
**Water for haemodialysis and related
therapies**

Eau pour hémodialyse et thérapies apparentées

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13959 was prepared by Technical Committee ISO/TC 150, *Implants for surgery*, Subcommittee SC 2, *Cardiovascular implants and extracorporeal systems*.

This second edition cancels and replaces the first edition (ISO 13959:2002), which has been technically revised.

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Introduction

Assurance of adequate water quality is one of the most important aspects of ensuring a safe and effective delivery of haemodialysis, haemodiafiltration or haemofiltration.

This International Standard contains minimum requirements, chemical and microbiological, for the water to be used for preparation of dialysis fluids, concentrates and for the re-use of haemodialysers and the necessary steps to assure compliance with those requirements. Haemodialysis and haemodiafiltration can expose the patient to more than 500 l of water per week across the semi-permeable membrane of the haemodialyser or haemodiafilter. Healthy individuals seldom have a weekly oral intake above 12 l. This over 40-fold increase in exposure requires control and monitoring of water quality to avoid excesses of known or suspected harmful substances. Since knowledge of potential injury from trace elements and contaminants of microbiological origin over long periods is still growing and techniques for treating drinking water are continuously developed, this International Standard will evolve and be refined accordingly. The physiological effects attributable to the presence of organic contaminants in dialysis water are important areas for research. At the time this International Standard was published it was premature to specify threshold values for organic contaminants below those published by various regulatory authorities.

The final dialysis fluid is produced from concentrates or salts manufactured, packaged and labelled according to ISO 13958 mixed with water meeting the requirements of this International Standard. Operation of water treatment equipment and haemodialysis systems, including ongoing monitoring of the quality of water used to prepare dialysis fluids, and handling of concentrates and salts are the responsibility of the haemodialysis facility and are addressed in ISO 23500. Haemodialysis professionals make choices about the various applications (haemodialysis, haemodiafiltration, haemofiltration) and should understand the risks of each and the requirements for safety for fluids used for each.

The verbal forms used in this International Standard conform to usage described in Annex H of the ISO/IEC Directives, Part 2. For the purposes of this International Standard, the auxiliary verb:

- “shall” means that compliance with a requirement or a test is mandatory for compliance with this International Standard;
- “should” means that compliance with a requirement or a test is recommended but is not mandatory for compliance with this International Standard; and
- “may” is used to describe a permissible way to achieve compliance with a requirement or test.

This International Standard is directed towards manufacturers and providers of water treatment systems and also to haemodialysis facilities.

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Water for haemodialysis and related therapies

1 Scope

This International Standard specifies minimum requirements for water to be used in the preparation of concentrates, dialysis fluids for haemodialysis, haemodiafiltration and haemofiltration and for the reprocessing of haemodialysers.

This International Standard does not address the operation of water treatment equipment nor the final mixing of treated water with concentrates to produce the dialysis fluids used in such therapies. That operation is the sole responsibility of dialysis professionals.

This International Standard does not apply to dialysis fluid regenerating systems.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1

action level

concentration of a contaminant at which steps should be taken to interrupt the trend toward higher, unacceptable levels

2.2

chlorine, total

sum of free and combined chlorine

NOTE chlorine can exist in water as dissolved molecular chlorine (free chlorine) or in chemically combined forms (combined chlorine). Where chloramine is used to disinfect water supplies, chloramine is usually the principal component of combined chlorine.

2.3

colony-forming unit

CFU

measure of bacterial or fungal cell numbers that theoretically arise from a single cell or group of cells when grown on solid media

NOTE Colonies can form from groups of organisms when they occur in aggregates.

2.4

dialysis fluid

aqueous fluid containing electrolytes and usually buffer and glucose, which is intended to exchange solutes with blood during haemodialysis

NOTE 1 The term "dialysis fluid" is used throughout this document to mean the fluid made from dialysis water and concentrates which is delivered to the dialyser by the dialysis fluid delivery system. Such phrases as "dialysate," "dialysis solution," or "dialysing fluid" can be used in place of dialysis fluid.

NOTE 2 The dialysis fluid entering the dialyser is referred to as "fresh dialysis fluid," while the fluid leaving the dialyser is referred to as "spent dialysis fluid."

NOTE 3 Dialysis fluid does not include prepackaged parenteral fluids used in some renal replacement therapies, such as haemodiafiltration and hemofiltration.

**2.5
dialysis water**

water that has been treated to meet the requirements of this International Standard and which is suitable for use in haemodialysis applications, including the preparation of dialysis fluid, reprocessing of dialysers, preparation of concentrates and preparation of substitution fluid for online convective therapies

**2.6
endotoxin**

major component of the outer cell wall of gram-negative bacteria

NOTE Endotoxins are lipopolysaccharides, which consist of a polysaccharide chain covalently bound to lipid A. Endotoxins can acutely activate both humoral and cellular host defences, leading to a syndrome characterized by fever, shaking, chills, hypotension, multiple organ failure, and even death if allowed to enter the circulation in a sufficient dose [see also **pyrogen** (2.12)].

**2.7
endotoxin units**

EU
units assayed by the *Limulus* amoebocyte lysate (LAL) test when testing for endotoxins

NOTE 1 Because the activity of endotoxins depends on the bacteria from which they are derived, their activity is referred to a standard endotoxin.

NOTE 2 In some countries, endotoxin concentrations are expressed in international units (IU). Since the 1983 harmonization of endotoxin assays, EU and IU are equivalent.

**2.8
feed water**

water supplied to a water treatment system or an individual component of a water treatment system

**2.9
Limulus amoebocyte lysate test**

LAL
assay used to detect endotoxin

NOTE The detection method uses the chemical response of the horseshoe crab (*Limulus polyphemus*) to endotoxin.

**2.10
microbial**

referring to microscopic organisms, bacteria, fungi and so forth

**2.11
microbial contamination**

contamination with any form of microorganism (e.g. bacteria, yeast, fungi and algae) or with the by-products of living or dead organisms such as endotoxins, exotoxins and cyanobacterial toxins (derived from blue-green algae)

**2.12
pyrogen**

fever-producing substance

NOTE Pyrogens are most often lipopolysaccharides of gram-negative bacterial origin [see also **endotoxin** (2.6)].

3 Dialysis water requirements

3.1 Dialysis water verification and monitoring

The quality of the dialysis water, as specified in 3.2 and 3.3, shall be verified upon installation of a water treatment system. Monitoring of the dialysis water quality shall be carried out thereafter.

3.2 Microbiological requirements

Total viable microbial counts in dialysis water shall be less than 100 CFU/ml, or lower if required by national legislation or regulations. An action level shall be set based on knowledge of the microbial dynamics of the system. Typically, the action level will be 50 % of the maximum allowable level.

Endotoxin content in dialysis water shall be less than 0,25 EU/ml, or lower if required by national legislation or regulations. An action level shall be set, typically at 50 % of the maximum allowable level.

NOTE See Clause A.1 for a history of these requirements.

3.3 Chemical contaminants

Dialysis water shall not contain chemicals at concentrations in excess of those listed in Tables 1 and 2, or as required by national legislation or regulations.

NOTE See Clause A.2 for explanation of values supplied.

Where the dialysis water is used for the reprocessing of haemodialysers, (cleaning, testing and mixing of disinfectants) the user is cautioned that the dialysis water shall meet the requirements of this International Standard. The dialysis water should be measured at the input to the dialyser reprocessing equipment.

Table 1 — Maximum allowable levels of toxic chemicals and dialysis fluid electrolytes in dialysis water ^a

Contaminant	Maximum concentration mg/l ^b
Contaminants with documented toxicity in haemodialysis	
Aluminium	0,01
Total chlorine	0,1
Copper	0,1
Fluoride	0,2
Lead	0,005
Nitrate (as N)	2
Sulfate	100
Zinc	0,1
Electrolytes normally included in dialysis fluid	
Calcium	2 (0,05 mmol/l)
Magnesium	4 (0,15 mmol/l)
Potassium	8 (0,2 mmol/l)
Sodium	70 (3,0 mmol/l)
^a The physician has the ultimate responsibility for ensuring the quality of water used for dialysis.	
^b Unless otherwise noted.	

Table 2 — Maximum allowable levels of trace elements in dialysis water

Contaminant	Maximum concentration mg/l
Antimony	0,006
Arsenic	0,005
Barium	0,1
Beryllium	0,000 4
Cadmium	0,001
Chromium	0,014
Mercury	0,000 2
Selenium	0,09
Silver	0,005
Thallium	0,002

4 Tests for compliance with microbiological and chemical requirements

4.1 Microbiology of dialysis water

Samples shall be collected where a dialysis machine connects to the water distribution loop, from a sample point in the distal segment of the loop or where water enters a mixing tank.

Samples shall be assayed within 4 h of collection, or be immediately refrigerated and assayed within 24 h of collection on a regular schedule. Total viable counts (standard plate counts) shall be obtained using conventional microbiological assay procedures (pour plate, spread plate, membrane filter techniques). Membrane filtration is the preferred method for this test. The calibrated loop technique is not accepted.

Culture media should be tryptone glucose extract agar (TGEA), Reasoners 2A (R2A), or other media that can be demonstrated to provide equivalent results. Blood agar and chocolate agar shall not be used. Incubation temperatures of 17 °C to 23 °C and incubation time of 168 h (7 d) are recommended. Other incubation times and temperatures may be used if it can be demonstrated that they provide equivalent results. No method will give a total microbial count.

The presence of endotoxins shall be determined by the *Limulus* amoebocyte lysate (LAL) test. Other test methods may be used if it can be demonstrated that they provide equivalent results.

4.2 Chemical contaminants test methods

Compliance with the requirements listed in Table 1 can be shown by using chemical analysis methods referenced by the American Public Health Association [3], methods referenced by the U.S. Environmental Protection Agency [46], methods referenced in applicable pharmacopoeia, and/or other equivalent validated analytical methods.

Compliance with the requirements listed in Table 2 can be shown in one of three ways.

- Where such testing is available, the individual contaminants in Table 2 can be determined using chemical analysis methods referenced by the American Public Health Association [3], methods referenced by the U.S. Environmental Protection Agency [46], and/or other equivalent analytical methods.
- Where testing for the individual trace elements listed in Table 2 is not available, and the source water can be demonstrated to meet the standards for potable water as defined by the WHO or local regulations, 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 2 can be met by using water that can be demonstrated to meet the potable water requirements of the WHO (see Reference [51]) or local regulations and a reverse osmosis system with a rejection of > 90 % based on conductivity, resistivity or TDS. Samples shall be collected at the end of the water purification cascade or at the most distal point in each water distribution loop.

Table 3 lists tests for each contaminant, along with an appropriate reference.

Table 3 — Analytical tests for chemical contaminants

Contaminant	Test name	Reference, test number
Aluminium	Atomic absorption (electrothermal)	American Public Health Assn, #3113
Antimony	Atomic absorption (platform)	US EPA, #200.9
Arsenic	Atomic absorption (gaseous hydride)	American Public Health Assn, #3114
Barium	Atomic absorption (electrothermal)	American Public Health Assn, #3113
Beryllium	Atomic absorption (platform)	US EPA, #200.9
Cadmium	Atomic absorption (electrothermal)	American Public Health Assn, #3113
Calcium	EDTA titrimetric method or atomic absorption (direct aspiration) or ion specific electrode or inductively-coupled plasma spectrometry (direct aspiration)	American Public Health Assn, #3500-Ca D American Public Health Assn, #3111B
Total chlorine	DPD ferrous titrimetric method or DPD colorimetric method	American Public Health Assn, #4500-Cl F American Public Health Assn, #4500-Cl G
Chromium	Atomic absorption (electrothermal)	American Public Health Assn, #3113
Copper	Atomic absorption (direct aspiration) or neocuproine method	American Public Health Assn, #3111 American Public Health Assn, #3500-Cu D
Fluoride	Ion selective electrode method or sodium 2-(parasulfo-phenylazo)-1,8-dihydroxy-3,6-naphthalenedisulfonate (SPADNS) method	American Public Health Assn, #4500-F ⁻ C American Public Health Assn, #4500-F ⁻ D
Lead	Atomic absorption (electrothermal)	American Public Health Assn, #3113
Magnesium	Atomic absorption (direct aspiration) or inductively-coupled plasma spectrometry (direct aspiration)	American Public Health Assn, #3111
Mercury	Flameless cold vapour technique (atomic absorption)	American Public Health Assn, #3112
Nitrate	Cadmium reduction method	American Public Health Assn, #4500-NO ₃ E
Potassium	Atomic absorption (direct aspiration) or flame photometric method or ion specific electrode or inductively-coupled plasma spectrometry (direct aspiration)	American Public Health Assn, #3111 American Public Health Assn, #3500-K D American Public Health Assn, #3500-K E

Table 3 (continued)

Contaminant	Test name	Reference, test number
Selenium	Atomic absorption (gaseous hydride) or atomic absorption (electrothermal)	American Public Health Assn, #3114 American Public Health Assn, #3113
Silver	Atomic absorption (electrothermal)	American Public Health Assn, #3113
Sodium	Atomic absorption (direct aspiration) or flame photometric method or ion specific electrode or inductively-coupled plasma spectrometry (direct aspiration)	American Public Health Assn, #3111 American Public Health Assn, #3500-Na D
Sulfate	Turbidimetric method	American Public Health Assn, #4500-SO ₄ ²⁻ E
Thallium	Atomic absorption (platform)	US EPA, 200.9
Total heavy metals	Colorimetric	European Pharmacopoeia, 2.4.8 US Pharmacopoeia, <231>
Zinc	Atomic absorption (direct aspiration) or dithizone method	American Public Health Assn, #3111 American Public Health Assn, #3500-Zn D

Annex A (informative)

Rationale for the development and provisions of this International Standard

A.1 Microbiology of dialysis water

NOTE The information in this clause is intended to give the reader a historical prospective of how the microbial limits were developed for this document.

Originally, it was considered that the water used to prepare dialysis fluid need not be sterile. However, several studies had demonstrated that the attack rates of pyrogenic reactions were related directly to the number of bacteria in dialysis fluid (Dawids and Vejlsgaard^[13]; Favero *et al.*^[17]; Favero *et al.*^[18]). These studies provided the rationale for setting the maximum level of bacteria in dialysis water at 200 CFU/ml in the original AAMI standard for water quality published in 1982. Later, the European community chose to use a slightly lower level of 100 CFU/ml as their bacterial limit for dialysis water and that value has been adopted in this International Standard. Because 7 d can elapse between sampling water for the determination of microbial contamination and receiving results, and because bacterial proliferation can be rapid, action levels for microbial counts were introduced into this International Standard. These action levels allow the user to initiate corrective action before levels exceed the maximum levels established by this International Standard.

Several groups of investigators have shown convincingly that pyrogenic reactions are caused by lipopolysaccharides or endotoxins that are associated with gram-negative bacteria. Furthermore, gram-negative water bacteria have been shown to be capable of multiplying rapidly in dialysis water prepared by distillation, deionization, reverse osmosis and softening. Dialysis fluid made with this water likewise provides a very good growth medium for these types of bacteria. Even at low levels of bacterial contamination, pyrogenic reactions have been reported when the source of endotoxin was exogenous to the dialysis system (i.e. present in the community water supply) (Hindman *et al.*^[20]). Consequently, it was thought prudent to impose an upper limit on the endotoxin content of dialysis water. A level of 2 EU/ml was chosen by AAMI as the upper limit for endotoxin, since compliance with that level could be easily achieved with contemporary water treatment systems using reverse osmosis, ultrafiltration or both. At the same time the European community chose to use an upper limit of 0,25 EU/ml for endotoxin. During revision of this International Standard in 2008, the 0,25 EU/ml limit was included as the upper limit for endotoxin in dialysis water.

A.2 Chemical contaminants test methods

NOTE This historical review is provided to help the reader understand the considerations given to the chemical contamination of water used for dialysis treatments.

Contaminants identified as needing restrictions on the allowable level that can be present in water for dialysis, are divided into three groups for the purposes of this International Standard. The first group includes chemicals shown to cause toxicity in dialysis patients. These chemicals include fluoride, aluminium, chloramines, sulfate, nitrate, copper, zinc and lead. Chlorine is included here because of its potential toxicity.

Toxicity of fluoride in dialysis patients at the levels usually associated with fluoridated water, 1 mg/l, is questionable. In the absence of a consensus on fluoride's role in uraemic bone disease, it was initially thought prudent to restrict the fluoride level of dialysis fluid (Rao and Friedman^[39]). Subsequently, illness in all of eight dialysis patients, with the death of one patient, was reported as a result of accidental overfluoridation of a municipal water supply (CDC^[11]). Fluoride levels of up to 50 mg/l were found in water used for dialysis that was treated only with a water softener. Probably these illnesses would have been less severe, if not prevented, if the dialysis water had been treated with deionization or reverse osmosis. In one case, where deionizers were allowed to exhaust, 12 of 15 patients became acutely ill from fluoride intoxication (Arnow *et al.*^[5]). Three

of the patients died from ventricular fibrillation. Fluoride concentrations in the water used to prepare the dialysis fluid were as high as 22,5 mg/l.

The suggested maximum aluminium level has been specified to prevent accumulation of this toxic metal in the patient (Kovalchik *et al.*^[29]; Masuyama and Tachibana^[32]). Aluminium is particularly likely to increase suddenly to high levels caused by changes in the method of water treatment to include aluminium-containing compounds. As with fluoride, water treatment would provide a measure of safety even if the aluminium levels should increase dramatically between chemical tests of the dialysis water.

The toxicity of chloramines is undisputed (Eaton *et al.*^[14]). Although the role of free chlorine in oxidative blood damage is unclear, its high oxidation potential and ability to form chloramines suggests the avoidance of highly chlorinated water in preparation of dialysis fluid. Chlorine can be present in water as both free chlorine and chlorine in chemically combined forms. Chloramines are a form of chemically combined chlorine. Determining the level of chloramines typically involves measuring both total chlorine and free chlorine and assigning the difference in concentrations to chloramines. During revision of this International Standard in 2008, the working group chose to simplify this situation by setting a maximum allowable level for total chlorine at the same value used previously for chloramine (0,1 mg/l), thus permitting a single test to be used.

Sulfate at levels above 200 mg/l has been related to nausea, vomiting and metabolic acidosis. The symptoms disappear when the level remains below 100 mg/l (Comty *et al.*^[12]). Nitrates are a marker for bacterial contamination and fertilizer runoff, and have caused methaemoglobinaemia (Carlson and Shapiro^[10]). They should, therefore, be permitted only at very low levels. Both copper and zinc toxicity have been demonstrated when these substances are present in dialysis fluid at levels below those permitted by the U.S. Environmental Protection Agency (EPA) standard (Ivanovich *et al.*^[21]; Petrie and Row^[35]). Hence, a lower level has been chosen.

Dialysis fluid lead levels of 52 µg/l to 65 µg/l have been associated with abdominal pain and muscle weakness (Kathuria *et al.*^[24]). There is no evidence of lead toxicity when lead levels in water or dialysis fluid are below 5 µg/l.

The second group of substances addressed in 3.3 and Table 1 consists of physiological substances that can adversely affect the patient if present in the dialysis fluid in excessive amounts. Calcium, magnesium, potassium and sodium are examples of these substances.

Of the physiological substances that can be harmful when present in excessive amounts, calcium has been reduced from the 10 mg/l originally selected to 2 mg/l on the basis of the critical role of calcium in bone disorders associated with renal disease. A level of 10 mg/l would have allowed a potential 20 % error in dialysis fluid calcium, whereas a level of 2 mg/l reduces that error risk to less than 5 %.

The third group of chemical contaminants addressed in 3.3 is based on a U.S. EPA^[47]. When the AAMI standard ANSI/AAMI RD5^[53] was initially developed, the U.S. EPAs^[47] included barium, selenium, chromium, silver, cadmium, mercury and arsenic. Selenium and chromium levels were set at the "no-transfer" level (Klein *et al.*^[27]). The "no-transfer" level was chosen even though it is above the U.S. EPA limit for selenium and 28 % of the U.S. EPA limit for chromium, because a restriction is not needed below the level at which there is no passage from the dialysis fluid to the blood. The standard specified the maximum allowable limits for the other contaminants in this group to be one tenth of the U.S. EPA maximum allowable limits because the volume of water used for dialysis far exceeds that used for drinking water, because protein binding of these solutes could occur in the blood, and because there is reduced renal excretion of these substances. These reduced limits were selected using the following assumptions: (1) feed water entering dialysis systems typically meets the U.S. EPA *Safe Drinking Water Act*; (2) typically, reverse osmosis treatment removes 90 % to 99 % of dissolved inorganic solids; (3) reverse osmosis-treated water is a suitable standard for safety of water used in dialysis. These assumptions are based on the recommendations of Keshaviah *et al.*^[25]. Although these assumptions can be questioned, it was reasoned that setting standards in this way would cause little or no economic impact, even though some feed water exceeds the U.S. EPA maximum allowable levels. It should be noted that the level for arsenic, 0,05 mg/l in the Keshaviah report, is a typographical error. The correct value is 0,005 mg/l as given in Table 2 of this International Standard (E. Klein, personal communication). It should also be noted that the EPA maximum allowable level for arsenic in drinking water was reduced to 0,01 mg/l, effective from January 26th, 2006.

Several changes occurred in the *Safe Drinking Water Act* after these levels were established. Specifically, antimony, beryllium, free cyanide and thallium were added to the list of contaminants covered by the Act and the maximum allowable level for cadmium had been decreased. For consistency, antimony, beryllium and thallium were added to the list of contaminants in the United States. The maximum allowable levels of antimony and thallium were set at values above one-tenth of the U.S. EPA maximum allowable level because of limitations in the sensitivity of commonly available analytical methods for these two contaminants. After considerable discussion, it was decided not to add free cyanide to the list of contaminants. There was concern that special requirements for sample collection and shipment, together with the need to pre-treat the sample before analysis to eliminate interfering substances, would impose a burden on dialysis facilities that could not be justified in the absence of specific toxicity data. It was also decided not to decrease the maximum allowable level of cadmium in the list of contaminants. This decision was based on the absence of toxicity data in dialysis patients treated with water that meets this International Standard and the minimum detection levels of currently used analytical methods.

Little, if any, data exist to indicate that haemodialysis patients are at particular risk from any of the third group of contaminants, which are included in the AAMI standard solely by virtue of their inclusion in the *Safe Drinking Water Act*. In the United States, there was discussion about eliminating the third group of contaminants from Table 2 and moving discussion of them to this annex. This discussion was prompted by the ongoing addition of contaminants to the U.S. *Safe Drinking Water Act*. As was the case with antimony, beryllium and thallium, in general no data exist to indicate that these new contaminants are of particular concern in the setting of haemodialysis. On the other hand, adding new contaminants to Table 2 has the potential to increase the operating constraints to dialysis facilities for testing water samples for compliance. There was enough discomfort about removing the third category of contaminants from Table 2 that it was decided to leave the list of contaminants unchanged, but to reorganize the table into three clear sections, and not to add new contaminants to the table unless there was accompanying evidence of toxicity in the setting of haemodialysis. During revision of this International Standard in 2008, a decision was made to separate the third group of contaminants into a separate Table. One reason for this change was to allow alternative approaches to monitoring these contaminants to facilitate use of this International Standard in areas lacking the appropriate analytical tools for measuring trace elements at the levels listed in Table 2. Three options are provided. The preferred option is to measure concentrations of the individual trace elements. If this option is not available, two other approaches may be used. The first, and preferred alternative, is to measure total heavy metals. The second, and least preferred alternative, is to use reverse osmosis with a demonstrated rejection of at least 90 %. Both these alternative approaches are based on the use of feed water meeting applicable potable water standards and it is the responsibility of the dialysis facility to ensure that its water supply routinely meets potable water standards.

Tables 1 and 2 of this International Standard should not be taken as a definitive list of harmful substances, but as a partial listing of those that might reasonably be expected to be present and have clinical implications. Iron is not included because it does not enter the patient's blood in sufficient quantities to cause toxicity. Iron can, however, cause fouling of water purification devices or dialysis fluid supply systems. While no specific limit has been set, water treatment equipment suppliers are encouraged to consider the iron content of the feed water when recommending suitable equipment. A concern was raised regarding the injection of formulated phosphates (known as polyphosphates) primarily to bind iron and manganese to avoid the staining of fixtures and clothing. The concern was raised that this practice could cause significant problems in water purification. Some municipal water suppliers were considering the use of chlorine dioxide as a disinfectant for potable water supplies. Chlorine dioxide breaks down in water to yield chlorite, chlorate and chloride ions. Little information could be found about the potential for chlorine dioxide and its daughter products to be toxic to haemodialysis patients. A limited study of 17 patients unknowingly treated with dialysis water prepared by carbon adsorption and reverse osmosis from water disinfected with chlorine dioxide showed no evidence of adverse effects (Ames and Stratton^[4]). In that study, the dialysis water used to prepare dialysis fluid contained 0,02 mg/l to 0,08 mg/l of chlorite ions and no detectable chlorate ions. However, the patient population was small, and potentially important haematological parameters were not measured. Further, there were only sparse data included on the removal of chlorine dioxide, chlorite ions and chlorate ions by carbon adsorption and reverse osmosis, and it was not clear that sufficiently sensitive methods were available for their analysis in a dialysis facility. Therefore, there was no basis for setting maximum allowable levels of chlorine dioxide, chlorite ions or chlorate ions in water to be used for dialysis applications, or for making recommendations on methods for their removal at that time. However, in specifying water purification systems, manufacturers of such systems should be aware of the possibility that municipal water suppliers may add chlorine dioxide to the water.

Limits could not be determined for toxic organic substances or for radioactive materials (Keshaviah *et al.*^[25]). However, the U.S. EPA drinking water standard^[47] lists maximum contaminant levels (MCL) for more than 50 toxic organic substances. Following the rationale used in establishing levels for other potentially toxic contaminants that have not been shown to be harmful to dialysis patients (see previous paragraph), it is reasonable that these levels should be reduced tenfold if they are monitored. These data are provided for information purposes only, because these substances are only representative of a vast number of contaminants that occur in tap water, all of whose toxic effects are largely unknown (Keshaviah *et al.*^[25]). In agreement with the Keshaviah report, it is thought that systems including reverse osmosis and carbon filtration would adequately remove most organics.

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