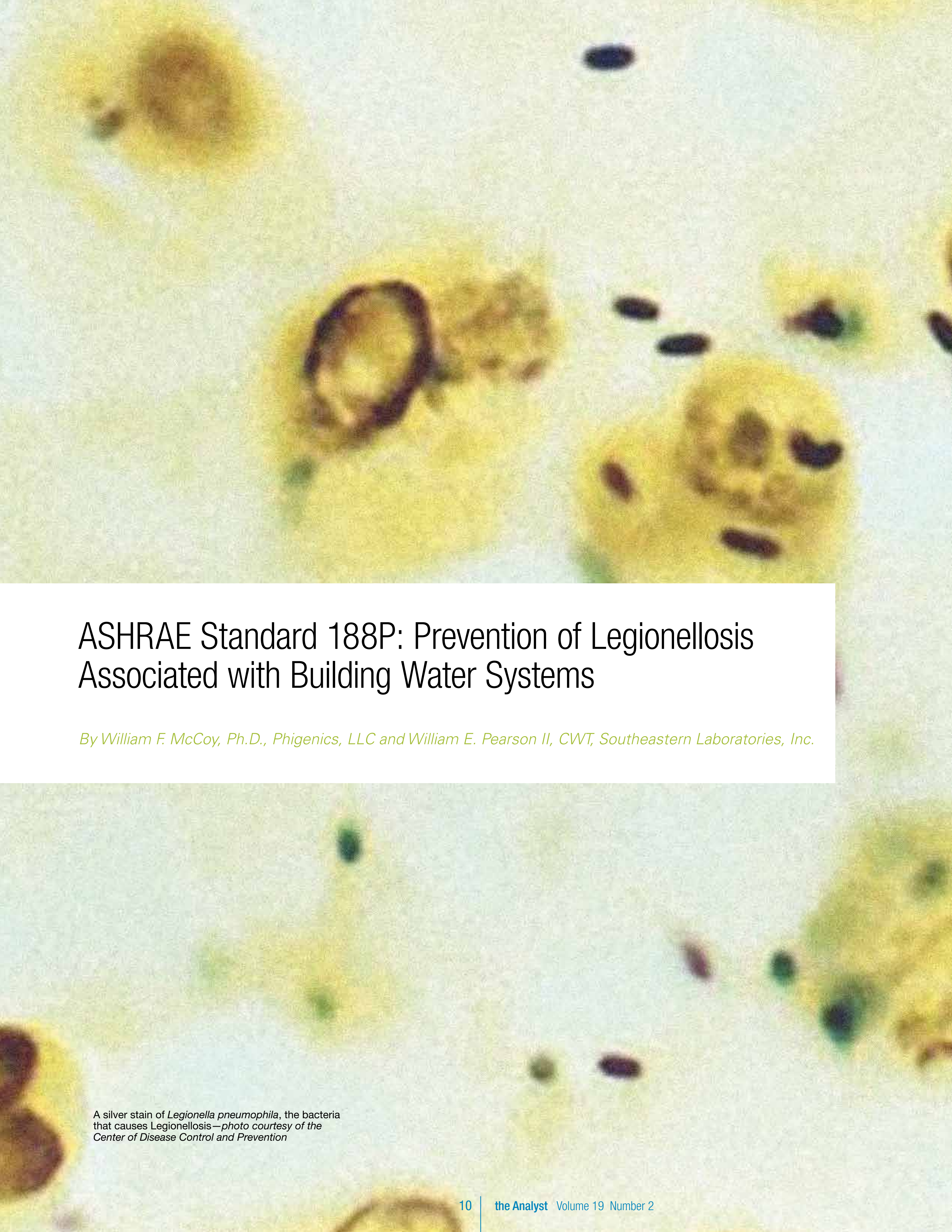

ASHRAE Standard 188P: Prevention of Legionellosis Associated with Building Water Systems

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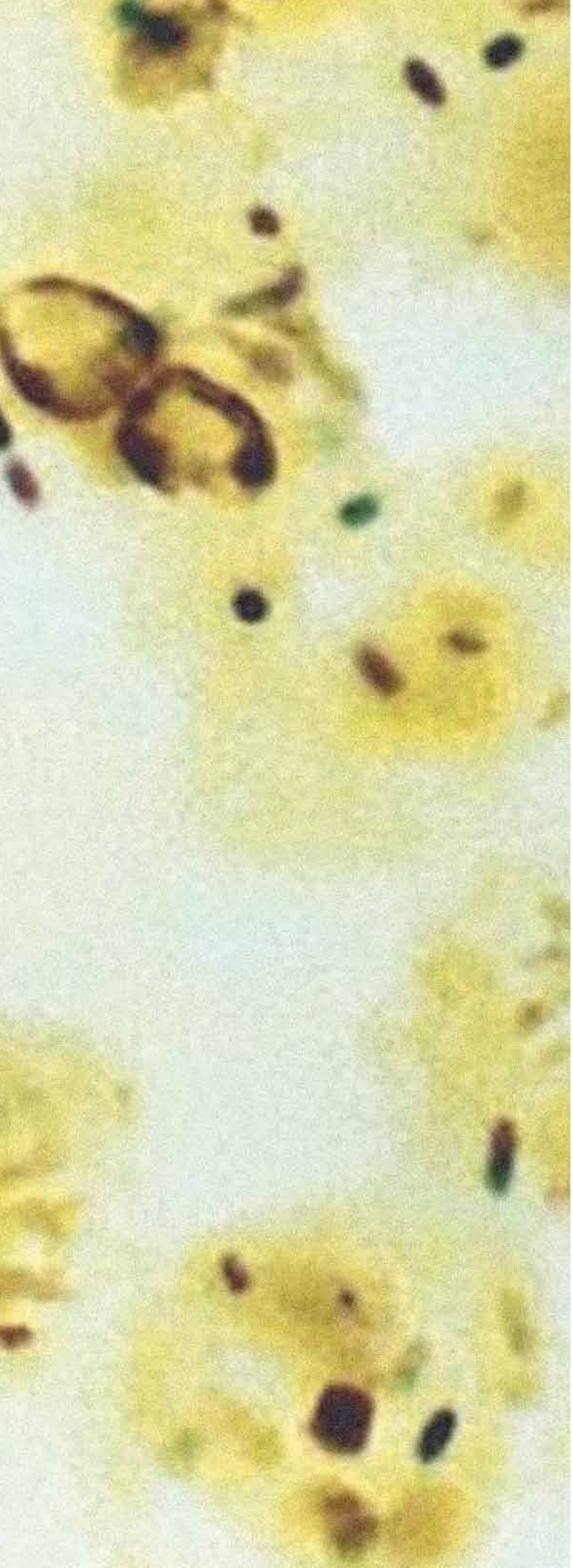
A silver stain of *Legionella pneumophila*, the bacteria that causes Legionellosis—*photo courtesy of the Center of Disease Control and Prevention*



The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has developed a proposed Standard Practice that specifies what is required to prevent legionellosis associated with building water systems. Standard 188P is a "Practices" standard—not a "Design" or "Method/Measure of Test" standard. The proposed Standard was approved in July 2010 for public review publication. The first public review was completed in November 2010. This article specifically describes and discusses what practice the proposed Standard would require. Perspective is given about the problem that the Standard addresses. A brief history is given of legionellosis prevention practice and risk management. The implementation and primary specifications of the Standard are also discussed.

The Need for a (Legionellosis) Standard Practice

Essentially all cases of legionellosis are associated with building water systems.

The cause of this disease and how to prevent it have been known for 30 years. In the U.S. government, academia and professional organizations have published many technical guidance documents about how to analyze and control the cause of legionellosis.[1] Most of these publications have been widely available at no cost for well over a decade.

The Association of Water Technologies (AWT) produced one such guidance document in 2003. It provides excellent and specific technical guidance for how to control *Legionella* in cooling towers, potable water systems and gives further prudent guidance for healthcare building water systems. It has been widely referenced and has been easily accessible at no cost for almost a decade.[2]

Internationally, there is a vast body of specific technical information, rich in substance and detail, which documents how to analyze and control *Legionella* in all relevant types of building water systems. An excellent compilation of this guidance was published by the World Health Organization in 2007 and is available as a free download.[3]

There is overwhelming evidence that control of *Legionella* can be achieved in all types of building water systems. Readily available, practical and technical guidance publications specifically instruct how to control *Legionella* and provide references that document successful applications. The same as with water treatment specifications, site-specific considerations are necessary because a "one-size-fits-all" remedy for legionellosis prevention cannot account for all the variations and conditions encountered in building water systems. The technical guidance publications available reference much of the scientific literature that documents successful real-world applications; the aforementioned full-length book by the World Health Organization[3] is an excellent example of such a publication and there is easy access to many others.

Thus, in reality, there is no mystery about how to analyze and control *Legionella* in building water systems. And yet, estimates continue that every year another 4,000 people in the U.S. will die from legionellosis and there will be an estimated 25,000 new cases.[4]

The number of legionellosis outbreaks in the U.S. has now surpassed the number of waterborne outbreaks of gastrointestinal disease.[5] *Legionella*, according to the CDC, causes the majority of waterborne disease outbreaks associated with building water systems, which are those outbreaks occurring outside the jurisdiction of U.S. public water utilities.

The number of serious or lethal infections that have occurred since we have worked out the cause and how to prevent legionellosis is astonishing. And so have been the costs.

Of the three leading causes of waterborne disease outbreaks in the U.S., legionellosis accounts for the largest direct healthcare dollar cost, eclipsing the costs due to the other waterborne disease outbreaks. Inpatient hospitalization costs per case average more than $34,000 for Legionnaires' disease in the U.S. and the annual direct healthcare cost of legionellosis probably exceeds several hundreds of millions of dollars.[6]

But the indirect cost of legionellosis in the U.S. is far greater than that. Since many *Legionella* infections result in severe pneumonia, data for indirect cost estimates of community-acquired pneumonia (CAP) are relevant and need to be considered. For every direct healthcare dollar spent on CAP, about $12 of indirect cost is incurred due to lost productivity, absenteeism and disability.[7] Thus, the annual cost of the thousands of cases of legionellosis associated with building water systems may well be counted in the billions of dollars.

What Then Is the Problem?

If technical information about how to analyze and control the hazard that causes legionellosis is widely available and is specific, practical and effective—then why is there so much legionellosis in the U.S.?

The prevention of legionellosis in the U.S. is not very effective because there is no standardized specification for exactly what to do with all the available hazard analysis and control information (data) about *Legionella*. Consequently, there is very little motive for facility managers/owners to assign responsibilities and accountabilities for actually doing anything whatsoever about it.

Put more succinctly: We know how to analyze and control this hazard. We need a standardized practice to specify for facility managers/owners exactly what must be done to control the hazard in a systematic and scientifically defensible way.

ASHRAE Standard 188P is intended to fulfill this need.

The Standard Practice

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) develops the following three types of voluntary consensus standards[8] in accordance with the American National Standards Institute (ANSI) rules and regulations, and as accredited by ANSI:

1. Method of Measurement or Test
2. Standard Design
3. Standard Practice

ASHRAE Standard 188P is a Standard Practice.

The Standard Practice specifications in ASHRAE Standard 188P are concisely summarized in the informative Foreword of the Standard. Consider the following boxed-in presentation as an Executive Summary of the Standard's specifications:

- Compliance with this Standard Practice requires that facility managers/owners establish a team with assigned responsibilities and accountabilities.
- The first job for the team is to describe for each facility the way water is processed and used in the facility. This description must be schematically represented in process flow diagrams. Each processing step must be named and numbered on the diagrams.
- Next, the team is required to perform systematic hazard analysis to: 1) identify the potential hazards for each step in the process; 2) decide if the risk of those hazards is significant (yes or no); and if "yes," 3) determine what hazard control is being applied or could be applied at that processing step. Every step in the process at which hazard control is applied must be designated a critical control point.
- For every critical control point, the team must address four issues about the hazard control method being applied: (1) the critical control limit; (2) the hazard control monitoring method; (3) the frequency of monitoring the hazard control; and (4) the corrective actions to be taken if the critical control limit is violated.
- Lastly, the team must decide how it will confirm that the overall plan is being implemented (verification) and provide evidence that the plan is effective (validation).

Development Of ASHRAE Standard 188P

In 1998, ASHRAE published a statement and position paper about legionellosis.[9] Even today, 13 years later, essentially all of the guidance given in this document about how to analyze and control the hazard that causes legionellosis is still applicable and generally correct. It is actually quite difficult to find any technical guidance in the 1998 ASHRAE document that is incorrect now and should be significantly rewritten or withdrawn, in our opinion. While there have been literally thousands of useful publications on the subject since 1998, if one had only this single document available for "how to do" *Legionella* analysis and control, then one's guidance would be quite adequate to certainly get started and be on the right track.

In 2000, ASHRAE published an updated and more extensive guidance document in Guideline 12-2000. While this document provides more detail and is more specific, it is also (still) very consistent with the ASHRAE 1998 publication.

In 2005, the ASHRAE guidance documents regarding legionellosis were reviewed. It was determined that updates were needed for the references and for certain recommendations about how to do things. However, it was also determined from study of the two publications and also from review of many other guidance documents published previously and to date[1], that what is really needed now is a standard practice for what to do with all the information about how to do *Legionella* (hazard) analysis and control.

Hazard Analysis And Critical Control Plans

With abundantly reliable information already available for how to analyze and control *Legionella* (the hazard) in building water systems, the task then centered on reaching consensus about the most appropriate and practical method (or practice) for what to do with the known (control) information about the hazard. The ASHRAE Standard Project Committee (SPC 188) studied many publications on risk management, consulted with experts in the field, and participated with international experts also working to establish a standardized hazard analysis and control planning practice to prevent legionellosis. The end result was to propose the use of a standard practice based upon the principles of the Hazard Analysis and Critical Control Point (HACCP) risk management system.

HACCP is the most widely used standardized practice for environmental-source disease prevention in the U.S.

This is also true internationally, especially if one includes those standardized practices which are directly based on HACCP or derived from it.

There is an enormous body of readily available technical information, training materials and resources about HACCP. Using any typical web-based search engine, the term "HACCP," will return more than 15 million hits in less than a second. A search on the terms "HACCP water" returns about 4 million hits. An easier place to start for relevant information and key literature references about applying HACCP to waterborne disease prevention was given in a paper presented at the 2008 AWT conference about application of HACCP for building water systems.[10]

A Brief History of Hazard Analysis and Critical Control Point Plans

People often associate HACCP with food safety. But food safety experts did not "invent" this system nor did they even develop it. Rather, they adapted it for food safety from a long, successful history of process hazard analysis and control practice developed in direct response to a specific need by the National Aeronautics and Space Administration (NASA).[11] So, it is quite accurate to say that the first applications of HACCP principles were not for food safety and that foodborne illness prevention was not the motive for developing a standardized method for what to do with hazard analysis and control information.

The U.S. Armed Forces and NASA were first to develop and codify these principles for many of their processes, such as making munitions and rockets (and using them safely) and also for a great many other processes. Today, these hazard analysis and control principles are the basis for many manufacturing processes including those used in the automotive industry. Ford Motor Company is well known for its leadership to establish manufacturing standard practices based on sound principles of failure mode effects analysis (FMEA). The HACCP system is derived directly from this rich and successful development history.[12]

Today, HACCP is now specified in the *Codex Alimentarius* published by the World Health Organization and is, without question, the global standard of practice for preventing environmental-source disease.

In February 2007, the World Health Organization published a definitive body of work loaded with specific technical guidance and references entitled "*Legionella* and the Prevention of Legionellosis".[2] This work is entirely organized around the principles of hazard analysis and control derived from HACCP principles. Every chapter in the book is arranged around HACCP principles. The work advocates that water safety for all building water systems should be managed in accordance with these principles.

Discussion of Components in ASHRAE Standard 188P

It is not the aim of this paper to reprint the text of the standard. Instead, the following is a brief overview and discussion of its various parts and content.

Title

The title of the Standard begins with the word "prevention." Sometimes people confuse or misinterpret that word to mean "elimination." Diseases caused by infective agents from the environment (such as bacteria common in water) can never be eliminated because the environments from which they come are impossible to control. But it is possible to prevent cases of environmental-source disease from occurring and it is practical to do so. Environmental-source disease prevention is effective and practical; otherwise, there would be millions of deaths each year in the U.S. from foodborne disease.

Note also that the title of the Standard does not include the word "risk." The Standard Practice specification is not about affecting risk; it is about preventing disease.

Purpose, Scope and Definition of Terms

Section 1—Purpose: The purpose of the Standard indicates that it is a "practices" specification. The purpose of the Standard is to specify what facility managers/owners must do with all the information that is available about *Legionella*. Using that information effectively will prevent cases of legionellosis associated with building water systems.

Section 2—Scope: The scope of the Standard includes practices for facility managers/owners of all centralized industrial and commercial building water systems; it excludes single-family residential buildings.

Section 3—Definition of Terms: Many words in common usage are often applied imprecisely or, worse, incorrectly in regard to legionellosis. For such a serious public health issue as this, a critical function of a standardized practice specification is to motivate use of the correct terms and enable correct usage of those terms with precise definitions. It is difficult to overstate the importance of the Definition of Terms section in this standard.

Compliance, Risk Characterization and Survey Requirements

Section 4—Compliance: Compliance with the standard requires a simple survey to qualitatively characterize the risk of legionellosis associated with the building and its water systems. Then, based upon the results of this simple risk characterization of the building and its water systems, the building facility management/owners are required to comply with the provisions of the standard.

Sections 5 & 6—Risk Characterization & Survey Requirements: Risk factors and building characteristics known to have been previously associated with outbreaks of legionellosis are itemized in Section 5. After the survey is completed, the preventive measures that are required for the building, if any, are specified in Section 6.

If risk characterization of the building and its water systems indicate that hazard analysis and control for a facility is required, then the standardized practice for what to do is exactly specified in the following sections of the Standard.

HACCP Plan General Requirements and Requirements for Specific Building Water Systems

Section 7—HACCP Plan General Requirements: General requirements are given for establishing a hazard analysis and control plan using the HACCP process. Specifications are set out for exactly what the facility management/owner must do to make certain that the required practices are accomplished and well documented. See the text in the box on page 14 for a concise summary of exactly what is required.

This specification is consistent with all HACCP-based risk management systems and with worldwide opinion about analysis and control of *Legionella* (see *Legionella* and the Prevention of Legionellosis; especially note Chapter 3, Fig. 3.2, p44 and pp. 45-56).[3]

Section 8—HACCP Plan Requirements for Building Water Systems: Building water systems are categorized in order to provide further specifications about what to do. There are specifications given for five building water system categories: 1) potable water systems, 2) cooling towers and evaporative condensers, 3) whirlpool spas, 4) decorative fountains and other water features and 5) aerosol generating air coolers, humidifiers and air washers.

References and Informative Appendices

Section 9—References: An often-stated concern by readers of the Standard is that so few references are listed in the normative (mandatory) section. Sometimes people are confused by this and worry because there are thousands, if not tens of thousands, of scientific publications in the literature relevant to the subject. However, note that this Standard is not a restatement of how to do hazard control; rather, it is a standardized specification about what to do with all that information about how to do it. Therefore, only the most fundamental references required for the mandatory compliance sections of the Standard are listed in Section 9, References. There are only 4 normative references and this is as it should be.

Informative Appendices: The Appendices that follow the normative specifications (normative = mandatory) are informative guidance appendices (informative = not mandatory).

Appendix A—Bibliography: Provided here is a list of many informative guidance documents that are intended to direct the user to highly regarded, widely available, "tried and true" guidance and informational publications—each of which include their own extensive reference lists that further direct the user to even more information, if needed or desired. Appendix A, accordingly, includes the AWT guidance document. The ASHRAE committee, SPC188, purposefully chose to not reproduce an extensive literature review or exhaustive reference list of scientific literature. Such a list is not necessary. The nine key guidance documents included in the informative references in Standard 188P comprise in themselves an adequate "how to do it" reference list of guidance documents. Each one of the guidance documents leads to hundreds (perhaps thousands) of other reference citations in the scientific literature that a user can easily obtain if so desired.

Appendix B—Guidance for HACCP: Provided here is an informative (not mandatory) example of a HACCP risk management plan that was developed by the Standard 188P committee for a building water system in the U.S. The examples and explanations of concepts in Appendix B are provided as example templates for exactly what is required by the Standard Practice.

Appendix C—Guidance for the Protection of Personnel: Provided here is informative guidance regarding personal protective equipment for cooling tower cleaning, repair and maintenance.

Implementation of ASHRAE Standard 188P (Practice)

Standard 188P is a voluntary consensus standard. ASHRAE has no enforcement or regulatory authority whatsoever.

However, the power of a voluntary consensus standard and practice specification standard is that it precisely defines a technical best practice about what to do regarding a particular problem. Because of strict and well-defined rules, the Standard language is normative (mandatory) and, therefore, "code ready." Many ASHRAE/ANSI standards are often incorporated into regulatory codes such as building codes and into local, state or federal regulations. As such, and in addition, they invariably become an important consideration in litigation proceedings.

Some readers of the proposed Standard questioned or wondered why ASHRAE has taken up a waterborne disease prevention issue.

ASHRAE develops standards for both its members and others professionally concerned with refrigeration processes and the design and maintenance of indoor environments.[8] And according to ASHRAE bylaws, control of indoor environments for the well-being of occupants is one of the ASHRAE's founding principles: "The Society is organized and operated for the exclusive purpose of advancing the arts and sciences of heating, refrigeration, air conditioning, and ventilation, and the allied arts and sciences and related human factors for the benefit of the general public, as defined in the Certificate of Consolidation. To fulfill its role, the Society shall recognize the effect of its technology on the environment and natural resources to protect the welfare of posterity." (ASHRAE Bylaws, Article I, Section 1.3)

For the ASHRAE legionellosis-related publications (Standard 188P, Guideline 12 and the Statement and Position paper on legionellosis updated in 1998), the cognizant (i.e., responsible) standing ASHRAE committee is the Environmental Health Committee (EHC). The mandate for EHC is: "The Environmental Health Committee coordinates ASHRAE activities in the areas of environmental health and indoor air quality."

The prevention of legionellosis is clearly within the scope of concern to ASHRAE and its membership because the cause of essentially all cases is exposure of susceptible people to bacteria (*Legionella*) inhaled from the air or aspirated (inhaled) from contaminated water in the indoor built environment.

Specific Standard Practice Requirements of Standard 188P

Brief discussions about critical aspects of practices in the proposed standard are presented as follows.

Establish a Team: The Standard practice would require facility managers/owners to assign individuals to responsibilities and accountabilities for their building water systems. Currently, a great many building water systems in the U.S. are well managed by competent, well-informed individuals; for these facilities, compliance to this part of the standard is easily achieved. However, a great many more building water systems are not well managed and there is no clearly identified individual or team of individuals who are responsible for the building water system. Since building water safety and quality are not within the jurisdiction of the public water utility, they must be, therefore, the responsibility of the building owner. The effects on water safety and quality of processing the water in the building, such as heating, conditioning, storing, filtering, distributing, etc. are at issue. Sometimes, these processing steps degrade the quality of the water or introduce risk factors for legionellosis and other waterborne diseases.

Process Flow Diagrams: The first job for the team is to describe how water is processed in the building water system and what uses there are for the water by occupants of the facility. These descriptions are to be simply and schematically represented in process flow diagrams, examples of which are given in Appendix B of the Standard and are readily available in the literature. Each processing step for water in the building is to be named and numbered. Since every building water system is comprised of two separated systems, potable water and utility water, a process flow diagram for each is required. This activity is hugely productive because the way in which water is processed in many facilities has never been schematically described, is generally unknown to the facility manager/owner, and because many facility managers/owners usually do not think about the fact that the water they purchase is actually being processed in their facility.

Hazard Analysis: Using the named and numbered water processing steps from the process flow diagrams, the Team is then required to identify at each processing step, the potential hazards, decide if the hazards are significant (Yes or No) and decide if hazard control at that step is necessary. This is often the most tedious part of establishing a hazard analysis and control plan. Hazard analysis will go much more smoothly if the team has produced process flow diagrams that accurately, yet simply, represent the way water is processed in the building. Template tables for hazard analysis summaries are given in Appendix B and are readily available in the literature.

Hazard Control—Critical Control Points: If the team decides that hazard control is necessary at a certain water-processing step, then that processing step is defined as a Critical Control Point (CCP). For example, the recirculation of water in a cooling tower is often, but not necessarily always, identified as a CCP in the utility water system; likewise, merely for example, a team may identify the need for hazard control in the hot water loop of a potable water system but this is not always necessary. Decisions about hazard control must be made on a site-specific basis. For every CCP, the team is required to decide: 1) the critical limit or range for the hazard control applied, 2) the method to be used to monitor the hazard control applied, 3) the frequency that the hazard control monitoring method will be used, and, 4) the corrective action that will be taken if the critical limit is violated.

Note that this is all regarding the applied hazard control, not the hazard itself. People new to hazard analysis and control risk management systems sometimes confuse this and it is even muddled in some of the risk management literature. Taking some time to clarify this point is important: the monitoring referred to here is not testing for *Legionella*. This is about monitoring the hazard control method. As an example, if chlorine is used to control the hazard, then the team must decide and document what chlorine concentration range to apply (this is the critical control limit), the method used to measure the chlorine, the frequency that the chlorine concentration will be measured using that method, and exactly what the facility people will do if measurements indicate that the chlorine concentration is outside the critical control limit (this is the corrective action). The team is required to decide these four aspects of hazard control for every CCP in the building water system. Usually, there are very few CCPs in a building water system. If there are more than just a few, then the team should consider this an opportunity to focus hazard control activities onto those processing steps that present the most significant risk. This may result in eliminating unnecessary and unproductive hazard control activities.

A Note About Critical Control Points: As previously discussed above in "A Brief History" (page 15), HACCP is derived from hazard analysis and control risk management systems going back long before they were adapted to food safety best practice. Adaptation of the process into HACCP for food safety resulted in development of algorithms and other systems to identify Critical Control Points in rigidly defined food production processes and food preparation recipes. Of course, the process of identifying a CCP for a food preparation recipe is not relevant for building water systems. Sometimes this causes confusion for people who are familiar with food safety HACCP because they imagine applying CCP identification systems for food safety to building water systems. This problem is easily solved: for building water systems, CCPs should be simply defined as that processing step in the building water system at which hazard control is applied. Typically, there should be only a very few CCPs in a building water system and some systems will not require any if the team so decides after hazard analysis.

It is important to note that the World Health Organization has adapted HACCP principles to develop its Water Safety Plan (WSP).[2] The WSP is functionally identical to HACCP and precisely defines all HACCP principles except one: the CCP. For Water Safety Plans, the four specifications for hazard control (critical control limits, monitoring method, frequency of monitoring and corrective actions) are required at any step at which hazard control is applied. In the language of process hazard analysis and control and in HACCP, this is identical to requirements for the CCP.

Validation and Verification: Critical to the success of the hazard analysis and control plan, the team must decide what evidence it has to prove that hazards have been controlled in the building water system (validation) and exactly how to confirm that the plan is actually being implemented (verification).

Simply put, validation is evidence (data) that hazards have been controlled in the building water system. It is the information used by the Team to answer this question: How do we know that the hazard has been controlled in our building water system? For an example of validation, data from the literature showing that a hazard control method is effective when applied according to critical control limits can be cited. Validation evidence can also be derived from test results for the hazard itself, such as test results giving the concentration of viable *Legionella* recovered from various locations in a building water system. The team is free to decide what validation evidence it will obtain. There is a great deal of guidance information freely and easily available for the team to consider when making its decision about how to validate hazard control in their building water system.

Verification is confirmation that the plan is actually being implemented. Examples of verification are minutes from team meetings, accurate up-to-date documentation of the plan, a regular update schedule for the plan, log books showing hazard control monitoring results and log books showing corrective actions taken. Verification must also include reassessment of the plan on a regular basis, for example annually.

Even the best-laid plans are not effective if not implemented and regularly reassessed.

Conclusions

Essentially all cases of legionellosis are associated with building water systems. Reliable, practical information about how to analyze and control *Legionella* has been abundantly available for many years. The ASHRAE (188P) Standard Practice specifies what to do with all of this information about how to analyze and control *Legionella* in various building water systems. The purpose of the Standard Practice is to prevent cases of legionellosis. This Standard Practice will be helpful and is certainly relevant to the AWT membership for many reasons, including:

- Facility managers/owners will be required to formally take responsibility for controlling *Legionella* in their building water systems. This is good for AWT members because often it is difficult for us to motivate facility managers to do all the right things with respect to good water treatment and, specifically, microbiological control programs.
- The potable water system in buildings, not just the cooling tower, is an equal focus of the Standard. This is good for AWT members because often, only (their) cooling tower water systems and (their) treatment programs are implicated in cases that, in reality, were caused by *Legionella* from building water systems they are not treating, i.e., the potable or other non-cooling tower water system.
- The Standard Practice will be hard on water treatment providers who are not competent and/or who "cut corners." One respected AWT member put it this way in comment to the authors, "The ASHRAE (*Legionella*) Standard will separate the good water treaters from the bad ones." This is as it should be.
- Competent water treatment providers are already doing, in their own fashion, most of what the Standard Practice requires; describing their current practice in the language of the Standard Practice should not be difficult or overbearing.
- Compliance with a Standard Practice is the best defense against an accusation of negligence in those cases which are caused by the hazard from unknown sources.
- Compliance with this Standard Practice will prevent legionellosis cases, perhaps thousands of cases every year in the U.S., and that is what really should motivate us most of all.

NOTE: A copy of the Standard can be found on the Members Only page of the AWT website.

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