Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Water Quality Matters

ULTRAVIOLET DISINFECTION OF PRIVATE WATER SUPPLIES FOR HOUSEHOLD OR AGRICULTURAL USES

NOVEMBER 2008

TRE-125-2008-11

INTRODUCTION

Ultraviolet (UV) light has become an established water treatment disinfection technology due to its extremely effective ability to kill or inactivate many species of disease-causing microorganisms. Ultraviolet light disinfection is effective on bacteria, protozoan parasites (e.g. *Giardia, Cryptosporidium*), and can also be effective for most viruses, providing sufficiently high UV dosage rates are used.

UV disinfection is suitable for a number of residential and commercial uses of water such as:

- Agriculture: Livestock, Irrigation, Dairy, etc.
- Domestic drinking water, residential use
- Domestic drinking water, municipal use
- Food and Beverage Industry
- Breweries, Wineries
- Secondary treatment of municipal wastewater

This technical bulletin provides basic knowledge on the following:

1. What is UV disinfection
2. How UV technology works
3. How to properly size and install a small-scale UV System
4. How to operate and maintain a UV system

This technical bulletin is a guide for the use of UV disinfection. UV devices are not stand-alone devices. Appropriate and properly designed pre-treatment (e.g. coagulation, filtration) are required prior to the use of UV devices.

WHAT IS UV DISINFECTION:

Typical UV disinfection systems involve the flow of water through a vessel containing a UV lamp as shown in Figure 1. As the water passes through this vessel, microorganisms are exposed to intense ultraviolet light energy which causes damage to genetic molecules (i.e. nucleic acids: DNA or RNA) needed for reproductive functions. This damage prevents the microorganism from multiplying or replicating in a human or animal host. Because the microorganism cannot multiply, no infection can occur. Disinfection of water is achieved when UV light causes *microbial inactivation*.

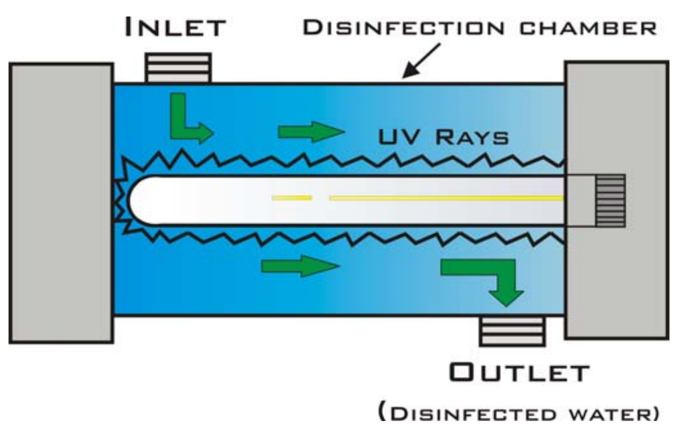


Figure 1: Basic schematic of UV unit with bulb

Canada

HOW DOES UV TECHNOLOGY WORK?

Ultraviolet (UV) light is electromagnetic radiation traveling in wavelengths in all directions from its emitting source (bulb). It is found in the spectral range of light between x-rays and visible light; UV light occurs with a wavelength ranging from 200 to 390 nanometers (nm). The most effective wavelength frequency, from the point-of-view of microbiological disinfection, is 254 nm as this is where the optimum energy intensity is found. This relationship between microbiological disinfection effectiveness and the wavelength frequency as emitted from the UV bulb is shown in Figure 2.

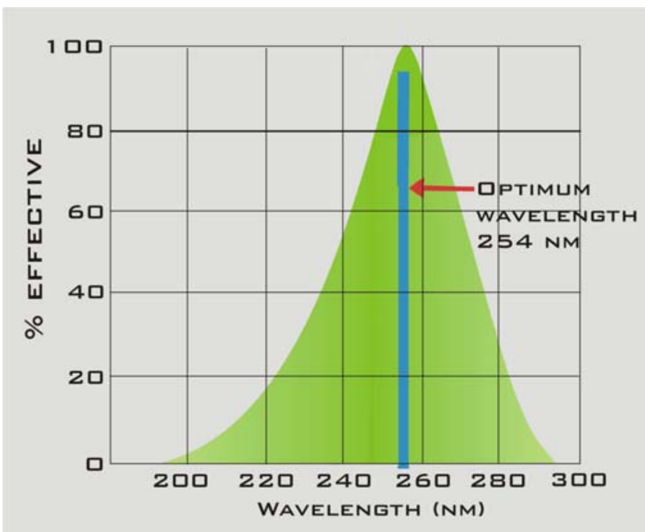


Figure 2: % Effectiveness vs. Wavelength Emitted from UV Unit

Generally, a UV disinfection unit is composed of a lamp or bulb, power supply, and electronic ballast. An example of a typical unit is shown in Figure 3.

Low-pressure mercury discharge lamps (the most common type used in small scale systems are similar in design and construction to fluorescent lamps) emit a wavelength of 254 nm, which has been found to be a good source of UV radiation to perform the disinfection process. An electronic arc the length of the lamp is formed and travels through an inert gas containing mercury. The heat generated by the arc vaporizes some of the mercury, which becomes ionized in the electric arc and gives off UV radiation.

The UV bulb is constructed using quartz glass, which easily allows the UV radiation to pass through it. This bulb is then encased by a protective quartz glass sleeve that allows the water to be exposed to the disinfecting UV radiation. This protective quartz sleeve prevents the water from contacting the UV bulb, which would change the temperature of the bulb glass, therefore affecting the pressure of mercury in the lamp and, in turn, the level of UV output. Although a Teflon® sleeve is an alternative to a quartz sleeve, quartz sleeves absorb only 5% of the UV radiation, while Teflon® sleeves absorb 35%; therefore, Teflon® is not recommended (Combs and McGuire, 1989, in Alternative Disinfectants and Oxidants Guidance Manual, EPA, 1999).

Figure 3: Schematic of UV Unit with Cover Removed

Ballasts are used to control the power to the UV lamps. They should operate at a temperature cooler than 60°C to prevent premature failure. Commonly used ballasts are electronic or electromagnetic. Electronic ballasts operate at a much higher frequency, resulting in lower lamp operating temperatures, less energy use, less heat production, and longer ballast life (DeMers and Renner, 1992, in Alternative Disinfectants and Oxidants Guidance Manual, EPA, 1999). Some types of electronic ballasts provide constant output to the lamp regardless of input voltage or frequency.

Amongst disinfection technologies, UV has a distinctive mode of action as it does not necessarily kill all the target organisms. Instead, UV light is absorbed by the microorganisms, damaging genetic nucleic acids (DNA, RNA) responsible for replicating or multiplying. Because the organisms cannot replicate, a human or animal host cannot be infected.

FACTORS AFFECTING UV PERFORMANCE

- Solarization and electrode degradation (See the section "How to Operate and Maintain a UV System")
- Fouling from scale films (ie. Iron, Calcium/ Magnesium Hardness, Manganese, *etc.*) and/or from biological films (from micro-organisms) that develop on the surface of UV lamps and/or the quartz glass sleeve
- Dissolved organics and inorganics
- Clumping of microorganisms
- Turbidity
- Color
- UV Transmittance (UVT)
- Short-circuiting in water flowing through the UV disinfection chamber

ADVANTAGES OF UV

The advantages of UV disinfection over other disinfection methods include:

- No use of chemicals (or a reduced amount of chlorine chemical when it is combined with UV disinfection)
- No known production of chemical by-products
- Simple to install, operate, and maintain
- Inline process requiring no contact tanks
- Inexpensive to operate

DISADVANTAGES / LIMITATIONS OF UV

(UV Limitations are extracted from: EPA's Alternative Disinfectants and Oxidants Guidance Manual, EPA's Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, and INAC's Design Guidelines for First Nations Waterworks)

The effectiveness of a UV system in eradicating microbiological contamination is dependent on the chemical, physical, and micro-biological qualities of the incoming water. The key limiting water quality parameters for effective UV disinfection include:

Disease-causing microorganisms – UV light is credited by Health Canada and the United States Environmental Protection Agency (US EPA) for disinfecting water with bacteria such as E. coli, protozoan cysts such as *Cryptosporidium and Giardia,* and most viruses. Because UV light is not as efficient for virus inactivation, the UV dosage rates must be much higher to inactivate viruses. Most viruses, however, can easily be inactivated with chlorine disinfection. It is therefore desireable to use a combination of UV and chlorine for small rural systems that use surface water supplies or ground water at risk of contamination from surface water (i.e. ground water under the influence of surface water). (For UV doses and removal rates of disease-causing pathogens, see Health Canada's Guidelines for Canadian Drinking Water Quality Technical Documents and US EPA's Table 1.4 in Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule)

Total Dissolved Solids (TDS) – prevents the penetration of light through the water. TDS is only a surrogate measurement for inorganic matter and potential inorganic foulants. Some UV manufacturers suggest TDS should be less than 800 to 1,000 mg/L.

Suspended Solids / Turbidity - shields microbes from the UV light and disease-causing micro-organisms will pass through the UV unit without being inactivated. Total Suspended Solids should be below 10 mg/L and Turbidity should be below 1.0 nephelometric turbidity units (NTU).

Iron/ Manganese - causes staining on the lamps or quartz sleeves. Iron affects the sleeves at levels as low as 0.1 mg/L of iron; ideally, iron should not exceed 0.3 mg/L and no iron bacteria should be present. Manganese concentrations should be below 0.05 mg/L.

Hydrogen sulphide – impairs lamps at concentrations > 0.2 mg/L; ideally, hydrogen sulphide odour should not be detected.

Calcium/Magnesium – combine to produce hardness and scale formation on the lamp or quartz sleeve at levels greater than 120 mg/L as $CaCO_3$.

Coliform Bacteria – UV disinfection is recommended to be limited to treating water with a maximum concentration of Total Coliforms of less than 1,000 counts/100mL.

UVT – UV transmittance is a measure of the percentage of transmittance of UV light, and is therefore an indicator of the potential ability of the UV lamp to be effective. EPA rates water for UV disinfection as follows: UVT > 95% is Excellent; UVT >85% is Good; UVT>75% is Fair. Most UV manufacturer's suggest UVT should be >75%. Some manufacturers mention that Tannins should be less that 0.1 mg/L as they can reduce UVT. Therefore, the UVT measurement is a more useful measurement and is simpler and less costly than doing a laboratory analysis for Tannins.

Primary disadvantages include:

- No residual disinfecting ability in storage (as there is with chlorine)
- No residual disinfecting ability in the distribution system (as there is with chlorine)
- Very high UV doses are required to inactivate viruses
- May require pre-treatment or pre-filtration to reduce turbidity of the raw water

These limitations must be considered whenever UV disinfection is incorporated into a system design. It may be advantageous to use a secondary disinfection method, such as chlorination, that will provide a disinfecting residual, depending on the system and the desired level of protection.

UV CLASSES

Dosage is defined as UV intensity multiplied by time. This is represented as milliJoules per square centimeter (mJ/cm^2), which is equal to milliWatt-seconds per square centimeter (mW-sec/cm^2) or 1000 microWatt seconds per square centimeter (µW-sec/cm^2). A short exposure time at a high intensity can be as effective as a long exposure time at lower intensity, as long as the product of intensity and time is the same.

There are two different classifications of UV systems used by the ANSI / NSF Standard 55 – Ultraviolet Microbiological Water Treatment Systems intended for point of use (POU)/point of entry (POE) systems:

Class A systems – 40,000 µW-sec/cm^2 (40 mJ/cm^2) systems are designed to disinfect and/or remove microorganisms from contaminated water, including bacteria, parasites and viruses, to a safe level. Class A systems may be used for household, rural Point-of-Use, or Point-of-Entry water treatment systems on private water supplies, providing the source water quality is acceptable, and/or adequate pre-treatment systems are adopted. Pre-treatment and filtration of the water source are mandatory initial steps (i.e. before installing a Class A UV device) on any surface water supply, ground water under the direct influence of a surface water, or any other ground water source with poor quality water (see Disadvantages/Limitations of UV).

Class B systems - 16,000 µW-sec/cm^2 (16 mJ/cm^2) systems are designed for supplemental bactericidal treatment of treated and disinfected public drinking water or other drinking water, which has been tested and deemed acceptable for human consumption by local health agencies. These systems are designed to reduce normally occurring, non-pathogenic or nuisance microorganisms only. Class B systems should **not** be used for rural household or small rural systems on private water supplies. Class B systems are not designed to disinfect and/or remove pathogenic microorganisms.

Certification to the NSF standard helps to ensure that the UV unit is built to currently recognized industry standards and has been adequately tested.

HOW TO PROPERLY SIZE AND INSTALL A UV SYSTEM

Sizing

Determining the proper capacity of a UV system is based on three variables: maximum flow rate, dose required, and UV transmittance of the water. Many manufacturers publish sizing tables and other technical information which can help in sizing the proper equipment for the specific application.

Step 1 – Determine the maximum flow rate

The maximum flow rate of a system occurs when water is drawn from multiple fittings and fixtures simultaneously. In general, a typical home with a 19 mm (¾ inch) service line will have a maximum flow rate of 27 Lpm (7 US Gpm). A home with a 25 mm (1 inch) service line may encounter peak flow rates as high as 57 Lpm (15 US Gpm) or more. Table 1 can be used to estimate the maximum flowrate expected for sizing a household UV unit. Other methods must be used to determine the maximum flowrate for agricultural applications such as livestock watering and washwater in barns.

Table 1: Typical Flowrate for the Average Home

Number of bedrooms	Number of bathrooms in home			
	1	1.5	2	3
	Flow Rate (USgpm)			
2	6	8	10	—
3	8	10	12	—
4	10	12	14	16
5	—	13	15	17

1 US Gpm = 3.78 Lpm
http://www.healthyhomemall.com/water-flow-rates-gpm.htm

Step 2 – Select an Appropriate UV Dose

Select an appropriate level of disinfection for the type of source water being treated. As mentioned earlier, there are basically two classes of UV units that each produce a different dosage, Class A or Class B (as noted in the section "UV Classes").

Step 3 – Measure the UV Transmittance of the Water

It can be advantageous to measure the UV Transmittance (UVT) of both the source water and the water entering the UV unit itself. UVT is a measure of the water's ability to transmit UV light. It is measured as a percentage of the UV transmission (%T) achieved in distilled or de-ionized water. Source water with high concentrations of minerals (ie. Iron, Calcium, Magnesium, Manganese, etc) will contribute to scale build-up on the UV lamp (see Disadvantages/ Limitations Of UV section). In addition, the higher the concentration of some microbes, the greater the likelihood of slime (or biofilm) growth on the glass sleeve or lamp housing. Both the scale and the biofilm will affect the system's ability to disinfect. The higher the UVT of the water being treated, the more effective disinfection the UV unit will achieve. Most deep wells have a UVT of about 85 % or more. Waters that have a UVT of less than 75 % will generally require pre-treatment to allow proper penetration of the UV light. The water may look relatively clear but have a low UVT. Testing for UV Transmittance can be done with a UV photometer at 254 nm (a specialized instrument that may be available from a laboratory or a supplier).

Step 4 - Determine Size Requirement

Using the information collected in steps one through three, determine the size of UV unit required using the manufacturer's product sizing table and technical assistance or publications available from reputable water treatment suppliers. Product manufacturers may also be contacted for additional assistance.

It is critical that the UV unit selected is not undersized for the application it is intended for. Undersizing may result in inadequate and potentially unsafe disinfection. If in doubt about the size of a UV unit, always use a larger size.

UV UNIT SELECTION AND SYSTEM DESIGN

Once the sizing of the UV unit is complete, the system selection and design can be completed. Some UV units may already have added features, already included.   It is important to consult with the manufacturer to select the features appropriate for the intended use of the water.

A number of useful add-on features are available for UV units.   Features such as a UV lamp intensity monitor connected to visual and/or audible alarms, timers, digital displays, temperature sensors, electronic ballasts, and high-output lamps can be quite valuable. Additional safety features can be incorporated into the design and layout of a system. In the event of a power outage, unit malfunction, or lamp failure, a solenoid valve can be used to prevent untreated water from entering the water distribution system.

Operation and maintenance should also be considered when designing the system layout. Installing a ball valve before the 5µm pre-filter, with a faucet and isolation valve after the UV unit, will allow the system to be isolated for maintenance, i.e. changing the pre-filter and UV bulb. The valve provides a sampling point and a location for pressure release. Water treatment systems typically incorporate disinfection as a final step in treatment, usually at a point that is nearest to the point of use or distribution, as shown in Figure 4.

UV units have been incorporated into the disinfection process for various system designs and configurations. Figure 5 shows a UV unit used with a carbon filter and water softener, while Figures 6 and 7 provide examples of point of use systems typically found under the kitchen sink.

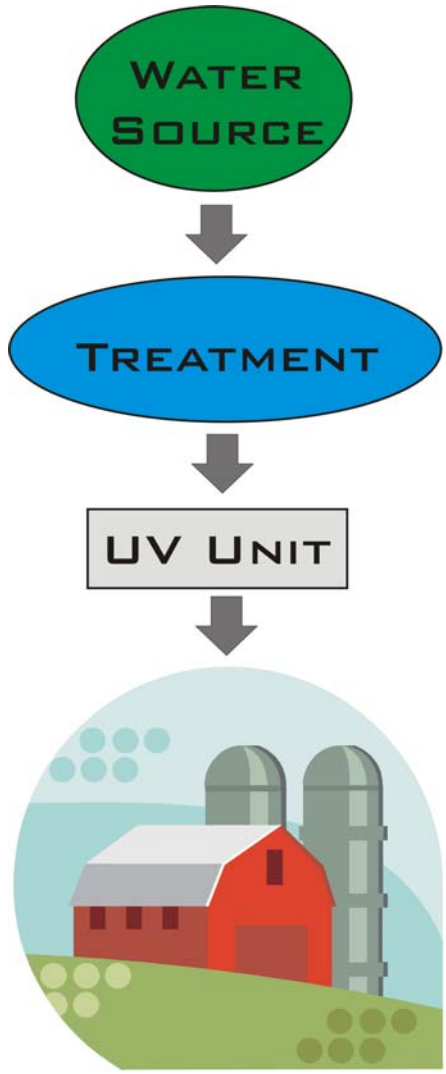


Figure 4: Treatment Process

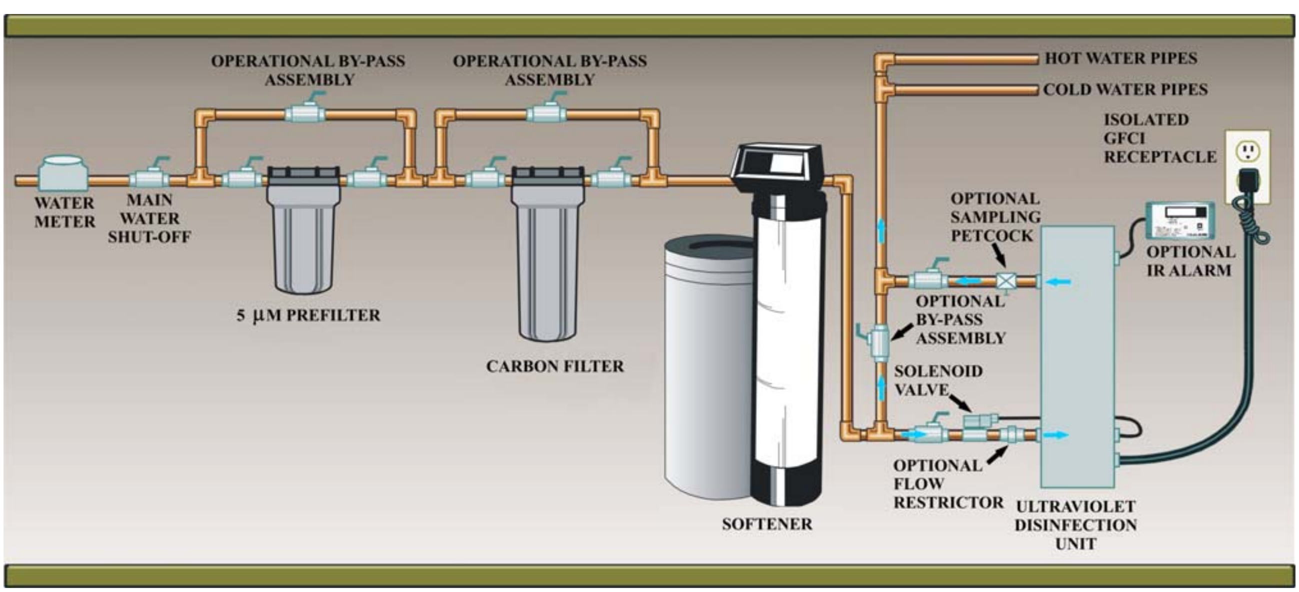


Figure 5: Typical Softening System with UV Disinfection

TRE-125-2008-11

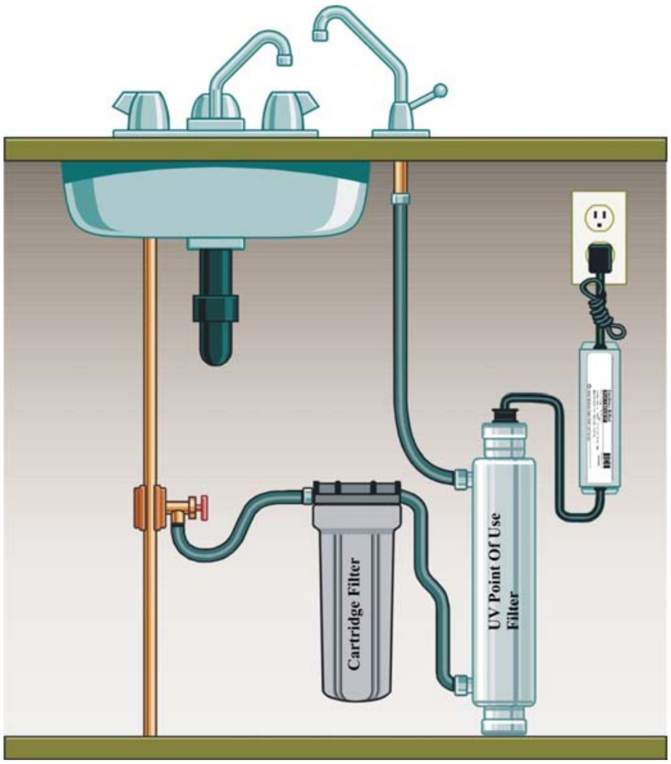


Figure 6: Typical Under Sink Point of Use UV Unit

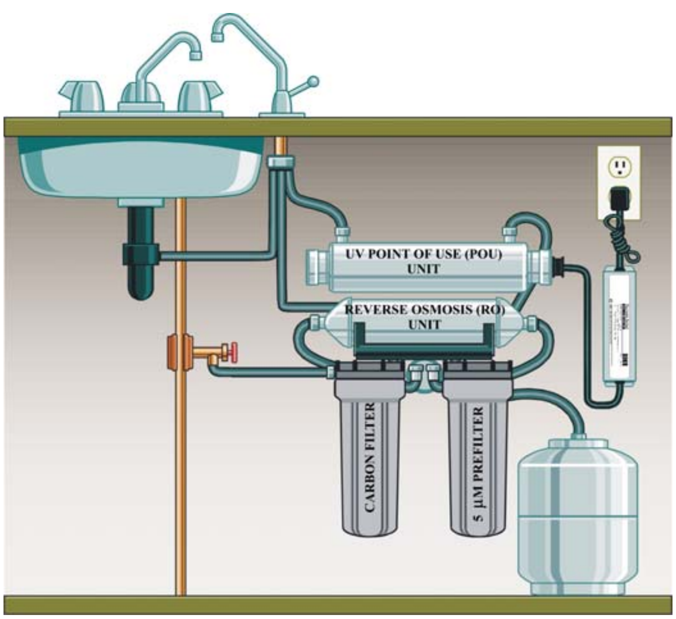


Figure 7: Typical Under Sink Point of Use UV Unit With Reverse Osmosis

INSTALLATION

Step 1 – Equipment and Supplies

Typical equipment and supplies required:

UV unit and a 5-micron (5µm) sediment filter

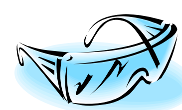
Plumbing

Pipe, two shut-off valves, faucet, connector fittings, elbows, propane torch, solid-core solder, paste flux, emery cloth, pipe cutter, pipe wrenches, Teflon tape, etc.

Electrical

GFCI (ground-fault circuit interruption) outlet or breaker, electrical box (if not already present or no circuit space available in existing breaker box), electrical wire, wire cutters, wire strippers, connectors, electrical tape, etc.

Basics



Screws, gloves, eye protection, measuring tape, ruler, screw drivers, drill, etc.

Step 2 – Manufacturers Information

Read the manufacturer's product information, installation instructions, and safety precautions before proceeding. Consult the manufacturer, supplier, or other reputable source for additional assistance where necessary.

Step 3 – Prepare Location

Select an appropriate location for mounting or install a plywood board to the wall to support all the necessary components of the system. Install a GFCI outlet to the board to supply power to the UV unit. Always ensure that the electricity has been shut off to safely make any electrical connections and that the installation meets local plumbing and electrical code requirements.

Step 4 – Filter Installation

Mount the 5µm pre-filter housing on the board or other suitable location in front of the UV unit. Attach the threaded connectors to the filter housing. Install a ball valve to the incoming end of the filter valve and consider installing sampling ports as shown in Figure 8.

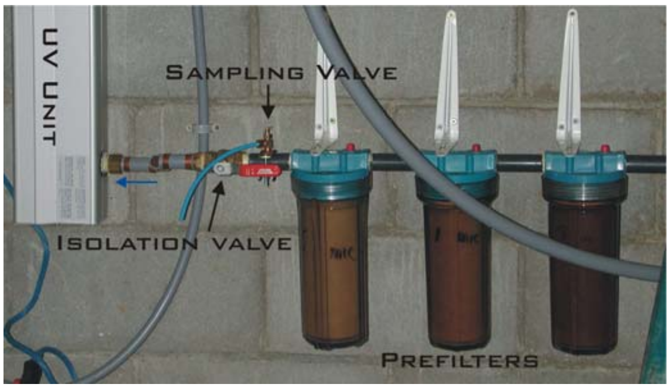


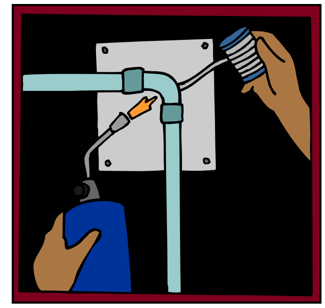
Figure 8: System including sample port, isolation valve, and pre-filters

Step 5 – UV Unit Installation

Secure the UV unit on the mounting board using either brackets or screws as shown in Figure 9. Ensure that the unit is mounted in a position that will facilitate straightforward maintenance.

Figure 9: UV unit and cartridge pre-filters securely mounted to wall

Step 6 – Plumbing



Begin by taking all the necessary measurements and start connecting plumbing. Dry fit the piping before soldering the connections. Before connecting the UV unit plumbing to the main water line, you should complete as much of the plumbing as possible. Consider installing a drain for maintenance and freeze protection. It is also important to eliminate any dead ends in the plumbing as this can introduce a source of contamination. Also, ensure that you are using lead-free solder.

Step 7 – Finalizing System

Insert the UV bulb into the chamber and install the pre-filter into the filter housing. Plug in the UV unit after water fills the new section of piping so as to not overheat the bulb and chamber. Disinfection of the water line can be accomplished by placing household bleach in the filter housing and flushing the system until chlorine odour is detected at all points of use. After approximately two hours or more of contact time, flush the entire system thoroughly (i.e., until the chlorine odour can not be detected). Check all connections including electrical wiring and plumbing to ensure no safety hazards or leaks are present and that the system is functioning properly. The system is now ready for operation.

INSTALLATION TIPS

- Safety first
- Read all of the manufacturer's instructions
- Do not undersize the UV unit
- Test the water (UVT, iron, manganese, coliforms, etc.)
- Measure twice: cut once
- Disinfect system with bleach when completed
- Install a sampling port
- Install valves to isolate system for maintenance
- Protect unit from extreme heat or freezing
- Consider adding a drain

- Get appropriate information when unsure
- Ensure the installation meets all local plumbing and electrical codes

HOW TO OPERATE AND MAINTAIN A UV SYSTEM

UV Lamp Replacement

The output of a UV lamp diminishes with time. Two factors that affect the lamps performance are solarization (which is the effect UV radiation has on the UV lamp causing it to become opaque) and electrode degradation occurring every time the lamp is cycled on and off. Frequent lamp cycling will lead to premature lamp aging. Average service life expectancy for low pressure bulbs is approximately 8,800 hours or one year.

Quartz Sleeve Cleaning

Fouling of the protective quartz sleeve reduces the amount of UV radiation penetrating the water, thereby reducing the disinfection effectiveness. Eventually, this glass sleeve will become coated in a film or scale of organic and inorganic contaminants in the water, reducing the transmittance of UV light through the sleeve into the water. Cleaning solutions, recommended by the manufacturer or supplier, can be used to remove much of the scale from the glass. Different solutions may be required to clean biofilms. No matter what method is used for cleaning, it is important that all instructions and safety information is read as some cleaners can have a negative reaction with some materials. For most small scale applications, an inspection and cleaning frequency of every six months to a year is normally adequate. The frequency of this cleaning will be dependent on the quality of the water passing through the UV unit. Be sure to only use chemicals that are safe for potable water systems and always follow recommendations from the UV manufacturer. It is important that the system be rinsed thoroughly after using any cleaning solution and prior to use.

Seasonal / Periodic Draining

If using the UV unit in a seasonal or periodic application, it may be desirable to install a drain to allow the water to be removed during the off-season. This is very important to prevent damage caused by freezing to both the plumbing and the UV unit itself. The UV unit must also be unplugged if drained and not in use.

APPLICATIONS

Water treatment systems can incorporate UV as a useful method of disinfecting treated water for safe use. Many other applications of this technology are possible, depending on the desired outcome. For instance, UV disinfection used in conjunction with chlorination can be a very effective disinfection system. UV is a cost effective method for treating bacteria, viruses and protozoa, while chlorine provides a chemical residual offering additional protection in the event of contamination being introduced in the distribution system or plumbing.

For surface water systems and ground water under the direct influence of surface water, filtration pre-treatment and other processes are required. After pre-treatment, it is desirable to install another polishing filter such as a 1 micron (1 µm) sediment filter which can exclude small organisms. If water is suspected to contain viruses, UV dosage and contact time may need to be increased and/or used in combination with chlorine disinfection (effective virus inactivation occurs by maintaining a concentration of 0.25 mg/L free chlorine for 1 minute of contact time).

Sometimes, small point-of-use reverse osmosis devices (installed at one dedicated tap) utilize a very small UV lamp at the last stage of treatment. This UV is used to disinfect the water before use. Small UV devices function in the same manner as larger UV devices, and require similar maintenance and replacement practices.

UV disinfection shows promise as a pre-treatment technique when used before a larger Point-of-Entry reverse osmosis treatment system, treating surface water (e.g. supplying water to a entire household or to an agricultural use such as livestock drinking water). In one pilot study conducted by PFRA (from 1998 to 2000), a UV system was installed as one component of the pre-treatment filtration system. The UV was installed after the 5 micron pre-filter for an RO treating a surface water with high dissolved solids concentrations, supplying the entire demands for one household. The addition of the UV in front of this RO membrane extended the frequency of membrane biofilm cleaning from several weeks to several months. It is likely the UV lamp improved the RO performance by reducing biological growth on the membrane surface and by reducing the organic fouling potential from the source water. Other studies confirm the potential of UV as one pretreatment step for RO devices treating organic-rich water (W. Song *et al*, 2004; López-Ramírez *et al*, 2002; Gabelich *et al*, 2001). Of course, post-disinfection after the RO is still required to ensure microbiologically safe water is supplied to the end user.

FAQ's

The cost for a basic self-installed unit can be as little as $300 – $800 but will vary based on the capacity and features of the UV unit selected. Some UV units can cost up to $1,200 or more with additional capacity and features such as flow restrictors to ensure the capacity of the UV unit is not exceeded, audible UV warning sensors, solenoid valves to shut off the flow in the event of a power outage, etc. Having a plumber or service technician install the system will increase the overall cost, but it can be advantageous due to the professional services and support associated with their particular line of business.

Can I install this myself or does it require professional installation?

You can choose to install the unit yourself or have a professional install it for you. If you have the time, are mechanically inclined, have the basic tools required, and feel comfortable with the work involved during the installation, then you can choose to perform the installation yourself.

There are a number of factors to consider when installing a UV system, which may be best left to a professional, depending on your technical knowledge and skills involved. These include assessing the incoming water, the need to install some new pipes, fittings, and the required electrical circuitry, as well as properly disinfecting the system.

If you choose to install the system by yourself, it is recommended that you discuss the required work with your local plumber and/or UV supplier. Remember to read and follow the manufacturer's instructions provided with the unit and to meet the relevant plumbing and electrical codes.

What are the annual maintenance costs?

The bulb may need to be replaced once a year or sooner depending on the water quality, costing approximately $50 - $100, depending on the size and model of the UV unit. Pre-filters and other filtration devices will most likely require replacement once a year or more; again, the frequency of replacement depends on the water quality. These costs should be relatively small but will depend on the type, size, and number of filters being used. Electrical costs will be approximately equivalent to the continuous use of a 60 watt light bulb.

Where can I buy a UV system?

UV systems can now be commonly purchased and installed by local plumbing shops, mechanical contractors, and water treatment dealers and suppliers. They can be easily located by using the YellowPages™, phone book, internet, or located through the manufacturer of a particular UV unit.

Is product certification important?

Health Canada strongly recommends that all products that come into contact with drinking water be certified to the appropriate health based performance standard developed by NSF International. In the case of UV light units, it is recommended that they be certified as meeting standard NSF/ANSI 55 for Class A or Class B devices. Components employed in conjunction with the UV system should also be certified to meet other applicable NSF/ANSI Standards. In Canada, CSA International, NSF International, the Water Quality Association, Underwriters Laboratories and the International Association of Plumbing and Mechanical Officials (IAPMO) have all been accredited by the Standards Council of Canada to certify drinking water materials as meeting the above-mentioned standards. These standards are widely accepted in North America, as they ensure the performance and mechanical integrity of the materials that come into contact with drinking water. Check the UV treatment unit's packaging or ask your dealer for a listing of the substances that the unit is certified to remove. Ensure the unit is installed and used only for the purposes for which it is certified.

Is a UV disinfection unit all the water treatment equipment I need?

If your water is obtained from a treated municipal supply that is regularly tested and deemed safe, then a UV unit may offer you additional reassurance as to the microbial quality of the water.

If your water is obtained from a private water supply or an untreated source, you will require more than a stand-alone UV unit. The UV unit is one piece of the overall treatment train required to provide safe drinking water. It provides the function of microbiological disinfection. Other treatment components are required to remove contaminants as well as to provide the necessary pre-treatment of the water entering the UV unit in order for it to operate properly. The degree of pre-treatment varies with each water supply, but will typically include a form of chemical treatment followed by specific filtration devices designed to improve specific water characteristics. Such pre-treatment is necessary prior to any disinfection device, including chlorine disinfection. On surface water supplies or groundwater supplies under the influence of surface water, UV disinfection should be used in combination with chlorination disinfection (to ensure effective inactivation of viruses).

How long has UV been used for treating water?

Ultraviolet light has been used for drinking water disinfection in the United States dating back to 1916. Since then, researchers have found more cost effective ways to use UV technology for both water and wastewater disinfection. Throughout the 1980's and 1990's, the small-scale, point of entry (POE) and point of use (POU) water treatment industry saw a large period of growth of UV technology being used for disinfection. These small scale units are now a cost effective alternative to traditional disinfection technology and have become quite popular for private water supply users.

Is UV effective against Parasites and Viruses?

A UV dose of 40 mJ/cm^2 achieves 4-log (99.99 %) inactivation of parasites and most viruses. A high UV dose of 186 mJ/cm^2 is required for a 4-log inactivation of adenovirus. For surface water supplies and ground water under the influence of surface water, a 40 mJ/cm^2 UV device can be used in combination with chlorine to effectively inactivate viruses. The addition of free chlorine (at a concentration of 0.25 mg/L free chlorine for 1 minute of contact time) can provide the desired 4-log inactivation of adenovirus (Baxter et al, 2007).

Where can I get more information?

For more information on protecting and improving rural water supplies, visit the Prairie Farm Rehabilitation Administration Water Supply and Quality webpages on the AAFC website:
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1187702145201&lang=e

Water Treatment and Disinfection Solutions – multimedia flash animation
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1185562486945&lang=e

Canadian Mortgage and Housing Corporation (water and wastewater information pertaining to the home owner)
About Your House- General Series – UV Water Treatment
http://www.cmhc-schl.gc.ca/en/co/maho/wawa/wawa_002.cfm

Health Canada (information regarding Health Canada's activities related to drinking water, and Guidelines for Canadian Drinking Water Quality Technical Documents)
http://www.hc-sc.gc.ca/ewh-semt/water-eau/index_e.html , and,
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc

National Drinking Water Clearinghouse on-line Tech Briefs and How-to's: http://www.nesc.wvu.edu/ndwc/ndwc_tb_available.htm
(National Environmental Services Centre program, sponsored by the US Dept of Agriculture's Rural Utilities Service)

NSF International (information regarding health-based performance standards relating to drinking water treatment units, listing of certified systems and products)
www.nsf.org

References

Alternative Disinfectants and Oxidants Guidance Manual, United States Environmental Protection Agency EPA 815-R-99-014, 1999 http://www.epa.gov/safewater/mdbp/alternative_disinfectants_guidance.pdf

Baxter, C.S., Hofmann, R., Templeton, M.R., Brown, M. and Andrews, R.C. (2007), *Inactivation of Adenoviruss Types 2, 5, and 41 in Drinking Water by UV Light, Free Chlorine, and Monochloramine.* Journal of Environmental Engineering Vol. 133-No.1, Jan 1, 2007. pp. 95-103.

Design Guidelines for First Nations Waterworks, March 16, 2006. Indian and Northern Affairs Canada, Gatineau, QC. http://www.ainc-inac.gc.ca/enr/wtr/pubs/dgf/dgf-eng.pdf
INAC Design Guidelines are based on the publication "*Recommended Standards for Water Works – 2003 Edition*" a report of the Committee of the Great Lakes - Upper Mississippi River Board of State Engineers (the Province of Ontario is a member). These Standards are known as the 10-State Standards, and were last updated in 2003.

Guidelines for Canadian Drinking Water Quality – Technical Documents, Health Canada, including documents for Microbiological Parameters (Protozoa, Enteric Viruses) and Bacteriological Quality (E. coli, Total Coliforms, Heterotrophic Plate Count, Bacterial Waterborne Pathogens) http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc

National Primary Drinking Water Regulations: Ground Water Rule. United States Environmental Protection Agency. Federal Register: November 8, 2006 (Volume 71, Number 216.

Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, United States Environmental Protection Agency EPA 815-R-06-007, 2006 (http://www.epa.gov/safewater/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf)

UV pre-treatment for organic-rich surface water on larger RO systems:

Gabelich, C.J, Yun, T.I, Coffey, B.M, Bergman, R.A., 2001. *Performance and Economic Evaluation of a 16-Inch-Diameter Reverse Osmosis Membrane for Surface Water Desalting*. American Water Works Association Membrane Conference Proceedings.

López-Ramírez, J.A., Sahuquillo, S. Sales, D., Quiroga, J.M. 2002. *Pre-treatment optimisations studies for secondary effluent reclamation with reverse osmosis.* Water Research 37 (2003) 1177-1184.

Song, W., Ravindran, V., Koel, B.E., Pirbazari, M., 2004. *Nanofiltration of natural organic matter with H_2O_2/UV pretreatment: fouling mitigation and membrane surface characterization.* Journal of Membrane Science 241 (2004) 143-160.

The web links mentioned in this document are accurate as of November 2008.

Author: S. Harley, B. Schuba, D. Corkal