or highlighted in more than 50 professional journals, and has sold in 25 countries. Freije is also the author of several articles and has served as a guest speaker for professional societies. He is a member of the American Society of Plumbing Engineers and of the Water Quality Association. Freije welcomes feedback on this report, especially suggestions for improvement. Please e-mail comments to mf@hcinfo.com.

Table of Contents

[Introduction](#)

[Distinguishing among spas, hot tubs, and whirlpool bathtubs](#)

[Associated illness](#)

[Precautions for whirlpool bathtubs](#)

[Recommendations for spas and hot tubs](#)

- [Introduction](#)
- [Overview of disinfection](#)
- [Disinfectant levels and other parameters](#)
- [Chemical monitoring and dosing](#)
- [Precautions in handling chemicals](#)
- [Draining and cleaning](#)
- [Filters](#)
- [Shock treatment](#)
- [Bacterial monitoring](#)
- [Other recommendations](#)

[Avoiding contamination from public spas and baths](#)

- [Public spas and baths](#)
- [Displays at stores and trade shows](#)

[References](#)

[Appendix](#)

- [Associations](#)
- [Magazines and web sites](#)
- [Automatic monitoring and dosing equipment](#)
- [Test kits for spa water](#)
- [Whirlpool bathtub cleaning equipment and products](#)

Tables

- [Table 1. Organisms found in spas](#)
- [Table 2. Effectiveness of chlorine and bromine relative to pH](#)
- [Table 3. Suggested bacteria limits](#)
- [Table 4. Common spa problems](#)

[Other publications from HC Information Resources](#)

Introduction

No new theories are presented in this document—just action steps based primarily on published material. For brevity, background data and scientific theories are excluded except where such information helps the reader decide what action to take.

Information is included for public (e.g., hotels, exercise clubs) as well as private (e.g., homes) spas, hot tubs, and whirlpool bathtubs. However, this document will be most useful for owners of private and small public systems.

Operators of public spas must investigate and comply with any state, province, county, or city regulations. In most if not all areas, public spa regulations pertain to any spa that is not located in a private residence. For example, a spa located in a private country club, though not open to the public, will be considered a public spa with respect to regulations. To find out about regulations in your area, call your local health department and ask for the sanitation or pool engineer. If the health department does not oversee spa and whirlpool bath regulations, it can probably direct you to the agency that does.

Distinguishing among spas, hot tubs, and whirlpool bathtubs

Spas and hot tubs are not the same as whirlpool baths. Spas and hot tubs are used for recreation rather than for bathing. Many private spas are located outdoors. They are not drained after each use. Most have heaters. The water is treated and filtered.^{1,2}

Spas are much the same as hot tubs except that spas are formed of plastic, concrete, or metal, while hot tubs are constructed with wood. In addition, spas are generally equipped with air jets, but many hot tubs are not.

Whirlpool bathtubs, by comparison, are essentially bathtubs with water jets. Most are located in bathrooms. They are drained after each use. Most units do not have heaters, and the water is not treated with chemicals.^{1,2}

Associated illness

Spas, hot tubs, and whirlpool bathtubs can provide a fertile breeding ground for many microbes, including organisms that cause disease.³ At greatest risk of illness and death are pregnant women, those with weakened immune systems, small children, the elderly, and smokers,³⁻⁶ which, combined, make up 25% of the US population.⁶ Individuals in generally good health can also become

infected, particularly if the microbial level is high.^{3,5}

Each person releases organic matter while using a spa or whirlpool bath, including dead skin cells, perspiration, a small amount of urine, oils, and cosmetics.⁷ Organic matter builds up much faster in spas than in swimming pools because the volume of water per bather is much lower and the water is usually warmer.⁷ If it is not removed, organic matter will become a haven and food source for microbes.⁷ The build-up of contaminants can be reduced by restricting the number of bathers according to the size of the spa and by requiring users to shower before entering, using soap to remove body oils.^{3,7}

Bubbles produced by air jets are an efficient means of transmitting microbes from the water to the bather. The bubbles burst at the water's surface, lofting fine droplets into the breathing zone of the users. People outside a spa can also be affected if the spray is carried by air currents or a ventilation system.^{1,8}

The illness most frequently associated with spas and whirlpool baths is dermatitis, a skin infection caused by *Pseudomonas aeruginosa* bacteria (*Pseudomonas* bacteria can also cause other illness).⁷ 48 Outbreaks of skin disease caused by *Pseudomonas aeruginosa* in 951 individuals were reported to the Centers for Disease Control and Prevention (CDC), Atlanta, USA, from 1985 to 1994.⁹⁻¹³ During the same period, five outbreaks of Pontiac fever were reported, affecting a total of 63 people.⁹⁻¹³ Pontiac fever is a flu-like illness that is caused by *Legionella* bacteria.

Experts estimate that a very low percentage of spa-related illness is reported to health authorities, so the actual number of cases that occurred from 1985 to 1994 is probably much higher than the reported numbers. In addition, only outbreaks associated with public spas are reported. The incidence of disease associated with residential spas is likely much higher.

Spas and whirlpool baths have been blamed for several cases of Legionnaires' disease, a deadly type of pneumonia.^{3,5} In 1993, a Vancouver (Canada) couple, both in their 50s, died of Legionnaires' disease about three weeks after purchasing a spa. They had used the spa frequently. The species of *Legionella* that was found in the spa matched the species found in both bodies.¹⁴ If only one of them had become ill, the physicians may not have suspected Legionnaires' disease, let alone the spa as the source. As suggested by this example, many individual cases of spa-acquired Legionnaires' disease may go undetected or unreported.

Cryptosporidiosis is a less common but potentially serious illness for immunosuppressed individuals and children. It is caused by *Cryptosporidium*, a parasite found in the feces of infected humans or animals. The parasite, which is too small to be seen without a microscope, is protected by an outer shell called an oocyst (oh-oh-cist). This protective shell allows it to survive outside the body for long periods of time. When a person or animal swallows *Cryptosporidium* oocysts, the parasite comes out of its shell and

can cause infection. In a typical case of diarrhea, one bowel movement can contain enough oocysts contaminate 100 million gallons of water—and swallowing a single mouthful of this water can cause illness.¹⁵

Cryptosporidiosis infection rates among pool users have ranged from 15% to 100%. Infection rates have been highest among children, presumably because children are more apt to have fecal accidents and also more apt to swallow pool water.¹⁵ Disease-causing organisms found in spas are listed in Table 1. Spas become contaminated primarily from the people who use them. In outdoor spas, dust and organic matter from animals, birds, and plants also facilitate bacterial growth.⁵

Disinfectants can destroy or inactivate bacteria in spas. Most viruses are more resistant to halogens (e.g., chlorine and bromine) than are bacteria, but can be controlled with regular disinfection, periodic water replacement, and proper cleaning.⁵

Protozoa (e.g., *Cryptosporidium*) are resistant to halogens at levels generally used in spas. Efficient filters may remove some types of protozoa but will not remove *Cryptosporidium* oocysts. It is thus crucial to enforce measures that might reduce the potential for *Cryptosporidium* contamination, such as showering before entering the pool, excluding persons with diarrhea or incontinence, or restricting diaper-age children to certain pools.¹⁵

Table 1. Organisms Found in Spas

Excerpted and adapted from *Guidance on water quality for heated spas*, by C. Broadbent.⁵ Used with permission.

Organism	Type	Associated illness
<i>Pseudomonas aeruginosa</i> (microbe most commonly found in spas)	Bacterium	severe skin rashes, eye and ear infections, pneumonia, urinary tract infections, cough, sore throat, flu-like symptoms. ^{3,16}
<i>Legionella</i>	Bacterium	Legionnaires' disease, a deadly type of pneumonia; Pontiac fever, a flu-like illness
<i>Escherichia coli</i> , <i>Staphylococcus</i> , <i>Streptococcus</i> , <i>Mycobacterium marinum</i> , <i>Salmonella</i>	Bacteria	flu-like illness, skin infections, sore throat, urinary tract infections, pneumonia
<i>Acanthamoeba</i> , <i>Naegleria fowleri</i>	Protozoa	skin, eye, and ear infections; fatal form of meningoencephalitis
<i>Cryptosporidium</i> , <i>Giardia</i>	Protozoa	intestinal infections
Enteroviruses (e.g., polio, coxsackievirus, hepatitis A)	viruses	gastro-enteric infections, jaundice, skin rashes, nervous system disorder
Adenoviruses (e.g., common cold)	viruses	sore throat, eye infection, fever

Precautions for whirlpool bathtubs

A whirlpool bath's circulation system provides an ideal habitat for bacteria and other microbes.^{1,3}

Water sits in the piping and fittings even after the tub is drained.^{1,17} According to manufacturing standards, a whirlpool bath circulation system can retain up to 1.5 fluid ounces of water per fitting and still be considered "fully drained"—nine ounces of water in the typical six-fitting system.^{1,17} Water can also seep into the air induction piping—when the tub has not drained but the pump is turned off.^{1,17}

The stagnant water allows biofilm to grow inside the circulation piping. Biofilm is a slimy coating composed of microbes that attach to underwater surfaces (e.g., the inside of a pipe). Biofilm is further fed and protected by the bath residue (e.g., hair, body oils, soap scum, body fluids, fecal matter) that builds up in the piping and fittings.^{1,17}

During operation, the outer layers of biofilm can flake off and flow into the water, releasing potentially high levels of microbes into the system. Bacteria that live in the circulation piping can thus contaminate the supply water each time the tub is filled.¹

In a 1999 survey, researchers at Texas A&M University found *Legionella* organisms (legionellae) in 67% (8 of 12) of water samples collected from whirlpool baths in homes and hotels throughout the United States. The samples were collected about 1-2 minutes after the tub was filled and the pump turned on. *Pseudomonas*, *E. Coli*, *Staphylococcus*, and other microbes were also found.¹⁸

Whirlpool baths with a piped circulation system cannot be thoroughly cleaned. Flushing procedures will not completely clean circulation piping because water remains in pockets after the tub is drained. In addition, the air induction piping will not be disinfected by flushing procedures because the chemicals will not circulate through it.^{1,17}

Nevertheless, flushing procedures should be done to keep the whirlpool bath as clean as possible. The following has been recommended by the National Council for Whirlpool Bath Health and Safety, Washington, DC:

- a. After each bath, flush the entire circulation system with a detergent capable of removing oily bath residue.^{1,2}
- b. Once a year, flush the circulation system with an acidic wash to remove scale.^{1,2} Oil deposits will cover scale, so the system must first be flushed with the oil-removing detergent used for regular flushes. After oil deposits have been removed, flush the system with an acidic cleaner to remove scale deposits. Consider having the annual flushing conducted by a professional who has special

equipment for this purpose.¹⁷ Public whirlpool baths may need to be flushed more than once a year.

Although bleach, baking soda, vinegar, and dishwasher detergent have been recommended, they are not effective (in reasonable quantities) for cleaning whirlpool bath circulation systems. At the typically recommended concentrations of 60-120 ml (2-4 ounces) per 190-380 liters (50-100 gallons) of water, none of the four household products will kill all bacteria or remove the buildup of scum in the piping

Use only cleaning solutions suitable for whirlpool bath circulation systems (see appendix).^{1,17} Before selecting cleaning products, consider getting advice from the manufacturer of your whirlpool bath.

People who are immunocompromised should not use whirlpool baths with piped circulation systems. No bather should submerge his or her head or ingest bath water, as this will increase the risk of infection.¹⁸

Whirlpool baths that utilize circulation piping may soon be replaced by pipeless models. The first pipeless whirlpool bath is to be on the market in the year 2000 (Sanijet, <http://www.sanijet.com>). The pipeless unit has a motor installed at each jet, directly behind the wall of the tub. According to the manufacturer, every wetted component of the pipeless bath can be removed and cleaned.

Recommendations for spas and hot tubs

Introduction

This report does not cover all aspects of health, safety, and maintenance for spas and hot tubs. The recommendations below pertain only to microbial contamination.

The recommendations apply to private spas as well as public spas unless variances are noted. However, as noted above, operators of public spas must investigate and comply with any state, province, county, or city regulations.

Overview of disinfection

Disinfectants are needed to destroy bacteria growing in the spa water, on the filter, and on tub surfaces and to kill viruses and organisms emitted by bathers.^{5,19}

Chlorine is commonly used in spas. It is effective because it acts quickly and leaves a *residual* that continues to destroy microbes throughout the spa water for hours or even days after dosing.⁶ With test kits, spa owners can measure the chlorine residual (sometimes called "free chlorine") to ensure that recommended levels are maintained.⁶

Sodium dichloro-isocyanurate, also known as sodium dichloro-striazinetrione ("sodium dichlor") and lithium hypochlorite can be used in spas. Each is available from spa retailers in granular form. Sodium hypochlorite in liquid form is also used in spas but is less common. Calcium hypochlorite, though used in swimming pools, is not suitable for all spas, particularly those supplied by hard water. When hard water is heated, calcium promotes scale buildup in piping.⁵

Sunlight will quickly break down chlorine unless cyanuric acid is added to the water. Cyanuric acid "stabilizes" chlorine, allowing a residual amount to remain in the water longer. However, chlorine must break down to remove contaminants from the water, so too much cyanuric acid will bind chlorine, rendering it ineffective.

Bromine compounds (e.g., bromochlorodimethylhydantoin or BCDMH) have also proved effective for disinfecting spas.⁵ When exposed to heat and sunlight, bromine is less stable than chlorine that has been stabilized by cyanuric acid.⁵ However, bromine from BCDMH is more stable than chlorine if the cyanuric acid level in the chlorinated spa is too low. Bromine sometimes leaves a green tint in the water and manila stains on walls and decks.¹⁶

Ozone and ultraviolet light are effective in killing organisms but are not a substitute for chemicals because they do not spread disinfectant throughout the spa water. Therefore, ozone- or UV-treated spas must be supplemented with chlorine or bromine at the levels recommended in the next section. Ozone, if used alone, can actually promote bacteria growth because it breaks down organic matter to a size that is easy for bacteria to consume.⁶ As with halogen-treated spas, ozone- and UV-treated spas must be shock treated periodically.⁵

A properly designed ozone or UV system will reduce the amount of chlorine or bromine required.^{3,5} Ozone is especially effective as a supplement because it destroys matter that "uses up" the chemicals.³

Ozone is effective only if the system is sized and designed properly. The ozone generator must make enough ozone. Also, ozone

systems must treat the spa water in an isolated contact chamber rather than injecting ozone into the spa itself. If the water is not in the contact chamber long enough, it will not be effectively treated. The contact chamber and chlorine feed must be far enough apart to ensure that ozone and chlorine are not mixed.¹⁵

Dirt and other matter hinders disinfection and "uses up" chemicals. With cleaner water, more disinfectant is available to kill organisms. Therefore, removing visible dirt, replacing the water periodically, and maintaining the filter are important practices for effective and efficient disinfection.¹⁹

Do not add chemicals directly to the water. High concentrations of chemicals can severely burn the eyes, nose, and skin.⁵

Disinfectant levels and other parameters

The following recommendations for chlorine- or bromine-treated spas are based on published guidelines.

Chlorine

Free residual chlorine, which is also referred to as free available chlorine or free chlorine, is chlorine that remains available for disinfecting—that is, it has not been "used up."

Combined chlorine, also called chloramines, is chlorine that has been "used up" and is no longer fully effective as a disinfectant. Total chlorine is the combined chlorine (chloramines) plus the free chlorine. Total chlorine and free chlorine should be monitored to determine the level of chloramines relative to free residual chlorine.

Only the portion of free chlorine that forms hypochlorous acid effectively disinfects the spa water. The percentage that forms hypochlorous acid varies with pH (Table 2). More hypochlorous acid forms at lower pH levels (i.e., more acidic) than at higher pH levels. Therefore, it is crucial to monitor pH and free chlorine levels rather than evaluate disinfection effectiveness based solely on free chlorine levels.

Chlorine levels are measured in parts per million (ppm). Parts per million chlorine is the weight of chlorine in relation to the weight of water. Parts per million is the same as milligrams per liter (mg/l).

Some experts recommend maintaining a free chlorine level of 2-4 ppm.^{3,5} Others suggest 3-5 ppm²⁰⁻²² or 4-5 ppm.⁸ Another group recommends a minimum of 5 ppm.¹⁹ These recommendations apply to private spas as well as public spas. Some experts warn that free chlorine should never be below 2 ppm or above 10 ppm.^{5,8,20-22}

Published guidelines suggest that chloramines be no higher than 0.5 ppm.^{19,21,22} Others have suggested a maximum level of 0.2

ppm.¹⁶ For those who use test strips to monitor spa water, the difference between 0.5 and 0.2 is irrelevant because the test strip colors and chart colors cannot be visually compared in increments less than 0.5 ppm. High levels of chloramines can irritate the eyes and cause a strong chlorine odor.²⁰

Maintaining a steady level of disinfectant is far more important than achieving the ideal level.²³ For example, maintaining 1 ppm free chlorine (which is less than recommended) continually throughout 10 days of nonuse is less likely to allow bacterial growth than maintaining 4 ppm free chlorine for four days followed by zero free chlorine for six days. Even short periods without disinfection can result in rapid microbial growth.⁵

In summary, published guidelines indicate that free chlorine should be maintained continuously at 3-5 ppm at a pH of 7.2-7.6. Lower chlorine concentrations may be ineffective. Higher concentrations can irritate the eyes, skin, and respiratory tract.⁵

Table 2. Effectiveness of Chlorine and Bromine Relative to pH⁵

pH	% free chlorine that forms hypochlorous acid	% free bromine that forms hypobromous acid
6.0	97	100
7.0	75	98
7.2	63	96
7.5	49	94
7.6	39	91
7.8	28	87
8.0	23	83
9.0	3	32

Bromine

Total bromine comprises free bromine and bromamines. However, bromamines disinfect better than chloramines, so it is less important to distinguish between free bromine and total bromine.⁵

For bromine, many guidelines suggest a range of 4-6 ppm.^{8,19-22} Broadbent recommends 4-8 ppm.⁵ Bromine levels should never be below 2 ppm or above 10 ppm.²⁰⁻²²

As with chlorine, only the portion of free bromine that forms hypobromous acid is effective, and the percentage also varies with

pH. However, bromine is more active than chlorine over the typical pH range (Table 2).

In summary, published recommendations indicate that free bromine should be maintained at 4-6 ppm at a pH of 7.2-7.6.

pH

Some guidelines recommend maintaining pH between 7.2 and 7.6,^{3,19} others between 7.2 and 7.8,^{5,8} and others between 7.4 and 7.6.²⁰⁻²² Combining all published sources derives an ideal range of 7.4 to 7.6. Do not allow pH to drop below 7.2 or go above 7.8.²⁰⁻²²

If pH is too high, chlorine is ineffective (Table 2). High pH can also lead to scale formation in piping, cloudy water, and eye irritation.^{5,20-22}

Low pH can damage concrete and corrode metal.^{5,20-22}

Total alkalinity

While pH measures the relative acidity/alkalinity of the water, total alkalinity refers to the total amount of alkali substance dissolved in the water. Alkali substances buffer acidic substances and help maintain a more neutral pH. If total alkalinity is too low, rapid fluctuations in pH can occur.⁵ High total alkalinity levels may lead to scaling.^{5,24}

Bromine (BCDMH tablets) and certain types of chlorine reduce total alkalinity more rapidly than other types of chlorine, so care should be taken to monitor this value.^{5,20-22} Total alkalinity should ultimately be kept at the level required to maintain pH and other water chemistry parameters at proper levels.¹⁶

Sodium bisulfate (dry acid) can be used to lower total alkalinity or sodium bicarbonate to raise it (follow product label instructions).⁵ Both are available in pool and spa stores.

Chlorine Stabilizer

Stabilizer (cyanuric acid) is not needed for indoor spas or those treated with bromine. For outdoor spas treated with chlorine, cyanuric acid levels must be maintained at 30-50 ppm. If the cyanuric acid level is too low, free chlorine is rapidly destroyed by sunlight. If the cyanuric acid level is too high, chlorine may be ineffective.²⁰⁻²²

The easiest way to lower the cyanuric acid level is to replace all or part of the spa water. If draining and refilling is not feasible (e.g., due to local water usage limits), a nanofilter can be temporarily installed to remove cyanuric acid. Contact a service company about installing a nanofilter for one or two days.¹⁶

Hardness

Hardness refers to the amount of dissolved calcium and magnesium

in the water. Low calcium levels can lead to corrosion and staining of equipment. High levels promote scaling.⁵

The NSPI recommends calcium hardness of 150-250 ppm for public spas and 200-400 ppm for private spas.²⁰⁻²² Others have recommended 150-200 ppm.¹⁹ Broadbent recommends 100-200 ppm.⁵ Bear in mind that the ultimate goal is to maintain all the water chemistry parameters at proper levels. Most test kits measure total hardness rather than calcium hardness. This is sufficient for most purposes..

Consider replacing all or part of the spa water if hardness is too high. Before doing so, however, test the hardness of your water supply. Replacing your spa water will be useless if your water supply is nearly as high in hardness (see recommendations for total dissolved solids, next).

Total dissolved solids

Total dissolved solids (TDS) refer to the total weight of the solid matter dissolved in the water. High TDS can cloud spa water, corrode fixtures, and inhibit disinfection.^{21,22}

- Private spas: Replace all or part of the spa water if TDS is above 2000 ppm.^{20,22}
- Public spas: Drain and refill public spas if TDS is more than 1500 ppm higher than the TDS of the water used to fill the spa.²¹

Oxidization Reduction Potential

The oxidization reduction potential or ORP measures the *activity* or *oxidizing power* of disinfectants (in contrast to the weight in parts per million).

ORP expresses several water chemistry parameters in a single value that indicates disinfection effectiveness. For example, monitoring spa water manually requires measuring free chlorine, total chlorine, pH, cyanuric acid, and other parameters to determine the effectiveness of the chlorine. An electronic ORP monitor automatically measures several parameters and gives a single value expressed in millivolts (mV).

A minimum ORP of 650 mV has been recommended for private and public spas.²¹ Others have recommended 650 mV for private spas and 750-900 mV for public spas.¹⁶

Suppliers of automation equipment are listed in the appendix.

Chemical monitoring and dosing

Test strips

Bromine, free chlorine, total chlorine, pH, total alkalinity, hardness, and cyanuric acid can be measured in parts per million with test kits.

Private spa owners may prefer test strips because they are easy to use. Tests are taken simply by dipping the strips in the spa water and then comparing the color on the strips with a color scale that shows levels of disinfectant, pH, and other parameters being measured.

However, accurately comparing colors on the strips with colors on the chart can be difficult. In checking free chlorine, for example, it would be easy to tell the difference between 0.0 ppm and 3.0 ppm on test strips, but difficult to distinguish 1.0 ppm from 2.0 ppm.

It is crucial to follow instructions exactly, particularly regarding timing. For example, if the instructions say to dip the strips in the water for five seconds, shake the water off, and then read the strips after 20 seconds, do just that using a watch. A reading taken after 10 seconds or after 30 seconds, rather than the required 20 seconds, may be inaccurate.

Test strips for bromine, total chlorine, free chlorine, total hardness, total alkalinity, and pH are available from spa retailers. Test kit suppliers are listed in the appendix.

DPD and OTO test kits

Two other types of test kits—DPD (diethyl-p-phenylenediamine) and OTO (orthotolidine)—involve collecting water in vials, adding reagents, and observing the color of the water to determine the level of chlorine, bromine, or pH. DPD kits indicate chlorine with a pink color, OTO kits with yellow.²³

Experts prefer DPD test kits to the OTO type.^{5,23,25} DPD tests measure free chlorine and total chlorine separately. OTO kits indicate free chlorine for only 5 to 30 seconds, and total chlorine thereafter.²³ Unless spa owners are quick to read the OTO tests, they will see total chlorine instead of free chlorine, which could give a false sense of security since the total chlorine reading includes the chloramines.²³

Most health departments require that professional pool services use DPD tests or electronic instruments rather than test strips or OTO kits.

For both DPD and OTO kits, as with test strips, determining disinfectant levels accurately based on color comparison is difficult.²³ One must ultimately estimate the levels based on a

judgment of how closely the colors match. A certain type of DPD test—called titrimetric—essentially eliminates this problem. Titrimetric DPD tests initially show color in the water sample. Drops of reagent are then added until the color is gone. The number of drops required to remove the color determines the chlorine or bromine level.^{23,25}

Testing TDS

Most pool and spa stores sell devices used to test for total dissolved solids. Private spa owners may prefer to bring a water sample to their spa retailer for analysis. Some stores will test for TDS at no charge for customers who purchase other supplies from them.

Automated ORP monitors

As mentioned above, an electronic ORP monitor analyzes several water chemistry parameters to give a single value expressed in millivolts (mV).

ORP monitoring does not eliminate the need for manual testing with test kits.²¹ For cruise ship spas with automatic dosing and monitoring equipment installed, manually testing every four hours has been recommended,⁸ but many public spas are tested once or twice an hour.¹⁶

Suppliers are listed in the appendix.

Monitoring frequency for private spas

If the spa is not monitored continuously with ORP monitors, chlorine levels should be measured manually before each use.^{3,5} If the level is low, add chlorine 30-60 minutes before use. After use, chlorine levels should be measured again and chlorine added if needed.^{3,5} In seasons during which the spa is not used, either drain the water, or add chlorine once a day.⁵ The amount of chlorine needed, and the frequency of dosing, will depend on the number of people using the spa, and the frequency of use.^{3,7}

Samples should be collected while the circulation (filter) pump is running but when the jets are off. If one pump operates both, keep it off when collecting samples.

Likewise, chemicals should be added while the circulation pump is running but with the jets off.⁵ If one pump operates both, it should be on while adding chemicals and left running for at least one hour afterward.

ORP monitors can be wired to chemical feeders to automate chemical dosing.⁸ Dosing is activated when the ORP monitor senses a need for a particular chemical.

Monitoring frequency for public spas

For public spas, free chlorine or bromine levels and pH should be measured and recorded at least hourly to ensure continuous levels

of biocide in the spa water, plumbing, and filter.^{5,8} Microbes can multiply rapidly in untreated water.⁵ Testing manually at least once an hour has been recommended even for spas that monitor ORP continuously.¹⁶

As noted above, samples should be collected while the circulation (filter) pump is on but while the jets are off.

Precautions in handling chemicals

The chemicals required for spa disinfection can be extremely dangerous when mishandled or inappropriately used. This partial list of precautions in handling such chemicals provide only preliminary instructions for safe disinfection practices:⁵

- Do not mix different chemicals.
- Do not allow any foreign substance (e.g., a carbonated beverage, suntan oil) to come in contact with chemicals.
- Be sure all chemical containers are labeled.
- Follow label instructions.
- Avoid breathing vapors.
- Wear protective gloves, clothing, and goggles per the material safety data sheets (MSDSs).
- Use separate measuring containers for each chemical, and be sure they are dry and clean.
- Do not add cyanuric acid and disinfectant to the spa simultaneously.

Do not add chemicals directly to the water when people are in the spa. High chemical concentrations can burn the eyes, nose, and skin.

Draining and cleaning

Spas should be drained, cleaned, and refilled periodically to prevent a build-up of total dissolved solids. When a spa is emptied or partially emptied, all exposed surfaces and the skimmer should be scrubbed and wiped down with a concentrated, chlorine-based disinfectant that will not damage the spa.^{3,5,7,8} Wear elbow-length PVC gloves throughout (per the MSDSs).^{3,5,7} After cleaning, purge piping and filters with clean water, and backwash the filter or change the filter cartridge (see the filter section).^{5,8}

In the recommendations listed below, note that the spa should be cleaned whenever *replacing the spa water* or *draining the spa* is mentioned, even though cleaning is not specifically stated each time.

Frequency for private spas

- Consider replacing at least 10% of the spa water weekly.⁵
- NSPI's recommendations for public spas may be appropriate for private spas as well:

Completely drain and clean the spa if the TDS is 1500 ppm higher than the TDS in the water used to fill the spa.²¹

Or, apply these formulas:

$$1/3 (\text{spa volume in gallons}) / \text{daily bather load} = \text{days between draining}^{21}$$

$$0.087 (\text{spa volume in liters}) / \text{daily bather load} = \text{days between draining}^{21}$$

Daily bather load means the average number of users per day. For example, for a 360-gallon spa used by two people each day (one use per day), the equation would be: $120 \div 2 = 60$ days between draining.

- Consider completely draining and clean the spa at least once every three months, even if tests indicate acceptable water quality (this applies to spas used daily).⁵

Frequency for public spas

- CDC recommends that cruise ship spas be drained, cleaned, and refilled at least daily.⁸
- One of NSPI's recommendations is to drain and clean the spa if the TDS in the spa water is more than 1500 ppm

higher than the TDS in the water used to fill the spa.²¹

- NSPI also recommends the following draining frequency based on user load:

$1/3$ (spa volume in gallons) / daily bather load =
days between draining²¹

0.087 (spa volume in liters) / daily bather load =
days between draining²¹

For example, a 600-gallon spa used by approximately 50 people each day should be drained and cleaned $200 \div 50$ or every 4.0 days.

A Canadian group has recommended a similar frequency.¹⁹

Filters

A highly publicized spa-related outbreak of Legionnaires' disease occurred in 1994. Forty passengers who had used one of the ship's three spas reported Legionnaires' symptoms within days after the Bermuda-to-New York cruise ended. Legionnaires' disease was confirmed in 11 of the passengers. Investigators cited a spa sand filter as the probable source of contamination.²⁵

Proper filter maintenance is crucial, not only because filters are essential for maintaining good water quality, but also because the filters themselves can become heavily contaminated with bacteria, including *Legionella* and *Pseudomonas aeruginosa*. As illustrated above, fatal cases of Legionnaires' disease have been caused by legionellae on spa filters.⁵

Be sure that the filter is in-line while the spa is operating (i.e., no bypass valves should be open).⁸

Types of filters

Three types of filters are commonly used on spas: sand, diatomaceous earth (DE), and cartridge filters. Sand filters and DE filters are categorized as granular filters.

Sand filters are backwashed by reversing the water flow through the filter so that built-up dirt is flushed out. Many DE filters are also cleaned by reversing the water flow through the filter. With DE filters, however, a part of the DE media is actually removed (rather than backwashed) during the reverse flow process. However, reverse-flow DE removal is generally referred to as backwashing, which is the term to be used by this report. Some DE filters are cleaned by knocking off the dirty DE rather than by backwashing.¹⁶

Cartridge filters require no backwashing but must be cleaned frequently and replaced periodically.²³

Maintaining cartridge filters

Cartridge filters must be removed and sprayed with water at least once a week.⁵

Thoroughly clean the filters whenever the spa is drained, but no less than once every four weeks. Cartridge filters used on public spas may need to be sprayed off and cleaned more frequently. Spray the filters with water, then soak them in chlorine for 20 minutes.⁵ A 1-to-20 bleach-to-water solution has been recommended.²⁶ Others have recommended different cleaning solutions and procedures.¹⁶ Check the filter manufacturer's recommendations and spa stores for cartridge filter cleaners. Because 25-35% filtering capacity is lost during each cleaning, filters must be replaced after three cleanings.¹⁶

Cartridge filters should also be inspected at least once a week (perhaps while cleaning them) for cracks, breaks, or damaged internal components as well as excessive build-up that may hinder filtering.^{5,8} The filter must be replaced immediately if the inspection turns up any excess wear; thus, at least one back-up filter element must be available at all times.^{5,8}

Maintaining granular filters

Granular filters must be backwashed whenever the water pressure is high (according to the manufacturer's guidelines). For many DE filters, backwashing is recommended when the pressure exceeds the normal clean-filter pressure by 10 pounds per square inch (refer to the owner's manual for specific instructions). Filters on cruise ship spas and other heavily used public spas should be backwashed at least once a day, depending on the pressure reading.^{5,8} When backwashing, continue the cycle for several minutes after the discharged water appears clean.^{5,8} Be sure to comply with regulations regarding the discharge of DE.

DE must be replaced on these filters after each backwashing in the amount recommended by the manufacturer. Inspect the filter media monthly: Relieve the pressure, open the filter housing, draw water down to the media, and look for signs of uneven filtration (e.g., holes, cracks, mounds) or excessive dirt build-up.^{5,8}

Every six months or whenever excessive build-up or uneven filtration is observed, replace the media and disinfect the filter housing (or hire a professional service to do it).^{5,8} Follow rules regarding the disposal of filter media.

Shock treatment

Shock treatment refers to the process of adding high doses of disinfectant. Shock treatment is used for removing excess chloramines as well as for other purposes.

Elevated chloramine level

Shock treatment is required when the chloramines reach 0.5 ppm (others have recommended a limit of 0.2 ppm).¹⁶ *Breakpoint chlorination*, a term sometimes used in place of shock treatment, more accurately describes the procedure used when the chloramine level is too high. *Superchlorination* is another term sometimes used in place of breakpoint chlorination or shock treatment.

Breakpoint chlorination is achieved by reaching a free chlorine level that is 7.6 times the chloramine level.¹⁶ It is important to reach the 7.6 multiple, because failing to do so could actually make the chloramine problem worse.¹⁶ Most guidelines recommend reaching a free chlorine level of 10 times the chloramine level.^{21,22} For example, if the chloramine level is 0.5 ppm, add enough chlorine to reach a free chlorine level of 5.0 ppm.

It is not necessary to have a test kit that can measure high free chlorine levels (e.g., 5 to 10 ppm). Instead, measure the chloramine level (total chlorine minus free chlorine), and follow the instructions on the product label to reach a free chlorine level that is ten times higher.

Another option is to dilute the spa water sample with four times as much bottled water, measure free chlorine with your regular test kit, then multiply the reading by five. For example, if you collect 100 ml of spa water, you would add 400 ml of bottled water, check the free chlorine level, and multiply the reading by five.

Other shock treatment uses

Algae, cloudy water, slime, musty odors, high bacteria counts, or persistently low disinfectant levels also indicate the need for shock treatment—and the need to make significant changes to the routine treatment regimen).²¹

Shock treatment is crucial for bacteria control, particularly if chemical monitoring and dosing is not automated. If disinfectants are not added during the day, a spa will likely have zero disinfectant after a day's use, leaving a condition conducive to bacteria growth.²³ If a spa in this condition is not shock treated at the end of the day, bacteria can multiply to such high levels in a short period of time that, by the time shock treatment is performed, normal shock dosing concentrations may be too weak to overcome the bacterial load.²³

If breakpoint chlorination is not required, potassium peroxydisulfate can be used for shock treatment if circumstances prohibit the use of chlorine.¹⁶ Potassium peroxydisulfate has two advantages over chlorine: Reaching a minimum level (breakpoint chlorination) is not necessary, and it works in minutes.¹⁶ However, potassium peroxydisulfate should be used only as a last resort due to its drawbacks: It does not kill bacteria or algae, it renders regular test kits useless as long as it remains in the water, it can cause bather discomfort (e.g., itching),

and it is much more expensive than chlorine.¹⁶

Bromine should not be used for shock treatment, even in brominated spas.⁵

Frequency of shock treatment

Shock treat private and public spas at the end of each day's use by maintaining 10 ppm free chlorine (or breakpoint chlorination, whichever is higher) for one to four hours.^{5,7,8,20,22} For private spas used infrequently, shock treating once a week may be sufficient.^{5,7}

In public spas and heavily used private spas, daily shock treatment is not an excuse for allowing disinfectant levels to fall to zero. As mentioned in the section on chemical monitoring and dosing, disinfectant levels should be checked at least hourly in public spas, and chemicals added as required. For this reason, automated monitoring and dosing may make sense for public spas as well as heavily used private spas.

No bathers should be in the spa during shock treatment, because high disinfectant concentrations can burn the eyes, nose, and skin.⁵

Bacterial monitoring

Spas should be tested for *Pseudomonas aeruginosa*, Coliform bacteria, and heterotrophic plate count (HPC). HPC, an estimate of the total number of live bacteria in the water, indicates whether the disinfectants are working.⁵ Spa operators should also consider testing for *Legionella*.

Pseudomonas aeruginosa and HPC can be tested by collecting water samples in sterile bottles for analysis by a qualified laboratory. However, *Pseudomonas* can be missed if only water samples are collected; it is more likely to be found in swab samples. Any surface with spa water residue can be swabbed: the hair and lint strainer, the water line, the filter tank, or items that have been in the spa.

Screen prospective laboratories thoroughly by asking several questions:

- Does it specialize in environmental samples or clinical specimens (environmental is required for spa testing)?
- Does it specialize in air samples or water samples?
- Does it specialize in microbiology, chemistry, or another field (bacteria testing requires expertise in microbiology)?
- Over the last five years, approximately how many spa water

samples has it tested for *Pseudomonas aeruginosa*, Coliform bacteria, and HPC?

Before finalizing your choice, be sure that the laboratory has all certifications or approvals offered or required by your country, state, or locality. After you select a laboratory, obtain its specific instructions and forms before collecting samples.

Tests for *Legionella* are conducted in a similar fashion. Water samples, as well as swab samples from filters or fittings, are collected and sent to a qualified laboratory. However, the laboratory work involved in culturing *Legionella* bacteria is even more specialized; you may have difficulty finding a qualified laboratory in your area. Before sampling for *Legionella*, read *Legionella Environmental Sampling Guide* (HC Report 306 or 306e), which includes screening questions for selecting laboratories, as well as a list of experienced laboratories in several countries.

Public spas should be checked for bacteria weekly during the first month after startup, then monthly if the test results indicate that the water is safe.⁵ If contamination is detected, the source must be identified and eliminated. Afterward, test weekly for one month to be sure that the problem is resolved, then continue on a monthly basis.

If the HPC exceeds 100 cfu/ml (see Table 3) or the limit established by your health department, the spa must be shock treated.^{5,21,22}

If Coliform or *Legionella* bacteria are detected, drain and clean the spa, thoroughly clean the filter (including scrubbing with a 1-to-20 chlorine-to-water solution), then refill and shock treat.^{5,16}

More is needed to remove *Pseudomonas*. Drain the spa, empty the filter tank, and scrub the spa walls, decks, and the inside of the filter tank with a 1-to-20 chlorine-to-water solution.¹⁶ Use the same solution to scrub and soak any items left in or near the spa.¹⁶ Finally, the circulation pipes (after closing the valves) should be filled with a 1-to-20 chlorine-to-water solution for 24 hours.¹⁶

Table 3. Suggested Bacteria Limits⁵

Bacterium	Suggested limit
HPC	Less than 100 cfu/ml
<i>Pseudomonas aeruginosa</i> , Coliform	None detected in 100 ml sample
<i>Legionella</i>	None detected in 1,000 ml sample

Other recommendations

Air injection piping

If air injection is no longer used, air injection piping should be isolated or sealed so that dirty water does not seep from it into the spa water.^{5,8}

Warning sign

In addition to signs listing standard safety precautions, install a sign that cautions people who are immunocompromised or who are taking immunosuppressant medicines not to use the spa.⁸

Cover

Cover outdoor spas to keep out leaves, dirt, and other organic matter.⁵

Recirculation

Make sure the circulation system runs the spa water through the filter at least once every 30 minutes.⁵ To evaluate your system, divide the volume of spa water by the flow rate of the circulation pump. For example, if your spa holds 400 liters (106 gallons), and the pump circulates the spa water through the filter at 15 liters per minute (4 gallons per minute), then all the water will theoretically be filtered in less than 27 minutes.

If your system does not have a flow meter, you can contact the manufacturer to obtain the pump flow rate. Before calling, write down all information on the pump label.

Maximum bather capacity

NSPI recommends a limit of one person per 9 sq. ft. (0.836 m²) of surface area in public spas. The rule is also practical for private spas. One person per 10 sq. ft. (0.929 m²) is the guideline for many US states.¹⁶ Be sure to adhere to regulations in your area.

For a square or rectangular spa, surface area is calculated by multiplying the length of two adjacent sides. For example the surface area of a rectangular tub 4 ft long and 5 ft wide would be 20.0 sq ft.

If your spa is round, you can use the following formula to calculate the surface area: $r^2 \times 3.14$ ("r" is the radius of the spa at the water line, which equals one-half the distance across the center of the spa). For example, the surface area for a round tub 5 ft across at the center would be 19.6 sq ft.

Biofilm removal

As noted earlier, biofilm is a slimy coating composed of microbes

that attach to underwater surfaces (e.g., the inside of a pipe). Biofilm and scale that form in fittings, on pipe walls, and in filter tanks not only feed bacteria but also protect them from disinfectants. Bacteria are further fed and protected by spa bather residue (e.g., hair, body oils, body fluids, fecal matter) that builds up in piping, fittings, and filters. Layers of biofilm can flake off and flow into the water, releasing potentially high levels of microbes into the system.

Soft white flakes dispersed into the water after the jets are activated could indicate biofilm build-up,²⁶ although white flakes could indicate other problems as well (e.g., excess calcium).¹⁶ On accessible surfaces, biofilm can often be detected by touch. It feels like a thin, slippery coating. If build-up is excessive, you may even be able to see it—it sometimes looks like marmalade.¹⁶

If unsafe microbial levels persist, consider flushing the system with a solution that will remove biofilm from the circulation piping and fittings without damaging them. Biofilm is difficult to remove from circulation piping with chlorine; very high concentrations are required.²⁶ Filling the pipes with a 1-to-20 chlorine-to-water solution for 24 hours has been recommended.¹⁶

Better biofilm removers may become available. Look for products that have proven (preferably through independent studies not performed by the manufacturer) to remove biofilm safely from piping. Make sure the products are approved for spas, because some are approved only for specific industrial applications.

Removing biofilm from accessible surfaces is easier because these surfaces (e.g., inside of filter tanks, skimmer, other accessible tub areas) can be scrubbed. with a 1-to-20 chlorine-to-water solution.

Spas that consistently fail to meet disinfectant or microbial criteria should be closed until the problems are solved.⁵ Spa problems and solutions are shown in Table 4.

Table 4. Common Spa Problems

Excerpted and adapted from *Guidance on water quality for heated spas*, by C. Broadbent.⁵ Used with permission.

Problem	Reason	Remedy
Chlorine odor and eye irritation	Chloramine level too high	Breakpoint chlorination
Discolored water or algae	Various metals such as copper entering spa pool (e.g., as corrosion product being oxidized by chlorine)	Increase pH to 7.4 or use a chelating agent to remove metals
Water has dark appearance	Breakdown of large amounts of organic material (e.g., from trees or plants)	Check filter operation; shock treat
Green water and slippery surfaces	Algae growth due to inadequate chlorination or circulation	Shock treat or use algicide; Brush and vacuum ²⁰⁻²²
Metal fixtures corroding	Water pH too low	Increase pH to 7.4
Scaling on spa pool surfaces or heater	Calcium hypochlorite (powder) added directly to spa pool water	Change to sodium hypochlorite (liquid)
Cloudy water*	Excessive chloramines; free chlorine rapidly dissipated	Breakpoint chlorination
Cloudy water*	Poor filtration; high pressure forcing DE into spa	Check filter and backwash or clean if necessary
Cloudy water*	High total dissolved solids	Replace all or part of the spa water
Cloudy water*	Poor circulation	Check filter and pump
Cloudy water*	Calcium hypochlorite added directly to spa pool water	Change to sodium hypochlorite
Foam	Persistent microbes, ^{21,22} oils, body fats, tile cleaners, certain algaecides	Shock treat daily; replace water; use antifoam agent ²⁰⁻²²
* Standing at the edge of the spa, you should be able to clearly see the bottom when the water is still. ^{5,20-22} Other possible reasons for cloudy water: chemicals added in too great a quantity in too short a time; low water level; algae bloom; lack of residual disinfectant; high cyanuric acid level, excessive chloramines, metal particles, air. ¹⁶		

Avoiding contamination from public spas and baths

Public spas and baths

If you have access to a public spa (e.g., at your exercise club), ask about the cleaning and maintenance practices before deciding whether to use it. If you are visiting a facility (e.g., a cruise ship or hotel), you can do little to determine whether the spa or bath is contaminated. You cannot always tell by looking. The tub and water can look clean and clear and still be contaminated with bacteria. If the water or tub appear dirty, or if there is a layer of slime on the tub, do not use it. If the water and tub look clean, realize that you assume a degree of risk in using it. High-risk individuals should not use a whirlpool spa or bath unless they know it is properly treated and cleaned and understand their potential risk.

Displays at stores and trade shows

In late February to early March, 1999, 242 people who visited a large flower show near Amsterdam (The Netherlands) became ill and 28 died. Seemingly healthy people were among the victims. Legionnaires' disease was confirmed or considered probable in 192 of the cases and 21 of the deaths. *Legionella* bacteria were found in a spa that was on display at the show. The strain of *Legionella* found in the spa was identical to that found in some of the patients.

In November 1999, an outbreak of Legionnaires' disease was traced to a trade fair in the northern Belgian town of Kapellen. Eighty persons developed symptoms similar to those caused by Legionnaires' disease. Positive urine tests confirmed Legionnaires' disease in 13 of the 80, and 4 of those 13 died. The media and *WHO WER and Epidemiological Bulletin* reported that data from the initial investigation implicated working whirlpool baths exhibited at the show as the most likely source of infection.

A whirlpool spa display at a retail store in Virginia (USA) was blamed for 14 cases of Legionnaires' disease in 1996, including 2 deaths.

Based on these anecdotes, you should avoid working (water-filled) whirlpool spas or baths on display at stores or trade shows unless you know the spa or bath is being chemically treated to kill bacteria.

References

1. *Issues Associated with the Manufacture, Sale, Cleaning, Maintenance, and Use of Whirlpool Baths*. Washington, DC: National Council for Whirlpool Bath Health and Safety. Available at <http://www.whirlpoolcouncil.com>.
2. Bridges R, Rosa F. The control of Legionella and other pathogens in whirlpool bath circulation systems. Available at <http://www.whirlpoolcouncil.com>.
3. *Tubs: Health and Safety Tips*. The Provincial Government, British Columbia, Canada.

4. Tablan OC., Anderson LJ, Arden NH, Breiman RF, Butler JC, McNeil MM, and the Hospital Infection Control Practices Advisory Committee. *Guideline for Prevention of Nosocomial Pneumonia*. Atlanta: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, 1994.
5. Broadbent C. *Guidance on water quality for heated spas*. Rundle Mall SA (Australia): South Australian Health Commission (for the National Environmental Health Forum), 1996.
6. Gerba CP. Ensuring safety: Why the industry needs to standardize residential pool and spa sanitization equipment. *Aqua*, Mar. 1999.
7. Sandel BB. Clean water is healthy water. *Aquatics International*, Sept./Oct. 1996.
8. *Final Recommendations to Minimize Transmission of Legionnaires' Disease from Whirlpool Spas on Cruise Ships*. Atlanta: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Mar. 1997.
9. Hunter PR. *Waterborne Disease*, 51. West Sussex, UK: John Wiley & Sons Ltd., 1997.
10. Levine WC, Stephenson WT, Craun GF. Waterborne disease outbreaks, 1986-1988. *Morbidity and Mortality Weekly Report* 39 (SS-1) (1990):1-13.
11. Herwaldt BL, Craun GF, Stokes SL, Juranek DD. Waterborne disease outbreaks, 1989-1990. *Morbidity and Mortality Weekly Report* 40 (SS-3) (1991):1-21.
12. Moore AC, Herwaldt, Craun, Calderon, Highsmith, Juranek. Surveillance for waterborne-disease outbreaks -- United States, 1991-1992. *Morbidity and Mortality Weekly Report* 42 (SS-5) (1993):1-22.
13. Kramer MH., Herwaldt BL Craun GF Calderon RL, DD Juranek DD. Surveillance for waterborne-disease outbreaks -- United States, 1993-1994. *Morbidity and Mortality Weekly Report* 45 (SS-1) (1996):1-33.
14. Jiwa S. Tragedy believed first of kind in B.C.: Rare illness claims Burnaby pair after three weeks' use of new tub. *Vancouver Province*, 28 June 1993.
15. *Cryptosporidium and Water: A Public Health Handbook*. Atlanta: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Working Group on Waterborne Cryptosporidiosis, 1997.
16. Personal communication, Alison Osinski, June, 2000.

17. Guimond M. Bacterial hazards in whirlpool baths. *American Society of Home Inspectors Technical Journal*, Spring 1993; 42-46.
18. Moyes RB. Microbial loads in whirlpool bathtubs: An emerging health risk. Unpublished paper.
19. *Hot Tubs/Spas: Water Quality and Safety*. Bruce-Grey-Owen Sound (Ontario, Canada) Health Unit.
20. *American National Standard for Portable Spas*. Alexandria, VA: National Spa and Pool Institute, 1998.
21. *American National Standard for Public Spas*. Alexandria, VA: National Spa and Pool Institute, 1998.
22. *American National Standard for Permanently Installed Residential Spas*. Alexandria, VA: National Spa and Pool Institute, 1998.
23. Lowry RN. CBC market place "troubled waters'." *Pool & Spa Marketing*, International Issue, 1997.
24. *Suggested Health and Safety Guidelines for Public Spas and Hot Tubs*. Atlanta: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, 1985.
25. Legionnaires' disease and spa water. *Pool & Spa Marketing*, Spring 1997.
26. Gerba C. Presentation at the National Spa and Pool Exposition, Dec., 1999.

Appendix

Associations

National Council for Whirlpool Bath and Safety

325 Pennsylvania Avenue, SE
Washington, DC 20003
USA

Tel: 202-362-1534

Fax: 202-362-2549

<http://www.whirlpoolcouncil.com>

National Spa and Pool Institute (NSPI)

2111 Eisenhower Avenue
Alexandria, VA 22314
USA

Tel: 703-838-0083

Fax: 703-549-0493

<http://www.nspi.org>

National Spa & Pool Institute of Canada

7370 Bramalea Road, Unit 4
Mississauga, ON L5S 1N6
CANADA

Tel: 905-676-1591

Fax: 905-676-1598

office@nspi.ca

<http://www.nspi.ca>

Magazines and web sites**Aqua Magazine Online**

<http://www.aquamagazine.com>

Pool & Spa Marketing

270 Esna Park Drive, Unit 12
Markham, Ontario L3R 1H3
CANADA

Tel: 800-268-5503 or 905-513-0090

Fax: 905-513-1377

Pool & Spa News

4160 Wilshire Boulevard
Los Angeles, CA 90010
USA

Tel: 323-764-4800

Fax: 323-964-4842

<http://www.poolspaworld.com>

Swimming Pool & Spa Age

6151 Powers Ferry Road
Atlanta, GA 30339
USA

Tel: 770-618-0249

Fax: 770-618-0343

<http://www.poolspa.com>

Automatic monitoring and dosing equipment**Acu-Trol**

11830 Kemper Road
Auburn, CA 95603
USA

Tel: 800-273-4667 or 530-823-9898

Fax: 530-823-9899

Aqua Serve Corporation

4287 Windswept Drive
Bethlehem, PA 18020
USA
Tel: 800-260-7760 or 610-317-2354
Fax: 610-317-8904

Aquasol Controllers Inc.

5151 Mitchelldale, Suite A-10
Houston, TX 77092
USA
Tel: 800-444-0675 or 713-748-7237
Fax: 713-748-8702

Barnant Company

28WO92 Commercial Avenue
Barrington, IL 60010
USA
Tel: 800-637-3739 or 847-381-7050
Fax: 847-381-7053
<http://www.barnant.com>

BioQuest (bromine systems for portable spas)

4750 Longley Lane, Suite 202
Reno, NV 89502
USA
Tel: 888-829-9993 or 775-829-1512
Fax: 775-829-0617
<http://www.bioquest.com>

Chemical Automation Technology

18568 Office Park Drive
Gaithersburg, MD 20879
USA
Tel: 800-657-2287 or 301-990-8825
Fax: 301-990-8907

Chemtrol

A Division of Santa Barbara Control Systems
5375 Overpass Road
Santa Barbara, California 93111
USA
Tel: 800-621-2279 or 805-683-8833
Fax: 805-683-1893
chemtrol@sbcontrol.com
<http://www.sbcontrol.com>

Hanna Instruments Inc.

584 Highland Corporate Drive
Woonsocket, RI 02895
USA
Tel: 800-426-6287 or 401-765-7500
Fax: 401-765-7575
<http://www.hannainst.com>

Kruger & Eckels Inc.

1406 E. Wilshire Avenue
Santa Ana, CA 92705-4423
USA
Tel: 800-355-7663 or 714-547-5165
Fax: 714-547-2009

Link Automation Inc.

75 E. County Road B
St. Paul, MN 55117
USA
Tel: 800-546-5008 or 651-487-6007
Fax: 651-487-6009

Liquid Metronics

8 Post Office Square
Acton, MA 01720
USA
Tel: 978-263-9800
Fax: 978-264-9172

ProMinent Fluid Controls Inc.

136 Industry Drive
Pittsburgh, PA 15275-1014
USA
Tel: 412-787-2484
Fax: 412-787-0704

Pulsafeeder Inc.

27101 Airport Road
Punta Gorda, FL 33982
USA
Tel: 941-575-3800
Fax: 800-456-4085

U.S. Filter, Stranco Products

595 Industrial Drive, P.O. Box 389
Bradley, IL 60915
USA
Tel: 800-882-6466 or 815-929-4149
Fax: 815-932-1760

Test kits for spa water

Environmental Test Systems

PO Box 4659
Elkhart, IN 46514-0659
Tel: 888-278-2243
<http://www.aquachek.com>

Industrial Test Systems

1875 Langston Street
Rock Hill, SC 29730
Tel: 803-329-9712
Fax: 803-329-9743
itw@cetlink.net
<http://www.sensafe.com>

Laporte Water Technologies

1400 Bluegrass Lakes Parkway
Alpharetta, GA, USA 30004
Tel: 800-445-2059 or 770-521-5999
Fax: 770- 521-5959
info@poolspacare.com
<http://www.poolspacare.com>

Whirlpool bathtub cleaning equipment and products

Hydravac Corporation

1461 S. Beltline Road, Suite 100
Coppell, TX 75019
Tel: 972-745-2284
Fax: 972-745-2285
info@hydravac.com
<http://www.hydravac.com>

Other publications from HC Information Resources

Item	Price (US\$)	Pgs	Title	URL for information
			Publications for a general audience	
310e	\$14	24	How to Reduce Your Risk of Legionnaires' Disease in Public Places (electronic)	http://hcinfo.com/310info.htm
311e	\$17	29	Spas, Hot Tubs, and Whirlpool Bathtubs: A Guide for Disease Prevention (electronic)	http://hcinfo.com/311info.htm
312e	\$14	25	Home Plumbing Systems: How to Reduce Your Risk of Legionnaires' Disease and Other Bacterial Infections (electronic)	http://hcinfo.com/312info.htm
313e	\$7	4	Dental Water Line Contamination (electronic)	http://hcinfo.com/313info.htm
314e	\$5	5	Home Humidifiers: Reducing Your Exposure to Harmful Bacteria (electronic)	http://hcinfo.com/314info.htm
316e	\$9	8	Cryptosporidium: What You Need to Know to Protect Yourself (electronic)	http://hcinfo.com/316info.htm
			Publications primarily for professionals: engineers, physicians, infectious disease/infection control professionals, public health officials, industrial hygienists, attorneys, water utility officials, water treatment specialists, epidemiologists, microbiologists, consultants	
104	\$79	144	Legionellae Control in Health Care Facilities: A Guide for Minimizing Risk (book) - best seller!	http://hcinfo.com/ldbook.htm
301 301e	\$14	20	Legionnaires' Disease: Facts, Legal Issues, Risk (paper and electronic)	http://hcinfo.com/301info.htm
302 302e	\$19	24	How to Make Plumbing Systems Less Conducive to Legionella and Other Bacteria (paper and electronic)	http://hcinfo.com/302info.htm
303 303e	\$19	25	Disinfecting Plumbing Systems of Legionella: Solving Problems Without Overspending (paper and electronic)	http://hcinfo.com/303info.htm
304 304e	\$19	18	Minimizing the Risk of Legionella in Cooling Towers (paper and electronic)	http://hcinfo.com/304info.htm
305 305e	\$14	14	Sample Water for Legionella? Weighing the Benefits Against the Costs (paper and electronic)	http://hcinfo.com/305info.htm

Item	Price (US\$)	Pgs	Title	URL for information
306 306e	\$24	32	Legionella Environmental Sampling Guide (paper and electronic)	http://hcinfo.com/306info.htm
307 307e	\$14	18	Getting Help with Legionella Problems: Guidance for Good Decisions (paper and electronic)	http://hcinfo.com/307info.htm
308 308e	\$19	13	Culture Methodology for Legionella Species (paper and electronic)	http://hcinfo.com/308info.htm
309e	\$11	40	Legionella Electronic Source Directory (electronic)	http://hcinfo.com/309info.htm
315e	\$17	151	Cryptosporidium and Water: A Public Health Handbook (electronic)	http://hcinfo.com/315info.htm
401	\$9	n/a	Point/CounterPoint: Surveillance Cultures for Legionella (audio cassette)	http://hcinfo.com/401info.htm

To order or get more information, go to <http://www.hcinfo.com>, or contact:

HC Information Resources Inc.
 PO Box 2109
 Fallbrook CA 92088-2109, USA
 Tel: 1-800-801-8050 (USA/CAN) or +1-760-451-1020
 Fax: 1-800-290-1967 (USA/CAN) or +1-619-839-3166
hcinfo@hcinfo.com
<http://www.hcinfo.com>

Your comments

PLEASE comment on this report! What should be added, deleted, or changed? Any suggestions will be greatly appreciated. Send your comments to hcinfo@hcinfo.com .

If the report has helped you, please tell others about it! E-mail your friends and mention it on listservs. If you have a web site, please link to hcinfo.com.

Thank you!