

Guide to the assessment of UV disinfection systems for local authorities

Summary of legislation, responsibilities and roles

The Drinking Water Directive (98/83/EC) requires water intended for human consumption to be wholesome and clean and not a risk to public health. The Drinking Water Directive for private supplies is implemented in England and Wales by the Private Water Supplies Regulations 2009 and the Private Water Supplies (Wales) Regulations 2010 (as amended), respectively.

The Drinking Water Inspectorate (DWI) is the competent authority for ensuring that the Drinking Water Directive requirements are met in England and Wales. The DWI has a statutory role to supervise local authorities in relation to the implementation of the Private Water Supplies Regulations, including the provision of technical and scientific advice.

Local authorities are the regulators for private water supplies and have a number of statutory duties under the Private Water Supplies Regulations. These duties include the requirement to carry out risk assessments and monitor private water supplies to determine compliance with drinking water standards. A supply to a private single dwelling as defined in Regulation 10 is excluded from the risk assessment and monitoring requirement unless requested by the supply owner or occupier.

The local authority has powers to require that a supply that is unwholesome or a potential danger to human health is improved by the owners or people who control the supply.

Risk assessment

The risk assessment carried out by a local authority considers all aspects of the private water supply:

- the likelihood of contamination at the source of the supply and the surrounding area;
- checks of any storage tanks, treatment systems and associated pipe work;
- identification of actual and potential hazards that may affect the health of those using the water for drinking purposes;
- identification of where action is necessary to make sure the water supply is wholesome and safe to drink.

Whilst the requirements of a local authority with regard to a private supply are wide ranging, this guidance considers only those aspects related to UV disinfection.

What is UV disinfection?

UV disinfection inactivates harmful micro-organisms that could otherwise cause illness if consumed in drinking water. The micro-organisms in the water are exposed to UV light generated by a UV lamp enclosed in a stainless steel or (less commonly) plastic chamber. The UV lamp operates optimally at

a temperature of about 40°C, and a quartz sleeve normally separates the lamp from the water to prevent the lamp from cooling.

To be consistent with standards that apply to UV disinfection for public water supplies, it is recommended that UV equipment installed for a private supply should be rated to provide a dose of 40 mJ/cm².

The rated UV dose is related to the design flow rate and water quality (typically described by a minimum UVT value). In practice, the dose delivered will depend on the actual water flow rate and quality delivered to the system.

For UV disinfection to be effective, the water must be of suitable quality and the applied UV dose must be sufficient. For these reasons, it is important that specialist advice was sought prior to the purchase and installation of the UV system. Details of the design specification, including water quality, flow rate, any pre-treatment and UV dose, should be requested from the supply owner or occupier.

Why is water quality important?

UV disinfection should never be installed without determination of the source water quality and its variation.

The majority of private water supplies are sourced from groundwaters, e.g. boreholes, wells, springs, etc., and it is essential that the infrastructure associated with protection of the source and abstraction is adequately maintained to avoid microbiological contamination from surface water. The catchment of the source water should be identified; potential sources of microbiological contamination include farming activities and discharges from septic tanks/soak away systems.

For UV disinfection to be effective, the water must be clear and relatively free from certain dissolved substances that may deposit on the quartz sleeve, reducing the amount of UV light reaching the harmful micro-organisms.

The clarity of water is usually expressed in terms of the amount of UV light that can pass - its 'Ultraviolet Transmittance' (UVT). The higher the UVT, the lower the reduction of UV light as it passes through the water and the greater the UV intensity to which micro-organisms are exposed. As a *guideline*, UVT should be greater than 75% for UV disinfection to be practicable. Minimum UVT values, typically greater than 90-95%, are commonly specified by UV equipment manufacturers/suppliers.

Dissolved substances that may deposit on the UV sleeve include colour, iron, manganese and hardness.

As an indication of the water quality required for UV disinfection, the water should at least meet the statutory physical and chemical standards for "wholesomeness" in Schedule 1, Part 1 of the Private Water Supplies Regulations, including:

- Colour – 20 mg/l Pt/Co (equivalent to °H)
- Iron – 200 µg/l
- Manganese – 50 µg/l
- pH – 6.5-9.5

Turbidity must be reduced to 1 NTU prior to disinfection.

Hardness is not a regulated parameter; as a *guideline* hardness should not exceed 120 mg/l CaCO₃/l for UV disinfection to be practicable.

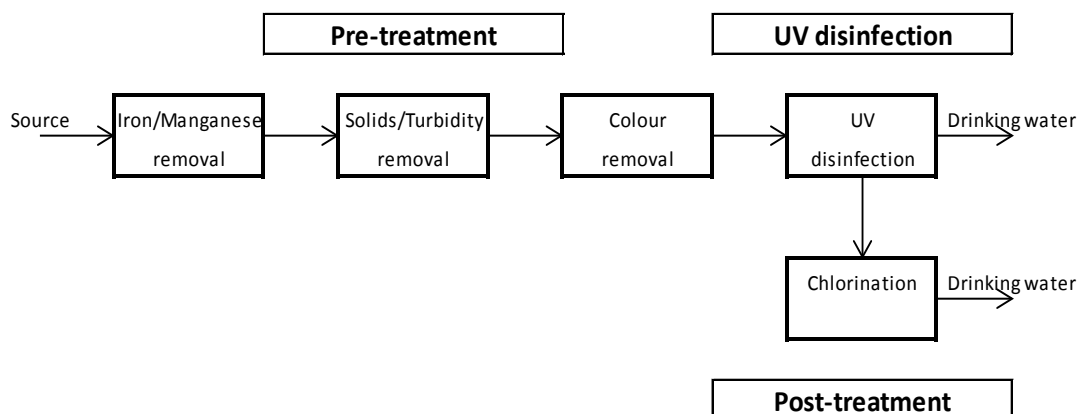
If source water quality is unsuitable for UV disinfection, it may be possible to pre-treat the water to an acceptable quality. Water treatment equipment is available to remove turbidity, colour, iron, manganese and hardness.

What should be included in the UV disinfection system?

This depends on the quality of the source water and the presence of any contaminants. In general, a groundwater source (e.g. borehole) will be of better microbiological quality than a surface water source (e.g. stream or lake). Treatment before UV should be sufficient to ensure that the water being disinfected meets the required quality.

Figure 1 shows a typical treatment flowsheet. Pre-treatment and post-treatment are optional, depending on the requirements of the supply.

Figure 1 Typical treatment flowsheet



Treatment to remove common contaminants that might affect UV disinfection includes:

- Suspended solids/turbidity – removed by filtration in replaceable cartridges, typically rated to remove particles larger than 5 µm, to around 1 NTU or lower.
- Colour – removed by activated carbon cartridges or membrane filters to around 20°H or lower.
- Iron and/or manganese – removed by oxidation and filtration in proprietary units to around 200 µg/l or 50 µg/l or lower, respectively.

How should the system be operated and maintained?

All treatment units must be operated and maintained according to manufacturers'/suppliers' instructions. In particular, cartridges, filters and UV lamps must be replaced at recommended intervals. A simple system may be maintained by its owner, but specialist companies should be used for more complex systems.

Copies of manufacturers'/suppliers' operating and maintenance instructions should be retained by the supply owner. In addition, a maintenance log should be maintained by the owner to record details of maintenance carried out and schedules for future maintenance.

UV disinfection equipment is compact and simple to operate, and maintenance is modest but essential. Most household units have little monitoring and control, often only a power on/off indicator and visual/audible alarms to indicate power or lamp failure. The units should be left switched on at all times and the operation of the lamp confirmed by regular and frequent observation.

Some UV systems include automatic shutdown of the water supply in the event of power or lamp failure, and this is recommended. Some systems also include manual override; it should be made clear that if the UV lamp is not functioning correctly, the water provided is not disinfected and should be boiled prior to consumption.

In the event of power or lamp failure, if the flow of water is not automatically interrupted, the drinking water produced will not be disinfected.

Can UV disinfected water be stored?

UV disinfection does not provide a long-lasting disinfectant residual. UV disinfected water for drinking or cooking should be supplied directly to an appropriate tap (usually the kitchen tap). Any water storage facilities must be hygienically maintained to ensure good quality, but should not supply drinking water.

Checklist to Help Assess an Installed UV System

The following checklist will help local authorities to assess the suitability of an installed UV system.

Water Supply Specification and Design
<p>The water supply should have been specified and designed to adequately treat the raw water and provide a sufficient flow rate of treated water.</p> <p>Request evidence and/or results from the supply owner or occupier of raw water analysis, particularly parameters that might affect UV disinfection (turbidity, colour, iron, manganese, <i>E. coli</i>), any seasonal variation in water quality, and average and peak water demand.</p>
Pre-treatment
<p>Water flowing to UV disinfection must be clear and free from dissolved substances that may deposit on the quartz sleeve, e.g. typically $UV_T > 90\%$, turbidity < 1 NTU, colour $< 20^\circ H$, iron $< 200 \mu g/l$, manganese $< 50 \mu g/l$. If this analysis has not been undertaken prior to installation it is possible for analysis to be carried out and pre-treatment installed.</p> <p>Where raw water analysis indicates that pre-treatment is required to meet the requirements of installed UV units, request evidence from the supply owner or occupier of the design specification (flow rate, contaminant levels) and performance (analysis of treated water) of installed units.</p>
UV System
<p>The UV system should be sized to provide an adequate UV dose for a suitable water quality - typically quoted as UVT but may include other contaminants (see above) - at a maximum flow rate. A UV dose of 40 mJ/cm^2 is recommended for effective treatment, but note that the actual dose delivered will be lower if the water quality is poorer and/or the flow is higher than the design specification. The actual UV dose will also be reduced if the lamp is not replaced at the recommended interval and/or the quartz sleeve is not cleaned as required. If a lamp is not achieving this dose, then manufacturers advice should be sought on whether to replace the whole unit or if an alternative lamp may be used.</p> <p>Request evidence from the supply owner or occupier of the design specification (UV dose, flow rate, water quality) for the UV system. If manufacturers'/installers' literature is not available, some information may be available from invoices and on equipment components.</p> <p>The UV equipment must be designed for drinking water use and, for equipment installed after 1 January 2010 in England, satisfy Regulation 5 of the Private Water Supplies Regulations 2009, or after 26 May 2010 in Wales, satisfy Regulation 4A of the Private Water Supplies Regulations (Wales) 2010 as amended. In practice this is likely to mean that products have WRAS approval.</p>
Monitoring and Control
<p>Simple UV systems have little monitoring and control, often only a power on/off indicator and local visual/audible alarms to indicate power or lamp failure; more complex systems may</p>

include facilities such as lamp hours run, UV intensity monitor and automatic water shutdown.

Automatic shutdown of the water supply in the event of power or lamp failure is recommended; if manual override or bypass is provided, the water should be boiled prior to consumption.

A UV intensity monitor measures the actual UV dose being delivered to the water. However, it is recognised that this is a relatively expensive option available on few smaller systems. Similarly, validated systems are recognised as offering additional safeguards regarding confirmation of applied dose. It is recognised however that few validated systems are available in the sizes typically used in private supplies. In all cases approved products designed for drinking water treatment should be used.

Where no such monitoring exists, daily checks should be made to ensure that the lamp has power and is working. Regular checks can be made to assess the extent of sleeve fouling and manufacturers instructions regarding maintenance and frequency of lamp replacement should be followed. Manufacturers can also be consulted regarding daily and weekly checks.

It should be noted that the germicidal range of UV cannot be seen. The blue light seen from UV lamps is not necessarily indicative of the units performance. Very often the blue light has a longer life than the 254nm output. It should also be noted that a drop in UV_T is not necessarily visible to the naked eye, and in the absence of any transmittance monitoring, appropriate pretreatment is a crucial control measure, and the recommended maintenance intervals for filters etc must be maintained.

Maintenance

UV systems and any pre-treatment must be maintained according to manufacturers'/suppliers' instructions. UV lamps must be replaced typically every 12 months – although frequent on-off operation will reduce the lamp life – and quartz sleeves cleaned at recommended intervals.

Request evidence from the supply owner or occupier of the maintenance history. Where the supply is maintained under contract, ideally this will be an up-to-date maintenance log but most likely will be a series of invoices indicating work carried out. Where the supply is maintained by the owner, request records of maintenance and look for any obvious signs of maintenance not being carried out, e.g. discoloured or odorous water.

Post-treatment and Storage

UV disinfection does not provide a long-lasting disinfectant residual. UV disinfected water for drinking or cooking should be supplied directly to an appropriate tap (usually the kitchen tap). For a longer distribution system, e.g. a commercial campsite, the UV disinfected water may be dosed with chlorine.