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1. INTRODUCTION

This document defines the aesthetic, chemical, microbiological and physical limits with which potable water, produced and distributed from Eskom installations, must comply. This will ensure that the quality of the potable water produced in Eskom installations does not pose unacceptable health risks to the consumers.

2. SUPPORTING CLAUSES

2.1 SCOPE

This Standard specifies the quality of acceptable drinking water, defined in terms of microbiological, physical, chemical and aesthetic determinands at the point of production as well as delivery.

This document takes a risk based approach in setting the limits for each parameter that is monitored for drinking water quality assessment. It is, in the main, based on the SANS 241-1, an SABS standard for drinking water, although some limits in this Eskom Standard are more stringent.

A risk based approach, as defined in SANS 241-2, to the surveillance requirements is also taken, this results in more frequent analysis for parameters that are exceeding the specified limits in order to minimise the health risks associated with that parameter.

2.1.1 Purpose

The purpose of this document is to set parameters for potable water to ensure that the aesthetic, chemical, microbiological and physical quality is at an acceptable level, and in line with the SANS 241 requirement for drinking water.

It also addresses the evaluation of water quality risks, monitoring and verification of water quality to enable the management of the identified water quality risks.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings SOC Ltd where drinking water is produced and thereafter distributed. It excludes systems where the drinking water is not produced by Eskom installations even if Eskom is responsible for the distribution of the said drinking water.

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] SANS 241-1:2015, Drinking Water. Part 1: Microbiological, physical, aesthetic and chemical determinands
- [2] SANS 241-2:2015, Drinking Water. Part 2: Application of SANS 241-1
- [3] SANS 5667-5:2006, Water quality — Sampling, Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems
- [4] 240-123919938 Legionella Control and Management in Water Systems

2.2.2 Informative

- [5] Water Research Commission report 281/1/94.
- [6] Drinking water quality IWEM booklet 3 1993.
- [7] American water works journal volume 87 no 2 February 1995.

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- [8] CSIR research report no 628 P L Kempster and R Smit 1985.
- [9] DWAf 1996 South African water quality guideline volume 1: domestic use.
- [10] Canada - Ontario Province Regulation 169/03 Safe Drinking Water Act, 2002 (Boron)
- [11] Blue Drop Program, Department of Water Affairs and Sanitation
- [12] E.coli 0157: H7 and Drinking Water from Private Wells, Centre for Disease Control and Prevention, July 2015.
- [13] World Health Organization (WHO), Guidelines for drinking-water quality, Fourth edition, Volume 1, 2011

2.3 DEFINITIONS

Definition	Description
Acute health risk	Determinand that poses an immediate unacceptable health risk if present at concentration values exceeding the numerical limits specified in SANS 241
Aesthetic	Determinand that taints water with respect to taste, odour or colour and that does not pose an unacceptable health risk if present at concentration values exceeding the numerical limits specified in this part of SANS 241
Chronic health risk	Determinand that poses an unacceptable health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified in this part of Sans 241
Excursion	An excursion is defined as the exceedance of the limits of any of the parameters as defined in this Standard.
Determinand	Micro-organism, physical or aesthetic property or chemical substance that is analysed for
Final Water	Final water produced, i.e. after sanitation, and as delivered for human consumption
Grab Sample	Individual sample taken from a sampling point for specific analyses of on-line analysers or to provide laboratory analytical data.
Limit	The parameter shall not exceed the specified limit under any conditions other than emergencies such as firefighting
Local Decision	The specific limits or frequency of analysis, which are left to the discretion of the Chemical Services manager. The justification and rationale for the decision must be documented in consultation with the relevant support Chemistry Specialist. Note that this does not imply that no surveillance is required.
Operational Determinand	Determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure
Potable Water	Drinking water quality - water that is intended for human consumption
Point Of Production	That point in the production process where treatment is complete and is prior to reticulation.
Produced and Distributed	This refers to potable water that is both produced and distributed by Eskom Installations. It does not refer to potable water that is received by Eskom and only distributed by Eskom installations.
Raw Water	untreated water abstracted from dams, rivers and groundwater <i>NOTE In the case of reclamation plants, raw water is the effluent from a</i>

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Definition	Description
	waste water treatment plant and in the case of a desalination plant, raw water is the feedwater to the inlet of the plant, eg. seawater, minewater
SANS 241-1& SANS 241-2	These are the governing potable water production standards for the Republic of South Africa. SANS 241-1 governs the quality of acceptable drinking water defined in terms of microbiological, physical, aesthetic and chemical determinands at the point of delivery whilst SANS 241-2 governs the application of SANS 241-1.
Treatment Chemicals	This refers to chemicals that are used in the treatment of Raw Water to produce Potable Water. This includes chemicals used for coagulation, flocculation, pH adjustment and chemical precipitation during the treatment process.

2.3.1 Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
$\mu\text{g.kg}^{-1}$	Micrograms per kilogram
μScm^{-1}	Microsiemens per centimetre
A	Annually
C	Continuous monitoring
CFUs	Colony forming units
D	Daily
DOC	Dissolved organic carbon
DPD	N,N Diethyl-1,4 Phenylenediamine Sulfate.
DWS	Department of Water and Sanitation
F	Fortnightly (every 14 days)
LD	Local Decision
M	Monthly
mg.kg^{-1}	Milligrams per kilogram
NTU	Nephelometric Turbidity Unit
pH	The negative logarithm of the hydrogen ion concentration reported at a defined temperature normally at 25 °C
Pt/Co	Platinum/Cobalt
Q	Quarterly
SABS	South African Bureau of Standards
SANS	South African National Standard
THM	Trihalomethanes
W	Weekly e.g. 2 x W means a frequency of twice a week
WHO	World Health Organisation
$\text{K}_{25^{\circ}\text{C}}$	Specific conductivity of a solution, measured in μScm^{-1} (micro Siemens per centimetre) and reported at a defined temperature normally 25 °C

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2.5 ROLES AND RESPONSIBILITIES

The Power Station Chemical Services Manager/Site Manager shall be responsible for the implementation of this Standard and ensuring that the requirements are met. The Chemical Services Manager/Site Manager shall increase the surveillance requirements, i.e the frequency of analysis (the revised frequency will be a local decision) for his particular site, on those parameters that are not controlled within the given limits as stipulated by this document, in order to closely monitor the success of implemented corrective actions.

The Corporate Consultant (Power Plant Chemistry) is responsible for review of compliance with the requirements of this Standard. Non-compliance to this standard must be reported to Site Occupational Health and Safety Department Manager and the Environmental Manager (if applicable).

The Senior Manager: Process and Chemical Engineering within Generation Asset Management is the custodian of this Standard and shall be responsible for periodic review and updating.

2.6 PROCESS FOR MONITORING

Analytical results beyond the limiting conditions of this Standard (out of specification values) 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 the Process and Chemical Engineering section of Generation Asset Management with corrective actions taken as and when required.

Furthermore a risk assessment [4] shall be undertaken at a minimum of annually to ensure that all determinands as listed within this Standard are adequately monitored and bear no risk to the population from a health perspective and to the plant from an operational perspective. It is important to note that changes in water quality and/or sources of raw water supply will trigger a risk assessment. In the event of risks being identified, these risks will be treated as per the requirements of [2].

2.7 RELATED/SUPPORTING DOCUMENTS

None

3. CHEMISTRY REQUIREMENTS FOR POTABLE WATER

3.1 SAMPLING POINTS

Sampling points and samples shall conform to the requirements of SANS 5667-5 with respect to:

- Representative sampling

Sampling points shall be selected in a manner that will ensure that the quality of the water can be verified throughout the entire water supply chain. Sampling points shall, at minimum, include the following as applicable to the water supply system:

- a) Raw water;
- b) Final water;
- c) Representative points of delivery; and
- d) Representative sample points within the distribution zone to ensure 80% coverage of the water supply system. Each distribution zone shall be monitored at its furthest supply point. All distribution zones, including outlets from reservoirs and towers, shall be included in the monitoring programme.

- * additional sample points can be included for monitoring of the effectiveness of treatment processes, eg. post clarification or filtration

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- Safe access
- None of the constituents concentrations should change between sampling and analysis

3.2 PHYSICAL, AESTHETIC AND CHEMICAL DETERMINANDS FOR POTABLE WATER

Table 1: Eskom Potable Water Quality Standard

Parameter	Standard limits ^a	Frequency of analysis		Risk
		Final Water	Distribution System	
Turbidity	≤ 1,0 NTU	Once every 8 hours	F	Operational ^{l,a,k} and Aesthetic
Colour	< 15 mg.kg ⁻¹ Pt./Co scale	A	A	Aesthetic
pH at 25°C ^b	pH 7,5 (minimum) 9,7 (maximum)	Once every 8 hours	F	Operational
Conductivity	≤ 1700 μ.Scm ⁻¹	D	Not Applicable	Aesthetic
Sodium	≤ 200 mg.kg ⁻¹ as sodium (Na)	A (M ^j)	A	Aesthetic
Chloride	≤ 300 mg.kg ⁻¹ as chloride (Cl)	A	A	Aesthetic
Sulfate	≤ 250 mg.kg ⁻¹ as sulfate (SO ₄)	A	A	Aesthetic and Acute health ^k
Nitrate ^{c,d}	≤ 11 mg.kg ⁻¹ as nitrogen (N ^b)	A	A	Acute health
Nitrite ^{c,d,e}	≤ 0.9 mg.kg ⁻¹ as nitrogen (N ^b)	A	A	Acute health
Combined nitrate plus nitrite ^{c,d,e}	≤ 1 mg.kg ⁻¹	A	A	Acute health
Ammonia	≤ 1,5 mg.kg ⁻¹ as nitrogen (N)	A	A	Aesthetic
Fluoride	≤ 1,5 mg.kg ⁻¹ as fluoride (F)	A	A	Chronic health
Zinc	≤ 5 mg.kg ⁻¹ as zinc	A	A	Aesthetic
Arsenic	≤ 10 μg.kg ⁻¹ as arsenic (Ar)	A	A	Chronic health
Cadmium	≤ 3 μg.kg ⁻¹ as cadmium (Cd)	A	A	Chronic health
Copper	≤ 2000 μg.kg ⁻¹ as copper (Cu)	A	A	Chronic health

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Parameter	Standard limits ^a	Frequency of analysis		Risk
Cyanide (recoverable)	$\leq 200 \mu\text{g.kg}^{-1}$ as cyanide (CN)	A	A	Acute health
Iron	$\leq 300 \mu\text{g.kg}^{-1}$ as iron (Fe)	A	A	Aesthetic and Chronic health ^k
Lead	$\leq 10 \mu\text{g.kg}^{-1}$ as lead (Pb)	A	A	Chronic health
Manganese	$\leq 100 \mu\text{g.kg}^{-1}$ as manganese (Mn)	A	A	Aesthetic and Chronic
Mercury	$\leq 6 \mu\text{g.kg}^{-1}$ as mercury (Hg)	A	A	Chronic health
Phenols	$\leq 10 \mu\text{g.kg}^{-1}$ as phenol	A	A	Aesthetic
Selenium	$\leq 40 \mu\text{g.kg}^{-1}$ as selenium (Se)	A	A	Chronic health
Nickel	$\leq 70 \mu\text{g.kg}^{-1}$ as Nickel (Ni)	A	A	Chronic health
Uranium as U	$\leq 30 \mu\text{g.kg}^{-1}$ as Uranium (U)	A	A	Chronic health
Aluminium	$\leq 300 \mu\text{g.kg}^{-1}$ as Aluminium (Al)	A (M ⁱ)	A	Operational
Barium	$\leq 700 \mu\text{g.kg}^{-1}$ as Barium (Ba)	A	A	Chronic health
Boron	$\leq 2400 \mu\text{g.kg}^{-1}$ as Boron (B)	A	A	Chronic health
Free chlorine ^f	$\leq 5 \text{ mg.kg}^{-1}$ as Cl ₂	Once every 8 hours	F	Chronic health
Total microcystin ^{ig}	$\leq 1 \mu\text{g.kg}^{-1}$ as LR	A (LD)	A	Chronic health
Monochloramine ^{f,h}	$\leq 3 \text{ mg.kg}^{-1}$	A	A	Chronic health
Total Dissolved solids	$< 1200 \text{ mg.kg}^{-1}$	A	A	Aesthetic
Antimony	$\leq 20 \mu\text{g.kg}^{-1}$ as Sb	A	A	Chronic health
Total Chromium	$\leq 50 \mu\text{g.kg}^{-1}$ as Cr	A	A	Chronic health
Total Organic carbon	$\leq 10 \text{ mg.kg}^{-1}$ as C	A	A	Chronic health
Chloroform ⁱ	$\leq 300 \mu\text{g.kg}^{-1}$	A	A	Chronic health
Bromoform ⁱ	$\leq 100 \mu\text{g.kg}^{-1}$	A	A	Chronic health
Dibromochloromethane ⁱ	$\leq 100 \mu\text{g.kg}^{-1}$	A	A	Chronic health
Bromodichloromethane ⁱ	$\leq 60 \mu\text{g.kg}^{-1}$	A	A	Chronic health

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Parameter	Standard limits ^a	Frequency of analysis		Risk
Combined Trihalomethanes ⁱ	≤ 1	A	A	Chronic health
Treatment Chemicals ^j	Requirement as per SANS 241-1	M	A	Operational and Chronic health ^k

Table 2: Frequency of Analysis of Raw Water

Parameter	Frequency of analysis – Raw Water	Risk
Turbidity	D	Operational ^a and Aesthetic ^k
Colour	A	Aesthetic
pH at 25°C ^b	D	Operational
Conductivity	D	Aesthetic
Sodium	A	Aesthetic
Chloride	A	Aesthetic
Sulphate	A	Aesthetic and Acute health ^k
Nitrate ^{c,d}	A	Acute health
Nitrite ^{c,d,e}	A	Acute health
Combined nitrate plus nitrite ^{c,d,e}	A	Acute health
Ammonia	A	Aesthetic
Fluoride	A	Chronic health
Zinc	A	Aesthetic
Arsenic	A	Chronic health
Cadmium	A	Chronic health
Copper	A	Chronic health
Cyanide (recoverable)	A	Acute health
Iron	A	Aesthetic and Chronic health ^k
Lead	A	Chronic health
Manganese	A	Aesthetic and Chronic health ^k
Mercury	A	Chronic health
Phenols	A	Aesthetic
Selenium	A	Chronic health

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Parameter	Frequency of analysis – Raw Water	Risk
Nickel	A	Chronic health
Uranium as U	A	Chronic health
Aluminium	A	Operational
Barium	A	Chronic health
Boron	A	Chronic health
Total microcystin ^{ig}	A (LD)	Chronic health
Monochloramine ^{f,h}	A	Chronic health
Total Dissolved solids	A	Aesthetic
Antimony	A	Chronic health
Total Chromium	A	Chronic health
Total Organic carbon	A	Chronic health
Chloroform ⁱ	A	Chronic health
Bromoform ⁱ	A	Chronic health
Dibromochloromethane ⁱ	A	Chronic health
Bromodichloromethane ⁱ	A	Chronic health
Combined Trihalomethanes ⁱ	A	Chronic Health

Table 3: Additional Determinands to be monitored

Parameter	Standard limits ^a	Frequency of analysis			Risk
		Raw Water	Final Water	Distribution System	
Odour and taste	Inoffensive	A	A	A	Aesthetic
Total hardness ^l	For monitoring purposes only	A	A	A	Aesthetic and operation
Magnesium	For monitoring purposes only	A	A	A	Aesthetic
“M” alkalinity ^l	For monitoring purposes only	A	A	A	Aesthetic and
DOC	For monitoring purposes only	A	A	A	Chronic health
Langelier index ^l	For monitoring purposes only	A	A	A	Aesthetic and operation

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Parameter	Standard limits ^a	Frequency of analysis			Risk
Calcium Carbonate Precipitation potential ^l	For monitoring purposes only	A	A	A	Aesthetic and operational?
Vanadium	For monitoring purposes only	A	A	A	Chronic health
Algae	For monitoring purposes only	A	A (LD)	A	Chronic health
Cobalt	For monitoring purposes only	A	A	A	Chronic health

^a Values in excess of those given in column 4 may negatively impact disinfection.

^b Low pH values can result in structural problems in the distribution system.

^c This is equivalent to nitrate at 50 mg NO₃⁻/L and nitrite as 3 mg NO₂⁻/L

^d See annex C of SANS 241-2:2014 for an example of the sum of Nitrate plus Nitrite ratio. The sum of the ratios of the concentrations of each (as detected in the sample) to its guideline value should not exceed 1.

^e Due to the dynamic nature of nitrite-nitrate conversion in distribution networks and the potential health impact of bottle-fed infants, the Standard is applicable at the point of consumption.

^f Disinfection shall be sustained at a level to ensure that all bacteriological limits as defined in Table 4 are achieved on a continuous basis.

^g Microcystin only needs to be measured where an algal bloom (> 20 000 cyanobacteria cells per millilitre) is present in a raw water source. In the absence of algal monitoring, an algal bloom is deemed to occur where the surface water is visibly green in the vicinity of the abstraction, or samples taken have a strong musty odour.

^h This is equivalent to 4,1 mg Cl as Cl₂/kg as measured by standard DPD colourimetric and ferrous titrimetric methods.

ⁱ See annex C of SANS 241-2:2015 for an example of the sum of THM ratio. The sum of the ratios of the concentrations of each to its respective guideline value should not exceed 1.

^j The actual treatment chemical measured will be site specific and constituents added must be monitored at a frequency of Monthly in the Final water and at a frequency of Annually in the Distribution system., If, for example, the treatment chemical is Aluminium based then the Aluminium concentration will need to be measured at a frequency of Monthly in the Final water and at a frequency of Annually in the Distribution system.

^k In cases where determinands are listed as: Aesthetic and Operational; Aesthetic and Acute, and Operational and Aesthetic, it is important to note that each determinand within this pairing has a numerical limitation in terms of SANS 241-1 and SANS 241-2, however for the purposes of this Standard the more stringent numerical determinand value has been selected.

^l The total hardness, m-alkalinity, Langelier Index and calcium carbonate precipitation potential are monitored to understand, treat and manage the scaling potential of the final water to ensure protection of the potable water system against scale build up or corrosion.

3.3 BACTERIOLOGICAL STANDARD FOR POTABLE WATER

The water shall comply with the numerical limits for the microbiological determinands specified in Table 4 below. Where a microbiological value exceeds the numerical limit given in column 2 of Table 4, an unacceptable risk to human health is implied, corrective action needs to be taken immediately.

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Table 4: Microbiological Determinands

Variable	Limit	Frequency		Risk
		Final Water	Distribution System	
<i>E.coli</i> ^a or faecal coliform ^b Count (CFUs) per 100 ml	Not detected	W	F ^h	Acute health
Protozoan parasites ^c Cryptosporidium species Giardia species count per 10L	Not detected	A	A	Acute health ⁱ
Total coliforms ^d count (CFUs) per 100ml	≤10	A	A	Operational
Heterotrophic plate ^e count (CFUs) per ml	≤1000	W	F	Operational
Somatic coliphages ^f count per 10 ml	Not detected	A	A	Operational
<i>Legionella</i> bacteria (CFUs/L) ^g	Less than 100	Q	Q	Acute Health

Should any microbiological population become problematic whilst chlorine levels, at point of production, are sufficient, the cleaning of potable water head tanks must be investigated.

^a Definitive, preferred indicator of faecal pollution.

^b Indicator of unacceptable microbial water quality, could be tested instead of *E.coli*, but is not the preferred indicator of faecal pollution. Also provides information on treatment efficiency and after growth in distribution networks

^c Confirms a risk of human infection and faecal pollution, and also provides information on treatment efficiency. The detection of selected protozoan parasites confirms a human health risk.

^d Provides information on treatment efficiency and after growth

^e Process indicator that provides information on treatment efficiency, after growth in distribution networks and adequacy of disinfectant residuals

^f Process indicator that provides information on treatment efficiency.

^g As per the [4] 240-123919938 *Legionella* Control and Management in Water Systems and SANS 893 -1 and 2.

^h The population served shall govern the frequency of bacteriological examination. The monitoring frequency for *E.coli* (or faecal coliforms) within the distribution systems shall at a minimum be in accordance with the requirements set out in Table 5.

ⁱ Determinand that is presently not easily quantifiable and lacks information pertaining to viability and human infectivity, which, however, does pose immediate unacceptable health risks if present in drinking water.

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The population served shall govern the frequency of bacteriological examination. The monitoring frequency for E.coli (or faecal coliforms) within the distribution systems shall at a minimum be in accordance with the requirements set out in Table 5. Thus, a minimum of 1 sample, twice a month at the furthest point of the distribution system needs to be sampled and analysed.

Table 5: Frequency of bacteriological examination in distribution systems as a function of population

Population served	Total number of samples per month ^a minimum
< 5000	2
5000 - 100 000	1 per 5000 head of population + 1 additional sample ^b
100 000 – 500 000	1 per 10 000 head of population + 11 additional samples ^b
500 000	1 per 20 000 head of population + 36 additional samples ^b

^a During the rainy season, sampling should be carried out more frequently to ensure that all spatial and temporal risks are identified.

^b See WHO, Guidelines for drinking-water quality

3.4 RISK ASSESSMENTS

Complete Risk Assessments shall be performed at a minimum of once per year. Excursions must be assessed when they are discovered and immediate mitigation must be put in place to prevent any potential harmful effect on the population. The site Occupational Health and Safety department must be informed when any health-risk excursion is discovered.

The water quality risk assessment shall provide information on the water quality at the following locations:

- Water abstracted for purification (raw water)
- Water emanating from a treatment plant (final water)
- Representative points of delivery
- Where the poorest water quality is anticipated

It should be performed at a frequency that covers periods when the poorest feed water quality to the treatment plant is anticipated or during peak demand to ensure that all temporal risks are identified. The risk assessments should also be conducted when:

- Any change in the raw water supply to the treatment plant that may render it difficult to meet the numerical requirements of this Standard.
- Failure of any component of the treatment plant that may render it difficult to meet the numerical requirements of this Standard.
- A new treatment system is put into service.
- A refurbished treatment system is re-commissioned.
- A new distribution system is put into service.
- A distribution zone is altered or re-commissioned

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- A different treatment chemical is used

In the event that a parameter is found to exceed the limits as set out in Table 1 (i.e. an excursion), the frequency of monitoring shall be modified as follows:

Table 6: Modification of monitoring frequency

Risk	Frequency		
	Raw Water	Final Water	Distributions System
Acute health Bacteriological risk determinands	LD ^a	LD ^a	LD ^a
Protozoan parasite risk determinands	Not Applicable	M	Not Applicable
Acute health chemical risk determinands	W	W	M
Chronic health risk determinands	M	M	M
Aesthetic risk determinands	M	M	Q
Operational risk determinands	W	W	M

^a The frequency increase for Acute bacteriological risk determinands shall be a local decision based on the extent of the non-conformance and logistical arrangements. This value shall however be greater than the frequency for this determinand as indicated in Table 4 and Table 5.

The requirements of Table 6 must also be applied when a determinand (s) exceeds the numerical limit (s) of this Standard. In such a case an investigation must be conducted to determine the cause of the excursion in conjunction with the increase in the frequency of monitoring as stipulated by Table 6. The modified determinand monitoring must continue up until the excursion has been rectified.

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4. AUTHORISATION

This document has been seen and accepted by:

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Bonginkosi Nyembe	Chief Scientist – Process and Chemical Engineering, Asset Management
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5. REVISIONS

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March 2014	1.1	B.K. Nyembe	Updated Draft prepared for Comments
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APPENDIX A: IMPACT OF DETERMINANDS MEASURED

CALCIUM

In areas where soft water is used for the production of potable water it may be necessary to increase the calcium content.

It is recommended that this is done by the addition of an appropriate amount of calcium chloride and that stabilisation is done with sodium carbonate. This system is preferred to lime dosing whereby both calcium enhancement and pH correction are done.

ALKALINITY

A limit for the "M" alkalinity should be established through the evaluation of the scaling or corrosion potential specific to the water quality used for potable water production.

NITRATE

Nitrate in drinking water is primarily of health concern in that it can be readily converted in the gastrointestinal tract to nitrite as a result of bacterial reduction. Upon absorption, nitrite combines with the red blood pigment, haemoglobin, to form methaemoglobinaemia, which is incapable of acting as an oxygen carrier. This condition is termed methaemoglobinaemia. The reaction of nitrite with haemoglobin can be particularly hazardous in infants under three months of age, and is compounded when combined with inadequate intake of vitamin C.

IRON AND MANGANESE

High concentrations of iron (Fe^{2+}) and manganese, (Mn^{2+}) in raw water used for potable water production lead to discoloration of the potable water and sanitary ware.

Both iron and manganese can be precipitated in the clarifier/ clariflocculator (if installed) or filtered out from the water after oxidation to Fe^{3+} and Mn^{4+} . The oxidants that may be used are oxygen, chlorine, chlorine dioxide or ozone.

The use of chlorine for this application should be evaluated, as trihalomethanes can be one of the undesired by-products of the treatment.

PHENOLIC COMPOUNDS

Phenols impart odour and taste to potable water especially when marginal chlorination is used. Breakpoint chlorination may control odour and taste problems in water containing phenols but if this is not successful powdered activated charcoal may be dosed into the clariflocculators.

The activated charcoal adsorbs the phenols, effectively removing them from the water.

LANGELIER INDEX (LI)

This index provides a measure of the tendency of water to either precipitate or dissolve calcium carbonate. Water with a positive index tends to precipitate calcium carbonate while a negative index indicates a tendency to dissolve calcium carbonate.

In order to provide a measure of protection to the potable water reticulation network a slightly positive LI is preferred when deciding on the operating limits.

The influence of temperature on the LI however should also be considered when deciding on the operating limits.

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The LI is a qualitative measure of saturation. As indicated, a positive or negative index shows a tendency of scaling or corrosion potential. A positive LI indicates CaCO_3 over saturation and is no guarantee of protection against corrosion. It would be better to employ the CaCO_3 precipitation potential with a range of 4 mg/l to 6 mg/l and a target of 5 mg/l (as CaCO_3). Using modified Caldwell-Lawrence diagrams or STASOFT softwater program, this is determined as readily as is LI - see Loewenthal et al "Softening and Stabilization of Municipal Waters".

FREE CHLORINE

Chlorine efficiency diminishes rapidly above pH 8 (White, 1972) i.e. the chlorine demand at pH 9 is significantly higher than at pH 7.

More trihalomethanes (THM) are formed with increased effluent ratios in the feedwater and higher chlorine concentration in water.

MICROBIOLOGICAL QUALITY

Escherichia coli is an indicator of faecal contamination, there are many strains of this bacteria. Many which may cause a mild diarrhea. However, *E. coli* O157:H7 produces a powerful toxin that can cause severe illness. *E. coli* may be found in water sources, that have been contaminated with faeces from humans or animals. Waste can enter the water through different ways, including sewage overflows, sewage systems, polluted storm water runoff, and agricultural runoff (CDC, 2015)

Giardia and Cryptosporidium are among the most common causes of parasitic infection and disease in humans and animals. They exist as environmentally robust spores outside a host. Both parasites are resistant to water treatment processes, including chlorination. Cryptosporidium is difficult to remove by filtration because it is smaller.

DISSOLVED ORGANIC CARBON

Dissolved organic carbon is not of direct health significance, but provides an indicator of the organic content of water. It is a non-specific test and is only an indication of the number of carbon atoms derived from the oxidation of the organic matter. Such organic material may pass through the water treatment process to the disinfection stage. If disinfection by chlorination is practised, dissolved organic carbon acts as a precursor for the formation of trihalomethanes (chloroform, dichlorobromomethane, dibromochloromethane and bromoform).

The source of dissolved organic carbon is important, since organic carbon of industrial or sewage origin is of considerable concern, while organic carbon of natural origin is of little significance although it is still a precursor.

Dissolved organic carbon can also have aesthetic implications (taste, odour and colour), which may be associated with both naturally occurring organic carbon and organics originating from domestic or industrial effluent discharge.

Dissolved organic carbon refers to the fraction of the total organic carbon content of water, which passes through a 0,45 μm membrane filter. The filtrate is analysed for organic carbon by oxidation to convert to organic carbon dioxide, and measurement of the carbon dioxide.

Particular care is required in preparation for sampling to avoid contamination of the sample. Preferably no plastic containers to be used for sampling, glass amber bottles should rather be used. (preferably not plastic) Samples should be analysed with minimum delay. Storage, if necessary, should be at 4 °C with minimal exposure to light and atmosphere.

Dissolved organic carbon is expressed as milligrams carbon (C) per litre (mg/l).

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ALGAE

Algae is a term referring collectively to a wide range of pigmented oxygen-producing photosynthetic organisms usually present in water. Virtually all aquatic vegetation that does not have true roots, stems and leaves is regarded as algae. Algae range from microscopically small unicellular forms, the size of bacteria, to larger weeds, which may be some metres in length. Like other plants, algae are primary producers requiring light, carbon dioxide, water, nutrients and in some cases vitamins for growth. They are common inhabitants of surface water exposed to sunlight.

Algae have an important role in the natural purification of surface waters through, for example, the assimilation of nitrogen species (ammonia and nitrate) during photosynthesis. Algal photosynthesis also releases oxygen as a by-product into the aquatic environment. Algae synthesise carbohydrates by means of the photosynthetic process using water, carbon (from CO₂) and energy from sunlight.

During water treatment, certain algae cause effects which render water aesthetically less acceptable for domestic use (colour, taste and smell). Algal toxins may pass through treatment processes, although the extent of this effect is still unclear. High concentrations of algae adversely affect water purification processes, e.g. clogging of filters, and could result in increased treatment costs and/or poorer quality of final treated water. Algae and their extracellular products constitute a major part of the organic matter that provides precursors in the formation of trihalomethanes (THMs) during chlorination. Algae have on occasion been found in water distribution systems.

TURBIDITY

High levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria and give rise to a significant chlorine demand. Where necessary, pretreatment is critical to reduce turbidity to as low as feasible in order to ensure the efficiency of disinfection are essential components in ensuring a safe drinking-water supply.

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