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## **1. INTRODUCTION**

This standard establishes the chemical control ranges for the chemical conditioning of stator cooling water systems, together with the limits for impurities within the systems.

Limits and ranges have been derived from credible literature sources, manufacturer recommendations and operating experience to constitute the best practical means of mitigating internal corrosion. Corrosion product deposition normally results in blockage of strands, overheating and subsequent failure in copper hollow conductor bars.

The standard specifies the minimum frequency for grab sampling and analysis together with the requirements for continuous on-line monitoring. In addition, the physical parameters that must be recorded are also specified.

Since the Eskom fleet is not uniform, the requirements of different equipment manufacturers have been taken into account. Eskom's recommended options are covered by this Standard and the rationale and explanation of the chemistry regimes is described in the companion document *Chemistry Guideline for Water Cooled Generator Windings (Stator Coolant)* 240-86847241.

## **2. SUPPORTING CLAUSES**

### **2.1 SCOPE**

This standard defines the chemical limits, ranges and surveillance requirements for parameters that shall be controlled in water cooled stator systems.

- A comprehensive list of the recommended physical parameters that shall be recorded alongside the chemistry results in the laboratory database is provided. It is recognised that not all parameters are available at every station. However, those that are available at specific power stations must be recorded. Where the station does not have the equipment to monitor all the required physical parameters, the station shall have on formal record all mitigations for those parameters not being monitored.
- The rationale for chemical parameters included in the specification tables is discussed in the companion document *Chemistry Guideline for Water Cooled Generator Windings (Stator Coolant)* 240-86847241. Ion exchange selection and operation and options for cleaning stator bars are also described in the companion guideline document. Only the elevated pH regimes are recognised within Eskom for copper hollow conductors - elevated pH/low oxygen and elevated pH/high oxygen.
- Neutral pH regimes are applicable only to circuits with stainless steel hollow conductors within Eskom; they are expressly prohibited within Eskom for use on circuits with copper hollow conductors.
- Parallel operation of the dual column mixed bed ion exchange system is described.

Under certain circumstances it may be possible that an exemption from these requirements, in whole or in part, could be granted, see 2.5 below

#### **2.1.2 Purpose**

The purpose of the standard is to ensure the integrity of the components of the stator cooling water system (SCWS) by operating under optimal aqueous chemistry conditions relevant to the specific SCWS

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system, thereby minimising corrosion, which may otherwise lead to stator bar flow restrictions (partial/total blockages), and/or flashover via tracking to ground.

### 2.1.3 Applicability

This document shall apply to the Engineering Department of the Technology Division and to the Generation Division; specifically those stations equipped with Water Cooled Generator Windings (Stator Coolant), and/or water-cooled Generator Circuit Breakers within Eskom Holdings SOC Limited.

## 2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

### 2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.

### 2.2.2 Informative

- [2] OEM Chemistry Specifications, in particular General Electric, Westinghouse, Parsons, ABB, Siemens and GEC/Alstom
- [3] EdF-GDL; "Document standard des specifications chimiques des paliers 900 MWe CP1/CP2" – D5710/IMC/1999/014970/00
- [4] EPRI; "Turbine Generator Auxiliary System Maintenance Guides, Volume 4: Generator Stator Cooling System" EPRI Report TR-1015669, Dec. 2008
- [5] Svoboda R. and M Svoboda M.; "Chemistry Related Monitoring of Generator Cooling Water Systems", Power Plant Chemistry (PPChem) Journal, Waesseri GmbH (Pub.), pp 128-135, March 2011
- [6] VGB Guidelines for Boiler Feedwater, Boiler Water and Steam of Steam Generators With a Permissible Operating Pressure > 68 bar, VGB-R 450 Le, 1988.
- [7] 240-55864792, Chemistry Standard for Coal Fired Units with Once through Boilers Operating at 17MPa.

## 2.3 DEFINITIONS

Definition	Description
Action Level (designated AL1/AL2/AL3)	A limiting value for a parameter that initiates a corrective action. Each Action Level has an associated duration of applicability. Action Levels are intended to provide a graded response to a deteriorating condition and to recognise the severity of the condition by the urgency of the response.
Continuous Measurement	The deployment of one (or more) dedicated on-line chemical analyser(s) to provide uninterrupted monitoring of a sample stream, facilitating early response to excursions and the formulation of fundamental operational decisions.
Limit Value	The maximum or minimum value (as appropriate) that a given parameter may take (i.e. the limiting condition) without initiating corrective action. In the case of dissolved oxygen this is synonymous with Action Level 1.
pH	For dilute aqueous solutions this is effectively the negative logarithm of the

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Definition	Description
	hydrogen ion concentration (mol/L) measured at 25°C, i.e. $-\log_{10}([H^+])$ .
Target Value	An upper or lower (as appropriate) parameter value (or range of values) for a given parameter that the Chemical Services Department shall strive to attain and maintain during normal operation.

### 2.3.1 Disclosure Classification

**Controlled disclosure:** controlled disclosure to external parties (either enforced by law, or discretionary).

## 2.4 ABBREVIATIONS

Abbreviation	Description
CACE	Conductivity After Cation Exchange; measurement of conductivity after passing the solution through cation type ion exchange resin in the hydrogen-form. Also known as acid conductivity, cation(ic) conductivity, after cation conductivity, and, peculiar to Eskom, K(HI).
CoE	Centre of Excellence
CSM	Chemical Services Manager
$EC_T/SC_T (K_T)$	The electrical (or specific, or straight, or direct) conductivity of a solution measured in micro-Siemens per centimetre ( $\mu S \cdot cm^{-1}$ ) at a defined temperature, subscript $T$ ; in most instances this will be the reference temperature, 25°C.
H/OH (or $H^+/OH^-$ )	Mixed Bed Ion exchange resin in which the cation resin portion is in the hydrogen ionic form and the anion resin is in the hydroxide ionic form.
HEX	Heat Exchanger
IX	Ion Exchange
LIMS	Laboratory Information Management System
LTPH	Long Term Plant Health
MB / MBIX	Mixed bed ion exchange resin containing intimately mixed cation and anion resin portions
MBIX-Na/OH (or $Na^+/OH^-$ )	Mixed Bed Ion exchange resin in which the cation resin portion is in the sodium ionic form and the anion resin is in the hydroxide ionic form.
OEM	Original Equipment Manufacturer
PEIC	Production Engineering Integration (Coal)
SCWS	Stator Cooling Water System

## 2.5 ROLES AND RESPONSIBILITIES

The Power Station Chemical Services Manager (CSM) shall be responsible for the implementation of this Standard to ensure adherence to the requirements.

The Power Station Electrical Engineering Manager shall include stator Long Term Plant Health (LTPH) in the outputs of the Generator System Engineer.

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From an assurance perspective, the Corporate Specialist (Chemistry) within Production Engineering Integration (Coal) (PEIC) shall be responsible to measure and report on the level of compliance with the requirements of this Standard. The Engineering Chemical Centre of Excellence (CoE) Manager is the custodian of this Standard and shall be responsible for its periodic review.

Should circumstances arise where, as a result of design deficiency or equipment failure, a unit is unable to comply with the requirements of this Standard, the custodian of this Standard, the Group Technology Engineering Chemical Centre of Excellence Manager, and the Corporate Specialist (Power Plant Chemistry) within Plant Engineering Integration Coal (PEIC), shall be consulted as to how to proceed. This may result in the CSM applying, in writing, to the Custodian for an exemption, in whole or in part, from the requirements of this Standard. Such application shall be accompanied by a full technical justification and an engineering risk assessment, and a recommendation from the Corporate Specialist (Chemistry). If the application is accepted, the exemption may be granted; exemptions shall be issued for a prescribed timeframe only, during which period the causative condition shall be resolved. The period of applicability of exemptions may not be open-ended.

## **2.6 PROCESS FOR MONITORING**

Compliance with the requirements of this Standard shall be monitored by inclusion of key parameters in the Sustainability Index.

Excursions beyond the limiting conditions of this Standard shall be monitored, tracked and reasons recorded within the Laboratory Information Management System (LIMS) maintained by each power station laboratory. The records shall be periodically reviewed by Chemistry Specialists within PEIC.

An assessment of Stator Coolant Chemistry data and compliance with this Standard shall be included in any Peer Review process that assesses Cycle Chemistry Control.

## **2.7 RELATED/SUPPORTING DOCUMENTS**

### **2.7.1 Related/Supporting Documents**

- a) 240-86847241 Chemistry Guideline for Water Cooled Generator Windings (Stator Coolant).

### **2.7.2 Superseded Documents**

- a) GGS0323 Chemistry Standard For Water Cooled Generator Windings (Stator Coolant)
- b) S4 36-689 Chemistry Standard For Water Cooled Generator Windings (Stator Coolant)

### **2.7.1 Records**

- a) Sustainability Index (Chemistry Index)
- b) LIMS Database
- c) Parameter Excursions

## **3. CHEMISTRY SPECIFICATIONS FOR WATER COOLED GENERATOR WINDINGS (STATOR COOLANT)**

The following tables provide the chemistry specifications applicable to SCWS and water-cooled breaker circuits. A listing of physical parameters that should be captured in association with the chemical parameters is also provided.

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The tables provide operating ranges and limiting conditions for chemical impurities and additives, where appropriate. Requirements for SCWS circuits with copper hollow conductors and those with stainless steel hollow conductors are addressed.

Four chemistry regimes are recognised internationally, viz.:

- i) Low Oxygen, Elevated pH
- ii) High Oxygen, Elevated pH
- iii) Low Oxygen, Neutral pH
- iv) High Oxygen, Neutral pH

Prior to the introduction of stainless steel hollow conductors, Eskom recognised only two of these four for application in copper hollow conductor circuits, i.e.

- i) Low Oxygen, Elevated pH
- ii) High Oxygen, Elevated pH

Following the introduction of stainless steel hollow conductor circuits, all four regimes are now recognised as acceptable to Eskom; however, copper hollow conductor circuits remain limited to options i) and ii), while options iii) and iv) are applicable to stainless steel hollow conductors. In principle all four regimes could be applied to stainless steel hollow conductor circuits, but elevated pH is unnecessary and limiting these circuits to options iii) and iv) reduces the risk of accidental elevated conductivity and electrical flashover.

Stainless steel hollow conductors are also indifferent to dissolved oxygen concentrations, unlike copper hollow conductors where the dissolved oxygen range 100 – 1000 µg/kg (as O<sub>2</sub>), and in particular the range 150 – 300 µg/kg (as O<sub>2</sub>) where copper release rates from the oxide deposits reaches a peak. Since there may be some residual copper bearing material in the circuit outside of the stainless steel hollow conductors, as a precautionary restrictions on oxygen operating ranges have been retained.

In every case, the applied oxygen regime shall be that specified by the Original Equipment Manufacturer (OEM); i.e. either high oxygen or low oxygen. Operation in the regime not specified by the OEM, e.g. operating high oxygen when the OEM specified low oxygen, or transit between the two oxygen regimes is prohibited. Should circumstances arise that preclude operation within the OEM specified oxygen regime, permission to implement the alternative oxygen regime shall be sought from the Engineering Chemical CoE Manager. The application shall be accompanied by a full technical justification, an engineering risk assessment, and a recommendation from the Corporate Specialist (Chemistry). If the application is successful, the Engineering Chemical CoE Manager may authorise the adoption of the alternative oxygen regime, and may also stipulate the procedure to be followed to effect the transit between the oxygen regimes.

For elevated pH regimes, the pH shall be monitored continuously by one of the following methods:

- i) Low Oxygen Circuit

In mildly alkaline, low ionic strength solutions, such as stator coolants, direct measurement of pH is difficult and generally requires the use of a flowing liquid junction potential reference electrode. If such is used, it shall be located on a sidestream sample of the bypass line feeding the H/OH MBIX resin. Following pH measurement the sidestream sample shall be returned to the inlet of the H/OH MBIX resin to ensure that:

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- the potassium in the reference solution is removed before return to the main circuit.
- There is no loss of sample from the system, to minimise make-up.

An alternative is to derive the pH from differential conductivity measurement. As with the direct measurement, the differential conductivity analyser (electrical conductivity before cation resin column and the cation conductivity following the cation resin column) shall be located on a sidestream sample ahead of the H/OH form MBIX, and returned to the inlet to the H/OH form MBIX resin; this to ensure no sample loss from the system.

The differential conductivity algorithm is adapted from the VGB Guidelines for Boiler Feedwater, Boiler Water and Steam of Steam Generators With a Permissible Operating Pressure > 68 bar, VGB-R 450 Le, 1988 [6].

$$pH = 8.6 + \log_{10} \left( EC - \frac{CACE}{3} \right)$$

Where: EC = Specific conductivity

CACE = Conductivity after cation exchange

The derivation of this algorithm, a modified version of the VGB original, is given in the companion document to this Standard, 240-86847241 *Chemistry Guideline for Water Cooled Generator Windings (Stator Coolant)*.

In the absence of air in-leakage, or if there is a low make-up rate bringing aerated make-up into the circuit, the electrical (specific/direct) conductivity can be used to derive the pH. Maintaining the conductivity within the specified limits will maintain the pH. The relationship is:

$$pH = \log_{10} \left( \frac{\kappa_{25}}{997} + \sqrt{\left( \frac{\kappa_{25}}{997} \right)^2 - 2.982 \times 10^{-8}} \right) + 2.778$$

The derivation of this algorithm is given in the companion document to this Standard, 240-86847241 *Chemistry Guideline for Water Cooled Generator Windings (Stator Coolant)*.

## ii) High Oxygen Circuit

In aerated systems, unless the system is very stable with low make-up rates, the presence of CO<sub>2</sub> in the stator water generally negates this simple correlation

It is assumed that all dual mixed bed circuits will have adopted parallel operation in accordance with previous requirements. Routing of either direct pH (flowing liquid junction) or derived pH (differential conductivity) to the H/OH form MBIX requires continuous flow through the bed (i.e. balanced flow through both beds).

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## 3.1 COPPER HOLLOW CONDUCTORS

## 3.1.1 Elevated pH Regimes

Table 1: SCWS specifications and surveillance requirements for  
Elevated pH Chemistry Regimes (applicable to copper hollow conductor circuits)

Parameter	Units	Target		Limit		Frequency
		Lower	Upper	Lower	Upper	
Elevated pH - Low Oxygen						
Specific conductivity <sup>1</sup>	(µS.cm <sup>-1</sup> )	> 1.00	< 2.00	0.50	2.50	C
pH <sup>2</sup>		> 8.60	< 8.90	8.30	9.00	C
Dissolved Oxygen <sup>3</sup>	(µg.kg <sup>-1</sup> )		< 30		50	C
Total Copper (as Cu) <sup>4</sup>	(µg.kg <sup>-1</sup> )		< 2		5	W
Sodium (as Na)	(µg.kg <sup>-1</sup> )	> 75	< 175	25	225	W
Silica (as SiO <sub>2</sub> )	(µg.kg <sup>-1</sup> )		< 10		20	W
Elevated pH - High Oxygen						
Specific conductivity <sup>1</sup>	(µS.cm <sup>-1</sup> )	> 1.00	< 2.00	0.50	2.50	C
pH <sup>2</sup>		> 8.60	< 8.90	8.30	9.00	C
Dissolved Oxygen <sup>3</sup>	(µg.kg <sup>-1</sup> )	> 4000	< 6000	2000		C
Total Copper (as Cu) <sup>4</sup>	(µg.kg <sup>-1</sup> )		< 2		5	W
Sodium (as Na)	(µg.kg <sup>-1</sup> )	> 75	< 175	25	225	W
Silica (as SiO <sub>2</sub> )	(µg.kg <sup>-1</sup> )		< 10		20	W

## Notes

- On dual column mixed bed systems, the demineralisers shall be operated in parallel mode. Flow shall be established through both demineralisers simultaneously. To achieve the desired pH, the flow through the Na<sup>+</sup>/OH<sup>-</sup> form mixed bed shall be maintained at normal flow rates, while adjusting the flow through the H<sup>+</sup>/OH<sup>-</sup> form mixed bed. Once the desired pH is attained the flow through the H<sup>+</sup>/OH<sup>-</sup> form bed should be maintained as constant as possible to control the pH. Automatic control of the dual column mixed bed system operation (based on conductivity measurement) is advised.

<sup>1</sup> Specific conductivity shall be controlled close as possible to the upper target of 2.00  $\mu\text{S.cm}^{-1}$ .

<sup>2</sup> pH shall be measured by either derivation from differential conductivity or directly via a measuring electrode and a flowing liquid junction potential reference electrode.

<sup>3</sup> Continuous dissolved oxygen measurement for high and low oxygen systems is specified. On-line monitoring installations shall be constructed in such a manner as to ensure serviceability of the equipment while the system is in operation, including changing of probes, etc., as necessary. An isolable sidestream configuration that allowing servicing of on-line instrumentation is preferred to extractable probes located in the main circuit. Should continuous measurement be temporarily unavailable, the frequency of off-line sample analysis shall be at least three times weekly for low oxygen circuits and twice weekly for high oxygen circuits.

<sup>4</sup> The total copper content shall be determined by analysis of an acidified sample

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- Resin change-out of the demineralisers is recommended at a frequency of 18 months or earlier as indicated by the deteriorating chemical parameters.
- For the low oxygen regimes, palladium dotted anion resin is normally loaded into the  $\text{Na}^+/\text{OH}^-$  column as this column must be in service at all times (except during resin change-out). This resin may be loaded in a separate specifically designed stainless steel basket inside the  $\text{Na}^+/\text{OH}^-$  column. Prior to loading, the palladium dotted resin shall be rinsed for a minimum period of 24 hours. It is not required that the palladium dotted resin be replaced every 18 months. The volume of palladium dotted resin should be 10% of the volume of the  $\text{Na}^+/\text{OH}^-$  column. Care should be taken not to disturb/damage the palladium particles, as they may detach from the resin beads and find their way into the SCWS as fine abrasive particles. Erosion of copper in the water boxes will occur resulting in elevated copper levels. It is important to immediately remove the palladium coated resin and flush the SCWS till the palladium particles are removed. Regular monitoring of the turbidity is essential. The turbidity will increase as a result of the above problem with palladium dotted resin. This is an intermittent problem and it is difficult to establish the root cause.
- Operation with elevated oxygen may be problematic during hydrogen in-leakage problems. The stator cooling water may turn milky; if a sample taken in a glass beaker clears up, from the bottom of the beaker, within a short time, excessive hydrogen is present. Venting of the excess hydrogen will simultaneously reduce the dissolved oxygen content. OEM's have limitations on hydrogen in-leakage which should be strictly followed. When the dissolved oxygen cannot be maintained  $> 750 \mu\text{g.kg}^{-1}$ , the unit shall be shut down and the hydrogen in-leakage defect detected and repaired.
- Loss of water from the stator coolant system will increase the dissolved oxygen as the demineralised make-up water on Eskom plant is seldom deaerated and is thus rich in dissolved oxygen. The stator water conductivity will tend to decrease as a result of the introduction of low conductivity demineralised make-up water. In the event that no visible leak can be found, the stator water may be leaking into the main cooling water due to a HEx tube leak. This is specifically problematic when the low oxygen regime is utilised. The HEx should be taken out of service, one at a time and pressure tested.

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**Table 2: Troubleshooting Guide for Out-of-Specification Dissolved Oxygen Conditions<sup>5</sup> under Elevated pH SCWS Chemistry Regimes.**

Regime	Target	Limit (AL1)	AL2	AL3
Elevated pH Low O <sub>2</sub>	< 30	> 50	≥ 80	≥ 100
Suggested Actions	None	<ul style="list-style-type: none"> <li>Check for air leak</li> <li>Bleed and feed system with de-aerated make-up.</li> <li>Pass over Pd-catalyst dotted ion exchange (IX) resin to remove O<sub>2</sub></li> <li>Check for water leaks and losses</li> <li>Check for loss of conductivity, if no external leaks, water could be lost due to Heat Exchanger (HEX) tube leak</li> <li>Pressure test HEX</li> <li>Increase monitoring frequency to 2W (if not C)</li> <li>Restore to &lt; 50 within 2 weeks or go to AL2<sup>6</sup></li> </ul>	<ul style="list-style-type: none"> <li>Check for air leak</li> <li>Bleed and feed system with de-aerated make-up</li> <li>Pass over Pd-catalyst dotted IX resin to remove O<sub>2</sub></li> <li>Check for water leaks and losses</li> <li>Check for loss of conductivity, if no external leaks, water could be lost due to HEX tube leak</li> <li>Pressure test HEX</li> <li>Increase monitoring frequency to D (if not C)</li> <li>Restore to &lt; 50 within 2 days or go to AL3<sup>6</sup></li> </ul>	<ul style="list-style-type: none"> <li>Check for air leak</li> <li>Bleed and feed system with de-aerated make-up</li> <li>Pass over Pd-catalyst dotted IX resin to remove O<sub>2</sub></li> <li>Inject hydrogen into stator water. Proper risk assessment</li> <li>Check for water leaks and losses</li> <li>Check for loss of conductivity, if no external leaks, water could be lost due to HEX tube leak</li> <li>Pressure test HEX</li> <li>Restore to &lt; 50 within 8 h or shutdown unit<sup>6</sup></li> </ul>
Elevated pH High O <sub>2</sub>	> 4000	< 2000	≤ 1000	≤ 750
Suggested Actions	None	<ul style="list-style-type: none"> <li>Check for H<sub>2</sub> in-leakage, Stator water could be milky</li> <li>Bleed and feed system with aerated make-up</li> <li>Inject O<sub>2</sub>/air</li> <li>Increase monitoring frequency to 2W (if not C)</li> <li>Restore to &gt; 2000 within 2 weeks or go to AL2<sup>6</sup></li> </ul>	<ul style="list-style-type: none"> <li>Check for H<sub>2</sub> in-leakage</li> <li>Determine hydrogen in-leakage rate-Refer OEM</li> <li>Bleed and feed system with aerated make-up</li> <li>Inject O<sub>2</sub>/air</li> <li>Increase monitoring frequency to D (if not C)</li> <li>Restore to &gt; 2000 within 2 days or go to AL3<sup>6</sup></li> </ul>	<ul style="list-style-type: none"> <li>Check for H<sub>2</sub> in-leakage</li> <li>Shut down unit to repair hydrogen in-leakage defect</li> <li>Bleed and feed system with aerated make-up</li> <li>Inject O<sub>2</sub>/air</li> <li>Restore to &gt; 2000 within 8 h or shutdown unit<sup>6</sup></li> </ul>

<sup>5</sup> All concentrations in the table are in µg.kg<sup>-1</sup>

<sup>6</sup> The rationale for the Action levels can be found in 240-55864792 [7]

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Table 3: Side-stream ion exchange demineraliser outlets for copper hollow conductors

Parameter	Units	Target		Limit		Frequency
		Lower	Upper	Lower	Upper	
Na <sup>+</sup> /OH <sup>-</sup> form Mixed Bed Outlet: Elevated pH regime						
Specific Conductivity <sup>7</sup>	(μS.cm <sup>-1</sup> )				2.5	C
H <sup>+</sup> /OH <sup>-</sup> form Mixed Bed Outlet: Elevated pH regime						
Specific Conductivity	(μS.cm <sup>-1</sup> )				0.2	C

<sup>7</sup> Specific conductivity shall be controlled close as possible to the upper target of 2.00  $\mu\text{S.cm}^{-1}$ .

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## 3.2 STAINLESS STEEL HOLLOW CONDUCTORS

## 3.2.1 Neutral pH Regimes

Table 4: SCWS specifications and surveillance requirements for the recognised chemical regimes for stainless steel hollow conductors

Parameter	Units	Target		Limit		Frequency
		Lower	Upper	Lower	Upper	
Neutral pH - Low Oxygen						
Specific conductivity	( $\mu\text{S.cm}^{-1}$ )		< 0.2		0.3	C
Dissolved Oxygen <sup>8</sup>	( $\mu\text{g.kg}^{-1}$ )		< 5			C
Soluble Copper (as Cu)	( $\mu\text{g.kg}^{-1}$ )		< 5		10	W
Iron (as Fe)	( $\mu\text{g.kg}^{-1}$ )		< 10		20	W
Silica (as SiO <sub>2</sub> )	( $\mu\text{g.kg}^{-1}$ )		< 10		20	W
Neutral pH - High Oxygen						
Specific conductivity	( $\mu\text{S.cm}^{-1}$ )		< 0.2		0.3	C
Dissolved Oxygen <sup>8</sup>	( $\mu\text{g.kg}^{-1}$ )	> 4000	< 6000			C
Dissolved Copper (as Cu)	( $\mu\text{g.kg}^{-1}$ )		< 5		10	W
Iron (as Fe)	( $\mu\text{g.kg}^{-1}$ )		< 10		20	W
Silica (as SiO <sub>2</sub> )	( $\mu\text{g.kg}^{-1}$ )		< 10		20	W

Table 5: Side-stream ion exchange demineraliser outlet for stainless steel conductors

Parameter	Units	Target		Limit		Frequency
		Lower	Upper	Lower	Upper	
H <sup>+</sup> /OH <sup>-</sup> form Mixed Bed Outlet: Neutral pH regime						
Specific Conductivity <sup>9 10</sup>	(μS.cm <sup>-1</sup> )		0.10		0.15	C

<sup>8</sup> A High Oxygen regime is applied for the early detection of hydrogen in-leakage. Reduction of dissolved oxygen concentration is an indication of hydrogen in-leakage. For stainless steel conductors, low dissolved oxygen has no known negative chemistry effect and is therefore not a mandatory parameter

<sup>9</sup> The single mixed bed demineraliser shall be in service at all times, except when resin change-out is carried out on-load (i.e. during unit power operation). The maximum allowable time to complete a resin change-out operation, i.e. the maximum period the stator coolant system may be without the demineraliser circuit, is 24h.

<sup>10</sup> Resin change-out of the demineralisers shall be performed at a frequency of 18 months or as indicated by conductivity increasing above the upper limit.

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### 3.3 WATER COOLED BREAKERS

Table 6: Chemical ranges and limits for water-cooled breakers

Parameter	Units	Target		Limit		Frequency
		Lower	Upper	Lower	Upper	
H <sup>+</sup> /OH <sup>-</sup> form Mixed Bed Outlet: Water-cooled breakers <sup>11</sup>						
Specific Conductivity	(μS.cm <sup>-1</sup> )				0.2	M

<sup>11</sup> The mixed bed resin shall be in a 1:1 equivalents H<sup>+</sup>/OH<sup>-</sup> ratio. The resin shall be changed at a frequency of 3 years or as prescribed by the OEM, whichever period is shorter, unless the conductivity of the cooling water deteriorates to the limit value

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### **3.4 ASSOCIATED PHYSICAL PARAMETERS**

Where available, the following physical parameters shall be recorded in the laboratory database alongside the chemical analysis results:

- a) stator differential pressure (inlet and outlet)
- b) filter differential pressure, where installed
- c) stator coolant main circuit flow, plus inlet pressure
- d) stator coolant ion-exchanger flow
- e) stator winding outlet water temperature, plus individual bar temperature
- f) generator load
- g) stator water cooler inlet and outlet temperature, where installed
- h) hydrogen gas leak rate, where installed

It is important that this information is kept with the chemistry data. However, it is recognised that this is largely duplication as this data is captured elsewhere and will in most cases be available from the Unit computer. It is acceptable to periodically download the required information from the Unit computer (in either electronic or hard copy format) for inclusion into the LIMS database.

It is also important that long term trending is carried out on all of the collected information, as this can provide early warning of impending problems.

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This document has been seen and accepted by:

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## 5. REVISIONS

Date	Rev.	Compiler	Remarks
May 2014	1	N van Eeden	TDAC Approved Documents
August 2014	1.1	N van Eeden	Removal of informative but extraneous material from Standard to accompanying document and reformatting
December 2014	1.2	N van Eeden	Updated Draft after Comments Review Process
January 2015	1.3	N van Eeden	Additional updates after Review
February 2015	1.4	N van Eeden	Final Draft for Second Comments Review Process
March 2015	1.5	N van Eeden	Updated Draft after Comments Review Process
March 2015	2	N van Eeden	Final Rev 2 Document for Authorisation and Publication
October 2016	2.1	N van Eeden	Dissolved oxygen continuous measurement made not compulsory for stainless steel conductors. Cycle Chemistry Care Group decision on 27 September 2016. Final Draft after SC Review
October 2016	3	N van Eeden	Final Rev 3 Document for Authorisation and Publication

## 6. DEVELOPMENT TEAM

The following persons were involved in the development of this document:

- N van Eeden
- KJ Galt

## 7. ACKNOWLEDGEMENTS

The contributions of previous compilers in the preparation of this standard and /or its predecessors is acknowledged:

- AJ Goosen
- JD Aspden
- D Dalgetty
- SP Mellor
- SDM Marais
- JJ van Noordwyk

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