The Control of Legionella in Dry/Wet Cooling Systems
(Sometimes referred to as “Hybrid” and “Adiabatic” coolers)

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Working Party members:
John Alvey • David Bebbington
Bob Macleod-Smith • Giles Green • Colin Brown

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The Control of Legionella in Dry/Wet Cooling Systems

1. In recent years there has been increasing use of dry/wet systems which are described in HSG274 Part 1 paragraphs 1.18-1.21. These are designed to operate both in dry air cooled mode and wet evaporative cooling mode. There are different types of dry/wet systems and these can have a wide range of risk profiles. The different types are sometimes referred to as “hybrid” or “adiabatic” coolers, and these can have a wide range of risk profiles. This WMSoc document is designed to supplement HSG274 Part 1 with more detailed information to help evaluate between different designs and risk profiles of dry/wet cooling equipment.

2. This guidance is to help dutyholders, which includes employers, those in control of premises and those with health and safety responsibilities for others, to comply with their legal duties. It gives practical guidance on how to assess and control the risks due to legionella bacteria in dry/wet cooling systems.

3. Any water system that has the right environmental conditions could potentially be a source for legionella bacteria growth. There is a reasonably foreseeable risk in your water system if:
   - Water is stored or re-circulated as part of your system;
   - The water temperature in all or parts of your system may be between 20-45°C;
   - There are deposits that can support bacterial growth, such as rust, sludge, scale and organic matter;
   - It is possible for water droplets to be produced and, if so, if they can be dispersed;
   - It is likely that any of your employees, contractors, visitors etc could be exposed to any contaminated water droplets.

4. The control of legionella in dry/wet systems is included in the Health and Safety Executive’s (HSE) Legionella Technical Guidance HSG274 Part 1 that accompanies the HSE Approved Code of Practice L8 (4th edition).

5. The Water Management Society (WMSoc) has undertaken to draw together people with expertise in the subject and those with knowledge in the control of legionella, as a working group to supplement HSG274 Part 1 and provide more detailed guidance in the control of legionella in these systems. The guidance offered here is the considered opinion of the WMSoc.

6. This is one of a series of guidance documents being produced by the WMSoc for the control of legionella in less common and ‘Other Risk’ systems.

Types of dry/wet systems

7. Conventional open and closed circuit cooling towers and evaporative condensers use the evaporative cooling principle for their operation and are known as ‘wet’ cooling systems. Further information is in HSG274 Part 1 paragraphs 1.14 – 1.17.

8. It is important to understand how the dry/wet system is being operated as the legionella risk can vary greatly depending on the design and operation. Some systems that operate in wet mode rely on the evaporative cooling principle in the same way as cooling towers and evaporative condensers, whilst some dry/wet systems use pre-cooling of the incoming air with water, usually by spraying water into the air stream or by trickling it over a medium through which air passes, to increase the cooling performance.
9. Certain dry/wet hybrid systems must be notified to the local authority in accordance with the Notification of Cooling Towers and Evaporative Condenser Regulations 1992 and paragraph 44 provides further guidance on assessing such systems against the notification requirements of the Regulations to determine if they need to be registered.

10. When assessing the range of risks associated with dry/wet systems it should be noted that this applies to both new and retro-fitted units. Designs range from a crude add-on spray system in front of the heat exchange coils, to units that are specifically designed to prevent or control the risk of legionella. Those systems that create aerosols, or where the water is sprayed onto or trickled into the air stream from a stored or recirculated water source, might pose a considerable legionella risk, especially where cooling in wet mode is infrequent or does not take place for prolonged periods. The risk is minimal in dry/wet systems that avoid the generation of aerosols or where there is no storage or recirculation of water.

11. There are also different levels of control for determining when to use the water system for cooling the air. In its simplest form the water is turned on manually when additional cooling is required. Others have sophisticated controls that only activate the water system when the load or ambient temperature indicates that dry operation alone cannot achieve the desired cooling. Likewise these controls turn off the water to allow the system to operate in dry mode when the load or ambient temperature drops. It is especially important to assess the risk presented by retro-fitted water spray systems as these will often not have an integrated design to assure minimum generation of aerosols, control of the wet operation, avoidance of water stagnation, etc.

**Risk Assessment**

12. The starting point with dry/wet systems is the same as for a conventional evaporative cooling system. A risk assessment must be carried out to determine if the system, including any storage tanks or other make up water components, could act as a breeding and dissemination device for legionella bacteria. The assessment determines the level of the risk and what, if any, control measures are necessary. It should also identify the person responsible for these actions and determine the frequency that they are to be carried out.

13. The recommendations made in this guidance document should be taken into account, but dutyholders must ensure that each system has its own specific risk assessment. For each system local factors such as design, operation and environment, as well as the previous history of the system need to be considered. Dry/wet cooling systems can vary widely in design and the implications of the variations should be understood. It is important that the person chosen to risk assess such systems has a suitable degree of experience, training and competence in order to complete the task of producing a suitable and sufficient risk assessment.

**Guidance on Factors and Controls Affecting Legionella Risks**

14. As with all water systems, dry/wet systems require a risk assessment to identify and assess the risk of exposure to legionella bacteria. This applies in all cases even when the design of the cooler minimises the risk.

15. The following factors need to be considered when assessing the risk of dry/wet coolers or condensers causing cases of Legionnaires’ disease.
**Exposure to aerosols**

16. Some dry/wet systems generate aerosols as part of their normal operation, whereas other types of systems do not. If aerosols are not generated then the possibility of disseminating legionella bacteria should be minimal, however, aerosols might be released at times e.g., during changeover from dry to wet operation, times of abnormal operation or during maintenance. The amount of spray generated may also be influenced by the number and orientation of nozzles, the system pressure, the nozzle orifice size, the prevailing wind directions, etc. Special precautions must be stated within the written scheme of control to take any release of aerosol into account.

17. It is best to select a design of dry/wet system that minimises aerosols. If a design that creates aerosols is being used then special care must be taken to ensure that the aerosols do not contain Legionella. For spray-type coolers where the water is stored or recirculated, the risk of bacteria in the aerosols must be prevented by proven chemical or physical controls, see paragraph 23, and a scheme must be put in place that will ensure the controls remain effective.

18. Extra precautions will be necessary if susceptible people, e.g., the immunosuppressed, could inhale aerosols from the system.

**Water quality**

19. The water used in dry/wet systems can be from a variety of sources. It could, for example, be direct from the mains, mains water via a storage tank, from rainwater harvesting, from a local borehole or watercourse, or grey water from an industrial process. If the supply is not mains water it may contain even higher levels of nutrients, salts, and other biomaterials that can support and promote microbiological growth. When water evaporates, pure water vapour is lost into the atmosphere, but other impurities such as dissolved solids, suspended solids and bacteria stay in the remaining water or precipitate. Even mains water will contain dissolved impurities which may lead to deposits as evaporation occurs. When aerosols form, they contain all the impurities that are in the water.

20. Water used in dry/wet systems when operating in wet mode must be of good quality and treated further to avoid scaling, corrosion, fouling and biological growth. The controls used for this type of plant will normally incorporate set points which activate the wet mode depending on the load or ambient temperature.

21. If mains water is not used, then it should be suitably treated to remove suspended matter and disinfected to destroy bacteria.

22. Water treatment regimes vary according to the water quality and requirements of the system, however the following elements will usually need to be considered.

   - **Pretreatment** - e.g., clarification by settlement or filtration, softening, reverse osmosis or demineralisation.

   - **Corrosion control** - where wetted components are susceptible to corrosion. Usually this requires measured automatic dosing of a proprietary corrosion inhibitor

   - **Scale control** - where the water is hard, scale control can sometimes be achieved by measured automatic dosing of a proprietary scale inhibitor

   - **Fouling** - wetted surfaces in the air stream frequently collect contaminants, whilst hard water can form scale deposits so a regime of inspection and cleaning may be required.
**Bleed** - recirculating systems accumulate impurities, so a means of controlling the level is usually necessary. This often takes the form of an automatic bleed of part of all of the water.

**Microbiological control** - biocidal control of the make up water is likely to be necessary where operation in wet mode is infrequent (less than weekly), where make up water is stored, where cooling water recirculates and where the water is discharged in a spray rather than trickle-fed onto a medium without splashing.

**Disinfection** - disinfection of part or all of the water system may be required, for example prior to start up after a period of operation in dry mode, or if indicated by risk assessment, monitoring or inspection.

23. Care should be taken in using biocides to ensure biocide residuals carried in the aerosol are not hazardous to health. Biocides must also be controlled in order to minimise potential corrosion risks. If the water supply is via a break tank, then the tank needs to be considered as part of the system, inspected at least annually and cleaned and disinfected as necessary. Precautions analogous to those used for tanks for hot and cold water systems might be recommended as a minimum.

**Temperature**

24. Legionella bacteria are said to be dormant at temperatures below 20ºC and if the water stays below this temperature growth will be minimal. However, if there are warm stagnant places within a normally cold system, legionella might grow in these areas and inoculate the rest of the system. Town mains supply water is normally below 20ºC, but if the supply pipes run through a factory or office they may be exposed to much higher temperatures allowing Legionella bacteria to proliferate (temperatures of 20 to 45ºC will allow this). Storage tanks can be heated either from the direct sunlight or from their general environment. Similarly, in systems that recirculate water, heat transferred from cooling fins may result in water temperatures that are conducive to legionella growth. The system that supplies the water needs to be considered fully when assessing the risks of dry/wet systems.

25. Wherever possible the water temperature should be kept below 20ºC and this may be problematic given that many of these systems operate only when ambient temperatures are high. If this cannot be done in storage or break tanks that feed the cooler then water treatment should be used to destroy any legionella bacteria, especially in those systems where water droplets can be disseminated. Any control regime must be maintained and the results and frequency of any required measures recorded.

**Stagnation**

26. Dry/wet coolers usually operate with water during the hottest part of the year, but there may be times (such as spring and autumn) when the systems only operate during the day. Stagnation might therefore occur during the night and early morning. Any stagnant area of the system is likely to be a breeding zone for Legionella. The spray from systems that falls and collects on local surfaces can also produce stagnant water. Deadlegs, blindends, and duty/standby loops and/or equipment in the feed-water line can all result in stagnation so must be managed to prevent growth of bacteria, or preferably removed.
27. Stagnation in dry/wet systems that use water to pre-cool the air should be avoided. This might be achieved by using a once-through water system fed direct from the mains or by automatically draining all the water out of the system at a frequency determined by the risk assessment. During periods in which the water usage is judged to be relatively low, the drain down needs to be more frequent (possibly daily). During periods where usage is judged to be higher, then drain down can be less frequent (possibly weekly). Draining needs to include both the pond and the spray nozzles and distribution pipework. When undertaking cleaning and disinfection of tanks, there must be a method statement indicating how the work is to be carried out and a Certificate of Disinfection completed at the time. If chemicals are to be used, a COSHH assessment for the handling of the chemicals must also have been issued before the work is carried out. Operators need to be trained in carrying out the work.

28. Critical attention should be paid to the design of the pipework between the source and the discharge point for the adiabatic side of the cooler. This run of pipework should avoid dead legs or areas of low water flow. It should have amongst its control measures periodic flushing and draining. It is especially important that adequate controls are in place to ensure that any bacteria that may have been growing in the supply system during long periods of inactivity are rendered harmless before using that water. The scheme of control should make provision for additional controls to be provided when changing from dry to wet mode of operation. The range of options will vary depending on the design of the system, but will include the cleaning and disinfection of tanks and pipework to the sprays. The method and frequency of these actions need to be covered within the risk assessment and the operator of the system should follow the recommendations of the risk assessment. This will ensure stagnant water does not present additional risks to the system.

Contamination

29. Contamination of dry/wet systems is normally either from the air or from the water. The air will contain impurities such as pollens, small insects, vegetable matter, fungal spores, bacteria, dust, oily smuts, volatile organic compounds and possibly dusts and gases from the process or a neighbouring site. Some of these can and do stick to exposed fins on the heat exchange coils. The warmth of the coil can give the ideal conditions for the growth of legionella or other bacteria on the fins. Unless demineralised water is being used, the dissolved salts which are precipitated when the water evaporates will build on the fins as a solid porous deposit. This not only reduces the heat transfer, but also acts as a host for bacteria.

30. If cooling pads are used ahead of the fins, these will not only reduce the risk of aerosol generation but also collect the precipitated salts and the airborne material. The pads therefore act as air filters, which helps to prevent the contamination of the fins of the coil, thus maintaining good heat transfer. It should be borne in mind that cleaning of the pads will be necessary and, when this is being undertaken, suitable techniques to prevent dispersion of contaminated aerosols will be necessary.

31. In systems that recirculate excess water, problems due to environmental contamination of the water are likely to be greater and should be taken into account in the maintenance, cleaning and disinfection programme for the system.

32. It is also possible for fungal spores to grow on wetted surfaces and for these spores to be released into the air in an explosive manner. Fungal spores can cause other health related problems, e.g., respiratory complaints and hypersensitivity.
33. The main control measure is to keep the equipment in a clean condition. This is especially true of the heat exchanger fins. Dirty fins result in corrosion and higher energy use, and where the dirt accumulates is where any residual water will reach its hottest temperature. This water on the fins could be as a result of the dry/wet cooling process, but may also result from rainfall. If there is any moisture present on the fins then bacteria can grow within the pollutants trapped within the fins. A regular regime of inspection and fin cleaning is recommended, the frequency depending upon the nature of local airborne contaminants (see below) and their rate of accumulation. It is normally recommended that frequent inspection regime is introduced initially and subsequent inspection and cleaning adjusted according to the results obtained.

34. Corrosion found anywhere in the system during inspection should be dealt with as soon as possible (e.g., by cleaning and coating, removal and refurbishment, etc.) to avoid increased risk of Legionella proliferation.

35. If there is particularly dirty air or air that is known to be likely to be contaminated with nutrient (e.g., foodstuffs, sugars, chocolate, yeast, fertilizers, etc.) then a more stringent cleaning regime might be recommended.

36. Materials of construction that do not support microbial growth also need to be employed. Ideally, where possible, WRAS approved materials are recommended. In addition, the coil matrix can have enhanced protection from possible contamination by the addition of approved coatings. Air screens will help improve cleanliness and thermal efficiency. Good and safe access points will aid operations.

37. In systems that operate by recirculating water, environmental contamination of the system is likely to be greater. Particular attention should be given to the condition of the sump and/or storage tanks to ensure that the levels of contamination do not encourage legionella growth.

**Maintenance, Cleaning and Disinfection**

38. The risk assessment should consider the comprehensiveness of the maintenance schedule, the frequency of cleaning and disinfection, the ease of access to those components that require cleaning and the dangers to the operatives who are carrying out the maintenance and cleaning as well as others in the vicinity during the work. A method statement for the cleaning and disinfection process should be available.

**Management and Procedures**

39. The management structure and procedures, definition of responsibilities, appointment of the responsible person, training and competence of personnel together with a current system line diagram are all essential elements for consideration when assessing the risk.

40. It is essential that the legionella risk assessment and written scheme are regularly reviewed to ensure they remain relevant and up to date in assessing and controlling the risk

**Record keeping**

41. All control works must be completed at the frequency as determined by the risk assessment. Records of work carried out, i.e., control measure checks, maintenance, updating of the risk assessment, safe systems of working, system diagrams, management structure and training should be kept for a minimum of five years.
42. Due to their different principles of operation, it is important the risk profile of each system is taken into account as the legionella risk can vary greatly depending on the design and operation of the system. Those systems that operate in wet mode using the evaporative principle similar to a cooling tower or evaporative condenser must be notified to the local authority in accordance with the Notification of Cooling Towers and Evaporative Condensers 1992 (NCTEC).

A ‘notifiable device’ means a cooling tower (a device whose main purpose is to cool water by direct contact between that water and a stream of air) or an evaporative condenser (a device whose main purpose is to cool a fluid by passing that fluid through a heat exchanger which is itself cooled by contact with water passing through a stream of air) except where it contains no water that is exposed to air; where its water supply is not connected; and where its electrical supply is not connected.

43. Based on their design and operating design characteristics, some dry/wet systems may require notification. For example, for a dry/wet system where water is applied directly to the heat exchange surface, either by spray or by trickle, then the device requires notification. Whereas in systems where water is sprayed away from the heat exchanger into the approaching air or trickled onto a medium in front of the heat exchanger, then the device does not require notification. Appendix 1 provides more detail on the design and operation of dry/wet systems, with an indication as to whether they require notification under the NCTEC Regulations or not.

Summary

44. Both the HSE and Local Authorities are becoming more aware of dry/wet systems and that they can create a risk to public health depending on their design, operation and level of maintenance. There must be a legionella risk assessment, a written scheme to control the risk where it is assessed that there is a risk of exposure to legionella bacteria; and records of the operation, maintenance and monitoring of the system. These should be readily available for review upon request by an HSE Inspector or Environmental Health Officer. Dry/Wet systems must be assessed against the Notification Regulations and registered with the local authority, where required.

Reference Sources and Further Information

- HSE Technical Guidance HSG274 Part 1 published 2014
- Notification of Cooling Tower and Evaporative Condenser Regulations 1992
- WMSoc: Guide to Legionella Risk Assessment
- CIBSE TM13:2013 Minimising the risk of Legionnaires’ disease
Appendix 1

Dry/wet Hybrid Systems

45. Dry/wet systems are becoming increasingly more common and there are many dry air-cooled systems which are also being retro-fitted to be able to operate adiabatically to increase performance. It is important to understand the distinction between dry and wet modes of operation. Evaporative condensers that can be operated in either dry or wet mode i.e. “hybrid” devices, should be treated in the same way as any other cooling tower or evaporative condenser and are addressed in HSE’s Legionella Technical Guidance - HSG274 Part 1: The control of legionella bacteria in evaporative cooling systems. Figure 1 gives an example of a common type of dry/wet device and is different to an evaporative condenser that can be operated in dry or wet mode and as such are likely to require notification under the NCTEC Regs.

46. Another approach is known as an “adiabatic” cooler. Dry air coolers (also known as air-cooled radiators or air blast coolers) are devices that cool a fluid, usually water or a glycol solution, by flowing that fluid through a heat exchange coil made up of a matrix of metal tubes and by passing ambient air over the outside of the tubes. The rate of heat transfer is improved if the tubes are made of highly conductive metal such as copper. Usually fins are fitted to the tubes to increase the surface area for heat transfer. However the efficiency of these devices depends on a significant temperature difference between the fluid being cooled and the ambient air temperature. In practice, the fluid can be cooled typically to within 6ºC above the ambient temperature. Air cooled condensers work on the same principle but condense refrigerant directly within the heat exchange coil.

47. In order to cool to below ambient dry bulb temperature, a different approach is required. Most people are familiar with open evaporative cooling, which achieves cooling to below ambient temperature by evaporation of some of the recirculating water. This is because evaporative cooling is dictated by the adiabatic saturation wet bulb temperature, which in all cases is below the ambient dry bulb temperature.

48. These systems use an alternative approach to cooling that employs both evaporative cooling and dry cooling processes. When in evaporative mode, these systems incorporate a two-stage process. The evaporation of water is used to cool the air entering the cooler, usually by spraying water into the air stream or by trickling it over a medium (e.g., cellulose pads or plastic mesh) through which the air passes. The cooled air then goes to a conventional dry cooler, increasing its cooling capacity. During the pre-cooling of the air, some or all of the water is evaporated. In some systems, excess water (i.e., that which is not evaporated in the evaporative cooling step) is collected and recirculated through the system. This may allow circumstances that permit legionella numbers to reach dangerous levels in much the same way as the operating characteristics of cooling towers and evaporative condensers can elevate risk. Systems that operate in this way present a greater risk than other designs where water is not recirculated and this risk will need to be managed appropriately, e.g., by implementing water treatment measures and applying an appropriate cleaning and monitoring regime.
49. There are several different types of these, which are distinguished by the mechanism whereby the air is cooled. These mechanisms are illustrated in Figure 2 and can be described as follows:

1. Spraying water away from the face of a finned coil

50. This type of equipment tends to be used as a conventional dry air cooler for long periods. Only when ambient temperatures or the cooling load rise, is water sprayed outwards in front of the coils to improve cooling effectiveness (see Figure 3). This spraying can produce significant amounts of aerosol in the vicinity of the unit which will be dispersed especially in windy conditions and, if the water has been standing in the supply system or a deadleg for some time, it may contain significant levels of bacteria including legionella. The aerosol will be disseminated into the surrounding area and if inhaled could constitute a high risk. Some of these systems are intended to evaporate all the water sprayed into the air but in practice this is difficult to achieve.

There is also a high risk of scale or other deposits precipitating onto the face of the coil/ fins as the water evaporates. This reduces the heat transfer effectiveness and so negates any advantage of adiabatically cooling the air. This type of system would not require notification under the NCTEC Regulations but creates a risk that needs to be managed and controlled.

Fig. 2 Examples of different configurations of dry/wet coolers
2. Spraying water towards the face of the finned coil

51. As for 1 above, aerosols are produced and if the water contains significant levels of legionella, may similarly constitute a high risk. This method carries a high risk of scaling on the face of the coil and normally needs the use of demineralised water supply. This type of system would require notification under the NCTEC Regulations.

3. Spraying water onto a mesh-like structure from which it evaporates

52. This design achieves better and more predictable performance than spray only units. However there remains the risk of generating aerosols if there are blocked nozzles or if not all of the spray water is evaporated. This type of system would not require notification under the NCTEC Regulations but creates a risk that needs to be managed and controlled.
4. Distributing water over cooling pads through which the air flows

53. When the unit is in wet mode a regulated volume of water is distributed over honeycomb-type cooling pads mounted in front of the heat exchange coils. Figure 7 illustrates this type of unit and Figure 8 shows the principle of operation where water is passed over / onto porous membrane cooling pads, through which the air flows horizontally. This achieves significantly improved pre-cooling of the air without creating aerosols. A portion of the water is evaporated and there is normally an overfeed to help wash the pads. In this instance it is important this water does not remain in the sump of the unit and either goes to drain or is re-used in a water recovery system. This type of unit is specifically designed to avoid the generation of aerosols. The air speed through the pads prevents droplets of water being stripped from them. This type of system is would not require notification under the NCTEC Regulations but creates risk that needs to be managed and controlled.

Fig. 7 Adiabatic cooler with cooling pads

Fig. 8 Schematic showing how air is cooled within cooling pads without the generation of aerosols
Disclaimer: the Water Management Society has published this document as part of a series of guidance papers designed to give support in the control of legionella. Guidance in this document does not replace any legislative requirements and should be used in conjunction with any manufacturers’ recommendations.

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The Water Management Society
6 Sir Robert Peel Mill, Hoye Walk, Fazeley, Tamworth, Staffs B78 3QD
Telephone: 01827 289558   Fax: 01827 250408   Email: admin@wmsoc.org.uk
www.wmsoc.org.uk

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