Office of Industrial Relations

Guide to *Legionella* control in cooling water systems, including cooling towers

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Queensland Government

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Contents

Introduction

This guide applies to cooling water systems in industrial usage or air-conditioning situations in Queensland that include components such as:

- a cooling tower
- closed circuit fluid coolers or evaporative condenser
- associated chiller and condenser.

This guide will to assist owners, anyone in control[1] of the above, or a person conducting a business or undertaking (such as a service contractor) for the above, or anyone considering reusing the bleed[2] water from a cooling tower to comply with their duty of care under the *Work Health and Safety Act 2011*, and in managing the risks from micro-organisms such as l*egionella* in the components of the cooling water system.

It is recommended that:

- owners, or persons in control of such cooling water system components in Queensland workplaces use this guide when deciding who will be involved in the risk management process and to evaluate the effectiveness of the risk management process
- water treatment service providers[3] (WTSPs) and chiller service providers (CSPs) use this guide to determine the standard of service they should be providing to owners or a person in control of cooling water systems, and to determine if they are managing the risks to the health and safety of their own workers
- designers and installers of cooling water systems use this guide to identify and minimise potential risk factors in system design.

This guide recognises these below Australian Standards as good starting points for *Legionella* risk management and provides additional risk management recommendations.

- *Australian/New Zealand Standard 3666 - Air-handling and water systems of buildings - Microbial control*, parts 1, 2, 3 and 4, and its supporting document *SAA/SNZ HB32 - Control of microbial growth in air-handling and water systems of buildings*, specify minimum requirements for design, installation, commissioning, operation and maintenance of air-handling and water systems in buildings to assist in the control of micro-organisms, including *legionella*.
- *Australian Standard AS 5059-2003 Power station cooling tower water systems – Management of Legionnaires' disease health risk*, sets out control strategies considered to be suitable for minimising the risk of Legionnaires' disease associated with power station cooling water systems.

[1] For example, a contractual arrangement between the owner of a cooling tower and the occupant of a workplace at which the cooling tower is located may give control of the cooling tower to the occupant.

[2] In addition to evaporation, water is lost from the cooling tower through 'blow down' or 'bleed-off '. This is the intentional release of some of the circulating water from the tower to remove suspended and dissolved solids left behind during the evaporation process. Without blow down, dissolved minerals would result in scale build-up in the system components.

[3] A person or organisation that provides a service to maintain the water of a cooling tower system, so as to minimise microbial growth, and/or scale formation, and/or corrosion within a cooling tower system, by the use of chemical and/physical agents.

1. Work health and safety legislation - duties of designers, owners, and persons in control of cooling water systems

Under section 22 of the *Work Health and Safety Act 2011*, a designer of plant, such as components of cooling water systems, must ensure that the plant is designed to be safe and without risk to health when used properly.

Under section 20 of the *Work Health and Safety Act 2011*, owners of plant, such as cooling towers and other components of cooling water systems, have a primary duty to ensure the plant is maintained in a condition that ensures the plant is safe, and without risk to health, when used properly.

Where a contractual agreement exists between an owner of a cooling water system and another person that gives effective control of the cooling water system to that person, section 21 of the *Work Health and Safety Act 2011* stipulates the person in control of a cooling water system in the relevant workplace area has a primary duty to ensure the cooling water system is safe and without risk to health and safety.

The Safe Work Australia Code of Practice Managing the Risks of Plant in the Workplace 2013 gives practical advice on ways to manage exposure to risks related to the use of plant in general. This guide is structured so it can be used in conjunction with the Plant Code of Practice. The *How to Manage Work Health and Safety Risks Code of Practice 2011* also contains useful risk management information.

2. Registration of cooling towers

If you are the owner of plant that incorporates a cooling tower it is **not required** for the cooling tower to be registered with the Office of Industrial Relations - Workplace Health and Safety Queensland Division.

3. Controlling the risk of microbial growth

To reduce contamination by *Legionella* in cooling water systems and the risk of its dispersal into the air, attention must be paid to design, installation, operation, and maintenance. The aim is to minimise microbial multiplication, to ensure treatment is adequate, and to minimise the production and release of aerosols.

Critical risk factors for *Legionella* growth in cooling water systems and resultant infection of people include[4]:

- stagnant water
- nutrient availability
- poor water quality
- deficiencies in the cooling tower
- location of the cooling tower system near the public and/or close to other air handling services.

Information on health effects from exposure to *Legionella* can be found in Appendix 5.

[4] These are a summary of the risks described in Table 2.1 of AS/NZS 3666.3.2011

4. Management of risk factors during the design, installation, and commissioning of cooling water systems

Critical risk factors are more easily controlled during the operation of a cooling water system if the system is designed, installed, and commissioned correctly.

Persons designing, installing, and commissioning a cooling water system should comply with the requirements of *Australian/New Zealand Standard 3666.1 - Air-handling and water systems of buildings - Microbial control, Part 1: Design, installation and commissioning*. This standard includes information on the following:

1. Water treatment systems for effective management of corrosion, fouling, scaling, and microbial growth.
2. Fabrication materials (e.g. corrosion-resistant materials).
3. Control of solids by way of an automatic bleed-off capacity.
4. Design, orientation and placement of cooling towers so that direct sunlight is minimised from the wetted surfaces of the cooling tower.
5. Positioning of the cooling water system by:
    - locating the cooling tower, closed circuit fluid coolers, or evaporative condenser to:
        - discharge the cooling tower exhaust at a level above any nearby structure or enclosure or building
        - avoid cooling tower drift contaminating air-intakes of any nearby air-conditioning and mechanical ventilation systems (e.g. lift shaft vents)
        - avoid where practicable contamination of the cooling tower itself from environmental detritus such as plant foliage, and constant wind-blown debris.
    - not locating the cooling tower:
        - in plant rooms that also contain the air-handling plant
        - near areas where people congregate.
    - preventing people congregating around a cooling tower by:
        - restricting access by use of physical barriers
        - displaying warning signs to advise of the restricted access
        - relocation of the cooling tower.
6. Safe access to cooling towers.
    - Cooling towers should be provided with safe access that includes appropriate fixed ladders, internal and external walkways, handrails, toe guards and platforms to facilitate the necessary inspection, maintenance and cleaning.
7. Drift control
    - Drift eliminators should be fitted to the cooling tower and be capable of controlling drift losses to less than 0.002 per cent at the maximum design water circulation rate through the tower.
    - Where ratings of drift loss are unobtainable, ensure that the drift eliminators are of modern and high efficiency design.
    - Ensure that any drift eliminators in a cooling tower have been well fitted to prevent drift escape past or around the drift eliminator panel/s.

The owner or the person in control of the cooling water system should verify that control measures 1 to 7 have been implemented.

5. Management of risk factors during operation and maintenance of cooling water systems

Persons operating and maintaining a cooling water system should comply at a minimum with the requirements of *Australian/New Zealand Standard 3666 - Air-handling and water systems of buildings - Microbial control*:

- Part 2: Operation and Maintenance

or

- Part 3: Performance based maintenance of cooling water systems.

A combination of requirements from each of these parts may also be appropriate for a particular cooling water system.

For each cooling water system the owner or person in control should engage a competent[5] person to assess each of the critical risk factors and to document appropriate procedures that address the operation and maintenance. The procedures could be part of a risk management plan that is unique to each cooling water system.

A risk management plan should outline:

- procedures to manage the critical risk factors
- key performance indicators and targets for the maintenance of the cooling water system
- maintenance, service, inspection, and cleaning requirements
- procedures for reporting maintenance, servicing, inspection, cleaning, disinfection, and required corrective actions to the cooling water system owner or person in control
- supply and means of providing makeup water of sufficiently high-quality so that biological contamination, corrosion, and scale deposits within the cooling water system are minimised
- how the operation of the chiller/s impact upon the cooling tower risks (e.g. the number of hours of operation for each chiller/s).

The owner or the person in control of the cooling water system should verify that the above procedures have been implemented.

The owner or the person in control of the cooling water system should regularly review the procedures and the risk management plan to ensure that they are effective and appropriate. A review should also occur on the occasion of a significant event (e.g. a cooling tower replacement or a major system upgrade).

Specific information on the components of a cooling water system service and maintenance program can be found in sections 5.2 to 5.3.

5.1. Quality of makeup water to the cooling water system

The standard or quality of makeup water supplied to a cooling water system should be of sufficiently high quality to minimise biological contamination, corrosion, and scale deposits within the cooling water system.

The quality of all makeup water should be assessed as part of the risk assessment for the cooling water system and should be tested as outlined in section 6.1 Table A, especially if the makeup water includes a non-drinking water supply.

[5] A competent person should have suitable experience and knowledge for the task/s being performed.

Traditionally potable (drinking) water from the municipal water supply is used for makeup water. Increasingly non-potable water such as recycled water is being used for make-up water. Non-potable water can vary in constituents such as ammonia, phosphate, nitrates, conductivity, suspended solids, total organic carbon, biological and chemical oxygen demand, and micro-organisms. Examples of an adverse impact of potential constituents of non-potable makeup water upon a cooling water system include:

Note: Actions when *Legionella* detections occur are addressed in Appendix 3. The owner or person in control of the cooling water system should ensure that a competent person is engaged to carry out the:

- maintenance, water treatment, inspection, cleaning, and disinfection/decontamination of the cooling tower system as outlined in this guide. WTSPs provide this service. Responsibilities of WTSPs are highlighted in section 7.
- inspection and maintenance of any chiller or condenser associated with the cooling water system. CSPs provide this service.
- ammonia impacting the ability of certain biocides to adequately inactivate micro-organisms.
- phosphates and nitrates enhancing biological growth potential.
- elevated conductivity from higher chlorides or sulphates can increasing corrosion rates.

Therefore the water treatment program must be specific to the quality of the makeup water, the operational characteristics, and the materials used in the construction of the components of the cooling water system. In other words the make-up water should be fit for the intended purpose within the cooling water system.

5.2. Maintenance and servicing of cooling water system by a competent person

Maintenance and servicing of the cooling water system components is required to control the *Legionella* critical risk factors including:

- stagnant water
- nutrient availability
- poor water quality
- deficiencies in the cooling tower.

A competent person should be engaged by the owner or person in control to maintain and service the cooling water system on a regular basis[6].

Typically, such services are supplied by WTSPs and CSPs. It is good practice for the owner or person in control to be clear about the standard of maintenance required and for this to be specified in writing. This should be documented in a service contract.

Recommendations of what could be included in a service contract can be found in section 7.

5.3. Water treatment program for the cooling water system

A key objective of a cooling water system water treatment program is effective management of:

- corrosion
- scaling
- fouling
- microbial growth, including *Legionella*.

[6] However the primary duty of care under the *Work Health and Safety Act 2011* for managing risks associated with the cooling tower still rests with the owner or person in control of the cooling tower and therefore contract management and supervision is critical to the success of such an arrangement.

The specific water treatment program requirements should be determined by a risk assessment process. The requirements may vary in different types of cooling water systems. A specific risk management plan should be documented for each system.

This guide supports the use of a variety of techniques that would provide consistent and adequate treatment of cooling waters, so that the desired control over microorganisms, scale formation and corrosion is achieved, and all regulatory requirements are met.

Water treatment options can include both chemical and non-chemical.

Careful consideration should be given before choosing any water treatment products/procedures to ensure that such products/procedures have been tried and proven by the manufacturer to be effective[7]. The products/procedures should be suitable for local conditions.

Evidence of the effectiveness of such water treatment products/procedures should be based on continuous trials operating under field conditions and should be validated by independent laboratory[8] testing of the cooling system water in conjunction with various end users. These analytical tests need to be supported by physical examination and inspection of the cooling water system for evidence that critical risk factors such as stagnant water, nutrient availability, and poor water quality are being controlled. Such trials would need to establish that the product/procedure is 'tried and proven' and the respective claims made by the manufacturer/supplier have been substantiated.

The water treatment program should include the following:

- A suitable, continuous water treatment program for effective management of corrosion, scaling, fouling and microbial growth, including *Legionella*. It is recommended that the water treatment be automated[9].
- Provision of an effective biocidal concentration/dose/action level in the system at all times as verified in part by test results of microbial samples taken from the system.
- Appropriate control of bleed-off rates suited to the system in use to prevent the build-up of solids. This is usually done by conductivity control (or Total Dissolved Solids) to ensure the correct cycles of concentration are obtained.
- Biocidal processes selected to avoid problems associated with particular bacteria developing a tolerance to a particular biocide process. Therefore dual or alternating biocidal processes are recommended.
- Where the water is being time dosed or slug dosed[10] with chemical biocides, the water treatment system should
  - incorporate a lock out so that the bleed drain cannot operate while the system is being dosed with the biocide
  - incorporate an automated dosing device, ideally operating on residual chemical in the system
  - include multiple biocides that are rotated periodically to avoid the bacteria developing a particular biocidal tolerance
  - ensure that all chemicals used are compatible and that the desirable pH range for their optimal effectiveness is maintained.
- The control of corrosion and scale. The effectiveness of corrosion control could be monitored using corrosion coupons, or on-line corrosion monitoring.

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[7] The effectiveness of the product/procedure should be proven with a reputable clearly defined methodology that allows consistent, reliable and repeatable results to be achieved under controlled conditions that demonstrate clear biocidal activity against *Legionella pneumophila* and the other pathogens found in cooling water.

[8] Laboratory shall have National Association of Testing Authorities accreditation for the water testing method.

[9] Auto-dosing can be used to control pH, the concentration of biocide(s) and corrosion inhibitors. Such equipment is not fail-safe and must be regularly checked and properly maintained to ensure the expectations of the water treatment program are achieved.

[10] The process of adding in a single dose a much higher amount of chemical biocide than is normally applied, with the intention of rapidly raising the concentration of the biocide in the water to a level expected to kill most if not all organisms in the water.

- Continuous monitoring of conductivity.
- Regular monitoring of pH.
- Monitoring of biocide concentration where practicable. Examples of where this is possible include chlorinated or brominated systems in conjunction with measurement of pH and ORP (oxidising-reduction potential).
- Where the tower is exposed to significant environmental contamination (e.g. when construction activities are occurring in proximity to the cooling tower), the use of side stream filtration[11] to reduce the level of solids and improve water quality may be considered. Alternatively an increase in cleaning frequency may be warranted.
- Where the tower system, or part of the system is idle, the risk of stagnant water should be minimised by the installation of a timer to the recirculating pump. This ensures that water (and chemicals such as biocide) circulates through the system which reduces the likelihood of biofilm and bacterial growth. If a system has been shut down for a period of time without any significant water or biocide circulation, the system should be cleaned, and water treatment reinstated before it is restarted[12].
- Water in standby equipment such as pumps, and standby chillers should also be exposed to the water treatment program on a regular basis as determined by risk assessment. Where stand-by pumps are used the start sequence should be alternated. A risk assessment may determine a need for automatic sequencing of stand-by pumps on a regular basis (e.g. for a short period every 24 hours).
- Dead legs[13] such as terminating pipe-work, chiller bypass lines, balance lines, and bypass lines should be located, then removed or activated by allowing treated water to flow continuously through the area.
- Removal of inactive or redundant water treatment sensors.
- The use of a biodispersant to help break down the biofilm on the wetted surfaces in the tower system.
- Protection of the tower basin from sunlight.
- Selection of an appropriate point for biocide dosing.
- Provision of a dedicated water sampling point – this can be the tower basin. However, sampling should not occur next to, or immediately downstream of, where make-up water or biocide is introduced into the system. Ideally the sampling point should be located off the return line to the cooling tower.

5.4. Routine servicing and inspection of a cooling tower

Inspection and servicing of the cooling tower and water treatment program should be carried out at least monthly[14] by a competent person (e.g. a WTSP, who can make an assessment of whether the cooling water system is being maintained correctly).

This servicing should include:

- a visual inspection[15] of the cooling water system, including all wetted surfaces, drift eliminator, and tower basin for the presence of:
  - scale and particulate matter such as dirt, dust, insects, and leaves
  - slime and microbial growth such as algae and fungi
  - corrosion products

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[11] Side stream filtration devices need regular maintenance and cleaning so as to minimise contamination and bacterial growth within the filtration device.

[12] Systems that are not in operation are more likely to have present critical risk factors such as excessive biofilm, algae, organic matter, dirt, or water of poor quality.

[13] A section of the system that does not permit the circulation of water.

[14] The risk assessment for the cooling tower may identify the need for more frequent servicing and inspection.

[15] Where the inspection task may result in exposure to aerosols the person should wear a P2 respirator as a minimum.

- checking the clarity of the water
- checking that the bleed-off system is functioning correctly and at the required rate
- measurement of the conductivity of the system to ensure that adequate cycles of concentration are being used
- checking that the water treatment system is functioning correctly, including
  - all dosing and control equipment (e.g. example sensors)
  - timers, pumps, and tubing
  - checks on flow rate of dosing equipment
  - adequacy of supply of any chemicals being dosed
- routine water analysis, for example as outlined in 6.1, Table A
- the calibration and inspection of water monitoring and dosing equipment
- repair of obvious physical defects or damage (e.g. damage to drift eliminators)
- checking for correct placement of the drift eliminator
- checking for changes in the local environment (e.g. local building demolition or construction that may cause increased entrainment of particulate matter into the cooling tower)
- checking for leaks and unexplained water losses.

The results of the water service should be recorded. Any problems identified should be rectified immediately where appropriate and reported as soon as practicable to the owner or person in control of the cooling water system. The WTSP should also give written recommendations, including the time period required, for any corrective action.

5.5. Routine servicing and inspection of the chiller system

In situations where the water from the cooling tower is pumped through a condenser, any heat exchange surfaces should be inspected for the presence of fouling and corrosion on a regular basis and cleaned. Fouling occurs from the build-up of scale, corrosion and biofilm. This biofilm can harbour bacteria and if dislodged could introduce bacteria into the cooling tower and recirculation water.

Scale/fouling can be controlled with an appropriate water treatment regime by the WTSP.

As it is usually a major exercise to inspect the tubes and water boxes of a condenser this is usually carried out on an annual basis by a competent person such as a CSP.

Chiller inspection and servicing may be performed by a CSP without experience in treating cooling tower water. Therefore, it is recommended that personnel from the WTSP be present during the inspection of the inside of the water boxes and tubes of the condenser vessel so that the WTSP and CSP people can work together to rectify any problems identified within the chiller.

In addition, to assist evaluation of the effectiveness of the water treatment program over time, it is recommended that photographs of the water boxes and tubes be taken and annotated with date and equipment identifier and included in the records of maintenance.

5.6. Routine cooling tower cleaning procedure

Tower cleaning procedures should be documented for each cooling water system.

Physical and chemical cleaning (to a visual state of cleanliness) should be performed on a routine basis, and when required as identified by inspection of the cooling tower. Cleaning includes removal of corrosion products, rust, scale, slime, sludge, mould, algae, biofilm and fungi. These pollutants are known to provide nutrients for the growth of micro-organisms such as *Legionella*.

The frequency of cooling tower cleaning maintenance programs should be determined by a risk management process. It is recommended, however that cooling tower systems undergo this cleaning process at least every six months.

Cooling towers may need to be cleaned more frequently and the frequency will be determined from the routine cooling tower inspections. The need to clean a cooling tower will depend on factors such as the clarity of the water, the cleanliness of the towers, abnormal contamination of the cooling water system with dirt and dust from activities such as nearby construction, and the results of water testing, including microbial testing (see sections 5.8 and 5.9 for further information on microbial testing). The cleaning process should include the cleaning of all wet surfaces in the system and all off-line equipment where practicable.

A sample procedure for cleaning cooling towers and related equipment is included at Appendix 1 of this guide. Because the cleaning of cooling towers is a high risk activity that generates aerosols that are potentially contaminated with *Legionella*, it is imperative that a competent person carry out the cleaning using a process that meets (or exceeds) the standard outlined in the sample procedure.

Because contaminated aerosols place people cleaning the cooling tower and anyone in the vicinity of the cooling tower at risk of exposure to *Legionella*, the sample cleaning procedure is designed to minimise exposure.

Where it is impracticable to shut down a cooling water system for periodic cleaning, for example as with large industrial cooling water systems serving power stations, co-generation plants and refining plants, *Australian/New Zealand Standard 3666.3* and *Australian Standard 5059* provide for a performance-based alternative based on risk management principles.

5.7. Emergency disinfection and decontamination of the cooling water system

Tables 1 and 2 in Appendix 3 indicate levels of bacteria at which disinfection or decontamination of the cooling water system is required. If analytical results of water sampling exceed these action levels the disinfection or decontamination procedures outlined in Appendix 4 must be carried out to that standard or higher.

5.8. Heterotrophic colony count testing and *Legionella* testing

The primary means for the control of *Legionella* is good hygiene practice for the cooling water system, as outlined above. Monitoring the cooling tower water for the presence of bacteria is important in verifying if control strategies for the critical risk factors are effective. Monitoring should include:

- Heterotrophic colony count (HCC), which is an estimate of the number of viable units (expressed as colony forming units) of bacteria per millilitre of water using the pour plate, spread plate or membrane filter test. Also known as total bacteria count, total plate count or viable bacteria count test.

and

- *Legionella* count, which is an estimate of the number of viable units (expressed as colony forming units) of *Legionella* pneumophila and a range of other *Legionella* species per millilitre of water using a test involving sample treatment followed by the spread plate technique.

Testing bacterial levels in the recirculating water of a cooling tower system and appropriate corrective action should be a part of the regular service program for every cooling water system.

Some guidance is provided below on the frequency of both HCC and *Legionella* testing. However it is essential that decisions on the frequency of this testing be based on a risk assessment of the critical risk factors for each cooling water system. This risk assessment needs to assess the potential for growth of *Legionella* combined with the potential for exposure of people to aerosols from the system.

For example, where it is impracticable to shut down a cooling water system for periodic cleaning, such as with large industrial cooling water systems serving power stations, co-generation plants and refining plants, a risk assessment may indicate the need for such testing to be more frequent than that outlined in the general guidance below. This is in keeping with *Australian/New Zealand Standard 3666.3* and *Australian Standard 5059* which provide for a performance-based approach based upon risk management principles.

The frequency of both HCC and *Legionella* testing may be influenced by factors such as:

- a change to the water treatment program which would necessitate an increased frequency of testing to verify the effectiveness of the new program
- recent elevated HCC and/or *Legionella* results which would necessitate an increased frequency of testing to verify if resultant changes to the water treatment system are effective
- alterations and changes to the water cooling system including replacement of equipment.

There is no direct correlation between HCC levels and *Legionella* concentration. For example, it is possible to have very low HCC levels and still detect *Legionella* up to significant levels of concern.

Equally, it is possible to have very high HCC levels, but not detect *Legionella*. However, a high HCC level (greater than 100,000CFU/mL) is an indicator that effective microbiological control is not being maintained and that the system may support *Legionella* growth unless action is taken to bring the system back under control.

It is difficult to use data specific to *Legionella* alone to control the microbial characteristics of a cooling water system because conventional laboratory analysis requires seven to 10 days to obtain a result. Newer analytical methods can provide results much faster, but they may not reliably quantify viable *Legionella* in the same way that culture-based analysis does.

Monitoring the overall bacterial level (HCC) in addition to the *Legionella* levels is recommended as it only takes several days after sampling for the HCC analytical data to be available.

Sampling points should be representative of the system and will usually be near the cooling tower, preferably off the return line to the cooling tower or, otherwise, up-stream of the chemical dosing points. Where there is more than one tower, a sample could be taken at each tower. This covers all ‘opening’ into the cooling water system and will assist in isolating problem areas. Sampling points should be labelled as ‘sampling points’.

Testing of water samples shall only be undertaken by laboratories accredited by the National Association of Testing Authorities (NATA) for technical competence in the performance of the bacterial analytical method. In choosing the laboratory, the WTSP should take account of the maximum delivery time between taking the sample and delivering it to the laboratory.

5.9. Heterotrophic colony count

HCC is used as a general indicator of water quality in cooling tower systems. The test measures the total bacterial load in the sample of water. It is reported as the number of colony forming units per millilitre (CFU/mL). HCC testing must be conducted at least monthly.

HCC test results indicate to those responsible for the system the extent of microbiological control over the cooling water system and, in particular, the potential of the system to promote bacterial growth, including *Legionella*.

However, reliance on HCC testing solely as an indicator of *Legionella* control is not recommended.

Guidance on water sampling for HCC analysis and analytical methodology is provided in Appendix 2.

AS/NZS 3666.3:2011 specifies a HCC of less than 100,000CFU/mL as a test result not requiring additional control strategies. However effective control should result in much lower and consistent levels of HCC.

The action that should be taken for an elevated HCC is outlined in Appendix 3, Table 1.

5.10. *Legionella* testing

Regular *Legionella* testing should be implemented as part of the water treatment management system. The frequency of testing should be based on a risk assessment of critical risk factors of the cooling water system. However a good starting frequency is testing every three months.
A risk management approach may also be considered when determining the frequency of *Legionella* testing. For example, more frequent testing could be considered as follows:

- in high risk areas such as hospitals and aged care facilities or areas with high numbers of people (e.g. central business districts, shopping centres)
- in large industrial type cooling water systems where periodic cleaning of the cooling water system is impracticable
- periodically to evaluate the ongoing effectiveness of the cooling water system maintenance program
- to evaluate the effectiveness of changes to the cooling water system maintenance program. Guidance on *Legionella* sampling and testing methodology is provided in Appendix 2.

AS/NZS 3666.3:2011 specifies a *Legionella* level of not detected or less than 10CFU/mL as a test result not requiring additional control strategies.

The action that should be taken for an elevated *Legionella* count is outlined in Appendix 3, Table 2.

5.11. Inspection of cooling water system by an on-site person

Since the water treatment service provider generally visits the cooling tower at periodic intervals (typically each month), it is possible that a dosing/monitoring malfunction could occur that results in a significant deterioration in water quality well before the next inspection. To minimise this possibility, some simple inspections of the cooling water treatment system should be performed by an on-site person (e.g. a maintenance supervisor a delegated employee trained for this purpose). Where problems are noted, these need to be reported to a responsible person, who can then authorise remedial action.

Inspections should aim to identify problems with the water treatment system for the cooling tower and may include:

- a check that any dosing devices are operating (e.g. by observing if there are any alarm messages on the monitoring display)
- confirming that delivery tanks/containers contain sufficient volume of treatment chemical to last to the next inspection
- confirming that the required volume of treatment chemical has been delivered from the reservoir container
- confirming any float devices still contain treatment tablets.

The need to perform, and the frequency of, such inspections by an on-site person will be influenced by factors such as the frequency of inspections by the WTSP, and the type and sophistication of the water treatment delivery system which in turn will influence the likelihood of a delivery failure and should be determined by a risk assessment in consultation with the WTSP. For example where a float system[16] that utilises biocide tablets that dissolve over time is used, there is a high likelihood that the biocide tablets will dissolve completely before the next WTSP inspection.

[16] Note – this is not a preferred or recommended water treatment delivery system.

Inspections should be formalised in a written procedure, with form fields to allow observations and actions to be recorded. A risk assessment[17] should be documented by the employer of the on-site person during the development of this procedure.

Guidance and training should be sought from the water treatment service provider to cover minimum requirements for these inspections.

If on-site inspections are not practicable, then consideration should be given to more frequent inspections of the water treatment system by the water treatment service provider, or the installation to the water treatment system of a remote alarm monitoring system. Advances in online monitoring and wireless technology are being deployed for management of cooling towers, including for their water systems. This monitoring can track trends in treatment performance and water quality and ensure a rapid response to alarms or urgent maintenance requirements.

5.12. Access to and egress from an area containing a cooling tower

The owner or person in control of the cooling water system should ensure safe access to cooling tower installations – including basins, all splashguards, fill and fan housing – is maintained with appropriate fixed ladders, internal and external walkways, handrails, toe guards and platforms to facilitate the necessary inspection, maintenance and cleaning of the cooling tower/s.

People should be prevented from congregating[18] in the area around a cooling tower through the use of locked access doors or appropriately worded signage. Any persons accessing the area around the cooling tower should be required to wear a P2 respirator at a minimum. Signage requiring the use of a respirator should be placed at appropriate points around the cooling tower.

5.13. Drift control

Drift eliminators should be installed correctly and be maintained in an intact state. They must be tested and rated by the manufacturer to achieve 0.002 per cent drift loss at the maximum design water circulation rate through the tower.

Drift eliminator panels must be fitted the correct way up. Also these panels must be fitted securely within the structure of the cooling tower so that exhaust air (and drift) cannot pass around the panels or through gaps between the panels.

5.14. Chemical safety

Safety data sheets (SDS) should be obtained for each chemical and be readily available in the proximity to where the chemicals are being used and stored. Chemicals should be stored and handled with appropriate personal protective equipment, spill containment (e.g. bunding) and cleanup equipment, incompatible chemicals should not be stored together, and appropriate chemical exposure controls should be implemented. Facilities/equipment for eye washing should be located near the point of chemical dosing.

[17] For example, where the inspection task may result in exposure to aerosols the person should wear a P2 respirator as a minimum.

[18] It should be noted that smoking cigarettes presents as one of the highest risk factors for the contraction of Legionnaires' disease.

6. Documentation and reporting

To assist the record keeping process, the owner or person in control of the cooling water system should ensure each cooling tower and chiller is labelled individually with a unique number. WTSPs and CSPs should, consequently, document the servicing, sampling, cleaning and testing results with the unique number/s for that system. This ensures proper communication of necessary corrective actions for each specific unit.

The owner or person in control of the cooling water system should ensure documented risk management information, including that listed below, is kept at the site of the cooling water system. This information should be immediately accessible to any service personnel and Workplace Health and Safety Inspectors, and should include:

- the documented risk assessment
- the water treatment specifications[19]
- planned service and maintenance requirements of cooling water system, including for the cooling tower and the condenser as outlined in a Service Contract
- all results of water sampling and analysis[20]
- key performance indicators and targets (see example below in Table A)
- current[21] safety data sheets for any chemicals used in water treatment
- water treatment dosing rates
- water storage volumes for dosing calculations
- tower cleaning procedures
- disinfection/decontamination procedures
- safe shut down and start up procedures
- emergency contact details
- service, inspection, corrective action, cleaning, disinfection, decontamination, microbial testing reports for the cooling water system, including the tower and the chiller condenser tubes and water vessels
- results of microbial testing following corrective actions for adverse events
- history of any previous action taken in response to significant key performance indicator (KPI)/target variations
- records of the inspection of the cooling water system and water treatment system by on-site person/s.

6.1. Cooling water system service reports

Service reports are the primary method of communication between the water treatment person and the cooling tower owner or person in control. These reports should include the outcomes of the regular service inspection and any other non-routine activities, and should include information on:

- date of service
- name and signature of the service person
- identification of the cooling water system component
- type/make/model of cooling water system component
- details of any visual inspection of the cooling water system (e.g. state of cleanliness of cooling tower, condition of drift eliminator, presence of water or chemical leaks) and checking of water treatment equipment (e.g. sensors and tubing)

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[19] Ideally this record should detail the design basis for the water treatment program adopted for each cooling tower system, including the calculations done to determine appropriate dose rates or treatment levels, make-up water requirements and bleed rates. Analytical results used in these determinations must also be maintained.

[20] NATA laboratory analytical data should be provided on the original NATA endorsed report.

[21] No older than 5 years.

- details of any actions, for example
  - if any chemicals were added and in what volumes
  - whether the bleed-off rate was checked
  - whether the water treatment dosing rate was verified as correct
  - whether the tower/s were cleaned
  - verification of attainment of KPIs and targets
  - whether the cooling tower was tested for bacteria, and if so what tests were requested and what was the name of the laboratory used
  - repairs to equipment or plant
- recommendations for corrective actions.

This service report should be signed by the customer or a representative of the site, at the time of the service visit (if available).

It is recommended that nominated key performance indicators, targets, and relevant corrective action/s for the cooling water system be recorded on the service reports (an example is provided in Table A).

The KPIs/Targets listed in the below table are provided for guidance. The owner or person in control of the cooling water system in consultation with the WTSP or other competent person, should establish the KPIs and Targets for each cooling water system based upon local conditions that include the chemistry of the local make-up water and the characteristics of the cooling water system's operation, maintenance, and risk factors. It is imperative that the WTSP measures and records the KPIs/Targets during the regular inspection of the cooling water system.

Table A - Examples of key performance indicators and targets for cooling tower water

Test/observation	Key performance indicator and target examples	Actual measurement / observation results	Corrective action taken
Key performance indicators			
Heterotrophic Colony Count	< 100,000CFU/mL		
Legionella species[(a)]	< 10CFU/mL		
Scaling rate	Negligible scaling in cooling tower		
Dissolved iron	< 1ppm		
Drift	No visible drift Drift not felt when in proximity to cooling tower		
Cleanliness of basin, interior of cooling tower (i.e. side walls, louvers, fill pack, drift eliminator panels, interior of fan cowling)	Clean (no evidence of sludge) Mildly dirty (up to 3mm sludge) Very dirty (extensive sludge, slime or algae, water murky)		
Copper corrosion rates	< 0.005mm/year		
Stainless steel corrosion rates	< 0.005mm/year; with no pitting		
Mild steel corrosion rate	< 0.15mm/year		
Drift eliminator	In correct position Not damaged Clean		
Targets			
Total dissolved solids*	Vary according to local make-up water		

Conductivity*	Vary according to local make-up water		
Suspended solids	Vary according to local make-up water		
Calcium or total hardness*	Vary according to local make-up water		
Chlorides*	Vary according to local make-up water		
pH* (for bromine compounds)	7–9		
pH* (for chlorine based compounds	7–8		
Total alkalinity*	80–300ppm		
Biodispersant	Dosed consistently at manufacturer's recommendations		
Corrosion inhibitor	Dosed consistently at manufacturer's recommendations		
Cycles of concentration	For balancing water conservation and prevention of scaling – determined by calculating the ratios of TDS or conductivity between recirculating water and make- up water		
[a] Knowledge of the likelihood of *Legionella* levels being above the limit of analytical detection in makeup water is useful information as part of overall risk management. * Tests should also be performed on the make-up water.			

6.2. Cleaning, disinfection and decontamination reports

These reports should document each of the steps in the cleaning, disinfection, and decontamination procedures (see Appendices 1 and 4 respectively) were carried out (e.g. documentation of the pH and frequency of testing, concentration of biocide during cleaning, disinfection, decontamination of the cooling tower, verification of the integrity of the drift eliminator, as in the sample procedures outlined in Appendices 1 and 4).

6.3. Availability of records and reports

All records and reports as described in sections 6.1 and 6.2 should be made immediately available on request by a Workplace Health and Safety Inspector.

7. Responsibilities of water treatment service providers

The owner or person in control of a cooling water system may engage persons to assist in meeting their duty of care to ensure the cooling water system is maintained in a condition that ensures that it is safe, and without risk to health, when used properly.

The owner or person in control of a cooling water system should make reference to the list of WTSP responsibilities as outlined below when choosing a WTSP and documenting a service contract.

Where the owner or person in control of a cooling water system has engaged a water treatment service provider to carry out the maintenance, servicing, cleaning, disinfection, and decontamination of a cooling water system, the *water treatment service provider has certain responsibilities*[22] including:

- maintain the water in a cooling water system in accordance with the requirements of a Risk Management Plan (RMP), the service contract, and the relevant regulations and standards, on behalf of the client
- report cooling water system deficiencies beyond their control to the owner and/or appropriate 'responsible person' for action as soon as is reasonably practicable, and to communicate the possible ramifications of inaction to the owner and/or 'responsible person' (in some cases this may be via contractual arrangements and agreed communication protocols)
- the ability to respond efficiently to the corrective actions required following notification of an adverse microbiological test result
- comply with the relevant legal requirements for cooling tower maintenance in Queensland
- inform the cooling water system owner or person in control of all service actions, testing results and any defects observed in the system and develop an agreed communication protocol for each client
- where required seek funds from the cooling water system owner or person in control (or their delegated representative) to rectify reported system deficiencies. Communication should be as soon as is reasonably practicable and be expedited with suitable speed in proportion to the severity of the potential consequences of inaction
- maintain a cooling water system's water quality such that the performance, efficiency and expected lifetime of operation of the system is maintained within acceptable limits
- ensure that water samples are taken from appropriately designated and identified sampling points in the cooling water system at appropriate intervals, and delivered to laboratories accredited by NATA for technical competence in the performance of the relevant methods so that testing can be conducted within reasonable timelines
- where continued inaction to rectify a deficient cooling tower system by the system owner or person in control or their delegated representative results in a potentially significant risk to occupational and/or public health, advise the relevant person in writing of the risk to health
- have contingency plans in place to ensure compliance with legislation in the event of notification of adverse events and water sampling results and subsequent remedial actions
- test and record chemical, microbiological, and physical parameters as required, to ensure that the treatment regime adopted for a cooling water system is being maintained within defined limits
- use appropriate chemicals at effective concentrations, as stated in the manufacturer's specifications, for the maintenance of the desired water quality within a cooling tower system
- ensure that where non-chemical water treatment is utilised for microbial control within a cooling water system, they are proven effective and fit for purpose, and that remedial chemical treatment is readily available if an adverse event occurs
- where possible, use auto-dosing equipment (or equivalent) for the maintenance of microbial control and, where possible, auto-bleed equipment (or equivalent) for the maintenance of water quality
- maintain records of maintenance, servicing, cleaning, and disinfection/decontamination. These records should be completed immediately upon completion of these activities. See also section 6.
- abide by all relevant occupational health and safety requirements on site, and work in a safe manner as directed by the WTSPs and/or client's health and safety management plan

[22] These responsibilities are similar to that suggested by other Australian government agencies, and as such the wording for these responsibilities has been based upon the Victorian Code of Practice for Water Treatment Service Providers. The *Work Health and Safety Act 2011* does not make these responsibilities mandatory for the WTSP. The owner or person in control of the cooling water system has the primary duty under the Queensland Work Health and Safety Act to ensure the cooling water system is safe.

- where changes to chemicals occur or changes to SDS occur, ensure that current sheets are provided and superseded ones are removed. The SDS should be located in close proximity to the chemicals
- ensure that all chemical containers left on-site are appropriately stored and labeled
- ensure that spill containment and cleanup facilities are available for chemicals
- have contracts with clients that clearly indicate the respective responsibilities of each party.

8. Evaluation of cooling water system maintenance program

Where a WTSP is contracted to maintain a cooling tower system on behalf of the owner or person in control, this contractual arrangement does not absolve the owner or person in control from their primary duty to ensure the cooling water system is maintained in a condition that ensures it is safe.

Therefore, the owner or person in control of the cooling water system should have in place a means of evaluating the effectiveness of the service provided by the WTSP and CSP.

This evaluation could include:

- a review of the
  - procedures that are in place to manage the critical risk factors – a competent auditor who is independent of the water treatment provider could be engaged to assist with this, or the owner or person in control could conduct this review themselves
  - achievement of the key performance indicators (KPIs) and targets for the maintenance of the cooling water system. For example the owner of the cooling water system or person in control could specify that the WTSP achieve at least 90 per cent compliance against the KPI's per year
  - inspection, maintenance, service, and cleaning records and compare with what was specified in the written service contract
  - completion of required corrective actions to the cooling water system
  - standard of the written records of service and maintenance
- an independent microbial sampling and testing of cooling tower waters. Sampling is usually undertaken by the WTSP as part of the range of professional services offered to the client. There may be special circumstances whereby regular or random independent sampling[23] is highly desirable, in order to avoid potential allegations of a conflict of interest, and/or to reassure the client, workers and/or the public about a system's performance
- a visual inspection of the cooling tower and condenser by the owner or person in control during the WTSP and CSP routine inspection of the cooling tower and condenser to verify the cleanliness and condition of the plant
- an evaluation of trends from water testing by the cooling water system owner or person in control.

[23] It is important to ensure that sampling and analytical methods are the same as that routinely used for the cooling tower water.

9. Occupational health and safety for water treatment service providers and chiller service providers

The WTSP and CSP have a primary duty under the *Work Health and Safety Act 2011* to ensure the workplace health and safety of all persons engaged as part of their business activities or undertaking. This includes independent contractors engaged by the WTSP or CSP.

The servicing of cooling tower systems by WTSPs can potentially expose service technicians to a number of potential hazards, for which procedures and practices to manage such risks must be in place. Appendix 6 provides guidance on the management of workplace health and safety risks for Water Service Treatment Providers.

10. Risk management of bleed water reuse

Drought conditions and changes to the *Plumbing and Drainage Act in 2007* have increased the likelihood of cooling tower bleed water being reused at workplaces for purposes such as toilet flushing, landscape irrigation, and cooling tower makeup water. The owner or person in control of a cooling tower has a duty under the WHS Act to control risks arising from the storage and use of the bleed water. The reuse of bleed water should comply with the risk management process outlined in Appendix 8 of this guide.

Bleed water from cooling towers can contain a range of contaminants including micro-organisms and chemicals used in the cooling tower water treatment program. These hazards can, if present in sufficient quantities in the bleed water storage system, cause a risk to people if not controlled and if people are exposed to the water for example by inhalation via aerosolisation, and direct skin contact with the water.

If bleed water is to be reused the presence of *Legionella* in the bleed water, the opportunity for *Legionella* to proliferate in bleed water storage and distribution systems, and the risk of exposure of people to chemicals in the bleed water must be controlled.

Before bleed water from a cooling tower can be stored and reused for other purposes the presence of *Legionella* in the cooling tower must be controlled by compliance with the requirements of this *Guide to Legionella Control in Cooling Water Systems, including Cooling Towers*, or a higher risk management process.

Bleed water from a cooling tower will contain residual chemicals from the tower chemical water treatment program. With biocides such as isothiazolone and glutaraldehyde, which are skin and respiratory sensitisers, this bleed water should not be reused unless it can be demonstrated that the workplace use of the bleed water will not expose people to these chemicals.

Guidance on a risk management system for a bleed water storage and distribution system is outlined in Appendix 8.

Assistance with the implementation of a risk management process and documentation of such can be found in the *How to Manage Work Health and Safety Risks Code of Practice 2011*.

Appendix 1 - Sample procedure for cleaning cooling towers and related equipment

Below is a sample procedure for cleaning cooling towers and related equipment. The process involves four steps:

1. before chemical disinfection and mechanical cleaning
2. chemical disinfection
3. mechanical cleaning
4. after mechanical cleaning.

The actual procedure used may be varied to suit the particular situation. However it is recommended the procedure generally covers the following criteria.

Step 1: Before chemical disinfection and mechanical cleaning

Provide protective equipment to workers who perform the disinfection, to prevent their exposure to:

- chemicals used for disinfection
- aerosolised water and biofilm that may contain *Legionella*.

Protective equipment should include full-length protective clothing, boots, impervious gloves, goggles, and a full or half-face respirator that combines a high efficiency particulate air filter of at least a P2 class (for filtering of aerosols) and a chemical cartridge filter of type B Aus or B1 (for filtering of disinfection chemicals) [for more information see *Australian/New Zealand Standard 1715 – Selection, Use and Maintenance of Respiratory Protective Devices*]. The person wearing the respirator should be clean shaven to maximise the seal between the respirator and face, and should be fit tested for the respirator and trained to fit check the respirator prior to each use.

It is important also to limit exposure of other people in the vicinity of water spray or debris.

Ensure that proper means of access are available and safe means of working at heights are ensured through appropriate equipment and training of the workers.

Use correct shutdown procedures:

- shut off and isolate heat load source (e.g. chiller, process plant)
- shut off and isolate cooling tower/evaporative condenser fans
- shut off the system blow-down (purge) valve, shut off automated blow-down controller, if present, and set system controller to manual
- keep make-up water valves open
- continue operating all water circulation pumps required to circulate water through all areas of the cooling system, including all standby chillers, pumps, balance lines and dead legs.

Step 2: Chemical disinfection

- Add either a low foaming chlorine-compatible biodispersant or low foaming bromine-compatible biodispersant to the recirculating system.
- Add chlorine-based compound to achieve free residual chlorine (FRC) level of at least 5 to 10mg/L[24]. Then maintain the FRC at not less than 5 to 10mg/L whilst continuously circulating the water through the system for a period of one hour, maintaining the pH of the water between 7.0 and 7.6. Measure and record the FRC and pH at 15minute intervals on the tower clean service report.

or

- Add a bromine-based compound to achieve a free residual bromine (FRB) level of at least 20 mg/L[25]. Then maintain the FRB at not less than 20mg/L whilst continuously circulating the water through the system for a period of one hour, maintaining the pH of the water between 7.0 and 8.5. Measure and record the FRB and pH at 15minute intervals on the tower clean service report.
- Some installations such as Multistack chillers need an alternative biocide to bromine or chlorine. Therefore an option is for the use of a biodispersant and fast acting non-oxidising biocide dosed in accordance with the manufacturer's instructions.
- During recirculation, a bleed off rate should be used to facilitate the removal of suspended particulate matter from the system. Ensure a controlled make-up flow so that all the system is adequately wetted. Flush all dead legs including sample line and pressure transmitters.
- Record the type and quantity of all chemicals used for disinfection and the time of the results of measurements of FRC or FRB and pH.

Step 3: Mechanical cleaning

- Shutdown and isolate the water circulation pumps. Isolate incoming make-up streams and drain the cooling tower to waste in accordance with the local water authority[26].
- Inspect all water contact areas for sediment, sludge and scale. Use brushes and a water hose or high pressure water cleaner to thoroughly clean the drift eliminators and fan inlet screens. Check that the drift eliminators are not damaged by the high pressure water.
- Likewise, clean all of the cooling tower water contact areas including the basin, sump, fill, spray nozzles and fittings, drift eliminators, side stream filtration, and air intake louvres. In cooling towers where the fill pack and/or drift eliminators are easily removed, these should be removed to facilitate cleaning.
- If possible, clean the cooling tower/evaporative condenser contact areas within the chillers.
- Ensure all loose deposits are removed from the sump and cooling tower basin. The use of a wet vacuum cleaner may make it easier to remove waste material from the basin floor.
- Reassemble all components and hose with clean water. If drift eliminators are moved, ensure that they are correctly installed on replacement.

Step 4: After mechanical cleaning

- Fill the cooling tower/evaporative condenser with water and switch on the recirculating pump.
- If the water is not visually clear, repeat steps 2 and 3 where necessary. Clean the water filters, strainers and repeat steps 2, 3, and 4 until the water quality is satisfactory. Side stream filtration can be used to facilitate removal of suspended matter and help minimise water being dumped.

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[24] The choice of 5 or 10mg/L will be dependent upon factors such as the size or fabrication material of the cooling water system. For example with large industrial cooling towers the volume of water may make it impractical to maintain a FRC of 10mg/L and therefore 5mg/L over a longer period of time may be practicable.

[25] Again in large industrial cooling towers the volume of water may mean it is practical to maintain a lower FBR.

[26] In order to conserve water and in situations where there is little or no suspended solids, it may be possible to filter and treat the water and hold it in a tank, and once the tower has been cleaned reuse the water to fill a percentage of the tower basin.

- 'Slug dose' the cooling water system with water treatment chemical/s at appropriate concentration.
- To reduce the risk of corrosion it may be necessary to neutralise excessive chlorine levels in the cooling system once cleaning has been completed[27]. Alternatively a decision might be made to allow the free chlorine levels to decay naturally, and therefore the corrosion inhibitor levels should be increased during these procedures to offer additional protection against any corrosion that could occur.
- Immediately reinstate comprehensive effective water treatment including biocide(s), corrosion inhibitors, and scale control.
- Record all actions in operations and maintenance logbook or cleaning report.

If the system is shut down for a period of time it should be cleaned and disinfected before it is restarted[28].

[27] The choice of neutralising agent, for example sodium thiosulphate or sodium metabisulphite, will depend upon factors such as the hardness of the water, whether maintenance of a residual of some free chlorine will be beneficial in controlling any microbes that could emerge during/following the process of cleaning as biofilm or dirt may not be all immediately removed during cleaning, and whether the neutralising agent contains residual sulphite or bisulphite in sufficient concentrations that may be detrimental to isothiazolinone stability.

[28] Systems that are not in operation are more likely to have presence critical risk factors such as excessive biofilm, algae, organic matter, dirt, or water of poor quality.

Appendix 2: Bacterial sampling and testing methods

Water samples should be taken from the same point in the cooling tower. It is recommended that samples be taken from the condenser water return to the cooling tower and whilst the system is in operation.

Avoid sampling for at least 72 hours after system operation following disinfection, slug dosing with biocide, decontamination or cleaning procedures to allow conditions to stabilise.

The size of each water sample should be at least 100mL. Refer also Appendix A of AS/NZS 3666.3.

Personal protective equipment appropriate to the sampling procedure shall be worn during the sampling (e.g. this should include gloves and respirator if sampling directly from the tower basin).

HCC water sampling method

It is recommended samples of the recirculating water be tested and analysed for HCC as follows:

- Sampled for HCC in accordance with *Australian/New Zealand Standard 3666.3: Air-handling and water systems of buildings - Microbial control - Performance-based maintenance of cooling water systems*.
- Taken in containers as described in *Australian Standard 2031—2012 Water quality—Sampling for microbiological analysis*. This describes the selection of suitable sample containers and preservation of the sample for later testing. This involves the sample being stored at between 2°C and 8°C prior to analysis.
- Analysis commenced within 12 hours of the sample being taken. It is preferable for analysis of the sample to be within 8 hours.
- The same method should be used for all samples from the same cooling water system so that method derived variance can be excluded when comparing results over time from the same cooling tower[29].
- The laboratory is accredited as complying with ISO/EEC 17025 by NATA.

HCC samples should be taken and analysed on a monthly basis. If the HCC level is greater than 100,000CFU/mL, undertake the correct control strategy as described in Table 1 of Appendix 3. This includes re-sampling allowing at least 72 hours after corrective actions have been completed.

Legionella water sampling method

It is recommended samples of the recirculating water be tested and analysed for *Legionella* as follows:

- Sampled for *Legionella* in accordance with Australian/New Zealand Standard 3666.3: Air-handling and water systems of buildings - Microbial control - Performance-based maintenance of cooling water systems.
- Taken in containers as described in *Australian Standard 2031—2012 Water quality—Sampling for microbiological analysis*. This describes the selection of suitable sample containers and preservation of the sample for later testing. This involves the sample being stored at between 2°C and 8°C prior to analysis.
- Analysis commenced within 48 hour of the sample being taken. It is preferable for analysis of the sample to be within 24 hours of the sample being taken.
- The same method should be used for all samples from the same cooling water system so that method derived variance can be excluded when comparing results over time from the same cooling tower[30].

[29] It is difficult to determine equivalence between permissible testing methods. Two methods can produce different results as a result of variations in the methods themselves.

30 It is difficult to determine equivalence between permissible testing methods. Two methods can produce different results as a result of variations in the methods themselves.

***Legionella* samples should be taken and analysed at least three monthly. If the *Legionella* level is 10CFU/mL or greater, undertake the correct control strategy as described in Appendix 3, Table 2. This includes re-sampling, allowing at least 72 hours after corrective actions have been completed.**

HCC and *Legionella* species analytical method

The water samples should be analysed by a laboratory that meets the following standards and use a test the meets the following standards:

- Quantifies the number of *Legionella* colony forming units in the sample tested, for example method *Australian/New Zealand Standard 3896:2017 - Waters – Examination for Legionellae including Legionella pneumophila*.

and

- Quantifies the Heterotrophic colony count in the sample tested, for example method *Australian/New Zealand Standard 4276.3.2 Water microbiology - Heterotrophic colony count methods – Plate count of water containing biocides*.
- If another method that is specifically equivalent to these method are used, then the laboratory should be accredited by NATA for technical competence in the performance of the method.
- The tests used are identified in the scope of the laboratory's accreditation.

and

- The laboratory is accredited as complying with ISO/EEC 17025 by NATA.

Appendix 3: Control strategies for presence of *Legionella* and other heterotrophic micro-organisms

The following tables 1 and 2 (adapted from tables 3.1 and 3.2 from Australian/New Zealand Standard 3666.3:2011) detail the recommended actions to be taken as part of the control strategies based upon HCC or *Legionella* concentrations respectively in the recirculating waters.

Treatment in cooling towers

Where indicated in Tables 1 and 2, on-line disinfection and decontamination should be carried out as described in Appendix 4.

Table 1 - Control strategies for the presence of other heterotrophic microorganisms

Result (CFU/mL)	**Required control strategy**
<100,000	1. Maintain monthly monitoring. Maintain water treatment program.
≥100,000 and <5,000,000	2. Investigate problem. Review water treatment program. Take necessary remedial action including immediate disinfection as described in Appendix 4 of this guide and undertake control strategy (3).
	3. Retest water within three to seven days of plant operation and if the test result is: • <100,000 CFU/mL repeat control strategy (1) • ≥100,000 but <5 000 000 CFU/mL undertake control strategy (2) • ≥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 disinfection as described in Appendix 4 of this guide and undertake control strategy (5).
	5. Retest water within three to seven days of plant operation and if the test result is: • <100,000 CFU/mL repeat control strategy (1) • ≥100,000 but <5,000,000 CFU/mL undertake control strategy (4) • ≥5,000,000 CFU/mL investigate problem and review water treatment program, carry out immediate decontamination as described in Appendix 4 of this guide.

Source: adapted from Australian/New Zealand Standard 3666.3:2011

Table 2 - Control strategies for the presence of *Legionella*

Result (CFU/mL)	**Required control strategy**
Not detected or less than 10	1. Maintain frequency of monitoring as determined by the risk assessment. Maintain water treatment program.
<1000	2. Investigate problem Review water treatment program Take necessary remedial action including immediate disinfection as described in Appendix 4 of this guide.
	3. Retest water within three to seven days of plant operation and if: • not detected, continue to retest water every three to seven days until two consecutive samples return readings of not detected and repeat control strategy (1) • detected at <100 CFU/mL repeat control strategy (2) • detected at ≥100 and <1,000 CFU/mL investigate problem and review water treatment program, immediately carry out decontamination as described in Appendix 4 of this guide and repeat control strategy (3) • detected at ≥1,000 CFU/mL undertake control strategy (4).
≥1000	4. Investigate problem Review water treatment program Take necessary remedial action including immediate disinfection as described in Appendix 4 of guide and undertake control strategy (5).
	5. Retest water within three to seven days of plant operation and if: • not detected, continue to retest water every three to seven days until two consecutive samples return readings of not detected and repeat control strategy (1) • detected at <100 CFU/mL repeat control strategy (2) • detected at ≥100 CFU/mL investigate problem and review water treatment program, immediately carry out decontamination as described in Appendix 4 this guide and repeat control strategy (5).

Source: adapted from Australian/New Zealand Standard 3666.3:2011

Appendix 4: Emergency disinfection and decontamination procedures

Disinfection

The following process is recommended for disinfection of cooling water systems:

1. Follow all relevant workplace health and safety procedures, including the use of personal protective equipment[34].
2. Suspend any water treatment program. Isolate any electrical equipment except the water treatment pump.
3. Add a low foaming chlorine-compatible biodispersant or low-foaming bromine-compatible biodispersant to the recirculating water.
4. Disinfect the system by dosing the water with a biocide
    - a chlorine-based compound (with detergent properties), equivalent to at least 10mg/L of free chlorine for at least one hour, while maintaining the pH of the water between 7.0 and 7.6

or

    - a bromine-based compound (with detergent properties), equivalent to at least 20mg/L of free bromine for at least one hour, while maintaining the pH of the water between 7.0 and 8.5
5. Review the water treatment program, tower operations and maintenance program.
6. Correct any faults and implement any necessary changes.
7. Record all actions and observations in the maintenance report.
8. Recommission and repassivate the circulating cooling water system, and reinstate the water treatment program.

Decontamination

The following process is recommended for decontamination of cooling water systems:

1. Follow all relevant workplace health and safety procedures, including the use of personal protective equipment[35].
2. Isolate any cooling tower fans to prevent operation.
3. Add a low foaming chlorine-compatible biodispersant or low-foaming bromine-compatible biodispersant to the recirculating water.
4. Dose the circulating cooling water system with a biocide
    - a chlorine-based compound, equivalent to at least 10mg/L of free chlorine for at least one hour, while maintaining the pH of the water between 7.0 and 7.6

or

    - a bromine-based compound (with detergent properties), equivalent to at least 20mg/L of free bromine for at least one hour, while maintaining the pH of the water between 7.0 and 8.5.
        - Add the disinfectant slowly, over five to ten minutes, to a turbulent zone of the tower basin to promote its rapid dispersion. Use an antifoaming agent if excessive foaming occurs.
        - Circulate the system for one hour, measure the pH and free chlorine or bromine levels regularly (i.e. every 15 minutes) and adjust as required and record levels and actions in appropriate written record.
        - Ensure that the water is circulated through all parts of the system, including the standby condenser pump and any chillers that may currently be off line.
5. Switch off equipment and drain the cooling tower to waste in a manner approved by the local water authority. The cooling tower should be drained[36]. The use of a wet vacuum cleaner can make it easier to remove waste material from the basin floor.
6. Refill with clean water and switch on the recirculating pump.

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[34] See Appendix 1, Step 1 for information on minimum PPE required.

[35] See Appendix 1, Step 1 for information on minimum PPE required.

[36] Where this is not practicable, a very high bleed off rate should be used during step 4 while still maintaining free disinfection concentration. This will facilitate removal of suspended particulate matter from the system and the partial replacement of cooling water with clean make-up water.

7. Repeat step 4. Then switch off the recirculating pump. Drain cooling tower system to waste in a manner approved by the local water authority.
8. Inspect the drift eliminators and clean, repair or replace as necessary. If the eliminators are moved, ensure they are correctly installed on replacement. Suitable precautions should be taken to minimise the release of aerosols during cleaning operations.
9. Thoroughly clean the internal shell, fill and tower sump by brushing and gently hosing all surfaces. Remove all debris. Avoid damage to the tower and accessories during this operation.
10. Thoroughly internally clean all water filters, strainers, separators, water nozzles and fittings associated with the water distribution system paying particular attention to the tower fill and distribution trays.
11. Re-assemble all components and hose with clean water.
12. Repeat step 4. Then switch off the recirculating pump. Drain cooling tower system to waste in a manner approved by the local water authority.
13. Refill with clean water and switch on the recirculating pump.
14. Repeat step 4 and then step 13 if the water is not visually clear. Clean the water filters, strainers and repeat step 13. Repeat this sequence until the water quality is satisfactory.
15. Immediately reinstate comprehensive effective water treatment including biocide(s), corrosion inhibitors and scale control.
16. Record all actions in appropriate written record.

Appendix 5: *Legionella* and Legionnaires' disease

What is *Legionella*?

Legionella are micro-organisms that can cause a serious infection in humans. It can cause an infection called legionellosis, which can take two forms: Legionnaires' disease and Pontiac fever.

Legionnaires' disease is an infection that presents as a type of pneumonia (lung infection) that can be severe and even life threatening. Pontiac fever is a milder form of respiratory illness.

Risk factors causing disease

Legionella occur naturally in the environment, in both water and soil. Artificial water systems may provide environments that allow *Legionella* to multiply in large numbers.

Warm water systems (including showers), spa pools, fountains, warm water storage systems, and potting mixes and compost may also provide an environment that allow bacteria to multiply but such risks are not covered by this guide.

The main risk factors for an outbreak of the disease caused by cooling water systems are:

- the presence of *Legionella*
- conditions suitable for multiplication of the organisms: suitable temperature (20°C to 45°C) and a source of nutrients such as sludge, scale, rust, algae and other organic matter
- a means of creating and spreading breathable droplets, such as the aerosol generated by a cooling tower
- exposure of susceptible people to these aerosols.

The effect of aerosols on humans

Water contaminated with *Legionella*, particularly the species *Legionella pneumophila*, could occur in a cooling tower and present a risk to health when the contaminated water from the tower is dispersed into the air as an aerosol and transported by natural and mechanical air currents. It may be inhaled by passers-by, or the aerosol may enter doors, windows, and air intake ducting of buildings where humans can then inhale it.

The elderly, smokers, and those individuals with impaired immunity are more likely to develop infection from highly contaminated aerosol. In Australia, the major outbreaks of Legionnaires' disease have been traced to contaminated water of cooling towers and evaporative condensers associated with a cooling water system. A small number of cases have been associated with warm water services, spa pools and the water distribution systems of hospitals and residential aged care facilities.

Appendix 7 contains information on the 'Requirement to report legionellosis', and the role of Queensland Health and Workplace Health and Safety Queensland".

Evaporative coolers

Evaporative coolers have less potential for similar infections. However, any sump water should be dumped and replaced with fresh water before the start-up of these units if there has been a significant period over which the recirculation system has been shut down. Owners or person in control of such plant will find useful information in the references of this guide.

Appendix 6: Occupational health and safety for water treatment service providers (WTSP)

All cooling tower systems that are to be serviced by a WTSP should have had an inspection conducted prior to undertaking such work, to investigate and anticipate any occupational health and safety issues that may be associated with servicing the system(s) in question.

Those occupational health and safety issues can include:

- potential exposure to *Legionella*
- potential exposure to chemicals
- potential exposure to electromagnetic radiation from nearby communication transceivers
- access/egress and working at heights
- confined spaces
- climatic considerations
- electrical safety
- hazardous manual tasks.

Where a cooling tower system presents unacceptable occupational health and safety risks beyond the control of the WTSP, such as access/egress issues, the client should be informed that servicing will be based on acceptable standards being met. Such safety requirements should be incorporated into the contract between the WTSP and the client.

Appendix 7: Requirement to report the detection of *Legionella* (in healthcare facilities), Legionellosis, and the role of Queensland Health and Workplace Health and Safety Queensland

This section provides guidance for the actions to be taken:

- in the event that legionellosis (a notifiable health condition) is detected in a person, that is, a person is actually infected

or

- if *Legionella* (bacterium that causes legionellosis) is detected in a water sample collected from a water cooling system in a healthcare facility.

Note: There is a difference between the notifiable health condition, legionellosis, and the detection of the *Legionella* (the bacterium which causes legionellosis).

Legionellosis

Legionellosis is a term that includes both Legionnaires' disease and Pontiac fever.

Legionellosis is a notifiable disease under the Queensland *Public Health Act 2005*, which means laboratories and clinicians are required to report the disease to Queensland Health.

Public Health Unit staff follow up legionellosis cases according to communicable disease guidelines. Where it is found that two or more cases may be linked, possible sources of infection are assessed. Under the *Work Health and Safety Act 2011*, where the cause of a confirmed case of Legionnaires' disease is work related, the person conducting the business or undertaking must notify Workplace Health and Safety Queensland immediately that an illness arising from the business or undertaking has occurred.

Therefore, there is no requirement for persons conducting a business or undertaking to notify Workplace Health and Safety Queensland of any person at their workplace becoming ill with a legionellosis until there is evidence that the cooling water system (or other source) at their workplace was the source of the legionellosis.

Further information on Legionnaires' disease can be found in the Queensland Health Fact Sheet on Legionnaires' disease at www.health.qld.gov.au.

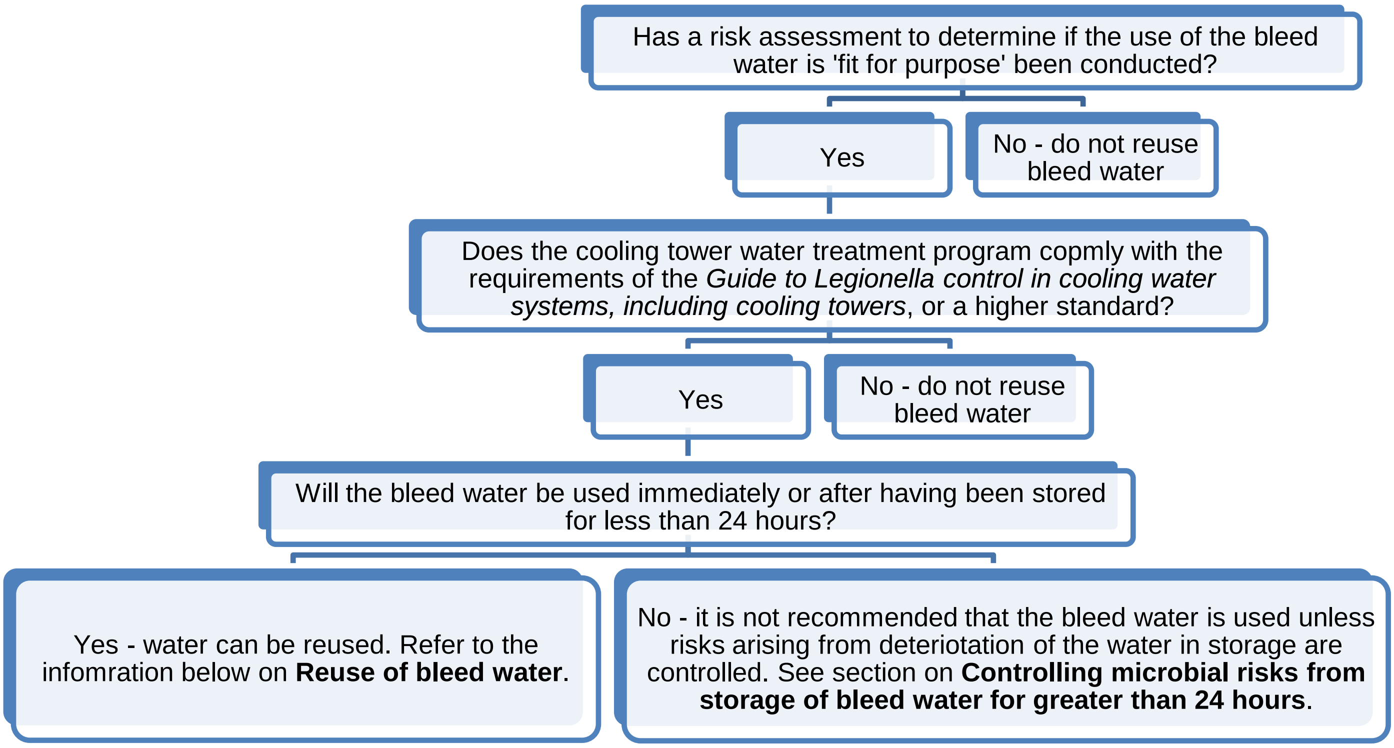
Detection of *Legionella*

There is a requirement (under the Water Risk Management provisions of the *Public Health Act 2005*) to notify Queensland Health (within one business day) of the result of a detection of *Legionella* from a water sample taken from a cooling water system, or water distribution system, of a healthcare facility. This requirement applies to public hospitals and public residential aged care facilities, as well as private health facilities licensed under the *Private Health Facilities Act 1999*. This notification requirement is the responsibility of the "person in charge" of the facility.

There is however no requirement for persons at a workplace to notify Workplace Health and Safety Queensland (or Queensland Health) of any elevated water sample HCC (irrespective of whether at a healthcare facility or not) or detection of *Legionella* from a cooling water system (not from a healthcare facility). Rather, the owner or person in control of the cooling water system should follow the recommended cleaning, disinfection, or decontamination processes outlined above in this guide.

Further information on reporting a *Legionella* detection at a **healthcare facility** can be found in the Queensland Health web pages (see Further Information towards the end of this guide).

Appendix 8: Risk management and water quality standard for the reuse of bleed/blowdown water from cooling towers



Reuse of bleed water

Bleed water that has been stored for less than 24 hours can be reused.

The following should be in place:

- Evidence of compliance with cooling tower risk management including all records of inspection, water treatment, water sampling, and an audit of the cooling tower *Legionella* risk management program on at least a yearly basis.
- The bleed water is filtered as it leaves the cooling tower so as to remove potential nutrient sources for micro-organisms during storage circumstances.
- The bleed water is disinfected prior to use – the use of a disinfection tank is recommended so as there is sufficient contact time with any biocide.
- The bleed water is used immediately or within 24 hours.
- The bleed water discharges automatically to sewer if not used within 24 hours.
- The water must be used in a manner that minimises aerosolisation, skin contact, and ingestion;
- Any tanks (e.g. disinfection tank) should be designed so as visual inspection (and cleaning as required) of the wetted surfaces can occur at least yearly.
- Tanks should be situated so they are not in direct sunlight.
- If *Legionella* are detected in cooling tower at levels >10CFU/mL the supply of bleed water to the storage/reuse system shall cease until the levels in the cooling tower are controlled below 10CFU/mL.
- If the HCC in the cooling tower is >10,000CFU/mL the supply of bleed water to the storage/reuse system shall cease until the levels in the cooling tower are controlled below 100,000CFU/mL.

- HCC and *Legionella* sampling (and intervention arising from sampling results) of the water in the disinfection tanks should occur as outlined below in the section on Controlling microbial risks from storage of bleed water for greater than 24 hours.
- As part of your risk assessment and before implementing your bleed water reuse system it is advisable to review risk controls of other bleed water reuse systems that are currently in operation at other workplaces.

Controlling microbial risks from storage of bleed water for greater than 24 hours

The storage system should be designed, constructed, and positioned such that:

- it is constructed of non ferrous, corrosion resistant materials with smooth internal surfaces devoid of crevices and joints
- ingress of organic matter and suspended solids is prevented by a filtration system, and keeping the system closed to the outside environment.
- insects and rodents are prevented from entering the system
- a means of visually inspecting the wetted surfaces is possible
- a means of cleaning the wetted surfaces is possible
- a means of ventilating the storage system with fresh air if entry to the storage system is required
- a means of draining the water from the storage system is possible
- the storage system is protected from warming by sunlight.

The water treatment program should include the following:

- A suitable, continuous water treatment program for effective management of corrosion, scaling, fouling and microbial growth, including *Legionella* It is recommended that the water treatment be automated[37]
- Provision of an effective biocidal concentration/dose/action level in the system at all times.
- Biocidal processes selected to avoid problems associated with particular bacterium developing a tolerance to a particular biocide process. Therefore dual or alternating biocidal processes are recommended.
- The control of corrosion and scale.
- Regular monitoring of pH.
- Monitoring of biocide concentration where practicable. Examples of where this is possible include for UV systems, or chlorine or bromine in conjunction with pH measurement, or an ORP system.
- A means of ensuring the water in the storage tank is circulated and has sufficient contact time with the chosen biocide.
- The use of a biodispersant to help break down the biofilm on the wetted surfaces in the storage system.
- The bleed water should be filtered when leaving the cooling tower so as to remove potential nutrient sources for micro-organisms.

Inspection and servicing of the bleed water storage system and water treatment program should be carried out at least monthly by a competent person[38] who can make an assessment of whether the water storage system is being maintained correctly.

[37] Auto-dosing can be used to control pH, the concentration of biocide(s) and corrosion inhibitors. Such equipment is not fail-safe and must be regularly checked and properly maintained to ensure that the expectations of the water treatment program are achieved.

[38] A competent person should have suitable experience and knowledge for the task/s being performed. It is likely that a WTSP would have the suitable experience and knowledge for this task. Responsibilities of WTSPs are described in section 7.

This servicing should include:

- a visual inspection of the storage system for the presence of
    - scale and particulate matter such as dirt, dust, insects, and leaves
    - slime and microbial growth such as algae and fungi
    - corrosion products
- checking the clarity of the water
- checking that the water treatment system is functioning correctly, including
    - all dosing and control equipment
    - timers, pumps, and tubing
    - checks on flow rate of dosing equipment
    - adequacy of supply of any chemicals being dosed
    - integrity of filtration system
- routine water analysis, including pH, HCC and *Legionella sp*
- the calibration and inspection of water monitoring and dosing equipment
- repair of obvious physical defects or damage
- checking for leaks and unexplained water losses.

A visual inspection of all wetted surfaces of the storage system with the storage system empty should also be conducted on a yearly basis – carrying this out at a time when the storage is empty would save water. Where the storage system is inspected by a diver, there must be compliance with the *Work Health and Safety Regulation 2011*, Part 4.8 – Diving work.

Cleaning procedures should be documented for each water storage system.

Physical and chemical cleaning (to a visual state of cleanliness) should be performed on a routine basis, and when required as identified by inspection of the storage system. Such cleaning includes removal of corrosion products, rust, scale, slime, sludge, mould, algae, biofilm and fungi. These pollutants are known to provide nutrients for the growth of micro-organisms such as *Legionella*.

The frequency of cleaning maintenance programs should be determined by a risk management process. It is recommended, however that the systems undergo this cleaning process annually.

The cleaning procedure should be based upon that outlined in Appendix 1.

HCC and *Legionella* sp should be tested on a regular basis as determined by risk assessment – HCC should be conducted at least monthly, and *Legionella* sp at least 3 monthly using the methods described in Appendix 2.

If *Legionella* are detected in the bleed water storage system at levels >10CFU/mL the supply of the stored bleed water to the downstream processes shall cease until the levels are controlled below 10CFU/mL. If the HCC in the bleed water storage system is >100,000CFU/mL the supply of the stored bleed water to the downstream processes shall cease until the levels are controlled below 100,000CFU/mL.

The appropriate interventions for unacceptable bacterial counts in the bleed water storage system are outlined in Appendix 3.

If *Legionella* are detected in cooling tower at levels >10CFU/mL the supply of bleed water to the storage system shall cease until the levels in the cooling tower return to below 10CFU/mL.

If the HCC in the cooling tower is >100,000CFU/mL the supply of bleed water to the storage system shall cease until the levels in the cooling tower are controlled below 100,000CFU/mL.

The owner or person in control of the bleed water storage system should ensure documented risk management information, including that listed below, is kept at the site of the storage system. This information should be immediately accessible to any service personnel and Workplace Health and Safety Inspectors, and should include:

- the documented risk assessment
- the water treatment specifications
- planned service and maintenance requirements of water storage system
- all results of water sampling and analysis
- key performance indicators and targets
- safety data sheets for any chemicals used in water treatment
- water treatment dosing rates
- water storage volumes for dosing calculations
- cleaning procedures
- disinfection/decontamination procedures
- confined space procedures for entry to storage systems
- emergency contact details
- service, inspection, corrective action, cleaning, disinfection, decontamination reports for the water storage system
- history of any previous action taken in response to significant KPI/Target variations.

As part of your risk assessment and before implementing your bleed water storage system it is advisable to review risk controls of other bleed water storage systems that are currently in operation at other workplaces.

References

Australian/New Zealand Standard 1715 – Selection, Use and Maintenance of Respiratory Protective Devices.

Australian/New Zealand Standard 1716 - Respiratory protective devices

Australian Standard 2031:2012 Water quality—Sampling for microbiological analysis

Australian/New Zealand Standard 3666.1 – Air-handling and water systems of buildings – Microbial control, Part 1: Design, installation and commissioning

Australian/New Zealand Standard 3666.2 - Air-handling and water systems of buildings – Microbial control, Part 2: Operation and maintenance

Australian/New Zealand Standard 3666.3 - Air-handling and water systems of buildings – Microbial control, Part 3: Performance-based maintenance of cooling water systems

Australian/New Zealand Standard 3666.4 - Air-handling and water systems of buildings – Microbial control, Part 4: Performance-based maintenance of air-handling systems (ducts and components)

Australian/New Zealand Standard 3896:2017 - Waters – Examination for Legionellae including Legionella pneumophila

Australian/New Zealand Standard 4276.3.2 Water microbiology - Heterotrophic colony count methods – Plate count of water containing biocides

Australian Standard AS 5059-2003 Power station cooling tower water systems – Management of legionnaire's disease health risk

How to manage work health and safety risks – Code of Practice 2011, Queensland Department of Justice and Attorney-General.

Managing the risks of plant in the workplace – Model Code of Practice 2012, Safework Australia

Plant Code of Practice 2005, Queensland Department of Justice and Attorney-General.

Further information

A Guide to Developing Risk Management Plans for Cooling Tower Systems. 2001. Public Health Division, Victorian Government Department of Human Services www2.health.vic.gov.au/about/publications/policiesandguidelines/Guide-to-Developing-Risk-Management-Plans-for-Cooling-Tower-Systems-November-2001.

Non-potable water. Workplace Health and Safety Queensland www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-exposures/non-potable-water.

Legionella and the prevention of Legionellosis, World Health Organization, 2007.

NSW Code of Practice for the Control of Legionnaires' Disease, 2nd edition, NSW Department of Health, June 2004 (under review) www.health.nsw.gov.au/environment/*Legionella*control/Pages/default.aspx

SAA/SNZ HB32 - *Control of microbial growth in air-handling and water systems of buildings*

(This is a free resource and can be accessed online – search by document title.)

Water risk management in healthcare facilities www.health.qld.gov.au/public-health/industry-environment/environment-land-water/water/risk-management.