vgbe’s standards to support flexible operation: Water Chemistry

VGB-S-006, VGB-S-010 & VGB-S-042

20.11.2013

ENERGY IS US

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1 General information on the responsible committees

vgbe energy - structure TCC Thermal Power

Technical Competence Center **Thermal Power**

Steering Forum **Thermal Power**

vgbe Committees

- TC **Biomass Ash**
- TC **Chemistry and Emission Control**
  - WG Chemical Engineering and Analytics
- TC **Civil Structures**
  - WG Construction technology for cooling towers incl. Recalculation
  - WG Deconstruction
  - WG Revision R-612
- TC **Conventional Steam Generation Process**
  - WG Big steam generators (GD)
  - WG Fuels, firing systems and flue gas cleaning technology
- TC **Cooling Systems**
- TC **Designation and Documentation**
- TC **Digitalisation**
- TC **Electrical Engineering**
  - WG Technical Experts and Grid Connection
  - WG Generators and Transformers
  - WG Research project SSTI
- TC **Energy from Waste**
  - WG Fluidised bed combustion and thermal sewage sludge treatment
- TC **Environment and Regulation**
  - WG Emissions and Immissions
  - WG Emissions Monitoring
- TC **Gas Turbines**
- TC **Health and Safety**
  - WG Contractor Management
  - WG Industrial Safety
  - WG Leading KPIs
  - WG Occupational Health and Safety
  - WG Working Materials
- TC **Industrial Cogeneration**
  - WG Biomass
  - WG BHKW
- TC **Instrumentation and Control**
  - WG OT-Security
  - WG PC KELI 2024
  - WG Control System Mauell

Tasks of responsible committees

TC „Chemestry and Emission Control“

- Steering of WGs, TPs, R&D, …
- Chemistry of the Water-Steam-Cycle regarding VGB-S-010
- Cycling operation
- Co-combustion and new fuels
- Boiler chemistry on the flue gas side (slagging, fouling....)
- Technology of flue gas side
- Carbon Capture

WG „Chemical Engineering & Analytics”

- Water supply and treatment regarding VGB-S-042
- Analytical methods in power plant analytics regarding VGB-S-006
- Certification and accreditation of laboratories
- Microbiology in cooling systems
- Chemical processes (FGD, WWT)
- Evaluation of new technological processes
- Assessment of the impact of legal requirements
- Influence on standardization

2 Tasks and objectives of VGB-S-042

vgbe Standards for the chemical dosing and monitoring of water/ steam circuits

- **VGB-S-042-00-2018-01-EN**
  Chemical Feeding and Feed Systems for Water/Steam Circuits

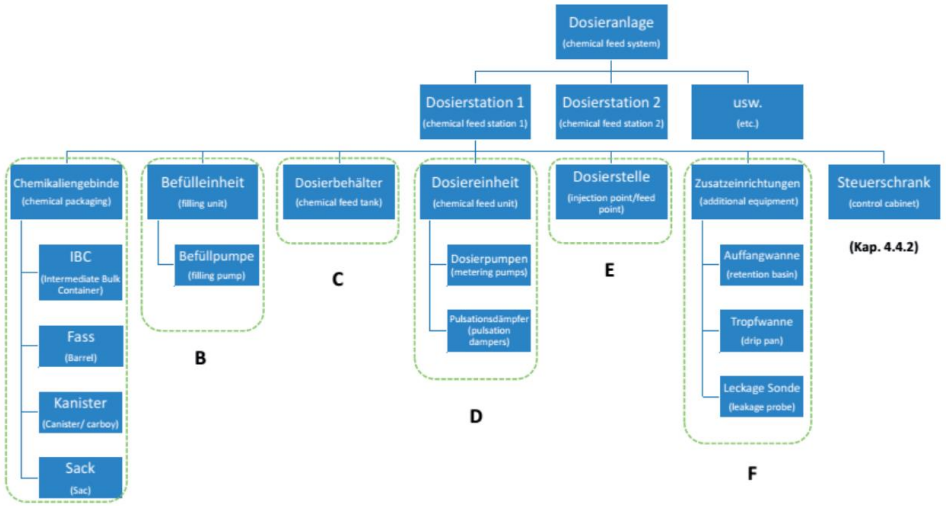
- **VGB-S-010-T-00;2011-12.EN**
  Feed Water, Boiler Water and Steam Quality for Power Plants

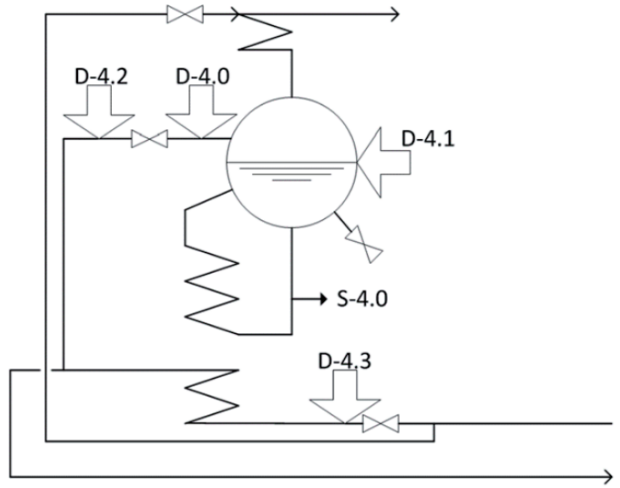
- **VGB-S-006-00-2012-09-EN**
  Sampling and Physico-Chemical Monitoring of Water and Steam Cycles

Chemical Feeding and Feed Systems for Water/Steam Circuits
(VGB-S-042-00-2018-01-EN)

Methods and systems for the chemical treatment of make-up water, boiler feed water, steam and condensate for the operation of water/steam cycles

- **Determination and design of feed points**
- **Design of delivery lines from the chemical feed system to the feed point**
- **Chemical feed system**
- **Chemical transfer equipment for storage tanks and feed vessels**
- **Accessories and protective equipment / EHS requirements**
- **Requirements for internal treatment chemicals**





2 Tasks and objectives of VGB-S-010

Feed Water, Boiler Water and Steam Quality for Power Plants
(VGB-S-010-T-00;2011-12.EN)

This VGB-Standard supports the operator of water-steam cycles in power plants and related branches in selecting and judging suitable water regimes

- **Recommendations for the complete water-steam cycle for economically sound and safe mode of operation**
- **flexibility by “action level” philosophy**
- **requirements for feed water, boiler water and steam of water-steam cycles in once-through and drum boilers and all pressure ranges**

Table 2: Once-through boilers with a copper free condensate/feed water system[1)]

Boiler Type			FEED WATER and Attemperator Spray Water	
Feed Water Treatment			Once-through; copper free condensate / feed water system	
			AVT (Alkaline)	OT
pH		N		
		AL 1	9.2	8.4
		AL 2	8.8	8.2
		AL 3	7.8	7.8
Acid Conductivity	µS/cm	N		
		AL 1		
		AL 2	0.20	
		AL 3	0.30	
Conductivity (only valid for ammonia dosing)	µS/cm	N		
		AL 1		
		AL 2	4.3	
		AL 3	1.7	
Oxygen (O_2)	µg/kg	N	0.25	
		AL 1		
		AL 2		
		AL 3		
Silica (SiO_2)	µg/kg	N		
		AL 1		
		AL 2		
		AL 3		
Iron (Fe), total	µg/kg	N		
		AL 1		
		AL 2		
		AL 3	50	
Sodium (Na)	µg/kg	N		
		AL 1		
		AL 2	10	
		AL 3	20	
Organics		N		

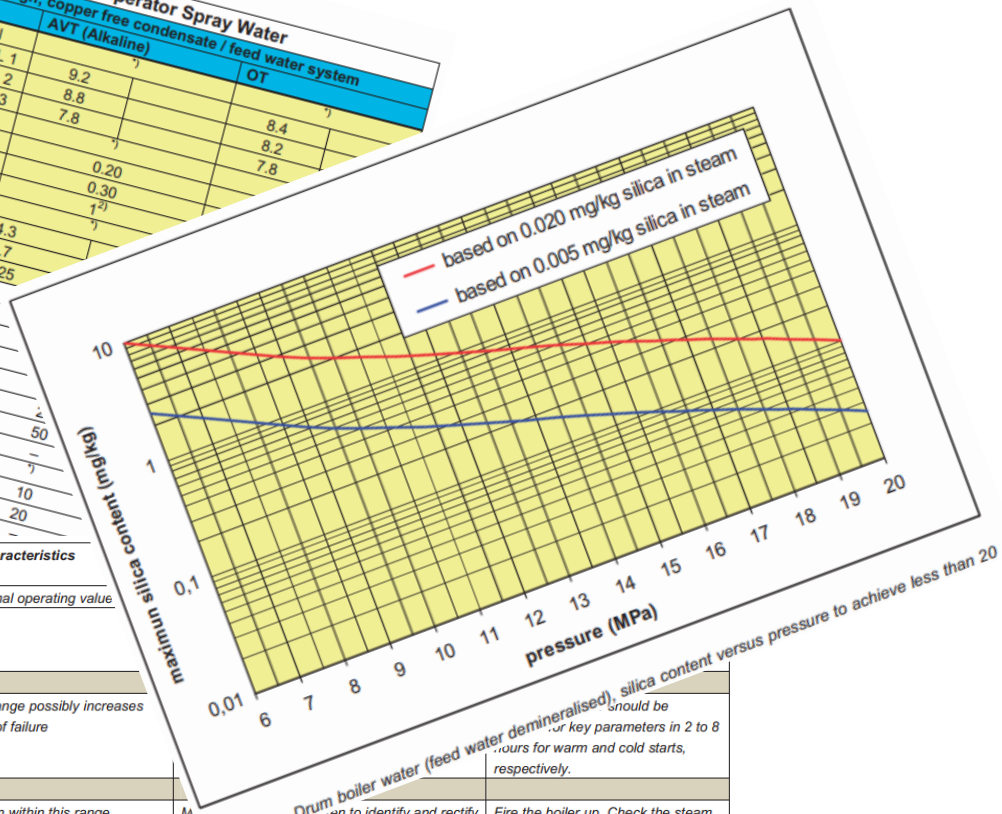


Figure 19: Drum boiler water (feed water demineralised): silica content versus pressure to achieve less than 20

Action level or range	Characteristics		
N	Plant-specific normal operating value		
N to AL 1	Acceptable range		
AL 1			
AL 1 to AL 2	Operation in this range possibly increases the long term risk of failure		should be for key parameters in 2 to 8 hours for warm and cold starts, respectively.
AL 2			
AL 2 to AL 3	Basically, operation within this range increases the risk of failure.	M…en to identify and rectify the …e excursion within a day. Fur…r actions to minimise possible damage to the plant should be taken	Fire the boiler up. Check the steam quality. At least action level 2 for all key parameters in steam should be reached before the turbine is brought into service.
AL 3			
Outside AL 3	Chemistry is out of control; operation is connected with immediate risk of damage.	The unit should be shut down as soon as possible using the normal shut-down procedure, if one of the key parameters is outside AL 3. For diagnostic parameters see AL 2 to AL 3.	The cause of excursion above AL3 must be identified and counter-measures taken before the start-up process is resumed.

Feed Water, Boiler Water and Steam Quality for Power Plants
(VGB-S-010-T-00;2011-12.EN)

Action level control system

- **system to avoid the shut-down requirement as long as there is any realistic chance to eliminate the source of trouble**
- **action levels AL1 to AL3 are defined as common limits to secure a safe operation of the plants**
- **if the N-range is adhered to, only supervision of the chemistry by means of the key parameters and the routine extent of laboratory analyses is necessary.**

Action level or range	*Characteristics*	*Action during operation*	*Action during start-up*
N	*Plant-specific normal operating value*	*Supervision of key parameters*	
N to AL 1	*Acceptable range*	*The supervision should be extended to diagnostic parameters in order to identify possibilities to go back to the N-range*	
AL 1			
AL 1 to AL 2	*Operation in this range possibly increases the long term risk of failure*	*Measures should be taken to identify and rectify the cause of the excursion within a week. Further actions to minimise possible damage to the plant should be taken*	*The action level 1 should be reached for key parameters in 2 to 8 hours for warm and cold starts, respectively.*
AL 2			
AL 2 to AL 3	*Basically, operation within this range increases the risk of failure.*	*Measures should be taken to identify and rectify the cause of the excursion within a day. Further actions to minimise possible damage to the plant should be taken*	*Fire the boiler up. Check the steam quality. At least action level 2 for all key parameters in steam should be reached before the turbine is brought into service.*
AL 3			
Outside AL 3	*Chemistry is out of control; operation is connected with immediate risk of damage.*	*The unit should be shut down as soon as possible using the normal shut-down procedure, if one of the key parameters is outside AL 3. For diagnostic parameters see AL 2 to AL 3.*	*The cause of excursion above AL3 must be identified and counter-measures taken before the start-up process is resumed.*

Feed Water, Boiler Water and Steam Quality for Power Plants
(VGB-S-010-T-00;2011-12.EN)

Example: Requirements on feed water for drum boilers:

- **Drum Boilers with a copper free condensate/ feed water system**
  - The key parameters to be monitored for the feed water are:
    - Conductivity / pH
    - Acid Conductivity
    - Oxygen
    - Silica
    - Iron
    - Sodium

FEED WATER and Attemperator Spray Water				
Boiler Type	**Drum; copper free condensate/feed water system**			
Feed Water Treatment			**AVT (Alkaline)**	**OT**
pH [1]		N	[2) *)]	[2) *)]
		AL 1	9.2	8.6
		AL 2	9.0	8.4
		AL 3	8.6	8.2
Conductivity (only valid for ammonia dosing)	µS/cm	N	*)	*)
		AL 1	4.3	1.1
		AL 2	2.7	0.7
		AL 3	1.1	0.4
Acid Conductivity	µS/cm	N	*)	*)
		AL 1	0.20 [3)]	0.15
		AL 2	0.50	0.20 [1)]
		AL 3	1	0.50
Oxygen (O_2)	µg/kg	N	*)	*)
		AL 1	100	100
		AL 2	250	250
		AL 3	-	–
Silica (SiO_2)	µg/kg	N	*)	*)
		AL 1	20	20
		AL 2	50	50
		AL 3	–	–
Iron (Fe), total	µg/kg	N	*)	*)
		AL 1	20	20
		AL 2	30	30
		AL 3	–	–
Sodium (Na)	µg/kg	N	*)	*)
		AL 1	5	5
		AL 2	20	20
		AL 3	–	–
Organics	see chapter 7.10			

*) Must be evaluated plant-specifically, see Chapter 8
N: Normal Level
AL 1 (2, 3): Action Level
(1) Once AL 2 is reached, stop oxygen dosing and change to AVT. The higher the acid conductivity is, the lower must the oxygen content of the feed water be in order to minimise the corrosion risk.
(2) The pH value of the feed water must be controlled such that the pH value according to Table 9 is achieved for the boiler water of the lowest pressure stage.
To estimate the pH value of the feed water see Chapter 5.3.1.4
(3) A higher value up to AL 2 may be acceptable if the increase of acid conductivity can be attributed to carbon dioxide

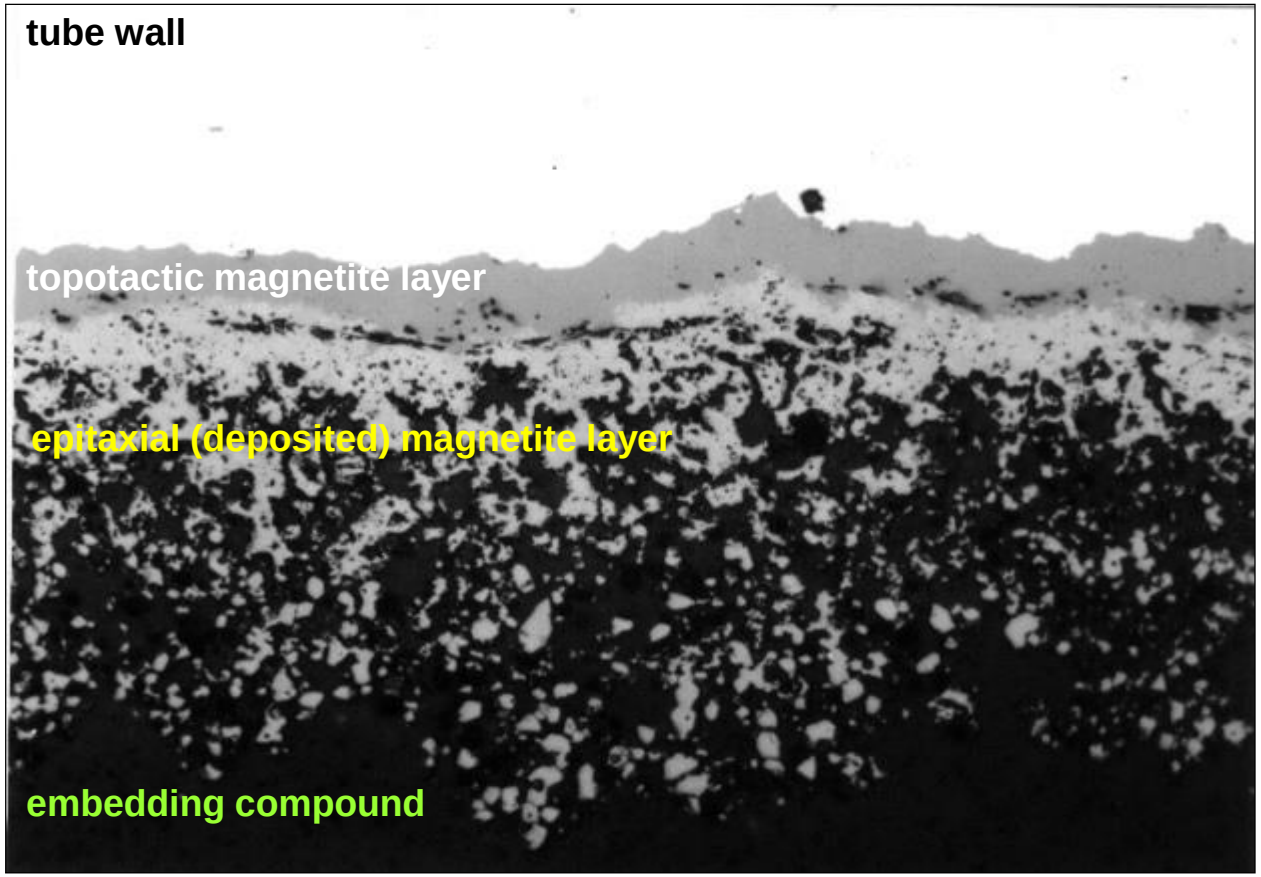
Feed Water, Boiler Water and Steam Quality for Power Plants
(VGB-S-010-T-00;2011-12.EN)

Conditioning is carried out to protect against corrosion and has an influence on the formation of the protective layer / the structural composition of the protective layer. The protective layer minimises the attack on the base material

Schikorr-Reaction (simplified)**:**

$$3Fe + 4H_2O \xrightarrow{>200\ °C} Fe_3O_4 + 4H_2$$

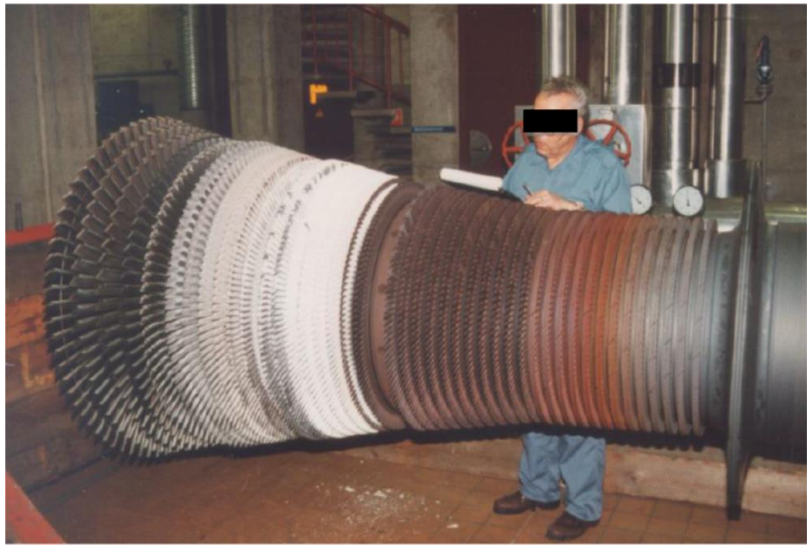
(Magnetit)



Example of the construction of a magnetite protective layer

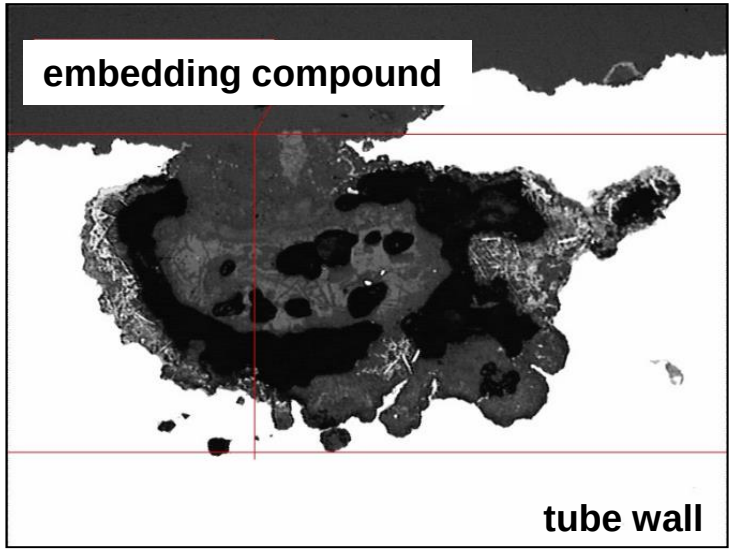
Feed Water, Boiler Water and Steam Quality for Power Plants
(VGB-S-010-T-00;2011-12.EN)

Examples of damage and malfunctions due to inadequate water chemistry monitoring



Turbine silicification

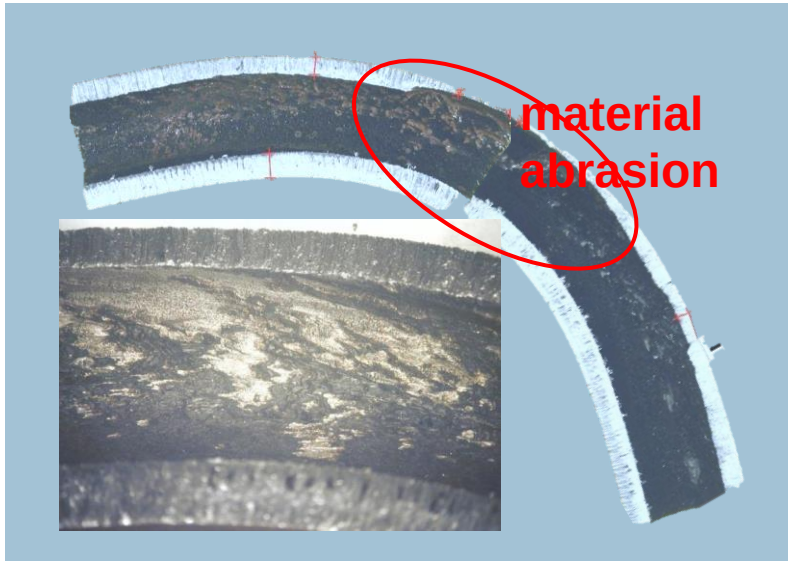
Hardness deposition



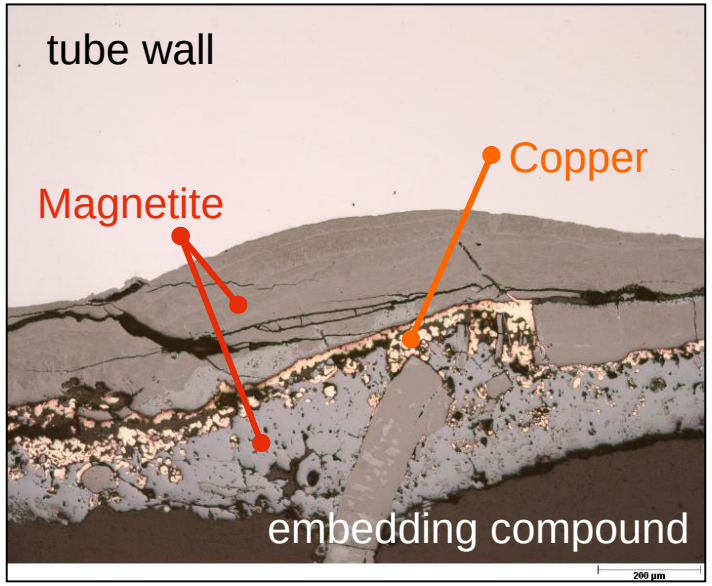
Pitting corrosion

Feed Water, Boiler Water and Steam Quality for Power Plants
(VGB-S-010-T-00;2011-12.EN)

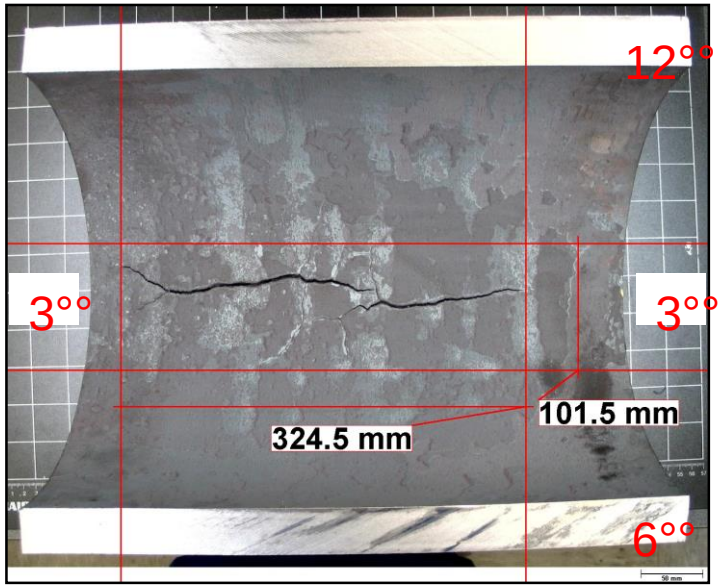
Examples of damage and malfunctions due to inadequate water chemistry monitoring



Erosion corrosion



Hydrogen embrittlement



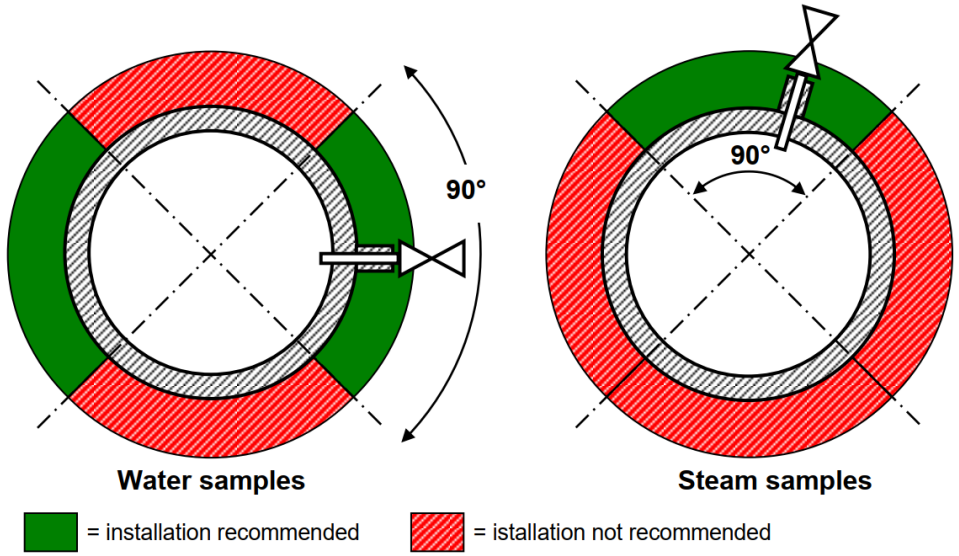
Stress corrosion cracking

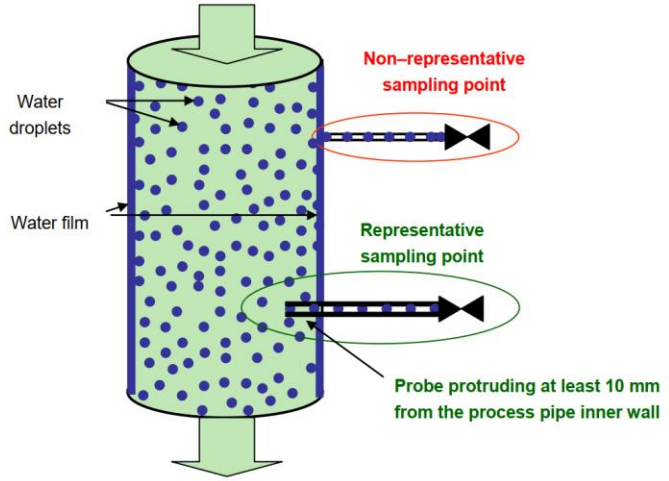
2 Tasks and objectives of VGB-S-006

Sampling and Physico-Chemical Monitoring of Water and Steam Cycles (VGB-006-00-2012-09-EN)

This standard is aimed at specifying and explaining methods and measuring equipment for analysing make-up water, feed water, boiler water, steam, and condensate during continuous monitoring of water/steam cycles.

- **determination and design of sampling points**
- **design of sampling line from the sampling point to the sampling device/equipment**
- **sample conditioning**
- **accessories and protective equipment**
- **measuring instruments**
- **processing of measured values and plausibility check**





Sampling and Physico-Chemical Monitoring of Water and Steam Cycles (VGB-006-00-2012-09-EN)

- **Only a correctly executed sampling can provide a true measurement value**
- **Examples of sampling systems**

optimal versus reality

Thanks for your attention

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be inspired
be connected
be informed

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