TGN8 - WATER TREATMENT - DISINFECTION

Introduction

All drinking water must be disinfected prior to supply. 'Disinfection' is defined under the Water Supply (Water Quality) Regulations 2016 and their equivalents in the devolved administrations as "*a process of water treatment to remove, or render harmless to human health every pathogenic micro-organism and pathogenic parasite that would otherwise be present in the water; and 'disinfected' shall be construed accordingly".*

This definition makes it clear that all microbiological hazards that may be present in the catchment (either intermittently or continuously) should be understood, taking into account their likely impact on the source water and variations brought about by environmental conditions. The treatment process(es) should be designed and operated to ensure the effective removal or inactivation of these organisms. Further, disinfection should be seen (where necessary) as a *series* of treatment processes whose *cumulative* effect results in a final water that is safe and pathogen free. It is important to recognise therefore, that the disinfection of many source waters does not merely refer to chlorination.

Water treatment processes should be matched and optimised to the quality characteristics of the water source(s) and they should be capable of producing adequately disinfected water for all the expected variations of raw water quality.

The Regulations do not specify the type of treatment process(es) required to achieve safe drinking water however, they do require water to have been pre-treated (where necessary) to ensure that it is adequately prepared for the final stage of disinfection (e.g.: chlorination or ultraviolet irradiation). Further, they specifically require that any of its properties (e.g.: pH) or substances (e.g.: ammonia) that are known to adversely affect disinfection have been modified accordingly and that water entering the final stage of disinfection has a turbidity of less than 1 Nephelometric turbidity unit (NTU).

The Regulations also require water undertakers and combined licensees to 'verify the effectiveness of disinfection'. Companies must be able to demonstrate how the disinfection process is designed for the microbiological challenges in the raw water and that the process(es) are operating within the design criteria. On its own, the absence of 'indicator bacteria' is insufficient evidence to show that water has been disinfected.

Finally, the Regulations require Companies to keep disinfection by-products "as low as possible" *without* compromising the effectiveness of disinfection.

Companies should have a written Disinfection Policy (supported by appropriate peer-reviewed scientific literature) to demonstrate that their disinfection processes (both removal and/or inactivation) are appropriately designed and operated to meet the microbiological and quality challenges present in the source water. The Drinking Water Inspectorate expects that such Disinfection Policies are approved by an appropriate Director of the company.

In addition to a company's Disinfection Policy, each water treatment works should have specific procedures that document how disinfection is achieved and ensure that the policy is effectively implemented. Such procedures should identify and document the critical control points for disinfection at each site.

Water treatment requires expert supervision and well-trained staff to ensure public health is not put at risk and that water quality standards are maintained. Operatives should have attained qualifications in

water treatment in accordance with the national Competent Operator Scheme (administered by EU Skills Ltd).

This TGN describes a range of good practice for ensuring water is adequately disinfected.

Good Practice

Physical Removal Processes

1. A risk assessment of the microbiological hazards likely to be present within the raw water should be carried out for each WTW.

2. Raw water monitoring for microbiological parameters should be carried out to assist the verification of the capability of the disinfection process. Processes should be in place to ensure that any significant changes in microbiological quality detected by such monitoring are acted upon.

3. Effectively managed solid/liquid separation processes may be necessary to remove pathogens which are resistant to chemical inactivation or ultraviolet irradiation.

4. Treatment processes should be operated within their process design criteria to achieve optimum performance. Specific and documented risk assessments should be carried out where processes are required to be operated outside of their 'design envelope'.

5. Many of the recommendations from the three expert group reports[1] on *Cryptosporidium* are still valid and Companies should satisfy themselves that their disinfection processes remain consistent with this guidance.

6. Coagulation, flocculation and clarification processes should be optimised with respect to turbidity and/or organic carbon removal and residual coagulant concentration. Coagulants, and where required, coagulant and/or flocculant aids should be used that are appropriate for the raw water quality and treatment process. Regular checks should be carried out to confirm process performance and optimisation.

7. Sand filters should be optimised in respect of turbidity removal. Filtration rates should be kept constant as far as practicable and maximum filtration rates, maximum filter flows and maximum rates of change should be determined. Backwashing should be optimised to prevent particle breakthrough.

8. Routine media depth checks should be made and recorded and be supported by procedures for media replacement and top-up.

9. Slow sand filters should have an appropriate cleaning regime, and should not be brought back into service without an adequate ripening period.

10. Turbidity should be monitored on-line at the critical stages in the water treatment process with appropriate alarms and shutdown systems as necessary.

11. The requirement for monitoring for Cryptosporidium should be determined by risk assessment.

12. Where granular activated carbon (GAC) is used, appropriate consideration should be

given to

- how the growth, accumulation and subsequent release of micro-organisms (and animalcules) from the media into the water stream may impact disinfection and
- the potential impact of returning adsorbers to service that may have become anoxic (and hence contain reducing compounds) during their outage.

13. Where membrane filtration processes are used as a primary disinfection barrier, appropriate monitoring of the integrity of the membranes should be in place. The performance characteristics of such membranes for removing organisms of a particular size should be documented and verifiable.

14. General water hygiene practices should be in place to prevent inadvertent contamination. Restricted operations areas should be identified and appropriate methods to prevent vermin access to such partially and fully treated water should be in place.

Chlorination Processes

1. Raw and partially treated water monitoring should be used to establish the likely microbiological challenge from those organisms intended to be inactivated by chlorination or UV) processes.

2. Where chlorination is used, the Ct required should achieve the required degree of inactivation under all operating ranges and conditions.

3. The hydraulic performance of tanks used for chlorination should be determined (for example by the use of tracer tests). Such tanks should preferably be designed and operated to achieve optimum "plug flow" conditions.

4. On-line chlorine residual monitoring (for free and/or total chlorine) should be carried out at critical control points to provide an on-going verification that Ct targets are being achieved. The requirement for multiple instrument monitoring (i.e.: dual or triple validation) should be assessed.

5. Alarms should be set to minimise the risk of inadequately disinfected water being supplied. Process loop times (i.e.: "dead-bands") should be minimised.

6. Where practicable, automatic shut-down mechanisms should be installed to prevent inadequately disinfected water being supplied. Where such "failsafe" mechanisms are not practicable, companies should satisfy themselves that operator response times provide a sufficient margin of safety.

7. Consideration should be given to the need for on-line monitoring of pH, especially where this is liable to fluctuate sufficiently to affect the chlorination process.

8. Final water chlorine residuals should be set to balance the need to maintain a residual disinfectant concentration within the supply network with the potential for customer complaints and disinfection by-product formation.

9. Disinfection by-product control – reference should be made to the associated guidance document for the aforementioned Regulations e.g. "Guidance on implementing the Water Supply (Water Quality) Regulations in England and Wales " .

Other Chemical Inactivation Processes

1. Ozone is not often used in the United Kingdom as a primary disinfectant due to a variety of factors including, control and monitoring issues, cost, health and safety and lack of a stable and persistent residual in treated water.

2. Despite these factors, numerous recent scientific studies on the efficacy of ozone as a disinfectant have shown it to be a powerful oxidant and effective against a wide-range of micro-organisms. Note, that for many organisms, these doses are higher than those required for pesticide removal.

3. Therefore, where ozone is used as a primary disinfectant (or is relied upon as part of the overall disinfection process), companies should have in place process validation, verification and control strategies similar to those applied for chlorination.

4. This approach should be used for any other disinfectant process deployed (e.g.: chlorine dioxide, chloramination, peroxide)

Ultraviolet (UV) Irradiation

1. In 2010, the Drinking Water Inspectorate issued 'Guidance on the use of Ultraviolet (UV) irradiation for the disinfection of public water supplies'. This document was reviewed and reissued in 2016. Companies who use, or wish to use, UV for this purpose should consult this detailed document.