be equally effective. However, in healthcare premises, careful consideration should be given to any equipment that is connected to the water system that may be affected by the application of a biocide, eg renal and haemodialysis units. Due to the extremely sensitive nature of renal water plants, for healthcare premises reference should be made to *Water systems: Health Technical Memorandum 04-01* Part B (for England and Wales), or to *Scottish Health Technical Memorandum 04-01* (for Scotland).

2.86 If hot water is not needed for other reasons, eg for kitchens or laundries, and there is no requirement to store hot water at 60 °C (or distribute at 50 °C), then hot water temperatures can be reduced. As reducing hot water temperatures will leave the system vulnerable if there are any lapses in the biocide control regime, the control system should be checked at least weekly to ensure it is operating effectively and continuing to control legionella.

2.87 Any reduction of hot water temperatures should be carried out in stages and temperatures only reduced when efficacy against legionella is confirmed, with monitoring for legionella and biocide levels in the water system carried out at each stage.

2.88 However, reducing calorifier temperatures to below 60 °C, and using a biocide as the primary control measure, is currently not permitted in healthcare premises where there are patients who are at an increased risk of contracting legionnaires' disease. Healthcare premises should refer to *Water systems: Health Technical Memorandum 04-01* Part B (for England and Wales), or to *Scottish Health Technical Memorandum 04-01* (for Scotland).

2.89 It is essential that these water treatment programmes are monitored to demonstrate that the programmes are working within the established guidelines and are effective in controlling legionella bacteria in water systems. The frequency of monitoring and test procedures will vary according to the method selected.

2.90 Biocides used to treat water systems where water is used for domestic purposes may be contrary to water legislation and may make the water unwholesome. These systems should be selected with care and must comply with the requirements of The Water Supply (Water Quality) Regulations 2001 and for Scotland, The Water Supply (Water Quality) (Scotland) Regulations 2001[29] and 2010.[30] Additionally, the installation of any biocidal system must comply with the requirements of The Water Supply (Water Fittings) Regulations 1999 and for Scotland, the Scottish Water Byelaws 2004.

Chlorine dioxide

2.91 Chlorine dioxide is an oxidising biocide/disinfectant that when used correctly, has been shown to be effective at controlling both legionella and biofilm growth in hot and cold water systems. In the appropriate application, it may be used to aid legionella control where maintaining a conventional temperature regime is difficult or where the removal of all dead legs and little used outlets is impractical. Chlorine dioxide is usually produced on site from a chlorite-based precursor using a chlorine dioxide generator or dosing system by reaction with one or more other chemical precursors or by a catalytic oxidation process.

2.92 Use of chlorine dioxide as a legionella control strategy is subject to BS EN 12671:2009[31] and national conditions of use require that the combined concentration of chlorine dioxide, chlorite and chlorate in the drinking water does not exceed 0.5 mg/l as chlorine dioxide.

2.93 Establishing and maintaining a chlorine dioxide residual (as total oxidant) of 0.1– 0.5 mg/l at an outlet is usually sufficient to control legionella in the preceding

pipework, although in a heavily colonised system higher residuals may be necessary. The dosage rate of chlorine dioxide required to achieve this residual will be dependent on the length and complexity of the water distribution system, the water turnover rate and the extent to which the water system is contaminated with an established biofilm. In a relatively clean water system with a high water turnover, a dosage rate of up to 0.5 mg/l is usually sufficient to achieve the desired residual at the outlets. While chlorine dioxide is not affected by the pH or hardness of the water, it is sometimes difficult to monitor chlorine dioxide samples in domestic HWS due to its increased volatility causing the chlorine dioxide reserve to be lost when taking a water sample. In a system containing infrequently used outlets, a programme of regularly flushing the outlets should be maintained until a chlorine dioxide residual is detected.

2.94 Chlorine dioxide is a water soluble gas and can penetrate and control established biofilms. If a system is heavily colonised then it will have a significant chlorine dioxide demand and it may be some considerable time before a stable chlorine dioxide residual is established at the extremities of the system. During the clean-up phase, it may be necessary to maintain a higher dosage rate than 0.5 mg/l and outlets normally used for drinking purposes will require additional controls. In such cases, an offline super-disinfection with an elevated level of chlorine dioxide (20– 50 mg/l) may be necessary, but this should only be undertaken following a detailed risk assessment and the system should be flushed through thoroughly after cleaning.

2.95 Where some of the water is used for drinking purposes, but the desired microbial control cannot be achieved without the combined total oxidant levels at the outlets exceeding 0.5 mg/l then the relevant outlets should be clearly labelled as unsuitable for drinking. Alternatively, the oxidants can be removed from the water at the POU by means of a suitable activated carbon-based drinking water filter. However, where such outlets are in neonatal or augmented care units, these should be clearly labelled as unsuitable for ingestion, including making up neonates' feeds.

2.96 When introducing chlorine dioxide, the dosing system should typically be installed, for a combined hot and cold water system, on the inlet to the tank supplying water to the remainder of the system. For a hot water system, this would be on the cold water inlet to the calorifier. The dosage of chlorine dioxide should be proportional to the water flow and the dosing system should incorporate safeguards to prevent inadvertent overdosing. In the case of hot water distribution systems with calorifiers/water heaters operating conventionally (ie at 60 °C), there will be a tendency for chlorine dioxide to be lost by 'gassing off', especially if the retention time in a vented calorifier/water heater is long. In most cases, however, some level of total oxidant should be found in the hot water, although at concentrations far less than the 0.5 mg/l injected.

2.97 It may be difficult to establish the desired chlorine dioxide residual throughout all areas of a large complex water distribution system from a single dosing point, particularly if it is colonised by an established biofilm. Installing satellite-dosing systems may be needed to boost the residual at key areas, such as interposing tanks or upstream of calorifiers.

2.98 Excessive levels of chlorine dioxide should be avoided since they can encourage the corrosion of copper and steel pipework and high levels of chlorine dioxide can degrade certain types of polyethylene pipework particularly at elevated temperatures. Users of chlorine dioxide systems will need to consider these issues and when choosing a system these points should be checked to ensure that the supplier addresses them satisfactorily.

2.99 The chlorine dioxide dosing system should be inspected at least weekly to confirm that it is operating correctly and that there is no evidence of chemical