Safe working practices for cooling towers and the control of Legionella

according to SZW Ministry publication AI32 and the *Arbobeleidsregel 4.87 (January 2004)*

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Safe working practices for cooling towers and controlling legionella

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Purpose of this booklet:

To minimise the risk of legionella infection by providing information and setting up a control plan.

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GENERAL INFORMATION ON LEGIONELLA

1.1 What is legionella?

Legionella is a bacterium that occurs in virtually all natural waters and waterways. The family of legionella bacteria has more than 40 different members, some of which can cause infectious diseases in humans. The most worrying one is a type of pneumonia that can kill its victims if the correct treatment is not given. In addition to this serious illness of the lungs, there is also a flu-like variation known as Pontiac fever, which passes by itself without treatment. There are no indications that these days legionella is more common than, say, a hundred years ago. Improved knowledge and people's changed patterns of behaviour have created the situation that every now and then is experiencing a legionella epidemic.

1.2 Under what conditions does legionella occur?

Legionella only lives in aqueous environments but prefers to attach itself to solid substances such as calcium precipitations or porous materials. Like most other bacteria, legionella grows best at temperatures between 30 and 45°C. At lower temperatures, legionella bacteria multiply very slowly, and high temperatures above 50°C are fatal. Above 70°C they die in just a few seconds. The water has to contain oxygen and sufficient nutrients to permit growth. The bacteria can be killed by biocides and powerful oxidising agents such as free chlorine.

1.3 How does infection occur?

A person can only become infected by legionellosis if the bacteria are present in large numbers in water drops that end up in the lungs of the victim. Legionella infection cannot be caused by contact with the skin or by drinking water. The legionella bacterium can cause Legionellosis, which is the collective name for a number of lung infections. There is no recorded case of infections between humans. If this illness is not treated correctly, it can result in fatal outcomes in about 15-20% of all cases. People with a diminished immune system are at the greatest risk.

1.4 Where is the legionella bacterium found?

The following installations and equipment have the potential to become dangerous sources of legionella:

1.4.1. Jacuzzis and swimming pools;
1.4.2. Cold and hot water pipelines;
1.4.3. Water softening installations;
1.4.4. Sprinkler installations;
1.4.5. Cooling towers;
1.4.6. Air humidifiers.

CONTROLLING LEGIONELLA IN COOLING TOWERS

2.1 Contamination of cooling towers

The thermal conditions in a cooling tower are very suitable for growth of legionella. The bacteria can settle in the more or less still water that is absorbed in waste deposits such as calcium, dust and biological deposits (scaling). The source of the infection is bacteria brought in by in the feed water.

2.2 Dangers posed by a contaminated cooling tower

If a cooling tower is contaminated with legionella and the bacterial concentration rises sharply (to more than 10,000 CFU (Colony Forming Units) per litre), then water drops containing bacteria that are expelled at the top of the cooling tower may cause the spread of legionellosis infectious diseases. These diseases can only occur if the bacteria enter the body via the lungs. In other words, infection cannot result from drinking contaminated water or from contact with the skin.

2.3 Preventing infection during tower operation

Correct water treatment will prevent the formation of deposits in the cooling towers, which reduces the risk of high concentrations of bacteria in still water. The bacteria can be killed by dosing discontinues biocide or powerful oxidators to the cooling water.
A regular inspection of the cooling plant will provide information about the condition of the tower. Water sample analysis can tell you whether legionella bacteria are present in the cooling tower. If legionella is found to be present, the tower will have to be disinfected in order to prevent the cooling plant from spreading the bacteria.

2.4 Preventing contamination at the design stage

The risk of contamination can be greatly reduced by taking the following measures during the design stage of cooling equipment:
- equip the cooling towers with a high efficiency droplet separator to reduce drop emissions to a minimum;
- design an efficient cooling tower that provides good access for cleaning and for component replacement;
- locate the cooling towers some distance from the air intake openings of airco installations, ventilation systems etc.;
- provide suitable water treatment facilities;
- prevent water to how back to other installations.

2.5 Alternatives for cooling towers

Cooling towers are installed where residual heat from a process can no longer be usefully employed. This residual heat is destroyed by evaporating water in the cooling tower. In this way, the surplus energy is carried away into the air.
However, this 'wet' cooling method is not the only one available: there are others, each with its own advantages and disadvantages, as shown below.

Example: In order to be able to discharge **1 MegaWatt (= 1 MJ/s) of residual energy**, we can use any of the following methods:

2.5.1 Wet cooling

In a cooling tower, approx. 1.6 m^3 of water per hour would have to be vaporised. This would require an air inflow of approx. 135,000 m^3/h (160,000 kg/h) (NB. Water absorption 10 g/kg dry air).
The air flow must be sucked in by a ventilator, which requires approx. 16 KW. (300Pa,η=70%).
Reasonably feasible temperatures: 22 to 26°C.
Set-up floor area required: approx. 15 m^2.

2.5.2. Dry cooling

There are not only 'wet' but 'dry' cooling towers too.
With these devices, the surplus energy is dissipated into the air via a heat exchanger that heats the air.
In order to discharge 1 MW, an air inflow of approx. 720,000 m^3/h (ΔT=5°C) is needed.
This requires ventilator power of approx. 43 KW. (150Pa,η=70%).
Reasonably feasible temperatures: 30 to 35°C.
Set-up floor area required: approx. 60 m^2.

2.5.3. Surface water cooling method

The energy can be discharged to the surface water via a heat exchanger. The volume of water required is 86 m^3/h (ΔT=10°C).
The additional pump power will be approx. 4 KW.
Reasonably feasible temperatures: 15 to 20°C.
Set-up floor area required: approx. 5 m^2.

2.5.4. Mechanical cooling

Mechanical cooling allows much lower temperatures to be achieved, but the disavantage is that the energy investment required is many times larger than for the above methods.

2.5.5. Comparison of the different alternatives

A comparison of the above methods shows that the preferred method will depend on the following criteria:
- The lowest temperature that needs to be achieved;
- Governmental provisions: are thermal discharges in the surface water permitted?;
- Energy consumption and environmental impact;
- Investment required in equipment.

The above mentioned methods can not be substituted.

PERSONAL PROTECTION AND RISK LIMITATION

3.1 Personal protection

Any personal protective equipment used against legionella infection must prevent water drops contaminated with legionella - which thus become airborne particles known as 'aerosols' - from ending up in the lungs.
There are two options:

3.1.1. Working using respiratory protection

Here, 'clean' air is supplied to a facial mask via hoses; alternatively, compressed air cylinders may be used.
The disadvantage of these methods is the limitation of freedom of movement, which raises the threshold for use.

3.1.2. Working with an aerosol filter

In this case, a full-face mask or half-face mask is used that contain an aerosol filter. The aerosol filter stops all small droplets out of the air.
The disadvantage is that the filter makes breathing a bit more difficult.

3.1.3. Working with a P3 disposable mask

A mouth mask fitted with a disposable filter is a simple and hygienic aid that is easy to use. Type FFP3 complies with European standard EN149.

3.2 Risk limitation

Legionella pneumophila infection in a person is caused by a combination of factors, the most important of which are the following:

A. Legionella bacteria have to be present in the cooling tower in high concentrations.
B. The cooling tower must be emitting 'aerosols' (airborne particles).
C. The aerosols must be ending up in the lungs.
D. The state of health of the person concerned must be such that the illness can develop.

The risk shown above can be limited by taking the following measures:

A. Use a suitable water treatment process in the cooling tower. From time to time, use biological analysis to check whether the cooling tower is still 'legionella deficient' (see also section 3.3).
B. Use droplet separators and service them often.
C. Avoid standing for longer than necessary in the cooling tower's concentrated outflow. Shut down the cooling tower before it is serviced or inspected. Use Personal Protection when working with suspect cooling towers.
D. Lead a healthy life.
   In the case of symptoms indicating pneumonia, inform the doctor immediately about possible exposure to legionella, allowing the right medication to be administered at an early stage.

3.3 Checking for the presence of legionella

The presence of legionella in a cooling tower can be established by taking and analysing samples. This can be combined with an annual inspection and maintenance visit.
The maintenance mechanic takes a sample of the recycled cooling water. Analysis of the sample at the C-mark Laboratory will commence within 24 hours.
It takes 8 days to establish whether colonies of legionella are present, and another 5 days

to establish the concentration, expressed in Colony Forming Units (CFU/litre).
For information on the classification of cooling towers and measures to be taken in the event that the presence of legionella is established, we refer you to the SZW Ministry's publication AI 32, which is briefly summarised in section 4.

When cooling towers are suspected of containing legionella, the spread of the bacteria will have to be controlled through more intensive water treatment or disinfection, after which another analysis will be carried out to see whether these measures have been effective.
It is desirable that dangerously contaminated cooling towers should be stopped immediately and disinfected with sodium-hypochlorite.

CONTROL IN ACCORDANCE WITH AI32

The AI32 publication was drawn up by the SZW (Dutch Ministry of Social Affairs and Employment) in the wake of the EU Directive **BREF**-cooling.
This **B**est Available Technology **REF**erence Document has been incorporated into the NER (Dutch Emission Guidelines).

4.1 Control plan

The owner of the cooling tower will have to draw up a control plan that contains the following effective measures and other information:
- avoid growth of Legionella
- measures to be taken during shutdown
- measures to prevent spread out of aerosols
- measures to prevent scaling and contamination
- maintaining safe and correct working practices
- diagram of the installation
- description of safe and correct system operation
- checking and monitoring plan
- applicable action levels
- disaster/ emergency procedure
- personal protective equipment
- Logbook administration

4.2 Risk categories

Cooling towers are assigned to a specific risk category depending on their physical location in a neighbourhood. Each category is assigned specific rules for legionella analysis and disinfection.

Category	*Position of cooling tower (CT) vis-à-vis*	*Disinfect system after it has been shut down for…*	*Monitoring/ legionella analysis*
1	CT less than 200m from hospital (people with deficient immune system)	5 days	12x / yr
2	CT less than 200m from concentrations of people (old people's homes, hotels etc.)	5 days	4x / yr
3	Industrial CT less than 600m from residential area	14 days	1-4x / yr
4	Industrial CT more than 600m from residential area	30 days	1x / yr

4.3 Cooling tower design

The following points should be borne in mind when designing cooling towers:
4.3.1. Avoid short circuits and note prevailing wind direction
4.3.2. Choose lowest possible design temperature
4.3.3. Choose easy-to-clean materials
4.3.4. Ensure good accessibility
4.3.5. Incorporate droplet separators

4.3.6. Incorporate air inlet louvres
4.3.7. Avoid dead pipeline sections

4.4 Regular Maintenance

It is very important that the cooling tower is serviced correctly.
This is part of the control plan:

Regular maintenance	Logbook	
	Droplet separator in good condition	
	Remove slime, algae and waste from water tank	
	1x or 2x a year: clean and disinfect thoroughly	Comfort cooling: clean before the season starts, and stow away at dry season's end.
		Industrial CT: ensure timely scheduling of regular measurements and maintenance. If necessary, carry out on cell-by-cell basis.
Regular inspections for contamination and of mechanical components	Ventilator area, Gearbox: fouling and oil leaks	
	Ventilator cone: fouling	
	Droplet separator: fouling; properly fitted	
	Water distribution: blockages, defects	
	Cooling fill:	fouling, damage
		wood rot, fractures
	Support for cooling units	
	Walls: leaks, damage	
	Basin: fouling, sludge, leaves and other waste	
	Record the inspection data and results in the logbook. Keep all records for 3 years.	
Other points	Inspect the water treatment process, dosing equipment, supply and discharge pipes and the equipment to be cooled.	

Taking the Comfort installation in and out of use	Clean the circuit around the CT	
	Degrease the system	
	Equip the clean system with a corrosion inhibitor	
	Disinfect with oxidising biocide, up to 5 mg FO/ litre	Procedure: for each 10m³ of cooling water, 1 litre of sodium hypochlorite (140g/l) + dispersant; allow to circulate for at least 6 hours; measure each hour and add sodium hypochlorite if necessary.
		Neutralise oxidising water (with sulphite or similar) before discharging.

4.5 Action levels

What action should be taken when legionella is discovered?
There are no standard procedures, but the following is a recommended action plan:

	Action plan:	*CT cat. 1,2,3*	*CT cat. 4*
A	System under control; no action	< 100 CFU/l	< 1000 CFU/l
B	Check that all dosages are OK	100-1000 CFU/l	1000-10,000 CFU/l
C	Check and add extra biocide	1000-10,000 CFU/l	10,000-100,000 CFU/l
D	System is moderately contaminated; online disinfection and cleaning; system requires immediate special attention.	10,000-100,000 CFU/l	100,000-1,000,000 CFU/l
E	Check employees' and visitors' exposure to aerosols (airborne particles).		
F	The system is seriously contaminated. Shut down the system as quickly as possible; as soon as it is offline, disinfect and clean. Inform *Arbodienst* (Health & Safety Executive) and local *GGD* (municipal health service).	>100,000 CFU/l	>1,000,000 CFU/l

PRACTICAL GUIDELINES

For servicing of cooling towers:

5.1 Remember that legionella infection can only occur when droplets containing high concentrations of bacteria end up in people's lungs.

5.2 Switch off the cooling water pump; if no water is sprayed around then almost no aerosols (airborne particles) will result.

5.3 Shut down the ventilator; the cooling tower will produce very few aerosols if there is no air flow.

5.4 Only stand in a cooling tower's gas outflow for as long as necessary to carry out your work; use personal protection equipment (PPE).

5.5 Always use PPE when using high/ pressure sprayers to clean the cooling tower.

5.6 For details of the PPE to be used, see section 3.1.

5.7 People in the surrounding neighbourhood may be greatly alarmed by an actual or suspected legionella outbreak. Prevent panic by exercising caution when making public statements about legionella and when deciding whether to walk round wearing gas masks. Information about legionella studies is confidential and may only be discussed with the immediate client.

5.8 In the case of symptoms indicating pneumonia, inform the doctor immediately about possible exposure to legionella, allowing the right medication to be administered at an early stage.

BIBLIOGRAPHY

6.1 Legionellosis Position Statement, CTI Houston, Texas, 1996

6.2 Educational Seminar Annual Conference 1999, Legionella, CTI Journal, Vol. 21, No.1 2000

6.3 Informatieblad Legionellabacteriën in watersystemen (Information sheet on legionella bacteria in water systems), WLO Onderzoek en Advies, Doetinchem, April 1999

6.4 Cooling Water Systems (Minimizing Risks associated with Legionellae), Aquazur, March 1999

6.5 The prevention or control of Legionellosis (including Legionnaires' Disease), ACP, January 1995

6.6 *Arbo* decree policy rule 4.87, Jan 2004

6.7 AI32 Legionella, SZW (Dutch Ministry of Social Affairs and Employment), published by SDU in Nov. 2004