Residential Water Treatment Design

Excerpted from WQA QuickCourse, How to Design a Residential Water Treatment System, *edited for clarity and updated.*

This article describes the steps required to properly design an effective residential water treatment system. Emphasis will be directed toward collecting and analyzing water supply data and selecting treatment techniques. Acid neutralizing, air induction, carbon filtration, chemical injection, filtration, oxidation-filtration, reverse osmosis, selective ion exchange, ultraviolet and softening will be addressed.

Proper application of treatment also includes installation of the equipment according to local codes and regulations and following the equipment manufacturer's specifications as well as training the end-user on maintenance procedures and maintenance schedules. Maintenance responsibilities should be discussed with the end-user before the system is actually installed. This will increase the likelihood of continued proper treatment system performance.

Steps in Designing a Residential Water Treatment System

The basic steps in designing an effective and properly functioning residential water treatment system are:

1. Identify the contaminants to be treated or conditions to be corrected through consultation with the end-user followed by proper water testing and analysis.
2. Select the treatment technique or techniques to be used by reviewing the best available technology for contaminant reduction, with emphasis on utilizing technologies with the fewest chemical additives and mechanical parts possible.
3. Study the quantitative water supply data for this system. Consult with your end-user to reach a reasonable system design which will meet the flow rate demand and daily volume requirements.
4. Select the equipment based upon the results of the previous three steps and determine how to sequence the treatment devices in the proper order to meet pretreatment requirements and provide maximum capability for reduction of contaminant concentration.

The designer must not become complacent because the contaminants are the same as found in other cases. Each project is unique, and must be given close study and careful consideration.

The next few pages will describe in greater detail how to effectively implement the steps outlined above.

Step One: Identify the Contaminants

Before beginning water treatment system design, the water specialist must determine the water quality goal of the end-user. The designer should ask the residents if they are targeting any specific contaminants or bothersome water problems. Awareness of the area's geology and water chemistry can also be an asset in identifying water contaminants or problems at a particular site.

There are two categories of contaminants as categorized by the United States Environmental Protection Agency (USEPA), Secondary (Nuisance) Standards and Primary (Health-related) Standards. Each category will be discussed separately.

Identifying Secondary Standards or Nuisance Contaminants

Contaminants on the Secondary Standards list often affect water-using appliances and/or plumbing fixtures. A walk-through household inspection to evaluate the nature and severity of possible plumbing fixture damage or staining of water-using appliances may provide evidence of contaminant residue. Water-using devices and areas where aeration occurs or heated water is used need careful inspection.

Table One: Common Secondary Standards or Nuisance Contaminants and Treatment Methods

Contaminant	Treatment Method
Arsenic	Reverse Osmosis (POU)
Bacteria	Ultraviolet (POE) Chlorination (POE)
Carbon Dioxide	Neutralizer (POE) Soda Ash Feeding (POE)
Chloride	Reverse Osmosis (POE or POU)
Chlorine	Activated Carbon (POE or POE)
Cyst	Sub-Micron Filtration (POU)
Fluoride	Reverse Osmosis (POU)
Hardness	Cation Softener (POE)
Hydrogen Sulfide	Aeration (POE) Oxidation-Filtration (POE) Chlorination (POE)

Identifying Primary Standards or Health-Related Contaminants

Contaminants on the Primary Standards list are

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hazardous to health. These contaminants are difficult to identify simply by visual inspection of the water-using appliances or fixtures because they typically leave no residue. Knowing the local geology and water chemistry will provide a strong basis for contaminant identification.

It is recommended that a state-certified water testing laboratory be used to confirm the presence and concentration of Primary contaminants. The water specialist should be aware of any state regulations which may mandate water testing procedures for specific contaminants.

The following contaminant list addresses only the most common contaminants from the Primary Standards. A complete water analysis for other contaminants listed under the Safe Drinking Water Act may be recommended if the specialist feels it advisable.

Table Two: Common Primary or Health-Related Contaminants

Responsible Contaminant	Most Common Health Effect
Arsenic	Sores on skin
Bacteria	Gastroenteritis
Cysts	Diarrhea
Fluoride	Mottling (staining of teeth)
Lead	Delays in physical and mental development in children; kidney problems, high blood pressure in adults
Mercury	Inflammation of the mouth
Nitrate	Temporary (but dangerous) blood disorder in infants
Turbidity	Protects organisms from disinfectants (not a health effect but interference with treatment for microbiological contaminants)

Step Two: Select the Treatment Technique

Knowing the effects of each contaminant is necessary to determine if the contaminant treatment technique should incorporate POE (Point of Entry) technologies to treat all the water in the house or POU (Point of Use) methods to treat only a portion of the water in the house. For example, POE treatment is mandatory when the health effect is caused by contaminant inhalation. POU can be utilized when the health effect is strictly caused by contaminant ingestion (taking in by drinking or in food). Table Three will assist in treatment selection.

When discussing with the end-user which contaminants are found in the water should be treated, the water specialist must be careful to try to reduce any exaggerated fears of the end-user and must make every effort not to create any unreasonable concerns. The USEPA established the maximum allowable concentrations for the contaminants on the Primary Standards list, which can be used as a starting point for discussing the need for treatment with the end-user.

Table Three: Common Treatment Techniques

Contaminant	Treatment Method
Arsenic	Reverse Osmosis (POU) Select Anion Exchange (POE)
Bacteria	Ultraviolet (POE) Chlorination (POE)
Carbon Dioxide	Neutralizer (POE) Soda Ash Feeding (POE)
Chloride	Reverse Osmosis (POE or POU)
Chlorine	Activated Carbon (POE or POU)
Cyst	Sub-Micron Filtration (POE or POU) Ultraviolet (POE or POU)
Fluoride	Reverse Osmosis (POU)
Hardness	Cation Softener (POE)
Hydrogen Sulfide	Aeration (POE) Oxidation-Filtration (POE) Chlorination (POE)
Iron Algae	Chlorination (POE)
Iron/Ferrous	Cation Softening (POE) Aeration-Filtration (POE) Oxidation-Filtration (POE)
Iron Sulfide	Aeration-Filtration (POE) Oxidation-Filtration (POE) Chlorination (POE) Reverse Osmosis (POU)
Lead	Specialty Filtration (POU) Reverse Osmosis (POU)
Low pH	Neutralizer (POE) Soda Ash Feeding (POE)
Manganese	Cation Softening (POE) Aeration-Filtration (POE) Oxidation-Filtration (POE) Filtration-Softening (POE)
Mercury	Reverse Osmosis (POU) Select Ion Exchange (POU) Select Ion Exchange (POE)

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Contaminant	Treatment Method
Nitrate	Reverse Osmosis (POU) Selected Anion Exchange (POE)
Sulfate	Reverse Osmosis (POU) Select Anion Exchange (POE) Select Anion Exchange (POU)
Turbidity	Filtration (POE) Filtration (POU)

Step Three: Study the Quantitative Water Data
Each treatment system must be designed to deliver the amount of water the end-users need each day at the pressure needed to make the plumbing fixtures and cleaning appliances work effectively. Therefore the water specialist must determine the output capabilities (flow rate and daily volume) of the particular water supply as well as analyzing what the family's daily water needs are. Even the most superior treatment system design is doomed to failure if improper water supply diagnosis is performed. But if this homework is completed intelligently, the total treatment system will perform effectively for many years. There are two types of residential water supplies: municipal water systems and water wells. The two types of systems require different approaches in evaluating output capabilities in terms of flow rate, daily volume requirement, and pressure.

Evaluating Output Capabilities of System Using a Municipal Water Supply
In analyzing the capabilities of a household water system using water from a municipal water system, the following questions need to be asked:

1. What is the diameter of the water meter outlet pipe?
2. What is the diameter of the main water supply pipe in the building?
3. What is the static water pressure on the piping systems?
4. Where is the end-user located along the municipal piping run? Near the end? Near the beginning?

The location of the end-user in respect to the municipal distribution piping layout can increase or decrease the concentration of certain contaminants. This variable must be incorporated into the approach to contaminant reduction. For example, at the end of the distribution line, there is likely to be more turbidity and greater iron concentration, but lower disinfectant residual concentration.

The water pressure and pipe diameter will provide the water specialist with maximum flow rate, as illustrated in Table Four. To find the maximum possible flow rate, find the intersection of the row of the appropriate static water pressure with the column corresponding to the internal pipe diameter.

Table Four: Maximum Water Flow Rates/Pipe Diameter/Static Pressure

Static Water Pressure	½" OD Pipe	¾" OD Pipe	1" OD Pipe
30.0 psi	5.0 gpm	10.0 gpm	16.0 gpm
40.0 psi	6.0 gpm	12.0 gpm	18.0 gpm
60.0 psi	7.0 gpm	14.0 gpm	21.0 gpm
80.0 psi	9.0 gpm	16.0 gpm	23.0 gpm

Evaluating the Output Capabilities of a Water Well System
In analyzing the capabilities of a household water system which draws its water from a private well, the following questions must be asked:

1. What is the well pump rating (volume per hour or volume per minute)?
2. What is the water pressure setting of the pressure switch?
3. What is the diameter of the main water system in the house?

The well pump rate can be determined by an on-site water flow test: 1) Have on hand a five-gallon bucket or container. 2) Open a water spigot located on or as near as possible to the well tank piping. The increase in pressure on the water pressure gauge on the well tank piping indicates pump operation. 3) When the pump begins to operate, immediately begin the timing process and time how long it takes to fill the five-gallon bucket or container. 4) Use this information to extrapolate the gallon per minute flow of the well pump as indicated below.

$$\text{Flow rate in gallons/second (gps)} = \frac{\text{5 gallons}}{\text{seconds to fill}}$$

Flow rate in gallons/minute (gpm) = flow rate (gps) x 60 min/sec.

For example:

$$\text{Flow rate in gallons/second (gps)} = \frac{\text{5 gallons}}{\text{40 seconds to fill}}$$

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Flow rate in gallons/second (gps) = 0.125 gps

Flow rate in gallons/minute (gpm) = 0.125 gps x 60 min/sec.

Flow rate in gallons/minute (gpm) = 7.5 gpm

The water pressure setting of the pressure switch is important because of the direct correlation between pressure, maximum flow rate and specific pipe diameters. (See Table Four)

Calculating End-User Flow Rate Needs and Daily Volume Demands

To ensure proper sizing of the equipment, the end-user's flow rate needs and daily volume demands must be estimated and matched with the equipment manufacturer's operational specifications and the output capabilities of the water system.

The treatment equipment must not be exposed to an excessive flow rate demand because this could cause contaminant breakthrough in undersized equipment. Improperly-sized equipment may be subject to premature equipment failure due to excessive service or to inadequate flow during regeneration.

The end-user's specific daily volume and flow rate requirements must be determined through a detailed evaluation of all the household water-using devices. During the walk-through household inspection, the water specialist should watch for plumbing fixtures such as whirlpools, which may create excessive water demand.

Flow rate demands are often most influenced by the number of bathrooms present, since most water usage devices are located there. All residential demand estimates assume intermittent, not continuous, water usage. Local plumbing codes should be referenced and followed for determining water demand sizing procedures. Typically, these are based on a count of plumbing fixtures in the home, which is then converted to a flow rate.

A concern is that the flow rate data used in the conversion calculations does not take into account the effects of water conserving fixtures and the change in habits in water use that result in lower flow rates. A treatment system sized to existing code requirements can be unnecessarily oversized. Research results from a study by Aquacraft in 2002 have shown that actual peak demand flow is significantly lower than what is referenced in the plumbing codes.[1] The state of Wisconsin, for example, allows for an alternative sizing method for specific residential applications to avoid oversizing treatment.[2] Model code writers are currently reviewing household flow rate research results to determine if changes to the model codes are needed.

Table Five compares flow rate demands between the current Uniform Plumbing Code (UPC) and the alternative sizing method recognized by the state of Wisconsin.

Table Five: Difference in Flow Rate in UPC vs. Alternative Sizing Methods

Homes with kitchen sink, dishwasher, automatic clothes washer, laundry tray, bar sink and...	Current code	Alternative method
One bathroom[a]	8.3	7.0
Two bathrooms[a]	0.9	7.0
Two bathrooms and one exterior hose bib[a,b]	12.2	11
Two bathrooms and two exterior hose bibs[a,b]	15.8	13.5
Three bathrooms[a]	13.4	7.0
Four bathrooms[a]	15.8	7.0
Four bathrooms, two half-baths,[a,b] and one whirlpool	22.7	8.3

[a] Bathrooms are assumed to have a lavatory sink, toilet and bathtub/shower combination
[b] All exterior hose bibs are ¾" size

The demand calculations in Table Five are based upon on the use of flow-restricted (water-conserving) devices only. Thus a three bathroom house would have a 7.0 gpm demand.

In lieu of local-code approved alternative sizing methods, Table Six demonstrates the sizing method required by most local plumbing codes, which calculates flow rate demand, sometimes referred to as load, by totaling up the fixture units for the household and then comparing that figure to the flow rate table shown in Table Seven. The information presented in Tables Six and Seven is for illustration only. Refer to your local plumbing codes for the appropriate flow rate demand calculation procedures and conversions.

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Table Six: Weighted Factors for Non-Flow Restricted Fixtures (Water Supply Fixture Units)

Type Fixture	Unit Factor
Bathtub	2.0
Clothes Washer	2.0
Dishwasher	2.0
Lavatory	1.0
Kitchen Sink	2.0
Outside Hose Bib	1.0
Shower	2.0
Toilet	3.0

Table Seven: Flow Rate Demand per Fixture Unit Total

Fixture Unit Total	Flow Rate Demand (in gpm)
5.0	4.0
10.0	6.0
15.0	8.0
20.0	10.0
25.0	12.0
30.0	14.0
35.0	15.5
40.0	17.0
45.0	18.5

Let's estimate the flow rate demand, in gpm, of a house with:

- 3 showers
- 3 toilets
- 3 lavatories
- 1 clothes washer
- 1 dishwasher
- 1 kitchen sink
- 1 hose bib

The total fixture count would equal 25.0 units (Table Six) which corresponds with a 12.0 gpm flow rate demand (Table Seven). The water specialist must now determine the daily volume water usage requirements of the end-user. Daily volume water usage is a function of the number of people living in the household.

The formula is:
Daily Volume Usage = Number of people in household x estimated daily volume water usage per person

The current estimate for daily volume water usage per person is 75 gallons.[3] So a household of four people would mean that:

Daily Volume Usage = 4 People x 75 gallons per person/day

Daily Volume Usage = 300 gallons per day

Step Four: Select the Specific Equipment
The next step is the actual selection of specific water treatment equipment which will reduce the targeted contaminants, function effectively within the water system's output capability range, meet the end-user's water supply flow rate (gpm) and daily volume demands, and operate within the manufacturer's specifications and performance recommendations.

Decisions about whether POE or POU treatment is needed will influence the choice of treatment and the position or sequence of each particular treatment device in the total treatment system.

The equipment manufacturer's literature should always be consulted to ensure proper contaminant reduction and consistent equipment and system performance as well as installation instructions and maintenance requirements.

In addition, the water specialist/system designer must always seek to further his knowledge of appropriate treatment techniques and should bring a considerable body of expertise to the process of treatment selection and equipment choice for a particular system.

Table Eight reviews in summary form the most common POE and/or POU treatment alternatives.

A discussion of some of the pretreatment and installation concerns follows the table.

Table Eight: Common Treatment Alternatives

Treatment Technique	Contaminant	POE	POU
Activated Carbon	Chlorine	Yes	Yes
Aeration-Filtration	Ferrous Ion Hydrogen Sulfide Iron Sulfide Manganese	Yes Yes Yes Yes	No No No No

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Treatment Technique	Contaminant	POE	POU
Oxidation-Filtration	Ferrous Iron Hydrogen Sulfide Iron Sulfide Manganese	Yes Yes Yes Yes	No No No No
Cation Softener	Hardness (Ca & Mg) Ferrous Iron Manganese	Yes Yes Yes	No No No
Chemical Feed Soda Ash	Carbon Dioxide Low pH	Yes Yes	No No
Filtration	Turbidity	Yes	Yes
Filtration-Softening	Ferrous Iron Ferric Iron Manganese	Yes Yes Yes	No No No
Neutralizer	Low pH	Yes	No
Reverse Osmosis	Arsenic Chloride Fluoride Lead Mercury Nitrate/Nitrite Sulfate	No Yes No No No No Yes	Yes Yes Yes Yes Yes Yes Yes
Selective Ion Exchange	Mercury Sulfate Nitrate/Nitrite	Yes Yes Yes	Yes Yes Yes
Sub-Micron Filtration	Cysts Turbidity	No No	Yes Yes
Ultraviolet Irradiation	Bacteria	Yes	Yes

Consider Pretreatment and Water Treatment Equipment Factors
Below are discussions of various factors that should be considered for each technology.

Activated Carbon can be utilized for dechlorination at both the Point-of-Entry or the Point-of-Use. Activated carbon systems are typically installed in municipally-supplied water systems, which should have adequate water quality controls to reduce the need for pretreatment. If the water supply is free of bacteria, iron, manganese and turbidity, the only mandatory pretreatment would be a turbidity reduction cartridge-type filter. This will increase bed life by reducing particulate matter and preventing it from collecting in the pore structure of the Granular Activated Carbon.

Aeration-Filtration is used as a POE technique and is restricted to well water applications due to the water pressure differential requirement of the system's air inductor. The air inductor is installed in the piping system between the well pump and the well tank due to the differential pressure requirement. The differential pressure and the well pump flow rate have a direct effect on the volume of air induced into the piping system. The inductor will induce air into the pressurized piping system only when the well pump is operating within a given pressure range. Contact the micronizer (air inductor) manufacturer for application data pertaining to water pressure and flow rate.

The aeration system should also include some type of air separation vessel which can be installed either before or after the well tank. This vessel will serve as a device to shear the air from the water and to subsequently vent the excess air from the vessel to the atmosphere. The air venting system utilizes float technology which consists of either an external or internal vessel.

The final piece of the aeration system is some type of depth filtration bed. The filtration bed utilizes standard filtration technology to trap the precipitated hydrogen sulfide, iron, iron sulfide and/or manganese from the aerated water supply. The composite media of this filter can vary from multimedia to pyrolusite.

Media-Based Oxidation-Filtration uses an oxidant such as chlorine, manganese oxides, or potassium permanganate and an oxidation-filtration media to augment the reaction between dissolved oxygen and the contaminant to be removed. This action causes precipitation of the contaminant, which the filter bed then traps by utilizing standard filtration forces. The oxidation capacities of the filter media vary and occasionally require rebedding. Oxidation-filtration can be implemented for the effective reduction of hydrogen sulfide, iron, iron sulfide and manganese.

Cation Water Softening is designed for clear water supplies with very low turbidity levels. POE cation exchange consists of a sulfonated polystyrene-divinylbenzene resin, which is predominantly ion selective for calcium, magnesium, iron and manganese. Cation resin can also be an alternative treatment method for barium, cadmium, lead and radium reduction, if applied correctly. Utilizing cation resin for specific contaminant reduction is job-specific and should not be assumed to be the best technology of choice for all applications. Contact your resin manufacturer for

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application details.

Chemical Feed systems as referred to in this paper will be synonymous with chlorine and soda ash. The POE chemical feed pump is normally used on well water treatment systems. In this case, the chemical feed pump is electrically actuated by the well pump electrical switch. An alternative electrical actuation circuit can be provided by a flow switch which operates the chemical feed pump on a preset minimum and maximum flow rate.

For treatment of contaminants such as bacteria, hydrogen sulfide, iron algae or iron sulfide, the chemical feed pump is used to inject a chlorine and water solution into a retention tank. The tank must be sized to provide sufficient contact time between the chlorine and contaminant it is being added to control. The amount of contact time needed will depend on the chlorine dosage used. The chemical feed injection point and retention tank would be located on the outlet side of the well tank. Chlorine has the potential to oxidize high levels of iron and manganese, which could result in the production of a very turbid solution requiring specialty depth filtration media on the outlet of the retention tank.

The chemical feed systems can also be used to control corrosion due to carbon dioxide or low pH. For corrosion applications, the chemical feed pump would inject a soda ash and water solution into a retention tank designed for 10-minute contact time. Thus a 5 gpm well pump would require a 50 gallon retention tank to provide ideal corrosion reduction.

Warning: Always use an activated carbon filter as post treatment to chlorine feed to protect the end-user from chlorine taste and odor and from possible disinfection byproduct contamination, which can result from the chemical reaction of chlorine and natural organics in the water.

Filtration Systems utilize media with irregular surface characteristics which create maximum removal capacities for suspended solids (turbidity). These POE filters utilize standard filtration forces to reduce suspended solids in a water supply. A treatment system could incorporate this type of filtration as post-aeration and/or post-chlorination treatment to trap precipitated contaminants.

Filtration-Softening is a viable POE treatment technique for reducing high levels of iron and manganese. The filtration medium is an oxidation-type medium to assist in iron and manganese oxidation. The cation softener then polishes the water by reducing the dissolved iron and manganese levels. This combination can reduce iron levels from 10.0 mg/L to 0.30 mg/L and manganese levels from 2.0 mg/l to 0.005 mg/l. The cation softener should be regenerated with a strong brine and resin cleaning solution. This regenerant combination provides an optimum resin bed cleaning which allows for years of trouble free service.

Neutralizers incorporate a limestone-based medium which sacrificially increases the alkalinity and subsequently the pH of the water supply. The rate of the limestone medium depletion is determined by the concentrations of carbon dioxide, hardness, pH and total dissolved solids (TOS) in the water supply. Limestone media is very effective in pH correction within the range of 6.0 to 6.9 and CO_2 concentration is below 200 ppm. When the pH is lower than 6.0, the water specialist should consider mixing magnesium oxide with limestone to widen the unit's pH correction range to 5.7 to 6.9. It is recommended that a chemical feed system be used to inject a soda ash and water solution into a retention tank when the pH is below 5.7. Remember, limestone-based media increase the water hardness at least two-fold. A neutralizer should be followed by a cation water softener to reduce the hardness to less than one grain per gallon (gpg).

Reverse Osmosis technology is typically classified as a POU technology. However, it can be an effective POE system. The expense of POE reverse osmosis reduces the number of systems installed at that treatment level. The majority of reverse osmosis systems are installed as POU devices designed to reduce specific contaminants from drinking water.

Reverse osmosis as POU technology is a safe technology for the reduction of many known health-related contaminants that are ingested, but it would not be very useful for contaminants absorbed through the skin or nasal passages since not all of the water in the household would be treated using the POU approach. A reverse osmosis system should be used as contaminant polishing system and should be preceded by proper pretreatment for contaminants such as bacteria, hardness, hydrogen sulfide, iron, iron algae, manganese and turbidity. The reverse osmosis membrane has different rejection percentages for each contaminant, so make a thorough study of the manufacturer's literature for proper contaminant application.

A reverse osmosis system generally incorporates the

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following features: 5-micron and/or carbon prefilter, CTA or Thinfilm membrane, acid-washed bituminous carbon postfilter, air gap faucet, 2-gallon permeate storage tank, membrane drain flow control, permeate check valve and a shut-off.

The RO system's filter maintenance schedule is dependent on contaminant concentrations, water pressure and temperature, pretreatment quality and usage patterns. An annual water analysis to confirm membrane performance is recommended.

Warning: Don't utilize reverse osmosis technology to reduce a health-effect contaminant which is inhaled or absorbed.

Selective Ion Exchange Technology can be employed for both POE and POU applications. There are many ion exchange resins available for specific contaminant reduction. However, not all of them are manufactured to FDA protocol. Only resins made to these standards should be used when treating residential water supplies. Ion-selective resins are manufactured in either the hydrogen or sodium chloride regenerant form. Since these resins utilize ion exchange, the regenerant form of the resin determines the potential change in either the treated water's sodium chloride content or its pH. These resins can be on-site regenerated when appropriate.

Contact your resin supplier for regeneration details. Due to the regenerant required and local sewage regulations, the resin is sometime discarded in lieu of on-site regeneration. Be sure to research the feasibility of proper disposal of the exhausted resin, because it could contain a regulated contaminant which requires special waste disposal procedures.

Sub-micron Filtration is designed as a POU device to reduce very small particulate matter or cyst-type microorganisms. The filters have absolute ratings from 0.40 to 1.0 µm. The flow rate is restricted to 1.0 gpm or less, and pretreatment is mandatory to achieve acceptable cartridge life. It is recommended that water to be treated with a sub-micron filter be pretreated with a 5-micron cartridge filter.

Some sub-micron filters are constructed of extruded carbon or polypropylene. The extruded carbon filter provides chlorine reduction as well as sub-micron filtration; the polypropylene filter provides only sub-micron filtration.

Ultraviolet Systems are normally used for POE treatment because bacteria can affect the end-user in the shower as well as contaminating the drinking water from a kitchen faucet. An ultraviolet system utilizes a ballast which energizes a lamp that produces light at a 254-nanometer wavelength. Coliform bacteria are destroyed when bombarded by intense light at this wavelength.

Proper pretreatment for ultraviolet systems is mandatory to assure maximum effectiveness of the ultraviolet system. Contaminants such as hydrogen sulfide, iron, iron algae, manganese and turbidity can decrease the effectiveness of the UV system by preventing the prescribed amount of UV light from getting to the bacteria. The bacteria will be shielded by, or will hide inside of, some of these contaminants and are therefore not exposed to the necessary amount of ultraviolet energy.

The germicidal lamp is protected from the water supply by a quartz sleeve. Some of these contaminants tend to precipitate on the hot quartz sleeve, reducing the amount of light transmitted and lowering the bacterial kill rate. The germicidal lamp must be replaced at least once a year, typically every 9000 hours of operation. The ultraviolet system is usually energized 24 hours per day to guarantee bacteria kill. Since this wavelength of light is invisible to the naked eye, it is recommended that the UV system include a lamp failure indicator or alarm to notify the end-user of the need for lamp maintenance.

Reviewing Manufacturer Specifications

For all treatment options, the designer must consider product limitations and pretreatment requirements which will affect longevity of performance and frequency of product maintenance. Close attention should be paid to manufacturer's installation and performance specifications to assure proper product sizing and performance.

Following is a list of common manufacturer's specifications that should be reviewed as part of the equipment selection process:

- Backwash Flow Rate
- Disinfection Procedures
- Drain Pipe Size
- Electrical Voltage Requirements
- Electrical Ground Fault Interrupter (GFI) Requirement
- Inlet and Outlet Pipe Size
- Maximum Drain Flow Height (lift)
- Maximum Influent Contaminant Concentration

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- Minimum Water Pressure
- Maximum Water Pressure
- Minimum Water Temperature (especially for RO)
- Maximum Water temperature (especially for RO)
- Rinse Flow Rate
- Service Flow Rate
- Total Regeneration Flow Rate
- Total Regeneration Volume Discharged

Reviewing Backwash Requirements
It is important that the water systems supply pressures and flow rate output (Table Four) meet the equipment manufacturer's specifications for backwash and service operations. If these pressures and flow rates do not meet specifications, the treatment equipment may not reach its optimum chemical treatment capability. POU technology typically requires minimum, if any, regeneration flow, whereas POE systems can require substantial regeneration flow rates due to the specific weight of the media.

Table Nine below identifies backwash flow rate specifications for the most commonly used residential equipment. Backwash and service flow rates are similar with some media.

If the treatment system receives excessive service flow rates or inadequate backwash flow rates, the media will foul prematurely, resulting in system failure. Contact your equipment manufacturer for detailed regeneration and service flow rate specifications.

Table Nine: Backwash Flow Rate Requirements per Medium and Tank Diameter

Medium	Flow Rates		
	8" Diameter Tank	10" Diameter Tank	12" Diameter Tank
Birm®	2.8	4.36	6.28
Cation Resin	1.58	2.45	3.53
Calcite	3.50	5.45	7.85
Greensand	3.15	4.90	7.06
Magnesium Oxide	3.50	5.45	7.85
Pumice	2.45	3.82	5.50
Pyrolucite	7.00	10.90	15.70

Step Five: Install According to Manufacturer's Specifications
Installation considerations will not be addressed in this excerpt. For more information, please refer to the full WQA QuickCourse, *How to Design a Residential Water Treatment System*, or consider the Installer training through WQA's Modular Education Program.

Note that equipment which is not properly installed will not give proper service. Installation procedures should follow equipment manufacturer's specifications and local codes. Installers must also be aware of industry-based recommendations which may go beyond codes to assure proper service.

Step Six: Discuss Proper Maintenance with the End-User
The equipment maintenance responsibilities should be discussed with the end-user prior to the installation of the equipment, and preferably during the equipment selection process. Provide a clear and readable maintenance schedule for the household and take the time to be sure the end-user understands what is required and when.

This communication link will allow for proper treatment system performance for years to come and will help to assure that the household has quality water and that you will have a satisfied customer in the community.

Providing the proper treatment system requires common sense, intelligence, water chemistry knowledge and installation know-how. Incorporating your company's expertise with impeccable maintenance service will provide for a lasting end-user relationship.

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Richard is an active member in the Water Quality Association, having served on a number of committees, task forces, and as the President of the association in 2013.

1. Analysis Of Indoor Peak Demands In 60 Selected Single-Family Homes, 2002, Aquacraft, Inc.

2. Hellenbrand, J., Trapp, L., Fixture Flow Rates: Wisconsin's POE Water Treatment Device Sizing Requirements, WC&P, Jan 2003, p46.

3. Water conservation measures could reduce the daily water usage volume per person to 65 gallons, or even 60 gallons. Treatment systems with electronic controllers can be used to monitor actual water usage to help optimize system performance.