Water-tube boilers and auxiliary installations —

Part 12: Requirements for boiler feedwater and boiler water quality

The European Standard EN 12952-12:2003 has the status of a British Standard

ICS 13.060.25; 27.040

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British Standards

National foreword

This British Standard is the official English language version of EN 12952-12:2003.

The UK participation in its preparation was entrusted to Technical Committee PVE/2, Water-tube boilers, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

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Water-tube boilers and auxiliary installations - Part 12: Requirements for boiler feedwater and boiler water quality

Chaudières à tubes d'eau et installations auxiliaires - Partite 12: Exigences relatives à la qualité de l'eau d'alimentation et de l'eau en chaudière

Wasserrohrkessel und Anlagenkomponenten - Teil 12: Anforderungen an die Speisewasser- und Kesselwasserqualität

This European Standard was approved by CEN on 24 July 2003.

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Foreword

This document (EN 12952-12:2003) has been prepared by Technical Committee CEN/TC 269, "Shell and water-tube boilers", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2004, and conflicting national standards shall be withdrawn at the latest by March 2004.

The European Standard EN 12952 concerning water-tube boilers and auxiliary installations consists of the following Parts:

- Part 1: General.
- Part 2: Materials for pressure parts of boilers and accessories.
- Part 3: Design and calculation for pressure parts. Part 4: In-
- service boiler life expectancy calculations.
- Part 5: Workmanship and construction of pressure parts of the boiler.
- Part 6: Inspection during construction, documentation and marking of pressure parts of the boiler.
- Part 7: Requirements for equipment for the boiler.
- Part 8: Requirements for firing systems for liquid and gaseous fuels for the boiler.
- Part 9: Requirements for firing systems for pulverized solid fuels for the boiler.
- Part 10: Requirements for safeguards against excessive pressure.
- Part 11: Requirements for limiting devices of the boiler and accessories.
- Part 12: Requirements for boiler feedwater and boiler water quality.
- Part 13: Requirements for flue gas cleaning systems.
- Part 14: Requirements for flue gas DENOX-systems using liquified pressurized ammonia and ammonia water solution.
- Part 15: Acceptance tests.
- Part 16: Requirements for grate and fluidized bed firing systems for solid fuels for the boiler.

CR 12952 Part 17: Guideline for the involvement of an inspection body independent of the manufacturer.

Although these Parts can be obtained separately, it should be recognized that the Parts are inter-dependent. As such, the design and manufacture of water-tube boilers requires the application of more than one Part in order for the requirements of the standard to be satisfactorily fulfilled.

NOTE Parts 4 and 15 are not applicable during the design, construction and installation stages.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This Part of this European Standard applies to all water-tube boilers as defined in EN 12952-1 which are heated by combustion of one or more fuels or by hot gases for the generation of steam and/or hot water.

This Part of this European Standard applies to those components between the feedwater inlet and the steam outlet of the steam generator. The quality of the steam produced is outside the scope of this standard.

This Part of this European Standard aims to ensure that the boiler is able to be operated to minimize risk to personnel, the boiler and associated plant components located near it.

NOTE 1 This part of this European Standard does not aim to achieve optimum economic operation. For certain purposes, it will be more appropriate to optimize the chemical characteristics in order to:

— increase the thermal efficiency;

— increase the availability and reliability of the plant;

— increase steam purity;

— reduce the maintenance costs – repair, chemical cleaning, etc.

This Part of this European Standard sets out minimum requirements for the specific types of water to reduce the risk of corrosion, sludge precipitation or formation of deposits which may lead to any damage or other operating problems.

NOTE 2 This Part of this European Standard has been prepared on the assumption that the user of this European Standard possesses a sufficient knowledge of the construction and operation of the boiler as well as an adequate appreciation of water and steam chemistry.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

EN 12952-1:2001, Water-tube boilers and auxiliary installations — Part 1: General.

EN ISO 9963-1, Water quality — Determination of alkalinity — Part 1: Determination of total and composite alkalinity (ISO 9963-1:1994).

ISO 5667-1, Water quality — Sampling — Part 1: Guidance on the design of sampling programmes.

ISO 5667-3, Water quality — Sampling — Part 3: Guidance on the preservation and handling of samples.

ISO 5814, Water quality — Determination of dissolved oxygen — Electrochemical probe method.

ISO 6059, Water quality — Determination of the sum of calcium and magnesium — EDTA titrimetric method.

ISO 6332, Water quality — Determination of iron — Spectrometric method using 1,10-phenanthroline.

ISO 6878, Water quality — Spectrometric determination of phosphorus using ammonium molybdate.

ISO 7888, Water quality — Determination of electrical conductivity.

ISO 8245, Water quality — Guidelines for the determination of total organic carbon (TOC) and dissolved organic carbon (DOC).

ISO 8288, Water quality — Determination of cobalt, nickel, copper, zinc, cadmium and lead — Flame atomic absorption spectrometric methods.

ISO 9964-1, Water quality — Determination of sodium and potassium — Part 1: Determination of sodium by atomic absorption spectrometry.

ISO 9964-2, Water quality — Determination of sodium and potassium — Part 2: Determination of potassium by atomic absorption spectrometry.

ISO 10523, Water quality — Determination of pH.

3 Terms and definitions

For the purpose of this European Standard, the terms and definitions given in EN 12952-1:2001 and the following terms and definitions apply.

3.1
direct conductivity
direct measured conductivity of water

3.2
acid conductivity
conductivity of water, measured in the hydrogenion concentration form continuously flow through downstream of a strongly acidic caution exchanger

3.3
make-up water
water which compensates for losses of water and steam from the system

3.4
feedwater
mixture of returned condensate and/or make up water supplied to the boiler inlet

3.5
demineralized feedwater
water with an electrolyte content according to an acid conductivity of < 0,2 μS/cm and a silica content (SiO_2) < 0,02 mg/l

3.6
boiler water
water within a natural or assisted circulation boiler

3.7
attemperator spray water
water for injection to control steam temperature

4 Conditioning

Certain quality characteristics of feedwater and boiler water shall be improved by treatment with chemicals.

This conditioning can contribute:

— to support the formation of magnetite layers or other protective oxide layers;

— to minimize corrosion by optimizing the pH value;

— to stabilize hardness and to prevent or minimize scaling;

— to effect chemical oxygen scavenging;

— to develop special coatings with protective effect by film formation on metallic surfaces.

Conventional inorganic conditioning agents include e.g. sodium and potassium hydroxide, sodium phosphate, sodium sulphite, ammonia and hydrazine.

Coordinated phosphate treatment can also be beneficial in controlling pH in the boiler water.

NOTE 1 The use of some of these chemicals can be restricted in some countries.

However, organic-based conditioning agents have been in use for many years now. If organic-based conditioning agents are used, the quantities and methods for use as well as analysis method shall be specified by the supplier of the chemical products.

NOTE 2 It is important to realize that the solubility of sodium phosphate decreases with increasing temperatures. This can lead to the precipitation of phosphates from oversaturated solution (hide-out phenomenon). If a boiler exhibits hide-out tendency (PO_4 concentration in the boiler water is lower than to be expected by calculation from injected quantity and concentration factor) only sodium hydroxide should be used as alkalizing agent, or the mode of operation should be changed to "All volatile treatment (AVT)".

5 Requirements

5.1 The values for the highest allowable concentrations of a number of impurities and for the maximum and minimum concentrations of chemical agents which are added in order to minimize corrosion, sludge formation and deposits, shall be in accordance with tables 5.1 to 5.3 and figures 5.1 to 5.5.

NOTE In certain cases when demineralized feedwater is used, oxygen may be applied as a conditioning agent to reduce corrosion mainly for once through boiler. This further limits the amount of impurities under normal operation as well as during load cycling.

Table 5.1 — Feedwater for steam boilers and hot water generators with natural or assisted circulation

Parameter	Unit	Feedwater containing dissolved solids			Feedwater and attemperator spray water demineralized	Make-up water for hot water generators
Operating pressure	bar (= 0,1MPa)	> 0,5 to 20	> 20 to 40	> 40 to 100	total range	total range
Appearance	—	clear, free from suspended solids				
Direct conductivity at 25 °C	µS/cm	not specified, only guide values for boiler water relevant, see table 5.2			—	not specified, only guide values for boiler water relevant, see table 5.2
Acid conductivity at 25 °C [a]	µS/cm	—	—	—	< 0,2	—
pH value at 25 °C [b]	—	> 9,2 [c]	> 9,2	> 9,2	> 9,2 [d]	> 7,0
Total hardness (Ca + Mg)	mmol/l	< 0,02 [e]	< 0,01	< 0,005	—	< 0,05
Sodium and Potassium (Na + K) concentration	mg/l	—	—	—	< 0,010	—
Iron (Fe) concentration	mg/l	< 0,050	< 0,030	< 0,020	< 0,020	< 0,2
Copper (Cu) concentration	mg/l	< 0,020	< 0,010	< 0,003	< 0,003	< 0,1
Silica (SiO_2) concentration	mg/l	not specified, only guide values for boiler water relevant, see table 5.2			< 0,020	—
Oxygen (O_2) concentration	mg/l	< 0,020 [f]	< 0,020	< 0,020	< 0,1	—
Oil/grease concentration (see EN 12952-7)	mg/l	< 1	< 0,5	< 0,5	< 0,5	< 1
Organic substances (as TOC) concentration	mg/l	see footnote [h]		< 0,5 [g]	< 0,2	see footnote [h]
Alternatively permanganate index	mg/l	5	5	3	5	—

[a] The influence of organic conditioning agents should be additionally considered.

[b] With copper alloys in the system the pH value shall be maintained in the range 8,7 to 9,2.

[c] With softened water pH value > 7,0 the pH value of boiler water according to table 5.2 should be considered.

[d] For injection water only volatile alkalizing agents shall be permitted.

[e] At operating pressure < 1 bar total hardness max. 0,05 mmol/l shall be acceptable.

[f] Instead of observing this value at intermittent operation or operation without deaerator, film forming agents and/or excess of oxygen scavenger shall be observed.

[g] At operating pressure > 60 bar, TOC < 0,2 mg/l is recommended.

[h] Organic substances are generally a mixture of several different compounds. The composition of such mixtures and the behaviour of their individual components under the conditions of boiler operation are difficult to predict. Organic substances can decompose to form carbonic acid or other acidic decomposition products which increase the acid conductivity and cause corrosion or deposits. They also can lead to foaming and/or priming which shall be kept as low as possible.

Table 5.2 — Boiler water for steam boilers and hot water generators with natural or assisted circulation

Parameter	Unit	Boiler water for steam boilers using								Boiler water for hot water generators
		Feedwater containing dissolved solids					Feedwater demineralized acid conductivity < 0,2 µS/cm [a]			
		direct conductivity > 30 µS/cm			direct conductivity ≤ 30 µS/cm		Alkalizing of the boiler water with solid alkalizing agents		All volatile treatment (AVT)	
Operating pressure	bar	> 0,5 to 20	> 20 to 40	> 40 to 60	> 0,5 to 60	> 60 to 100	≤ 100	> 100	total range	total range
Appearance	—	clear, no stable foam								
Direct conductivity at 25 °C	µS/cm	see figure 5.1 [b]			recommended value in figure 5.2		< 100	< 30	—	< 1 500
Acid conductivity at 25 °C — without phosphate dosing — with phosphate dosing	µS/cm	—	—	—	—	—	< 50	< 30 < 40	< 5 [c]	—
pH value at 25 °C	—	10,5 to 12,0	10,5 to 11,8	10,3 to 11,5	10,0 to 11,0	9,8 to 10,5	9,5 to 10,5	9,3 to 9,7	≥ 8,0 [d]	9,0 to 11,5 [e]
Alkalinity	mmol/l	1 to 15 [b]	1 to 10 [b]	0,5 to 5 [b]	0,1 to 1,0	0,1 to 0,3	0,05 to 0,3	—	—	< 5
Silica (SiO_2) concentration	mg/l	pressure dependent, according to figure 5.3 or figure 5.4								—
Phosphate (PO_4) [f]	mg/l	10 to 20	8 to 15	8 to 15	5 to 10	< 6	< 6	< 3	—	—
Organic substances	—	see footnote [g]								

[a] Without conditioning agents.

[b] With superheater consider 50 % of the indicated upper value as maximum value.

[c] Acid conductivity < 3 if heat flux > 250 kW/m^2.

[d] The pH value shall be adjusted in the feedwater and should be ≥ 8,5 at operating pressures > 60 bar.

[e] If non-ferrous materials are present in the system, e.g. aluminium, they can require lower pH value and direct conductivity. However, the protection of the boiler has priority.

[f] If coordinated phosphate treatment is used higher PO_4-concentrations are acceptable (see also clause 4).

[g] See [h] in table 5.1.

Table 5.3 — Feedwater and attemperator spray water for once-through boilers [a]

Parameter	Unit	Salt free water
Operating pressure	bar	total range
Appearance	—	Clear, free from suspended solids
Direct conductivity at 25 °C	μS/cm	not specified [b]
Acid conductivity at 25 °C	μS/cm	< 0,2
pH values at 25 °C	—	7 to 10 [c] see figure 5.5
Sodium + Potassium (Na+K) concentration	mg/l	< 0,010
Iron (Fe) concentration	mg/l	< 0,010 [d]
Copper (Cu) concentration	mg/l	< 0,003
Silica (SiO_2) concentration	mg/l	< 0,020
Oxygen (O_2) concentration	mg/l	≤ 0,250 [c] see figure 5.5
Organic substances (as TOC) concentration	mg/l	< 0,2

[a] For once-through boilers producing wet steam, feedwater containing dissolved solids in accordance with table 5.1 can be used.

[b] Direct conductivity can be used as an auxiliary variable for pH setting, and recommended instead of pH and/or ammonia measurement.

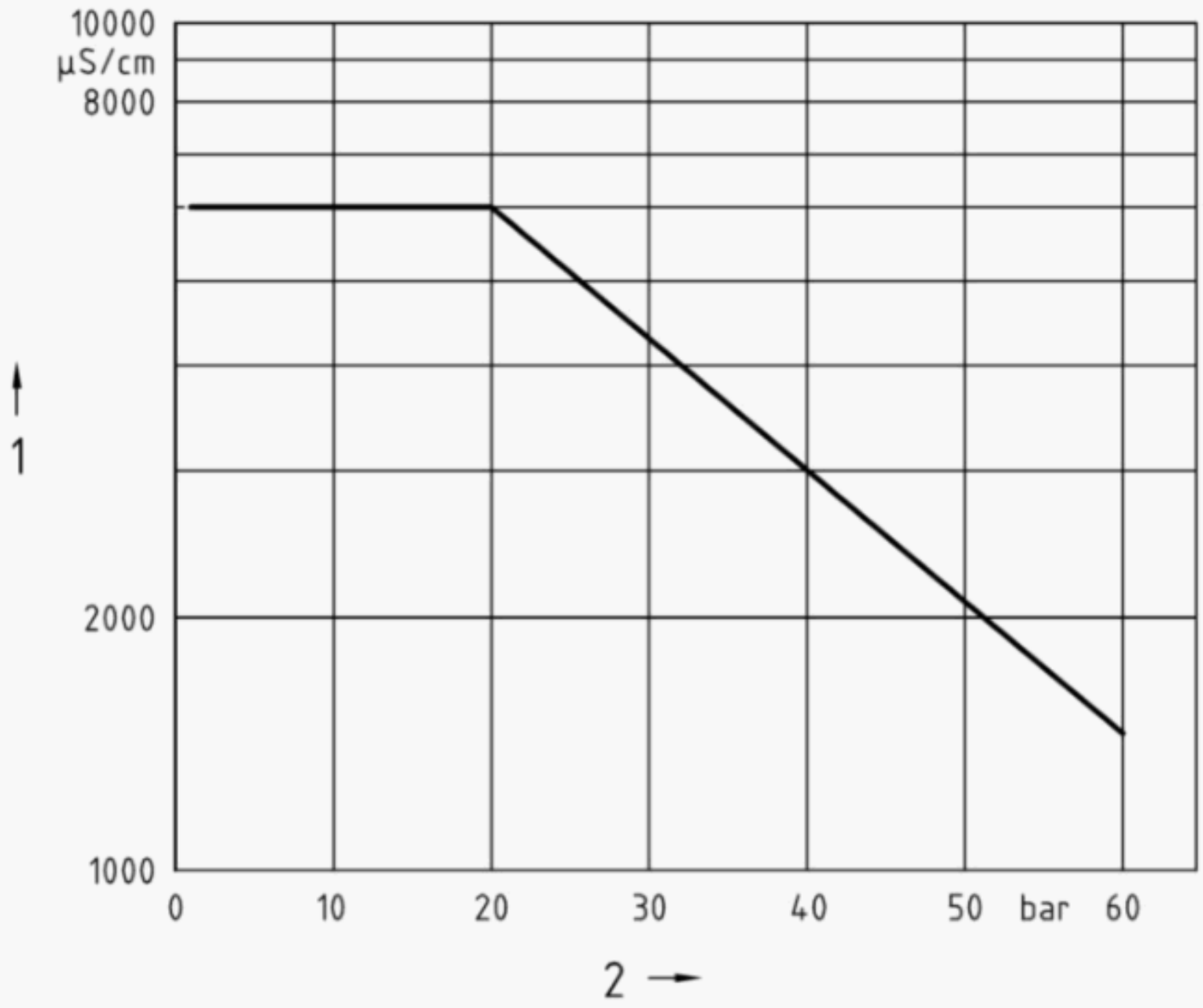
[c] The following shall be considered when examining the correlation between pH and oxygen concentration:

— The permissible upper pH limit is given by materials other than steel, e.g. copper or aluminium alloys, in the system;

— Oxygen is necessary for conditioning at low pH values, but is also acceptable at higher pH values, in addition to the alkalizing agent. At pH > 9 oxygen concentration close to 0 are also possible. There is a correlation between pH value and oxygen concentration, as generally, the more the pH value approaches the lower value of 7 the higher the oxygen concentration shall be;

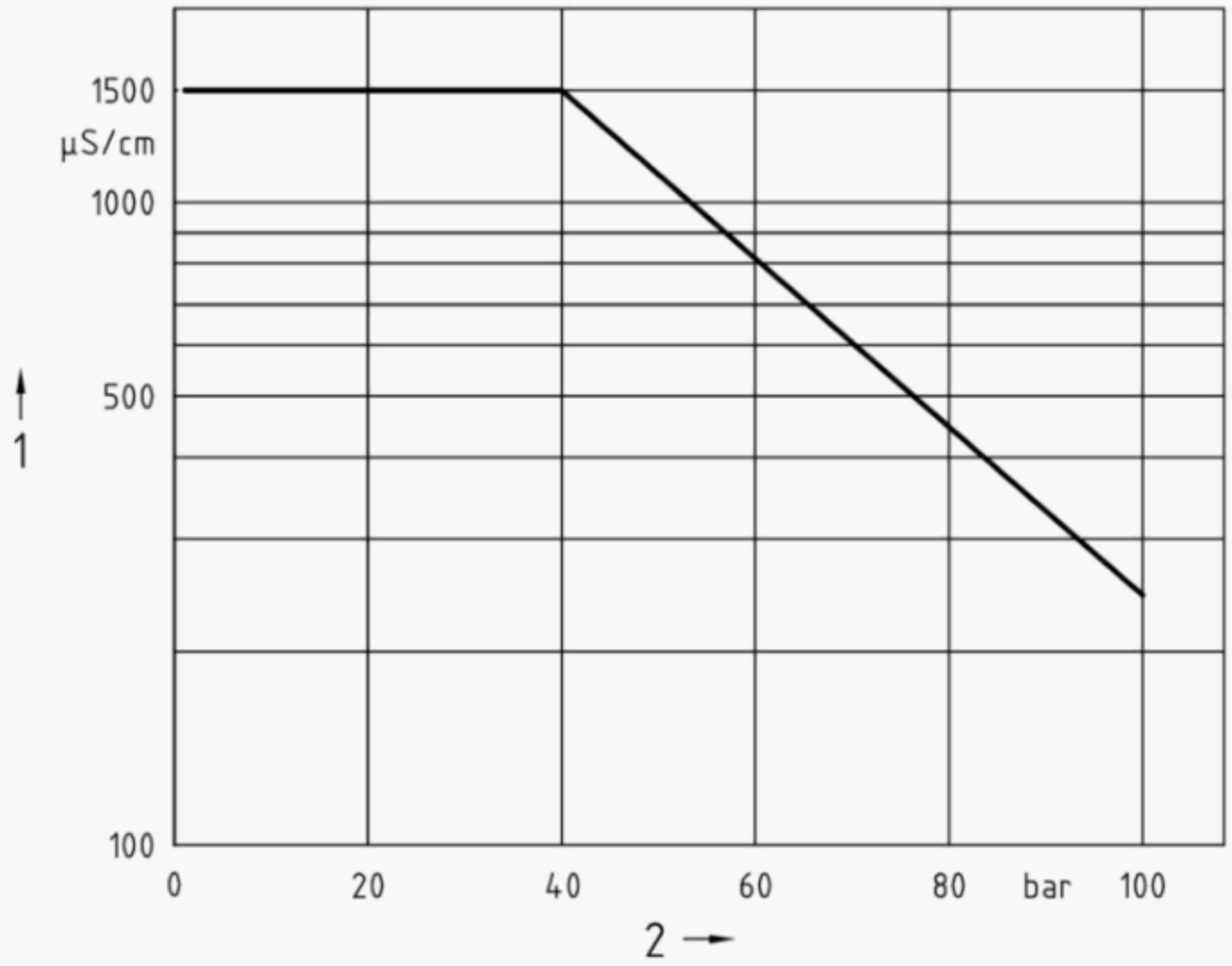
— Within the limits stated, pH value and oxygen concentration shall be adjusted so that the iron and the copper concentration in the feedwater upstream of the boiler feedwater inlet are minimized.

[d] At operating pressure up to 60 bar, Iron (Fe) concentration < 0,020 mg/l is acceptable.



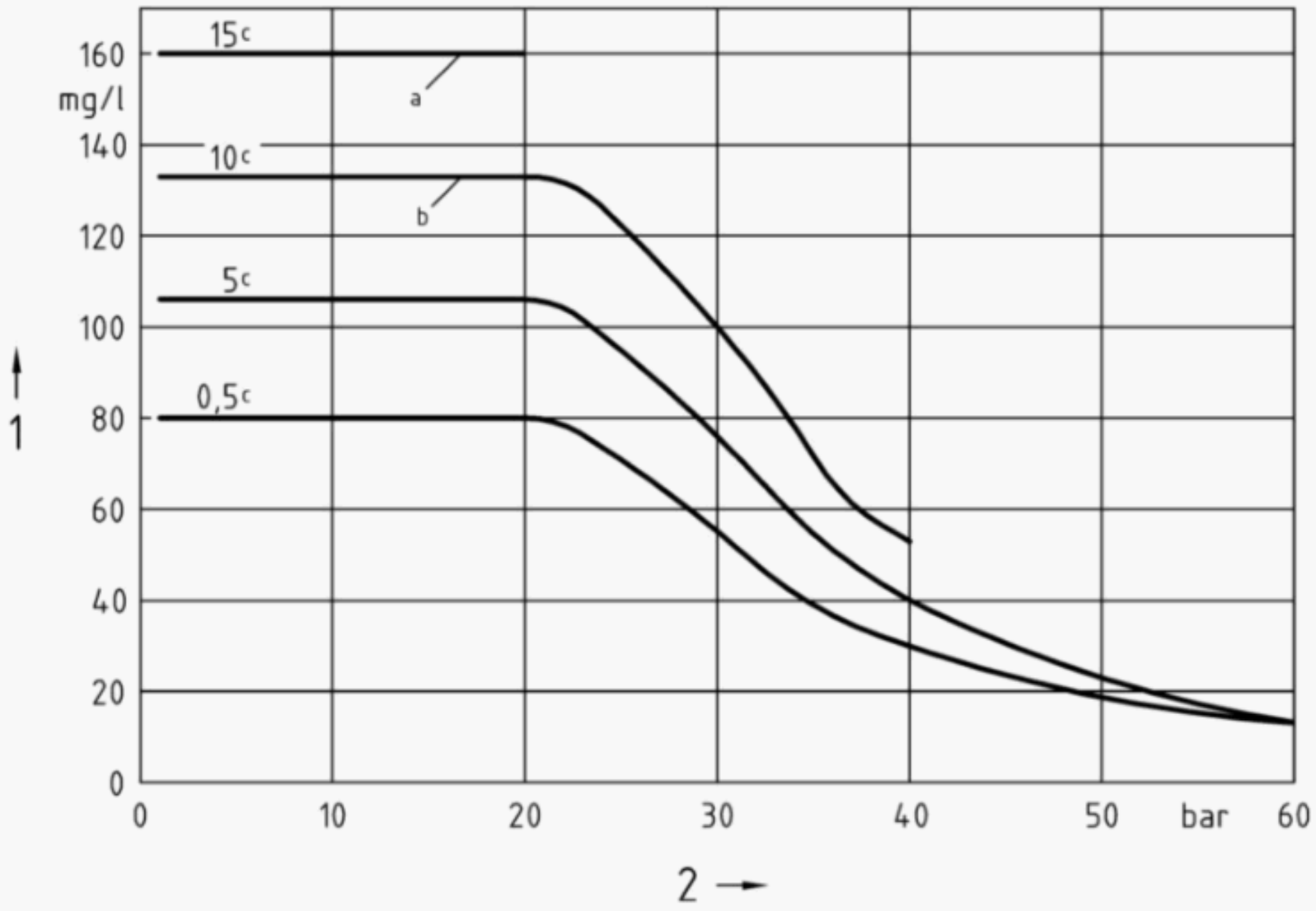
Key
1 Direct conductivity
2 Operating pressure

Figure 5.1 — Maximum acceptable direct conductivity of the boiler water dependent on the pressure; feedwater direct conductivity > 30 S/cm



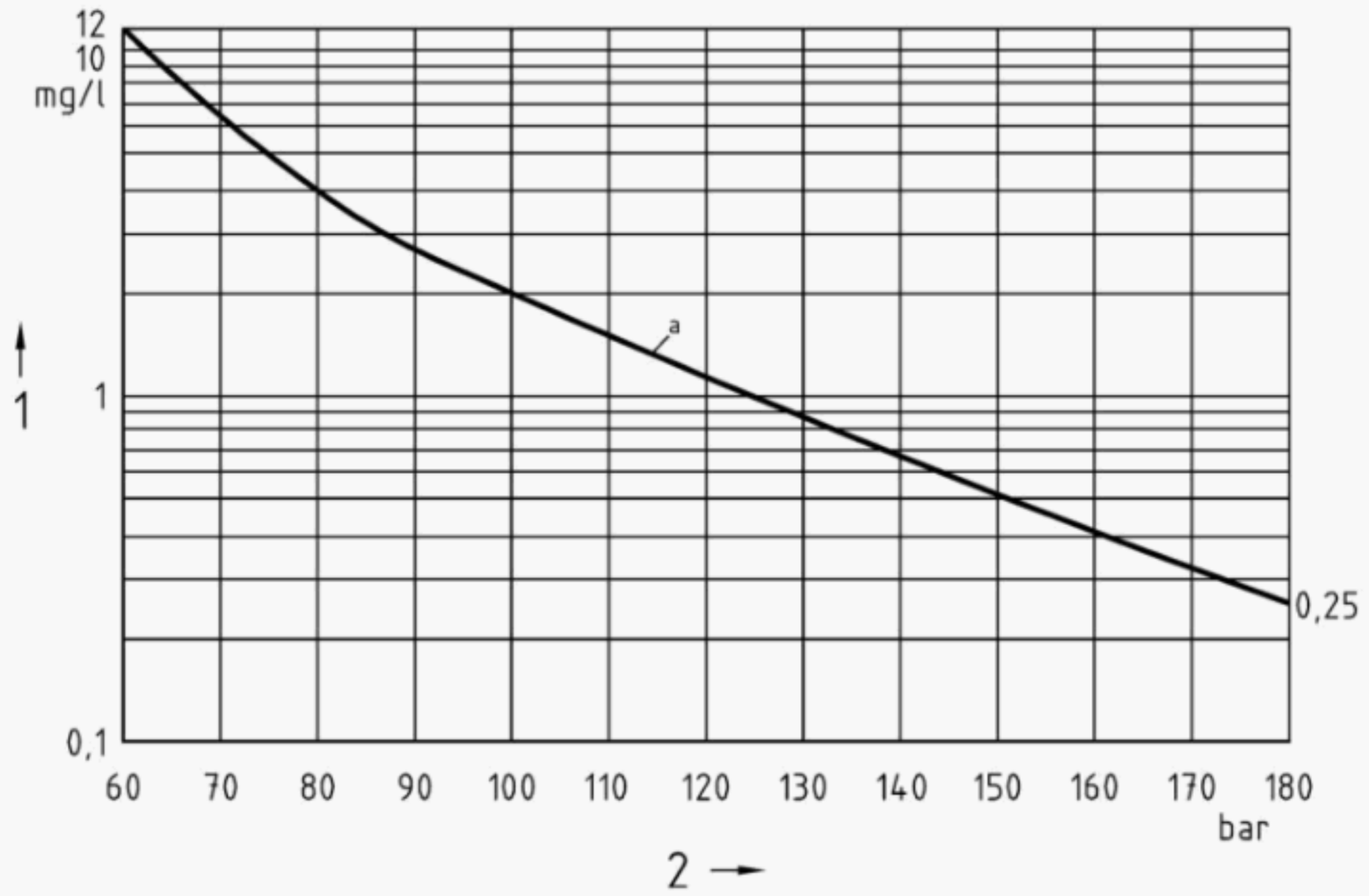
Key
1 Direct conductivity
2 Operating pressure

Figure 5.2— Maximum acceptable direct conductivity of the boiler water dependent on the pressure; feedwater direct conductivity 30 S/cm



Key
1 Silica content
2 Operating pressure
a This level of alkalinity is not permissible > 20 bar
b This level of alkalinity is not permissible > 40 bar
c Alkalinity in mmol/l

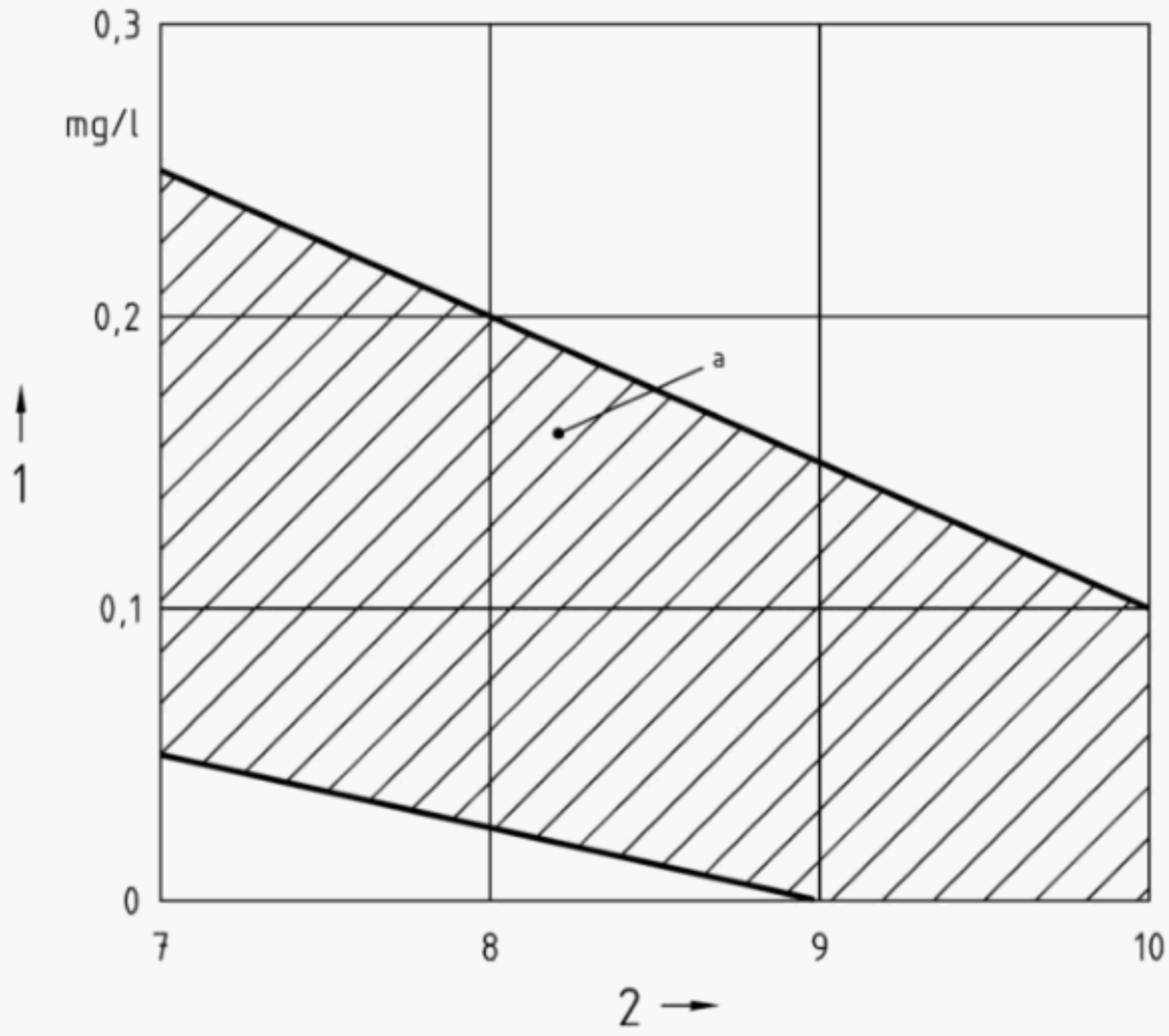
Figure 5.3 — Maximum acceptable silica content (SiO_2) of the boiler water dependent on the pressure, range > 0,5 bar to 60 bar



Key
1 Silica content
2 Operating pressure

a based on < 0,02 mg/l SiO_2 in steam

Figure 5.4 — Maximum acceptable silica content (SiO_2) of the boiler water dependent on the pressure, range > 60 bar to 180 bar



Key
1 Oxygen content
2 pH value
a Operation range

Figure 5.5 — Correlation between pH-value and oxygen content of feedwater for once-through boilers

5.2 The operating conditions of a boiler and/or the choice of certain materials or special design can cause further limitation to some of the parameters stated in the tables or require specialist advice to set new control parameters. Such special considerations include:

— heated crevices and/or heated phase boundaries;

— operation at pressures much lower than the design value;

— materials other than carbon steel, e.g. stainless steel.

Attemperator spray water for the control of steam temperature shall be demineralized feedwater and/or uncontaminated condensate dosed only with volatile chemicals. It shall not adversely affect the required quality of the steam.

The use to which the steam or hot water will be put, shall necessitate further quality limitations. If applied, for instance, in the food or pharmaceutical industry or fed to steam turbines, special steam quality requirements may be needed. The strictest requirement of the individual application shall be complied with.

5.3 The values stated shall apply to continuous operation. During start-up, shutdown or major operational changes, some values may deviate from the normal value for a short period and to a limited extent depending on the operating parameters and the type of boiler. The extent of any deviation shall be specified by the manufacturer.

The values shall be brought within the continuous operation limits as soon as possible.

When the stated values deviate during continuous operation this may due to:

— faulty treatment of the make-up water;

— Insufficient feed water conditioning;

— contamination of the water caused by in-leakages of impurities from other systems, e.g. condensers, heat exchangers;

— on-going corrosion of certain plant parts.

Appropriate modifications shall be made immediately to secure correct operation. For instance, condensate recycled to feed shall not adversely affect the feedwater quality and shall be polished, if necessary.

The chemical composition of the boiler water in drum boilers can be controlled by dosing of conditioning chemicals as well as by continuous or intermittent blowdown of a proportion of the water volume which shall be done in such a way that both dissolved and suspended impurities can be removed.

6 Test of the chemical composition

6.1 General

To ensure the appropriate chemical conditions prevail, quality parameters shall be checked on a continuous and/or periodical basis.

The feed, boiler and attemperator spray water in steam boilers and the boiler water in hot water boilers shall be checked for the relevant parameters such as pH, direct conductivity, acid conductivity, hardness and oxygen or oxygen scavenger.

The frequency of such testing shall be specified by the manufacturer of the boiler in the operating instructions.

NOTE By using reliable continuous recording analyzers the frequency of manual checks of the water quality can be reduced.

6.2 Sampling

The sampling of water and steam from the boiler system shall be performed in accordance with ISO 5667-1 and the preparation and handling of samples in accordance with ISO 5667-3.

6.3 Sampling points

Sampling points shall be provided at representative locations in the system.

Typical sampling point locations are:

— feedwater from the inlet valve;

— boiler water from a downcomer or from a continuous blowdown line;

— make-up water downstream of the make-up water treatment plant or storage tanks;

— condensate at the outlet of the condenser, if any; otherwise the condensate shall be sampled at a point as near to the feed tank as possible.

7 Analysis

7.1 General

The proof of compliance with the values given in tables 5.1 to 5.3 shall be provided in accordance with written procedures applying analysis methods to 7.3, where applicable.

If the analyses are performed according to other standards or by indirect methods, calibrations for the methods shall be made.

NOTE 1 In some types of water the amount of dissolved matter can be estimated from the conductivity. For totally demineralized water, it is possible to derive a pH value from the correlation between the direct and acid conductivities.

NOTE 2 It is preferred that continuously operating monitors for main parameters should be installed. Periodical laboratory checks are essential and are sometimes the only possible test.

7.2 Visual criteria

Changes in the appearance of the water regarding suspended solids, colour or foam can indicate that uncontrolled changes have occurred or are about to occur at the plant.

7.3 Analysis methods

The check of parameters shall be carried out according to the following standards where applicable:

Acid capacity	EN ISO 9963-1
Conductivity	ISO 7888
Copper	ISO 8288
Iron	ISO 6332
Oxygen	ISO 5814
pH	ISO 10523
Phosphate	ISO 6878
Potassium	ISO 9964-2
Silica	1)
Sodium	ISO 9964-1
TOC 2)	ISO 8245
Total Hardness as Ca + Mg	ISO 6059

Acid conductivity shall be measured in the hydrogenion concentration form continuously in the same way as the conductivity after the sample has passed through a strongly acidic cation exchanger with a volume of at least 1,5 l. The exchanger shall be placed in a cylinder with a diameter to height ratio of 1:3 or less and with exchanger medium in at least three quarters of the cylinder. The ion exchanger shall be regenerated when it is two thirds depleted; this can be seen using an exchanger with an indicator of colour and a transparent cylinder.

1) Up to now no European or International Standard is available; see e.g. DIN 38405-21 German standard methods for the examination of water, waste water and sludge; anions (group D); determination of dissolved silicate by spectrometry (D 21).

2) Alternatively the determination of permanganate index in accordance with ISO 8467 can be measured if values have been specified.

Bibliography

[1] EN 12952-7, Water-tube boilers and auxiliary installations — Part 7: Requirements for equipment for the boiler

[2] ISO 8467, Water quality – Determination of parmanganate index

[3] DIN 38405-21 German standard methods for the examination of water, waste water and sludge; anions (group D); determination of dissolved silicate by spectrometry (D 21)

[4] Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment OJEC, L181.

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