2009 WQA Educational Kit

Expand Your Knowledge

Water Quality Association
4151 Naperville Road
Lisle, Illinois 60532-3696 USA

Introduction

"My certification sets me apart from my competitors, and customers remember me as the person with the certification title after my name."

That's why George Yen, founder of Topway Global, Inc., (Brea, California) earned – and now maintains – his WQA certification as a CWS-VI. George is like nearly 1,800 professionals who understand the value of this unique continuing education package.

WQA introduced professional certification 30 years ago. Leaders in the industry wanted a program that would keep them up on changes in the field and, at the same time, enhance their services with a distinctive edge. With WQA certification, you're standing out as a tradesperson who is committed to doing the best work you can.

WQA offers this special education kit as an exclusive member service, as an educational piece for you and your entire staff, and/or to help you earn needed credits for recertification. By reading these four articles and answering the quizzes at the back of the booklet, you can earn an entire credit (1.0 CPD).

In addition to a convenient way to earn certification credits, in these pages you'll find a wide scope of topics to help you broaden your water treatment knowledge.

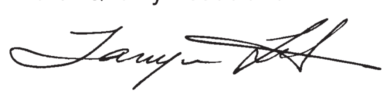
If products are a commodity, then the value and distinction is in the service and level of expertise of the seller. Imagine a residence or a small commercial facility on a private well, and consider the problem of water quality from the customer's perspective. Most locations require that the well be put in by a licensed well driller. Then a licensed pump installer must add the well pump. A licensed plumber needs to be called for any modifications to the distribution system, and finally, a knowledgeable water treatment professional is needed to provide the desired water quality.

Now imagine that the knowledge of all four of these professionals is confined to the license/certificate they hold. The well driller doesn't know which treatment equipment to recommend, the plumber doesn't understand why copper pipe might be a problem downstream of a point-of-entry reverse osmosis system. the pump installer is unaware that the new pump he's recommending is going to cause channeling in the existing softener, and the water treatment professional doesn't realize that the well pump doesn't provide the proper flow rate and/or water pressure for the treatment equipment to operate correctly. The final responsibility for integrating all four water professionals falls to the residence of facility owner, who understands even less about the overall system and its components and does not need the additional headache of figuring this all out. What if you could take that burden of integration from the residence/facility owner, but your competitor could not? Would the relationship you have with your customer change? Would it lead to your customers calling you before they call your competitor?

I'm not suggesting water treatment professionals should become licensed well drillers, or pump installers, or even plumbers – although those that already hold such licenses will agree that they're an asset – but you should at least familiarize yourself enough with your customer's concerns that you can offer knowledgeable support. Seeing the world through your customer's eyes is an undisputed tenet of good sales technique.

Good luck!

Water Quality Association



Tanya Lubner, PhD
Director of Education & Certification

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*Any questions on the WQA Professional Certification Program may be addressed to the education department at **630 505 0160**.

Critical Flow – Planning for Water Safety & Quality

By Larry Cohen and Peter Kennedy
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Depending on gender, age, and proportion of muscle-to-fat, the average human body is composed of approximately 50% to 70% water—the element that is essential for all life to exist. In a sense, then, we really are what we drink. For those of us who manufacture food and beverage products that contain water as an ingredient or that use water for production and other processes in the plant, we know that the quality and safety of this essential fluid has a significant impact on the quality of finished products. Just like our bodies, we know that our food products really are what we put into (or onto) them. Since water quality is so critical to the manufacturing of safe, wholesome foods, we must manage it effectively, from sourcing and receipt through production and packaging of product.

Water may be adulterated by a number of chemical, heavy metal, microbial, and physical hazards that pose potential public health risks if they are present at high levels. Microbial hazards include waterborne pathogens such as *E. coli, Salmonella,* and *Listeria* monocytogenes, *Vibrio cholerae,* and viruses and parasites, such as Hepatitis A virus, *Giardia* and *Crytosporidium* parvum. Chemical and heavy metal hazards in water range from the presence of lead, copper, methyl-tertiary-butyl-ether (MTBE), total trihalomethanes (TTHM), arsenic, and benzene, to name a few. Physical hazards may include natural particulates, and glass and metal fragments. The potential for any one of these hazards to be present in a facility's water supply requires food manufacturers to develop a solid water quality and safety management strategy. From the processor's perspective, water quality and safety begins at the source of the raw materials, and the key to good water safety and quality management is for all manufacturing facilities to have effective programs in place to control water microbiological, chemical, and physical quality, and to verify that the water meets specified requirements for both direct and indirect product uses. Developing a risk-based water monitoring program, or water safety plan, as part of the operation's Hazard Analysis and Critical Control Points (HACCP) program is an excellent way to ensure that effective controls for water are achieved to prevent product exposure to spoilage or pathogenic microorganisms, to potential chemical contaminants, and to possible physical hazards. Assessing and monitoring water quality and safety includes considering incoming water requirements, water utilities controls and treatments, and microbiological and chemical sampling and testing protocols that best meet your operation's needs.

Incoming Water: Assessing the Supply Stream

The first step in developing a water safety plan is to establish basic requirements for incoming water. At minimum, the food processing plant's potable water supply system must meet all applicable US Environmental Protection Agency (EPA) Safe Drinking Water Act (SDWA),World Health Organization (WHO), and federal and local government regulations. A company standard for potable water should be established that can be used for unregulated water supplies.

Once the fundamental regulatory and standards compliance requirements are identified, the manufacturer can determine what water disinfection treatment (for either municipal or well water sources) is required for all incoming water used in plant processing areas, which includes all water suitable for drinking and product contact applications (potable) and all water that is used as an ingredient and/or used on equipment post-process (process). Some type of pretreatment of the water is a necessary precursor to its receipt in-house for a variety of reasons, including weather-related events, seasonal run-offs, or other changes that might affect the municipal or well water source adversely.

Conducting municipal water source surveys will assist in the identification of the appropriate treatments, protozoan and viral controls, microbiological and chemical testing, and verification methods for the processing facility. The best defense against potential contaminant intrusion is to know where the water is sourced. The ability to monitor throughout the supply chain will help the processor hone that defense. For example, if your operation is supplied by a municipality that receives its water from a reservoir, you may want to obtain some information on the watershed protection program to see whether Canadian geese fly over that water source and cause bacterial or particulate/foreign material contamination issues. Does the municipal treatment center have a filtration or biocide protocol for the reservoirs as part of its watershed protection system, or is the assumption that the commercial user down the line is expected to take action to treat the water for this issue?

If the plant is using a private or onsite well water source, a similar survey should be conducted to ensure that such seasonal, climatic, or geological events that may impact the raw water quality are factored into pretreatment monitoring plans.

Further, establishing a dialogue with the water supplier can provide valuable information that can be incorporated into your operation's risk-based water monitoring program. Ask to see its water assessment reports to find out about specific water quality issues that may affect the water your plant will receive. For example, does the municipality monitor particular organisms or chemical compounds more closely at certain times of the year when there is

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Requirements and instructions for water quality programs/ controls must be documented and available to those involved. Such programs will include, but are not limited to, water used as/for:

- Chlorination and dechlorination
- Ingredient
- Drinking fountains and cooler dispensers
- Processing aid
- Post-process package cooling
- Cook water (in RTE meat)
- Chill water (in RTE meat)
- Brine solutions (in RTE meat, in RTE natural cheese)
- Blanching/cooling water (pasta, rice, vegetables)
- Retort water (low-acid canned foods)
- Hand wash
- Sanitation final rinse
- Reclaimed water
- Ice (drinking or product contact)
- Laboratory water
- Cheese curd or "white" rinse water
- CIP make-up water
- Recirculated cooling (heat plate exchanger, jacketed tanks, closed loop)
- Bulk water (transported by tanker for further processing)
- Irrigation water (produce)

Table 1. *Examples of typical direct and indirect product uses of water in a food processing facility*

a spike in numbers due to some localized seasonal change? Are there concerns about the emerging problem of trace chemicals being recycled into fresh water supplies from waste streams, such as pharmaceutical waste, inorganic chemicals (IOCs), synthetic organic chemicals (SOCs), or volatile organic chemicals (VOCs), which, if found, above regulatory maximum contaminant levels, may cause a host of serious human health issues?

Of course, the municipal supplier must meet government standards for water monitoring and disinfection. Typically, the supplier's water quality program requires monitoring of pesticides, VOCs, and metals within a three-year compliance period, as well as addresses routine monitoring and treatment of waterborne pathogens. Although there are minimum monitoring standards for chemical and microbiological contaminants in the case of public water supplies, food processors may discover, through surveying the water supplier's programs, that certain contaminants require the plant to do more frequent or additional monitoring and testing upon receipt of supplies. For example, recent US studies have reported the presence of viruses in a large percentage of groundwater used by municipal water suppliers nationwide, so even though a company may be in compliance with the applicable microbiological guidelines, these organisms are of concern to water users. Thus, a food processor may want to establish additional monitoring and testing programs or risk controls for waterborne viruses and parasites, such as noroviruses and *Cryptosporidium parva,* in the facility HACCP plan since these organisms may not be as closely monitored at the water treatment plant.

Finally, check with the municipal water provider to determine what disinfection methods are used at the treatment plant, and what microorganisms or chemical contaminants are tested and at what levels. This information is very useful in providing guidance about what types of barriers for chemical and microbiological contaminants are appropriate to include in the processor's HACCP plan.

Facility-Centered Incoming Water Requirements

Again, whether the facility is receiving its water supply from a municipality or from private wells, the minimum requirement for incoming water is that it has been treated with an approved disinfection process. This applies to all applications and within all plant processing areas, as well, including both direct product use such as water used as an ingredient, as plant drinking water, or for sanitation of equipment, or indirect processing uses such as for handwashing or recirculating cooling water (Table 1). Approved disinfection methods for water include chlorination, ozonation, and ultraviolet (UV) light, biocides and others, depending on the type and sensitivity(ies) of the product(s) that you are manufacturing.

It should be noted that there are a few circumstances that warrant exception to the disinfection requirement. The requirement can be waived, for instance, if there is a documented history of microbiological quality compliance of the incoming water supply, supported by increased, intensive, ongoing testing. The disinfection mandate may also be waived for products and processes that are not tolerant to chlorine or other disinfection treatments, such as vinegar generation or ready-to-drink (RTD) beverages.

There are several requirements for incoming water that food manufacturers should also include the following general control and verification measures in the water safety plan:

- Require backflow preventers on each potable water line used for production and drinking as a control measure for all incoming water.
- Require ozone/oxygen generator or chlorine dioxide systems for plant well sources that pose a potential risk of containing protozoan pathogens.
- Verify the incoming municipal or plant well water system for disinfection by chlorine, ozonation, or other treatment methods and perform verification activities at a set frequency schedule to demonstrate control.
- Chlorine testing requirements and sampling plans for verification must address the following criteria:

1. Chlorination levels for plant and/or incoming treated systems must be specified, monitored, and recorded. Ideally, municipal water inlet(s) and

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plant well water storage tanks or plant inlets are tested for free (residual) chlorine at parts per million (ppm) level (0.1 ppm – 4.0 ppm) during production. Test for total chlorine (minimum 0.2 ppm) if the municipality treats the water supply with chloramines instead of chlorine. Checking chlorine levels is also important since it is possible that the manufacturing plant is at the end of a given water distribution chain, which may mean that the incoming water has free residual chlorine levels lower than the required 0.1 ppm.

2. Municipal chlorinated water sampling and verification testing should be conducted daily until documented historical test data may be used to justify reduced frequencies. Multiple plant inlet locations can be rotated throughout the week. Further point-of-use sample locations throughout the plant are optional.

3. Well water, chlorinated water sampling, and testing should be conducted on a routine basis (e.g., daily). Chlorine concentration shall be properly maintained, monitored, verified, and documented.

- Bromate and halogenated compounds should be tested for ozone and chlorine dioxide-treated well water and ozonated bottled water on a quarterly basis.
- Ozone-related water sampling practices should address the following criteria:

1. Ozone treated water at the plant shall be sampled and tested after deozonation to verify that you're getting the correct control measure of residual ozone. Sample deozonation of equipment at each shift of production. Further sampling locations throughout the plant are optional.

2. Ozone concentrations shall be properly maintained, monitored, and verified during production with an online meter and documented.

3. Bulk water shipments (spring well source) receiving ozone or chlorine treatment (externally) shall be accompanied by a certificate of analysis (COA) indicating concentration of the disinfectant residual (if required by local state agency having jurisdiction) at the time of loading and unloading. The receiving plant shall verify compliance.

4. If ozonation is used as an equipment sanitizer, it should be sampled at the end of the sanitization circuit and recorded per documentation requirements. With its short half-life and very rapid dissipation, ozonation requires you look at equipment to make sure that the residual effects are going to be high enough to achieve the proper and expected disinfection results.

- Other modes of disinfection (UV, ozone) of incoming water and produce wash water systems (chlorine dioxide, peroxyacetic acid, hydrogen peroxide, etc.) shall be properly maintained, and system functionality verified during production and documented.
- Overall water chemistry should be monitored to establish and verify control of microbiological hazards. In particular, total dissolved solids (TDS) and water hardness are important measures of water quality. For example, water hardness may spike seasonally due to regional droughts or runoff, and for plants using UV light to control microbial load, this change can create a film that can cause the UV light to be coated with microorganisms. Instituting routine monitoring of water hardness will reveal these problematic spikes and help you to establish the correct standards and maintenance for particular types of equipment to prevent microbiological problems from developing unbeknownst to you.
- Equipment to control physical hazards present in the incoming water supply, that may not have been captured at the water treatment plant, should be utilized. High levels of particulate contamination can wreak havoc on machinery used to process water, such as sand or stone that might come from the municipal water, making the use of physical filtration meshes (e.g., 200-mesh filter) critical to ensuring particulate removal.
- Where turbidity testing is a specified requirement (typically for surface or well water sources), a visual assessment of turbidity shall be carried out on a routine basis. The testing frequency, and justification for any reduced testing level, must be documented. Testing shall be carried out following any event which may adversely impact turbidity, such as abnormally heavy rainfall and/or flooding.
- Establish and audit a well water disinfection requirement for contract manufacturers and sensitive ingredient suppliers. Make sure that you have a supplier quality audit program that incorporates the same type of water quality policy or program that you use internally and ensure that this protocol is part of the HACCP plan, For example, if your beverage plant is receiving liquid fructose, the supplier should have water listed as an ingredient in its own company HACCP plan, including any identified hazards and corrective actions, if warranted. By extending your guidelines and standards to a certain extent into your supply chain, you will gain additional assurance that water-based ingredients or raw materials that have come into contact with water have not been compromised by sources outside of your plant before entering your manufacturing facility, which could adversely impact the effectiveness of your disinfection treatments or controls.

In addition, establishing and maintaining an auditing program covering the set microbiological, chemical, and disinfection requirements for contract or well water suppliers will result in an audit trail that is useful in verifying that your plant's specifications are met, which reduces potential added expenditures in time and labor rechecking the quality of the water or ingredient you've received.

Water Utilities Control

Control of the water utilities within the processing plant is another important component of an effective water safety

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plan. Some of the requirements that must be included are:

- When the plant utilizes and treats wells for its water source, check the plant chlorination system to ensure that proper controls are in place. Items to be checked include level probes, retention time, pumps, and piping.
- The plant water systems within the facility must be periodically reviewed and checked whenever work is performed on the system to ensure no cross-connections exist between treated and untreated supplies. This applies to all incoming water, whether it is plant-treated or municipal-treated. As a best practice, it is important to develop updated piping diagrams and labeling showing which pipes handle potable and nonpotable water sources within the plant facility. This prevents inadvertent use of nonpotable water for cleaning equipment or as drinking water.
- Ozone sensors/alarms, UV bulbs, and charcoal filtration systems shall be inspected and maintained. In cases in which there is no disinfection system in the plant, such systems play important roles as water utilities controls, which have to be inspected and maintained. For example, a plant using a charcoal filtration system to remove the chlorination when producing a beverage will change filters on a routine basis. The filters should be closely monitored for microbiological load before and after the filter is changed.

There are other types of water besides direct use water within a food manufacturing facility that require control measures. There may be cooling water that is used indirectly to cool jacketed tanks, and so on, which also has to be microbiologically maintained. A recirculated cooling water system may require a biocide and/or sanitizer treatment to the system. Water that is used for other purposes, such as reclaimed water for dairy products which is not potable water, must follow more specific requirements such as the Pasteurized Milk Ordinance (PMO) requirement. In dairy plants, a prevalent use of reclaimed water is for prerinse in clean-in-place (CIP) applications, so another type of utility control of this indirect water is needed. The same holds for steam that is delivered into the plant; it must be of the correct quality and purity for its intended use, such as a culinary or nonculinary steam.

High Risk
- Nonchlorinated process (until chlorination or disinfection is in place)
- Incoming water from plant well head prior to chlorination
- Testing after any maintenance repairs to process and cooling water lines

Medium Risk
- Process water with no lethal step after water addition
- Potable plant water (sanitation rinse, drinking, and handwashing) for wet processing plants, and ice used on product
- Flume water and reused brine solutions
- Postprocess package indirect cooling water

Low Risk
- Process water used in acidified products
- Process water with a lethal step after water addition
- Recirculated heat plate exchanger and jacketed cooling water (indirect)
- Deionized/RO lab water

Table 2. *Examples of food plant processes/products requiring microbiological sampling and testing, ranked by risk level*

In the Plant: Microbiological Sampling and Testing

Developing a program of risk-based microbiological testing for water used in the food processing facility is imperative to ensure that your operation applies the proper and verifiable control measures at the product and process critical control points. In addition to the microbiological testing of incoming water described above, water used at various points in the process—ingredient, indirect or, direct product water cooling, equipment sanitation rinse, drinking water, etc.—will also be specified in the water safety and quality plan requirements. These microbiological testing programs should be evaluated and modified as necessary based on the historical data and product/process risk conditions as identified in the HACCP plan. Table 2 lists examples of primary uses of water in a food plant by risk rankings that might be identified as a result of conducting a microbiological risk assessment.

Water testing plans for specific products/ ingredients must be defined and documented, and must indicate the following: sample location and size; chlorine and/or ozone sampling and testing (well and municipal water) as described; test frequency; required test(s) and test methodology; acceptance criteria; unacceptable results and retesting; corrective action criteria; and records.

Water sampling for microbiological testing – Water sampling practices shall address the following criteria:

1. Sampling will be at a point of use (e.g., site closest to point of entry from source and site within processing areas).
2. Sampling site shall be rotated.
3. Water shall run 2 to 3 minutes before sampling.
4. Well water sample valves and/or sample ports shall be alcohol sanitized followed by water flushing for a minimum of 30 seconds before sampling.

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5. Chlorinated water samples will be treated with sodium thiosulfate to neutralize the chlorine.
6. Testing must be completed within one hour of sampling or the samples must be refrigerated and held no longer than 24 hours.

Basic test requirements – All plant microbiological testing can be conducted using two indicator organism tests, aerobic plate and coliform counts, which predict the microbial load of the water and enable the plant to establish corrective actions based on action levels contained in the EPA Safe Drinking Water Act. To comply with EPA water standards for potable water, the action level for APC is <500 per 1 ml and the action level for coliform testing is <1 ml absence/presence per 100 ml. It is important that you pull 125-ml samples for both APC and coliform testing to ensure that you have the 100 mL required to conduct the coliform test. As mentioned above in the sampling criteria, it is important that you use a water sampling kit that contains a sodium trisulfate tablet that neutralizes the chlorine to ensure accurate test results. These indicator tests will also detect the potential presence of generic *E. coli* and *E. coli O157:H7* in cases where a well water source supplies the plant.

Some microbiological testing programs concentrate not just on coliform aerobic plate counts, but also look at heterotrophic plate counts (HPC using Standard Methods Agar), which are useful in identifying areas in the plant's water system susceptible to the development of biofilms. HPC, formerly known as the standard plate count, is a procedure for estimating the number of live heterotrophic bacteria in water. This test can provide useful information about water quality and supporting data on the significance of coliform test results. High concentrations of the general bacterial population may hinder the recovery of coliforms.

Test methods. There are many screening and detection test kits commercially available to food processors that work well for water testing applications. Free and total chlorine testing can be conducted with a colorimeter or photometer (using EPA-approved methods) with a detection limit to 0.05 ppm level for chlorine. Several test kit manufacturers offer easy-to-use APC and coliform enumerative methods based on a variety of techniques recognized by AOAC International, including film-based, defined substrate technology, binary detection technology, chromogenic media, immunoassay, colorimetry, immunomagnetic beads, as well as automated plating, immunoassay and molecular detection systems.

Frequency – The frequency at which sampling and testing for either pathogen or spoilage risk should occur is based on product/process sensitivity to microbiological contamination and determined by the appropriate quality and microbiological or food safety functions. Another factor to consider when determining testing frequencies is the number of water sites in the plant. Due to a large number of point-of-use sites within a given facility, your time is well spent in mapping out the important areas where the most testing is warranted as indicated by historical data or through risk assessment to determine a frequency that makes sense for each site.

When considering the types of risk-based microbiological water testing, you should factor in the sensitivity of the product and whether the water is used in a product processed with or without a lethal kill step. For example, in cases where product is made without a lethal kill step, the plant will want to consider more frequent monitoring (e.g., weekly) to ensure that alternative control measures are working adequately. A similar testing program can also be implemented for any product to which you are applying water after the kill step, such as chill water used on meat after it goes through the smokehouse, water used to chill down filled beverages, or ice that is used for fresh cheeses. A less frequent monitoring program (e.g., monthly) might be advisable for product that is processed with a kill step or for acidified products like salad dressings in which the formulation itself, the acid in the product, provides a kill step.

Testing frequencies will typically range from daily or weekly, to monthly and quarterly schedules based on variables such as the water source, type of disinfection treatment used, and the product/process risk factors.

Unacceptable results, retesting, and corrective actions – What do you do when microbiological levels are exceeded? In all cases of unacceptable microbiological test results, prompt corrective action steps must be taken, and appropriate communications should occur. Affected water will need to be retested at the original and additional sites, including point of entry to the plant at an increased frequency, for determination of possible source of contamination. Retested water sites with coliform results should be communicated to the plant quality, engineering, and applicable management staff. Coliform results from the plant well, and/or in-plant sites taken for regulatory purposes, also must be reported, Specifically, noncompliance of specific SDWA quarterly sampling and testing (coliforms) performed by an outside certified lab must be reported to the appropriate state agency within 48 hours.

If test results exceed the acceptance criteria limits and continue to occur beyond one month, the company will then determine the appropriate action steps. Depending on the results of any investigation into the source of non-standard microbiological results, the following corrective actions should be taken:

- Check the chlorination system (level, retention time, indicating probe, pump/piping, etc.), as applicable. Recheck samples for free chlorine levels at specified sampling locations. Review test methodology used.

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If free chlorine levels (<0.1 mg/L) continue, the municipality shall be contacted to review chlorine test verification programs. Contact the municipality if the levels are > 3.0 – 4.0 ppm.

- Water lines shall be traced for potential sources of contamination and/or biofilm formation. These would include: water inlet, filters, softening equipment, backflow preventers, dead end piping, recent plumbing changes, "shock absorbers", etc. The water lines shall be checked, steam cleaned, chlorinated, and sections replaced as applicable. Well water line leaks can be tested by an outside contractor.
- Water lines, hoses and nozzles, faucets, etc., will be checked, repaired, cleaned, and chlorinated, as applicable.
- Recirculated cooling water circuits and exchange water will be checked, cleaned, exchange water and, if necessary, initiate chlorination.
- Plant well water inlet shall be tested three additional times within a one week period. If any out-of-standard results are reported, the next steps shall include "shock treating" with chlorine. Indirect cooling water system biocide and/or sanitizer treatment will be checked and treated with FDA-approved biocide treatments, as applicable.
- Corrective action steps shall be documented.

In the Plant: Chemical Contaminant Testing

Like microbiological testing for water quality, a testing program for chemical contaminants can be predicated on a risk assessment approach and should be included as part of the food manufacturing facility's HACCP plan. Establishing a chemical water standard for your plant begins with following the compliance requirements of the EPA SWDA standard, which lists the various waterborne chemical contaminants and metals of concern to food manufacturers. Regulated chemicals should be placed on a testing frequency based on your operation's knowledge of known or likely contaminants that could enter or flow through the plant's water supply. Depending on the chemical concentrations found, the plant may want to institute routine water sampling and analyses more often than required by the national safe drinking water standards.

Because there are many chemicals, both regulated and unregulated, that can adversely impact your operation's water quality, testing for these analytes needs to be based on historical data for both your water supplier and your particular facility. For example, perchlorates and methyl-tri-butyl-ether (MTBE), both fuel additives, have caused extensive chemical particulate contamination in water aquifers nationwide, becoming a concern for all food manufacturers using water. Even so, testing is not required for these chemicals, and a processing plant would include additional testing for these analytes in the water quality plan only if local concerns exist. The total trihalomethanes (TTHMs) family, which includes chloroform and other chemicals formed in the water disinfection treatment process, is another group of potential contaminants found in water that can negatively affect food quality.

Another potential issue of concern is detectable traces of chemicals in the water supply that are allowable, but that, when blended together through application, may form another chemical that is not regulated. This might cause blips on your chemical assay but will be difficult to identify, much less to adequately monitor or test to determine whether it poses a hazard to your product.

Make sure that the sanitation chemicals and disinfection agents used in the plant are compliant with standards applicable for use around food products. A supplier may have reformulated cleaning products and these could contain new and unexpected chemical components that are unacceptable for use around your food products.

Beyond chemicals, some plants may want to consider testing for heavy metals in the product/process water supply, particularly if there are any leaded water distribution lines leading into the plant. Heavy metal contaminants can affect the product quality, both in reduced flavor profiles and shelf life.

Test methods – Testing total dissolved solids (TDS) and water hardness are fundamental water tests that should be conducted on a daily basis. These measurements help determine whether the water coursing through your processing lines is acting as a solvent. The mechanical action of water on pipes, for example, can break down piping and other water conveying equipment. Knowing your water chemistry will give you a good idea of whether you have water that is stable or more aggressive. The measurement of pH is another important test that can be used to verify water disinfection, as is often done in the produce industry.

There are many commercially available sampling and test kits that can help you screen incoming water supplies for a variety of chemical contaminants and heavy metals. Since the cost for a full analysis of a given chemical can be quite steep, it is a good idea to look at families of chemicals, such as VOCs and SOCs, and to use that data as a precursor to refine your water quality program chemical testing requirements. A quick screening test is an inexpensive way to discover whether you have a problem that will require you to dig deeper to identify contaminants in your water supply for which you need to institute quality control points.

Unacceptable results and corrective actions – In the event that you receive an unacceptable chemical test result, first check with the municipal or private water supplier to see if the chemical intrusion is a result of a natural climatic or geological event, or a treatment applied prior to the water's arrival at the plant. Check your own plant water process systems as well, including reviewing the disinfection treatment protocols and control measures in place for chemicals of concern, and/or seek expert help.

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Tapping Into Higher Quality Water
Food and beverage processing operations that use a risk-based water monitoring program to control pathogens, spoilage organisms, and chemical contaminants can significantly increase confidence that water supplies are of high quality. Effective management of water utilities with respect to equipment design, performance, and quality is necessary to ensure that not only are compliance with applicable regulations and company food safety requirements met, but that the integrity of food products and associated services are assured at a gold standard level. Well-planned microbiological and chemical sampling and testing programs to verify that the water safety controls are working efficiently are also invaluable with regard to greater assurance for the plant.

Ultimately, water safety planning and the establishment of appropriate control measures and monitoring systems not only assures regulatory compliance, but will have a significant impact on the efficiency of the company's overall food safety management system. Increased production efficiencies improve the quality and safety of finished products, ensuring consumer confidence in the safety quality of your brands—and your company's confidence that the food protection mission is achieved.

***Larry Cohen** is a Food Safety Program Manager in the Global Microbiology and Quality groups for Kraft Foods in Glenview, IL. Larry has 26 years of management experience in quality, microbiology, research and development, auditing and plant operations with Kraft Foods North America and Heinz USA. He is responsible for executing food safety initiatives, including HACCP plans, pathogen and spoilage controls, allergen controls, water quality and testing optimization programs. He is a member of the International Association of Food Protection, United Fresh Produce Association, Institute of Food Technologists, and American Society for Microbiology. Larry can be reached at lcohen@kraft.com.*

***Peter Kennedy** is President of Quality Flow, Inc., a leading independent consulting firm that provides expertise to assure safe water and water treatment to some of the world's leading names in the food service industry, from suppliers of restaurant beverages and beveragemaking equipment to internationally famous franchises. Peter can be reached at pkennedy@qualityflow.com.*

QUIZ 1: "Critical Flow: Planning for Water Safety & Quality" (0.45 CPD)

1. **Based on this article, why should food manufacturers develop additional water testing plans and protocols beyond potable water standards?**
   a. Ensure disinfectants don't interfere with product formulation
   b. Help measure water use by the plant
   c. Ensure only grey water is used to flush toilets
   d. Ensure correct calibration of instrumentation
2. **While thorough assessment of water quality and safety is required for a food manufacturer, it does not include monitoring which of the following to assure product safety:**
   a. Municipally-treated water supply
   b. Private well water
   c. Potable water supplies
   d. Plant waste stream
3. **Once the incoming water meets all applicable regulatory standards, who has the responsibility to determine the disinfection treatment required for incoming water used in plant areas?**
   a. USEPA
   b. World Health Organization (WHO)
   c. Food Manufacturer
   d. Municipality
4. **How could a municipality's switch from chlorine disinfection to chloramine disinfection affect the food manufacturing plant?**
   a. Treatment with chloramines still leaves a chlorine residual; no effect
   b. Chloramines introduce ammonia compounds to the incoming water; potential affect on product formulation
   c. Chloramines introduce different disinfection by-products to the incoming water; potential affect on product formulation
5. **What conclusion can be drawn on the effect of seasonal changes on municipally-treated supplies?**
   a. Municipalities must provide potable water, regardless of seasonal changes, eliminating the need for additional testing at the food plant.
   b. Seasonal spikes in all types of contaminants – inorganic, organic, and microbiological – will be caught by the municipality's monitoring program.
   c. To stay within compliance with regulations, municipalities may change treatment methods, altering the chemical composition of the water entering the food plant.
6. **The total trihalomethanes (TTHM) family of chemicals that are formed in the water disinfection treatment process includes:**
   a. Chlorine dioxide
   b. Chloramine
   c. Chloroform
7. **Perchlorate and methyl-tri-butyl-ether (MTBE) are both:**
   a. Fuel additives
   b. Food preservatives
   c. Chlorine suppressants
8. **The action levels for aerobic plate count (APC) and for coliform in water are:**
   a. Absence of any detectable amount
   b. <20 per 1 milliliter for APC and < 10 per 1 milliliter for coliform
   c. <500 per 1 milliliter for APC and < 1 (absence) per 110 milliliters for coliform

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QUIZ 1: "Critical Flow: Planning for Water Safety & Quality" (0.45 CPD) *(continued from page 8)*

9. **HPC (heterotrophic plate count) microbial water analyses, using Standard Methods Agar, are useful for identifying:**
   a. Health hazards in the water system
   b. A more complete count of coliform bacteria
   c. Areas in the water system susceptible in the development of biofilms

10. **A compound used to neutralize residual chlorine in microbiological testing sample bottles is:**
    a. Sodium chloride
    b. Sodium thiosulfate
    c. Sodium hypochlorite

11. **Cooling water that is used indirectly to cool jacketed tanks must be microbiologically maintained:**
    a. True
    b. False

12. **Piping diagrams and labels are for the purpose of showing:**
    a. Locations of cross connections
    b. Which pipes handle potable and nonpotable water sources
    c. Age of the plumbing infrastructure
    d. Type of piping materials used

13. **Microbiological problems in ultraviolet light systems can be caused by:**
    a. Total dissolved solids (TDS)
    b. Peroxyacetic acid
    c. Vinegar generation
    d. Water hardness

14. **For ozone and chlorine dioxide-treated well water and ozonated bottled water, bromate and halogenated compounds should be tested:**
    a. Daily
    b. Quarterly
    c. Annually
    d. Tri-annually

15. **Some plants may be at the end of a distribution chain for a municipality that disinfects with chlorine, resulting in a lower-than-required chlorine residual. What is the best way to check if this is true?**
    a. Contact the municipality to determine the required residual at the plant
    b. Compare how much chlorine the municipality is adding to the chlorine demand of the source water.
    c. Measure the concentration of the chlorination by-products in the incoming water.
    d. Measure the concentration of free chlorine in the incoming water.

16. **For incoming water that has been treated with chlorine, the minimum level of residual chlorine should be:**
    a. 0.05 ppm
    b. 0.1 ppm
    c. 1 ppm
    d. 5 ppm

17. **For incoming water that has been treated with chloramine, the minimum level of residual chlorine should be:**
    a. 2.0 ppm
    b. 0.2 ppm
    c. 4.0 ppm
    d. 0.4 ppm

18. **A food product process that is not tolerant to chlorine or other disinfection treatments is:**
    a. Diary products
    b. Liquid fructose production
    c. Vinegar generation
    d. Produce rinsing

19. **When can disinfection treatment of the incoming water be omitted in food manufacturing?**
    a. When the manufacturing process is followed by a kill step
    b. When the disinfectants interfere with the product formulation
    c. When a permit has been obtained from the USFDA
    d. When proper bacterial testing is in place

20. **Approved disinfection processes for food manufacturing facilities include:**
    a. Ozonation
    b. Iodination
    c. Bromoform treatment
    d. Reduction treatment

21. **The minimum requirement for incoming water to a food manufacturing facility is that it be treated with:**
    a. Water softening by ion exchange
    b. An approved disinfection process
    c. Sediment reduction by filtration

22. **Why are TDS and hardness concentrations a concern in systems with UV-light disinfection?**
    a. High TDS always results in high turbidity, leading to reduced disinfection efficacy
    b. In sufficient concentration, hardness can form a film on UV lamps, leading to reduced disinfection efficacy
    c. TDS compounds in solution can shadow microorganisms from UV light, leading to reduced disinfection efficacy

23. **Viruses are present in a large percentage of groundwater supplies:**
    a. True
    b. False

24. **Food plant processes and products requiring microbiological testing can be separated into three risk categories, high, medium, and low, as shown in Table 2 of the article. What could be said about the types of processes that are in the low risk category?**
    a. These types of processes are regulated by the USEPA
    b. These types of processes include water in direct contact with product
    c. These types of processes include a built-in disinfection step
    d. These types of processes include only potable water as a starting material

25. **In addition to quality control of water coming into the plant, what other types of water applications require risk assessment for product safety?**
    a. Any water application within the plant
    b. Only the plant wastewater
    c. Any water to be used in direct contact with food
    d. Any water to be used for indirect contact with food

The following article explains the role plumbing fixture counts play in determining selection of pipe material and diameter in building design. As explained in WQA's *Installer's Home Study Course*, fixture counts are also used at the time a water treatment system is specified to ensure that the new treatment system is 1) appropriate for the existing water flow rate and pressure conditions, and 2) will not have an adverse effect on the operation of downstream plumbing fixtures.

Flow rate, pressure, building demand, pipe size, and fixture count calculations also become important in residential applications with new building additions/plumbing renovations, in commercial bids, and in industrial applications of water treatment.

Additional information on calculating and using fixture counts can be found in WQA's *Installer's Home Study Course* and *Commercial Education Module 1: Commercial Sizing, Plumbing Design, and Applications.*

Back to Basics: Water Pipe Sizing

By Julius Ballanco, PE, CPD

Originally published in *PM Engineer Magazine*, November 2007. Used with permission of the publisher.

It all revolves around a very basic equation to determine velocity and rate of flow.

Editor's Note: "Back to Basics" is a column that will run periodically in PM Engineer reviewing the basic principles of plumbing engineering.

Sizing a water piping system is relatively easy. The basic pipe flow equation is Q = VA. This equation can be converted to normal units of measure, as well as using the inside pipe diameter. The new equation would read: Q = 2.448 V d2

Where:
Q = flow rate in gpm
V = velocity in ft/sec
d = diameter in inches

Importance of Flow Velocity/Rate

When attempting to determine the appropriate pipe diameter for a water distribution system, one needs to know the velocity of flow and the flow rate. The velocity of flow is established by evaluating the performance of the piping material, the noise in the pipe, and the potential for elevated hydraulic shock.

Velocities of less than 12 feet per second tend to not create high levels of noise in the piping system. However, this high a velocity can result in higher intensities of hydraulic shock or water hammer. The system would have to be evaluated for protection from hydraulic shock.

Several piping-material manufacturers recommend maximum velocities of flow for plumbing water distribution systems. *Table 1* lists the recommended maximum velocities.

When determining the pipe size, engineers often consider the anticipated length of time that the system will flow at the maximum velocity. If the maximum velocity is only anticipated for a short period of time, a velocity slightly higher than the listed velocities may be selected. When there is an anticipated continuous flow, a lower velocity is often selected.

With the velocity selected, the flow rate or "Q" must be determined. This is the hardest part of engineering a plumbing water distribution system. Plumbing fixtures are used on an intermittent basis. To determine the flow rate, the simultaneous use of the plumbing fixtures must be determined. This maximum flow rate is also known as the "peak demand."

Table 1

Piping Material	Maximum Velocity in Ft/Sec
Copper tubing cold water	8
Copper tubing hot water	5
Galvanized steel pipe	8
CPVC pipe	10
PEX tubing	12

There are various methods for determining the peak demand of a water distribution system. The most popular method of determining peak demand is the Hunter Method. This method, using water supply fixture units, was developed by Dr. Roy Hunter in the early part of the 20th century. According to published reports by Dr. Hunter, he points out the inaccuracies of the method.

The Hunter Method assigns a water supply fixture unit to each fixture. This fixture unit value is a probability factor used to determine the total use of water within a given system. Hunter developed a curve that establishes the flow rate for any given water supply fixture unit value.

The Hunter Method originally assumed two types of buildings; one that used tank-type water closets and one that used flushometer-type water closets. The problem with this concept is that it does not account for the normal operation of a building. A football stadium will have a different demand on a water distribution system than an office building. Similarly, a large home with five bathrooms will have a different demand than an apartment with one bathroom.

The other concern with the original fixture unit design concept was the change in the use of water since the 1920s. All fixtures discharge a lower amount of water today. *Table 2* points out the difference in flow rates from the 1920s to today.

Back to Basics: Water Pipe Sizing

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Table 2

Plumbing Fixture	1920 Flow Rates (gpm)	Current Flow Rates (gpm)
Shower	8-10	2.5
Bathtub	4	
Lavatory	4	
Kitchen Sink	4-5	
Urinal	23-35	
Water Closet Tank Type	5-7 gallons per flush	1.1-1.6 gallons per flush
Water Closet Flushometer	25-40	25

When Hunter did his research, a typical home had one bathroom. Today, a typical home has 3, 4, 5 or 6 bathrooms. The size of a typical family is also less than when Hunter performed his studies.

These changes lead to a research project by the Stevens Institute of Technology to re-evaluate the Hunter Method. The project was considered somewhat controversial at the time, since many engineers wanted to do away with Hunter's method and come up with a completely new design concept.

About the Stevens Method
The Stevens Method utilized the Hunter curve and simply adjusted the water supply fixture unit rates for each fixture. The new table lists values for four different categories of buildings. The categories include: one- and two-family dwellings, multifamily dwellings, high-use assembly buildings, and other buildings or commercial buildings. Some of the values of the new table are listed in *Table 3*.

Table 3

Plumbing Fixture	One and Two Family	Multifamily	Other	Heavy Use Assembly
Shower	2	2	2	–
Bathtub	4	3.5	–	–
Lavatory	1	.5	1	1
Kitchen Sink	1.5	1	1.5	–
Urinal	–	–	4	5
Water Closet Tank Type	2.5	2.5	2.5	4
Water Closet Flushometer	5	5	5	8
Bathroom Group	5	3.5	–	–
1-1/2 Bath	6	–	–	–
2 Bath	7	–	–	–
2-1/2 Bath	8	–	–	–
3 Bath	9	–	–	–
3-1/2 Bath	9.5	–	–	–
4 Bath	10	–	–	–

The only Plumbing Code that completely includes the Stevens Method is the National Standard Plumbing Code. Both the International Plumbing Code and Uniform Plumbing Code include some of the provisions from the Stevens Method. It should be noted that all of the Plumbing Codes permit the water distribution system to be sized by accepted engineering practice. This would allow for the use of the Stevens Method.

The methods listed in *Table 3* are for the total use of the water distribution system. When calculating the peak demand flow rate for the hot or cold water distribution system, the values in the table must be multiplied by 0.75.

To determine the size of the water distribution system, each fixture is assigned three values: the total water value fixture unit, the hot water fixture unit value, and the cold water fixture unit value. The values are added to determine the flow rate at any location in the piping system. The total fixture unit value is the number used for the pipe sizing upstream of the water heater.

When determining the flow rate using the Hunter or Stevens Method, the curve has two values — one listing is for flush tank water closets, the other is for flush valve. *Table 4* lists some of the common flow rates on the Hunter's curve.

Table 4

Water Supply Fixture Unit	Flow Rate (gpm) Tank	Flow Rate (gpm) Flush
5	4.5	22
10	8	27
20	14	35
40	25	47
60	33	55
80	39	62
100	44	58
120	49	74
140	53	78
160	57	83
180	61	87
200	65	91
300	85	110
400	105	125

Even with the modified Stevens Method, not all systems can be sized using this method. Like all sizing methods, there are limitations regarding high-end and low-end water distribution systems.

A good example would be a football stadium. Even the heavy-use assembly values will undersize the water distribution system for a football stadium. On the other extreme would be a row of lavatories that have aerators with a flow rate of 0.5 gpm. This method would oversize the flow rate for these fixtures.

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Any sizing method needs a common sense approach for establishing the flow rate in the piping system.

Once the flow rate is determined, the pipe size can be selected knowing the maximum design velocity and the diameter of the pipe. *Table 5* lists the flow rates and velocities of flow for various piping materials that are 3/4 inch in diameter.

The table demonstrates the differences between the various piping materials. For a flow of 12 gpm, the velocity in the pipe ranges from a low of 7.22 feet per second for galvanized steel pipe, to a high of 10.57 feet per second for PEX tubing. This also demonstrates why the water distribution system must be sized based on the particular piping material that is to be installed. A general sizing for all piping materials would not produce the correct results.

Once the pipe size is selected, the pressure loss in the piping system must be evaluated (which is a separate topic). This is all a part of sizing a water distribution system.

Julius Ballanco, P.E., is Editorial Director of PM Engineer and president of J.B. Engineering and Code Consulting, P.C. in Munster, IN. Prior to starting J.B. Engineering, he served as head of plumbing and mechanical engineering for Building Officials and Code Administrators International, one of the organizations that formed the International Code Council (ICC). His engineering consulting work includes the design of plumbing, mechanical and fire-protection systems; forensic engineering; training; and serving numerous manufacturers in different capacities. In addition, Ballanco is the current president of ASPE and a member of both ICC and IAPMO. He can be reached by email at jbengineer@aol.com.

Table 5

Flow Rate (gpm)	Copper Type M Vel (ft/sec)	Copper Type L Vel (ft/sec)	Galvanized Steel Vel (ft/sec)	CPVC Vel (ft/sec)	PEX Vel (ft/sec)
1	0.62	0.66	0.60	0.80	0.88
2	1.24	1.33	1.20	1.60	1.76
3	1.86	1.99	1.80	2.40	2.64
4	2.48	2.65	2.41	3.20	3.52
5	3.11	3.31	3.01	4.00	4.40
6	3.73	3.98	3.61	4.79	5.29
7	4.35	4.64	4.21	5.59	6.17
8	4.97	5.30	4.81	6.39	7.05
9	5.59	5.97	5.41	7.19	7.93
10	6.21	6.63	6.02	7.99	8.81
11	6.83	7.29	6.62	8.79	9.69
12	7.45	7.95	7.22	9.59	10.57
13	8.07	8.62	7.82	10.39	11.45

QUIZ 2: "Back to Basics: Water Pipe Sizing" (0.20 CPD)

1. **How does counting plumbing fixtures help in water treatment?**
   a. Helps in water treatment system sizing
   b. Helps in faucet selection for point-of-use systems
   c. Helps in determining placement of a point-of-entry system
   d. Helps in preventing treated water being used to flush toilets

2. **What is the maximum recommended flow velocity for pipes?**
   a. A measure of the maximum attainable flow velocity in an existing distribution system
   b. The resulting flow rate in gallons per minute at peak usage times
   c. The flow velocity manufacturers calculate that reduces potential for noise and hydraulic shock
   d. A measure of required flow rate based on fixture counts

3. **Why are peak demand determinations considered the hardest part of engineering a plumbing system?**
   a. The calculations require working through a number of different formulae.
   b. They're based on estimates of how many fixtures would be used all at once.
   c. The calculations are performed based on blue prints instead of actual facilities.
   d. Different plumbing codes use different values for fixture counts.

4. **What is the limitation of the Hunter Method for determining peak demand?**
   a. It didn't differentiate tank-type water closets from flushometer-type water closets.
   b. It didn't take into account different operations of buildings with similar fixtures.
   c. It didn't take into account probability factors for total use of water in a system.
   d. It didn't use water supply fixture units.

5. **Which plumbing code completely includes the Stevens Method?**
   a. Uniform Plumbing Code
   b. Council of American Building Officials
   c. National Standard Plumbing Code
   d. International Plumbing Code

6. **The Stevens Modified Fixture Unit values table (Table 3) lists only the values for the total use of the water distribution system. If a water treatment system is to be applied to hot water only, what needs to be done to convert the total values?**
   a. Multiply the total value by 0.20
   b. Multiply the total value by 0.50
   c. Multiply the total value by 0.75
   d. Divide the total value by 2

7. **What is the author's recommendation in using the modified Stevens Method for accurate sizing?**
   a. The Stevens Method is a good update of the Hunter Method, eliminating all limitations.
   b. The Stevens Method is an unnecessary update of the Hunter Method.
   c. The Stevens Method completely accounts for all possible situations.
   d. The Stevens Method still has limitations in high-end and low-end water distribution systems.

8. **Which is the correct arrangement of piping material relative to water velocity at 12 gpm, going from slowest to fastest?**
   a. Copper Type M, Copper Type L, Galvanized Steel, PEX
   b. Copper Type L, Copper Type M, Galvanized Steel, CPVC
   c. Galvanized Steel, CPVC, PEX, Copper Type M
   d. Galvanized Steel, Copper Type M, CPVC, PEX

Product Certification Programs

Excerpt from April 2009 article by Joseph F. Harrison, PE, CWS-VI and Regu P. Regunathan, PhD

Certification of POU and POE devices ensures that the performance of the units matches the claims of the manufacturer. ANSI has adopted the standards for POU and POE devices developed by NSF International (NSF).

POU and POE devices must be independently certified according to the applicable NSF standard(s) by an ANSI-accredited certification organization. Lists of certified products are available on the Internet from the certifying laboratories of NSF (www.nsf.org/Certified/DWTU/), Underwriters Laboratories (UL) (www.ul.com), the Water Quality Association (WQA) Gold Seal Program (www.wqa.org), and the Canadian Standards Association (www.csa-international.org). Units certified to meet the requirements of one or more of the above standards are evaluated for the following:

- Verification of contaminant reduction as claimed by the manufacturer and as required in the standard. A unit may be effective in controlling many different contaminants, but it is not required to control all contaminants covered by a particular standard.
- Structural integrity to ensure the unit's capability to withstand water pressures in the home
- Toxicological assessment and extraction testing of all materials in contact with water for product materials' safety
- Review and acceptance of all sales literature and labeling as per the test results for the specific contaminants

ANSI/NSF standards cover six types of POU and POE devices described below:

- Standard 42: *Drinking Water Treatment Units—Aesthetic Effects* – This standard applies to several types of filters and adsorption units. It covers contaminants that can affect the taste, odor, and color of the drinking water, including many USEPA secondary contaminants. The devices include activated carbon units and several grades of particulate filtration units, along with certain chemical feed mechanisms. Some of the claims covered by this standard include bacteriostatic effects, taste and odor reduction, chlorine reduction, chloramines reduction, particulate reduction in six different levels of capability, iron reduction, and scale and corrosion control.
- Standard 44: *Cation Exchange Water Softeners* – Covers residential point-of-entry water softeners designed to remove water hardness and reduce other specific contaminants such as barium and radium. Sodium chloride or potassium chloride can be used as a regenerant.
- Standard 53: *Drinking Water Treatment Units—Health Effects* – This standard applies to several different types of units and covers contaminants that may affect human health if present in concentrations exceeding regulatory levels. Devices include activated carbon units, ion exchange units, fine filtration units, and different types of adsorptive units. Claims covered by this standard include filterable cyst reduction, lead reduction, arsenic reduction, TTHM reduction, and VOC reduction. Units allowed to make VOC reduction claims are tested to provide 95% reduction results from a 300 ppb challenge level of chloroform. Units that successfully pass the chloroform reduction test are then allowed to claim a list of 51 different VOCs including many of the halogenated disinfection byproducts (DBP) as shown in Table 4. Use of chloroform as a more difficult to remove surrogate has been verified by NSF and the Water Quality Research Foundation (WQRF) through extensive testing.

Table 4

Contaminants That May Be Claimed Under the Chloroform Reduction Test of ANSI/NSF Standard 53

Alachlor	Haloketones
Atrazine	Heptachlor
Benzene	Heptachlor epoxide
Carbofuran	hexachlorobutadiene
Carbon Tetrachloride	Hexachlorocyclopentadiene
Chlorobenzene	Hexachlorocyclopentadiene
Chloropicrin	Lindane
2,4-D	Methoxychlor
Dibromochloropropane	Pentachlorophenol
o-Dichlorobenzene	Simazine
p-Dichlorobenzene	Styrene
1,2 Dichloroethane	1,1,2,2-tetrachloroethane
1,1-Dichloroethylene	Tetrachloroethylene
cis-1,2-Dicloroethylene	Toluene
trans-1,2-Dicloroethylene	2.4.5-TP (Silvex)
1,2-Dichloropropane	Tribromoacetic acid
cis-1,3-Dichloropropylene	1,2,4-Trichlorobenzene
Dinoseb	1,1,1-Trichloroethane
Endrin	1,1,2-Trichloroethane
Ethylbenzene	Trichloroethylene
Ethylene dibromide	Trihalomethanes
Haloacetonitriles	Xylenes

- Standard 55: *Ultraviolet Microbiological Water Treatment Systems* – This standard defines two classes of ultraviolet light (UV) systems:

  Class A System—designed to disinfect microbiologically contaminated water that meets all other public health standards. The system is not designed for water obviously contaminated with raw sewage. These units are

Product Certification Programs

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required to have built-in sensors, alarms, and/or solenoids, and demonstrate a UV dose level higher than 40,000 (µW · s)/cm2.

Class B System—designed for supplemental treatment of public or other drinking water that has been tested and considered safe for human consumption. This is meant for nonpathogenic or nuisance organisms only, even though a dose level higher than 16,000 (µW · s)/cm2 has to be demonstrated. No UV sensors, alarms, or shutoff devices are required.

- Standard 58: *Reverse Osmosis Drinking Water Treatment Systems* – This standard applies to systems where water is forced by pressure through a semipermeable reverse osmosis membrane. POU reverse osmosis (RO) systems incorporate pre- and postfilters, which can be certified separately under Standard 42 and/or 53. Claims covered by Standard 58 include many of the heavy metals, arsenic(V), nitrates, and total dissolved solids (TDS). Units can also be tested and verified for the reduction of asbestos fibers, filterable cysts, turbidity, and VOC reduction if an appropriate certified carbon-based unit is part of the system.
- Standard 62: *Drinking Water Distillation Systems* – This standard applies to batch and flowing distillation systems that reduce dissolved contaminants by heat converting water to vapor and subsequent condensation to liquid. Claims include reduction of many inorganic and microbiological contaminants along with some larger organic contaminants. When coupled with a carbon device certified under Standard 42 and/or 53, additional claims for removal of other organics may also be made.

Joseph F. Harrison, PE, CWS-VI, is the technical director for the Water Quality Association (WQA). He started with WQA in 1990. Prior to his position with WQA, Mr. Harrison was Chief, Safe Drinking Water Branch for Region V of the US Environmental Protection Agency for 17 years. His many responsibilities with the EPA included the overview and enforcement of drinking water standards in Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin, and protection of underground sources of drinking water in the region.

Dr. "Regu" P. Regunathan has been part of the water treatment industry for over 38 years. He has served as Vice President of R&D and Operations and later as President of Everpure, Inc., Senior VP of Science & Technology of Culligan Water Technologies, and US Filter Consumer Group. He currently provides consulting services to different companies and organizations including Water Quality Association and NSF International.

QUIZ 3: "Product Certification Programs" (0.25 CPD)

1. **A device certified to any of the drinking water standards has been tested for which of the following?**
   a. Particulate reduction of all materials in contact with water
   b. Aesthetic effects of all materials in contact with water
   c. Bacteriostatic function of all materials in contact with water
   d. Toxicological assessment of all materials in contact with water

2. **Devices certified with Standard 42 can make claims regarding:**
   a. Taste of drinking water
   b. pH of drinking water
   c. Health effects of drinking water
   d. Sodium content of drinking water

3. **Water softeners certified for Standard 44 can claim:**
   a. Perchlorate reduction
   b. Degree of deionization
   c. Radium reduction
   d. Sodium reduction

4. **Why is chloroform used as the challenge surrogate in VOC removal testing?**
   a. Chloroform is more readily available than most VOCs on the EPA primary standards list.
   b. Chloroform is more difficult to remove than most VOCs on the EPA primary standards list.
   c. Chloroform is less expensive than most VOCs on the EPA primary standards list.
   d. Chloroform is easier to handle than most VOCs on the EPA primary standards list.

5. **Which standard covers filterable cyst reduction?**
   a. Standard 53
   b. Standard 55
   c. Standard 58
   d. Standard 62

6. **What can be said about Class A and Class B UV Systems?**
   a. Both systems require alarms and built-in sensors to monitor lamp performance.
   b. Both systems require demonstration of more than their respective minimum dosage.
   c. Both systems must be placed on a water source considered safe for human consumption.
   d. Both systems must be capable of shutting off the flow of water in case of lamp failure.

7. **Under what conditions can reverse osmosis units be certified for filterable cyst reduction?**
   a. No special conditions necessary; RO by its nature removes cysts
   b. Only if carbon prefilters, separately certified for cyst removal, are present
   c. Only if the RO will be operating under sufficient pressure
   d. Only if the RO storage tank is properly sized to avoid stagnant water

8. **Which technology can be certified to remove volatile organic compounds without pretreatment?**
   a. Activated carbon units
   b. Cation exchange softening
   c. Distillation
   d. Reverse osmosis

Selective Contamination Control

Eliminating Perchlorate From Groundwater in California

By Daryl Gisch, Dow Water Solutions

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Since water is essential to sustain life, improving access to reliable water can result in tangible benefits to health and economic development. Every effort should be made to achieve the safest possible water quality.

One suspected carcinogen threatening the drinking water supply is perchlorate (ClO_4^-). This anion, used to make matches, pyrotechnics, road flares and similar products, occurs naturally and as a manmade chemical. ClO_4^- has been introduced to the environment as a contaminant in ground and surface waters from various chemical and industrial processes during the past 50 years, and is persistent and long lasting. It migrates freely with water flows and is not easily reduced to a less oxidative state.

Perchlorate may trigger ill effects in humans—even at parts per billion (ppb) concentrations—and may have contaminated large sections of the United States, negatively affecting the nation's drinking water supplies in some regions. The level that triggers health issues, and to which ClO_4^- should be treated, is still debated and discussed.

Identifying the Issue

Perchlorate contamination is highest in the state of California, where cities such as La Puente and San Gabriel, already impacted by water scarcity and high populations, continue to lose water capacity due to perchlorate contamination. In the United States, perchlorate has been detected in nearly 400 sites, primarily in the western and southwestern regions. More than 11 million people are estimated to have perchlorate in their drinking water supplies at concentrations of 4 ppb or greater.

As early as 1955, water regulators in California found ClO_4^- in local ground waters. Through the 70s, 80s and early 90s, ClO_4^- appeared with increasing frequency in EPA reports. There were ongoing issues with detection accuracy at 25 to 100 ppb levels and debates on the potential health effects. In 1992, the direct link between ClO_4^- and disruption of the thyroid gland in humans was confirmed. However, the level at which this could be triggered was still open for debate.

In 1997, a California State lab developed a more accurate testing method for perchlorate, allowing for accurate detection at the level of 4 ppb. Armed with a more effective method to detect the suspected carcinogen, the EPA established that ClO_4^- was a fairly widespread issue, affecting at least 21 states besides California.

By 2000, a number of new models suggested that ClO_4^- could trigger ill effects to human health at fairly low levels. The EPA issued a statement that the reference dose for ClO_4^- is 0.0009 mg/kg/day, which yields a drinking water concentration of 32 ppb in the standard adult exposure model (70-kg adult, drinking 2 L of water/day), and a 5 ppb standard infant exposure. These statements caused confusion, as they were not meant as a quantitative measure but for consideration that long-term exposure to perchlorate can result in the blockage of iodide transport, resulting in thyroid disruption.

With all that is known about perchlorate, the suspected carcinogen is still an unregulated contaminant—meaning the EPA has not set its set maximum contaminant level (MCL). Working with other federal agencies, states and water suppliers to monitor perchlorate levels of contamination in drinking water, the agency has determined 1 ppb as the recommended

reference dose for drinking water. This is still four to 100 times less than the toxicity of most perchlorate compounds found in the United States, including the Colorado River and Lake Mead.

With the EPA no closer to setting a standard MCL for perchlorate, California has established its own water remediation treatment when the water source contains more than 4 ppb contamination. The lack of EPA regulation on the issue is causing cities across the state to miss possible funding from other government and environmental agencies, which is a large problem considering that the nationwide perchlorate cleanup is estimated to cost more than $500 million in the next decade.

Combating the Carcinogen

A wide range of technologies have successfully treated and eliminated ClO_4^- from drinking water. Treating ClO_4^- at low concentrations in which it is found and handling large volumes of water that require processing are difficult. If the resin is selective for ClO_4^- (over other anions), it will be more effective at water remediation. Biological and ion (anion) exchange systems are among possible treatment technologies, with additional systems under development.

Anion exchange resins offer a workable solution for the binding and removal of ClO_4^-, even at low concentrations and in the presence of other anionic species. Although a range of anionic resin types will retain and bind perchlorate, both the functional group and the matrix type affect resin performance with respect to binding, selectivity and potential leakage. One successful resin is a gel-type anion resin based upon a tri-n-butylamine functional group.

Gel-type anion resins offer good selectivity for perchlorate over other anions because they bind in such a way that leakage is nearly impossible. This makes the resin almost ideal for concentrating low levels of perchlorate from large volumes of water onto a much smaller volume of resin, making the removal from the site and the environment much easier.

Selective Contamination Control

continued from page 15

Remedying California's Perchlorate Problem
Three different sites in California tested a gel-type anion resin. Each site monitored the concentration of the perchlorate, both before the resin treatment on the influent side and after treatment on the effluent side. The goal of the study was to evaluate how much clean water could be produced before the resin showed perchlorate breaking through to the effluent side at each site.

The gel-type anion resin successfully bound and held perchlorate at low ppb levels from varied feed water streams when applied in a continuous column operation.

Constituent	La Puente	San Gabriel B6	Valley County
pH	8.2	7.4	7.4
Alkalinity (mg/L as CaCO3)	141	175	315
Calcium (mg/L)	58	77	124
Magnesium (mg/L)	14	15	28
TDS (mg/L)	321	353	536
Conductivity (µS/cm)	499	590	814
Chloride (mg/L)	23	27	39
Perchlorate (µg/L)	40	23	12
Nitrate (mg/L as N)	5.6	7.3	13.5
Sulfate (mg/L)	37	44	53

A profile of three California-based perchlorate sites

Feed waters holding perchlorate ranging in the 12 to 40 ppb level easily reduced the perchlorate to less than 2 ppb. One liter of resin remediated approximately 250,000 liters (~65,700 gallons) of water. The resin also produced perchlorate-free water while concentrating and binding the trace contaminant in the resin so the perchlorate can be removed from the site and disposed of in a safe manner.

The resin is commercially available, meets the NSF standard 61 for drinking water and offers a solution for the removing perchlorate even at low ppb levels.

Conclusion
Even if the appearance of perchlorate in public drinking water supplies is a mystery, the technology for treating this suspected carcinogen is not. With the right tools—anion exchange resins, proper maintenance programs and disposal practices—removing or reducing the perchlorate in drinking water is within reach.

References
Perchlorate Water Treatment, *Pollution Engineering*, October 2003.
Health Assessment Section: Perchlorate, Bureau of Environmental Health, April 2004.

Daryl Gisch joined Dow Water Solutions Ion Exchange Team in 1989 after working for Supelco/RohmHaas. He has been involved in the development and application of new media and separation techniques to solve separation and purification needs over a wide range of industries. Daryl holds a Ph.D. from the University of Wyoming in synthetic organic chemistry. Contact Dr. Gisch at 1-989-636-9254 or djgisch@dow.com.

QUIZ 4: "Selective Contamination Control" (0.10 CPD)

1. **Perchlorate exists in water as:**
   a. A particulate
   b. A cation
   c. An anion

2. **Concerns about perchlorate in drinking water are because of:**
   a. Thyroid disruption
   b. Suspected carcinogen
   c. a and b

3. **Perchlorate has been found:**
   a. In 21 states
   b. Only in California
   c. Only in groundwaters

4. **The lowest reference dose (estimated daily exposure likely to be without deleterious effects) recommended by the USEPA for perchlorate in drinking water is:**
   a. 32 ppb (parts per billion)
   b. 4 ppb
   c. 1 ppb

5. **The Safe Drinking Water Act regulation (MCL) established by the USEPA for perchlorate is:**
   a. 4 ppb
   b. 1 ppb
   c. No regulatory standard

6. **Gel-type selective resins are effective for perchlorate removals from water because of:**
   a. Fine filtration characteristics
   b. Low leakage
   c. Easy to regenerate off the resin

7. **In reducing perchlorate in the range of 12 to 40 ppb in feed waters down to less than 2 ppb, one cubic foot of gel-type selective resin could treat approximately:**
   a. 65,700 gallons
   b. 1.9 million gallons
   c. 19 million gallons

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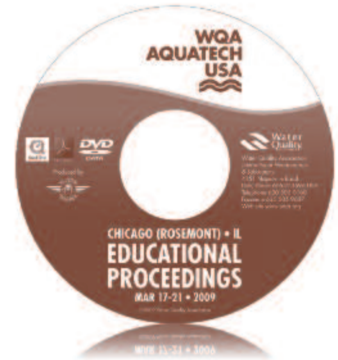

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Many employees want professional development and training to enhance their satisfaction at work. The continued development can help make their jobs easier, whether that's knowing how to properly maintain an older valve, how to conduct oneself in a customer's home on a service call, or how to ask the right questions on a sales call. Less frustration at work leads not only to higher morale, but also improves employee loyalty to the manager or employer who took the time to provide the necessary training.

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Organizing a training session can be a daunting task. A good training session requires identifying training goals and desired outcomes, it requires relevant and practical ideas that can be put to use the very next day, and it requires training materials. Considering the effort involved, wouldn't it be nice to have someone else actually provide the training and do it in-house so that you, the manager, or the employer, don't have to take the time to create the materials?

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"The message for any US worker is that continued learning is a lifelong journey,"* says Bernadette Kenny, chief career officers at Adecco. "I think it's going to become [even] more true in terms of globalization, speed, and expectation of employers."

*Kowan, Kristina "Continuing Education: A Lifelong Pursuit That Pays," Payscale.com, March, 2008.

Education and Certification Exam Schedule

- **Indiana WQA**
  June 24-25, 2009
  Exams: June 25, 2009
- **2009 Texas WQA Annual Convention**
  July 8-12, 2009
  Exams: July 11, 2009
- **South Atlantic Well Drillers Jubilee**
  August 1-3, 2009
  Exams: August 3, 2009
- **2009 Wisconsin WQA Annual Convention**
  September 11-12, 2009
  Exams: September 12, 2009
- **WQA Mid-Year Leadership Conference**
  September 16-18, 2009
  Exams: September 18, 2009
  Bloomingdale, Illinois
- **Colorado WQA Conference**
  October 2-4, 2009
  Exams: October 2, 2009
  Pretest Review Session with Joe Harrison – October 2, 2009
- **2009 Pacific WQA Convention and Tradeshow**
  October 13-16, 2009
  Exams: October 14 & 16, 2009
  Water Treatment Fundamentals Seminar – October 13, 2009
- **2009 Eastern WQA Annual Conference and Trade Show**
  November 11-13, 2009
  Exams: November 11, 2009
- **WQA Aquatech USA 2010**
  March 9-12, 2010
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Instructions
Please use the answer sheet below to record the correct answers. When you have completed the quizzes you'd like graded, detach the answer sheet from the booklet and mail it to the address below. The answers must be 70% correct to earn credit. These quizzes may also be taken online at http://training.wqa.org/2009edkitqz/index.htm.

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Please use blue or black ink. **Shade Circles Like This** → ● **Not Like This** → ☒ ✓

QUIZ 1:
"Critical Flow – Planning for Water Quality & Safety"

	A	B	C	D	E
1.	○	○	○	○	○
2.	○	○	○	○	○
3.	○	○	○	○	○
4.	○	○	○	○	○
5.	○	○	○	○	○
6.	○	○	○	○	○
7.	○	○	○	○	○
8.	○	○	○	○	○
9.	○	○	○	○	○
10.	○	○	○	○	○
11.	○	○	○	○	○
12.	○	○	○	○	○
13.	○	○	○	○	○
14.	○	○	○	○	○
15.	○	○	○	○	○
16.	○	○	○	○	○
17.	○	○	○	○	○
18.	○	○	○	○	○
19.	○	○	○	○	○
20.	○	○	○	○	○
21.	○	○	○	○	○
22.	○	○	○	○	○
23.	○	○	○	○	○
24.	○	○	○	○	○
25.	○	○	○	○	○

QUIZ 2:
"Back to Basics: Water Pipe Sizing"

	A	B	C	D	E
1.	○	○	○	○	○
2.	○	○	○	○	○
3.	○	○	○	○	○
4.	○	○	○	○	○
5.	○	○	○	○	○
6.	○	○	○	○	○
7.	○	○	○	○	○
8.	○	○	○	○	○

QUIZ 3:
"Product Certification Programs"

	A	B	C	D	E
1.	○	○	○	○	○
2.	○	○	○	○	○
3.	○	○	○	○	○
4.	○	○	○	○	○
5.	○	○	○	○	○
6.	○	○	○	○	○
7.	○	○	○	○	○
8.	○	○	○	○	○

QUIZ 4:
"Selective Contamination Control"

	A	B	C	D	E
1.	○	○	○	○	○
2.	○	○	○	○	○
3.	○	○	○	○	○
4.	○	○	○	○	○
5.	○	○	○	○	○
6.	○	○	○	○	○
7.	○	○	○	○	○

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