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Legionella control in evaporative cooling systems: underlying causes of breaches in health and safety compliance

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Evaporative cooling systems, such as cooling towers and evaporative condensers, are susceptible to colonisation by *Legionella* bacteria. Previous evidence has demonstrated that they can be responsible for sporadic outbreaks of infection, ranging in scale both in terms of numbers infected and severity. When outbreaks occur, they frequently infect members of the public rather than workers and, in many cases, are a major public health concern.

HSE inspected 1,906 premises with evaporative cooling systems between 1st April 2013 and 31st August 2014. While the majority of sites required no enforcement, material breaches were found at 625 sites (33% of those inspected), including 409 Improvement Notices (INs) and 12 Prohibition Notices (PNs) served at 229 sites (12.0% of those inspected).

Underlying causes of breaches of health and safety compliance were analysed. The main ones were lack of training, failure to maintain the cleanliness of cooling towers and the water within them, absence of, or inadequate, risk assessments, and absence of, or insufficiently detailed, written control schemes. Further analysis looked into the reasons why cooling towers were not cleaned properly.

These results provide a valuable resource which can be used to focus future strategies to improve dutyholder compliance.

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HSE Books

Legionella control in evaporative cooling systems: underlying causes of breaches in health and safety compliance

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KEY MESSAGES

Evaporative cooling systems, such as cooling towers and evaporative condensers, are susceptible to colonisation by *Legionella* bacteria. Previous evidence has demonstrated that they can be responsible for sporadic outbreaks of infection, ranging in scale both in terms of numbers infected and severity. When outbreaks occur, they frequently infect members of the public rather than workers and, in many cases, are a major public health concern.

HSE led a proactive inspection programme of 1,906 premises with evaporative cooling systems between 1st April 2013 and 31st August 2014. While the majority of sites required no enforcement, material breaches were found at 625 sites (33% of those inspected), including 409 Improvement Notices (INs) and 12 Prohibition Notices (PNs) served at 229 sites (12.0% of those inspected).

Data from INs and PNs were examined to categorise underlying causes (termed failings) of breaches in health and safety compliance. Some notices were served for multiple failings, therefore 501 of these were recorded.

Major underlying causes were:

- Lack of training;
- Failure to maintain the cleanliness of cooling towers and the water within them;
- Risk Assessments either being absent or no longer representing the risks present; and
- Written Control Schemes being absent or insufficiently detailed.

Further detailed analysis provides a breakdown of reasons why cooling towers were not clean. This showed that it was mainly due to a lack of pack inspection or a lack of pack removal for cleaning (or enhanced *in situ* cleaning methods where pack removal was not reasonably practicable). Lack of training of a responsible person or deputy was also a major contributor.

These results provide a valuable resource which can be used to focus future approaches to improve dutyholder compliance.

EXECUTIVE SUMMARY

Many industrial processes have a cooling requirement because the process generates excessive heat, or there is a need to remove heat for the purposes of freezing/chilling. This can be achieved by cooling towers or evaporative condensers, collectively referred to as evaporative cooling systems. Unless they are satisfactorily managed, they are susceptible to colonisation by *Legionella* bacteria. Previous evidence has demonstrated that they can be responsible for sporadic outbreaks of infection, ranging in scale both in terms of numbers infected and severity. When outbreaks occur, they frequently infect members of the public rather than workers and, in many cases, are a major public health concern.

Using this evidence, an intervention programme was planned as a joint initiative between HSE, Office for Nuclear Regulation (ONR) and Local Authorities, based upon an analysis of both the risks posed and the likely impact that would arise from an outbreak. This was structured as proactive inspection of premises operating evaporative cooling systems, as well as stakeholder engagement, education and advice and the promotion of good practice.

The total number of sites confirmed as within scope for inspection by HSE and ONR was 1,988, of which 1,906 (95.9%) were inspected between 1st April 2013 and 31st August 2014. Sites were rated against four topics - Risk Assessment; Written Control Scheme; Implementation of Control Scheme and Record Keeping. Compliance was found at the majority of sites, but further action as a result of material breaches was required at 625 sites, 33% of those inspected, with 409 Improvement Notices (INs) and 12 Prohibition Notices (PNs) being served at 229 sites (12.0% of those inspected).

Scientists from HSE's Buxton Laboratory Microbiology Team were tasked by HSE Legionella Committee with undertaking an examination of IN and PN data from HSE's operational database COIN (**C**orporate **O**perational **IN**formation System) to categorise underlying causes (termed failings) of breaches in health and safety compliance. Some notices were served for multiple failings, therefore 501 of these were recorded.

The analysis has highlighted that 'Implementation of Control Scheme' was the cause of more than half of all the INs issued, with 'Risk Assessment' and 'Written Control Scheme' each being the cause for issue of just under a quarter of all INs. Examining these in more detail highlighted that the major problems were lack of training, failure to maintain the cleanliness of cooling towers and the water within them, the absence of risk assessments or those no longer representing the risks present, and the absence of or insufficiently detailed written control schemes. Further detailed analysis provides a breakdown of reasons why cooling towers were not clean, showing this was mainly due to a lack of pack inspection or a lack of pack removal for cleaning (or enhanced *in situ* cleaning methods where pack removal was not reasonably practicable). Lack of training of a responsible person or deputy was also a major contributor. These results provide a valuable resource which can be used to focus future approaches to improve dutyholder compliance.

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1 INTRODUCTION

1.1 LEGIONELLA AND INDUSTRIAL WATER SYSTEMS

Legionella bacteria are aquatic organisms commonly found in low concentrations in natural water sources such as rivers, lakes and reservoirs with minimal risk of causing human infection. However, outbreaks of respiratory illness can occur when the bacteria colonise water systems, proliferate and are spread by aerosol generation. Any water system in the built environment may become colonised, including hot and cold water systems, spa pools and industrial sources using process water. Legionnaires' disease is a potentially fatal pneumonia-like illness, while Pontiac and Lochgoilhead fevers are similar, but generally milder, illnesses that are not fatal.

Many industrial processes have a cooling requirement because the process generates excessive heat, or there is a need to remove heat for the purposes of freezing/chilling. This can be achieved by cooling towers or evaporative condensers, collectively referred to as evaporative cooling systems. Such systems generally produce an aerosol when the water stream interfaces with airflow. Drift eliminators are normally fitted to reduce and prevent aerosol spread. They trap most, but not all, of the aerosol as a small proportion will always escape to atmosphere even where the drift eliminators are in good condition and well-fitted. Where the quality and cleanliness of cooling water is not maintained satisfactorily, it is possible for a contaminated aerosol to be dispersed over a wide area, potentially affecting workers on site, neighbouring workplaces or nearby members of the public. Certain factors contribute to the growth and spread of *Legionella* bacteria including:

- Storage of and/or re-circulation of water;
- Water temperature between 20–45 °C;
- A source of nutrients for the organism, e.g., presence of sludge, scale or fouling;
- Aerosol created by a cooling tower, or water outlets.

In favourable conditions as described above the bacteria may grow rapidly. The growth and spread of *Legionella* bacteria in system water must therefore be effectively controlled by maintaining both plant and process water in a clean condition and reducing, so far as is reasonably practicable, the possibility of aerosol generation or spread. In most cases, this is augmented by the addition of a proprietary biocide, although in some circumstances other technologies may be used that do not rely on chemical treatment, or alternatives to wet cooling systems can be considered and the risk thus eliminated. More information on *Legionella* bacteria and conditions favouring growth is available on the HSE 'Legionella and Legionnaires' Disease' web page at http://www.hse.gov.uk/legionnaires/what-is.htm.

1.2 OUTBREAKS OF LEGIONNAIRES' DISEASE ASSOCIATED WITH EVAPORATIVE COOLING SYSTEMS

Contamination of water systems in the workplace by *Legionella* bacteria has resulted in sporadic outbreaks of infection, ranging in scale both in terms of numbers infected and severity. When outbreaks occur, they frequently infect members of the public rather than workers and, in many cases, are a major public health concern. A further complication is the wide range of premises with water systems that have the potential to create a risk from *Legionella*, including those where health

and safety is enforced by Local Authorities (LA) or the Office for Nuclear Regulation (ONR) rather than HSE.

On behalf of HSE's Legionella Committee, HSE microbiologists analysed published data on outbreaks over a ten year period up to September 2011, as well as reviewing HSE's inspection and investigation data stored on HSE's operational database COIN (**C**orporate **O**perational **IN**formation System) to identify trends in affected sectors, water systems and failures to meet the standards described in the Approved Code of Practice L8 (http://www.hse.gov.uk/pubns/books/l8.htm). This analysis was reported by HSE in July 2012 (http://www.hse.gov.uk/research/hsl_pdf/2012/hex1207.pdf?eban=rss-legionnaires-disease). Although overall there were more reported cases of Legionnaires' disease (LD) associated with hot and cold water systems than with evaporative cooling systems, individual outbreaks linked to the latter involve larger numbers of cases. Seven outbreaks were attributed to evaporative cooling systems over the 10-year period and were responsible for 229 infections and 10 fatalities. Large numbers of people are potentially affected because of the range over which plumes of infected aerosols may travel.

1.3 CONTEXTUAL DATA FROM US STUDY OF CAUSES OF OUTBREAKS

In the USA, the Centre for Disease Control (CDC) receives and collates reported cases of LD and investigates outbreaks. Currently, approximately 5,000 cases of LD are reported to CDC each year. However, from 2000 to 2014, the rate of reported cases of LD and Pontiac fever increased nearly 4-fold. This corresponded to an increase from 0.42 per 100,000 persons in 2000 to the current rate of 1.62 cases per 100,000 persons. To address concerns raised over this increase, and to identify opportunities for prevention, summaries of all CDC field investigations of outbreaks of LD in North America from 2000 to 2014 were reviewed[1]. The aim was to characterise water system maintenance deficiencies leading to those outbreaks.

Between 2000 and 2014, CDC investigated 38 outbreaks that resulted in 415 reported cases of LD. Of these, 323 (78%) were subsequently confirmed and 92 (22%) remained suspected. All were caused by *L pneumophila* serogroup 1, and led to 65 deaths. Some outbreaks, including those on cruise ships, were excluded from the analysis, leaving 27 outbreaks for further analysis.

Hot and cold water systems were the most frequent source of exposure, in 15 out of 27 outbreaks. Although only six outbreaks were associated with cooling towers, cumulatively these accounted for more cases than any other source, 184 out of the 415 reported (44%), and 33 out of the 65 (51%) recorded deaths. This was consistent with our previous findings in the UK in terms of the high impact of cooling tower contamination.

Investigation summaries were reviewed to identify possible root causes that could facilitate *Legionella* growth and transmission. Of the 27 outbreaks, 23 had sufficient information to evaluate, and findings were assigned to one or more of four categories as follows:

1) Process failures, in which a process, such as a water management programme, was missing or inadequate, were attributed to 15 outbreaks (65% of total);

[1] ***Reference:*** *Garrison LE, Kunz JM, Cooley LA, Moore MR, Lucas C, Schrag S, Sarisky J, Whitney CG. Vital Signs: Deficiencies in Environmental Control Identified in Outbreaks of Legionnaires' Disease — North America, 2000–2014. MMWR Morb Mortal Wkly Rep 2016;65: 576-584., This report was posted as an MMWR Early Release on the MMWR website (http://www.cdc.gov/mmwr) on June 7, 2016.*

2) Human errors, in which a person did not perform as expected, such as not replacing hot tub filters according to manufacturer's recommendations, were attributed to 12 outbreaks (52% of total);

3) Equipment failures, in which a piece of equipment did not operate as expected, such as a malfunctioning disinfectant delivery system, were attributed to 8 outbreaks (35% of total); and

4) Unmanaged external changes, in which adjustments were not made to account for events outside a building water system, such as nearby construction leading to changes in potable water quality, were attributed to 8 outbreaks (35% of total).

Deficiencies in more than one category occurred in 11 outbreaks (48%). Inadequate water disinfection levels were attributed to causing 16 outbreaks (70%), and 12 (52%) reported water temperatures optimal for *Legionella* growth.

Out of the six outbreaks where cooling towers were cited as the source, four had sufficient detail to identify failings. Table 1 summarises these, including the failings as described in the report, and how these possibly relate to the failings categories used in HSE's intervention programme (see results section in this report).

Table 1. Details of outbreaks in USA between 2000 and 2014 attributed to cooling towers

Setting	**Year**	**Cases (deaths)**	**Failings**	**Category**	**Cross refers to HSE failings categories***
Community	2004	9 (2)	Tropical storm with heavy rain and flooding immediately before symptom onset of first case	Unmanaged external change	Risk assessment 1.7
Long-term care facility	2005	82 (23)	Inadequate disinfectant in cooling tower because of timed delivery that did not allow disinfectant to be delivered when cooling tower was not running	Equipment failure	Implementation of written control scheme (WCS)
Hotel/ Resort	2010	8 (1)	Inadequate disinfectant in cooling tower because of irregular addition of disinfectant by contractor Inadequate record keeping	Human error	Implementation of WCS / Record keeping
Workplace	2010	29 (0)	Lack of start-up and shutdown procedures for cooling tower Lack of staff training on operation and maintenance of cooling tower Cooling tower dysfunction, prompting opening of windows Heavy rainfall, high humidity, and warm temperatures preceded onset of cases	Process failure Process failure Equipment failure Unmanaged external change	WCS 2.10 Implementation of WCS 3.2 Implementation of WCS 3.2 Risk assessment 1.7

1.4 HSE INTERVENTION PROGRAMME

Using this evidence, an intervention programme was planned as a joint initiative between HSE, ONR and LAs, based upon an analysis of both the risks posed and the likely impact that would arise from an outbreak.

This was structured as proactive inspections for premises operating evaporative cooling systems, as well as stakeholder engagement, education and advice and the promotion of good practice. The programme was designed to maximise the potential for partnership working and to encourage industry to take ownership and lead work to bring about sustained improvements in standards. Alongside this, the message was reinforced that HSE, ONR and LA inspectors should deal immediately with any *Legionella* related issues that constitute a matter of potential major concern arising during any visits, whether or not this related to the planned inspection or investigation. Under HSE operational guidance, cooling tower operation and maintenance is considered a matter of potential major concern (MPMC), i.e., "those which have a realistic potential to cause either multiple fatalities or multiple cases of acute or chronic ill-health" (http://www.hse.gov.uk/foi/internalops/ocs/001-099/18_12.htm). An inspection topic guidance pack was used to inform and advise inspectors and to achieve a consistency of approach to the programme (http://www.hse.gov.uk/legionnaires/assets/docs/cooling-tower-programme-inspection-pack.pdf).

Based on LA data from statutory notification of evaporative cooling systems under the Notification of Cooling Towers and Evaporative Condensers Regulations (NCTEC) 1992, it was estimated that there were around 5,000 premises. Those categorised as 'risk level 1' were prioritised for inspection based on the responses (or lack of) to a questionnaire sent to all notified premises, but with the aim of inspecting as many premises as possible over the duration of the programme.

The inspection initiative was supported by local dutyholder events (undertaken jointly with the Legionella Control Association) to highlight issues, working with identified industry champions and other players, such as water treatment and cleaning companies. HSE also worked with industry bodies to develop tools (such as 'Tool-box talk' material) to help dutyholders manage *Legionella* risks. The programme was undertaken between April 2013 and August 2014.

The total number of sites confirmed as within scope for inspection by HSE and ONR was 1,988, of which 1,906 (95.9%) were inspected. Sites were rated against each of the four inspection topics:

- Risk Assessment;
- Written Control Scheme;
- Implementation of Control Scheme; and
- Record Keeping.

A table of compliance indicators was provided to illustrate what successful compliance should look like for each inspection topic (see http://www.hse.gov.uk/legionnaires/assets/docs/cooling-tower-programme-inspection-pack.pdf). A judgement was made by Inspectors on the overall picture of compliance in each area and accordingly determined the initial enforcement expectation. The risk ratings (scores) applied were linked to HSE's Enforcement Management Model, with 10 being fully compliant or verbal advice only and 40 being Improvement/Prohibition Notice/consider prosecution. Details of the outcome of the intervention programme were summarised in an HSE Board Paper in March 2015 (http://www.hse.gov.uk/aboutus/meetings/hseboard/2015/250315/pmarb1527.pdf).

Data presented in the Board Paper shows a general picture of compliance at the majority of sites in GB. However, as may be expected from a major inspection initiative, material breaches[2] were found, requiring further action at several sites. In total, material breaches were found at 625 sites, (33% of those inspected) including 400 (later amended to 409) Improvement Notices (IN) and 11 Prohibition Notices (PN) being served at 229 sites (12.0% of those inspected).

The inspectorial information captured during the programme is potentially a rich source of data, providing information on the underlying causes for breaches of health and safety compliance against the topics as described above. Detailed examination of IN and PN data could potentially be of value to target future intervention strategies. Consequently, through the HSE Legionella Technical Working Group, scientists from HSE's Buxton Laboratory Microbiology Team were tasked with undertaking an examination of IN and PN data from COIN to categorise underlying causes of breaches of health and safety compliance. Although data from LAs was summarised in the Board Paper, only the HSE data was examined as it was readily available from COIN, and considered to be a representative overview of the programme data as a whole. This report summarises the outcome of those analyses.

[2] A material breach is where a health and safety law has been broken and the inspector judges this is serious enough to justify a notification in writing. This can be a notification of contravention, an improvement or prohibition notice.

2 METHODS

Analysis was undertaken to identify the root causes leading to the issue of INs and PNs to duty holders, in relation to breaches of legislation on *Legionella* control.

Data from the intervention was mined from HSE's COIN record system and included the following recorded information for each of the site inspections:

- Service Order identification number;
- Standard Industrial Classification (SIC) code for industries;
- Number of health-related *Legionella* notices that were served[3];
- The distribution of these notices under each of the four main topics covered at inspection - Risk Assessment, Written Control Scheme, Implementation of Control Scheme, Record Keeping;
- Visit notes, detailing the failings and the subsequent enforcement action that was taken.

Common failings were enumerated under each of the four inspection topic areas. The inspection notes for each visit were then analysed using this list to record the reasoning behind the issue of INs and PNs and to determine the root causes for the majority of non-compliances.

[3] *Note that notices were also served under other Regulations such as Work at Height for unsafe access to the system etc.*

3 RESULTS

INFORMATION SUMMARY:

Improvement Notices in numbers

A TOTAL OF 501 IDENTIFIED FAILINGS LED TO 409 INs BEING SERVED

95 INs (23% of total) attributable to inadequate RISK ASSESSMENT

Including:

- 31 failings because they were not up to date; *and*
- 15 failings because they were absent.

93 INs (23% of total) attributable to inadequate WRITTEN CONTROL SCHEME

Including:

- 39 failings for absence of information; *and*
- 23 failings for inadequate information.

217 (53% of total) attributable to inadequate IMPLEMENTATION OF THE WRITTEN CONTROL SCHEME

Including:

- 69 failings for lack of training; *and*
- 76 failings for cooling tower or system not being clean

3.1 OVERALL SUMMARY OF DATA

Although the March 2015 HSE Board Paper reports the issue of 400 INs and 11 PNs during the *Legionella* intervention programme 2013-2014, final figures following the data analysis concluded 409 INs were served on duty holders along with 12 PNs. The percentage of INs issued under each of the four topics used by inspectors as compliance indicators is summarised in Figure 1. The majority of INs issued were for the 'lack of effective implementation of a written control scheme', with 53% of all INs being served in this topic area.

To qualify and provide context to some of the results, during the period in which the intervention programme took place HSE's new *Legionella* guidance HSG274 was issued in November 2013 (http://www.hse.gov.uk/pubns/books/hsg274.htm). One of the changes in the new guidance was that the timing of requirement for reviewing risk assessments went from 'every 2 years' to 'periodically, or when a significant change had been made'. In early stages of the intervention programme some enforcement may have been taken on risk assessments not being up to date because they were greater than 2 years old, but later during the transition period after issuing the new guidance some inspectors may still have considered it a failing if a risk assessment had gone more than 2 years, but this may or may not have been a real problem. The new guidance also

clarified the requirements for pack cleanliness. Many dutyholders were working to pre-existing guidance and this may have led to a relatively high level of enforcement in this particular area.

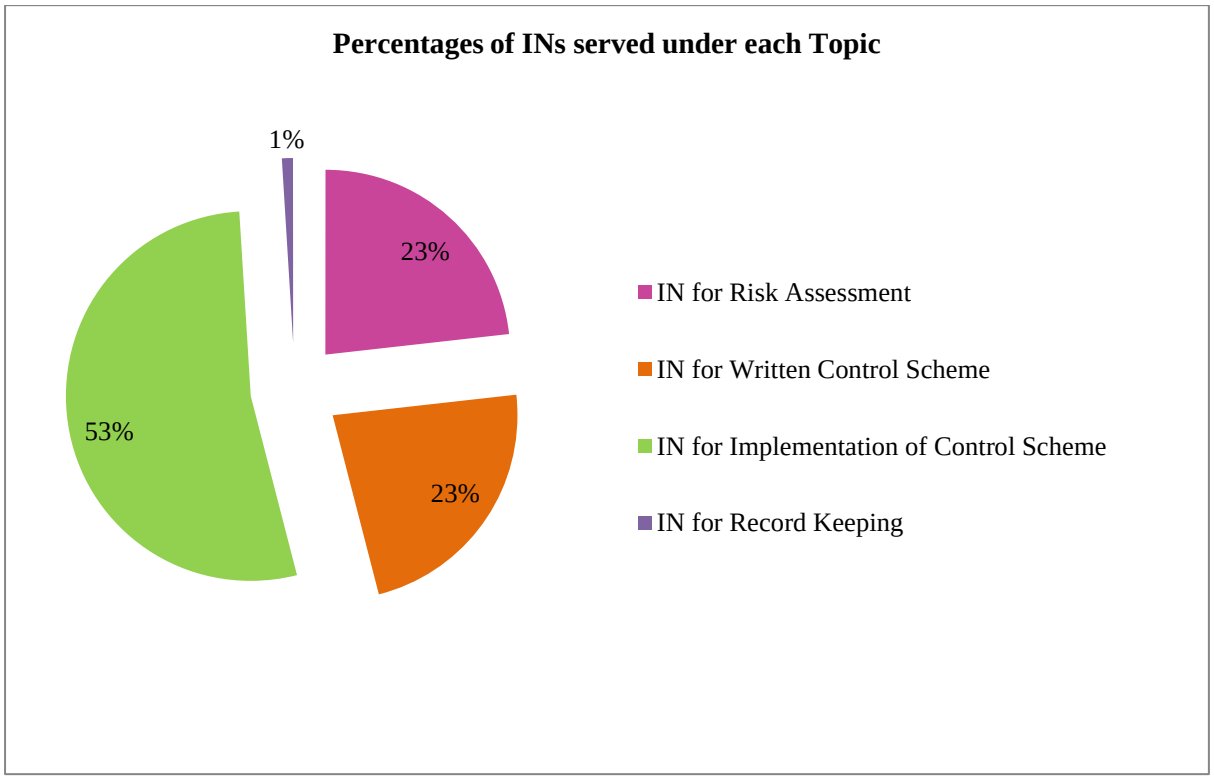

Figure 1. Overview of INs served during the intervention programme under each of the four inspection topics

INs were often served because of multiple deficiencies (failings) in a single topic area, e.g., no schematic drawing and no safe shut down/start up procedures. This therefore means that there are more failings recorded (501) than the number of INs served (409). Table 2 summarises the ratio of failings to INs served under each.

Table 2. Overall failings reported and subsequent number of INs served during the intervention programme

Topic	Number of Failings	Number of INs Served
Risk Assessment	114	95
Written Control Scheme	136	93
Implementation of Control Scheme	247	217
Record Keeping	4	4
Total	**501**	**409**

A breakdown of the reasons for failings under each of the four inspection topic areas is presented in Table 3.

Table 3. Summary of reasons for failings leading to INs under each inspection topic.

Legionella Cooling Tower Intervention Failings			Number of failings based on COIN data
1[1]	**RISK ASSESSMENT (ACOP para in brackets)**[2]	**95 INs Served**	
1.3	Not up to date (32)		31
1.4	Not sufficient – no other details given (28)		18
1.7	Does not cover all risk factors (38)		17
1.1	Absent (28)		15
1.9	Does not take into account nearby population susceptibility		12
1.2	Generic i.e. not site or system specific (38)		7
1.5	Does not include all parts of the system (38)		6
1.8	Failed to identify deadlegs (38)		4
1.6	Does not identify access problems		3
1.10	Other		1
	TOTAL FAILINGS		**114**
2	**WRITTEN CONTROL SCHEME**	**93 INs Served**	
2.1	Absent (58)		39
2.3	Inadequate information in written scheme – no other details given (58)		23
2.10	Does not include/not adequate safe start up/shutdown procedures		16
2.7	Schematic diagram not up to date/does not cover all system (60)		13
2.5	Roles and responsibilities not adequately defined (65)		10
2.6	No schematic diagram (60)		7
2.9	Remedial actions not described in event of abnormal/emergency condition (60)		7
2.4	The correct system operation is not described (60)		6
2.2	Generic - i.e. not site or system specific (58)		5
2.12	No suitable management/control system (65)		4
2.8	No method statement for inspection, cleaning and disinfection (65)		3
2.11	Does not include MSDS or chemical safety information		2
2.13	Other		1
	TOTAL FAILINGS		**136**
3	**IMPLEMENTATION OF CONTROL SCHEME**	**217 INs Served**	
3.7	Cooling Tower not clean/no cleaning of system (65)		76
3.2	Lack of training (48)		69
3.8	Drift eliminators missing/dirty/misaligned/damaged/not checked (65)		37
3.4	Monitoring checks late or missed or incorrect (65)		26
3.5	Remedial action not taken/in timely manner (65)		14
3.6	Remedial action inappropriate/ineffective		7
3.9	Other		7
3.1	Responsible person or deputies not appointed (48)		6
3.3	Physical inspections late or missed (65)		5
	TOTAL FAILINGS		**247**
4	**RECORD KEEPING**	**4 INs Served**	
4.1	Records missing/incomplete (70 - 72)		4

[1]These numbers refer to category and sub-category code used in data collection

[2]The numbers in brackets cross refer to the paragraph numbers of the relevant ACOP statement in L8

In Table 4, the most common recorded sub-category causes of failings are aggregated into common themes, and the percentage of all failings is given.

Table 4. Most common causes of failings (with similar causes aggregated). Data expressed both as percentage of total number of failings and of sub-total within category

Failings	Number	% of category	% of all failings
Risk assessment:	**n = 114**		
1.1 absent + 1.3 not up to date*	46	40.4	9.2
1.7 Does not cover all risk factors + 1.4 Not sufficient – no other details given	35	30.7	7.0
Written control scheme:	**n = 136**		
2.1 absent	39	28.7	7.8
2.3 inadequate information + 2.10 lack of procedure detail + 2.4 and 2.6 and 2.7 inadequacies in descriptions of system operation and schematic diagram	65	47.8	13.0
Implementation of Control Scheme	**n = 247**		
3.7 Cooling Tower not clean/no cleaning of system	76	30.8	15.2
3.2 Lack of training	69	27.9	13.8
3.8 Drift eliminators missing/dirty/misaligned/damaged/not checked	37	15.0	7.4
3.4 Monitoring checks late or missed or incorrect + 3.3 Physical inspections late or missed	31	12.6	6.2

*As context for this failing, 'not up to date' accounted for 31 failings. See Section 3.1 for qualification of these data.

3.2 DETAILED ANALYSIS OF DATA

3.2.1 Risk Assessment

A total of 114 failings were recorded under the risk assessment topic in the COIN inspection notes following the site visits of the *Legionella* intervention programme. This resulted in the serving of 95 INs in this area which represents 23% of all INs issued throughout the programme. The majority of INs served under this topic was a result of the risk assessment not being up to date. This accounted for 27% of all failings in the risk assessment topic and 6% of overall failings across each of the four topic areas.

Table 5 takes data relating to why the risk assessment was not up to date or not sufficient from subcategories 1.3 and 1.4 and summarises the details, if recorded in the inspection notes. It should be recognised that some notes were more comprehensive than others and this is reflected in the table.

Table 5. Reasons given as to why risk assessments were not up to date or not sufficient*

Reason	Number of Failings
Needs updating/reviewing – no further details given	22
Modifications to or additions of towers	5
Changes to personnel	3
Chemical usage out of date	2
Not reviewed after positive Legionella result	2
New monitoring system in place	1
Total	**35**

*As context for 'not up to date', see Section 3.1.

3.2.2 Written Control Scheme

Failings recorded under the topic of written control scheme accounted for 93 INs, which is 23% of the total number served during the programme. A total of 136 failings were recorded in this area. The absence of written control schemes led to the majority of INs being issued within this topic area. Most dutyholders who fell within this category had some basic paperwork in place, although this may have only consisted of the risk assessment and a logbook of historical test and monitoring records. The absence of written control schemes accounted for 29% of all failings in the written control scheme section and 8% of the total failings that were recorded across all four topic areas overall.

3.2.3 Implementation of Control Scheme

Failings recorded under the topic of implementation of control scheme led to 53% of all INs served throughout the *Legionella* intervention programme. The highest number of INs served in this area, and the highest number of INs served throughout the entire programme, were due to inadequate cleaning of the system and subsequent dirty cooling towers. Unclean towers were responsible for 31% of failings in this area, and 15% of failings overall. Table 6 takes data relating to unclean towers from subcategories 3.7 and 3.8 and summarises the details, where recorded.

Table 6. Further details relating to INs issued for towers not being clean

Unclean Tower Issues	Number of Failings
Pack not clean - no inspection/removal for cleaning	20
Cleaning & disinfection of tower required	19
Evidence of surface corrosion within tower	17
Contamination/debris within sump	13
Pack not clean - scale accumulation	7
Pack not clean - no further details given	6
Pack not clean - algae/biofilm accumulation	6
Evidence of scale accumulation within tower	5
Total	**93**

Where visit notes recorded that the pack was not clean due to a lack of inspection or removal for cleaning, 45% of failings here were a result of access problems.

Inadequate training of employees engaged in the scheme of control was another main failing in this area, resulting in 14% of failings recorded during the programme. Table 7 takes data relating the

types of training issues from subcategories 3.1 and 3.2 and summarises the details that were documented in the inspection notes.

Table 7. Types of training issues documented in visit details

Training Issues	Number of Failings
Lack of training of responsible person or deputy	55
Lack of training for staff undertaking control measures	13
Lack of Legionella awareness training	3
Lack of training for dipslide testing	2
Total	**73**

3.2.4 Record Keeping

Four INs were issued due to non-compliances with record keeping. These were all served for records being either incomplete or missing.

3.2.5 Prohibition Notices

During the intervention programme twelve PNs were issued. Two were issued at one site along with four INs, with one PN issued at each of ten more sites. At one of these, four INs were also served; at another, three INs were also served; and at another, one IN was also served. Reasons for serving PNs were mostly due to observed poor condition of cooling towers, i.e., build-up of biofilm fouling in tower or on packs, sludge in ponds, drift eliminators damaged or missing, or fans not working properly.

3.3 DATA IN THE CONTEXT OF HSE APPROVED CODE OF PRACTICE

The Legionella ACOP L8 outlines the responsibilities of the dutyholder and third party service providers. By linking the failings that led to INs to the relevant paragraphs in L8, the aim is to provide context not only to the reason for the failing but also to the most significant causes. Data presented in Table 3 is therefore re-examined, and Table 8 summarises the findings. Note that not all failings map directly onto paragraphs in L8, therefore not all subcategories are listed.

Table 8. Failings broken down by sub-categories compared to relevant paragraph in L8

Number of failings recorded	Description of failing	Relevant ACOP paragraphs
Failing attributable to Risk Assessment		
33	Risk assessment 'not sufficient' or 'absent'	L8 states (para 28): "A suitable and sufficient assessment must be carried out to identify and assess the risk of exposure to *Legionella* bacteria from work activities and water systems on the premises and any precautionary measures needed. The duty holder is responsible for ensuring the risk assessment is carried out."
31	Risk assessment 'not up to date'	L8 states (para 32): "You need to review the assessment regularly and specifically when there is reason to believe that the original risk assessment may no longer be valid. You should also review management and communication procedures as appropriate."
20 12 17	Risk assessment 'generic', 'not including all of system'. Failing to identify dead legs or access problems Risk assessment not taking in to account nearby population susceptibility Risk assessment does not cover all risk factors	L8 states (para 38): "As part of the risk assessment, take into account the individual nature of each site and consider the system as a whole and not, e.g. the cooling tower in isolation." L8 states (para 30): "The risk assessment should identify and evaluate potential sources of risk."
Failing attributable to inadequate written control scheme		
39 23 5	Absence of a written control scheme Inadequate written control scheme Written control scheme too generic	L8 states (para 58): "Where the assessment shows that there is a reasonably foreseeable risk of exposure to *Legionella* bacteria …….there should be a written scheme for controlling the risk from exposure …. properly implemented and managed …. specify measures to take to ensure that it remains effective."
20 6 16	No schematic diagram or not up to-date/does not cover all system The correct system operation is not described Does not include/not adequate safe start up/shut down procedures	L8 states (para 60): "The written scheme should include where appropriate, and with reference to the risk assessment: An up-to-date plan showing the lay out of the plant or water system, including parts temporarily out of use (a schematic diagram is sufficient); A description of the correct and safe operation of the system; (c) & (d)…

Number of failings recorded	Description of failing	Relevant ACOP paragraphs
7	Remedial actions not described in event of abnormal/emergency condition	(e)The remedial action to take if the written scheme is shown not to be effective".
Failing attributable to problems with implementation of the written control scheme		
6	Failing to appoint a responsible person to implement the control scheme	L8 states (para 48): "If the assessment shows that there is a reasonably foreseeable risk and it is reasonably practicable to prevent or control the risk from exposure, the duty holder under paragraph 28 should appoint a competent person or persons to help undertake the measures needed to comply with the requirements of COSHH."
69	Failing to provide training to implement the control scheme	L8 states (para 49): "Those appointed under paragraph 48 to carry out the risk assessment and draw up and implement precautionary measures should have such ability, experience, instruction, information, training and resources to enable them to carry out their tasks competently and safely."
76 37 26 21 5	Failure to clean the system Drift eliminators missing/dirty/damaged/not checked Monitoring checks late, missed or incorrect Remedial action not undertaken in a timely manner/inappropriate/ineffective Physical inspections late or missed	L8 states (para 65): "For precautions to remain effective, the condition and performance of the system will need to be monitored. The appointed responsible person should oversee and manage this. Or, where appropriate, an external contractor or an independent third party can do it. Management should involve: (a) checking the performance and operation of the system and its component parts; (b) inspecting the accessible parts of the system for damage and signs of contamination;"
Material Breaches relating to Record Keeping		
4	Records missing/incomplete	L8 states (para 71): "Records should include details about: The appointed responsible person(s) for conducting the risk assessment, managing, and implementing the written scheme; Any significant findings of the risk assessment; The written scheme and its implementation; details about the state of the water system, i.e. in use/not in use; The results of any monitoring inspection, test or check carried out, and the dates."

4 DISCUSSION

The *Legionella* intervention programme was a major undertaking for HSE involving the inspection of almost two thousand premises. As well as enforcement, it had captured a large quantity of valuable information. The data in this report presents a comprehensive analysis of the underlying causes of failure of dutyholders to control conditions in evaporative cooling systems that could result in *Legionella* growth. HSE inspectors assessed these failings to be sufficiently below the legal standard to warrant the serving of INs or, where it was felt that there was an immediate risk of serious ill health, PNs.

Failings relating to 'Implementation of Control Scheme' were cited in more than half of all the INs issued, with failings relating to 'Risk Assessment' and 'Written Control Scheme' each being cited when issuing just under a quarter of all INs, as summarised in the Infobox in Section 3. Examining these in more detail showed that major problems were:

- Lack of training;
- Failure to maintain the cleanliness of cooling towers and the water within them;
- Risk Assessments either being absent or no longer representing the risks present; and
- Written Control Schemes being absent or insufficiently detailed.

These results provide a valuable resource which can be used to focus future approaches for HSE to target interventions to improve dutyholder compliance.

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Legionella control in evaporative cooling systems: underlying causes of breaches in health and safety compliance

Evaporative cooling systems, such as cooling towers and evaporative condensers, are susceptible to colonisation by *Legionella* bacteria. Previous evidence has demonstrated that they can be responsible for sporadic outbreaks of infection, ranging in scale both in terms of numbers infected and severity. When outbreaks occur, they frequently infect members of the public rather than workers and, in many cases, are a major public health concern.

HSE inspected 1,906 premises with evaporative cooling systems between 1st April 2013 and 31st August 2014. While the majority of sites required no enforcement, material breaches were found at 625 sites (33% of those inspected), including 409 Improvement Notices (INs) and 12 Prohibition Notices (PNs) served at 229 sites (12.0% of those inspected).

Underlying causes of breaches of health and safety compliance were analysed. The main ones were lack of training, failure to maintain the cleanliness of cooling towers and the water within them, absence of, or inadequate, risk assessments, and absence of, or insufficiently detailed, written control schemes. Further analysis looked into the reasons why cooling towers were not cleaned properly.

These results provide a valuable resource which can be used to focus future strategies to improve dutyholder compliance.

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