

Legionella in Factory Water Systems – Challenges and Solutions

Technical Progress in the Sugar Industry, 12-13.05.2014, Zakopane

Dr. Christer Bergwall

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Responsible: Dr. Christer Bergwall
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1. **Background**
2. **Cooling water systems**
3. **Sanitary hot/cold water systems**
4. **Waste water purification plants**

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1. **Background**
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3. Sanitary hot/cold water systems
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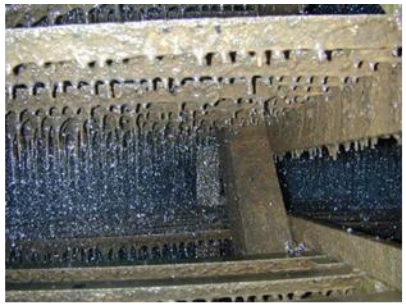
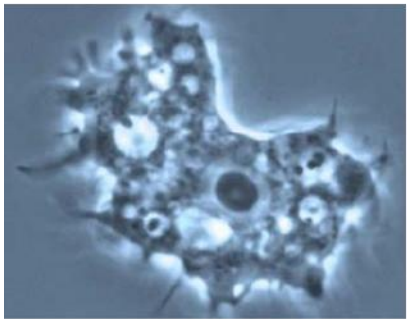
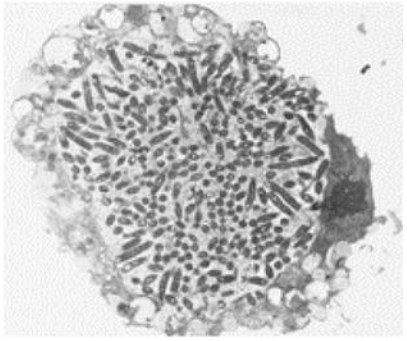
What is Legionella?

- Bacteria in fresh water, moist soil and wet sludge.
- Can be found in natural and man made water systems.
- Optimal temperature range: 20 to 45°C.
- Carbohydrates are not utilised as energy - KEY ISSUE!
- Iron and amino acids are required for growth.
- Main source is biofilm with release of bacteria into water.
- Intracellular parasite in protozoa (amoebae).
- Spread in the air via water droplets in aerosols.
- Invade lung and white blood cells → Legionnaire's disease.
- High risk individuals:
  - People over 45 years of age.
  - Smokers and heavy drinkers.
  - People with an impaired immune system or chronic diseases.







Analogy – Chemical and Biological Time Bombs

- Persistent Organic Pollutants (POP) such as PCB, DDT and dioxins.
- The chemicals are resistant to degradation and can accumulate in the environment.
- POP in the environment often described as **Chemical Time Bombs.**

- Same reasoning apply to Legionella, but on a smaller scale (factory, hospital, hotel).
- Legionella can grow in a water system for a long time.
- Legionella outbreak (local or community) when reaching critical threshold levels.
- Legionella in factory water systems can be described as **Biological Time Bombs**

PCB, Polychlorinated biphenyls

DDT, Dichlorodiphenyltrichloroethane

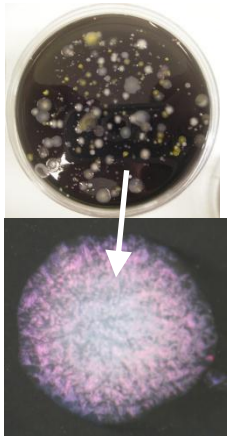
Dioxins, Polychlorinated dibenzo-p-dioxins & Polychlorinated dibenzofurans

Major Legionella outbreaks in cooling towers 2000 to 2013

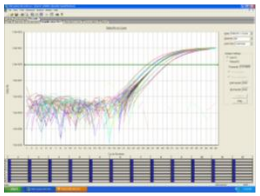
Year	Location	Cases	Dead	Mortality rate (%)
2013	Warstein (DE)	165	2	1 to 20
2012	Quebec City (CA)	180	13	
2012	Edinburgh (UK)	101	3	
2010	Madrid (ES)	46	5	
2009	Ulm (DE)	65	5	
2005	Sarpsborg (NO)	53	10	
2004	Lidköping (SE)	32	2	
2004	Lens (FR)	85	13	
2001	Murcia (ES)	449	6	
2000	Melbourne (AU)	125	4	

Analysis methods for Legionella

- ISO 11731:1998 Water quality - Detection and enumeration of Legionella.
  - Time demanding method, 10 to 14 days for verified results.
  - Problem with high concentrations of background bacteria.
  - Underestimating the true level in water samples due to selective sample pre-treatment.
  - Difficult method for successful process control of cooling water systems.



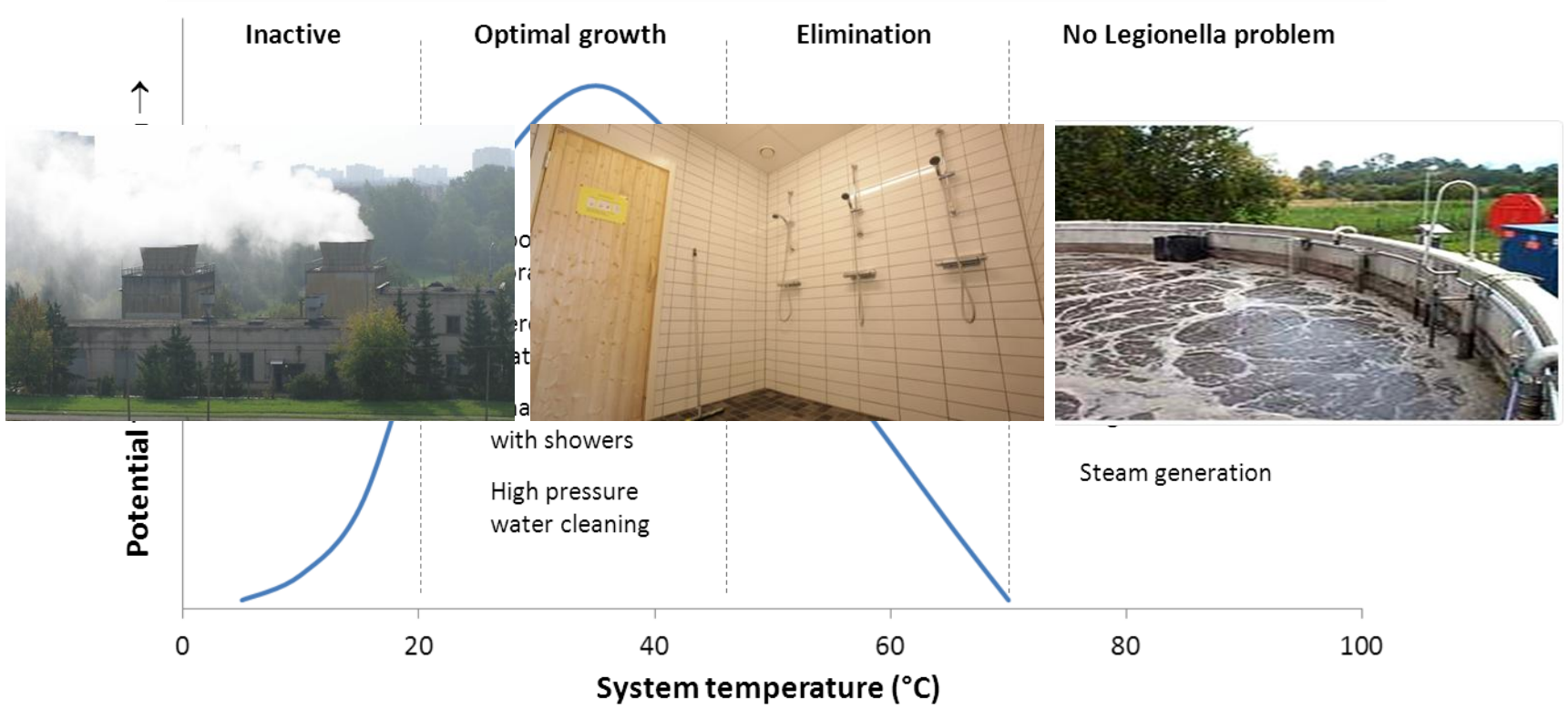
- Internal rapid quantitative Real Time PCR-assay for *L. pneumophila.*
  - Unique DNA-sequence in target microorganism (mip gene).
  - *Advantage:* Fast (3 hours) and 100% specificity.
  - *Disadvantage:* Quantification of dead *L. pneumophila* cells (dead DNA).
  - Overestimation due to inactive DNA handled by frequent analyses.
  - Analysing trends: decreasing, stable or increasing levels.
  - Suitable for process control of cooling water systems.



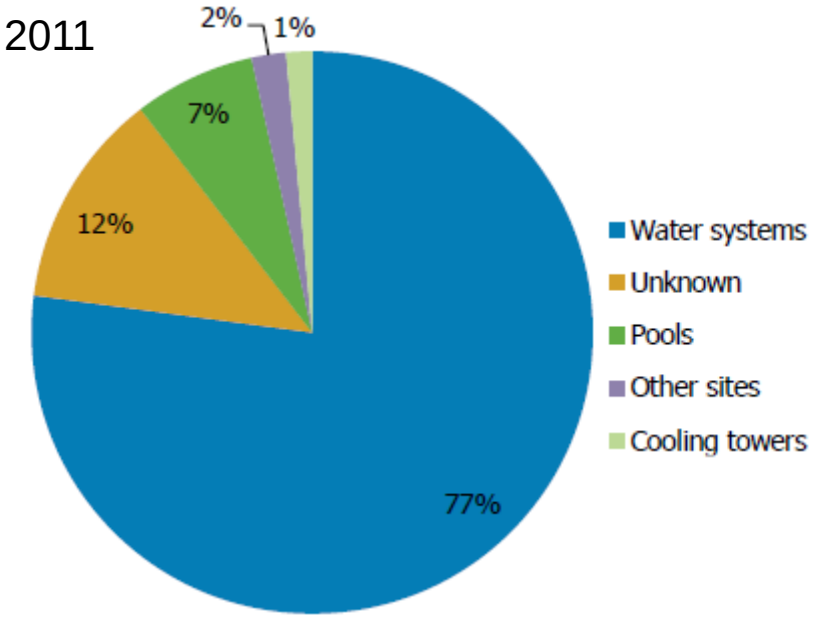
Importance for the sugar industry

- Safe working conditions for factory staff
- Safe living conditions for people living close to the factories (village/city housing)
- Legionella is a Notifiable Infectious Disease (Hospital → Authorities → Industry).
- If a sugar factory is suspected to be responsible for a Legionella outbreak
  - Immediate cooling tower shut down (= often total factory shutdown)
  - Total sanitation of the cooling system.
  - More than 14 days required until start up.
- Legionella is a typical “SCANDAL BUG”.
  - Intensive focus on the outbreak in press radio and TV.

Identifying critical areas at sugar factories/refineries



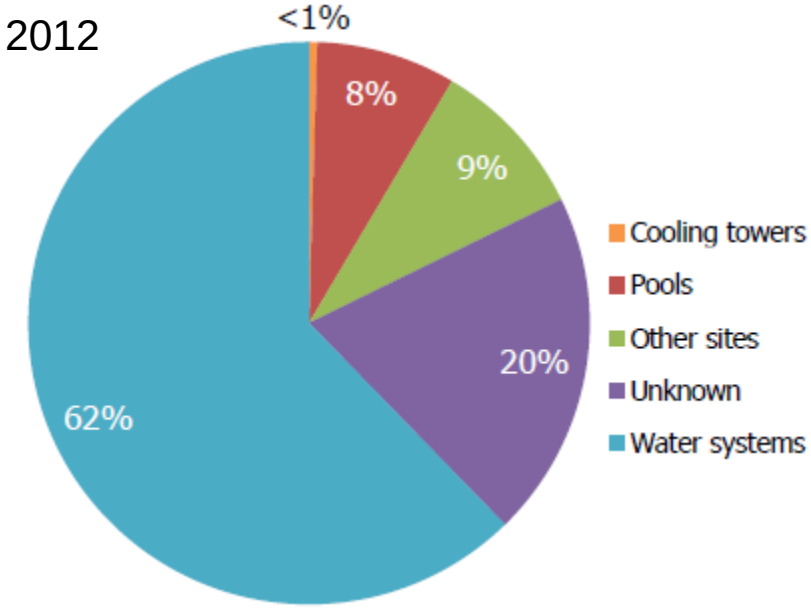
Distribution of sampling sites testing positive for Legionella



ECDC SURVEILLANCE REPORT

Legionnaires' disease in Europe

2011



ECDC SURVEILLANCE REPORT

Legionnaires' disease in Europe

2012

ecdc
EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL

Employee safety is important!

- Protective equipment should be worn in the critical areas according to a risk assessment made by a factory.
- Apply to factory employees and external contractors/visitors.
- Respiratory protection critical - disposable breathing mask or other respirator types.
- A FFP2 mask used for short-term visits such as sampling and simple maintenance.
- A FFP3 mask used for long-term work such as sanitation, sludge removal and complex maintenance.



1. Background
2. **Cooling water systems**
3. Sanitary hot/cold water systems
4. Waste water purification plants

Challenges – Cooling water systems

- No clear EU regulations to support factory risk assessment.
- EU member states have national guidelines or regulations.
- Tower aerosol can spread up to several kilometers depending on climatic conditions.
- Hazard to factory employees and people (houses to large city) living close to a factory.
- Legionella positive systems require strict control to ensure safe conditions.
- Significant bio-fouling occurs frequently with reduced cooling capacity.
  - Bio-fouling is characterised as growth of bacteria and algae in the cooling tower fill material, which will reduce the cooling capacity by physical blockage.
- Two major challenges in cooling water systems
  - Effective cleaning/sanitation of cooling water systems before the campaign.
  - Optimal type of biocides for a specific cooling water system (find, use and optimise).

Solutions – Cooling water systems

- Successful operation of a cooling tower is depending on the;
  - System status in the start of the campaign
  - Optimal use of biocides during the campaign.
- Cleaning the cooling system before the campaign.
  - Cleaning will reduce the bacterial load in the system.
  - Biocide dosing can normally be controlled effectively.
  - Cleaning is work intensive, but cost effective in the long-term.
  - Respiratory protection is recommended during cleaning.
- Cleaning procedure
  - STEP 0: System design - remove all dead zones in the system.
  - STEP 1: Physical cleaning of main system components.
  - STEP 2: Flushing the system with water.
  - STEP 3: Bio-dispergator, surfactant, cleaning of the system (OPTIONAL).
  - STEP 4: Biocide treatment of the system.

Solutions – Cooling water systems cont.

- Active biocide program if
  - Cooling water system is documented as a Legionella positive system.
  - Significant bio-fouling occurs frequently with reduced cooling capacity of the tower.
- Biocide approach
  - Two biocides used in an alternating pattern for the best effect on bacteria and algae.
  - Large portfolio of effective biocides available (national regulations and company strategy).
  - Find optimal cycle strategy for the two biocides (days or week).
  - Evaluate need for bio-dispergator (surfactant attack on biofilm).
  - Frequent residual level measurements recommended if oxidative biocides are used.
  - If cooling water is used in the sugar process only limited number of biocides available such as chlorine dioxide and hydrogen peroxide
- Environmental waters such as lake and stream water should not be used to start the cooling water system or as emergency water during the campaign.

Legionella control in cooling water using oxidative biocides

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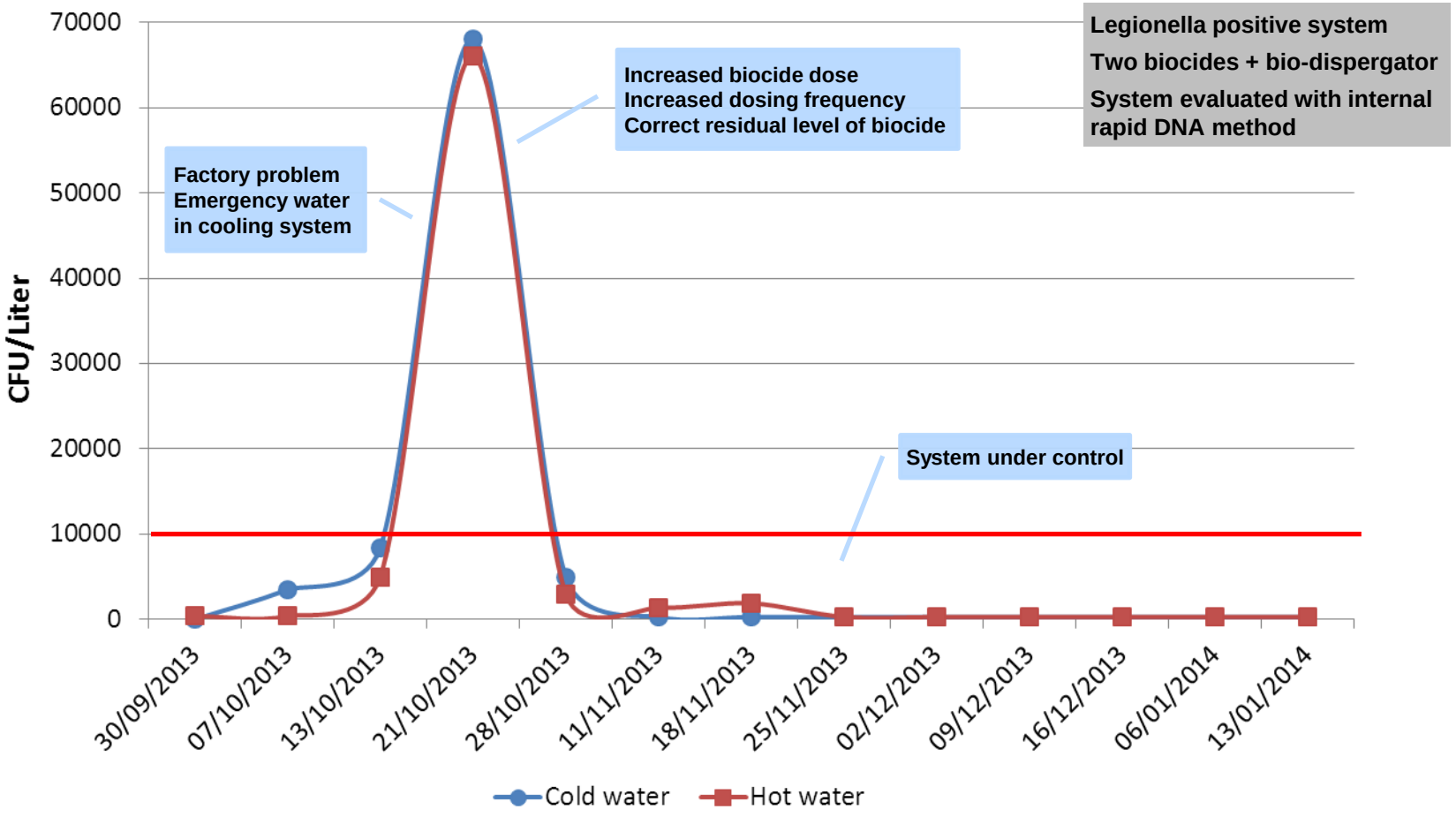
Cooling water systems



System monitoring

Recommended factory monitoring of the cooling system in order to evaluate system performance.			
	Frequency	**Observations**	**Actions**
Visual inspection of cooling tower fill material	Weekly	Significant bio-fouling (biofilm) observed in the cooling tower fill elements.	Increase biocide dose. Increase dosing frequency. Evaluate use of a secondary biocide.
Target temperature of cooled water	Continuous	Cooled water temperature higher than the target for cooled water.	
Residual level of oxidatíve biocide	Daily	Residual level between X and Y ppm is a general target for efficient biocide treatment.	Optimise dosing level to reach correct residual level in return water from the cooling tower.
Total bacterial count/ Dip slide analysis	Weekly	If bacterial level above critical target	Increase biocide dose. Increase dosing frequency.

Risk assessment – Legionella in cooling water systems

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Cooling water systems

Risk assessment in relation to the level of Legionella bacteria in cooling water expressed as CFU/ L.				
	<1000	**>1000**	**>10 000**	**>1 000 000**
Cooling towers **Spray ponds** **Wet scrubbers**	No risk. No actions required.	Low to medium risk. System must be re-sampled immediately. Water samples must be sent to accredited laboratory for official Legionella analysis. Biocide dosing is required if official levels are above 1000 CFU/L Alternating dosing of two biocides recommended. Review the control measures for the system.	Medium to high risk. System must be re-sampled immediately. Water samples must be sent to accredited laboratory for official Legionella analysis. increase biocide dose and dosing frequency if official levels are above 10 000 CFU/L. Evaluate alternative biocides. Prepare for total sanitation of the system.	High risk. Water samples must be sent to accredited laboratory for official Legionella analysis. Controlled factory shutdown if official values are above 1 000 000 CFU/Liter. Total sanitation of the cooling tower system. Perform sanitation with external company. After completed sanitation send water samples to an accredited laboratory for official Legionella analysis.



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4. Waste water purification plants

Challenges – Sanitary hot/cold water systems

- Showers in changing rooms are high risk areas.
- Employees will come in close contact to aerosols in shower rooms or cabins.
- Require strict control of sanitary water system.
- High number of Legiollenosis cases reported to ECDC.
- Two major challenges in sanitary water systems.
  - Too low water temperature in water storage tank and outgoing water.
  - System design is not acceptable e.g. old installation or extending the installation.
- Two types of water systems
  - Recirculating systems with water recirculated from pipes to storage tank
    - Normally easy to secure due to continuous water flow.
    - Complex systems with more maintenance.
  - Non-recirculated system with water flow out of the system.
    - Difficult to secure due to standing water.
    - Technically easy systems.
    - Non-recirculating systems should be rebuilt into a recirculating system whenever possible.

Solutions – Sanitary hot/cold water systems cont.

- Recirculated systems
  - System design - remove all dead zones in the system.
  - Target temperature of minimum 60°C for water storage tank and outgoing water.
  - Return water in the system should be minimum 50°C.
  - Install thermostatic mixing valves in the shower rooms to minimize scalding (water burning).
  - Run recirculation pumps continuously and exclude them from energy saving measures.
- Non-recirculated systems
  - System design - remove all dead zones in the system.
  - Target temperature of minimum 60°C for water storage tank and outgoing water.
  - Shower units must be flushed through to the draining system on a weekly basis (5 to 30 min).
  - Install thermostatic mixing valves in the shower rooms to minimize scalding (water burning).
- Technical improvement of non-recirculated systems
  - Electric heat tracing in combination with insulation of the pipe line system.
  - Point of use electric water heaters with direct cold water feeding.

Solutions – Sanitary hot/cold water systems cont.

- Heat treatment of the sanitary water system
  - Periodic heat treatment of the system if a set-point temperature of 60°C cannot be maintained.
  - Increase storage tank water temperature to min. 70°C
  - Maintain 70°C for a minimum of one hour.
  - All showers and/or taps must be flushed for 5 to 30 min at the full temperature.
  - Shift back to the original temperature set-point after the completed heat treatment cycle.
  - Temperature treatment should be performed on a weekly basis.
- Disinfection of a sanitary water system
  - Clean water storage tank (lime scaling and/or sludge).
  - Chemical disinfection is recommended to reduce or eliminate Legionella bacteria.
  - Disinfection is normally carried out by chlorination or chlorine dioxide.
  - Flush the system with water to remove excess chlorine.
  - Finalise with heat treatment of the system as described above.

System monitoring

Monitoring of water parameters in a recirculated and non-recirculated cold and hot water systems.				
Frequency	**Action**	**Target**		**Remarks**
		Cold water	**Hot water**	
Monthly	Temperature measurement of water in shower and taps.	<20°C after two (2) min of flushing	Min. 60°C after one (1) min of flushing.	First and last shower/tap in a hot water system.
Monthly	Temperature measurement of cold and hot water storage tanks.	<20°C	Outgoing water at min. 60°C. Return water of recirculating systems at min. 50°C	Fixed thermometer on the water storage tank and on the return pipe to the storage tank.
Yearly	Water storage tanks	No lime scaling or sludge/sediment	No lime scaling or sludge/sediment	Tank must be cleaned if significant lime scaling or sludge/sediment is observed. Thermal/chemical disinfection of the system.

Risk assessment - Legionella level in sanitary water systems

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Sanitary hot/cold water systems

Risk assessment in relation to the level of Legionella bacteria in sanitary water expressed as CFU/L.			
	<1 000	**>1 000**	**>10 000**
Sanitary water systems	No to low risk. No actions required.	Medium risk. System must be re-sampled immediately. Water samples must be sent to accredited laboratory for official Legionella analysis Review the control measures for the system with focus on the system temperature profile. Inspect water storage tank for lime scaling or sediment/sludge. Thermal disinfection of the system is recommended if official results is above 1 000 CFU/L.	High risk. Water samples must be sent to accredited laboratory for official Legionella analysis Close the sanitary water system immediately if official values are above 10 000 CFU/L. Inform the employees. Thermal and/or chemical disinfection of the system is required. Inspect and clean water storage tank of lime scaling and sediment/sludge. Review the control measures for the system with focus on the system temperature profile. After completed disinfection send water samples to an accredited laboratory for official Legionella analysis.



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Challenges – Waste water purification plants

- Legionella bacteria can be present in the aerobic part of the WWPP.
- Legionella control via biocides is not possible due to the biological purification activity.
- No published values for critical levels of Legionella in aerobic WWTP exist today.
- Legionella case at a paper mill in Northern Sweden in 2004
  - 44 paper mills with water purification plants were evaluated.
  - 50% of the paper mills (aeration tank/pond) positive for Legionella.
  - Legionella level observed between 10 000 and 21 000 000 000 CFU/Liter.
- Aeration step promoting Legionella
  - Large volumes of air injected into the water to maximize aerobic purification of waste water.
  - High amount of sludge with host protozoa (amoebae).
  - Nutrient composition in water supporting Legionella.

Solutions – Waste water purification plants

- Preliminary risk assessment
  - Risk assessment of WWPP in relation to a cooling water system.
  - Aerosol formation from aerobic WWTP is small compared to a cooling tower.
  - Direct hazard of aerosols is likely to be limited to factory employees.
- Protective equipment
  - Protective equipment should be worn according to a risk assessment made by the factory.
  - Respiratory protection is recommended (maintenance, sludge removal and cleaning).
  - Apply to factory employees and external contractors/visitiors.
- New control strategies in WWPP
  - New purification technologies.
  - Reconstruction of existing plants (roof on tank/pond with UV-disinfection or air filtration).
  - Development of Legionella specific inhibitors.

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Thank You

for Your Attention!