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1 Scope of the Operating Instructions

These Operating Instructions contain basic information. They apply in combination with the following operating instructions:

- A002 Basic Safety Instructions

For the operation of the system as a whole, the operating instructions for the individual components are binding along with the relevant statutory provisions and official requirements.

2 Use in Accordance with Regulations

The limit values given have been laid down in accordance with TÜV Süd are apply for steam generators made from unalloyed or low-alloy steel. They are based on the long-term experience in practice and on the minimum requirements, binding in terms of safety technology, given in EN 12953 Part 10, for the reduction of:

- corrosion risks
- sludge elimination and
- the formation of deposits.

The use of the generated steam may require further limitations. If it used, for example, in the food or pharmaceutical industry or for steam turbine supply, special requirements may be laid down for the quality of the steam which are not taken into consideration here.

If dosing agents are used other than those mentioned in this guideline, their active substances must demonstrate comparable characteristics. The person in charge of checking the suitability and effects of such agents is the supplier. The supplier is obliged to issue the dosage instructions and to make appropriate analysis methods available.

3 Safety

Please read the Operating Instructions:

- A002 Basic Safety Instructions

4 Operating and Maintenance Staff

Please read the Operating Instructions:

- A002 Basic Safety Instructions

5 General Risks and Accident Prevention

Please read the Operating Instructions:

- A002 Basic Safety Instructions

5.1 Dangerous situations

During the operation of the boiler plant dangerous situations may arise as a result of operation. Damage can only be avoided if these situations are recognised in good time and if the correct measures are taken immediately. The following list of dangerous situations makes no claim to be complete, but is based on values from experience that have been gathered through decades of observing our products. If other installations or system components are present, the measures that apply for these system components must be coordinated with the manufacturer of these installations or components.

- The operating staff must report any dangerous situations immediately to the supervisor responsible.
- According to the regional regulations, damage to pressure-carrying walls of the boiler and – if provided – to the superheater and/or flue gas heat exchanger which would cause a halt in operation because of the danger to the operating staff or third parties must be reported to the competent supervisory authority and/or monitoring organisation which is responsible for safety inspections of the boiler system.

5.2 Formation of deposits



Danger! *There is a danger of deposits forming. The formation of deposits can destroy the boiler. There is an acute risk to life for everyone in the vicinity of the boiler from flying parts and from the hot medium (steam, hot water). Extremely serious damage can be caused to the boiler by insufficiently prepared water, unsuitable dosing agents or dirty condensate. Deposits should not be regarded as harmless. The thickness of the deposits is no indication of their effect in restricting heat.*

If deposits are observed on the water side, further operation of the boiler system is not allowed.

The boiler may only be started up again once the deposits have been removed and if an expert allows the boiler to be fired up after a suitable test has been carried out. The manufacturer recommends that this inspection is carried out by a suitably trained service engineer on the manufacturer's staff, an expert or persons who have been expressly authorised by the manufacturer to carry out this work.

It is recommended that an experienced specialist company is employed to remove the coating and/or deposits. If chemical cleaning is required, this must be noted in the operating log.



Note: *Boilers may only be cleaned with boiler scale solvents which are approved under regional regulations. The regulations on safety and environmental protection must be strictly complied with. These regulations and instructions are given on the cleaning product containers or in the corresponding safety data sheets. These data sheets are available from the supplier of the cleaning product.*

5.3 Corrosion



Danger! *Danger from corrosion. Corrosion can destroy the boiler. There is an acute risk to life for everyone in the vicinity of the boiler from flying parts and from the hot medium (steam, hot water). Extremely serious damage can be caused to the boiler by insufficiently prepared water, unsuitable dosing agents or dirty condensate.*

If corrosion is observed on the water side, further operation of the boiler system is not allowed.

The boiler may only be started up again once the deposits have been removed and if an expert allows the boiler to be fired up after a suitable test has been carried out and measures have been taken to repair the corrosion, or at least to prevent the corrosion from spreading any further.

The manufacturer recommends that this inspection is carried out by a suitably trained service engineer on the manufacturer's staff, an expert or persons who have been expressly authorised by the manufacturer to carry out this work.

6 Requirements for feed water and boiler water quality

6.1 raw water

Raw water is water that is supplied to the water treatment plant. The connection is to the regional water system or company well.

6.2 Make-up water

Make-up water is water that is supplied after the water treatment plant.



Note: *Chloride level*

The permitted chloride concentration in the make-up water may not exceed 200 mg/l (to avoid chloride-induced corrosion of stainless steel components, e.g. deaerators).

6.3 Feed water

Independent of the quality of the feed water, the boiler systems can be operated with a high or low salt content. The quality of the feed water must be higher for salt-free operation.

See also Tab. "Requirements for the boiler water" in this regard.

Table 1: Requirements for feed water

		Shell boilers Working gauge pressure ≤ 20 bar all pressure stages	Shell boilers Working gauge pressure > 20 bar
General requirement ⁸⁾	[-]	Colourless, clear, free of insoluble matter and foaming agents	
pH value at 25°C ¹⁾	[-]	> 9.2	
direct electrical conductivity at 25°C ⁵⁾	[μS/cm]	≤ 5% of the boiler water threshold	
K _{S 8.2} (p-value) <i>containing salt/low-salt</i>	[mmol/l]	≤ 0.7	≤ 0.5
K _{S 8.2} (p-value) <i>salt-free</i>	[mmol/l]	≤ 0.1	
alkaline earths ^{2) 8)}	[mmol/l]	< 0.01	
(total hardness) ^{2) 8)}	[° d]	< 0.05	
Oxygen (O ₂) ⁴⁾	[mg/l]	< 0.05	< 0.02
Oxygen binding agent ^{4) 8)}	[mg/l]	see legend	
Total iron (Fe)	[mg/l]	< 0.3	< 0.1
Total copper (Cu)	[mg/l]	< 0.05	< 0.03
Oil, grease	[mg/l]	< 1	
KMnO ₄ consumption	[mg/l]	< 10	
Salicylic acid (SiO ₂)	[mg/l]	≤ 5% of the boiler water threshold	

➡ **Note:** A demineralisation rate of approx. 5% based on the generated steam quantity is taken as the basis for the values of electrical conductivity, K_{S 8.2} and silicic acid as given in the information in Tab. 1. If the values in the feed water are higher, the demineralisation rate is increased. See also Sec. "Explanations for Tab. 1 and 2", Footnote 5.

➡ **Note:** When commercially-available pH measuring devices are used to measure the pH value of water with a conductivity of < 10 μS/cm the measurements are inaccurate. In order to obtain correct pH values, calcium chloride solution (pH neutral) should therefore be added to the water sample to increase the conductivity.

6.4 Boiler water

Independent of the quality of the feed water, the boiler systems can be operated with a high or low salt content. The quality of the feed water must be higher for salt-free operation.

Table 2: Requirements for the boiler water

Boiler design		Shell boilers				
Hydrochemical operation		Containing salt		Low salt	Salt-free	All areas
Area of application		≤ 20 bar	> 20 bar and all double flame- tube boilers	all boilers	all boilers	all systems with water analyser WA
Column		1	2	3	4	5
General requirement ⁸⁾	[-]	Colourless, clear, free of insoluble matter and foaming agents				
pH at 25°C ¹⁾	[-]	10.5 - 12.0	10.5 - 11.8	10.0 - 11.5	9.5 - 10.5	As column 1 - 4
K _{S 8.2} (p- value) ⁷⁾	[mmol/l]	1 - 12	1 - 8	0.1 - 3	0.05 - 0.3	As column 1 - 4
Alkaline earths ^{2) 8)}	[mmol/l]	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
(total hardness) ^{2) 8)}	[° d]	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Phosphate (PO ₄ ³⁻) ^{3) 8)}	[mg/l]	10 - 30	10 - 30	10 - 30	< 6	> 5
Sodium sulfite oxygen binder ^{4) 8)} (Na ₂ SO ₃)	[mg/l]	10 - 30	10 - 20	10 - 20	-	> 2 ⁴⁾
direct electrical conductivity at 25 °C ^{5) 7)}	[μS/cm]	< 6000	< 4000	< 2000	< 150	As column 1 - 4
KMnO ₄ consumption ⁷⁾	[mg/l]	< 150	< 100	< 50	< 30	As column 1 - 4
Salicylic acid (SiO ₂) ⁷⁾	[mg/l]	< 150	< 80	< 40	< 4	As column 1 - 4

6.5 Notes on Tables 1 and 2

1) Setting of alkalinity (pH value or K_{S 8.2}):

with operation with salt with solid-matter alkalies (trisodium phosphate or tripotassium phosphate, sodium hydroxide), with the alkalinity does not adjust automatically. If nec. add liquid product.

With low-salt operation primarily using trisodium phosphate or tripotassium phosphate, with the addition of volatile agents (ammonia) if necessary. If volatile chemicals cannot be used due to the required steam purity (food industry, sterilisation, air humidity, etc.), small quantities of caustic soda or sodium hydroxide can also be dosed in addition to phosphate.

If operating in salt-free mode, only with trisodium phosphate, tricalcium phosphate or volatile agents (e.g. ammonia). Using caustic soda or sodium hydroxide to adjust the alkalinity is not permitted due to the risk of lye-induced stress crack corrosion in heated pipe gaps.



Note: When using salt-free feed water with added ammonia, the conductivity measured downstream of the highly acidic sampling cation filter is decisive!

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Note: When dosing ammonia, avoid the use of non-ferrous heavy metal resources in areas coming into contact with the media!

- 2) Both feed and boiler water should be practically hardness-free. Because the detection limit of current hardness tests is min. 0.01 mmol/l or 0.05°d, the same limit values have been set for both waters irrespective of any thickening.

Use of a dosing agent for binding or stabilisation of residual hardness is recommended, e.g. a phosphate-based product. If the dosing agent used for hardness stabilisation is one which produces negative results for hardness using the usual hardness test methods, then its excess concentration is to be tested with the test kit prescribed for that purpose according to supplier specifications, in place of the hardness measurement.

- 3) Limit values with phosphate dosing.

If operating in low-salt and salt-free mode, dosing with trisodium phosphate or tricalcium phosphate is required - as long as (particularly with salt-free operating mode) volatile agents (e.g. ammonia) are not used - see footnote 1.

With operation containing salt, phosphate-free agents may be used for earth alkaline compounds.

Limit values for PO₄ are not applicable in this case. The supplier is obliged to issue dosing instructions for the respective dosing agent and to make available appropriate analysis methods. The use of a dosing agent is to be agreed with the manufacturer (see also Chapter 11). However, ultimate responsibility for the suitability and functioning of the dosing agent lies with the supplier.

- 4) The oxygen in the feed water must be reduced primarily using physical processes, e.g. thermal pressure deaeration, to the described limit values. Because in practical operation, partly through frequent down times, start-up and run-down processes etc. and with partial deaeration systems, compliance with the limit value is not guaranteed using deaeration alone, an oxygen binder should be added.

Non-volatile sodium sulphite, for example, has proved effective – there are no hygienic/ toxicological restrictions. Addition to the feed water should be carried out in such a way that the limit values for the boiler water are maintained.

The need for this and the choice of a suitable dosing agent must be decided in each individual case.

For salt-free operation is not essential to dose an oxygen binder, even when an WA is used.



Note: Film-forming amines are not oxygen binders!

- 5) In addition to the electrical conductivity, the silicon dioxide content (SiO₂) and the pH (auxiliary parameter K_{S 8.2}) are important parameters, and their maximum values must not be exceeded in the boiler. If one of these values is reached because of thickening in the boiler before the maximum conductivity value, this is then decisive for desalting. Because the desalting is regulated via a conductivity measurement, the corresponding conductivity value at which one of the named parameters reaches its permitted maximum value replaces the conductivity limit value shown in Table 2. To determine the necessary desalination quantity, see also operating manual K006.

The values given in Table 2 are the maximum permitted conductivity values. For plants in which the conductivity is incorporated into the safety chain, when these values are reached (at the latest), the firing is switched off and locked, i.e. the conductivity to be regulated is to be set with a sufficient distance from the limit value (min. 30%).

If unusually pure steam is needed, it may be, under some circumstances, that the maximum conductivity value in the boiler water needs to be lowered for this special case.

The limit values for electrical conductivity, pH (auxiliary parameter K_{S 8.2}) and silicon dioxide in the feed water are the result of the desalting rate (assumed at 5%) and the limit value of the boiler water. Higher feed water conductivity, K_{S 8.2} value or silicon dioxide contents are permitted, whereby compliance with the boiler water values (Table 2) is binding. However, then desalting rates greater than 5% will occur, and an examination of the boiler components (e.g. desalting valve, feed pump, burner, deaeration, etc.) is urgently required.

- 7) For shell boilers with superheaters, the boiler water limit values must be halved for operation containing salt (direct electrical conductivity in the feed water at 25°C > 30 µS/cm) for K_{S 8.2} (p-value), direct electrical conductivity at 25°C, KMnO₄ consumption and silicon dioxide (SiO₂).

- 8) Dosing agents on the basis of tannin and lignin compounds are used as oxygen-binding agent and for residual hardness stabilisation and alkalisation, among other things. They cause brown discolouring of the boiler water and bind any residual hardness in the boiler water; however, this residual hardness remains measurable as such through the use of conventional residual hardness measuring instruments.

Therefore, in the event that such substances are used, the respective supplier shall make sure through the operating instructions of the respective dosing chemical that the protection objective of the operating instructions B002 - guideline on water characteristics for steam boilers is complied with. Other specifications (e.g. in relation to appearance, permissible residual hardness, excess oxygen binding agent, etc.) must be explained and covered by substitute values or handling specifications in the operating instructions of the dosing chemicals, so that any deviations that arise are immediately identified.

6.6 Condensate

If it possible for foreign matter to enter into the boiler feed water via returned condensate, measures must be taken to prevent this (e.g. police filters, earth alkali turbidity or conductivity monitoring with control of drain-off fittings).

When using volatile dosing agents, e.g. for the protection of the supply line, it may be necessary to check that there is excess dosing agent in the condensate. To facilitate this, the condensate line must be configured to allow the extraction of water samples. The required excess for the particular dosing agent is to be determined by the supplier. The supplier is obliged to make appropriate analysis methods available.

6.7 Injection water

Only salt-free make-up water or salt-free condensate without the addition of solid matter chemicals such as sodium hydroxide, potassium hydroxide etc. and trisodium phosphate or tripotassium phosphate may be used as Injection water for cooling superheated steam. Saltfree water is make-up water or condensate with an electrical conductivity $< 0.2 \mu\text{S}/\text{cm}$ and a silica concentration $< 0.02 \text{ mg}/\text{l}$.

7 Initial filling

Steam boilers may only be filled for the first time with treated, at least softened water to which at least 50 g trisodium phosphate (20 % P_2O_5) per m^3 should be added.

8 Down times

To avoid corrosion during down times (in the event of long interruptions in operation or delayed commissioning), steam boilers and the associated system components must be properly preserved. Instructions for this are given in the operating instructions for the corresponding components and Operating Instructions G012 Wet and Dry Conservation.

9 Water investigation

9.1 General

The characteristics of the feed water and boiler water (for shell boilers) must be checked at least every 72 hours.



Important! There must be **daily** monitoring in the case of boiler systems, which are not equipped with conductivity monitoring or conductivity control.

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Important! The water samples must only be taken from the system during normal operation, i.e. not when cold or in start-up operation.

For the analysis, a representative sample is necessary which, via a suitable cooling device (e.g. water sample cooler from the manufacturer) allows the water to be tested to be cooled to 25 °C. For instructions on taking the water sample, see Operating Instructions E004 Water sample cooler module SCM.

Scope of water investigations:

Feed water:

- pH value
- $K_{S\ 8,2}$
- Earth alkalies (total hardness)
- Oxygen or oxygen binders
- electrical conductivity
- operating temperature

Boiler water:

- pH value
- $K_{S\ 8,2}$
- Earth alkalies (total hardness)
- Oxygen binders
- Phosphate or alkalisation products
- electrical conductivity
- appearance

The results should be entered in logbook L010 for steam shell boilers. The investigation of the other parameters should be carried out, where relevant, on a monthly basis, and the analysis methods mentioned in EN 12953-10 should be applied where possible.














Important! Should national requirements require more frequent or more comprehensive water investigations, these shall have priority over the manufacturer's requirements.



Note: Only experienced specialist companies should be asked to supply and install water treatment systems or water treatment devices. We have found that the support provided by the customer service units of these companies and/or departments specialising in water chemistry to be very useful.











10 Measures in the event of unusual observations and operating faults

If anything unusual is observed and/or operating faults are displayed, the following table provides initial information on repair:


Observation/fault: Fluctuating boiler water level, frothing Water carried along, water impacts in system Deposits on valves and pipes or on consumers		
Cause	Repair	By whom?
Water treatment = Softening system and also high carbonate element in raw water at the same time (This leads, in the boiler to 'soda splitting', with the formation of NaOH, which stays in the boiler and increases the $K_{S\ 8,2}$ (p value) and pH value, and CO ₂ , which escapes into the steam network, lowers the pH value and can trigger corrosion processes)	Use another water treatment process (e.g. decarbonisation or osmosis)	Operator
$K_{S\ 8,2}$ (p value) too high in boiler water	Increase desalting rate, set water values according to Boiler Water table	
	Increase blowdown rate	
Conductivity too high in boiler water	Increase desalting rate, set water values according to Boiler Water table	
	Increase blowdown rate	
	Check chemicals dosing	
	Penetration of regeneratong agent from water treatment → Check water treatment	
Level of dissolved organis substances too high (KMnO ₄ consumption)	Increase desalting rate, set water values according to Boiler Water table	
	Increase blowdown rate	
	Check condensate network for leakages → provide condensate monitoring (conductivity, turbidity) with corresponding drain-off device.	
Level of suspended solids too high	Increase desalting rate, set water values according to Boiler Water table	
	Increase blowdown rate	

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Cause	Repair	By whom?
Phosphat content too high	Increase desalting rate, set water values according to Boiler Water table	
	Increase blowdown rate	
	Check chemicals dosing	
General: water values different from Boiler water table	Set water values in accordance with boiler water table	
	Check chemicals dosing	
	Provide water separator, Drain steam pipes regularly	Operator
	Check desalting device	
Overdose of dosing chemicals	Check surplus according to boiler water table	
	Check the setting of the dosing pump (stroke, frequency) and dosing pump controller (for WA)	
Too much steam taken out of boiler	Limit steam output to max. nominal output	
Marked load fluctuations in steam removed	Reduce set speed at consumer valves	
	Provide three-component regulation	Operator





Observation/fault: Water limiter device triggered

Cause	Repair	By whom?
See: fluctuating water level	See: fluctuating water level	
Excess oil or fat level (collection of oil/fat in level limiter protector pipe, simulates lack of water)	Provide condensate monitoring (conductivity, turbidity) with corresponding drain-off device. Conductivity: acids, alkalies, hardness, sea water Turbidity: Oils, fats, milk, dyes	Operator

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Observation/fault: Turbid boiler water

Cause	Repair	By whom?
Hardness precipitation (earth alkali phosphates)	Increase desalting rate, set water values according to Boiler Water table	
	Determine cause of hardness precipitation	
	Increase blowdown rate	
Entry of corrosion products	Check make-up water treatment and condensate system (see corrosion in condensate pipe)	
Use of unsuitable chemicals	Consult specialist firm	Operator

Observation/fault: Coating in boiler, flue gas heat exchanger, superheater

Damage repair: Repair of damaged heating surfaces, removal of coating













Cause	Repair	By whom?
Make-up not properly prepared	Check water treatment, with ion exchange systems, if nec. trigger regeneration	
	Set water treatment to changed raw water values. (Check through flow between two regenerations, correct if nec.)	
	Set constant pressure before water treatment plant	
	Use higher-quality water treatment method (e.g. osmosis)	Operator
Foreign bodies entering the condensate (oils, fats, organic matter, acids, alkalis, hardness..)	Provide condensate monitoring (conductivity, turbidity) with corresponding drain-off device. Conductivity: acids, alkalies, hardness, sea water Turbidity: Oils, fats, milk, dyes	Operator
Use of film-forming amines in combination with salt-free or low-salt operation	Stop using film-formers	Operator

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Observation/fault: Corrosion in boiler, flue gas heat exchanger, superheater

Damage repair: Build-up welding. Component replacement. This work may only be carried out by the manufacturer or personnel authorised by the manufacturer.







Cause	Remedy	By whom?
Oxygen leaking in during down times	During down times proceed according to Operating Instructions G012 Wet and Dry Conservation. For shorter down times, keep system under pressure	
Insufficient deaeration of feed water	Check thermal deaeration (constant pressure or temperature, sufficient vapour steam volume)	
	Check excess O ₂ binder	
Insufficient chemical dosing	Check excess according to boiler water table	
	Check chemicals dosing	
Overdose of dosing chemicals	Check excess according to boiler water table	
	Check the setting of the dosing pump (stroke, frequency) or dosing pump controller (for WA)	
Use of unsuitable chemicals	Consult specialist firm	Operator
Acids / alkalis have leaked in via water treatment (with regeneration with acids/alkalis)	Check water treatment	
Foreign bodies entering the condensate (oils, fats, organic matter, acids, alkalis, hardness, etc.)	Provide condensate monitoring (conductivity, turbidity) with corresponding drain-off device. Conductivity: acids, alkalis, hardness, sea water Turbidity: oils, fats, milk, dyes	Operator
Higher Cu concentration in condensate	Remove components containing copper	Operator
	Keep pH value in condensate area between 8 and 9	
	Check ammonia dosage	
Marked build-up of boiler sludge	Increase blowdown rate	
	Check condensate and make-up water for foreign bodies	

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Observation/fault: Corrosion in steam pipe

Damage repair: Replace corroded pipe sections

Cause	Repair	By whom?
Oxygen build-up during down times	Keep system under pressure	
	Make pipes in corrosion-resistant material	Operator
Insufficient deaeration of feed water	Check thermal deaeration (constant pressure, or temperature, sufficient vapour steam volume)	
	Check excess O ₂ binder	
Boiler water taken in with steam	Set water values in accordance with boiler water table	
	Limit steam output to max. nominal output	
	Reduce set speed at consumer valves	
	Provide three-component regulation	Operator
	Provide water separator, drain steam pipes regularly	Operator
	Make pipes in corrosion-resistant material	Operator
Condensation due to insufficient insulation	Insulate pipes sufficiently	Operator






Observation/fault: Replace corroded pipe sections

Damage repair: Exchange the corroded pipes

Cause	Repair	By whom?
Water treatment = Softening system and also high carbonate element in raw water at the same time (This leads, in the boiler to 'soda splitting', with the formation of NaOH, which stays in the boiler and increases the K _{S 8,2} (p value) and pH value, and CO ₂ , which escapes into the steam network, lowers the pH value and can trigger corrosion processes)	Use another water treatment process (e.g. decarbonisation or osmosis)	Operator
	Dosing of ammonia or volatile dosing agents if no Cu or non-ferrous metals are present in the pipe system and the consumers are not damaged by this (keep pH value in condensate area between 8 and 9)	
	Make pipes in corrosion-resistant material	Operator

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Cause	Repair	By whom?
Insufficient deaeration of feed water	Check thermal deaeration (constant pressure, or temperature, sufficient vapour steam volume)	
	Check excess O ₂ binder	
Boiler water carried along with steam	Set water values in accordance with boiler water table	
	Limit steam output to max. nominal output	
	Reduce set speed at consumer valves	
	Provide three-component regulation	Operator
	Provide water separator, drain steam pipes regularly	Operator
	Make pipes in corrosion-resistant material	Operator
Foreign bodies entering the condensate (oils, fats, organic matter, acids, alkalis, hardness..)	Provide condensate monitoring (conductivity, turbidity) with corresponding drain-off device.	Operator
	Conductivity: acids, alkalies, hardness, sea water Turbidity: Oils, fats, milk, dyes	

11 Guarantee notes

The guarantee will be rendered invalid in the following cases:

- Use of film-forming amines in conjunction with low-salt or salt-free operation (osmosis, partial or complete desalination)
- Use of caustic soda or sodium hydroxide with salt-free operation
- Non-compliance with the limits for water quality.
- Documentation of the measured water values not available.

If special operational requirements exist (e.g. reduced operating pressure, high steam purity), agreement must be reached between the operator and manufacturer regarding the limits.



Important! When using protective chemicals, the regulations of the relevant manufacturer and supplier apply exclusively. The boiler manufacturer fundamentally cannot be held liable for damage to boiler systems due to chemicals and insufficient protective measures.