

Rail Delivery Group



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Issue Three

Date October 2019

Guidance Note – Control of Risk Posed by the Presence of Legionella Bacteria in On-train Water Systems

Synopsis

This Guidance Note provides advice on assessment of risk posed by the presence of legionella bacteria in on-train water systems not required to be 'wholesome' along with associated control and mitigation measures. Such measures will generally also be effective against other micro-organisms.

Applicability

This Guidance Note has been prepared for passenger train operating companies. However, its content may also be of use to others.

Authorised by

A handwritten signature in black ink, appearing to read "Ellie Burrows".

Ellie Burrows
Chair, RDG TOC Safety Forum

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RDG Guidance Note – Control of Risk Posed by the Presence of Legionella Bacteria in On-train Water Systems

Issue record

Issue	Date	Comments
One	January 2013	Original ATOC document
Two	October 2014	Following revision of HSE guidance (Fourth edition of ACoP L8 and issue of Technical Guidance HSG274)
Three	October 2019	Review, update and put into RDG format plus replacement of potable water with wholesome that links to the legal definition

Contents

Part 1 About this document.....	5
1.1 Responsibilities.....	5
1.2 Explanatory note.....	5
1.3 Guidance Note status.....	5
1.4 Supply.....	5
Part 2 Purpose, applicability and introduction	6
2.1 Context	6
2.2 Purpose	6
2.3 Scope.....	7
2.4 General application.....	7
2.5 Applicability to 3rd parties.....	7
2.6 Introduction	7
Part 3 Definitions	8
Part 4 Standards and Legal Position	9
4.1 Existing Standards for water not required to be wholesome	9
4.2 Legal position.....	9
4.3 HSE publications L8 and HSG274	10
4.4 HSE suggested action levels following sampling	12
Part 5 Legionella and Legionnaires’ disease	13
5.1 Overview of legionella	13
5.2 Overview of Legionnaires’ disease.....	13
5.3 Infection and aerosol production	13
5.4 Individual susceptibility.....	13
5.5 Occurrence	14
5.6 Summary of risk components	14
Part 6 Testing and re-testing.....	15
6.1 General requirements.....	15
6.2 Actions to be taken in the event of a positive test result	15
6.3 Trains returning to use after being out of service	15
Part 7 Risk posed by the presence of legionella in on-train water systems not required to be wholesome	16
7.1 Findings from T985 research.....	16
Part 8 Risk factors posed by the presence of legionella & associated risk reduction measures	16
8.1 Contamination.....	16
8.2 Amplification	17
8.3 Temperature	17
8.4 Presence of nutrients.....	17

8.5	Presence of biofilms	18
8.6	Materials used in ground-based and on-train water systems not required to be wholesome.....	18
8.7	System throughput	18
8.8	Hose management	19
8.9	Amplification – treating existing high concentrations of bacteria.....	20
8.10	Transmission	20
8.11	Exposure to aerosols.....	21
8.12	Host susceptibility.....	21
	Part 9 Record keeping.....	21
9.1	Overview.....	21
	Part 10 Responsibilities and training	21
10.1	Overview.....	21
	Part 11 References and other sources of information	22
11.1	Guidance and information:	22
11.2	Websites:.....	22
	APPENDIX A - COMPARISON OF LEGIONELLA DOSING AGENTS	23

Part 1 About this document

1.1 Responsibilities

- 1.1.1 Copies of this Guidance Note should be distributed by RDG members to persons within their respective organisations for whom its content is relevant.

1.2 Explanatory note

- 1.2.1 RDG produces RDG Guidance Notes for the information of its members. RDG is not a regulatory body and compliance with RDG Guidance Notes is not mandatory.
- 1.2.2 RDG Guidance Notes are intended to reflect good practice. RDG members are recommended to evaluate the guidance against their own arrangements in a structured and systematic way. Some or all parts of the guidance may not be appropriate to their operations. It is recommended that this process of evaluation and any subsequent decision to adopt (or not to adopt) elements of the guidance should be documented.

1.3 Guidance Note status

- 1.3.1 This document is not intended to create legally binding obligations between railway duty holders and should be binding in honour only.

1.4 Supply

- 1.4.1 Copies of this Guidance Note may be obtained from the RDG members' website

Part 2 Purpose, applicability and introduction

2.1 Context

- 2.1.1 Legionella bacteria are responsible for legionellosis, the collective name for a number of pneumonia-like illnesses, the most serious of which is legionnaires' disease, a potentially fatal form.
- 2.1.2 Legionella can be found in the environment, including natural and man-made aquatic sources but are a particular concern in water management systems, especially those with sitting or low flow of water at warm temperatures between 20-50, as these are most associated with the risk of transmission of infection to the public and workers (WHO 2007).
- 2.1.3 Those at greatest risk from legionella include the elderly, those with long-term health conditions and smokers, all of whom can be found on passenger train services.
- 2.1.4 Any water system that has the right environmental conditions could potentially be a source for legionella bacteria growth and this includes on-train water systems not required to be 'wholesome'. General health and safety law accordingly places duties on employers or persons in control of a premises to take suitable precautions to prevent or control the risk of exposure to legionella where there is reasonably foreseeable risk.
- 2.1.5 The HSE has published two documents - an ACoP/guidance on regulations (L8) and a technical guidance document (HSG274) - that together provide comprehensive guidance on the applicable legal requirements and how compliance with them may be achieved. These should be regarded as the definitive source of all legionella related information appropriate to railway undertakings and attention is drawn to them accordingly – further details are provided in section 2.8.3.

2.2 Purpose

- 2.2.1 The presence of legionella bacteria in on-train water systems, i.e. those systems typically supplying water to toilets and hand basins, poses a potential risk to both passengers and staff. Should non-potable water systems contain high concentrations of legionella, they pose a hypothetical risk when an aerosol is generated through using toilets or taps or in manual drainage or filling operations. As it is not possible to guarantee that any water system will be free from legionella, the aim should be to reduce the risks through preventing the circumstances in which legionella thrive.
- 2.2.2 The concentrations of such bacteria, the speed at which they multiply and their ability to result in human infection are determined by a wide variety of different factors. Given this, together with a general absence of scientific studies on the specifics of on-train non-potable water system, it is not possible to identify prescriptive control measures which are universally effective against and proportionate to the risks faced by different operators.

- 2.2.3 Rather than setting out specific requirements in terms of dosing agents, methods, periodicities, etc., this Guidance Note is therefore intended to assist railway undertakings in undertaking risk assessments and identifying and applying control and mitigation measures for reducing the risks posed by the presence of such bacteria in on-train water systems not required to be 'wholesome' that are appropriate to their own circumstances.
- 2.2.4 While the content of this document and the results of RSSB research project T985¹ on which it draws are specific to legionella, it is reasonable to expect that the suite of risk reduction measures referred to in this Guidance Note – with the possible exception of specific dosing agents - will also be effective against other micro-organisms which may potentially also be present.

2.3 Scope

- 2.3.1 This Guidance Note is produced for the benefit of all member organisations of the RDG Train Operations and Engineering Schemes that operate rolling stock with on-train water systems not required to be 'wholesome'.

2.4 General application

- 2.4.1 This Guidance Note applies to on-train non-potable water systems along with the ground-based systems/facilities which supply them and which are hence potential sources of contamination. It does not address other off-train water systems not required to be 'wholesome' (such as train washing plants, rolling stock underframe cleaning, building water systems, etc.), though its content may also be of relevance to managing legionella related risks associated with these.

2.5 Applicability to 3rd parties

- 2.5.1 Railway undertakings should ensure that any 3rd party supplying non-potable water to its trains and/or any 3rd party responsible for maintaining on-train non-potable water systems on its behalf is conversant with and complies with any measures it deems suitable and sufficient to manage the risks described in this Guidance Note.
- 2.5.2 A separate RDG Guidance Note covers on-train required to be 'wholesome' (i.e. drinking) water systems GN021 - Provision of Drinking Water for On-Train Use.

2.6 Introduction

- 2.6.1 Typically, 300-500 or so cases of legionella are reported in the UK each year, of which around one third are acquired through travel abroad, half are community acquired and the remainder are associated with healthcare or unknown sources (European Centre for Disease Control).
- 2.6.2 Rail travel is not a recognised risk unlike travel by modes with complex water systems such as cruise ships, and there is no evidence from the UK, nor, so far as is known, from elsewhere in the world, that anyone has ever contracted Legionnaires' disease (the form of pneumonia caused by the legionella bacterium) from travelling on a train. However, routine sampling and testing of vehicle toilet water tanks undertaken by one UK railway undertaking in early 2011 identified the presence of significant concentrations of legionella bacteria.

¹ T985 – Identification and analysis of risks posed by legionella bacteria in on-train non-potable water systems – see part 9

- 2.6.3 In response to this, more widespread sampling was conducted by a number of other railway undertakings and the collated results from these tests revealed a significant percentage of vehicles to have concentrations of legionella bacteria present in their on-train water systems not required to be wholesome in excess of those for which the relevant HSE Approved Code of Practice and guidance required action to be taken².
- 2.6.4 RSSB was accordingly asked by the Association of Train Operating Companies (ATOC) to commission research to determine the extent of the problem and likely causes, quantify the risk posed to passengers and staff, and identify effective and proportionate mitigation measures.
- 2.6.5 As explained in greater detail in part 5, lack of data precluded a robust quantification of the risk and hence it was not possible to determine the maximum justifiable expenditure on mitigation measures. The research did however demonstrate that risk is dependent on a number of factors and that appropriate mitigation regimes will therefore vary between TOCs and even between rolling stock types and/or depots operated by the same TOC. It also identified a number of potentially practical risk reduction measures. This Guidance Note draws on the findings and recommendations from this research and also the content of the HSE publications L8 and HSG274 (see 2.8.4) and promotes a systematic assessment and management of water systems that could pose a legionella risk

Part 3 Definitions

Term	Definition in the context of this document
Aerosol	A suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having a negligible falling velocity. In the context of this document, it is a suspension of particles which may contain legionella with a typical droplet size of <5µm that can be inhaled deep into the lungs.
Biofilm	A community of bacteria and other microorganisms embedded in a protective layer with entrained debris, attached to a surface.
Bowser	A mobile means of transporting water from a mains distribution system to the site for loading water onto a vehicle.
CFU	Colony Forming Unit – a means of measuring the concentration of bacteria.
Dosing	Treatment of water systems or components thereof with chemicals as a means of countering/removing contamination by legionella bacteria, including chlorination, application of hydrogen peroxide, chlorine dioxide, etc.
Ground-based system	System/facilities which supply water to the train, such as storage tanks, stand pipes, water bowzers, etc. The scope of the ground-based system extends from the main water supply up to and including the hoses connected to the tanking points on each vehicle.
Legionella bacteria	The bacterium Legionella pneumophila.

² At the time this was HSE publication L8 - Legionnaires' disease - The control of legionella bacteria in water systems Approved Code of Practice and guidance (Third edition), published 2000. This information is now contained in HSE publication HSG274 Part 2 Legionnaire's Disease Part 2: The control of legionella bacteria in hot and cold water systems though the trigger concentrations and actions to be taken are themselves essentially unchanged.

Legionnaires' disease	A potentially fatal form of pneumonia of which the Legionella pneumophila bacterium is the predominant cause (c. 80-90% of cases).
Water not required to be 'wholesome'	Water that is not of drinking water quality, as used in on-train sinks and toilets.
Testing	Sampling, testing and analysis of results.
Wholesome water	Means water which meets the national standards for drinking water quality and is suitable for drinking, cooking and other domestic purposes; it is the quality of water supplied by the Water Supplier as defined in the legislation

Part 4 Standards and Legal Position

4.1 Existing Standards for water not required to be wholesome

- 4.1.1 Unlike wholesome (i.e. drinking) water, no quality standards for the control for water not required to be wholesome are known to exist within the UK.
- 4.1.2 Guidance on managing the risks associated with the presence of legionella bacteria in water systems in general is available from the following HSE publications:
- i) L8 - Legionnaires' disease - The control of legionella bacteria in water systems Approved Code of Practice and guidance on regulations (Fourth edition), published November 2013.
 - ii) HSG274 Technical Guidance: Legionnaire's Disease Part 2: The control of legionella bacteria in hot and cold water systems, published June 2014
 - iii) Legionnaires' disease – A brief guide for duty holders, published in April 2012.;

and also the British Standards Institute publication *BS 8580-1 - Water quality. Risk assessments for Legionella control. Code of practice* published in January 2019.

An overview of the content of L8 and HSG274 is provided in section 4.3.

4.2 Legal position

- 4.2.1 While there is no legislation specific to legionella, railway undertakings are subject to general health and safety legislation that requires that personnel and the public are protected from risks and this should be taken to include those associated with legionella. More specifically:
- i) Control of Substances Hazardous to Health Regulations 2002 (COSHH) – where "substance" is defined as meaning 'a natural or artificial substance whether in solid or liquid form or in the form of a gas or vapour (including micro-organisms)'

- ii) Health and Safety at Work etc. Act 1974 - Sections 2, 3 and 4 respectively place a duty on every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all employees; to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety; and on each person who has control of premises to take such measures as it is reasonable for a person in his position to take to ensure, so far as is reasonably practicable, that the premises are safe and without risks to health.
- iii) While the term 'premises' is not defined within the Act, it would seem prudent to assume that this could be taken to include trains, including in the event of a prosecution
- iv) The Management of Health and Safety at Work Regulations 1999 – requires every employer to make a suitable and sufficient assessment of the risks to the health and safety of his employees to which they are exposed whilst they are at work; and the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking and then to identifying measures for reducing such risks.

4.3 HSE publications L8 and HSG274

4.3.1 Between them, HSE publications L8 and HSG274 provide comprehensive guidance on all legal and risk control aspects of legionella management.

4.3.2 *L8 – Approved Code of Practice and guidance on regulations*

The fourth edition of HSE publication L8 - Legionnaires' disease - The control of legionella bacteria in water systems Approved Code of Practice (ACoP) and guidance on regulations was published in November 2013. It contains:

- i) Legionnaire's disease – including an overview of the legionella bacteria, where it may be found, conditions favourable to its proliferation and the risk it poses to human health and this may be reduced.
- ii) Health and safety law – an overview of requirements under the Health & Safety at Work Act and COSHH pertinent to the control of risks from exposure to legionella, including risk assessments, access to competent help, the putting in place of control measures where risk cannot be eliminated; maintenance, examination and testing of such control measures; and provision of information, instruction and training.
- iii) Identification and assessment of risk - including the competence of those undertaking the risk assessment, the need to regularly review assessments, the need to consider the system as a whole, factors to consider as part of the risk assessment, the need to record the significant findings and the importance of monitoring the effectiveness of any control measures put in place.
- iv) Management responsibilities, training and competence – including the appointment of a competent person, trained, aware of their responsibilities and with sufficient authority, to help undertake the measures needed to comply with COSHH requirements; provision on information, instruction and training; and implementation and management of the control system.

- v) Preventing or controlling the risk from exposure to legionella bacteria – including (where there is a reasonably foreseeable risk of exposure and it is not reasonably practicable to eliminate the risk) the need for a written scheme to control the risk that should be properly implemented and managed, including measures to take to ensure it remains effective. The written scheme should include:
 - a) an up-to-date plan showing the layout of the water system;
 - b) a description of the correct and safe operation of the system;
 - c) the control measures to take;
 - d) checks to carry out to ensure the written scheme is effective and the frequency of such checks; and
 - e) the remedial action to take if the written scheme is shown to be not effective.
- vi) Review of control measures: Monitoring and routine inspection – including checking the performance and operation of the system and its component parts; inspecting the accessible parts of the system for damage and signs of contamination; monitoring to ensure that the treatment regime continues to control to the required standard; and interpretation of results by a competent person.
- vii) Record keeping – including details of what should be recorded and retention periods.
- viii) Responsibilities of designers, manufacturers, importers, suppliers and installers – this section is of limited relevance to railway undertakings.
- ix) Glossary.
- x) References/further reading/further information.

4.3.3 *HSG274 technical guidance*

Previous versions of the L8 ACoP included associated technical guidance but on its re-publication (fourth edition) in 2013 this was split out and included in a separate document HSG274, published in June 2014. HSG274 is itself divided into three parts and it is Part 2 – The control of legionella bacteria in hot and cold water systems, that is relevant to on-train water systems not required to be wholesome. Other parts concern evaporative cooling systems and ‘other risk systems’. Though outside the scope of this Guidance Note, it should be noted that the latter includes vehicle washers for railway rolling stock. The content of HSG274 Part 2 may be summarised as follows:

- i) Health and safety law – as per L8.
- ii) Identify and assess sources of risk – suggesting that a reasonably foreseeable legionella risk exists in any water system where:
 - a) water is stored or re-circulated as part of the system;
 - b) the water temperature in all or some part of the system may be between 20–45 °C;
 - c) there are deposits that can support bacterial growth, such as rust, sludge, scale and organic matter;
 - d) it is possible for water droplets to be produced and, if so, if they can be dispersed;
 - e) it is likely that any employees, contractors, visitors, etc could be exposed to any contaminated water droplets.

and including factors to be considered and evaluated as part of the risk assessment.

- iii) Managing the risk – as per L8.

- iv) Preventing or controlling the risk – as per L8.
- v) Record keeping – as per L8.
- vi) Types and application of hot and cold water systems.
- vii) Water system design and commissioning.
- viii) Operation and inspection of hot and cold water systems – including details to be recorded.
- ix) Water treatment and control programmes for hot and cold water systems – including temperature regime, a comparison of biocide treatments and supplementary measures.
- x) Microbiological monitoring – including sampling, analysis of samples and recommended action levels (see section 4.3).
- xi) Cleaning and disinfection – including thermal and chemical disinfection and specific guidance on chlorine-based disinfection.
- xii) Other sections not relevant to railway undertakings, including shared premises and residential accommodation: Landlords and special considerations for healthcare and care homes.
- xiii) Appendix – Legionella risk assessment – including a checklist.
- xiv) Appendix – Legionella written control system – including suggested detailed content.
- xv) Other appendices covering action to take if there is an outbreak of legionellosis and examples of sentinel points in both simple and complex hot water systems.
- xvi) Glossary.
- xvii) References, further sources of advice and further information.

4.3.4 BS 8580 – 1

This standard supplies the standard guidance on the way to conduct a legionella risk assessment.

4.4 HSE suggested action levels following sampling

4.4.1 HSG274 Part 2 includes the following guidance on action to be taken if legionella is found in a water system:

Legionella bacteria (cfu/litre)	Action required
More than 100 but less than 1000	Either: (a) If the minority of samples are positive, the system should be resampled. If similar results are found again, a review of the control measures and risk assessment should be carried out to identify any remedial actions or (b) If the majority of samples are positive, the system may be colonised, albeit at a low level. An immediate review of the control measures and risk assessment should be carried out to identify any other remedial action required. Disinfection of the system should be considered.
More than 1000	The system should be resampled and an immediate review of the control measures and risk assessment carried out to identify any remedial actions, including possible disinfection of the system. Retesting should take place a few days after disinfection and at frequent intervals afterwards until a satisfactory level of control is achieved.

Part 5 Legionella and Legionnaires' disease

5.1 Overview of legionella

- 5.1.1 Legionella bacteria are common and can be found naturally in environmental water sources such as rivers, lakes and reservoirs, usually in low numbers. As such they may eventually colonise manufactured water systems such as hot and cold water systems and other plant which use or store water. Low levels of legionella bacteria are to be expected in water systems and are not seen to pose a risk. Higher concentrations have been associated with a number of human infections, in particular Legionnaires' disease (see section 5.2), though no precise link between levels of bacteria and the likelihood of infection has yet been established.
- 5.1.2 The bacteria can survive under a wide variety of environmental conditions and have been found in water at temperatures between 6°C and 60°C, with temperatures in the range 20°C to 45°C seeming to favour growth. They also require a supply of nutrients to multiply, such as commonly encountered organisms within the water system itself such as algae, amoebae and other bacteria while the presence of sediment, sludge, scale and other material within the system, together with biofilms, are also thought to play an important role in harbouring and providing favourable conditions in which the legionella bacteria may grow.

5.2 Overview of Legionnaires' disease

- 5.2.1 While legionella bacteria can cause a number of less serious illnesses (e.g. Pontiac Fever), the greatest risk is from Legionnaires' disease, a potentially fatal form of pneumonia for which the Legionella pneumophila bacterium is responsible in c. 80-90% of cases.

5.3 Infection and aerosol production

- 5.3.1 Human infection occurs through inhaling an aerosol containing legionella bacteria. As any mechanical action that results in the surface of a liquid being broken - such as water drops falling onto a hard surface, running a tap or flushing a toilet – may result in the production of aerosols it is effectively impossible to eliminate their generation, though measures can be taken to reduce it.

5.4 Individual susceptibility

- 5.4.1 Individuals vary both in their risk of becoming infected and in their vulnerability to Legionnaires' disease. Certain groups of people are known to be at higher risk of contracting the disease; for example, men appear more susceptible than women, as do those over 45 years of age, smokers, alcoholics, diabetics and those with cancer or chronic respiratory or kidney disease who may be immunosuppressed. Similarly, while it can generally be fatal in up to 12% of cases, higher rates may apply among those within the more susceptible population as described above.

5.5 Occurrence

- 5.5.1 355 cases of Legionnaires' disease were confirmed in England and Wales in 2016, slightly higher than the annual average for the previous 10 years³. As the disease is a form of pneumonia, with similar systems and an identical treatment regime there is little incentive for hospitals to conduct the tests necessary to differentiate between Legionnaires' disease and other forms of pneumonia and based on studies the true number of cases within the UK is estimated to be significantly higher than this. Because of the seriousness of the disease, known cases tend to be high profile and attract significant media attention.

5.6 Summary of risk components

- 5.6.1 The risk to humans is governed by a five-stage process:
- i) Contamination of a water source, i.e. an initial source of legionella bacteria.
 - ii) Amplification in water, i.e. the ability of the bacteria to multiply so as to achieve concentrations which pose a risk. This is influenced by a variety of factors.
 - iii) Transmission, i.e. the generation of aerosols large enough to contain the bacteria but small enough to be inhaled deep into the lungs.
 - iv) Exposure to such aerosols.
 - v) Host susceptibility, i.e. the susceptibility and vulnerability to the disease of the individual.

Each of the above is described in more detail in part 7.

- 5.6.2 With low levels of legionella bacteria occurring naturally and generally accepted as presenting no health risk to humans, totally eliminating contamination is not a realistic option. Indeed, there is no standard with regard to the presence of legionella in drinking water and water companies do not therefore undertake to ensure that their mains supplies are entirely legionella free.
- 5.6.3 Similarly, it is not generally possible to influence the susceptibility/vulnerability of individuals.
- 5.6.4 It follows that measures to reduce the risks associated with legionella need to be focused on treating high concentrations of the bacteria. In addition, it is advisable to avoid the conditions under which the bacteria are able to multiply, reduce aerosol generation (while acknowledging that total elimination is unlikely to be possible) and reduce human exposure to such aerosols through good practice.

³ Legionnaires' disease in residents of England and Wales – 2016, published by PHE in March 2018

Part 6 Testing and re-testing

6.1 General requirements

- 6.1.1 It is recommended that railway undertakings undertake testing of water samples to ensure that the concentration of legionella bacteria is consistently maintained below the action levels set out in HSE publication HSG274 Part 2 – see table in section 4.3. Determining when and how often testing is appropriate is likely to be an iterative process based on previous results but should be part of a legionella risk control strategy. Note: There are other considerations outside the scope of this Guidance Note, e.g. off-charging costs as well as publicity and other customer service aspects.
- 6.1.2 It follows that measures to reduce the risks associated with legionella need to be focused on treating high concentrations of the bacteria. In addition, it is advisable to avoid the conditions under which the bacteria are able to multiply, reduce aerosol generation (while acknowledging that total elimination is unlikely to be possible) and reduce human exposure to such aerosols through good practice.
- 6.1.3 Analysis of water samples for legionella should be carried out by a laboratory which has UKAS (United Kingdom Accreditation Service) accreditation for legionella testing and which is registered with the Health Protection Agency's (now Public Health England's) Water EQA Legionella Isolation Scheme. The interpretation of any results should be carried out by experienced microbiologists.

6.2 Actions to be taken in the event of a positive test result

- 6.2.1 In the event of a positive test result showing levels of legionella bacteria contamination in a water storage tank in excess of the upper action level defined in HSE publication HSG274 Part 2 L8 ACoP (i.e. >1000 cfu/l) then the following immediate actions should be taken:
- i) The water storage tank in question to be completely drained.
 - ii) The water tank in question to be flushed until no sediment is present in the tank or at the outlet.
 - iii) The water tank in question to be subject to appropriate chemical dosing (see appendix A).
 - iv) Re-testing should be undertaken within 3-7 days of the above to check the effectiveness of the actions taken.

These actions should also be considered for contamination in excess of the lower action level (i.e. between 100 and 999 cfu/l) – see table in section 94.3.3).

6.3 Trains returning to use after being out of service

- 6.3.1 A requirement to flush through the system and undertake testing or dosing of vehicles which have been out of service for a significant period should be incorporated in return to service examinations.

Part 7 Risk posed by the presence of legionella in on-train water systems not required to be wholesome

7.1 Findings from T985 research

7.1.1 The research commissioned by ATOC from RSSB included a specific requirement to quantify the risk posed by the presence of legionella in on-train water systems not required to be wholesome to passengers and staff in terms of fatalities and weighted injuries (FWI). In the event this proved impossible to achieve for the following reasons:

- i) There are no known cases, either within the UK or elsewhere in the world of an individual contracting Legionnaires' disease as a result of travelling by train.
- ii) No studies have been identified that explicitly explore the relationship between levels of legionella bacteria, aerosol generation and probability of human infection.
- iii) No studies have been identified that examine aerosol generation in the on-train environment.

7.1.2 With regard to the first of the above bullets, it should be noted that the Public Health England (PHE) typically succeeds in identifying the cause of only 30-50% of the cases of Legionnaires' disease reported to it (though between one third and one half of cases are associated with overseas travel). With reported cases thought to comprise only around 5% of total cases (see section 5.4), it follows that the source of around 97.5% of all Legionnaires' disease cases remains unidentified. In addition, the analysis undertaken by the HPAPHE when cases are reported to it has not historically taken into account use of rail transport.

7.1.3 With insufficient data to support calculation of the FWI risk associated with the presence of legionella or even support a broad assumption regarding the level of risk it followed that it was not possible to calculate the maximum justifiable expenditure. It did prove possible, however, to qualitatively assess various risk reduction/mitigation measures and these are described in the following section.

Part 8 Risk factors posed by the presence of legionella & associated risk reduction measures

8.1 Contamination

8.1.1 As noted in section 5.6 it should be assumed that low levels of legionella bacteria may be present in the water received into the ground-based system from the mains supply. It follows that measures should be put in place to control amplification, both within the ground-based system and within the on-train water systems not required to be wholesome itself.

8.2 Amplification

- 8.2.1 The following have been shown to influence the speed at which and degree to which legionella bacteria are able to multiply. Railway undertakings should consider each of these in the context of their own operations as they will have a material effect both on the nature of the risk reduction measures that need to be employed and the frequency of their deployment. They should be considered with respect both to the ground-based system and the on-train system.

8.3 Temperature

- 8.3.1 Legionella bacteria are able to survive in water temperatures between 6°C and 60°C, however the organisms do not appear to multiply, but rather stay dormant, below 20°C and above 50°C. Some growth occurs from 20-25°C and also between 45-50°C but is greatest in the temperature range 25-45°C. Temperatures may also influence virulence; legionella bacteria held at 37°C have greater virulence than the same legionella bacteria kept at a temperature below 25°C. This is reflected in the higher incidence of UK national Legionnaires' disease cases reported during the summer months.
- 8.3.2 Legionella HSG274 Part 2 recommends that hot water should be stored at a minimum of 60°C and distributed so it reaches a minimum temperature of 50°C within one minute at outlets. In addition to ambient temperatures, other sources of heat include sunlight (particularly where on-train tanks are located directly below roofs which are typically dark coloured and thus absorb heat) and engine exhaust pipes.
- 8.3.3 A risk reduction stakeholder workshop conducted as part of the T985 research initially identified a number of measures that could be taken to reduce the risks of water within the ground-based or on-train water systems being stored at temperatures favourable to bacterial growth but subsequently rejected on financial/practicality grounds (though some – such as relocating/ insulating on-train storage tanks - may be viable for new build or major refurbishments).

Recommendation:

Railway undertakings should recognise that temperature is a major factor in determining the rate of bacteria growth and take this into account when determining testing and dosing regimes. Regular monitoring of water temperatures should be considered.

8.4 Presence of nutrients

- 8.4.1 Legionella bacteria require a supply of nutrients to multiply. Sources include commonly encountered organisms within the water system itself, such as algae, amoebae and other bacteria, and also the presence of sediment, sludge, scale and other material within the on-train system.

Recommendations:

1. Ground-based and on-train systems should avoid use of materials that harbour bacteria and other micro-organisms or provide nutrients for microbial growth. In general, low-corrosion materials (copper, plastic, stainless steel, etc.) perform best in this respect and are also easy to clean and disinfect.

2. Ground-based and on-train systems, and in particular storage tanks, should be flushed out and/or cleaned/disinfected so as to remove as far as possible sediment, sludge, scale etc.
3. Ground-based and on-train systems should be subject to regular maintenance.

8.5 Presence of biofilms

- 8.5.1 Biofilms similarly contribute to bacteria growth and additionally serve to protect legionella bacteria from temperatures and concentrations of biocide that would otherwise kill or inhibit these organisms if they were freely suspended in the water.

Recommendations:

1. Ground-based and on-train systems should avoid use of materials that support biofilms. In general, low-corrosion materials (copper, plastic, stainless steel, etc.) perform best in this respect and are also easy to clean and disinfect.
2. Ground-based and on-train systems, and in particular storage tanks, should be flushed out and/or cleaned so as to remove/inhibit growth of biofilms.
3. Products that are able to break down biofilms are likely to be more effective as part of a dosing regime than those which target only legionella bacteria (see section x).

8.6 Materials used in ground-based and on-train water systems not required to be wholesome

- 8.6.1 As noted in Part 82 and 8.3 above, the materials used within water systems will influence the amount and nature of nutrients and biofilms.

Recommendation:

Railway undertakings should determine what materials are used in their ground-based and on-train water systems and how these affect the supply of nutrients needed for bacterial growth and the development of biofilms. While it may not be possible to change these in the short term, a proper understanding of how they contribute to the overall risk will help in determining the optimum dosing regime.

8.7 System throughput

- 8.7.1 Water which is stored undisturbed is likely to provide the best conditions for bacteria growth. Conversely, regular complete flushing of a water system is an effective way of preventing amplification.

- 8.7.2 Use of on-train toilets is highly dependent on the type of service operated. Those making journeys in excess of 3-4 hours will generally be more likely to make use of the toilet than those on shorter journeys, conversely regular commuters, with an option to use toilet facilities either at home or the workplace may rarely do so. These habits may be further reinforced by a perception that the condition of toilets on commuter and shorter distance services will be less acceptable than that on InterCity type services. This may be taken to imply that conditions favourable to amplification are more likely to be found on stock where the system is rarely drained completely as a result of a lack of customer use or not being included within maintenance procedures. However, the design of many on-train systems is such that undisturbed water may be present in parts of the system and even remain when the system as a whole is drained.
- 8.7.3 It should also be remembered that high levels of throughput within the on-train system will offer no protection if water taken onto the train already has high concentrations of bacteria as a result of low throughput within the ground-based system. This may result, for example, from tanking a train at an unusual location or from a bowser that is not regularly used.
- 8.7.4 It should also be noted that systems will almost invariably contain areas where water may build up and remain undisturbed locally. Examples include taps/nozzles, hoses and associated connections and these should be flushed out periodically according to the local risk assessment.

Recommendations:

1. Consideration should be given to periodic complete discharge of any tanks or other storage media (such as bowzers), both ground-based and on-train, that are not subject to regular complete emptying as a result of routine customer use
2. Hoses should be flushed out routinely before being connected to on train tanking points to remove any water that may have been left undisturbed within them

8.8 Hose management

- 8.8.1 Poor management of hoses used to connect ground-based systems to vehicle tanking points represents a significant risk. This includes using hoses of inferior quality, hoses which are damaged, leaving hoses lying on the ground when not in use and failing to leave hose ends in sterilising solution when not in use. Such practices not only lead to re-contamination but also allow bacteria to multiply in situ with the likelihood of high levels of contamination being imported to other components of the ground-based and on-train systems.

Recommendation:

1. Good hose/connections management and hygiene regimes are easily implemented and effective at reducing overall risk. These should include:
 - i) Use of appropriate grade hoses.
 - ii) Replacement of worn or damaged hosing.
 - iii) Proper storage of hoses (e.g. on a reel) when not in use.
 - iv) Placing hose ends in disinfectant solution when not in use.
 - v) Wherever possible ensuring that hoses are permanently attached to filling points.
 - vi) Covering train connection points when not in use.
 - vii) Cleaning/disinfecting train connection points prior to use.

8.9 Amplification – treating existing high concentrations of bacteria

- 8.9.1 While it may be possible to take certain measures to inhibit the growth of legionella bacteria, it is unlikely that it will be possible to suppress it entirely. It follows that some form of periodic chemical dosing of both ground-based and on-train systems may be needed. It is also advisable to undertake a full dosing prior to introducing other risk reduction measures to ensure, as far as possible, that these are being applied to a 'clean' system.
- 8.9.2 Because of the number of different factors involved and the potentially considerable variability in these between different TOCs and even between different depots/types of rolling stock in use within the same TOC it is not possible in the Guidance Note to recommend a particular dosing regime as optimum to use in all cases. A number of potential dosing agents are available – Appendix A provides a summary of the most common along with the associated advantages and disadvantages of each.
- 8.9.3 Similarly, it is not possible to specify an optimum frequency for dosing.
- 8.9.4 Railway undertakings should accordingly determine whether a dosing regime is needed and if so adopt one that is appropriate to their circumstances. One possible approach is to base the dosing regime on the results of sampling/testing of water (see part 6) while another is to adopt a particular dosing periodicity. In practice a combination of the two may be most effective with the dosing regime adjusted in the light of experience. An alternative is to implement continuous in-line low level dosing.

8.10 Transmission

- 8.10.1 While as noted in part 7 and 5.2 respectively i) no direct link has been established between the degree of aerosol generation and the likelihood of human infection and ii) the nature of aerosol generation is such that it is impossible to eliminate it altogether within the on-train toilet cubicle as long as water continues to be present, it is nonetheless intuitively the case that reducing aerosol production must also reduce the risk of infection.
- 8.10.2 The key factors that influence aerosol production from on-train water systems not required to be wholesome are:
- i) Rate of flow – the faster the rate of flow of water emerging from the sink tap or delivered into the toilet bowl the greater the agitation of the water and hence the amount of aerosol produced. In practice, on-train systems are generally gravity fed with the header tank located only slightly above the toilet cubicle fittings, hence water pressure and flow rate are both low.
 - ii) Design of sink taps – taps fitted with a spray nozzle separate the flow into smaller drops which are more likely to generate aerosols. Removal of spray nozzles from taps is a low cost, practical risk reduction measure and is recommended accordingly.
 - iii) Design of sink – water delivered to a sink at right angles to the surface of the basin will result in greater agitation and hence aerosol production than water hitting the basin at a more acute angle. In some cases, it may be possible to modify the angle of taps accordingly.
 - iv) Type of toilet – modern vacuum based toilet systems both use less water than traditional systems and are likely to generate less free aerosol due to the method of evacuating water from the bowl. While replacing toilets solely as a legionella risk reduction measure is not practicable, the design of toilet should be taken into account when assessing the overall risk posed by legionella.

8.11 Exposure to aerosols

- 8.11.1 With active discouragement of passengers from using on-train toilets, or using the sink after doing so, both unacceptable, it is not generally possible to reduce the exposure of those passengers using the toilet to the aerosols that are present there. The one exception to this is to encourage closure of the toilet lid prior to flushing (achieved with many modern systems through design in that the flush button is only accessible with the lid closed and able to be encouraged in the case of other systems by the provision of signage) by placing the flush button behind the lid in practice.
- 8.11.2 However, the level of exposure to passengers more generally – and particularly those who are not using the toilet but may be exposed to aerosols that escape from the toilet cubicle into vestibules and seating areas will be influenced by the following:
- i) The length (and type) of journey being undertaken, in as much as this determines the frequency with which on train toilets are used.
 - ii) The number of toilets on the train.
 - iii) The location of toilets on the train – the number of passengers exposed to aerosols outside the toilet compartment will be less if (say) both toilets in a four-car unit are located opposite each other in the same coach than would if they are located in separate coaches.:

8.12 Host susceptibility

- 8.12.1 Railway undertakings are not in a position to influence the susceptibility of individuals to Legionnaires' disease or their vulnerability to it. However, there is no evidence to suggest that the demographic profile of rail passengers is materially different from that of the population at large as far as susceptibility is concerned

Part 9 Record keeping

9.1 Overview

- 9.1.1 Comprehensive records should be kept of the significant findings from risk assessments, including the person(s) responsible and when carried out. Similarly, records of all samples taken, including dates, associated results and any resulting corrective actions, should be maintained. They should be analysed on a regular basis, both with a view to detecting trends and also to inform the dosing regime and application of other risk reduction measures

Part 10 Responsibilities and training

10.1 Overview

- 10.1.1 Railway undertakings should assign specific responsibilities to individuals and/or roles in respect of managing the risks associated with the presence of legionella bacteria in on-train water systems not required to be wholesome. These responsibilities should be documented, and the staff concerned given appropriate training and be subject to periodic competence assessment.

Part 11 References and other sources of information

11.1 Guidance and information:

- ATOC/GN021 – RDG Guidance Note – Provision of Drinking Water for On-Train Use <https://catalogues.rssb.co.uk/rgs/oodocs/ATOCGN021%20Iss%202.pdf>
- RSSB Research Report – T985 Identification and analysis of risks posed by legionella bacteria in on-train non-potable water systems (note of wholesome standard) September 2019 <http://www.rssb.co.uk/pages/research-catalogue/t985.aspx>
- The Use of Public Water Supplies in Railway Premises – Information and Guidance note No9-06-03 Water Regulations Advisory Scheme, June 2006 https://www.wras.co.uk/downloads/public_area/publications/general/ign_railways_9-06-03.pdf
- HSE publication L8 - Legionnaires' disease - The control of legionella bacteria in water systems Approved Code of Practice and guidance on regulations (Fourth edition) November 2013 <http://www.hse.gov.uk/pubns/books/l8.htm>
- HSE publication HSG274 Legionnaire's Disease Technical Guidance Part 2: The control of legionella bacteria in hot and cold water systems, June 2014 <http://www.hse.gov.uk/pubns/priced/hsg274part2.pdf>
- HSE publication Legionnaires' disease - A brief guide for dutyholders, April 2012 <http://www.hse.gov.uk/pubns/indg458.pdf>
- British Standards Institute publication BS 7592:2008 - Sampling for Legionella bacteria in water systems. Code of practice, November 2008 <http://shop.bsigroup.com/ProductDetail/?pid=000000000030161148>
- British Standards Institute publication BS 8580-1:2019 - Water quality. Risk assessments for Legionella control. Code of practice, January 2019 <https://shop.bsigroup.com/ProductDetail?pid=000000000030367524>

11.2 Websites:

- European Working Group for Legionella Infections (EWGLI) – www.ewgli.org
- HSE – www.hse.gov.uk
- PHE – <https://www.gov.uk/government/organisations/public-health-england>
- UK Accreditation Service – www.ukas.com
- The Water Management Society – www.wmsoc.org.uk

APPENDIX A - COMPARISON OF LEGIONELLA DOSING AGENTS

Note: The following table brings together information drawn from a number of sources, including TOC experience. It is not intended to provide a comprehensive list or analysis of all possible agents and it is recommended that when selecting a product advice is sought from a professional who understands decontamination and the complexities involved. HSE publication HSG274 Part 2 provides further comparative details in a number of cases, including chlorine-based disinfection.

Method	Advantages	Disadvantages
<p>Chlorination – by hypochlorite salts – includes numerous means of application: sodium hypochlorite (liquid bleach), calcium hypochlorite, stabilised in tablet and powder form.</p> <p>Can be used as a shock treatment at high concentrations and a method of continual control at lower levels.</p> <p>Tablets and powder products may be better though more expensive. Sodium Dichloroisocyanurate commonly used for drinking water disinfection and swimming pool treatment is easy to use. (see Chlorine Dioxide below)</p>	<p>Relatively easy to use with low capital outlay.</p> <p>L8 specifies shock treatment of at least 50ppm for 1 hour or 20 ppm for 2 hours.</p> <p>A free chlorine residual of 0.1-0.5 ppm is adequate to control bulk water organisms if the residual concentration can be maintained for a sufficient period of time.</p>	<p>It is not considered particularly effective with biofilm unless at higher concentrations and disinfection times.</p> <p>The stability of hypochlorite solutions is adversely affected by heat, light, pH, and metal contamination. Chlorine gas is given off if mixed with strong acids or oxidising agents and has caused fatalities. Chlorine is corrosive and there are handling and COSHH considerations especially with liquids. Though the issue of harmful bi-products is not considered significant unless there is likely to be reactions with large amounts of organic material which may also neutralise the chlorine and reduce its efficacy.</p> <p>Concentration must be reduced (e.g. by neutralising with sodium thiosulphate) after shock disinfection due to risk of affecting sewage treatment plants, and potential contact with persons using the facilities.</p>
<p>Hypochlorous acid.</p>	<p>Hypochlorous acid is a weak acid which is similar to sodium hypochlorite as it's the "hypochlorite" ion in the solution. It is claimed to work at lower concentrations than sodium hypochlorite, however, it is more reactive, and obviously acidic.</p> <p>Manufacturers claim pure hypochlorous acid has advantages over other disinfectants.</p>	<p>Limited scientific research information available. Pure hypochlorous acid systems are being installed in hospitals to clean and disinfect endoscopes. This is a relatively recent development in hospitals, replacing the more traditional toxic disinfectants like glutaraldehyde and peracetic acid.</p> <p>It has similar COSHH considerations as sodium hypochlorite.</p>

Method	Advantages	Disadvantages
Bromination	Similar action to chlorine in water.	Less generally used.
Chlorine dioxide (gas) Can be used in self generating tablet form. Used extensively in aircraft to treat the domestic water.	Chlorine dioxide has superior penetration into bio-films than chlorine. Corrosive effects are much less than those of chlorine. This may be considered a good option for an initial shock dosing.	It may not be as long lasting as other disinfectants. The gas is unstable, therefore, it is normally generated in situ, or can be produced from self-generating tablets which require careful storage. There may be disposal problems due to chlorite ions at high dosing levels.
Monochloramine	Commonly used as a secondary disinfectant by water companies by adding ammonia to chlorinated water, has less effect and takes longer to act than chlorine, but more stable and longer lasting.	Not considered very effective against bio-films. It may be more effective in maintaining a low dose control in clean systems. Further research required to form an opinion on practicality of use.
Hydrogen peroxide	A generally effective disinfectant, it is reported to be much more effective when stabilised with silver; there are a number of commercial products available. It is superior to some other oxidising disinfecting agents such as chlorine. It has less skin contact hazard, less corrosive, less ingestion hazard, reduces odour, and is effective on biofilm. Water with a disinfecting dose of perhaps 50 to 75 ppm would still be safe to use, even drink.	Unstable so the effect is not sustained. This may not be a disadvantage in the railway setting where tanks are dosed periodically. Not totally effective against legionella - the HPA cites a case where hydrogen peroxide was used on a ship that was implicated in an outbreak.
Ozone – requires injection equipment, handling of gases.		Not considered a practical option for numerous small systems. It is not effective against bio-films.
Copper silver ionisation – Copper and silver ions are introduced into the water stream by means of electrolytic action.		Relatively high capital outlay and is more effective in large buildings where its ability to reach all parts of a water system is one of its main advantages. There are reports of legionella being resistant to copper-silver ions.

Method	Advantages	Disadvantages
		This is not considered practicable or cost effective for numerous small self-contained systems.
Thermal		Not practical for train toilets which are cold water systems.
Ultra violet light		This is generally a point of entry with no residual effect. Expensive option not considered practical with numerous small systems.