THE WATER MANAGEMENT SOCIETY

Guidance for End Users on Remote Temperature Monitoring Systems - Part Two

Interpretation and management of data

Guidance produced by
Water Management Society Working Party

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Scope and Introduction

1. This Part 2 guidance is intended to follow on from the Part 1 remote temperature monitoring guidance published by WMSoc[1]. The first part gives advice on the principles to consider when selecting a remote temperature monitoring system. This document is intended to give guidance on data interpretation in terms of risk and how to use the data for practical risk management. It provides general advice on the principles involved, but cannot give firm and fast metrics for remote monitoring that are universally applicable. Users must develop and take responsibility for their own schemes of control. For the avoidance of doubt, this document does not deal with other uses of remote monitoring such as resource deployment for flushing or leak detection, but users could consider its wider application.

Introduction

2. Compliance is a term often used in Legionella management in relation to specific metrics contained within guidance such as HSG274[2]. The compliance required is with the law rather than with guidance from HSE, WMSoc or any other source. The law is written in such a way that duty holders are responsible for the risk created by their undertaking. The requirement is to reach a level of risk that is as low as reasonably practicable (ALARP) through a process of risk assessment, risk elimination, substitution, and control of residual risk.

3. What is reasonably practicable is not a fixed quantity. The expectation for control and monitoring will evolve as technology develops. The use of remote sensors is something that may not have been practicable in the past but is now becoming more mainstream. Use of this type of technology may become the expectation for what is reasonably practicable in complex and high risk systems in the future.

4. This document is aimed primarily at duty holders and end users but it is acknowledged that it is likely, and expected, to also be used by service providers.

5. Remote temperature monitoring systems will generate larger volumes of data than more traditional manual monitoring. Due to the volume of data gathered and the timing of data collection, it is expected this will also include many readings that would traditionally be considered out of specification. It is important not to be overwhelmed by the volume of data created and not to lose sight of the goal of risk management. This technology can provide enhanced insight on several of the key principles of Legionella risk management.

6. The deployment of remote monitoring may be a recommendation that arises from a Legionella risk assessment, operational concerns, the duty holder, or availability of monitoring resource. The decision process for selecting remote monitoring is covered in part 1 of this guidance and for the purposes of this document, it is assumed that remote monitoring has been chosen.

How Remote Monitoring Relates to Risk Assessment and Written Scheme of Control

Risk Assessment

7. How remote monitoring is deployed for the purpose of routine monitoring of control in a domestic hot and cold water system should be dependent on the findings of the risk assessment for that system. There is a wealth of published guidance on water system risk assessment, including the Water Management Society's W043 (2023)[3], and the British Standards Institution's BS 8580-1: 2019[4]. Both documents highlight the need to assess the inherent and residual risks posed by the water system.

8. Legionella risk assessors undertaking formal risk assessment need to gain an understanding of the control profile within the building they are assessing. If a control system is based on temperature this will be a thermal control profile. At the time of writing this guidance, it is acknowledged that most risk assessments conducted on water systems use traditional methodologies that involve physical examination of the system and its components, e.g., manual temperature profiling of the hot and cold services. This usually involves a limited data set taken over a relatively short period. The temperature measurements that are taken are assessed against currently available guidance that, in effect, appraises the ability of the hot and cold services to reach set target temperatures within a defined period. It is accepted widely, however, that these measurements do not necessarily reflect normal operation of the water system, and that they do not always provide reliable assurances that the entire water system is operating safely. This can become more of an issue as the size and/or complexity of the water system increases.

9. If there is a remote monitoring system already in place there may be a wealth of data available that would be invaluable to the risk assessor. This information should be asked for by the assessor and provided by the duty holder to inform the assessment of risk. While the manual recording of a thermal profile becomes less important if there is remote data, manual validation by the risk assessor during the risk assessment process is still important.

10. An existing risk assessment and its rating of the inherent risk presented by a water system can be a useful tool in deciding how many sensors are required and where they should be deployed. Where a water system presents a high inherent risk, the number of remote sensors required to provide assurance that the system is operating safely will likely be more than for those with lower inherent risk. The locations of the sensors around the system will also be influenced by the inherent risk and remote monitoring technology may be one of the measures identified to help reduce risk to ALARP.

11. However, once the remote monitoring system has been operational for a period of time, it may identify operational characteristics of the water system that had not been recognised in the original assessment (e.g., poor flow through subordinate and tertiary loops, bypassing of parts of the system). If this is the case, the risk assessment should be reviewed and updated, and actions required to remedy any faults identified and implemented.

12. Remote monitoring may also influence the choice of sentinel outlets across a water system. Often, risk assessments identify these outlets based on their proximity to either the heating source (calorifier or plate heat exchanger) or the source of cold water (storage tank or mains supply). This type of approach may be appropriate for smaller simple water systems, but can be of limited value in larger, more complex systems. The use of remote monitoring may well identify areas of the water system that are more prone to failure, e.g., subordinate and tertiary loops where there may

be low or no flow, long runs of non-circulating pipework in the cold water distribution network. Where these areas are identified, the risk assessment should be updated to include the newly identified sentinel outlets.

13. A unique property of remote monitoring, subject to how it is applied to the water system, is its ability to determine reliably the time that has elapsed since a water outlet was opened. In other words, it can be used to identify infrequently used outlets with a high degree of certainty, which was not possible before. Keeping water moving through a water system to avoid stagnation and conditions where waterborne pathogens can proliferate in biofilms is a very important facet of control. The reliable identification of infrequently used outlets should also elicit review of the risk assessment.

14. The nature of remote monitoring systems is such that much greater detail on the way water systems operate in normal use (rather than when being subject to risk assessment or traditional monitoring procedures) can be gathered and analysed. The greater volume and quality of data collected gives better visibility of the level of risk associated with a water system and should be used to inform a continuous review of the risk assessment, i.e., as problems are identified, these are recorded, and actions are taken to remedy them. Most likely, this will be of greatest value in the early stages of deployment, as actual operational characteristics of the system come to light, but it should also provide an ongoing means to identify other problems that might arise in a timely and reliable way.

Written Scheme of Control

15. Written schemes of control must be based on identified risk specific to the individual building and water system. Guidance, including this, can be drawn on to help develop a scheme of control, and if remote sensors form part of the monitoring process, their use should be included in the written scheme.

16. The written scheme of control should be based on the findings of the risk assessment. When a remote monitoring system is used and it identifies factors that influence risk, but which had not been identified in the original risk assessment, these should be used to inform a review of the risk assessment and written scheme of control.

17. The review might include adding outlets that require flushing and identifying additional or alternative sentinel outlets as monitoring points. The written scheme of control should be reviewed and updated as and when new information becomes available from the remote monitoring system and should reflect the revised assessment of risk.

18. Guidance indicates that we should update our risk assessment when changes occur, the use of remote monitoring can provide greater levels of intelligence to fulfil this requirement by way of circulation, sentinel, outlet usage, temperature and plant monitoring. With the correct (and appropriate) outputs from these elements feeding into the written scheme of control the water system can be managed in a more proactive, effective, and economic way.

Specific Short Term Applications

Assistance with Risk Assessment

19. As part of the process of risk assessment it may be useful to deploy a temporary installation of remote sensors for days or weeks to obtain a high quality, detailed thermal profile. With the above in mind, it is possible to monitor many aspects of a water system simultaneously and this can offer an effective means to gather information at specific times in a water system's life span, such as during the commissioning phase of a new installation or for risk assessment purposes.

Investigative Monitoring

20. Where problems have been identified in a building's water system and further investigation is required, deploying remote monitoring to aid in investigation works and supporting a diagnostic phase pre or post an event, can achieve better outcomes.

Alert Philosophy and Design

Alerts Best Practice

21. Remote monitoring systems should be set to alert the appropriate people if, or when, the water system requires attention. The setting of these alerts, sometimes known as notifications or alarms, needs to be undertaken with a specific purpose in mind and be effective in communicating the requirement for action, clearly identifying the cause of the issue and the action to be completed. Alerts should be set as detailed within the system's written scheme of control and routinely tested.

22. There is limited guidance on the setting of alerts in relation to management of water systems, the most relevant supporting guidance is BS EN 62682:2015[5]. Whilst this guidance is not specific to water management in the context of Legionella risk, the principles can be applied.

23. Once an alert has been raised it must be dealt with in a timely manner, the time for resolution will depend upon the nature of the alert and the type and setting of the water system (e.g., in a healthcare building, the response time might be shorter than elsewhere). The remote monitoring system should be capable of logging that the corrective action has been taken and by whom. Where an alert has not been dealt with within the specified timeframe, it must be escalated. Systems used must have a way of escalating alerts effectively, which may be via a separate system, such as a CAFM system.

For further guidance on alerts see Appendix.

Managing Alerts in Water Systems

24. The duty holder must ensure that staff are fully trained and understand the data and alerts raised. There may be more data points that appear 'non-compliant' with the conventional recommended temperatures, but staff should recognise that this is normal and does not necessarily mean that the system is out of control. The alert settings should reflect the operational use of the water systems concerned and recognise that, for many systems, the water temperatures are unlikely to be the same as we would expect to see when an outlet is run for traditional monitoring purposes. For this reason, the control scheme, for certain assets, may be based more on water use and water movement than the temperature achieved.

25. Alert rationalisation is the process of optimising the alert system for safe operation by reducing the number of alerts, reviewing their priority, and validating the alert. By undertaking such steps, unnecessary actions are avoided, and when a high priority alert occurs, it has more visibility.

26. The use of a RAG (red, amber, green) alert stages is generally considered appropriate, e.g., where red alerts require immediate attention and amber alerts require monitoring. N.B. Green alerts should not be raised for actions.

27. Where water systems and buildings are in a repeated state of alert, it will be necessary to identify why this is the case. Remote monitoring may have identified that regular flushing or changes to the water system are necessary. Modifications to the system may take some time to implement and flushing will be required in the interim. Risk decisions based on remote monitoring data will focus on temperature and flow, and CATES and other data sets are often required to make an informed decision on the data presented for the whole system.

28. Where there is a connection of the remote monitoring system with other software systems, such as asset management tools and BIM, then it must be decided which platform will lead and issue alerts. It must also be decided on which platform responses from alerts and actions will be recorded and the digital logbook be maintained.

Interpreting Data

29. When reviewing real time temperature data there needs to be a holistic approach to risk management, that encompasses planned maintenance records and other relevant information, such as sample results, combined with the 'real time' data. This will help understand on site conditions and the risks presented, allowing for a greater level of understanding.

30. Analysis of the wealth of data gathered should more clearly show trends and issues which may allow pre-emptive interventions to solve problems before they occur. The supporting data may also help in justification of costs for maintenance and repair.

Risk Factors that May Not Trigger an Alert

31. When reviewing data, we should be wary of:

- Any graph that shows little or no fluctuations in temperature readings.
- Mirroring where temperatures are mirroring other external influences. e.g., where a graph shows temperature of mains reaches equilibrium of the ambient temperature inside the building.
- Non-compliant intermittent spiking, where taps such as non-concussive taps operate but briefly giving a false sense of flow.
- System ambient recovery, where a flow event has been realised and the system reverts to ambient influences rapidly.
- Data veracity, where data from different sources such as representative outlet monitoring does not match remote monitoring data.
- When looking at graphs over a long period of time the graph can be flattened giving a false representation of data.
- Operators should satisfy themselves that automatically generated reporting is correctly reflecting the system operation.

What the Data Means to You

32. The data from remote monitoring must be translated into a judgement and then, if necessary, an action. This judgement should be based on the likelihood of Legionella developing within the system, based on a combination of information relating to water temperature and water movement.

33. If water is not allowed to stagnate and control temperatures can be achieved, the system is far less likely to promote the growth of Legionella than a system that contains static areas and cannot achieve temperature.

34. There are decisions that must be made when designing a control scheme using remote monitoring that need to be realistic and pragmatic. There are four key areas where decisions must be made for alert setting:

- Parts of the system where temperature can realistically be controlled – tanks, calorifiers, plate heat exchangers, circulating hot water, etc. These areas can have control limits defined that are relatively simple and would follow traditional advice in HSG274 part 2 for manual monitoring.
- Parts of the system where water movement is intended and expected to occur – circulating hot water principal, subordinate, and tertiary loops, etc. Circulation criteria can be set for these areas relatively simply and schemes of control can be programmed to consider times when circulation may be switched off e.g., out of hours.
- Parts of the system where it is likely and expected that water temperatures will not be maintained constantly, non-circulating hot or cold water pipework to outlets, spurs leading from circulating loops to outlets, etc. These are the parts of the system where determining alert criteria can be challenging. Water movement is likely to be more relevant to risk than static temperature in these areas. The capability of reaching temperatures that do not favour Legionella growth, capability of reaching temperatures that will kill Legionella relatively quickly, or regular water usage all factor into lower risk.
- Control schemes must consider what 'acceptable' is in the context of that system. This definition should consider expectations for temperature at critical control points (tanks, calorifiers, plate heat exchangers, etc.), water movement criteria for parts intended to circulate, and a combination of the two for all other monitoring points.

Summary

35. The use of remote monitoring can greatly improve the risk assessment and risk management process, especially in complex buildings, and help identify issues pre and post events. The risk assessment process is critical to the correct deployment of remote monitoring devices. Where remote monitoring is deployed it must be included in the written scheme of control.

36. Remote monitoring presents a unique opportunity to understand the usage of water within a building. Individual results are important but the ability to analyse trends is key and allows timely and proactive measures to be taken and faults to be remedied to create safer systems.

37. As outlined in Part 1, where a duty holder has decided to use remote monitoring, they should take the same steps that they would when deciding upon a service provider for any provision of competent help and ensure that the systems are suitable and any contractors that they use are competent.

38. The duty holder must ensure that staff understand the information that they are being asked to rely upon and ensure that alternatives are in place if the technology fails. All parties should expect more data points that appear 'non-compliant' with the conventional recommended temperatures, but recognise that this is normal and does not necessarily mean that the system is out of control.

39. Suitable periods of time should be allowed for the system to 'bed-in' and to understand what the data mean, and then set the appropriate alerts protocol. Once this is in place, it must be agreed who will act upon these alerts and what they will do when they receive them.

40. Remote monitoring will change how we monitor and view our water systems and they should consequently be safer. There is vast scope for further development in remote monitoring with the application of other sensors and the use of AI to interpret the large data sets generated. The WMSoc will continue to review this technology and issue further guidance as required.

Glossary of Terms

ALARP - As Low As Reasonably Practicable risk. ALARP risk is a judgement for the risk assessor to make, often in consultation with the responsible person. ALARP is the target to reach, and the recommendations in the risk assessment must bridge between where the risk is now (residual risk), and the ALARP risk level. It is important for risk assessors not to make impossible or impracticable recommendations in their risk assessments. Cost, however, is not an overriding factor on all levels of practicability. While it may not be possible to reach a level of 'no risk', the acceptable level of risk is ALARP. A recommendation for the use of remote monitoring may be an output from a risk assessment to achieve ALARP risk.

AI - Artificial Intelligence or machine learning. The use of computers to recognise patterns and solve problems with large data sets. In the context of remote monitoring AI might be used to draw a conclusion from available data on a metric not directly measured, for example flow.

Asset Management Tools - a dedicated application which is used to record and track an asset throughout its lifecycle from procurement to disposal. In the area of remote monitoring these will provide centralised visibility via a dashboard where all assets can be monitored, and some come equipped with remote diagnostic features that enable remote teams to access relevant data and tools to identify and resolve problems without the need for onsite intervention. Asset management tools often include analytics capabilities that allow organisations to analyse and provide varied reporting allowing for a more holistic performance trending analysis, identifing areas for improvement, and making data-driven decisions. These insights empower teams to optimise asset utilisation and maximise ROI.

BIM - Building Information Modelling is a workflow process based around modules used for the planning, design, construction and management of building and infrastructure projects.

CAFM - Computer Aided Facilities Management software enables Facility Managers to plan, execute and monitor all activities involved in reactive and planned preventative maintenance, asset management, operational facility services, and other services.

CATES - The CATES approach to risk assessment is a systematic method for evaluating the risk of exposure to contaminants in the environment. It involves considering five key factors: Contamination, Amplification, Transmission, Exposure, Susceptibility. Further details can be found in BS 8580-2[6].

Inherent risk - This is the underlying risk if there were no controls in place, or if controls were to fail or be removed. The inherent risk is influenced by a range of factors, including the size and complexity of the system, its design characteristics, materials of construction, and patterns of usage. Importantly, the likely susceptibility of users of the system to infection by opportunistic waterborne pathogens, such as legionellae, should also affect the assessment of inherent risk. For example, a hot and cold water system with storage tanks and large calorifiers is a higher inherent risk than a mains fed system with a point of use instant heater. Some systems will generally always be higher inherent risk as they rely on water treatment for control, for example, cooling towers or spa pools. Similarly, if there are prolonged periods where the system, or parts of it, are underused, inherent risk increases. If the water system is likely to be used by people who are more vulnerable to infection (e.g., because of their age or immune status), the inherent risk presented by the system is likely to be elevated (e.g., in healthcare premises, nursing and care homes).

The inherent risk is something that the risk assessor needs to quantify, and it may be possible to make recommendations to reduce the inherent risk with changes to the system. The hierarchy of control outlined in COSHH[7] starts here with elimination or substitution of risk. For example, removing a cold water storage tank and converting to mains feed will reduce the inherent risk presented by the water system.

Real-time - data received by a processing system or user as it is recorded. Many remote monitoring systems batch their data transmission, but for all intents and purposes the data are real time in comparison to manual monitoring.

Reasonably Practicable - weighing the risk of not doing an action against the trouble, time and money needed to complete the action to control the risk. A dutyholder must first consider what can be done – that is, what is possible in the circumstances for ensuring health and safety. They must then consider whether it is reasonable in the circumstances to do all that is possible.

Residual risk - This is the risk observed by the assessor during the risk assessment process with the current controls in place. These might include physical and procedural mitigation measures, such as insulating hot and cold elements of the system to minimise heat transfer, flushing of systems to reduce the likelihood of stagnation and biofilm formation, and cleaning parts of the system (e.g., storage vessels, valves, and shower fittings). Residual risk can be reduced with additional controls or by reducing the underlying inherent risk. For example, the residual risk of a hot water calorifier running at 40°C is high and this can be reduced by applying the control measure of increasing the hot water temperature to store at 60°C and distribute above 50°C. The risk could alternately be reduced by addressing the inherent risk and fitting a non-storage point of use heater.

Sentinel - The term sentinel, as it is applied to water safety, refers to the use of that outlet or point in the system as one that required extra attention because it is where things are most likely to go wrong, i.e., it acts as a look out to provide early warning if the system fails.

Written scheme of control - a written plan for the control of the identified risk. HSG274 appendix 2 gives detailed guidance on what should be included in a written scheme of control including detailing the analytical and operational checks in place. Remote monitoring must be included in the written scheme of control when it is used as it is one of the analytical and operational checks that have been chosen to address the identified risk.
A written scheme of control is usually specifically for Legionella control but in some cases may incorporate other elements or pathogens. In healthcare or some other complex settings, it may be more appropriate to have a water safety plan that may include or replace the written scheme of control.

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Appendix

Alert Guidance

Below are some important guidelines for the use of alerts on water systems;

1. **Only set an alert if you have an action to be completed.** There is a risk when setting up a new system that alerts are set too stringently. This means that alerts may start to be ignored if it is the case that when they are received, there is no action to be completed.

   Further to this, once alerts are appropriately set there should be a clear set of instructions for the person responding to the alert as to what steps/actions to take.

2. **Alerts should be set to allow sufficient time for action.** The set point for any alert should be early enough to ensure that there is sufficient time for action to be taken. This may mean you have different set points on different parts of your water system because to act in different areas may require longer or shorter periods of time. For example, if you are remotely monitoring somewhere a significant travel distance from your main site then travel time should be considered when setting the alert criteria.

3. **Alerts should be routinely tested.** Testing should be of the whole alert process and not just the alert itself. The test should ensure that when an alert is triggered the correct persons are notified and that they have sufficient information, training, and competence to take the appropriate action.

4. **What happens if things break.** Sometimes technology breaks, there are power or Wi-Fi outages. Ensure you have an effective plan to cover both short and long term outages of your remote management system.

5. **Alerts should be set to clearly identify the cause of issues.** Often remote monitoring systems will have multiple parameters set that will raise alerts. This can be beneficial in ensuring a good monitoring of conditions across the water system. However, issues can arise when one fault, for example non-functioning of a calorifier, causes alerts to be triggered across the water system leading to large numbers of alerts that may make identification of the root cause time consuming.

The alerts themselves should also be reviewed as you would with any Legionella control or monitoring system, and as part of the written scheme of control. Management must review the system information to gain better understanding of risk, and it is recommended that alerts are reviewed on a monthly or quarterly basis.

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