Guide for local authorities

1.1 Introduction

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 by the Private Water Supplies Regulations 2016 and The Private Water Supplies (England) (Amendment) Regulations 2018; and in Wales by the Private Water Supplies (Wales) Regulations 2017.

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 domestic dwelling, where there is no commercial or public activity, and (Wales only) is not part of a domestic tenancy, as defined in Regulation 10, is excluded from the risk assessment and monitoring requirement unless requested by the supply owner or occupier; however, LAs may choose to monitor such a supply, at their own expense, if they suspect a potential risk to health.

The local authority has enforcement powers to require that a supply that is unwholesome or a potential danger to human health is improved by the relevant person(s) (as defined in Section 80 of the Water Industry Act 1991).

Risk assessment

The risk assessment carried out by a local authority considers all hazards and potential hazards from source to tap on private water supplies in its area, excluding those to single dwellings only (unless rented to tenants), including:

- the likelihood of contamination at the source of the supply and the surrounding catchment area;
- checks of any collection chambers, storage tanks, treatment systems and associated pipe work;

- identification of actual and potential hazards that may affect the health of those consuming the water; and

- identification of where remedial 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 chemical disinfection.

What is chemical disinfection?

The objective of chemical disinfection is to kill or inactivate harmful micro-organisms and parasites that could otherwise cause illness if consumed in drinking water.

The effectiveness of chemical disinfection depends on a number of factors:

- The disinfectant chemical used;

- The type of micro-organism or parasite;

- Water quality;

- The dose of disinfectant chemical applied;

- The contact time; and

- The numbers of micro-organisms present.

What chemical disinfectants can be used?

Only chemicals that meet the requirements of Regulation 5 of the PWS Regulations can be used in private supplies. Only products specifically produced for drinking water applications should be used.

Chlorine

Chlorine is the most common chemical disinfectant used for drinking water treatment. It can be supplied as a liquefied gas, as a solution (sodium hypochlorite), or as a solid (calcium hypochlorite tablets). It is also possible to produce sodium hypochlorite locally by the electrolysis of brine.

Chlorine dioxide

Chlorine dioxide is an unstable compound which is generated at the point of use, most commonly by mixing solutions of sodium chlorite and either hydrochloric acid or sodium hypochlorite.

1.2 Guidance aligned with DWI Risk Assessment Lite Tool

The guidance in this section is aligned to those parts of the DWI Risk Assessment Lite Tool which may apply to chemical disinfection.

1.2.1 Catchment, Section B

If there is a risk of *Cryptosporidium* being present in the water source, neither chlorine nor chlorine dioxide can be relied upon to provide adequate disinfection.

1.2.2 Treatment plant

Section P1: Does the plant design take into account the raw water quality?

Raw water quality parameters that can interfere with chemical disinfection are listed below.

Turbidity

Turbidity is caused by fine particulate matter, which can shield micro-organisms from the chemical disinfectant. Ideally, turbidity at the point of disinfection should not exceed 1 NTU.

Iron and manganese

Dissolved iron and manganese will react with, and consume, chemical disinfectants, and precipitate nuisance solids. Both metals are more likely to be present in a dissolved state in groundwater which is low in dissolved oxygen.

Hydrogen sulphide

Hydrogen sulphide will react with, and consume, chemical disinfectants, and may precipitate nuisance solids. It may be present in a dissolved state in groundwater which is low in dissolved oxygen.

Ammonia

Ammonia can be present in surface or groundwater sources as ammonium ion. It reacts with chlorine, the products of the reaction being dependent on the relative proportions of chlorine and ammonia. Chloramines may be formed which are much weaker disinfectants than free chlorine and may impart objectionable taste and odour. Other chemical disinfectants do not react with ammonia.

Natural organic matter and colour

Dissolved natural organic matter reacts with chemical disinfectants to varying degrees, generating undesirable disinfection by-products. The principal concern under the current water quality regulations is the formation of trihalomethanes (THMs) by chlorination. Coloured waters are likely to be particularly high in dissolved organic matter. Another group of halogenated organic compounds, haloacetic acids (HAAs), are included in the proposed revisions of the Drinking Water Directive and thus are likely to be incorporated into future UK regulations.

pH

The pH of the water influences the disinfection strength of chlorine. The pH for chlorine disinfection should be less than pH 8. The disinfection strength of chlorine dioxide is relatively insensitive to pH across the range pH 6-9.

Section P2: Is there adequate pre-treatment (e.g. cartridge filters) in place if required?

Options for treatment of water quality parameters that can interfere with chemical disinfection include those given below. Further guidance on treatment processes is available from the DWI website: http://www.dwi.gov.uk/private-water-supply/installations/treatment-guide.html

Turbidity

For small supplies, disposable cartridge filters are suitable. Media filters with backwash facility might be more appropriate for larger supplies. Membrane filtration is another option.

Iron and manganese

Removed by oxidation and filtration using catalytic media in proprietary units.

Hydrogen sulphide

For low concentrations of hydrogen sulphide, granular activated carbon (GAC), aeration or a combination of the two may be sufficient. Catalytic media used for iron and manganese removal may also oxidise hydrogen sulphide. Oxidation by chlorine is another option.

Natural organic matter and colour

Removed by activated carbon cartridges, ion exchange, or some types of membrane filter.

Ammonia

Ammonia reacts with chlorine, and if present in trace amounts can be removed by a process known as breakpoint chlorination. The chlorine consumed by reactions with ammonia is not available for disinfection. Higher concentrations of ammonia are problematic – the amount of chlorine required for breakpoint chlorination can be excessive, and the process is difficult to control, with a risk of generating chloramines which have objectionable taste and odour.

1.2.3 Treatment plant: Disinfection: chlorination

Section S4: Are the chemicals of drinking water grade?

Solutions of sodium hypochlorite with a bromate concentration compliant with the BS EN 901:2013 Type 1 specification should generally be used. If there is potential for the chlorine dose to exceed 4 $mgCl_2/L$, a solution with a bromate concentration lower than that permitted by the Type 1 specification should be used.

Where sodium hypochlorite is generated by on-site electrolysis (OSE) of brine using non-membrane OSE equipment, salt which meets the specifications for Type 1 product under BS EN 14805:2008 should be used.

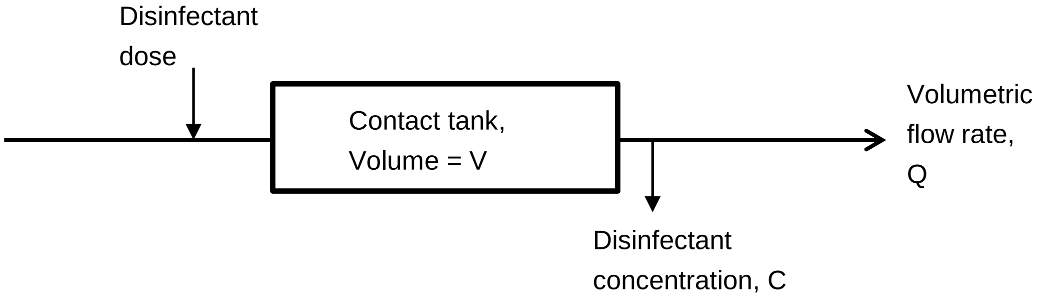
Section S5: Is the existing dosing effective?

The effectiveness of a chemical disinfectant depends on both the concentration, C, of the chemical and the contact time, t. The regulations that apply in England and Wales do not prescribe values of C or t. The World Health Organisation[1] (WHO) recommends that for disinfection of bacteria and viruses:

- There should be a free chlorine concentration of ≥ 0.5 $mgCl_2/L$ after at least 30 minutes contact time, at pH < 8.0.
- Turbidity should not exceed 1 NTU.
- At the point of delivery, the minimum free chlorine concentration should be 0.2 $mgCl_2/L$.

The free chlorine concentration must be measured after the contact time has elapsed, as indicated in Figure 1.

Figure 1 Schematic of chemical disinfection system



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[1] WHO (2017). Guidelines for Drinking-water Quality (4th edition incorporating the First Addendum). http://apps.who.int/iris/bitstream/handle/10665/254637/9789241549950-eng.pdf;jsessionid=333F280D00A8B037844DDA7A2B142A1B?sequence=1

$$\textit{Hydraulic residence time,} \quad HRT = \frac{V}{Q}$$

The *effective* contact time is less than the hydraulic residence time (HRT) as defined in Figure 1 because of short-circuiting. A purpose-designed contact tank is configured to promote plug flow, which means minimising short-circuiting, stagnant zones and axial mixing, such that each discrete volume of water passing through the tank has a similar residence time as close as possible to the HRT. This is achieved in various ways, including:

- The inlet should disperse the flow over the full width and avoid jetting.
- The outlet should collect the flow from across the full width and avoid discharging from a single point.
- In the absence of baffles, a longer, narrower tank is preferable to a shorter, squat tank.
- There may be baffles within the tank to promote a longer, narrower flow path.

Features that will promote short-circuiting include:

- Relatively small-bore inlet pipe entering tank through the wall, discharging in the general direction of flow.
- Relatively small-bore outlet pipe leaving tank through the wall.
- Bell-mouth or stand-pipe type outlet.
- Inlet and outlet at same end of the tank.

In practice, it is often the case with private supplies that the dosed water discharges into a storage tank that is essentially a service reservoir rather that a contact tank, and which was not designed with hydraulic efficiency in mind. The HRT may be very large – from many hours to days – in which case if there is a measurable chlorine residual at the outlet it can be reasonably assumed that the WHO recommendation has been met in terms of chlorine residual and contact time. If the HRT is less than 6 hours, a closer inspection of the tank is advisable to check if severe short-circuiting is possible. If HRT is less than 2 hours, a closer inspection of the tank is essential, because if poorly designed the risk of not providing an effective contact time of 30 minutes is high.

Flow in a pipe is inherently closer to plug flow than can be achieved in a tank, and if there is no contact tank then the distribution system may provide sufficient effective contact time.

Records of all chlorine residual measurements should be available from the supply owner/operator. Small systems might not have a flowmeter, but should have a water meter, from the readings of which the flow rate can be estimated.

1.2.4 Treatment plant: Other

Section T1: Are all chemicals used for water treatment approved and in date?

Specific advice for storage of sodium hypochlorite solution

Sodium hypochlorite solutions should not be exposed to light.

Long-term storage of high-strength solutions (14-15% active chlorine) is incompatible with the current regulatory requirement to minimise disinfection by-products because of the generation of chlorate as hypochlorite decays, and risks breaching a future PCV for chlorate of 0.25 mg/L that has been proposed by the EU. Ideally, 14-15% solutions should be stored at a temperature below 15ºC. At temperatures above 15ºC, such solutions should ideally be used within one month. At 15ºC, such solutions should ideally be used within 2 months, and at lower temperatures should ideally be used within 3 months.

If it is necessary to store sodium hypochlorite solution during the summer for longer than 1 month in the absence of temperature control, a lower strength solution (e.g. 10% active chlorine) should be considered.

Each container of solution should be consumed as a batch. Fresh solution should not be mixed with older stock.

Specific advice for on-site electrolysis (OSE) generated sodium hypochlorite solution

OSE-generated solution should be consumed within 2 days of production.

For non-membrane OSE equipment, salt with a bromide concentration lower than that permitted for a Type 1 product under BS EN 14805:2008 is preferable. BS EN 14805:2008 Type 2 salt should not be used.

Specific advice for chlorine dioxide

There is a regulatory restriction (in Annex 2 of the Approved Products list[2], which applies under PWS Regulation 5) on how much can be dosed: the sum of chlorine dioxide, chlorate and chlorite concentrations must not exceed 0.5 mg/L. The practical consequence is that unless there is close control of dose, it should be limited to 0.5 mg/L.

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[2] http://www.dwi.gov.uk/drinking-water-products/approved-products/index.htm

1.2.5 Distribution: Distribution network

Section V3: Is there evidence of disinfection by-products in the network?

While a high free chlorine concentration does impart taste and odour, and will increase by-product formation, THMs themselves are unlikely to be detectable by taste.

A strong chlorinous taste could indicate the presence of chloramines, and thus of ammonia in the raw water.

If using chlorine dioxide, chlorite and chlorate are generated as by-products. As a consequence, there is a regulatory restriction (in Annex 2 of the Approved Products list[19], which applies under PWS Regulation 5) on how much chlorine dioxide can be dosed: the sum of chlorine dioxide, chlorate and chlorite concentrations must not exceed 0.5 mg/L. The practical consequence is that unless there is close control of dose, it should be limited to 0.5 mg/L.

1.2.6 Distribution: Storage

Section W8: Are the reservoirs regularly maintained and cleaned with appropriate records?

Sediment can harbour bacteria, so is not desirable. If a reservoir requires periodic cleaning to remove accumulations of sediment, then the source of the sediment should be investigated as it would suggest inadequate treatment is being applied before disinfection; the sediment could be due to particulate material in the raw water, or precipitation of dissolved metals. Alternatively, there could be ingression.

1.3 Sources of additional information

Further information can be obtained from:

- The Drinking Water Inspectorate (DWI) (http://dwi.defra.gov.uk/private-water-supply/index.htm)
- Private Water Supplies (Technical and Sampling Manuals) (www.privatewatersupplies.gov.uk)
- Manual on Treatment for Small Water Supply Systems (updated report) (http://www.dwi.gov.uk/private-water-supply/RHmenu/Updated%20Manual%20on%20Treatment%20for%20Small%20Supplies.pdf)
- Principles and Practices of Drinking-water Chlorination (WHO)

(http://www.searo.who.int/entity/water_sanitation/documents/Drinking_Water_Chlorination/en/)