Australian/New Zealand Standard™

Air-handling and water systems of buildings—Microbial control

Part 3: Performance-based maintenance of cooling water systems

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PREFACE

This Standard was prepared by Joint Standards Australia/Standards New Zealand Committee ME/62, Ventilation and Airconditioning.

This Standard forms Part 3 of a series of Standards for microbial control of air-handling and water systems, as follows:

AS/NZS
3666 Air-handling and water systems of buildings — Microbial control
3666.1 Part 1: Design, installation and commissioning
3666.2 Part 2: Operation and maintenance
3666.3 Part 3: Performance-based maintenance of cooling water systems

The term 'normative' has been used in this Standard to define the application of the appendix to which it applies. A 'normative' appendix is an integral part of a Standard.

CONTENTS

FOREWORD

AS/NZS 3666.2, *Air-Handling and water systems of buildings—Microbial control*, Part 2: *Operation and maintenance*, requires shutdown of cooling water systems for periodic cleaning. This is impracticable for many systems, such as the large industrial types serving power stations, co-generation plants and refining plants. However, microbiological control at these plants is usually effective and no reported outbreaks of Legionnaires' disease have been attributed to such sources. The continuous engineering attention they receive means they are generally well maintained. However, it became apparent that the AS/NZS 3666 series should provide for a performance-based alternative to the prescriptive maintenance requirements set out in Clause 2.5 of AS/NZS 3666.2. This performance-based alternative can be applied to any cooling water system for which the specific requirements of this Standard can be met.

This Standard provides such an alternative option. It follows risk management principles including—

(a) risk identification and assessment

(b) control; and

(c) monitoring and corrective actions.

These principles are applied to the key causal factors, understood to lead to a risk of multiplication of legionellae within a system, as set out in the Foreword to AS/NZS 3666.1.

A central issue in the management of health risk arising from microorganisms is the degree of scientific certainty about the underlying causes of growth, dissemination and infection. Control strategies adopted may need to change as new knowledge becomes available.

Sampling for legionellae is not required by AS/NZS 3666.2 but is considered to be a relevant monitoring activity in a performance-based approach. Although the sample taken may not accurately represent the microbial distribution and variety within the system, it is presently the most direct means of assessing the effectiveness of maintenance regimes on the multiplication of legionellae. Such specific tests need to be complemented with other assessments such as total bacterial count (also called heterotrophic colony count) and system water quality characteristics to provide reassurance that the system is well maintained and operating in a hygienic condition.

The concentration level of legionellae required to cause infection has not been established at this time. The risk of disease depends substantially on the susceptibility of the person exposed. However, it is reasonable to assume that increased risk is associated with exposure to increased concentrations of microorganisms. Available data suggest that most outbreaks are associated with a concentration of 1000 cfu/mL or greater, although lower levels may well be associated with sporadic cases of disease. It is the intention of this Standard that cooling water systems operate with non-detectable concentrations of legionellae. This Standard requires corrective actions to be carried out whenever a 'detectable' concentration of legionellae is found (10 cfu/mL or greater) in order to provide confidence that the system is hostile to these microorganisms. More demanding and prompt actions are required when a higher concentration is detected.

The primary aim is to avoid conditions that may allow microorganisms, including legionellae to multiply in the cooling water system thus creating a health risk.

An important strategy in minimizing health risks associated with cooling water systems involves the management of system water quality. Water treatment is designed to preserve the cooling tower and the cooling water system of which it is a part, maintain heat transfer efficiency and help ensure an acceptable standard of occupational and public health. These

factors interact so that properly implemented microbial control, for reasons of disease prevention, should also assist in system longevity and efficiency. The water treatment program for microbial control needs to be well managed, and be more comprehensive than a program for those systems that are routinely cleaned in accordance with AS/NZS 3666.2. Water treatment program management approaches may differ in detail from site to site and, therefore, need to be documented in a specific plan for each site.

This Standard addresses only the maintenance of cooling water systems and is to be read in conjunction with Part 1 and the relevant clauses of Part 2. Aspects such as maintenance manuals, records, log books, safety procedures and the like, are as important for the application of this Standard, as they are for a prescriptive approach to maintaining a clean system.

Further explanatory information regarding the subject of microbial control of cooling water systems can be found in the Standards Australia/Standards New Zealand Handbook SAA/SNZ HB32:1995, *Control of microbial growth in air-handling and water systems of buildings*, and the National Environmental Health Forum Monograph, *Guidance for the control of Legionella*, published by the South Australian Health Commission (1996) on behalf of the Commonwealth Department of Health and Aged Care, and the *Application Manual No. DA18, Water Treatment*, which is published by the Australian Institute of Refrigeration Air-conditioning and Heating Inc (AIRAH).

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Australian/New Zealand Standard
Air-handling and water systems of buildings—Microbial control

Part 3: Performance-based maintenance of cooling water systems

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard outlines a performance-based approach to the maintenance of cooling water systems with respect to the control of microorganisms, including Legionellae, within such systems. This approach combines automatically regulated water treatment with monitoring, assessment and control strategies to help create a low risk environment within the cooling water system.

The provisions of this Standard are an alternative to the prescriptive requirements of AS/NZS 3666.2 for the maintenance of cooling water systems.

NOTE: This Standard addresses only the performance of maintenance programs for cooling water systems and is to be read in conjunction with Part 1 and the relevant clauses of Part 2. Aspects such as maintenance manuals, records, log books, safety procedures, and the like, are as important for the application of this Standard as they are for a prescriptive approach to maintaining a clean system.

1.2 OBJECTIVE

The objective of this Standard is to provide a performance-based approach to cooling water system maintenance to assist users in the control of microorganisms, including legionellae, within such systems.

1.3 FUNCTIONAL STATEMENT

Cooling water systems shall be maintained and monitored to minimize the growth and dissemination of microorganisms, and in particular, legionellae in and by such systems.

1.4 PERFORMANCE REQUIREMENTS

The monitoring, assessment and control strategies for key performance indicators shall be in accordance with Section 3.

NOTE: Following these performance requirements is deemed to comply with the prescriptive requirements of Clause 2.5 of AS/NZS 3666.2.

1.5 REFERENCED DOCUMENTS

The following documents are referred to in this Standard.

AS

2031	Selection of containers and preservation of water samples for chemical and microbiological analysis
2031.2	Part 2: Microbiological
4276	Water microbiology
4276.3.1	Method 3.1: Heterotrophic colony count methods—Pour plate method using plate count agar

AS/NZS	
3666	Air-handling and water systems of buildings—Microbial control
3666.1	Part 1: Design, installation and commissioning
3666.2	Part 2: Operation and maintenance
3896	Waters—Examination for legionellae including *Legionella pneumophila*
4360	Risk management

1.6 DEFINITIONS

For the purposes of this Standard the definitions given in AS/NZS 3666.1, AS/NZS 3666.2 and those below apply.

1.6.1 Cycles of concentration

The degree of concentration of the dissolved solids of the cooling system make-up water as a result of the evaporation that takes place in the cooling tower.

NOTE: The degree of concentration of the dissolved solids is typically determined from the ratio between the chlorides in the cooling water and the chlorides in the make-up water.

1.6.2 Key performance indicator

A risk factor that is identified as testable, assessable and controllable for the performance, monitoring and verification of the system.

1.6.3 Total dissolved solids (TDS)

The total weight of dissolved solids in water, which would remain if all the water were evaporated.

1.7 TESTING

Microbiological tests required to be carried out by this Standard shall be carried out by a registered microbiology laboratory accredited to examine water samples for legionellae and other heterotrophic bacteria.

SECTION 2 IDENTIFICATION AND ASSESSMENT OF RISK FACTORS

2.1 SCOPE OF SECTION

This Section lists risk factors that contribute to the growth and dissemination of microorganisms within cooling water systems.

2.2 RISK FACTORS

The risk factors given in Table 2.1 shall be assessed and documented for each site. Appropriate control measures should be implemented. Key performance indicators identified in Table 2.1 shall be monitored and controlled in accordance with Section 3.

NOTES:

1 Many of these factors will be controlled by compliance with AS/NZS 3666.1 and AS/NZS 3666.2.

2 Other factors that may lead to the risk of acquiring a disease caused by microorganisms include transport of microorganisms, virulence of microorganisms and host susceptibility. These factors are not within the scope of this Standard.

2.3 RISK ASSESSMENT

A risk assessment shall be undertaken as part of the implementation of this Standard and shall identify, evaluate and report on all factors given in Table 2.1. The risk assessment shall be undertaken and documented by a person competent to evaluate the condition of the cooling water system.

The risk assessment shall be revised if there are any reasons to believe that the findings are no longer valid, if monitoring reveals the need for preventative or corrective action, if significant change in local environment, work practices or equipment occur or if five years have elapsed since the last assessment or revision. The risk assessment report shall form part of the operating and maintenance manual.

NOTE: AS/NZS 4360 provides information on risk management.

2.4 WATER TREATMENT

Cooling water systems shall be provided with automatically regulated water treatment systems for effective management of corrosion, scaling, fouling and microbial growth.

TABLE 2.1

RISK FACTORS TO BE ASSESSED AND CONTROLLED

Risk area	Risk factor
Opportunity for multiplication	Presence of water (especially if stagnant, e.g. dead legs or system not in use)
	Concentration of legionellae (all species are considered as potential pathogens)*
	Concentration of other heterotrophic bacteria*
	Presence of protozoa and algae
	Presence of nutrients
	System size [surface area available for biofilm development (compared with water volume)]
	Presence of biofilm
	Water quality — cleanliness* — pH*, total alkalinity*, chlorides* — presence of corrosion products* — presence of scale and fouling — conductivity/TDS* — control limits out of range* — suspended solids (e.g. from nearby construction work) — control of water treatment chemicals, bleed*
	Water temperature*
	Characteristics of make-up water (physical, chemical, microbiological)
	Direct sunlight (which promotes algal growth)
	Physical condition of system*
	Microbial control program
	System location and environment
Mechanism for dissemination	Open system
	Aerosol generation
	Mode of operation — intermittent operation — seasonal usage
	Drift elimination
	Aerosol dispersion
	System location (distance to other cooling water systems, air intakes and passers by)

* Risk factor identified as a key performance indicator.

SECTION 3 PERFORMANCE MONITORING AND CONTROL

3.1 SCOPE OF SECTION

This Section outlines the requirements for monitoring and control of risk factors identified as key performance indicators. Where separate monitoring and assessments lead to different control strategies, the higher requirements shall apply.

3.2 PRESENCE OF LEGIONELLAE

3.2.1 Monitoring

A representative sample of cooling water shall be taken in accordance with Appendix A, at least once per month when the system is in use, and assessed in accordance with Clause 3.2.2.

3.2.2 Assessment

An examination for the presence of legionellae shall be carried out in accordance with AS/NZS 3896. If legionellae are detected (i.e. greater than or equal to 10 cfu/mL), a control strategy shall be immediately initiated in accordance with Clause 3.2.3.

NOTES:

1 Other equivalent, validated and accredited test methods may be used.

2 The risk assessment may provide for variations to monitoring frequency, e.g. additional monitoring during summer months and reduced frequency of monitoring during winter, as appropriate to the site.

3.2.3 Control

The control strategy adopted shall be in accordance with Table 3.1. A flow chart detailing the assessment and control process is given in Figure 3.1.

3.3 PRESENCE OF OTHER HETEROTROPHIC MICROORGANISMS

3.3.1 Monitoring

A representative sample of cooling water shall be taken in accordance with Appendix A, at least once per month when the system is in use, and assessed in accordance with Clause 3.3.2.

3.3.2 Assessment

A heterotrophic colony count (HCC) test shall be carried out in accordance with AS 4276.3.1 using the 35°C/37°C method. If the test result is greater than or equal to 100 000 cfu/mL, a control strategy shall be immediately initiated in accordance with Clause 3.3.3.

NOTE: Other equivalent, validated and accredited test methods may be used.

3.3.3 Control

The control strategy adopted shall be in accordance with Table 3.2. A flow chart detailing the assessment and control process is given in Figure 3.2.

3.4 WATER QUALITY MANAGEMENT

3.4.1 Monitoring

The effectiveness of the water quality management system (including water treatment) shall be assessed, at least monthly when the system is in use, in accordance with Clause 3.4.2.

3.4.2 Assessment

3.4.2.1 *General*

Performance criteria and operating control ranges shall be set for the water management program and the system shall operate within these parameters. Assessment shall include physical checks of the system and chemical analysis of the water system. Assessment shall be made against the documented performance criteria and operating control ranges.

3.4.2.2 *Chemical analysis*

The system water shall be tested for the following:

(a) Total alkalinity.

(b) Chlorides.

(c) Conductivity/TDS.

(d) pH.

(e) Other criteria appropriate to the site (e.g. hardness).

3.4.2.3 *Other checks*

The system shall be subject to the following checks:

(a) Physical condition of the system.

(b) Operation of the bleed control system.

(c) Operation of the make-up water system.

(d) Cycles of concentration.

(e) Corrosion rate.

(f) Adequacy of scale and corrosion inhibition.

(g) Cleanliness of wet surfaces, i.e. visibly free from accumulations of sludge, foam, slime, rust, scale, dirt, dust and larger mineral or organic deposits.

(h) Changes in the local environment (e.g., local building demolition or construction).

3.4.3 Control

Assessed parameters shall fall within the documented operating control ranges. Where results fall outside these limits, remedial action including further assessment shall be carried out to bring the parameters within the specified limits prior to the next monthly monitoring and assessment.

3.5 WATER TEMPERATURE

3.5.1 Monitoring

The temperature of the operating system shall be measured at the return line to the cooling tower, at least monthly when in use, and assessed in accordance with Clause 3.5.2.

3.5.2 Assessment

The temperature of the operating system shall be assessed against the optimal temperature for the system design and current operating conditions.

NOTE: Reducing the system operating water temperatures to the lowest practicable value improves control of microorganisms, including Legionellae and usually improves operating efficiency.

3.5.3 Control

The operating conditions for the system operating pumps and the cooling tower fans shall be reviewed.

TABLE 3.1

CONTROL STRATEGIES FOR THE PRESENCE OF LEGIONELLAE

Test result (cfu/mL)	Required control strategy
Not detected (<10)	(1) Maintain monthly monitoring. Maintain water treatment program.
Detected as <1000	(2) Investigate problem Review water treatment program Take necessary remedial action including immediate on-line disinfection in accordance with Appendix B and undertake control strategy (3)
	(3) Retest water within 3 to 7 days of plant operation (a) If not detected, continue to retest water every 3 to 7 days until two consecutive samples return readings of not detected and repeat control strategy (1) (b) If detected at <100 cfu/mL repeat control strategy (2) (c) If detected at ≥100 cfu/mL investigate problem and review water treatment program, immediately carry out on-line decontamination in accordance with Paragraph C2 of Appendix C and repeat control strategy (3) (d) If detected at ≥1000 cfu/mL undertake control strategy (4)
Detected as ≥1000	(4) Investigate problem Review water treatment program Take necessary remedial action including immediate on-line decontamination in accordance with Paragraph C2 of Appendix C and undertake control strategy (5)
	(5) Retest water within 3 to 7 days of plant operation (a) If not detected, continue to retest water every 3 to 7 days until two consecutive samples return readings of not detected and repeat control strategy (1) (b) If detected at <100 cfu/mL, repeat control strategy (2) (c) If detected at ≥100 <1000 cfu/mL investigate problem and review water treatment program, immediately carry out on-line decontamination in accordance with Paragraph C2 of Appendix C and repeat control strategy (5)
	(d) If detected at ≥1000 cfu/mL investigate problem and review water treatment program, immediately carry out system decontamination in accordance with Paragraph C3 of Appendix C and repeat control strategy (5)

TABLE 3.2

CONTROL STRATEGIES FOR THE PRESENCE OF OTHER HETEROTROPHIC MICROORGANISMS

Test result (cfu/mL)	Required control strategy
<100 000	(1) Maintain monthly monitoring Maintain water treatment program
≥100 000 <5 000 000	(2) Investigate problem Review water treatment program Take necessary remedial action including immediate on-line disinfection in accordance with Appendix B and undertake control strategy (3) (3) Retest water within 3 to 7 days of plant operation (a) If test result is <100 000 cfu/mL repeat control strategy (1) (b) If test result is ≥100 000 cfu/mL but <5 000 000 cfu/mL undertake control strategy (2) (c) If test result is ≥5 000 000 cfu/mL undertake control strategy (4)
≥5 000 000	(4) Investigate problem Review water treatment program Take necessary remedial action including immediate on-line disinfection in accordance with Appendix B and undertake control strategy (5) (5) Retest water within 3 to 7 days of plant operation (a) If test result is <100 000 cfu/mL repeat control strategy (1) (b) If test result is ≥100 000 cfu/mL but <5 000 000 cfu/mL repeat control strategy (4) (c) If test result is ≥5 000 000 cfu/mL investigate problem and review water treatment program, carry out immediate on-line decontamination in accordance with Paragraph C2 of Appendix C and repeat control strategy (5)

3.6 START UP

Where a system has not been in operation for a period of more than 30 days an assessment in accordance with Clauses 3.2 to 3.5 shall be carried out within three to seven days of system operation.

3.7 RESULTS AND RECORDS

Each month a report shall be prepared detailing the test type, the control range, the test results, remedial actions taken or recommended and the name of the person or organization undertaking the assessment.

Operating and maintenance manuals, risk assessment reports, test results and maintenance records shall be readily available for inspection by authorized personnel upon request. For the purposes of maintenance management, the maintenance records shall be retained in a legible form for a minimum period of seven years.

3.8 EVIDENCE OF COMPLIANCE

Records that are required to be retained (see Clause 3.6) shall provide evidence of compliance with the requirements of this Standard.

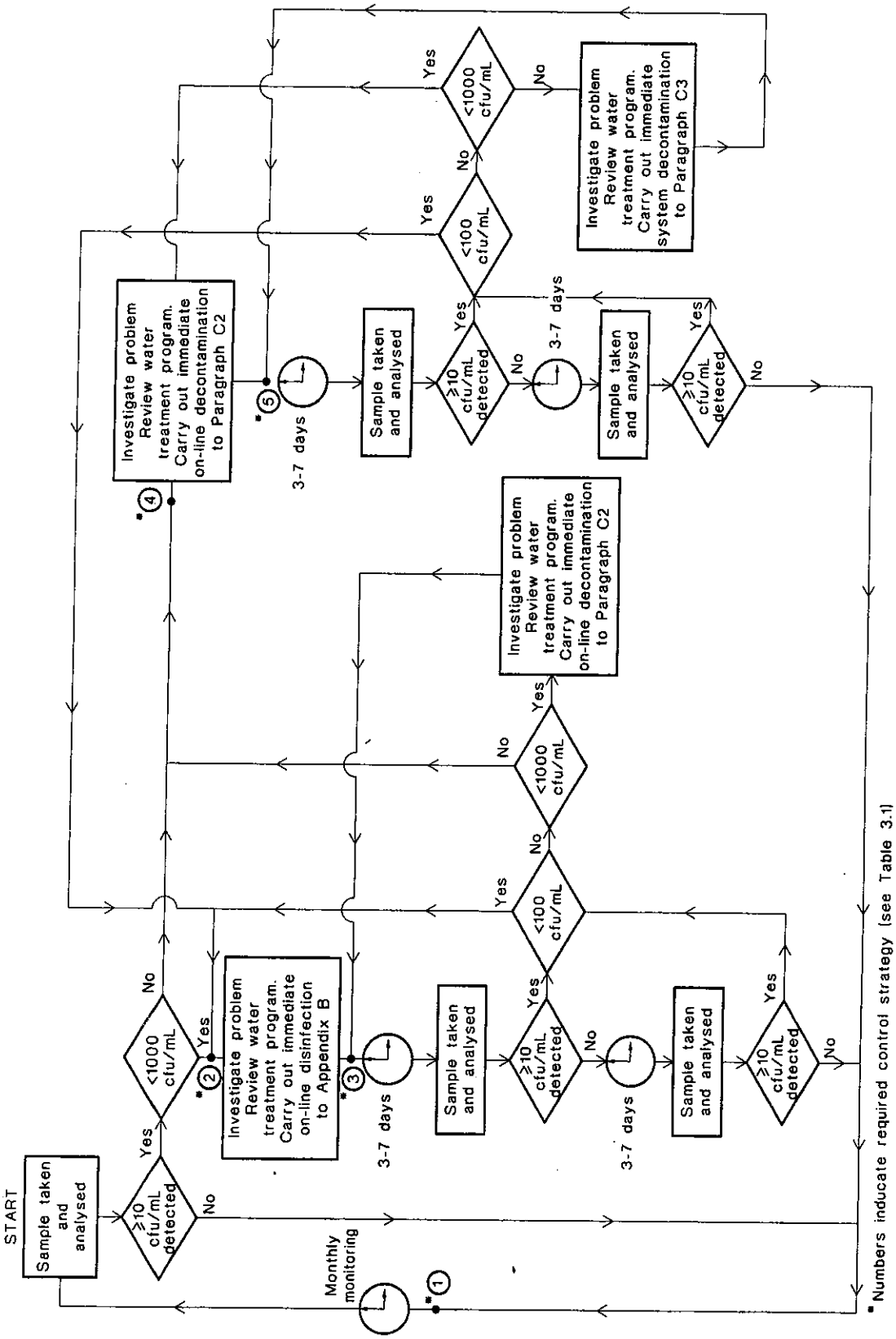
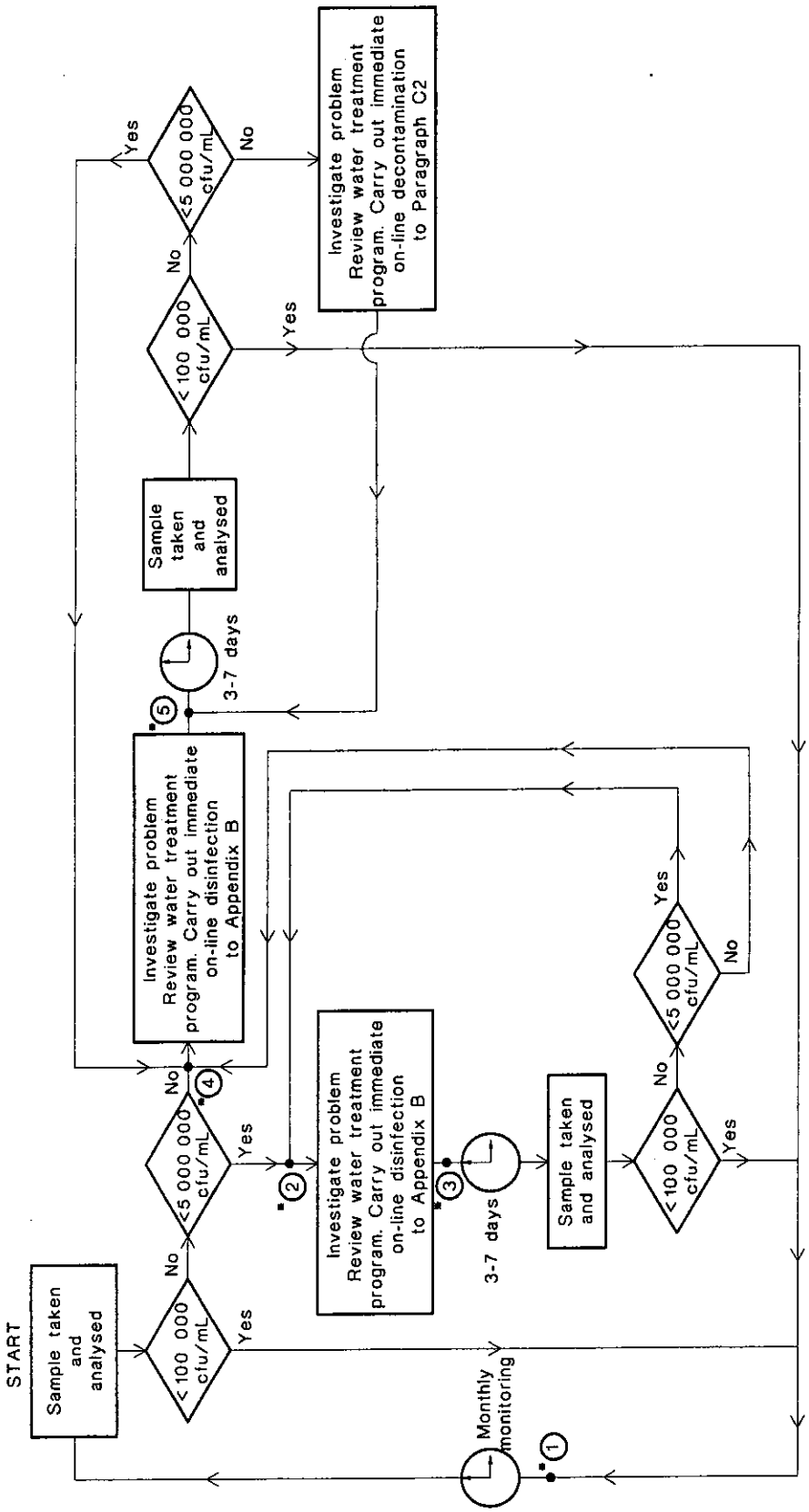


FIGURE 3.1 PRESENCE OF LEGIONELLAE.—MONITORING, ASSESSMENT AND CONTROL FLOW CHART



*Numbers inducate required control strategy (see Table 3.2)

FIGURE 3.2 PRESENCE OF OTHER HETEROTROPHIC MICROORGANISMS—MONITORING, ASSESSMENT AND CONTROL FLOW CHART

APPENDIX A

COOLING WATER SAMPLING PROCEDURE

(Normative)

A1 SCOPE

This Appendix sets out the procedures for the collection of water samples from cooling water systems for subsequent microbiological examination.

A2 PERSONNEL CARRYING OUT SAMPLING

Personnel involved in carrying out the sampling procedures shall be appropriately trained in the work.

NOTE: Training should include practical instruction on basic principles of sampling for microbiological and chemical tests. At a cooling tower, techniques should be demonstrated by the trainer and practised by the trainee. Training should also include instruction on relevant codes, legislation and personal safety procedures.

A3 SAMPLE STORAGE AND TRANSPORT

For *Legionella* testing, the sample storage and transport requirements of AS/NZS 3896 shall apply and for HCC testing the requirements of AS 2031.2 shall apply.

NOTE: The time of sampling and transport arrangements should preferably allow the laboratory to commence testing within 24 hours of sampling.

A4 PARTICULARS OF SAMPLING CONTAINERS

Sampling containers shall be in accordance with AS 2031.2. Prior to taking the sample, the following shall be recorded in indelible and legible form on the container label:

(a) Unique identification for each sample.

(b) Name of organization that took the sample.

(c) Date and time of sampling.

(d) The tests required to be carried out.

NOTE: The microbiology laboratory should be consulted as to the required water sample size and details required for the analysis request.

A5 PARTICULARS OF SAMPLING

The following shall be recorded:

(a) Name of person and organization that sampled the water.

(b) Date and time of sampling.

(c) Date and time (where known) of the latest addition of biocide.

(d) Product name (where known) of biocide.

(e) Unique identification for each sample.

(f) Whether sample is from the cooling tower or from a defined sampling point.

(g) The tests required to be carried out.

A6 TECHNIQUE OF SAMPLE COLLECTION

Avoid sampling for at least 72 h after system operation following disinfection, decontamination or cleaning procedures to allow conditions to stabilize.

Where practicable, prior to sampling, the water shall be circulated throughout the system for not less than 30 min.

NOTE: Ideally sampling should occur while the system is in operation.

The sample shall be collected from the cooling tower or a defined sampling point, located on the cooling water return line to the cooling tower. The following procedure shall be adopted for sample collection:

(a) Take the sample for microbiological examination before any sample required for chemical analysis, to help prevent contamination of the sampling point.

(b) Remove the sample container cap only when ready to sample. Keep the cover turned downwards. Do not insert fingers inside the container or the lid. Do not flush the container or the lid prior to sampling.

NOTE: Flushing is not allowed as these containers are required to be sterile and may contain a neutralizing agent.

(c) When sampling from a sampling point, allow water to run freely for a minimum of 30 s prior to filling the sample container.

(d) When sampling from a basin, hold the sample container from its base and plunge it, neck downwards, to about 50 mm below the water surface and clear of any surfaces of the cooling tower and any associated equipment. Collection of the sample shall not be taken from the vicinity of the make-up water (inlet) or near the application point of any water treatment. Turn the container until the neck points slightly upwards. Create an artificial current by pushing the container horizontally forwards and away from the hand.

(e) Avoid collection of sludge and slime.

(f) Leave some ullage (air space) in the container.

(g) Replace the cap on the container immediately after collection.

NOTE: When sampling, personal protective equipment should be worn in line with the recommendations of AS/NZS 3666.2.

APPENDIX B

ON-LINE DISINFECTION PROCEDURE FOR COOLING WATER SYSTEMS

(Normative)

B1 SCOPE

This Appendix sets out the procedures for the on-line disinfection of cooling water systems.

B2 BIODISPERSANT

Prior to on-line disinfection a biodispersant shall be circulated.

NOTE: Some biocides have inherent biodispersant properties and this step may not be required.

B3 DISINFECTION

Dose the cooling water system with a biocide of different chemical composition, or similar composition but increased concentration, to that of the regular water treatment program.

NOTE: The concentration level should be in strict accordance with the biocide manufacturer's instructions.

B4 CIRCULATION

Circulate the biocide through the cooling water system for the time specified by the biocide manufacturer.

B5 OPERATION

Return the system to normal operation.

APPENDIX C

DECONTAMINATION PROCEDURES FOR COOLING WATER SYSTEMS

(Normative)

C1 SCOPE

This Appendix sets out the procedures for the decontamination of cooling water systems where required by this Standard.

C2 ON-LINE DECONTAMINATION

On-line decontamination shall be carried out in accordance with the following procedure:

(a) Dose the recirculating water with a chlorine-based compound, equivalent to at least 5 mg/L of free residual chlorine for a least one hour, whilst maintaining a pH between 7.0 and 7.6.

(b) Review the water treatment program, tower operation and maintenance program.

(c) Correct any faults and implement any necessary changes.

(d) Record all actions and observations in the maintenance report.

(e) Recommission and repassivate the circulating cooling water system, and reinstate the water treatment program.

C3 SYSTEM DECONTAMINATION

System decontamination shall be carried out in accordance with the following procedure:

(a) Isolate any cooling tower fans to prevent operation. Prior to system decontamination, circulate a dispersant.

(b) Dose the circulating cooling water system to maintain 5 to 10 mg/L of free residual chlorine at pH 7.0–7.6, monitor at intervals of 15 min, and allow to circulate at this level for a minimum of 1 h.

(c) Isolate the cooling tower and drain to the sewer/trade waste in accordance with the requirements of the appropriate regulatory authority.

(d) Open all system drains temporarily, to flush drain lines with disinfected water.

(e) Clean all wetted surfaces of the cooling tower in accordance with the supplier's instructions or by using water spray and mechanical cleaning as necessary. Exercise care to avoid damage to components.

(f) Refill the cooling tower.

(g) Dose the circulating cooling water system to maintain 1 to 5 mg/L of free residual chlorine at pH 7.0–7.6, monitor at intervals of 15 min, and allow to circulate at this level for a minimum of 30 min.

(h) Recommission and repassivate the circulating cooling water system, and reinstate the water treatment program.

Where cooling water systems cannot be shut down for cleaning, system decontamination shall be carried out as directed or as required by the regulatory authority with jurisdiction.

NOTE: Specific decontamination instructions may be established by the regulatory authority. These specific instructions may take the form of:

(a) specific directives in an individual case; or

(b) a general decontamination procedure that is either published or referenced as the method to be followed in the jurisdictional area of the regulatory authority.