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Guideline on water treatment systems, dialysis water and dialysis fluid quality for haemodialysis and related therapies

Clinical Practice Guideline

Prepared on behalf of

The Renal Association and The Association of Renal Technologists

October 2015

Review Date 2020

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Conflict of Interest Statement

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Introduction

Water of the appropriate quality used in the preparation of dialysis fluid is an essential requirement of haemodialysis and related therapies. International standards have been developed to promote the installation of fit for purpose water treatment systems for haemodialysis and to safeguard the routine production of dialysis water suitable for use for haemodialysis and haemodiafiltration.

Quality requirements for the water and concentrates used to prepare dialysis fluid, and for dialysis fluid, are provided inBS ISO 13959;2014: *Water for haemodialysis and related therapies*, BS ISO 13958;2014: *Concentrates for haemodialysis and related therapies*, and BS ISO 11663;2014:*Quality of dialysis fluid for haemodialysis and related therapies*[1-3]. In addition the requirements for water treatment equipment are provided in BS ISO 26722;2014: *Water treatment equipment for haemodialysis and related therapies*[4]. BS ISO 23500;2014: *Guidance for the preparation and quality management of fluids for haemodialysis*addresses the quality management of the water treatment system and distribution loop within the renal unit[5]. At the time of preparation of this document BSI have not issued ISO13958:2014 *Concentrates for haemodialysis and related therapies*, and the current British Standard is BS EN 13867:2002+A1:2009*Concentrates for haemodialysis and related therapies*. Copies of the Standards may be purchased at the BSI Online Shop at http://shop.bsigroup.com/or can be accessed via subscription to British Standards Online (BSOL) at http://shop.bsigroup.com/en/Navigate-by/BSOL/

The rationale for the development of these standards is to protect haemodialysis patients from adverse effects arising from known chemical and microbiological contaminants found in water and improperly prepared dialysis fluid.

In spite of the availability of standards, there have been instances of failure to achieve the requirements outlined in the standards, particularly in new build renal units where the responsibility for the water treatment plant operation and monitoring lies outside NHS remit and is provided either by external contractors under a private finance initiative (PFI) or by an equivalent scheme. Under these schemes, responsibility for the delivery of infrastructure and services (such as maintenance) required to provide a public service is transferred to a third party in the private sector.

The recommendations in this guideline have been graded using the modified GRADE system whenever appropriate [6,7]. In addition for clarity and consistency the terminology used in this guideline has been standardised with the BS ISO standards as follows:

"shall" means that compliance with a requirement or a test is mandatory for compliance with the International Standards;

"should" means that compliance with a requirement or a test is recommended but is not mandatory for compliance with the International Standards; and

"may" is used to describe a permissible way to achieve compliance with a requirement or test.

"feed water" is used throughout this guideline tomean water supplied to a water treatment system or an individual component of a water treatment system. Synonyms such as raw water, source water, supply water or potable water may be used instead of feed water.

"product water" is used throughout this guideline to meanwater produced by a water treatment system or an individual component of a water treatment system. Synonyms such as permeate, treated water, purified water or reverse osmosis water may be used instead of product water.However this does not specify any limits, and consequently the International Standards introduce the term dialysis water.

"dialysis water" is used throughout this guideline to meanwater that has been treated to meet the specified limits for chemical and microbial contaminants inBS ISO 13959;2014 and is suitable for use in haemodialysis applications, which include the preparation of dialysis fluid, reprocessing of dialysers, preparation ofconcentrates and preparation of substitution fluid for online convective therapies.

"dialysis fluid" is used throughout this guideline to mean the fluid made from dialysiswater and concentrates that is delivered to the dialyser by the dialysis fluid delivery system. Synonyms such as "dialysate" or "dialysis solution" may be used in place of dialysis fluid.

This guideline incorporates and updates the section on water quality and water treatment for haemodialysis in the haemodialysis module of the 5th edition of the Renal Association Clinical Practice Guidelines [8]. The guidance has been harmonised with the previous guideline on this topic from the European Renal Association whenever possible [9] and also links with guidance from the Department of Health on the requirements for water supplies to healthcare facilities [10,11].

Literature search criteria – Date, Database, Search terms

The guideline, in addition to water and dialysis fluid quality also addresses environmental and sustainabilityaspects. Furthermore, since the last revision of these guidelines there has been increased awareness of the need to risk assess water storage and distribution systems to prevent or control hazardous substances including biological agents such as legionella. Guidance on legal obligations can be found in the Health and Safety Executive publication HSG274 Part 2 & 3 [12, 13]. Since the water is used for the preparation of dialysis fluid, the new version of the guideline also contains recommendations for the specification and operation of haemodialysis concentrate production and distribution systems.

The primary aim of this guideline is to assist the entire multidisciplinary team involved in the provision of safe water treatment for haemodialysis by providing a single, user friendly document for the routine delivery of fit for purpose dialysis water and dialysis fluid, which has been peer reviewed and approved by the membership of the Association of Renal Technologists and Renal Association and other stakeholders.

The second aim is to reduce adverse events that arise from inappropriate planning, installation, operation and maintenance of water treatment facilities and cause risks to patients. This is highly relevant at present as approximately 50% of the water treatment systems for haemodialysis in the UK are at least 10 years old.

It should be emphasised that this document does not replace any of the national standards and the interpretive guidance contained MUST be read in conjunction with the appropriate International Standards [1-5].

The layout of this guideline follows in a logical sequential manner the planning, design, installation validation, routine monitoring and maintenance of the water treatment infrastructure for haemodialysis (Sections 1-5). Additional sections deal with the provision of water treatment for the Intensive Care Unit (ICU), (Section 6),for home haemodialysis (Sections7). A new section relating to Haemodialysis concentrate production and distribution systems has also been added (Section 8)

References

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Summary of clinical practice guideline on water treatment systems, dialysis water and dialysis fluid quality for haemodialysis and related therapies

1. Clinical governance of water treatment facilities for haemodialysis

Guideline 1.1 – Designation of water treatment systems

We recommend that water treatment systems for haemodialysis are CE marked medical devices as defined by the Medical Devices Directive.Manufacturers should also comply with BS EN ISO 13485:2012which sets out the requirements for a quality management system and quality assurance systems relating to the design, development, production, installation and servicing of medical devices. (Not graded)

Guideline 1.2 – Responsibility and governance

The management of water treatment systems, the quality of water produced, and its clinical utilization should be encompassed by the organisations risk management and clinical governance systems.

We recommend that the senior clinician in charge of the renal unit (or designated deputy) has responsibility for the overall clinical governance in respect of water treatment facilities. The verification of efficient operation of the water treatment system should be considered an integral element of the organisations risk management and clinical governance systems. In the current NHS infrastructure the users and operators of water treatment systems for haemodialysis may not be the same. To minimize potential problems, the setting up of a Water Quality Management Group, involving all parties should be considered.(1C)

Guideline 1.3 – Responsibility for planning of new or replacement water treatment systems

We recommend that the clinician (or designated deputy) with responsibility for clinical governance is involved throughout the planning, designation and installation of a new or replacement water treatment system for haemodialysis. (1C)

2. Planning and commissioning of water treatment systems for haemodialysis

2.1 Source and supply of feed water for haemodialysis

Guideline 2.1 - Specification of the water supply for haemodialysis

We recommend that new build renal units should have a direct feed (drinking or potable) water supply separate from that of the hospital water supply. If water treatment systems use a hospital water supply there should be awareness of the potential risks that may arise from the introduction of chemicals into the hospital water supply by hospital engineering staff. To prevent the occurrence of adverse effects arising from such actions, the introduction or addition of chemicals into the hospital water supply should not be undertaken without prior consultation with Renal Services. (1C)

2.2 Setting the design specification for the water treatment infrastructure

Guideline 2.2.1 – Specification of the maximum allowable limits for microbiological contaminants in water produced in new water treatment systems

We recommend that all new water treatment infrastructures when used with a rigorous proactive sanitisation strategy shall be capable of producingwater with microbial and endotoxinconcentrations of < 0.1 CFU/mL and < 0.03EU/mL, respectively. (1D)

Guideline 2.2.2 - Design specification of the water treatment system for haemodialysis

We recommend that the complete water treatment, storage and distribution system shall meet the requirements of all of the following standards: (1B)

BS ISO 13959;2014: *Water for haemodialysis and related therapies*,

BS ISO 11663;2014: *Quality of dialysis fluid for haemodialysis and related therapies,*

BS ISO 26722;2014: *Water treatment equipment for haemodialysis and related therapies*.

BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*

Guideline 2.2.3 –Design specification of the water treatment system for haemodialysis in a main renal unit haemodialysis facility

We recommend that the specification fora new or refurbished main renal unit haemodialysis facility should specify that the new or refurbished facility should be capable of performing acute haemodialysis 24 hours per day. (Not graded)

Guideline 2.3 – Haemodialysis facilities

Guideline 2.3.1 – Satellite haemodialysis facility

We recommend that the specification for anew or refurbished satellite haemodialysis facility should adhere to the guidelines that are described in Health Building Note 07-01 Satellite Dialysis Unit (2013). (Not graded)

Guideline 2.3.2 – Main renal unit haemodialysis facility

We recommend that the specification fora new or refurbished main renal unit haemodialysis facility should adhere to the guidelines that are described in Health Building Note 07-02 Main Renal Unit (2013). (Not graded)

3. Installation and validation of water treatment systems for haemodialysis

Guideline 3.1 – Installation and validation of water treatment systems for haemodialysis

We recommend that each stage of the installation, performance validation and initial, performance and operational qualification should be agreed and documented in advance and signed off by the manufacturer and the clinician responsible for water quality (or designated deputy). (1C)

4. Operation and maintenance of water treatment systems for haemodialysis

Guideline 4.1 – Routine maintenance and monitoring of water treatment systems

We recommend that the maintenance and monitoring plans for the water treatment plant be established usingthe knowledge acquired during the validation process for the water treatment system in accordance with BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis*. Policies and procedures should be set up to ensure that routine maintenance and monitoring are mandatory and implemented at the earliest opportunity. (1B)

Guideline 4.2 – Operators of water treatment systems for haemodialysis

Guideline 4.2.1 – Training of operators

We recommend that operators should be trained in the use of the water treatment facility by the manufacturer or their UK distributor. The training should be specific to the functions performed. Competence with procedures should be assessed and documented. Periodic audits of the operators' compliance with procedures should be undertaken and documented and there should be an ongoing training programme to maintain the operator's knowledge and skills. (1C)

Guideline 4.2.2 – Continuing education and development of operators of water treatment systems

We suggest that national organisations, such as the Association of Renal Technologists, should participate in the continuing education and development of operators of water treatment systems by arranging training sessions at annual meetings and/or co-ordinating regular training days. (2D)

Guideline 4.2.3 – Continuing education and development of operators of water treatment systems

We suggest that a Renal Technologist, who is not already on the Register of Clinical Technologists, should undertake the Association of Renal Technologist training scheme as this training will provide background knowledge on renal water treatment systems. (2D)

Guideline 4.3 - Monitoring of feed, product and dialysis water for haemodialysis

Guideline 4.3.1 – Routine testing of feed, product and dialysis water for haemodialysis

We recommend that routine testing procedures for dialysis water should form part of the renal unit policy. Each water treatment system should have standard operating procedures in place for sampling, monitoring and recording of feed, product and dialysis water quality. (1C)

Guideline 4.3.2 – Frequency of monitoring of product and dialysis water for haemodialysis

We recommend that the minimum frequency of monitoring of dialysis water should be as follows (1D):

Contaminant	**Frequency of testing**
Total chlorine	At least weekly
Total viable counts	At least monthly
Endotoxin	At least monthly
Chemical contaminants other than chlorine	At least every 3 months

It is normal practice to measure the total chlorine of the product water after the carbon filters as reverse osmosis membranes are susceptible to oxidative damage by free chlorine. The maximum exposure to chlorine of the reverse osmosis membrane should be ascertained from the system supplier. Considerable daily as well as seasonal variations in the chlorine and chloramine levels of the water entering the water treatment system (feed water) are known to exist and therefore the guidance to test for total chlorine at least weekly should be regarded as an absolute minimum.If practical and feasible, testing for chlorine or chloramine on a daily or shift basis is recommended. It is however recognised that such an approach may place an undue burden on staff, and if it can be demonstrated that the chlorine levels in the feed water are consistently low (<0.5 mg/L) and chloramines are not used, then

weekly monitoring of the dialysis water is sufficient. However, if chloramines are used and the level of total chlorine in the feed water exceeds 1.0 mg/L, daily or shift based monitoring should be adopted.

Guideline 4.3.3 – Records of monitoring

We recommend that records should be kept of all chemical and microbiological test results and remedial actions in respect of feed water and dialysis water. If the interval between sample testing exceeds those indicated in the Table in 4.3.2, documentation should be in place to demonstrate that the sampling schedule used has been based on trend analysis.The operating procedures should include details of the procedures to be followed if the prescribed limits are exceeded. Records of feed water contaminants can be obtained from the municipal water supplier. However there should be awareness that if the supply to the renal unit water system is not 'direct feed' the possibility exists that chemicals may have been added to minimize legionella contamination. (1C)

Guideline 4.4 – Mutual responsibilities of water supply companies and renal units

We recommend thatrenal units shall inform the water supply companies of the location of all home haemodialysis patients as well as haemodialysis units so that the water companies are empowered to inform the renal unit of changes in supply delivery arising out of remedial or other work to the distribution system. Water companies should also advise the renal unit if there are plans to alter the range of chemicals added to the water supply to ensure compliance with the drinking water directive. (Not graded)

5. Monitoring the quality of dialysis water for haemodialysis and dialysis fluids

Guideline 5.1: Chemical contaminants in dialysis water used for the preparation of dialysis fluid

We recommend that the concentrations of chemical contaminants in product water used to prepare dialysis fluid shall not exceed the limits stated in BS ISO 13959;2014: *Water for haemodialysis and related therapies.* A programme of improvement should begin immediately if routine monitoring demonstrates that concentrations of chemical contaminants exceed the maximum allowable limits. (1B)

Guideline 5.2: Microbiological contaminants in dialysis water used for the preparation of dialysis fluid

Guideline 5.2.1 – Maximum allowable concentrations of microbiological contaminants in dialysis water used for the preparation of dialysis fluid

We recommend that the quality of water produced by the water treatment system shall meet the concentration limits for microbiological contaminants detailed in BS ISO 13959:2014. This states that dialysis water shall contain a total viable microbial count of less than 100 CFU/ml and an endotoxin concentration of less than 0.25 EU/ml. If routine monitoring demonstrates microbiological contaminant levels in excess of 50% of the maximum permitted levels (based on the analysis of historic data) a programme of corrective measures should be commenced immediately. (1B)

Dialysis water containing a total viable microbial count of less than 100 CFU/ml and an endotoxin concentration of less than 0.25 EU/ml is also the starting point in the production of ultrapure dialysis fluid or for on line infusion fluid used in haemodiafiltration (HDF). This is generally achieved by point of use filters forming part of the dialysis machine in use. BS ISO 23500:2014 states there is no requirement to test for bacterial growth or endotoxins when the haemodialysis system is fitted with endotoxin retentive filters that are operated according to the manufacturer's instructions, unless the manufacturer requires the test to be performed

Guideline 5.2.2 – Methods of measuring microbiological contaminants in dialysis water used for the preparation of dialysis fluid

We recommend that the test procedures used for monitoring microbial contamination of water for dialysis be standardised and appropriate to the type of organisms found in water. The test procedures should be adhered to stringently. (1C)

Guideline 5.3 - Preparation and composition of dialysis fluid

Dialysis fluid is produced by the mixing of dialysis water with acid and bicarbonate concentrates. The microbiological contaminant levels for acid and bicarbonate concentrates are defined in BS ISO 13958; 2014: *Concentrates for haemodialysis and related therapies*. For dialysis fluid thus produced, or if non bicarbonate buffered or modified bicarbonate buffered dialysis fluid is used, we recommend that the microbiological contaminant levels of the dialysis fluid shallnot exceed those cited in BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*. (1B)

Guideline 5.4- Quality of dialysis fluid

We recommend that dialysis fluid production uses dialysis water produced by compliance with the requirements of BS ISO 13959;2014: *Water for haemodialysis and related therapies*. The dialysis fluid thus produced should additionally comply with the requirements of BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*, namely that dialysis fluid shall contain a total viable microbial count of less than 100 CFU/ml and an endotoxin concentration of less than 0.5 EU/ml with action levels set typically at 50% of the maximum permitted levels

Standard dialysis fluid is considered as the minimum quality, ultrapure dialysis fluid is recommended for routine haemodialysis and ultrapure dialysis fluid is mandatory for creating on-line prepared substitution fluid used in convective therapies such as on-line haemodiafiltration. The process used for the production of on-line prepared substitution fluid shall bevalidated by the system manufacturer to produce fluid that is sterile and non-pyrogenic.We recommend that all haemodialysis dialysismachines are fitted with endotoxin retentive filter (s) topermit the production of ultrapure dialysis fluid. (1B)

Guideline 5.5 - Responsibility for policies for monitoring and recording of quality of dialysis water and dialysis fluid

We recommend that the senior renal technologist shall be the person responsible for ensuring concordance with policies for monitoring and recording of the quality of dialysis water and dialysis fluid. If this person is absent from work, procedures shall be in place to ensure continuance of policies. (Not graded)

6. Water treatment systems for the treatment of acute kidney injury

This section deals with portable water treatment systems intended for use with a dialysis delivery system to deliver dialytic therapies at the bedside. This section excludes equipment that may be used to supply three or more points of use in an “acute dialysis” setting. These systems are considered “central” water systems and thus are covered by the preceding section.

Guideline 6.1 - Water Treatment systems

We recommend that water treatment systems for haemodialysis are CE marked medical devices as defined by the Medical Devices Directive. Manufacturers should also comply with BS EN ISO 13485:2012which sets out the requirements for a quality management system and quality assurance systems relating to the design, development, production, installation and servicing of medical devices. (Not graded)

Guideline 6.2 - Water supply

We suggest that a direct feed for water is used where haemodialysis is undertaken in a non-dialysis unit setting. (Not graded)

Guideline 6.3 - Backflow prevention

We recommend that a backflow prevention device should be installed at the point of connection to the potable water system. (Not graded)

Guideline 6.4 - Electrical safety

We recommend that the water treatment systems used in an acute kidney injury treatment setting should comply with applicable electrical safety standards regarding electrostatic discharge (ESD), electromagnetic compatibility (EMC), and any other electrical safety standards as outlined in IEC 60601 1. Portable water treatment system component enclosures should possess a level of water resistance equal to IEC 60529 IPX 1. (Not graded)

Guideline 6.5 - Microbial control strategies

Guideline 6.5.1 - Prevention of bacterial proliferation in the water delivery system

We recommend thatany water system for intermittent use for haemodialysis for acute kidney injury outside the renal unit should be designed and maintained to minimize bacterial proliferation. (Not graded)

Guideline 6.5.2 - Endotoxin retentive filters

We recommend that, due to the intermittent nature of equipment use, a point of use endotoxin filter should be used in order to provide a safety barrier. This filter should be discarded at the end of the schedule of treatments performed on the patient. (Not graded)

Guideline 6.6 - Frequency of monitoring of dialysis water used for the preparation of dialysis fluid for haemodialysis for acute kidney injury

We recommend that the chemical and microbial quality of the treated or product water used for the preparation of dialysis fluid in acute haemodialysis setting should be monitored according to a schedule determined by the frequency of use. (Not graded)

Guideline 6.7 - Policy for monitoring and recording of quality of dialysis water for haemodialysis for acute kidney injury

We recommend that the senior renal technologist shall be the person responsible for ensuring concordance with policies for monitoring and recording of the quality of dialysis water and dialysis fluid. If this person is absent from work, procedures shall be in place to ensure continuance of policies. (Not graded)

7. Water treatment systems for home haemodialysis

This section deals with water treatment equipment used in the patient's home, and applies to equipment that has been designed to deliver dialytic therapies at a patients home.

Guideline 7.1 - Water treatment systems

We recommend that water treatment systems for haemodialysis are CE marked medical devices as defined by the Medical Devices Directive. Manufacturers should also comply with BS EN ISO 13485:2012which sets out the requirements for a quality management system and quality assurance systems relating to the design, development, production, installation and servicing of medical devices. Additionally, the equipment used in the home environment should comply with the requirements of BS EN 60601-1-11:2015 Medical electrical equipment - Part 1-11: General requirements for basic safety and essential performance - Collateral standard: Requirements for medical electrical equipment and medical electrical systems used in the home healthcare environment (Not graded)

Guideline 7.2 – Maintenance of the water and power supply

We recommend that the utility companies providing water and power to the patient's home be notified that home dialysis is being performed, and that they have details of patients' addresses on their risk register to ensure that patients are notified of any proposed interruption of supply and that restoration of supply is a priority. (Not graded)

Guideline 7.3 – Training of the patient and/or helper

We recommend that the patient and/or helper in the home should be formally trained in the correct operation and maintenance of the water treatment system by an appropriately trained technologist. There should be a record of the training, and the patient and /or helper should keep a log of the maintenance and monitoring procedures. (Not graded)

Guideline 7.4 – Home haemodialysis installations

We recommend that all installations for home haemodialysis should include carbon filters/beds with built in redundancy, heat disinfection, a reverse osmosis unit and point of use ultrafiltration. If needed, a water softener should also form part of the treatment process. When installing a new haemodialysis water treatment system in the home, the installation must comply with BS EN 60601-1-11;2010 *Requirements for medical electrical equipment and medical electrical systems used in the home healthcare environment*. (1C)

Guideline 7.5 – Frequency of monitoring of water used for home haemodialysis

Guideline 7.5.1 – Frequency of monitoring of feed or source water used for home haemodialysis

We recommend that if used, water from a private well should be tested for chemical and microbial quality at least every six months whereas the chemical and microbial quality of water from municipal suppliers should be assessed annually using data obtained from the supplier. (1C)

Guideline 7.5.2 – Frequency of monitoring of dialysis water used for the preparation of dialysis fluid for home haemodialysis

We recommend that the chemical and microbial quality of the water used for the preparation of dialysis fluid for home haemodialysis should be monitored at least every six months. (1C)

8. Haemodialysis concentrate production and concentrate distribution systems

Guideline 8.1 - Specification of haemodialysis concentrate production and concentrate distribution systems

We recommend that haemodialysis concentrate production and distribution systems meet the requirements of ISO 13958:2014: *Concentrates for haemodialysis and related therapies* and are CE marked medical devices as defined by the Medical Devices Directive. (Not graded)

Guideline 8.2 – Operation of haemodialysis concentratemixer systems and concentrate distribution systems

We recommend that concentrate mixer systems should be operated according to the manufacturer instructions. (Not graded)

Particular attention is required to comply with instructions required to test batches of concentrate or to disinfect the equipment. The disinfection of acid concentrate tanks is not normally necessary as the fluid is bacteriostatic.

Rationale of clinical practice guideline on water treatment facilities, dialysis water and dialysis fluid quality for haemodialysis and related therapies

1. Clinical governance of water treatment facilities for haemodialysis

Guideline 1.1 – Designation of water treatment systems as patient equipment

We recommend that water treatment systems for haemodialysis are CE marked as defined by the Medical Devices Directive. Manufacturers should also comply with BS EN ISO 13485:2012which sets out the requirements for a quality management system and quality assurance systems relating to the design, development, production, installation and servicing of medical devices. (not graded)

Guideline 1.2 – Responsibility for clinical governance

We recommend that the senior clinician in charge of the renal unit (or designated deputy) has responsibility for the overall clinical governance of the water treatment system.The verification of efficient operation of the water treatment system should be considered an integral element of the organisations risk management and clinical governance systems.In the current NHS infrastructure the users and operators of water treatment systems for haemodialysis may not be the same.To minimize potential problems, the setting up of a Water Quality Management Group, involving all parties should be considered. (1C)

Guideline 1.3 – Responsibility for planning of new or replacement water treatment facilities

We recommend that the clinician (or designated deputy) with responsibility for clinical governance is involved throughout the planning, designation and installation of a new or replacement water treatment system for haemodialysis. (1C)

Rationale for 1.1-1.3

The water treatment systems for haemodialysis and related therapies should be CE marked to ensure compliance with the regulations and standards which have been established for such equipment. Manufacturers should also comply with BS EN ISO 13485:2012 which sets out the requirements for a quality management system and quality assurance systems relating to the design, development, production, installation and servicing of medical devices

The overall responsibility for the care of the dialysis patient rests with the clinician.Informed engagement from the clinical director in respect of water quality is essential. [(1)]. The verification of efficient operation of the water treatment system should be considered an integral element of the organisations risk management and clinical governance systems. Due to the technical nature of the treatment system, the clinician in charge may wish to appoint a deputy who may be a senior renal technologist to take responsibility for the water system and to act as line manager for clinical governance.

In the current NHS infrastructure the users and operators of water treatment systems for haemodialysis may not be the same.For example in a renal unit funded through PFI or an equivalent scheme, the operator of the water treatment infrastructure may be an external contractor whilst the user is the renal service. In other instances, operation may be by members of the renal services technical staff or NHS estates staff. To minimize potential problems, the setting up of a Water Quality Management Group, involving all parties should be considered. Such a group ensures that there is collaboration between estates departments (or PFI agents) and EMBE/Med Physics/Clinical Engineering groups responsible for water treatment systems, and that maintenance,testing and result reporting are undertaken, and the results obtained shared, at regular meetings that is attended by the line manager for clinical governance of the water treatment system. In the event of failure to meet the requirements outlined in the appropriate standards, the person responsible for the clinical governance and risk management of the water treatment system is pivotal in undertaking a root cause analysis to establish the cause of any problem, evaluate the associated risks, and determine mitigating steps.

There should be clear lines of communication established between the nephrologist, who is ultimately responsible for the clinical care of the patient, internal or external staff responsible for the operation and maintenance of the equipment. Good record keeping in association with robust lines

ofcommunication should also exist between senior renal unit personnel and those who undertake the monitoring and maintenance of the water equipment plant to ensure that there is a timely transfer of information.
The Medicines and Healthcare Products Regulatory Agency (MHRA) has produced guidance on managing medical devices to outline a systematic approach to the purchasing, deployment, maintenance, repair and disposal of medical devices [(2)] and concordance with this guideline should ensure that the maintenance and monitoring of water treatment systems for haemodialysis are performed by personnel who have a full understanding of theory/maintenance of water treatment for haemodialysis.

Given that the senior clinician and/or technologist will have responsibility for clinical governance of the water treatment system, it is essential that they are closely involved at each stage of the planning, designation, installation and validation of new or replacement water treatment facilities for haemodialysis [(1)]. Commissioners and contractors of new build or refurbished water treatment facilities should liaise with an ART approved, NHS employed, registered Clinical Technologist with renal expertise who has the scope of practice to give advice on the specification, selection process and installation of the new water treatment system.

References

1. ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*
2. Managing Medical Devices. Guidance for healthcare and social services organisations, MHRA, April 2015
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/421028/Managing_medical_devices_-_Apr_2015.pdf

2. Planning and commissioning of water treatment systems for haemodialysis

2.1 Source and supply of feed water for haemodialysis

Guideline 2.1 - Specification of the water supply for haemodialysis

We recommend that new build renal units should have a direct feed (drinking or potable) water supply separate from that of the hospital water supply. If thewater treatment system uses a hospital water supply there should be awareness of the potential risks that may arise from the introduction of chemicals into the hospital water supply by hospital engineering staff. To prevent the occurrence of adverse effects arising from such actions the introduction or addition of chemicals into the hospital water supply should not be undertaken without prior consultation with renal services. (1C)

Rationale

Individual components used in the water treatment infrastructure can vary due to feed water quality and product water requirements. The technical features of the water treatment component of that system should be based on the criteria detailed in BS ISO 26722. In addition to the general specifications outlined the system design should also comply with local building and water regulations. If the feed water is from a private well, an annual analysis of the quality of the product water may not be sufficient to ensure that the treatment system will remove all of the contaminants present and a more frequent analysis may be needed if the well is subject to seasonal changes or contamination from sources such as septic tanks, underground fuel storage tanks or agricultural waste and chemicals. Such monitoring might not need to be the full chemical analysis if only certain contaminants are known to be of concern.

Water used to feed the water treatment plant in renal units is generally expected to comply with drinking water requirements. Such water contains chemicals to ensure microbiological safety to the consumer. The commonly used chemical to control microbiological contaminant level in drinking water is chlorine. Chloramine may also be used as an alternative. The presence of both of these compounds is controlled in the water used for the preparation of dialysis fluid. Alternative chemicals may be used such as chlorine dioxide, to control for the presence of Cryptosporidium oocysts. In

water,chlorine dioxide breaks down to yield chlorite, chlorate, and chloride ions. Currently, there is little information about the potential for chlorine dioxide and its daughter products to be toxic to haemodialysis patients. To minimise risk from nosocomial infections, hospitals employ a range of preventive strategies to control for the presence of Legionella in the water distribution system of the building, by the use of chemical agents such as silver-stabilised hydrogen peroxide.

Low-molecular-weight chemical breakdown products are associated with the use of chlorine dioxide and hydrogen peroxide. Such products can pass through the reverse osmosis membrane and are removed only by carbon filtration; however, at high concentrations, there may be incomplete removal. Whilst a separate mains feed to the haemodialysis unit water treatment system will control for the presence of disinfectant breakdown products arising from the local addition of chemicals there should be continued awareness and communication with the water provider to ensure that previously unused chemicals are not introduced into the drinking water supply .

It should be noted that a risk assessment of water storage tanks, softeners and carbon filters within the water treatment system as detailed by HSG274 may require disinfection of these component.[1,2]

References

1.Health and Safety Executive Legionnaires disease Part 2: The control of legionella bacteria in hot and cold water systems
http://www.hse.gov.uk/pubns/priced/hsg274part2.pdf
2.Health and Safety Executive Legionnaires disease Part 3: The control of legionella bacteria in other risk systems
http://www.hse.gov.uk/pubns/priced/hsg274part3.pdf

2.2 Setting the design specification for the water treatment infrastructure

Guideline 2.2.1–Specification of the maximum allowable limits for microbiological contaminants in water produced in new water treatment systems

We recommend that all new water treatment infrastructures when used with a rigorous proactive sanitisation strategy shall be capable of producingwaterwith concentrations of microbial contaminants and endotoxin< 0.1 CFU/mL and < 0.03EU/mL, respectively. (1D)

Guideline 2.2.2 - Design specification of the water treatment system for haemodialysis

We recommend that the complete water treatment, storage and distribution system shall meet the requirements of all of the following standards: (1B)

BS ISO 13959; 2014: *Water for haemodialysis and related therapies*,

BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*,

BS ISO 26722; 2014: *Water treatment equipment for haemodialysis and related therapies*.

BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*

Guideline 2.2.3 –Design specification of the water treatment system for haemodialysis in a main renal unit haemodialysis facility

We recommend that the specification fora new or refurbished main renal unit haemodialysis facility should specify that the new or refurbished facility should be capable of performing acute haemodialysis 24 hours per day. (Not graded)

Rationale

In drawing up the initial design specification providers and users are encouraged to obtain detailed descriptions of all treatment processes used by the water utility, together with the operating manuals

and maintenance procedures from the manufacturer or the vendor providing the water purification and distribution system to permit informed decisions to be made.

The design specification of new water treatment facilities for haemodialysis should refer to and meet all of the BS ISO standards [1-4].

Commissioners should state clearly in the contract specification for tenderers, suppliers and manufacturers of a new or refurbished water treatment facility that the water treatment facility shall comply with the requirements of BS ISO 26722; 2014: *Water treatment equipment for haemodialysis and related therapies*. The water produced should comply with the requirements of BS ISO13959:2014*Water for haemodialysis and related therapies*
The supplier of water treatment equipment is responsible for recommending a method of cleaning the equipment so that dialysis water meeting the microbial requirements of ISO 13959 can routinely be produced when typical feed water is presented. Beyond this qualification, it becomes the responsibility of the user of the system to monitor the system for ongoing compliance with ISO 11663.
It should be noted that ISO 13959 merely states the requirements for dialysis water. Such water, may not without additional treatment (such as by point of use filtration) meet the requirements for ultrapure dialysis fluid. To achieve this, a rigorous and proactive sanitization strategy should be in place. Published data has indicated that in the presence of such proactive measures, monthly microbiological monitoring of dialysis water demonstrated the attainment of <0.1 CFU/ml in 567 of 685 (82.8%) samples and < 0.03 EU/mL in 653 of 663 (98.5%) samples [5] Routine production of high quality product water should utilize point of use filtration in the preparation of ultrapure dialysis fluid from product water and concentrates. Manufacturers of point of use filtration require that they be used in accordance with the manufacturers' instructions.
The use of ultrapure dialysis fluid is associated with a range of clinical benefits [6-9]. Its use for haemodialysis has been associated in the short term with lower indices of inflammatory response (serum CRP and IL-6), in the medium term with better preservation of residual renal function, nutritional status and correction of anaemia and in the longer term may reduce the risk of complications due to dialysis-related amyloidosis. Although the clinical benefits of ultrapure dialysis fluid have not been established in a large scale randomized trial it would seem prudent to ensure that water is as pure as reasonably possible.
The European Best Practice Guideline recommends the use of ultrapure dialysis fluid for all haemodialysis treatments [10].

At the planning stage, the following should also be considered:

- ***Dialysis water capacity during sanitization***
  If heat sanitization is planned for the system, the distribution loop is sanitized along with the links from the distribution loop to the dialysis machines. The demand for water during such sanitization is higher than required by the dialysis machines during operation.

- ***Dialysis water capacity during the winter months.***
  Commonly, reverse osmosis systems capacity is rated at a specified incoming water temperature. There should be awareness that such temperatures may not be achieved during the winter months, and the efficiency of the system will fall. To meet the required water demand there may be a need to pre heat the feed water or to install a plant with increased capacity to compensate for the fall in reverse osmosis efficiency during the winter months.

- ***Use of RO reject water for non drinking applications.***

  HTM 07-04 encourages the reuse of reverse osmosis waste water for applications such as flushing toilets.

- ***Sanitization of the system***
  Integrated heat sanitization of the distribution system and the haemodialysis machines is recommended as this method can be performed regularly with less disruption to dialysis schedules than chemical sanitization. If chemical sanitization is to be used, the period of down time should be sufficient to enable the chemicals to be rinsed completely from the system prior to the commencement of the next dialysis shift.

If it is possible to sanitize the haemodialysis machines at the same time as the distribution ring, then this should be done as this is the easiest and simplest. It may be that the system size will not permit all of the machines to be sanitized at the same time or the dialysis schedules will not allow all to be done at the same time. If this is the case then the renal service should endeavour to arrange the fitting of a dead space free loop, which can be fitted to any machine but may require adaptation of the distribution point at the wall.

- ***Compliance with* BS ISO 13958;2014: *Concentrates for haemodialysis and related therapies***Compliance is only necessary if the hospital/renal unit is producing its own concentrates. If the concentrate is purchased from a commercial supplier they will have already complied with this requirement.

- ***Central concentrate delivery system***
  The installation of a central concentrate delivery system should be considered in new water treatment systems to reduce waste associated with the use of point of use concentrate containers. The users of central concentrate systems responsibilities are outlined in BS ISO 13958:2014

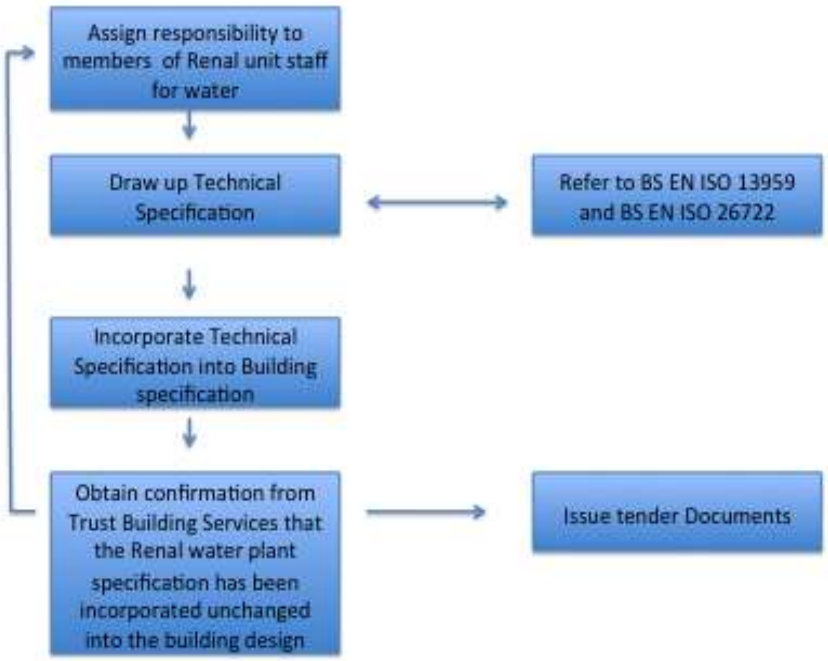
- ***Connectors for non dialysis water outlets within the dialysis area***
  If such connectors are present, there is a risk of dialysis machines being connected. Such risks should be minimized by ensuring that this can not occur, for example by the use of connectors that can only be fitted to the outlet intended for dialysis water supply.
  The use of potable water outlets as a means of supplying water to water treatment systems intended for single patient may occasionally be necessary due to capacity issues or the requirement for emergency dialysis during routine maintenance of the water treatment plant or distribution system. In such circumstances the connectors should only permit the water treatment system and not the haemodialysis machine to be connected to the potable water outlet.

- ***Contingency plans in the event of system failure or malfunction.***
  Contingency plans should describe how to deal with events that completely prevent dialysis from being performed, such as failure of the facility's water supply or electrical service following a natural disaster or water main break. Planning should also address how to deal with unplannedchanges in municipal water quality, such as for example additional chemical dosing of the water supply following work on the distribution system or the introduction of non standard chemicals to control water main infestation.

The layout of the water treatment system should provide easy access to all components of the system, including all meters, gauges, and sampling ports used for monitoring system performance. Critical alarms, such as those associated with deionizer exhaustion or low water levels in a storage tank, when used should be configured to sound in the patient treatment area as well as in the water treatment room.

Figure 1

Planning chart for the design specification of a new water treatment system for haemodialysis.



References

1. BS ISO 13959; 2014: *Water for haemodialysis and related therapies,*
2. BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*
3. BS ISO 26722; 2014: *Water treatment equipment for haemodialysis andrelated therapies*
4. BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*
5. Penne EL, Visser1 L, van den Dorpel MA, van der Weerd1 NC et al.Microbiological quality and quality control of purifiedwater and ultrapure dialysis fluids for onlinehemodiafiltration in routine clinical practice. Kidney Int 2014; 76:665-672
6. Schiffl H, Lang SM, Fischer R. Ultrapure dialysis fluid slows loss of residual renal function in new dialysis patients. Nephrol Dial Transplant 2002; 17:1814-1818
7.Lonnemann G. The quality of dialysate: an integrated approach. Kidney Int 2000; 58(Suppl 76):S112-119
8. Panichi V, Rizza GM, Paoletti S et al. Chronic inflammation and mortality in renal replacement therapies. Results from the RISCAVID study. Nephrol Dial Transplant 2008; 23:2337-2343
9.Furuya R, Kumagai H, Takahashi M, Sano K, Hishida A Ultrapure dialysate reduces plasma levels of beta2-microglobulin and pentosidine in hemodialysis patients. Blood Purif. 2005;23:311-316
10. European Best Practice Guidelines for haemodialysis Part 1. Section IV. Dialysis fluid purity.Nephrol Dial Transplant 2002; 17: Supplement 7 S45-S46
http://ndt.oupjournals.org/content/vol17/suppl_7/index.shtml

11. Health Technical Memorandum 07-04. Water management and water efficiency – best practice advice for the healthcare sector.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/147948/HTM_07-04_Final.pdf

Guideline 2.3 – Haemodialysis facilities

Guideline 2.3.1

We recommend that the specification for anew or refurbished satellite haemodialysis facility should adhere to the guidelines that are described in the NHS Estates Health Building Note 07-01 Satellite Dialysis Unit (2013). (Not graded)

Guideline 2.3.2

We recommend that the specification of a new or refurbished main renal unit HD facility should adhere to the guidelines that are described in the NHS Estates Health Building Note 07-02 Main Renal Unit.(2013) (Not graded)

Rationale

The need for high quality water treatment facilities for haemodialysis is highlighted in the recent WHO guidance on water safety in buildings. [(1)] Water treatment facilities installed in all new and refurbished satellite and main renal unit HD facilities should be integrated within the specification that is required for a modern haemodialysis unit which has been outlinedinthe National Service Framework for Renal Services [(2)] and documented in detailin Health Building Notes 07-01 and 07-02 for satellite and main renal units respectively, published by the Department of Health[(3,4)].

There has been need for guidance on the detailed specification of water treatment systems as well as the building of haemodialysis units [(3,4)] so that the dialysis water is fit for purpose for modern haemodialysis therapies (haemodiafiltration and high flux haemodialysis). There have been a number of reported instances of water treatment systems failing to meet the users' specifications after installation leading to delayed use of the system, clinical risk and financial penalties. Concordance with all three sections of guidelines 1 and 2 in this document will improve corporate governance and should reduce the risk of installing below standard water treatment systems in future.

References

1. Water safety in buildings. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland, March 2014. http://whqlibdoc.who.int/publications/2014/9789241548106_eng.pdf
2. The National Service Framework for Renal Services Part 1: Dialysis and Transplantation, Department of Health, London, UK, January 2004. (www.doh.gov.uk/nsf/renal/index.htm)
3. Renal Care. Health Building Note 07-01: Satellite Dialysis Unit., Department of Health, 2013 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/147869/HBN_07-01_Final.pdf)
4. Renal Care. Health Building Note 07-02: Main Renal Unit. Department of Health, 2013 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/147873/HBN_07-02_Final.pdf)

3. Installation and validation of water treatment systems for haemodialysis

Guideline 3.1 – Installation and validation of a water treatment system for haemodialysis

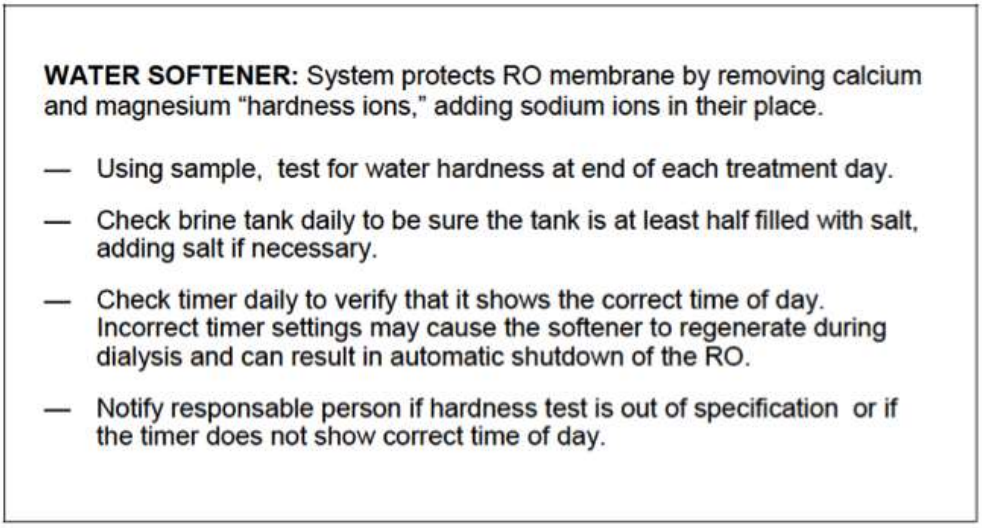
We recommend that each stage of the installation, performance validation and initial, performance and operational qualification should be agreed and documented in advance and signed off by the manufacturer and the clinician responsible for water quality (or designated deputy). (1C)

Rationale for the 6 sequential stages of guideline 3.1

3.1.1 Installation

The installation of the water treatment infrastructure should be by qualified personnel in line with the manufacturer's recommendations. On completion schematic diagrams that identify components, valves, sample ports, and flow direction should be available and the system appropriately marked. Major water system components should be marked in a manner that not only identifies a device but also describes its function, how performance is verified, and what actions to take in the event performance is not within an acceptable range.

Figure 2
An example of the type of labelling required for each component of the water treatment system to describe how each component is tested and its action limits.



3.1.2 Performance validation and system verification

Performance validation is a process of documenting that the dialysis water treatment and dialysis fluid production systems, when installed and operated according to the manufacturer's recommendations, consistently produce dialysis water or dialysis fluid meeting the stipulated quality levels. Simply, validation demonstrates that the system is "fit for purpose".

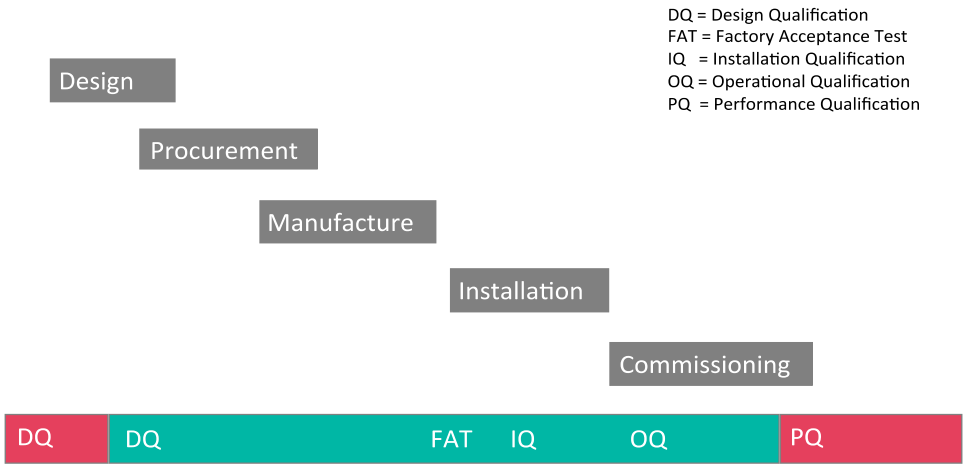
The validation process should provide documentary evidence that the system will consistently produce water, dialysis fluid, or substitution fluid meeting the quality requirements of ISO 13959 or ISO 11663. The contractor or supplier of the water treatment system should draw up the validation plan, which must be submitted to and approved by a member of the renal services with responsibility for clinical care of the patient.

It is recognised that not all nephrologists will have sufficient background knowledge for such approval and a designated technical expert may deputise on their behalf. If such a designated person is not part of the renal team, this should be clearly indicated on the documentation together with signed approval

from a member of the renal team. Furthermore, it should be noted that there is a cost implication associated with the validation process which is the responsibility of the provider.

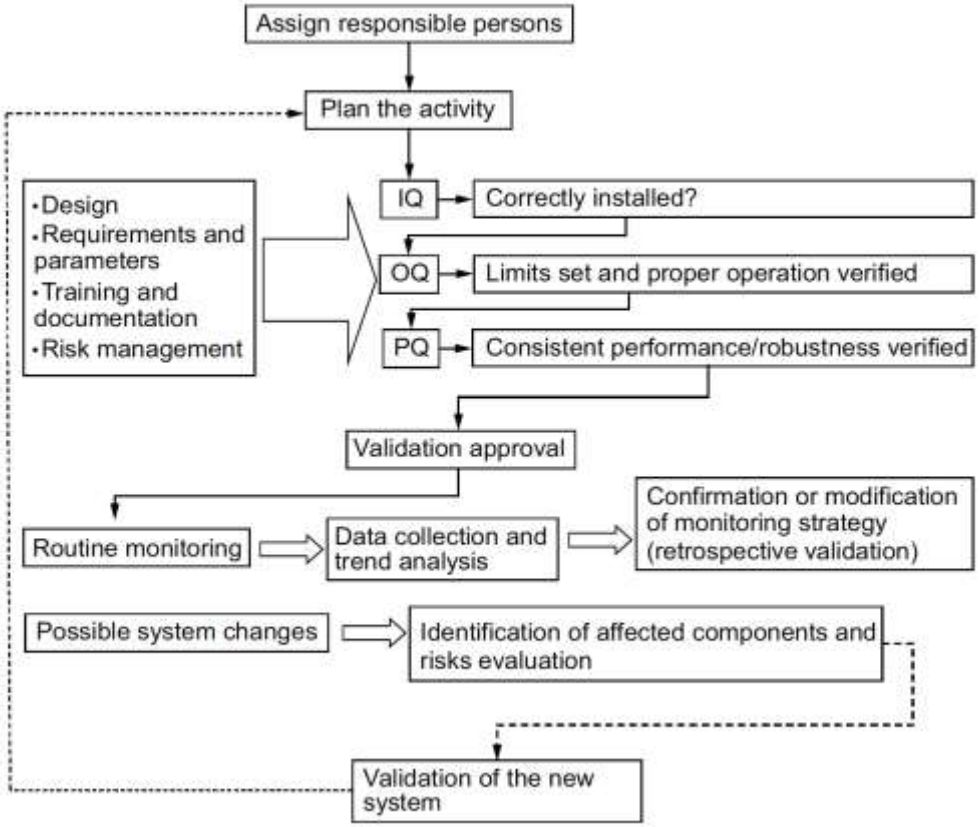
The term “verification” may also be used and this refers to demonstrating that the system complies with applicable regulations, specifications, or other conditions.

Figure 3
A typical validation timeline



A detailed diagram of the validation process is given in BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*. A simplified version of this is shown in Figure 4.

Figure 4
A simplified flow diagram of the validation process

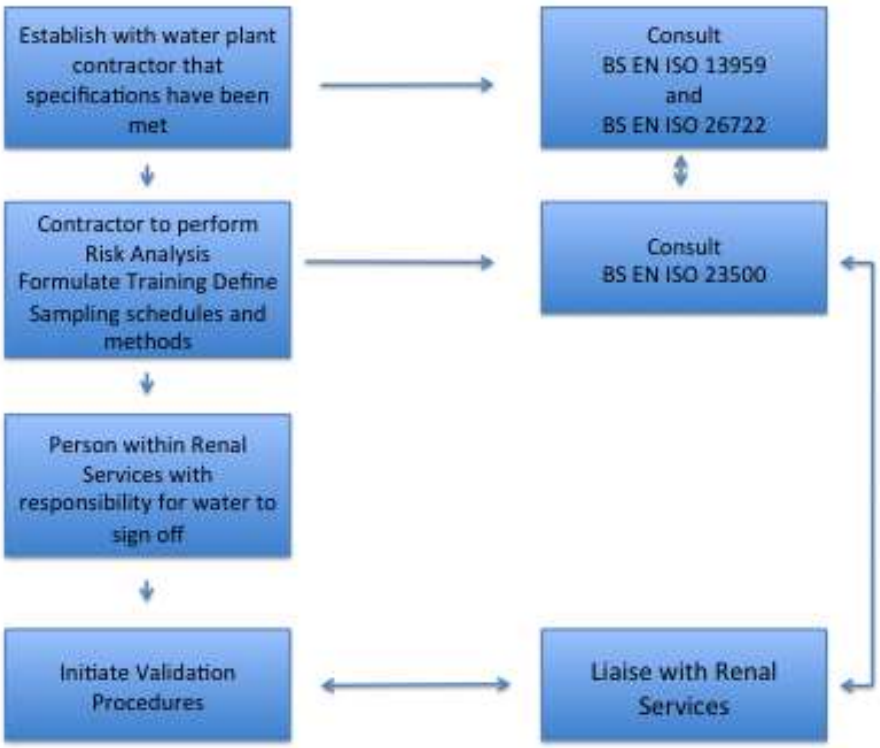


3.1.3 Completion of installation of water treatment system

The water treatment facility when completed should be confirmed to have met all aspects of the design specification. This needs to be agreedand signed off by the manufacturer/installer, commissioning team and by the person within the renal service with responsibility for clinical governance of the water treatment system. (Guidelines 1.2 and 1.3).

Figure 5

Outline of the Essential actions required on completion of building of the water treatment system.



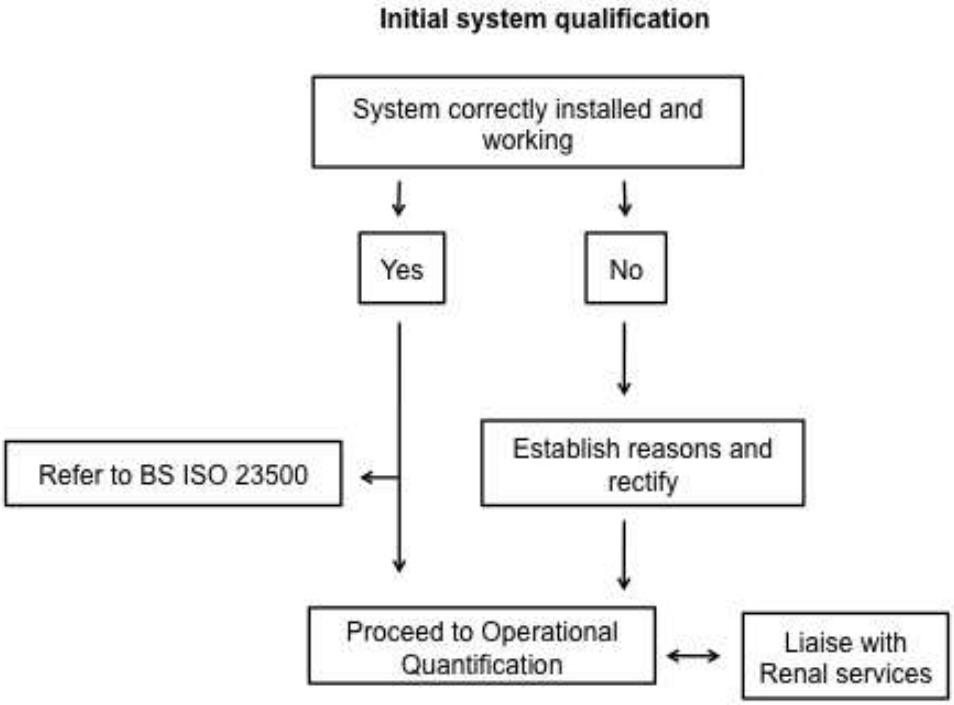
3.1.4 Initial qualification

On completion of installation, full system documentation should be available including system flow diagrams, layout, log books and operator's manuals. Following completion of the installation, an installation qualification is performed. The purpose of this is to define and provide documented proof that the system has been installed in accordance with the approved plans and the manufacturer's technical requirements and specifications.

Problems have arisen from a lag between completion of the installation process and the commencement of the validation process. To avoid such problems, it is imperative that the water treatment system and distribution system are not left for any period during which there is fluid present in the system but there is no flow through the system and that the system is run in accordance with manufacturers instructions regarding disinfection procedures and frequencies following the completion of the installation process.

Furthermore, it is highly desirable that the entire system is run for short periods on a daily basis. If this is not possible then suitable alternate approaches will need to be established and discussed with a designated technical expert. If the designated technical expert is not part of the renal team, this should be clearly indicated on the documentation together with signed approval from a member of the renal team.

Figure 6
The initial system qualification process.

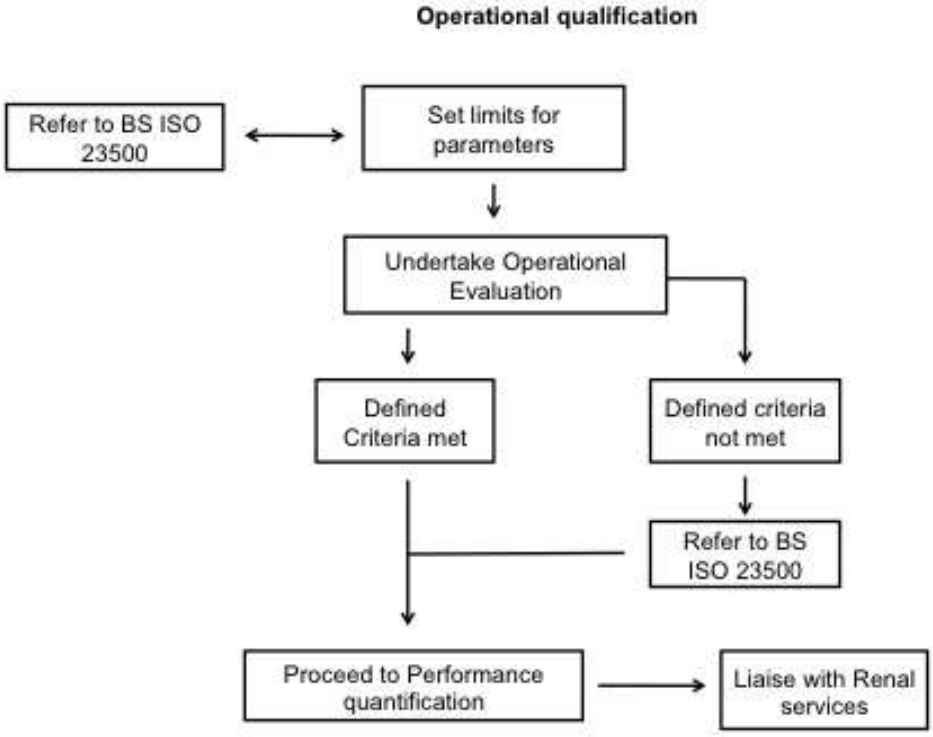


3.1.5 Operational qualification

The initial qualification of the water treatment system is followed by an operational qualification, the purpose of which is to verify the proper operation of the system, including operating range, set point, interlock and functional testing. On completion the following information should be available:

- test records;
- set up record;
- calibration schedule;
- sampling procedures;
- maintenance plans (e.g. disinfection, filter changes, etc.) and monitoring plans (e.g. conductivity, microbiological analysis);
- record of operator(s) training.

Figure 7
The operational qualification process.



3.1.6 Performance qualification

Performance qualification generally follows a successful completion of the validation plan. The purpose of the performance qualification is:

- demonstration that the plant has been installed in accordance with the design plans and follows the manufacturer's procedures for installation (i.e. Installation Qualification).
- demonstration of the consistency and robustness of the system under local operational conditions.
- demonstration that the system performs all the required actions and can be operated in accordance to relevant technical manuals (i.e. Operational Qualification).

During this period all the information about the system behaviour is collected and fine-tuning of the action levels performed. During the performance quantification phase of the system, the testing frequency of the microbiological parameters is kept at a higher level to create a 'trend analysis' to identify any deviations from the requirements outlined in BS ISO 13959; 2014: *Water for haemodialysis and related therapies* and to ensure that the dialysis fluid produced with the treated water meets the requirements of BS ISO 11663; 2014*: Quality of dialysis fluid for haemodialysis and related therapies*[1,2].

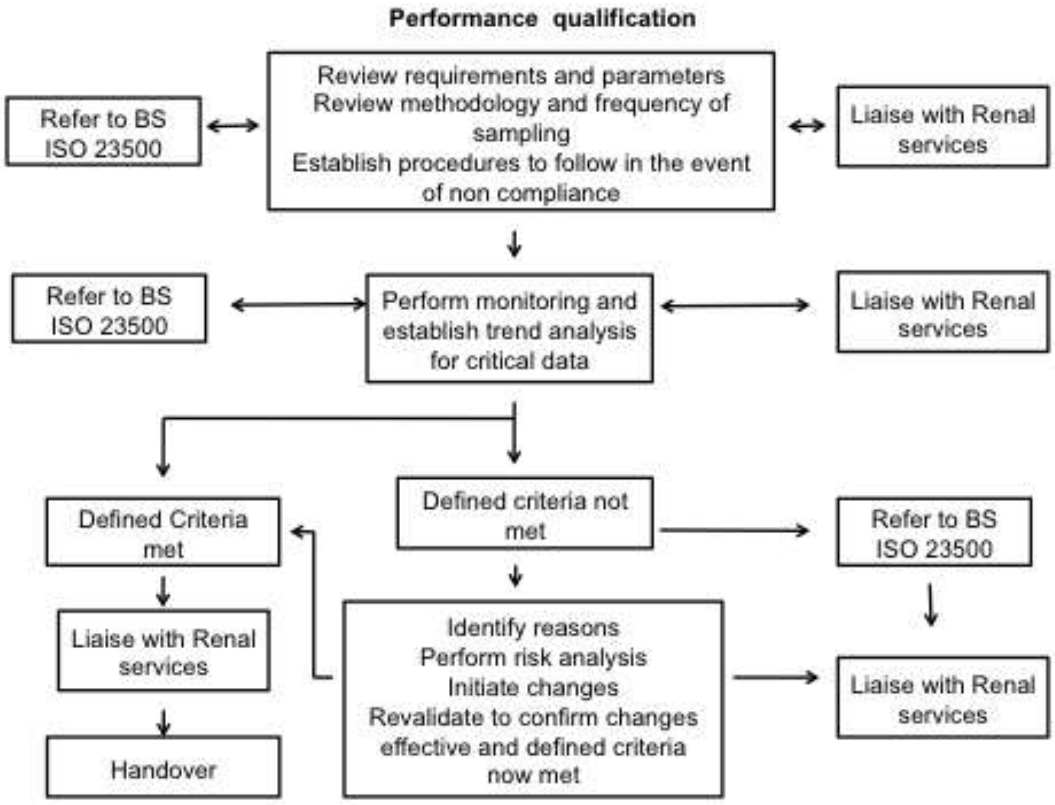
On completion of the Performance Qualification, the following information should be available:

- test records;
- chemical and microbial analyses;
- key performance indicators [for example, pre treatment efficiency, reverse osmosis (RO) recovery/rejection rate, etc];

- (initial) trend analysis;

For newly installed systems, the person with overall clinical responsibility for dialysis (possibly supported by technical experts) may authorize use of dialysis fluid for patient treatments once chemical and microbiological analyses show full compliance with the quality requirements in the manufacturer's specifications, and any applicable regulatory requirements.

Figure 8
The performance qualification process.



References

1. BS ISO 13959; 2014: *Water for haemodialysis and related therapies*,
2. BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*

4. Operation and maintenance of water treatment systems for haemodialysis

Guideline 4.1 – Routine maintenance and monitoring

We recommend that the maintenance and monitoring plans for the water treatment plant are established usingthe knowledge acquired during the complete validation process for the water treatment system which are in accordance with BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis*. Policies and procedures should be set up to ensure that maintenance and monitoring are mandatory and implemented at the earliest opportunity. (1B)

Guideline 4.2 – Operators of water treatment systems for haemodialysis

Guideline 4.2.1 – Training of operators of the water treatment facility

We recommend that operators should be trained in the use of the water treatment equipment by the manufacturer or their UK distributor. The training should be specific to the functions performed. Competence with procedures should be assessed and documented. Periodic audits of the operators' compliance with procedures should be undertaken and documented and there should be an ongoing training programme to maintain the operator's knowledge and skills. (1C)

Guideline 4.2.2 – Continuing education and development of operators of water treatment systems

We suggest that national organisations, such as the Association of Renal Technologists, should participate in the continuing education and development of operators of water treatment systems by arranging training sessions at annual meetings and/or co-ordinating regular training days. (2D)

Guideline 4.2.3 – Continuing education and development of operators of water treatment systems

We suggest that a Renal Technologist, who is not already on the Register of Clinical Technologists, should undertake the Association of Renal Technologist training scheme as this training will provide background knowledge on renal water treatment systems. (2D)

Guideline 4.3 - Monitoring of feed, product and dialysis water for haemodialysis

Guideline 4.3.1 - Routine testing

We recommend that routine testing procedures for water for dialysis should form part of the renal unit policy. Each water treatment facility should have standard operating procedures in place for sampling, monitoring and recording of feed and product water quality. (1C)

Guideline 4.3.2 – Frequency of monitoring

The frequency of monitoring is generally recommended by the equipment manufacturer or by local operating procedures. We recommend that the minimum frequency of monitoring of water for dialysis should be as follows (1D):

Contaminant	**Frequency of testing**
Total chlorine	At least weekly
Total viable counts	At least monthly
Endotoxin	At least monthly
Chemical contaminants other than chlorine	At least every 3 months

It is normal practice to measure the total chlorine of the product water after the carbon filters as reverse osmosis membranes are susceptible to oxidative damage by free chlorine. The maximum chlorine level exposure of the reverse osmosis membrane to total chlorine should be ascertained from the system supplier.
Considerable daily as well as seasonal variations in the chlorine and chloramine levels of the feed water are known to exist and therefore the guidance to test for chlorine/chloramine at least weekly should be regarded as an absolute minimum.If practical and feasible, testing for chlorine or chloramine on a daily or shift basis is recommended. It is however recognised that such an approach may place an

undue burden on staff, and if it can be demonstrated that the chlorine levels in the feed water are consistently low (<0.5 mg/L) and chloramines are not used, then weekly monitoring of the dialysis water would be sufficient. However, if chloramines are used and the level of chlorine in the feed water exceeds 1.0 mg/L, the daily or shift based monitoring should be adopted.

Guideline 4.3.3 – Records of monitoring

We recommend that records should be kept of all chemical and microbiological test results and remedial actions.If the interval between sample testing exceeds those indicated in the Table in 4.3.2, documentation should be in place to demonstrate that the sampling schedule used has been based on trend analysis.The operating procedures should include details of the procedures to be followed if the prescribed limits are exceeded.
Records of source water contaminants can be obtained from the municipal water supplier (1C)

Guideline 4.4 – Mutual responsibilities of water supply companies and renal units

We recommend thatrenal units shall inform the water supply companies of the location of all home haemodialysis patients as well as haemodialysis units so that the water companies are empowered to inform the renal unit of changes in feed water delivery to the patient's home in terms of supply and composition. The water companies should also advise the renal unit if there are plans to alter the range of chemicals added to the water supply to ensure compliance with the drinking water directive. (Not graded)

Rationale for 4.1-4.4

The manufacturer of the water treatment and distribution system should demonstrate that the requirements for microbial contamination are met throughout the complete system at the time of installation [(1)]. No specific recommendations regarding the frequency of monitoring are made but it should be performed at least monthly in respect of the dialysiswater and after any maintenance work on the water treatment system. The frequency of monitoring of the feed (or source water) quality may be performed less frequently. Chemical contaminant levels in water feeding the water treatment system can generally be obtained from the water supplier, unless the supply is via a well,

For home installations it may be impractical to maintain a monthly testing programme and to ensure adequate patient safety the dialysis machine should be fitted with point of use filtration.

The laboratory tests required to demonstrate compliance with the recommendations for monitoring of chemical contamination of dialysis water should be carried out during commissioning and thereafter three monthly or following alterations to the water treatment plant. The frequency of testing may be modified once local trends have been established, but should not fall below annually. An initial full test on the supply water is advisable and regular monitoring of water quality data from the supplier is essential when tests are omitted based on low levels of contamination in the water supply.

The absence of any type of bacteriostat in the water following treatment makes it susceptible to bacterial contamination of the dialysis water distribution system. Microbial contamination may be enhanced by stagnant areas within the distribution network or irregular cleaning. The presence of microbial contamination contributes to the development of biofilm which may also be found in the dialysis fluid pathway of the proportionating system, particularly when non-sterile liquid bicarbonate concentrate is used. Such biofilm is difficult to remove and results in the release of bacteria and bacterial fragments (endotoxins, muramylpeptides, and polysaccharides). The dialysis membrane prevents transmembrane passage of intact bacteria but bacterial fragments can have molecular weights that allow them to pass across the membrane into the bloodstream. Considerable differences exist between membranes, which may permit the passage of short bacterial DNA fragments [(2-4)]. Current proportionating systems generally incorporate filters for the removal of such fragments on the basis of size exclusion and hydrophobic interaction. The aim of implementing a disinfection programme is to prevent formation rather than elimination of biofilm and a routine testing procedure for microbiological contaminants in dialysis fluid, dialysis water and feed water should form part of the renal unit policy. It is not necessary to perform microbiological monitoring of dialysis fluid or substitution fluid if production paths are fitted with validated endotoxin retentive filters operated and monitored within the

manufacturer's instructions.

Testing for chemical contaminants will normally include continuous conductivity monitoring of the water leaving the reverse osmosis system, and regular in-house checks of hardness and total chlorine [5].

a) Removal of chlorine chloramine and chlorine dioxide

Carbon is used to remove chlorine chloramine and chlorine dioxide from the water supply. These chemicals are added by the supplier to ensure compliance with drinking water requirements. The carbon may be in the form of beds or filters that have been appropriately sized to meet the water demand. As the removal of these compounds is critically dependent upon carbon filtration, technical staff performing the testing should ensure data on the carbon filter empty bed contact time for the carbon beds in use required for the effective removal of these compounds is available. If chorine dioxide is used, then renal service technical staff are advised to contact the supplier of their carbon material to ensure that the removal characteristics for chlorine dioxide by products such as chlorite and chlorate are known and sufficient to ensure that the patient is not placed at risk.

b) Monitoring for chlorine chloramine or chlorine dioxide.

Although chlorine is widely used for ensuring that drinking water meets microbiological requirements, water providers may without prior warning to consumers change to using the more stable chloramine. Chlorine dioxide may also be used. Chlorine dioxide is less corrosive than chlorine, and superior for the control of Legionella. Because of this improved control, it is used widely to prevent growth of Legionella bacteria in hospital water systems. If the dialysis unit draws water from such a system rather than a direct “rising main” supply, then residual chlorine dioxide and a range of by products such as chlorite, chlorate and organic disinfection by products (DBP) may be present in the feed water. It should be recognised that removal of these by productsare critically dependent upon the carbon in use.

Due to their volatility, chlorine and chloramine testing must be performed immediately after drawing the sample. Free chlorine may be measured using syringaldazine (FACTS) or tetramethylbenzidine (TMB)-based test strips. Total chlorine may be measured using Thio-Michler’s ketone (TMK) or N-Diethyl-p-phenylenediamine (DPD)-based test strips or tablets .Other monitoring methods such as the ferrous colorimetric/titrimetric-based assay or test strips for free and/or total chlorine are also available When using commercially produced indicators care should be taken to ensure that the indicator selected is appropriate for the application. For example Palintest (Palintest House, Kingsway, Team Valley, Gateshead, Tyne &Wear NE11 0NS England) currently produce four different DPD indicators in tablet form : DPD1 to measure free available chlorine, DPD2 used in combination of DPD1 to measure combined chlorine, DPD3 in combination with DPD1 to measure total chlorine and DPD4 to measure total available chlorine. Hach water quality test strips (HachAquacheck) detect both free and combined chlorine.
Users of DPD indicators should be aware that the presence of manganese and organic chloramine may interfere with DPD tests. Furthermore, because test strips can be sensitive to heat and humidity, manufacturer's instructions for storage and use must be stringently adhered to
There is no direct test method for the chloramine content of the water. Chloramine content is generally determined by calculating the difference between measured total- and free-chlorine concentrations. When total-chlorine tests are used as a single analysis, the maximum level for both chlorine and chloramine should not exceed 0.1 mg/L. Since there is no distinction between chlorine and chloramine, this safely assumes that all chlorine present is chloramine. Such measurements can be made using the DPD assay or a "dip and read" test strip, or by an on-line monitor. In measuring such low levels, there may be a uncertainty in the measurement as colour changes are subjective to the human eye and can be read differently from person to person. Oxidized manganese is alsoknown to cause a false positive for chlorine when using the DPD indicator.

When chlorine dioxide is used as a sterilant, residual chlorine dioxide and a range of breakdown products namely chlorite, chlorate, and organic disinfection byproducts (DBPs) may be present. Tests intended for the quantification of chlorine or chloramine should not be used for the quantification of chlorine dioxide or breakdown products. . Details of accurate methods of quantification of chlorine dioxide and its by products are available from the United States Environmental Protection Agency (EPA) website. (http://www.epa.gov/ogwdw/mdbp/alternative_disinfectants_guidance.pdf).

At present the national or International standards do not address the maximum permitted levels of chlorine dioxide or their breakdown products in dialysis water.There is little information about the potential toxicity of chlorine dioxide and its daughter products to haemodialysis patients.Areview of the literature yielded a single historic report of 17 dialysis patients treated with water containing 0.02 to 0.08 mg/L of chlorite ions and no detectable chlorate ions, in whom haematological changes were noted. [1]It is suggested that, if chlorine dioxide is used, chlorinedioxide levels in the feed and product water be measured using a commercially available test kit and that the maximum acceptablechlorine dioxide level in the product be set at 0.1 mg/l.

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c) Frequency of monitoring of chemical contaminants other than chlorine

The concentrations of chemical contaminants other than "chlorine" should be performed at least three monthly. Depending upon trend analysis and historic data, the frequency of monitoring may be increased,.However when the interval is increased, there should be awareness that this increase is based on historic data, the water supplier may source the water from a different location to that used normally, especially at times of water shortages Seasonal variations may also exist.
The frequency of monitoring will further be dependent on whether the feed water is via a direct or indirect tanked supply. If the feed water is via a tanked supply, more frequent checks may be necessary, especially if chemicals are introduced into the tank locally to control bacterial proliferation. No chemicals should be introduced into the tank without prior consultation of the renal services, and renal unit technical staff should ensure that this is incorporated into the hospital's operating procedures and that the tank area is appropriately marked.

d) Frequency of monitoring of microbial contaminants and endotoxin

Total viable counts and endotoxin levels should be monitored at least monthly. A scheme should be drawn up which defines the points at which the sampling is performed. The sampling points should include the furthest point in the distribution loop as well as a randomly selected feed point to a proportionating system.

e) National standards and testing of feed water

Water used in the preparation of dialysis fluid originates either from a public or a private water supply. Since such water is also used as drinking water, it must meet the requirements outlined in the EU Drinking Water Directive (/98/83/EC)EU member state government translate these requirements of the directive into local laws, namely The Water Supply (Water Quality) Regulations for: England (2000), Wales (2001), Scotland (2001) and the Private Water Supplies Regulations in Northern Ireland. These legal statutes, lay down the requirements for monitoring and analysis, public reporting of data, use of treatment chemicals and materials in contact with water and action that must be taken if a required value in a standard is exceeded. Compliance with the legal statutes is overseen by the Drinking Water Inspectorate (DWI). The DWI publishes an annual report which details water companies regulatory sampling programmes and lists cautions and prosecutions. These reports are available on line from (http://dwi.defra.gov.uk/about/annual-report/index.htm).
Major water suppliers maintain their own websites on which, they provide details information concerning drinking water quality. For example the United Utilities website who provide water in the North West on their website give the option of checking water quality relative to a specific postcode. Despite the availability of this information, it is important for renal unit technical staff establish regular contact with the technical services section of the supplier. By establishing such links, the renal units are kept abreast of any changes in water quality and treatment and adjust their monitoring accordingly and in a timely manner. It should be noted however that such a relationship does not negate the responsibility for performing regular reviews of water supply contaminant data.

References

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5. Monitoring the quality of dialysis waterfor haemodialysis and dialysis fluids

Guideline 5.1: Chemical contaminants in dialysis water used for the preparation of dialysis fluid

We recommend that the concentrations of chemical contaminants in dialysis water used to prepare dialysis fluid shall not exceed the limits stated in BS ISO 13959; 2014:*Water for haemodialysis and related therapies.* A programme of improvement should begin immediately if routine monitoring demonstrates that concentrations of chemical contaminants exceed the maximum allowable limits. (1B)

Rationale

Knowledge of the potentially harmful effects of trace elements and chemicals continues to expand and techniques of water treatment are continuously being modified. Recommendations for the maximum allowable concentrations of chemical contaminants have been prepared by a variety of standard developing organisations, professional societies and pharmacopoeias, such, International Standards Organisation [(1)] and the European Pharmacopoeia [(2)] . While there is general agreement concerning the maximum allowable levels of inorganic chemicals with documented toxicity in haemodialysis patients (aluminium, chloramines, copper, fluoride, lead, nitrate, sulphate, and zinc) there are some exceptions e.g. the current edition of the European Pharmacopoeia does not explicitly specify maximum allowable levels for copper or chloramines. Of note, is that none of the standards and recommendations includes limits for specific organic chemical contaminants. Whilst there has been a recent report of patient exposure following inadequate removal of organic chemicals in the preparation of dialysis water [(3)],the rationale for this omission is that organic chemicals with specific toxicity in haemodialysis patients have not been identified and that carbon adsorption and reverse osmosis removes most organic compounds.

Tables 1-3 below lists the contaminants for which a maximum allowable limit is defined for water for dialysis in ISO 13959:2014 [(1)].

Table 1: Maximum allowable concentrations of chemical contaminants in dialysis water for which monitoring is mandatory (reproduced from ISO 13959)

Chemical contaminant	Maximum recommended concentration (mg/l=ppm)
Aluminium	0.01
Calcium	2 (0.05mmol/l)
Total chlorine	0.1[1]
Copper	0.1
Fluoride	0.2
Magnesium	4 (0.15mmol/l)

Nitrate (as N)	2 (equates to 9 mg/l NO_3)
Potassium	8 (0.2mmol/l)
Sodium	70 (3.0mmol/l

Note [1]There is no direct method for the measurement of chloramine. It is generally established by measuring total and free chlorine concentrations and calculating the difference. Ifa single test is used, then total chlorine shall be measured, using a maximum allowable limit of 0.1 mg/l. Since there is no distinction betweenchlorine and chloramine, this safely assumes that all chlorine present is chloramine.

All of the above chemical contaminants when indicated should be tested initially every 3 months apart from total chlorine concentrations which should be tested at least weekly.As considerable daily as well as seasonal variations in the chlorine and chloramine levels of the water entering the water treatment plant (feed water) are known to exist, the guidance to test weekly for total chlorineat least weekly should be regarded as an absolute minimum.If practical and feasible, testing on a daily or shift basis is recommended. It is however recognised that such an approach may place an undue burden on staff, and if it can be demonstrated that the total chlorine level in the feed water are consistently low (<0.5 mg/L) and chloramines are not used, then weekly monitoring of the dialysis water is sufficient. However, if chloramines are used and the level of total chlorine in the feed water exceeds 1.0 mg/L, the daily or shift based monitoring should be adopted. The maximum recommended concentration for total chlorine is 0.1mg/l (ppm) in ISO 23500 [(6)].

Table 2 defines a group of contaminants for which the drinking water limit is 2 to 5 times the recommended limit for dialysis [(4)]. In water treated by reverse osmosis, these contaminants will only exceed the limits in Table 2 if they occur at relatively high levels in the water supplied to the unit. These contaminants can be omitted from routine tests if data is available to show that the levels in the water supplied to the unit rarely exceed the limit in Table 2. Such data is generally available on request from the municipal water supplierand reviewed on an annual basis. Tests on the drinking water should be undertaken every 6 months if it is obtained from a private source and used for the provision of water for dialysis either in the hospital or home.

Table 2: Maximum allowable concentrations of chemical contaminants in dialysis water which may be omitted from routine monitoring (reproduced from ISO 13959)

Chemical contaminant	Maximum recommended concentration (mg/l=ppm)
Arsenic	0.005
Cadmium	0.001
Chromium	0.014
Lead	0.005
Mercury	0.0002
Sulphate	100

The final group of contaminants (barium, beryllium, silver, thallium, tin and zinc) are those for which a limit has been defined for water for dialysis and there is no limit specified for drinking water in the UK. These trace elements are not considered to occur in levels that give cause for concern and, if low levels are present, they are removed effectively by reverse osmosis. Testing is only required if there is evidence of high levels in the local water supply (zinc, for example, can be introduced in the pipework or silver, present if the hospital water supply is treated with silver containing compounds to minimize the presence of Legionella bacteria). Selenium (ISO limit 0.09 mg/l) and Antimony (ISO limit 0.006 mg/l) have been excluded from the requirements for monitoring as the limit for drinking water in the UK is lower than the limit set in standards in respect of water for dialysis.(0.01 and 0.005mg/L respectively)

Table 3: Maximum allowable concentrations of chemical contaminants in dialysis water which only require monitoring when indicated.

Chemical contaminant	Maximum recommended concentration (mg/l = ppm)
Barium	0.1
Beryllium	0.0004
Silver	0.005
Thallium	0.002
Zinc	0.1

Compliance with the requirements listed in Tables 1-3 can be shownusing chemical analysis methods detailed in Table 3 of BS ISO 13959; 2014:*Water for haemodialysis and related therapies*or other equivalent analytical methods. Testing may be carried out in house provided such facilities exist, or by an external provider. Laboratories undertaking the analysis should hold current UKAS accreditation. Renal units may find it helpful to use the Table shown in Appendix 1 for comparing results from

If testing for trace elements is not available, compliance may be demonstrated by compliance with standards for potable water as defined by the WHO or local regulations, alternately, an analysis for total heavy metals can be used with a maximum allowable level of 0,1 mg/l. If neither of these options is available, compliance with the requirements of Table 3 can be met by using water that can be demonstrated to meet the potable water requirements of or local regulations and by use of a reverse osmosis system with a rejection of >90 % based on conductivity, resistivity, or TDS.

The manufacturer or supplier of a complete water treatment system should ensure that the recommended system is capable of meeting the above requirements based on a source or feed water analysis and allowing for seasonal variations in feed water quality. The complete water treatment, storage and distribution system should meet the requirements of ISO 26722 [(5)] and be shown to be capable of meeting the requirements of ISO 13959 [(1)] at the time of installation.

References

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5. BS ISO 26722; 2014:*Water treatment equipment for haemodialysis and related therapies*
6. BS ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*

Guideline 5.2: Microbiological contaminants in dialysis water used for the preparation of dialysis fluid

Guideline 5.2.1 – Maximum allowable concentrations of microbiological contaminants in dialysiswater used for the preparation of dialysis fluid

We recommend that the quality of water produced by the water treatment facility shall meet the concentration limits for microbiological contaminants detailed in BS ISO 13959:2014. This states that dialysis water shall contain a total viable microbial count of less than 100 CFU/ml and an endotoxin

concentration of less than 0.25 EU/ml. If routine monitoring, which should be undertaken by laboratories participating in an appropriate UK proficiency scheme that demonstrate that the laboratory can reliably detect such levels on a consistent on going basis, demonstrates microbiological contaminant levels in excess of 50% of the maximum permitted levels a programme , based on historic data, corrective measures should be commenced immediately. (1B)

Dialysis water containing a total viable microbial count of less than 100 CFU/ml and an endotoxin concentration of less than 0.25 EU/ml is also the starting point in the production of ultrapure dialysis fluid or for on line infusion fluid used in haemodiafiltration (HDF). To meet the appropriate requirements, the dialysis fluid will require further filtration by ultrafilters incorporated in the dialysis machine. BS ISO 23500:2014 states there is no requirement to test for bacterial growth or endotoxins in ultrapure dialysis fluid when the haemodialysis system is fitted with endotoxin retentive filters that are operated according to the manufacturer's instructions, unless the manufacturer requires such test to be performed.

Guideline 5.2.2 – Methods of measuring microbiological contaminants in product water used for the preparation of dialysis fluid

We recommend that the test procedures used for monitoring microbial contamination of water for dialysis be standardised and appropriate to the type of organisms found in water. The test procedures should be adhered to stringently. (1C)

Rationale

The dialysis membrane was regarded as an effective barrier against the passage of bacteria and endotoxin (potent pyrogenic materials arising from the outer layers of bacterial cells) from dialysis fluid to blood. This produced a complacent attitude towards the purity of dialysis fluid until about 20 years ago when several in vitro studies showed that intact membranes used in dialysers are permeable to bacterial contaminants [1-2]. The pore size of the membrane appears to be less important than the thickness of the membrane or the capacity of the membrane to adsorb bacterial products. Consequently low flux (standard) dialysis does not necessarily translate into higher microbiological safety than high flux dialysis or haemodiafiltration. Patients receiving standard dialysis treatment with low flux cellulose-based membranes (thickness 6–8 microns), may therefore be at greater risk of pyrogenic reactions (see below) than those treated using thicker synthetic membranes which have higher capacity to adsorb bacterial endotoxin.

Water produced for the preparation of dialysis fluid produced by older, water treatment plants may not be suitable for use in ultrapure treatments unless it is further treated by point of use ultrafiltration. Nevertheless, the microbiological quality of the water produced should comply with the requirements of BS ISO 13959; 2014: Water for haemodialysis and related therapies, namely that total viable microbial counts shall be less than 100 CFU/ml, and the endotoxin content shall be less than 0.25 EU/ml, which is suitable for use for low flux haemodialysis. If routine monitoring demonstrates microbiological contaminant levels in excess of 50 CFU/ml and 0.125 EU/ml for bacteria and endotoxin (i.e. 50% of the maximum permitted levels) a programme of corrective measures should be commenced immediately [3]. However it is important to recognise that an increase in the concentrations of microbial contaminants and/or endotoxin below 50% of the maximum allowable levels can indicate that microbial growth is present and/or disinfection procedures are inadequate as shown in Table.4 and is based on personal communication Rolf Nystrand. It should be noted, that this guidance represents the opinion of an experienced professional, and there is no experimental data available to support this.

Table.4 Microbiological status of the water treatment system

Total viable counts (CFU/ml)	Interpretation	Endotoxin concentrations (EU/ml)	Interpretation
<1	System is in perfect order	-	-
1-5	System is in good order	<0.03	System is in good order
6-10	Surface growth is in "start up"	0.03-0.1	Microbial growth is present and residuals from former growth are present
11-50	Surface growth is established	0.1-0.25	Microbial growth is established and disinfection is ineffective
>50	Disinfection program is ineffective, especially if fungi and/or yeast is present	>0.25	Microbial growth is substantial

In patients treated with high flux membranes, a risk of pyrogen transfer due to backfiltration (a movement of dialysis fluid into the blood pathway of the device due to an inverted pressure gradient rather than the diffusion gradient discussed above) may exist. Lonneman et al, however, concluded that diffusion rather than convection is the predominant mechanism of transmembrane transport of pyrogens, and backfiltration across pyrogen adsorbing membranes does not necessarily increase their passage [(4)]. It should be emphasised that the adsorption capacity of the synthetic membranes is not infinite and that a breakthrough of pyrogenic substances can occur in the event of excessive water contamination.

A raised C-reactive protein (a sensitive marker of activation of the acute phase response) is associated with a significantly increased risk of death [(5,6)] and has led to speculation that micro-inflammation associated with transmembrane transfer of endotoxins and bacterial fragments may contribute to raised serum levels of CRP in patients undergoing regular haemodialysis. Impure dialysis fluid has also been implicated in the pathogenesis of dialysis-related amyloidosis and an increased rate of loss of residual renal function. Ultrapure dialysis fluid is produced by additional ultrafiltration of dialysis fluid in dialysis machines and used as an online substitution fluid in convective therapies such as haemodiafiltration or haemofiltration. It may also be used in high flux haemodialysis. A number of clinical studies have shown that the use of ultrapure dialysis fluid is associated with a range of clinical benefits [(7-10)]. Its use for haemodialysis has been associated with lower indices of inflammatory response (serum CRP and IL-6), with better preservation of residual renal function, nutritional status and correction of anaemia and may reduce the risk of complications due to dialysis-related amyloidosis. In a prospective 30 month observational study patients with combined high levels of CRP and pro-inflammatory cytokines showed an increase in all-cause mortality (RR =2.57, $p < 0.001$) and cardiovascular death (RR = 1.9, $p < 0.001$) [(9)]. Although the clinical benefit of ultrapure dialysis fluid has not been established in a large scale randomized trial it would seem prudent to ensure that water is as pure as reasonably possible..

The concentrations of microbial contaminants and endotoxin in ultrapure dialysis fluid shall be < 0.1 CFU/mL and < 0.03EU/mL respectivelywhen used for high flux haemodialysis. However the ultrapure dialysis water requires further treatment if it is to be used as infusion or substitution fluid in convective therapies. In some dialysis units up to 100% of treatments are now performed with such convective techniques. Modern dialysis machines permit the production of substitution fluid on site and on-line allowing large reinfusion volumes to be used. This on-lineprocess shall bevalidated to produce fluid that is sterile and non-pyrogenic. Compliance of on-line produced fluid with the requirements of BS ISO 11663 cannot bedemonstrated with traditional test procedures. For this reason, compliance with this standardshallbe ensured by proper operation of a validated system, verified according to the manufacturer'sinstructions at the time of installation, and confirmed by the user with a regular monitoring and maintenanceschedule. The user shall follow the manufacturer's instructions for use of the validated system, and the user'smonitoring and maintenance schedule shall be designed to confirm that the water and concentrates used toprepare the substitution fluid continue to meet the specifications of BS ISO 13958 and BS ISO 13959.

The test procedures used for monitoring microbial contamination of water for dialysis should be appropriate to the type of organisms found in water and need to be adhered to stringently. Membrane filtration using a filter pore diameter of 0.45 microns or less and a filtration volume between 10-1000ml are required [12]. A low nutrient agar, such as Tryptone Glucose Extract Agar (TGEA) or Reasoner'sAgar2A, should be used [13-16] and samples should be incubated for at least 7 days at 17-23ºC [13,17]. These conditions have been shown to give good recovery for most environmental bacteria found in purified water. Details of methods for sampling and culturing of water for dialysis are available in the EDTNA/ERCA Guidelines on Control and Monitoring of Microbiological Contamination in Water for Dialysis [16], which also gives specific test conditions for fungi.Detailed procedures for the collection and analysis of samples of water and dialysis solution for microbiological analysis also form part of ISO 23500[11].
It should be noted that these methods are at variance with those that are specified in some pharmacopoeia in respect of water for pharmaceutical purposes that use 48-72 hours to generate results.

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Guideline 5.3 – Preparation and composition of dialysis fluid

Dialysis fluid is produced by the mixing of dialysis water with acid and bicarbonate concentrates and the microbiological contaminant levels for acid and bicarbonate concentrates are defined in BS ISO 13958; 2014: *Concentrates for haemodialysis and related therapies*. For dialysis fluid thus produced or if non bicarbonate buffered or modified bicarbonate buffered dialysis fluid is used, we recommend that the microbiological contaminant levels of the dialysis fluid should not exceed those cited in BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies* (1B)

Rationale for 5.3

Whilst a standardisation of the levels electrolyte components of the dialysis fluid is desirable, it is recognised that patient's clinical requirements vary. Consequently, clinical practice may necessitate individualization of the composition of the dialysis fluid notably in terms of potassium, calcium, magnesium concentrations. In addition, some haemodialysis units use a centralised delivery of concentrate for the preparation of dialysis fluid which also provide for some adjustment of dialysis fluid composition.

One of the critical functions of dialysis is the correction of the metabolic acidosis caused by the failure of the diseased kidneys to excrete non-volatile acids and to regenerate bicarbonate. Bicarbonate is the natural buffer normally regenerated by the kidneys and was used historically as the dialysis fluid buffer. If, however, sodium bicarbonate is added to a calcium- or magnesium-containing dialysis fluid, carbonate salts will precipitate unless the dialysis fluid is maintained at a low pH level. To circumvent this, acetate,whichdoes not precipitate calcium or magnesium, and is rapidly converted to bicarbonate in the liverbecame widely used as a buffer,notably with the introduction of single patient proportionating systems [(1)]. In the late 1970s and early 1980s, a number of studies suggested that some of the morbidity associated with haemodialysis could be attributed to the acetate component of the dialysis fluid[(2,3)]. This appears to have been unmasked by the introduction of high-efficiency and short-duration dialysis, using membranes with large surface areas. This acetate intolerance led to the reappraisal of bicarbonate as a dialysis buffer in the early 1980s and together with technical solutions to the problem of precipitation of carbonate led to its replacement by bicarbonate.

Current haemodialysis treatments utilize proportionating or mixing technology which uses two separate concentrates mixed with dialysis water; the acid concentrate, and the bicarbonate concentrate. The acid concentrate sometimes referred to as acidified concentrate as it contains small amounts of acid also contains most of the electrolytes. The bicarbonate concentrate contains sodium bicarbonate. The use of two separate concentrates is necessary to avoid the precipitation of carbonate formed by bicarbonate coming into contact with divalent ions in particular calcium and magnesium, which if formed presents major technical problems. Depending on the type of acidified concentrate in use, the acid component may be in the form of sodium acetate, sodium di-acetate or citric acid. Acetate is metabolized to bicarbonate in a 1:1 ratio, whilst citric acid generates bicarbonate in a 3:1 molar ratio. Thus during dialysis the buffering capability of the dialysis fluid is derived from two separate sources: the metabolism of the acidic component and from the bicarbonate component.

Clinical experience has highlighted the fact that, when physicians are prescribing individualized bicarbonate levels in the dialysis fluid they may not be fully aware of the role that compounds present in the acid concentrate play in buffering and that the total buffer available for the correction of acidosis, can be different from the bicarbonate content of the concentrated bicarbonate solution. This can be further complicated by the fact that, some proportionating systems display only the bicarbonate content of the dialysis fluid without taking into account the contribution from the acidic component, whilst others, take into account the contribution from the acid component and hence for every different acid concentrate used a different conversion factor which has to be programmed into the machine by the technicians. In view of this, there should be awareness that high dialysis fluid bicarbonate, especially prolonged exposure, may contribute to adverse outcomes, through development of post-dialysis metabolic alkalosis.

It is not possible to set evidence-based standards for the other components of the dialysis fluid. However there is evidence that non-diabetic haemodialysis patients using glucose-free dialysis fluid have a surprisingly high rate of asymptomatic hypoglycaemia without an associated counter-regulatory response [(4, 5)]. The long-term effects of repeated dialysis-induced hypoglycaemia are uncertain. Hypoglycaemia is not observed if the dialysis fluid contains glucose, but glucose-containing dialysis fluid is slightly more expensive. In elderly and diabetic patients higher insulin levels coupled with higher dialysis fluid glucose levels (2g/L) impair potassium removal during haemodialysis. Hyperglycaemia also activates inflammatory pathways and contributes to the pro-inflammatory state of haemodialysis patients. The recent study by Burgmeister et al suggested that a level of around 1g/L would be appropriate for both diabetic and non-diabetic patients [(6)]. For these reasons the use of dialysis fluid containing a more physiological glucose concentration is now routine clinical practice.

References

1 Mion CM, Hegstrom RM, Boen ST *et al*. Substitution of sodium acetate for sodium bicarbonate in the bath fluid for hemodialysis. Trans Am SocArtif Intern Organs 1964; 10:110-115
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Guideline 5.4 – Quality of dialysis fluid

We recommend that dialysis fluid production uses dialysis water produced by compliance with the requirements of BS ISO 13959;2014: *Water for haemodialysis and related therapies*. The dialysis fluid thus produced should additionally comply with the requirements of BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies* which states that dialysis fluid shall contain a total viable microbial count of less than 100 CFU/ml and an endotoxin concentration of less than 0.5 EU/ml with action levels set typically at 50% of the maximum permitted levels

Standard dialysis fluid is considered as the minimum quality, ultrapure dialysis fluid is recommended for routine haemodialysis and ultrapure dialysis fluid is mandatory for creating on-line prepared substitution fluid used in convective therapies such as on-line haemodiafiltration.

The process used for the production of on-line prepared substitution fluid shall bevalidated by the system manufacturer to produce fluid that is sterile and non-pyrogenic.We recommend that all haemodialysis dialysis machines are fitted with endotoxin retentive filter (s) to permit the production of ultrapure dialysis fluid.

Rationale

Haemodialysis patients are directly exposed to large volumes of dialysis fluid, with the dialyser membrane being the only barrier against transfer of hazardous contaminants from the dialysis fluid to the patient. To minimize this hazard, BS ISO 13958; 2014: *Concentrates for haemodialysis and related therapies* and BS ISO 13959; 2014: *Water for haemodialysis and related therapies*, set out the quality requirements for the water and concentrates used to prepare dialysis fluid [(1,2)]. However, dialysis fluid could contain unacceptable levels of contaminants even though it is prepared from water and concentrates meeting the requirements of the above standards. Furthermore, the dialysis fluid might be used as the starting material for the online preparation of fluids intended for infusion into the patient, for example, in therapies such as online haemodiafiltration. For these reasons, BS ISO 11663;2014: *Quality of dialysis fluid for haemodialysis and related therapies* outlines the acceptable limits for microbiological contaminants of the dialysis fluid. BS ISO 11663;2014: *Quality of dialysis fluid for haemodialysis and related therapies* defines three levels of quality of dialysis fluid: standard dialysis fluid, ultrapure dialysis fluid, and online prepared substitution fluid [(3)].

a) Standard dialysis fluid shall contain a total viable microbial count of less than 100 CFU/ml and an endotoxin concentration of less than 0.25 EU/ml. The action level for the total viable microbial count in dialysis fluid should be 50 CFU/ml. If microbial counts exceeding the action levels are observed in the dialysis fluid, corrective measures, such as disinfection and retesting, should be taken promptly to reduce the levels.

b) Ultrapure dialysis fluid shall contain a total viable microbial count of less than 0.1 CFU/ml and an endotoxin concentration less than 0.03 EU/ml. As for standard dialysis fluid, if the limits are exceeded corrective measures should be taken to reduce the levels to an acceptable range. The production of ultrapure dialysis fluid necessitates the treatment of standard dialysis fluid using point of use filtration.

The filters used for this, must be used and operated in accordance with manufacturers instructions for use.

c) Microbiological requirements for online prepared substitution fluid

Substitution fluid for convective therapies, such as haemodiafiltration and haemofiltration, may be produced online by a process of ultrafiltration with bacteria and endotoxin retentive filters. This online process shall be validated by the manufacturer to produce fluid that is sterile and non-pyrogenic. Compliance of online produced fluid with the requirements of BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies* cannot be demonstrated with traditional test procedures. For this reason, compliance with BS ISO 11663;2014: *Quality of dialysis fluid for haemodialysis and related therapies* shall be ensured by proper operation of a validated system, verified according to the manufacturer's instructions on installation, and confirmed by a regular monitoring and maintenance schedule.

1. BS ISO 13958;2014: *Concentrates for haemodialysis and related therapies*
2. BS ISO 13959; 2014: *Water for haemodialysis and related therapies*
3. BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*

Guideline 5.5 - Responsibility for policies for monitoring and recording

We recommend that the senior renal technologist shall be the person responsible for ensuring concordance with policies for monitoring and recording of the quality of dialysis water and dialysis fluid. If this person is absent from work, procedures shall be in place to ensure continuance of policies. (Not graded)

Rationale

Responsibility for the policies for monitoring and recording of quality of feed water, water for dialysis and dialysis fluid shall be part of the job plan of the senior renal technologist in the renal unit. The senior renal technologist should be accountable to the Clinical Director of the renal unit for monitoring and recording of the quality of dialysis water and should report immediately to the Clinical Director whenever action limits are exceeded.

6. Water treatment systems for the treatment of acute kidney injury

This section deals with portable water treatment systems intended for use with a dialysis delivery system to deliver dialytic therapies at the bedside. This section excludes equipment that may be used to supply three or more points of use in an “acute dialysis” setting. These systems are considered “central” water systems and thus are covered by the preceding section.

Guideline 6.1 Water treatment systems

We recommend that water treatment systems for haemodialysis are CE marked medical devices as defined by the Medical Devices Directive. Manufacturers should also comply with BS EN ISO 13485:2012which sets out the requirements for a quality management system and quality assurance systems relating to the design, development, production, installation and servicing of medical devices. (Not graded)

Guideline 6.2 Water supply

We suggest that a direct feed for water is used where haemodialysis is undertaken in a non-dialysis unit setting (Not graded)

Rationale

Ideally, renal units should have a direct (rising main) feed for the water used in the preparation of dialysis fluid. This is also applicable to rooms where dialysis is undertaken in a non dialysis unit setting. In instances where dialysis is performed in a setting where dialysis is not normally undertaken, the presence of a rising main feed may be established by seeking a cold water tap which is marked with a label stating that the water supplied from the tap is suitable for drinking. Such water will contain chemicals to ensure microbiological safety to the consumer. The commonly used chemical to control microbiological contaminant level in drinking water is chlorine. Chloramine may also be used as an alternative. The presence of both of these compounds is controlled in the water used for the preparation of dialysis fluid. Alternative chemicals may be used such as for example chlorine dioxide, to control for the presence of Cryptosporidium oocysts. In water, chlorine dioxide breaks down to yield chlorite, chlorate, and chloride ions. Currently, there is little information about the potential for chlorine dioxide and its daughter products to be toxic to haemodialysis patients. In the absence of data regarding the haemolytic potentialof chlorine dioxide, it is suggested that, in the interim, chlorine dioxide levels be quantified and that the maximum acceptable chlorine dioxide level be set at 0.1 mg/l.
If no such water supply exists in the room where dialysis is proposed, there is a possibility that the water supply is via an indirect feed, and the supply may contain chemicals such as silver stabilized hydrogen peroxide added within the hospital to ensure that the distribution network is free of pathogens (e.g, Legionella, pseudomonas, and mycobacteria). Prior to using such a supply technical personnel responsible for haemodialysis need to be aware of any potential effects that the disinfection of the hospital water treatment system may have on the product water used in the preparation of dialysis fluid. Additionally, hospital engineering personnel need to be made aware that dialysis is being performed to avoid the addition of chemicals to the water whilst treatment is being performed.
It should be noted that both chlorine dioxide and silver stabilized hydrogen peroxide break down to produce low molecular weight byproducts that can pass though a RO membrane. Consequently the treatment system used should incorporate a carbon filtration component to ensure that such byproducts of sanitization are effectively removed

Guideline 6.3 Backflow prevention

We recommend that a backflow prevention device should be installed at the point of connection to the potable water system (Not graded)

Rationale

Water treatment systems are generally linked to potable water systems. A backflow prevention device, should be installed at the point of connection to the potable water system.
Spent dialysis fluid and reject water from a reverse osmosis system unit should be discharged to drain in a manner that minimizes the potential for contamination of the patient-care area and the dialysis machine. Ideally, a floor drain or pipe connected to a hand sink drain should be used. If this is not available, the spent dialysis fluid and reverse osmosis reject water may be discharged directly into a sink. During dialysis, the sink should not be used for other purposes and the sink should be thoroughly cleaned after use.

Guideline 6.3 Electrical safety

We recommend that the water treatment systems used in an acute kidney injury treatment setting should comply with applicable electrical safety standards regarding electrostatic discharge (ESD), electromagnetic compatibility (EMC), and any other electrical safety standards as outlined in IEC 60601 1. Portable water treatment system component enclosures should possess a level of water resistance equal to IEC 60529 IPX 1. (Not graded)

Rationale

It is critically important that electrical noise and current leakage be minimized particularly if the equipment is used in an Intensive Care Unit setting, where other electrical equipment used in the treatment of the patient may be in close proximity.

Guideline 6.5 Microbial control strategies

Guideline 6.5.1 – Prevention of bacterial proliferation in the water delivery system

We recommend thatany water system for intermittent use for haemodialysis for acute kidney injury outside the renal unit should be designed and maintained to minimize bacterial proliferation. (Not graded)

Rationale

In contrast to renal unit use, the equipment used for acute dialysis, may not be in daily use. In addition, it may be moved frequently and connected and disconnected from the water supply whenever and wherever patients need to be treated. Equipment additionally may be reserved specifically for use in an acute kidney injury setting. Thus, any water system for use in such an application should be designed and maintained to minimize bacterial proliferation. To facilitate this there needs to be consideration given to the frequency of sanitization. The reverse osmosis system should be disinfected according to the manufacturer's instructions and more frequently if the equipment is not operated for several days or if test results demonstrate that the disinfection schedule is inadequate to ensure compliance with the microbiological quality requirements of 4.1 of BS/ISO 11663. The potential for bacterial proliferation can be diminished by operating the equipment for at least 15 min each day, regardless of whether or not a treatment is being performed. Alternately, a bacteriostatic agent (e.g. sodium bisulphite) may be added to minimize bacterial growth when the equipment is not in use. If such an agent is added, the equipment should be clearly labelled to indicate the presence of that agent.
Carbon media provides the potential for bacterial proliferation. Because of this, the manufacturer's instructions for scheduled replacement of carbon media should be followed and the replacement period should not exceed six months. If the machine is not disinfected daily, it should be disinfected before it is used. There should be awareness that the line supplying water to the dialysis machine is not disinfected when the machine is disinfected, this line should be disinfected when the reverse osmosis system is disinfected and should be given to replacing this line on a regular basis.

Guideline 6.5.2–Endotoxin retentive filters

We recommend that, owing to the intermittent nature of equipment use when treating acute kidney injury, consideration should be given to the use of a point of use endotoxin filter. (Not graded)

Guideline 6.6– Frequency of monitoring of dialysis water used for the preparation of dialysis fluid for haemodialysis for acute kidney injury

We recommend that the chemical and microbial quality of the treated or product water used for the preparation of dialysis fluid for the treatment of acute kidney injury should be routinely monitored. (Not graded)

Guideline 6.7- Policy for monitoring and recording of quality of dialysis water for haemodialysis for acute kidney injury

We recommend that the senior renal technologist shall be the person responsible for ensuring concordance with policies for monitoring and recording of the quality of dialysis water and dialysis fluid. If this person is absent from work, procedures shall be in place to ensure continuance of policies. (Not graded)

References

1. BS ISO 26722; 2014: *Water treatment equipment for haemodialysis andrelated therapies*
2. ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*. *Annex G:* Special considerations for acute haemodialysis
3. BS ISO 13959; 2014: *Water for haemodialysis and related therapies,*
4. BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*

7. Water treatment systems for home haemodialysis

The quality of dialysis water used to prepare concentrate and dialysis fluid is as important for home haemodialysis as it is for in-centre haemodialysis. While many of the provisions in previous sections of this document are applicable, it is recognised that the provision of dialysis facilities in a domestic setting might pose some special challenges not encountered with in-centre haemodialysis. Similarly, home haemodialysis might require some departures from the provisions in respect of water treatment and monitoring provisions compared to that used in a renal unit sited in a hospital. The recommendations included in this section apply to water treatment systems assembled from individual components rather than to systems for home haemodialysis containing integrated water treatment equipment. Such integrated systems produce water and dialysis fluid of the quality required by BSISO 13959 and BSISO 11663 and continued compliance will be dependent upon ensuring that manufacturer's instructions are adhered to.

Home haemodialysis further differs from in-centre haemodialysis in that the patient or a helper will be responsible for day-to-day operation and maintenance of the water treatment and other dialysis equipment. In general, these individuals will not have received formal technical training therefore, the dialysis unit responsible for the patient should ensure that the patient and/or helper are competent in the use of the equipment, and that their competency has been formally demonstrated and recorded.

Guideline 7.1 Water supply

We recommend that the domestic water supply used in the patient's home should support the maximum demand of the water treatment components and backflow protection should be installed before the start of the water treatment system in compliance with water supply regulations (Not graded).

Guideline 7.2 – Maintenance of the water and power supply

We recommend that the utility companies providing the water and power to the patient's home be notified that home dialysis is being performed and they have details of patients' addresses on their risk register to ensure that patients are informed in a timely manner of any proposed interruption of supply and that restoration of water and power supply is a priority. (Not graded)

Guideline 7.3 – Training of the patient and/or helper

We recommend that the patient and/or helper in the home should be formally trained in the correct operation and maintenance of the water treatment equipment by an appropriately trained technologist. There should be a record of the training, and the patient and /or helper should keep a log of the maintenance and monitoring procedures. (Not graded)

Guideline 7.4 – Home haemodialysis installations

We recommend that all installations for home haemodialysis should include carbon filters/beds with built in redundancy, a reverse osmosis system that is heat disinfected and point of use ultrafiltration. (1C)

Guideline 7.5 – Frequency of monitoring

Guideline 7.5.1 – Frequency of monitoring of feed water

We recommend that feed water from a private well should be tested for chemical and microbial quality at least every six months. The chemical and microbial quality of feed water from municipal suppliers should be assessed at least annually. In many instances such assessment may be made by reference to published data from the water supplier. (1C)

Guideline 7.5.2 – Frequency of monitoring of dialysis water used for the preparation of dialysis fluid for home haemodialysis

We recommend that the chemical and microbial quality of the product water used for the preparation of dialysis fluid in a home haemodialysis setting should be monitored at least every six months. (1C)

Rationale for 7.1-7.5

The general considerations described in the previous sections of this document are equally applicable to home haemodialysis installations. To incorporate a haemodialysis machine in a home, the home will need a water supply, a drain connection, and a power source. There will also be a need to consider backflow prevention. In respect of this reference should be made to:

www.wras.co.uk/consumers/resources/interpretations and advice/backflow prevention/b03/

The piping to a single-patient system should be at least 1 cm in diameter. The water pressure should meet the minimum requirements of the water treatment system, typically at least 150 kPa (approximately 20 psi or 1.5 bar). As other devices in the home such as toilets, clothes washers dishwashers and showers can temporarily reduce the water pressure when in use, consideration should be given to this during the planning stage, to ensure that their use does not interfere with dialysis. Furthermore, in areas that are using domestic water meters the installation of a separate water meter to the dialysis water infrastructure should be installed to ensure that water use for dialysis purposes is charged separately to that used for domestic applications. If the use of domestic appliances causes fluctuations in water pressure, a bladder tank may be installed in the line supplying water to the water treatment system to allow the system to continue operation during periods of low water pressure. In homes where water is supplied via a well or borehole, it may be necessary to install a booster pump to ensure that adequate water pressure to permit operation of the RO unit during periods of heavy water use.

In isolated rural locations, water temperature of the feed water might be an issue, particularly during winter. The performance of an RO system is temperature dependent, with the product-water flow rate decreasing as the temperature decreases. Removal of chloramine by activated carbon is also temperature dependent, with the efficiency of removal decreasing as the temperature decreases. If the water temperature decreases below 10°C, the heater in the dialysis machine might be unable to increase the temperature to the desired dialysate temperature. To ensure that these limitations do not prevent treatment in the home, a tempering valve may need to be installed to ensure a consistent supply of water of an adequate temperature.

If the feed water to the home is from a private well, an annual analysis of the quality of the product water may not be sufficient to ensure that the treatment system installed will remove contaminants present and a more frequent analysis may be needed, particularly if the well is subject to seasonal changes or liable to contamination from sources such as septic tanks, underground fuel storage tanks or agricultural waste and chemicals.

The equipment selected for home haemodialysis should be as simple as possible to operate. The equipment selected should comply with the requirements BS ISO 26722; 2014: Water treatment equipment for haemodialysis and related therapies [(1)], and the dialysis water produced should meet the requirements of BS ISO 13959; 2014: Water for haemodialysis and related therapies. As such equipment may be in a different area to where dialysis is being undertaken. Any alarm associated with a component of the water treatment system which does not invoke alarms on the proportionating system should be audible and visible in the patient treatment area.

There are a number of specific points pertinent to home installations in respect of the components that are used to make up the water treatment system [(2)]:

a) Carbon beds/filters

Carbon beds or carbon block filters are used to effect removal of total chlorine from the source or feed water and if the water is derived from a well, to also remove organic contaminants from ground water. Due to the limitations in space, compared to renal units, where carbon beds are commonly used, home treatment infrastructure relies on small carbon filters. When using such filters, either singly or in series, it should be recognised that the size, configuration and exchange frequency of the filters will be critically dependent upon the level of chlorine/chloramine and organic contaminants in the feed water and a well defined schedule of replacement should be in place. The selection of the appropriate filter requires specialist advice that should be sought at the earliest opportunity.

b) The distribution system for dialysis water

Because systems used for home haemodialysis operate intermittently, the distribution system should be designed and maintained to minimize bacterial proliferation. The system should allow regular sanitisation of the distribution loop up to the point where it connects to the machine. The use of heat sanitization is preferable to eliminate the use of disinfecting chemicals by the home haemodialysis patient, reducing the associated exposure risk.

c) Point of use ultrafiltration

Installation ofaendotoxin retentiveultrafilter in either the dialysis water or dialysis fluid path to remove endotoxin and other microbial contaminants is desirable. If installed, the endotoxin retentive filter should be maintained and replaced according to the manufacturer's instructions.

d) Monitoring of water and dialysis fluid quality

Routine monitoring of each treatment

A log sheet should be provided by the renal unit and used to record all measures of water treatment system performance. Measurements should be made at least 15 minutes after the water treatment system has been set in operation butbefore dialysis is initiated. To ensure that dialysis is not undertaken with suboptimal water quality, prior to each treatment, the performance of the reverse osmosis system should be monitored and recorded by checking the product water conductivity and percent rejection. If the reverse osmosis system is found to be outside its acceptable range, the renal unit responsible for the patient should be notified. If the water treatment includes a stand alone softener, the water hardness should be monitored prior to each treatment using a sample obtained through a labelled sample port located between the softener and the reverse osmosis system. For hardness tests requiring colourdifferentiation, the person performing the analysis should be able to distinguish between the colours of blue, purple, and red. If the person cannot differentiate these colours, an automated meter should be used. The results obtained should be recorded on the log sheet and reviewed by the renal technologist as part of the maintenance and service of the home haemodialysis installation.

Monitoring for chemical and microbiological quality

The chemical quality of the dialysis water used for dialysis should be analyzed at least every six months to ensure it meets the requirements of BS ISO 13959; 2014: *Water for haemodialysis and related therapies*[3]. A more frequent analysis may be needed if there are seasonal variations in source water quality or if the source water is supplied from a well. When any repairs or component replacements are made to water treatment equipment, the impact on water quality should be evaluated and a chemical analysis performed if indicated.

The microbiological quality of the dialysis fluid should also be analyzedat least every six months using the appropriate techniques to ensure it meets the requirements of BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies* [4].This document defines three types of dialysis fluid: standard dialysis fluid, ultrapure dialysis fluid, andonline-prepared substitution fluid prepared from ultrapure dialysis fluid. Standard dialysis fluid is considered the minimum acceptablequality and the use ofultrapure dialysis fluid is recommended for routine haemodialysis. Ultrapure dialysis fluid involves the use of a endotoxin retentive filter. When such a filter is fitted, is validated by the manufacturer and operated and monitored according to the manufacturer'sinstructions, tests for bacterial growth and endotoxins are not required unless the manufacturer requires such tests in the instructions for use.

It should be noted that if daily dialysis schedules are being performed, this frequency may be insufficient.

If the interval between sample testing exceeds six months documentation should be in place to demonstrate to detail the rationale used. Operating procedures should include details of the procedures to be followed if the prescribed limits are exceeded.

Sampling should be prior to any disinfection of the water treatment system and dialysis machine and a system should be in place to ensure proper collection of the samples and their timely submission to the

testing laboratory. If patients or helpers are expected to perform sampling, they should have received adequate training to do so and this training should be appropriately documented.

References

1. BS ISO 26722; 2014: *Water treatment equipment for haemodialysis andrelated therapies*
2. ISO 23500; 2014: *Guidance for the preparation and quality management of fluids for haemodialysis and related therapies*. *Annex F:* Special considerations for home haemodialysis
3. BS ISO 13959; 2014: *Water for haemodialysis and related therapies*,
4. BS ISO 11663; 2014: *Quality of dialysis fluid for haemodialysis and related therapies*

8. Haemodialysis concentrate production and concentrate distribution systems

Guideline 8.1 - Specification of haemodialysis concentrate production and concentrate distribution systems

We recommend that haemodialysis concentrate production and distribution systems meet the requirements of BS ISO 13958:2014: *Concentrates for haemodialysis and related therapies* and are CE marked medical devices as defined by the Medical Devices Directive. (Not graded)

Guideline 8.2 – Operation of haemodialysis concentratemixer systems and concentrate distribution systems

We recommend that concentrate mixer systems should be operated according to the manufacturer supplied literature. Particular attention is required to comply with any instructions to test batches of concentrate or disinfect the equipment. The disinfection of acid concentrate tanks is not normally necessary as the fluid is bacteriostatic. (Not graded)

Rationale for 8.1-8.2

ISO 13958:2014: *Concentrates for haemodialysis and related therapies* contains minimum requirements for haemodialysis concentrates. This guidance is primarily intended for manufactures of concentrates, concentrate mixers and concentrate distribution equipment. However when bulk concentrate is delivered to a dialysis facility the obligation to maintain concentrate quality passes to the customer. To ensure good quality control those specifying concentrate production or distribution systems need to ensure these systems will not endanger patients or operators.
The standards states that components of the system shall not interact chemically or physically or contribute microbiological contamination to the concentrate.
The concentrate production or distribution system shall also meet the requirements of BS EN 60601-1:2006 *Medical electrical equipment. General requirements for basic safety and essential performance* as there could be a conductive fluid pathway between the system and the patient (via the haemodialysis machine), or BS EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use*,if the system is ‘stand-alone’ and not patient connected.
Haemodialysis concentrate mixer systems should be operated in accordance with manufacturer’s instructions, particularly regarding the final composition of the concentrate as the user is responsible for undertaking any tests advised by the manufacturer. It should be noted that when a bulk delivery of concentrate occurs the responsibility for compliance with this standard passes from the manufacturer to the user at the legal point of transfer. The user should therefore ensure the written documentation of the delivery corresponds with the product that was ordered and it is transferred to the correct storage tank.

The user should ensure the distribution system outlets are labelled appropriately to minimise the possibility of error in the transfer of concentrate.

Appendix 1

Site :

Contaminant	Drinking Water Limits		Drinking Water Results	BS ISO 13959 limits		RO Water Results	Follow-up required? **Y/N**
	mg/l	µg/l		mg/l	µg/l		
Aluminium	0.2	200		0.01	10		
Calcium				2			
Total Chlorine				0.1	100		
Copper	2			0.1	100		
Fluoride	1.5			0.2	200		
Magnesium				4			
Nitrate as NO_3	50			9			
Potassium				8			
Sodium	200			70			
Bacteria (TVC)	0			100 cfu/ml			
Endotoxin				0.25 IU/ml			
Arsenic	0.01	10		0.005	5		
Cadmium	0.005	5		0.001	1		
Chromium	0.05	50		0.014	14		
Lead	0.01	10		0.005	5		
Mercury	0.001	1		0.0002	0		
Sulphate	250			100			
Barium				0.1	100		
Beryllium				0.0004	0		
Silver				0.005	5		
Thallium				0.002	2		
Zinc		.		0.1	100		
			Date			Date	

Checked by: