Legionella Control in large buildings

Apartment & Office-Center, Ulm (Germany)
300 apartments, medical practices, offices

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Legionella-Control through Seccua-Filtration at Point-of-Entry

In 2014, the facility management of a large apartment center in Ulm (Germany), together with its consulting engineering firm, decided to break new ground to rehabilitate the drinking water system. The 40-year old piping system had severe problems caused by an out dated design philosophy that resulted in high concentrations of legionella. A Seccua Phoenix 10 System was installed at the Point-of-Entry to achieve current drinking water standards.

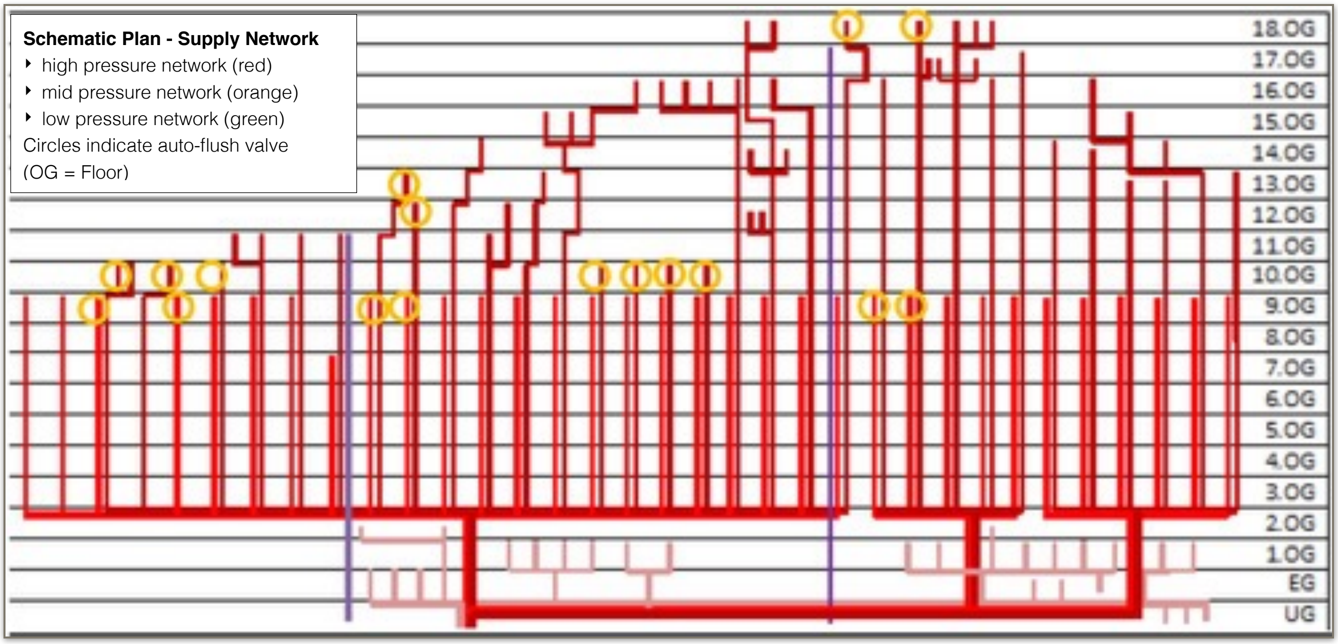
The facility was built in 1973. Retail shops are located on the ground floor. The second and third floors are occupied by medical and other professional offices. The remainder of the 19 floors are comprised of some 300 private apartments. The apartments, offices and medical practices are all privately owned. There are 500 people in permanent residence.

Legionella regulation

In Germany, allowable concentrations for Legionella at the Point-of-Use are regulated by the Drinking-Water-Guidelines (TrinkWV), which follow EU Directives. In 2012 the allowed concentrations were lowered from 1,000 to 100 CFU/100 mL (colony forming units per 100 mL of water) and a new threshold was established at 10,000 CFU/100 ml, which requires immediate action to prevent human exposure.

Whenever a concentration greater 100 CFU / 100 mL occurs, „technical actions“ are required to reduce the contamination-level to under the threshold, e.g. pipe- flushing or disinfection. Whenever a concentration of 10,000 CFU/100 ml is exceeded, immediate actions are mandated to prevent human exposure to contaminated water.

For comparison, the U.S. Occupational Safety & Health Administration (OSHA) has defined two thresholds for allowed Legionella concentration in potable water: i) 10 CFU / 1 mL (10 times higher than the EU guidelines), above which „technical actions“, like disinfection or flushing of pipelines are required; and ii) at 100 CFU / 1 mL (the same as under the EU guidelines), above which human exposure is to be avoided.



High contamination levels required immediate action

Samples taken in the building at various Points-of-Use showed high concentrations of Legionella within the hot and cold water lines. At some sampling points, concentrations of greater than 15,000 CFU/100 mL were measured, enough to call for immediate action to prevent human exposure to highly contaminated water. The local health authority prohibited the use of showers for the entire building and released an order for the water supply system to be immediately disinfected.

The old design installed all of the piping systems (cold water, hot water, hot water circulation and heating system) in close proximity within single supply shafts.

Due to old and ineffective insulating material, the heat radiated from the hot-water and heating-pipes to the cold-water lines. Temperatures of up to 40°C (104°K) were measured in the cold water at Points-of-Use in the upper level apartments, while the hot water temperature barely reached a maximum of 40°C (104 °K) in those locations.

As such the cold water was too warm, which promoted Legionella growth, and the hot water was not sufficiently hot to control the growth.

Thermal and chemical disinfection failed

For disinfection of the hot-water lines, temperatures of 70°C (158 °K), would need to be applied for at least 20 minutes.

Those temperatures would have resulted in warming the close-by and poorly insulated cold-water lines; therefore promoting Legionella growth in the cold water lines as well.

Therefore, two shock disinfections using chlorine were performed. Both times, Legionella concentrations returned to the same levels as before disinfection within only a few days.

A continuous dosing system for chlorine was subsequently installed. However, this also did not show any reduction of the Legionella concentration - even after one year of continuous chlorination. The biofilm, which had built up over the last four decades, was not removed by continuous chlorination. The colonies embedded within the biofilm were isolated from chlorine exposure and constantly supplied with nutrients contained in the incoming city-water.

None of these disinfection measures resulted in reduction of Legionella concentrations to satisfy health authority standards. Consequently, the health authority ordered that an engineering company evaluate whether the water-supply system could be rehabilitated or whether it required removal and replacement.

Assessing the options

After more than a year, the building owners finally located an innovative, young engineering company that took over the challenge of finding methods to rehabilitate the old piping system to meet health authority standards for Legionella concentration. They started by drafting a Hazard Analysis and Critical Control Points (HACCP) plan to develop a strategy for renovating the water supply system within the building.

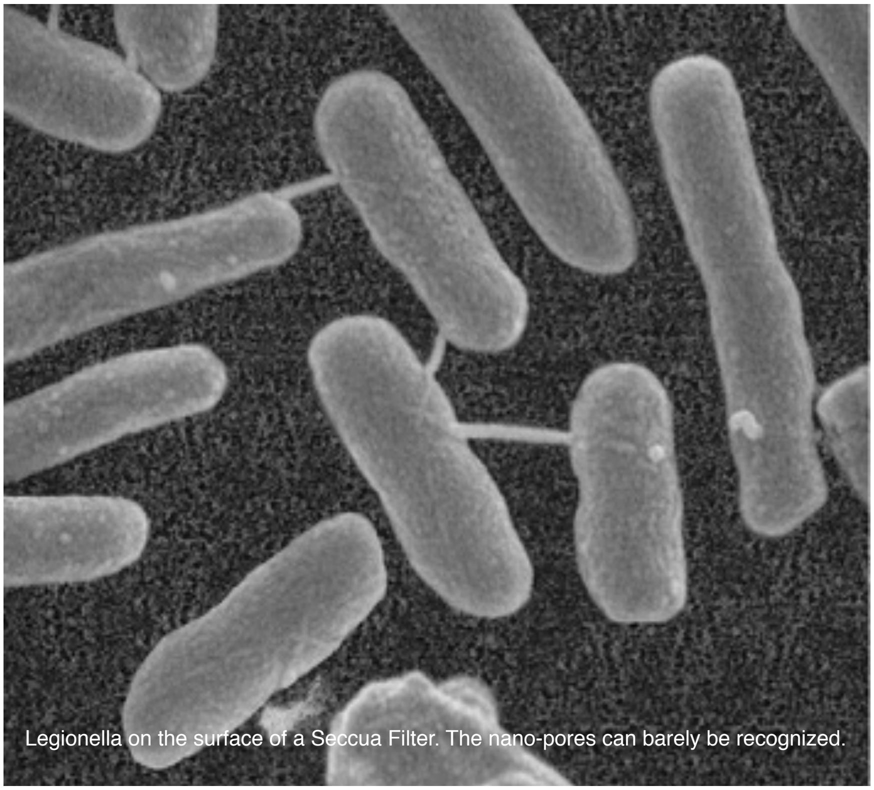
The assessment itself turned out to be a difficult challenge because the existing drawings did not accurately represent what was actually constructed and because the engineers and contractors that designed and installed the piping system were no longer in business. Furthermore apartments had been bought, sold, modified and merged.

3 main goals for renovation:

- Hygiene: Protect tenants and users from Legionella infection, according to German Drinking Water Regulation TrinkWV.
- Renovation: Achieve stable, sustainable operation of the system, preserve the value of the building.
- Pre-emptive care: Prevent new contamination with Legionella.

To achieve those goals, three main options were considered:

1. Replace the supply lines and insulation: The way the building was constructed made it nearly impossible to implement because replacing the supply lines would require removal of the walls in every unit to gain access for removal and reconstruction. The firm estimated this work would result in a cost of around 7 to 8 Mio. € ($8M to $9M); this cost figure excludes the relocation and temporary housing that would be incurred by the tenants.
2. Retrofit the hot-water re-circulation loop to provide for hydraulically balancing with flow control. This also was impracticable because of the lack of accurate construction drawings.
3. Install decentralized water heating into every unit and then shut down and cut off the highly contaminated hot water lines. This solution also could not be implemented because the existing power supply system was not adequately sized to accommodate the needed increased power load required to support the additional water heaters. The required investment to upgrade the power infrastructure was estimated at 570 - 620 thousand € ($0.6M to $0.8M). However, even if this modification was implemented, the problem of heat transfer from the hot-water lines feeding the radiator heating system would still remain as previously discussed.



Legionella on the surface of a Seccua Filter. The nano-pores can barely be recognized.

When considering the existing contamination of the cold water lines by biofilm, there remained significant doubts that any of those measures either alone or in combination would be effective in preventing high Legionella concentrations caused by contamination in the cold water system.

The conclusion reached by the engineering firm was that only new, innovative approaches would be effective in achieving a successful solution.

Important facts about Legionella:

- Are naturally occurring, minor concentrations are found in every water source
- Multiply only within biofilm
- Are dependent on amino acids from dead cells for a food source
- Survive even high temperatures of 70 °C (158 °F) within the biofilm
- Are protected against chemical disinfection within the biofilm
- Can go into a dormant mode, where they are not multiplying and therefore are not detectable by plate counting methods

Water Wonderful Life

Biofilm inside a 10“ municipal water supply line in Boston (MA, U.S.) on the left and inside a 2“ pipe from a domestic installation in Munich, Germany.

Seccua Filtration: The missing new-technology-link

An innovative process solution was clearly required to address the problem. A solution was needed that would quickly reduce Legionella concentrations to meet health authority standards (and lift the ban on showering imposed by the health authorities), AND that offered a permanent solution to rehabilitate and sanitize the old piping system to prevent the reoccurrence of Legionella contamination.

Seccua’s fully-automated filtration systems, installed at the Point-of-Entry of the cold-water line into buildings, had previously proven to be effective in many installations throughout Germany in eliminating Legionella from existing piping systems.

Seccua-Filtration utilizes a filter-membrane with pores that are smaller than all of the pathogens and micro-organisms typically found in water supplies.

Like a fire-wall, Seccua filters prevent Legionella, Pseudomonas, Amoeba and all other bacteria, parasites, virus and single-cell organisms from entering the supply systems of buildings.

Filtration thereby consumes only a couple of Watts of energy, and does not require the use of chemicals for disinfection.

How does Seccua-Filtration at Point-of-Entry remove Legionella at Point-of-Use?

Amazingly we are still using the same analytical methods that were used 100 years ago to determine whether our drinking water is safe; and that method is plate counting. The general consensus (misinformed as it may be) is that our drinking water is safe to drink if it contains not more than 300 colony forming bacteria per mL.

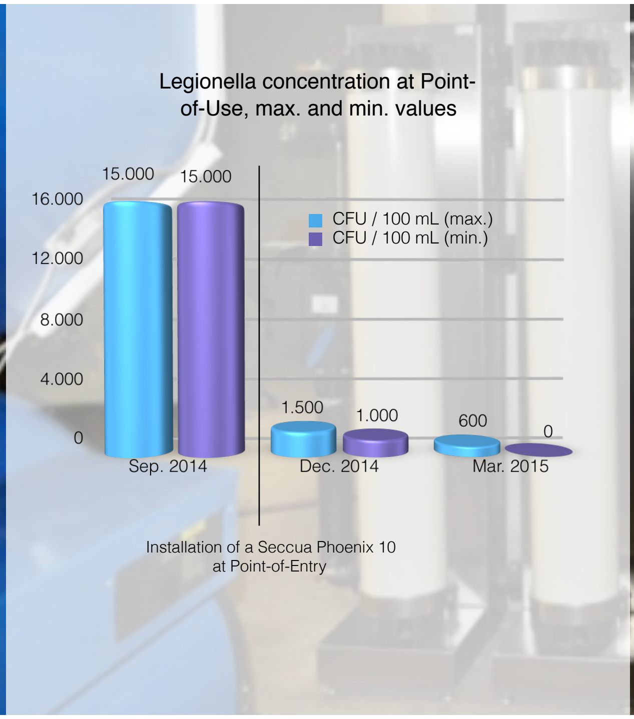
Modern analytical methods, such as Flow Cytometry, when applied to determine levels of micro-biological contamination in drinking water, show that regular city water contains between 10,000 and 200,000 micro-organisms per one mL - more than 99,9% greater than can be detected with plate counting.

What are main criteria and nutrients for biofilm, especially Legionella, to strive?

- Temperature: 18°C/64°F to 50°C/122°F are ideal. Science has shown that Legionella survive temperatures of even 70°C/158°F for more than one hour.
- Main nutrient: Catabolic products of living micro-organisms or parts of dead bacteria.
- Nitrogen, dissolved organic carbon, Phosphorous (natural or e.g. from agriculture)

These concentrations of bacteria and other harmful micro-organisms form and feed on biofilms growing on the inside of piping systems in our buildings.

Bacteria, living in a biofilm, produce „Extracellular-Polymeric-Substances“, aka EPS, a slime made from mostly Polysaccharides, which serves as food source and shelter. EPS shields these micro-organisms from environmental



stresses, including thermal or chemical[1] disinfection.

Biofilms host all manner of bacteria and other harmful micro-organisms, such as amoeba, virus and Legionella and Pseudomonas, all of which play a major role in hospital hygiene and „health-care-associated“, so called nosocomial infections.

Biofilms regularly migrate to places where more favorable growing conditions exist, thereby spreading throughout the piping system. Another strategy biofilms employ to spread is to release swarms of bacteria, also Legionella, to migrate to downstream in the piping system.

In this case, the biofilm had been building up over the course of some 40 years, continuously fed by incoming biomass.

Seccua filtration, installed at the Point-of-Entry, filters the entire water supply entering the building, before it splits up into cold and warm water lines. During this filtration step, Seccua filtration fully removes all bacteria, all parasites, all single-cell-microbes, most virus and all particles from the supply water.

Effects of Seccua-Filtration at Point-of-Entry of water into existing buildings:

- Interrupts nutrient supply to the existing biofilm.
- Immediately limits the growth potential of legionella, which largely depend on amino acids of dead micro-organisms.
- Compensates technical shortcomings which cannot be solved physically in an economical manner.
- Removes particles from water, so the water becomes crystal-clear.

Seccua filtration literally filters out billions of micro-organisms per day, which would otherwise contribute to maintenance issues and the growth of biofilms on the piping walls.

Two phase strategy

In order to immediately protect the tenants from the risk of Legionella and to eliminate the financial exposure of the owners resulting from the total renovation of the water and heating supply piping systems, the consulting engineering firm recommended a two phase strategy.

Phase one:

Objective: Remove Legionella contamination in the cold water lines and reduce contamination in the hot-water lines.

Measures: i) Install a Seccua-Filtration system at the Point-of-Entry to stop particles and bacteria from entering the facilities' piping system; ii) resolve the technical issues as described below that will assure continuous and sustainable low concentrations of Legionella to comply with health authorities standards and that can be implemented at affordable cost for the owners.

After implementation it was planned to verify the efficacy of the phase one and then determine whether the second phase of the strategy should be implemented.

[1] „Microbes in Pipes: The Microbiology of the water distribution system, 2013“, American society for Microbiology, 2013, http://academy.asm.org/index.php/browse-all-reports/520-water-distribution-system

Phase two:

Objective: Reduce Legionella concentrations in the hot-water lines to levels below the threshold imposed by regulators.

Measures: Upgrades to the electrical power system to support installation of decentralized water heaters at the Point-of-Entry to each unit.

After the municipal health authority had agreed to this strategy, the two phase strategy was also unanimously approved by the owners.

Implemented measures

In the course of implementing the first phase, the following technical short-comings of the piping system had been remedied:

- The sprinkler-pipes were separated from the drinking water supply system.
- Dead-end connections were removed.
- The cold water headers were replaced and properly insulated where they could be accessed.
- Hydraulic balancing of the hot-water-circulation system was implemented as far as the system was accessible.

Additionally the following process equipment was installed to improve hygienic conditions short and long-term:

- A scale protection technology (template assisted crystallization) to protect the old piping system against further scaling.
- A Seccua Phoenix system at the Point-of-Entry of the cold-water-supply, which is capable of treating up to 20 Liters per Second (317 gpm) to provide immediate relief from the very high Legionella contamination, both in cold- and hot-water.

Remarkable Results

The first samples were taken eight weeks following start up of the Seccua-Filtration system, which took place in September 2014. All previously problematic sampling points showed an approximate decrease of legionella by factor ten, with a maximum value of 600 CFU/100 mL of Legionella (before 15.000 CFU/100 mL).

To the immense relief of the tenants , the local health authority lifted the shower-prohibition immediately after the positive results had been obtained. Prior to that time, the prohibition had been in place for more than one and a half years.

Two months later, ongoing sampling showed that the microbiological quality of both, the hot- and cold-water lines showed continuing improvement: 18 out of more than 35 very critical sampling points, all of which were part of the cold water supply, showed 0 CFU / 100 mL of Legionella.

Most of the hot water samples out of those 35 sampled points showed concentrations of Legionella between 0 / 100 mL and 100 / 100 mL and only one single maximum value of 600 CFU / 100 mL.

In combination with implementation of other easy to perform minor renovations and other upgrades to the piping system, the integration of the Seccua-Filtration at the Point-of-Entry of the city-water-line into the building was the key to the successful rehabilitation of the forty year old piping system.

About Seccua Phoenix

The Seccua Phoenix system, which has been installed into the basement of the facility, treats a peak flow of 20 Liters per Second (317 gpm).

Its full removal of pathogens has been certified by many independent laboratories and authorities, amongst many others the California Department of Public Health. The removal performance of the filters has been tested to U.S. EPA, ANSI and DVGW standards.

Alarms and Control

The programmable logic controller (PLC), supplied with the Seccua Phoenix Ultrafiltration system, controls the UF filters and performs

- Filtration
- Fully automatic cleaning cycles, which adapt to varying inlet water quality by monitoring the membrane fouling
- Fully automatic Direct Membrane Integrity test meeting US EPA filtration guidance manual standards, triggered daily and by a turbidity threshold in filtrate.

The systems monitor the following parameters:

- Flow rate
- Filtrate turbidity
- Temperature
- Inlet pressure
- Transmembrane pressure
- Real clock time
- Removal ratio as detected during a fully automatic membrane integrity test

Water Wonderful Life

A Phoenix 20 unit, installed at Point-of-Entry, treats peak-loads of up to 30 Liter per Second (474 gpm).

In its extensive data-log storage, the Seccua controller records the following data every 15 minutes (adjustable) and upon every action or alert:

- Time and date
- Actuated component or incoming alert
- Filtrate turbidity
- Log removal value of a performed integrity test
- Feed- and filtrate-pressure
- Flow
- Water temperature
- Alert type

Those data can be downloaded from the units either through the built-in USB connection, through the BUS interface of the units and, an option which wasn't installed in this case, through GPRS cellular modem.

Once downloaded, those data are available as .CSV file for further processing in any available spreadsheet software or through Seccua's Utilization Tool for data-logger.

The systems are putting out alerts to the operator upon occurrence of the following events:

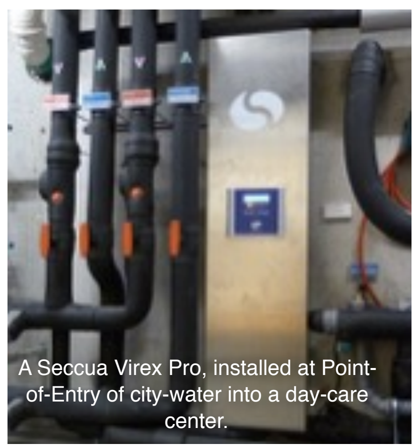
Even greater effects of Seccua-Filtration at POE of new buildings:

- Prevent legionella and micro-organisms from ever entering the water supply
- Removes all tiny particles like hard-water flakes or rust sediments
- Allows the pipes inside a building to stay cleaner in the long-term and prevents critical biofilms from even forming.
- Allows heat pumps and other low-energy heating systems to run at their highest efficiency, without endangering the hygienic of the water system
- Protects the investment for the water supply system of the whole building.

- Too high Transmembrane pressures across the filter system
- Failed Direct Integrity Test
- Ineffective automatic cleaning
- Filter fouling quicker than expected
- Other failures in the process

Direct Membrane Integrity Testing

In order to receive 99,99% removal credit (4-log) for bacteria and parasites, membrane filtration systems must provide for an automated Direct Integrity Test (DIT). A DIT must be able to detect defects in the filter, which would allow bacteria and parasites to pass through.



A Seccua Virex Pro, installed at Point-of-Entry of city-water into a day-care center.

The Phoenix series are able to detect damages down to 0.8 μm (micron), small enough to reliably obtain 99,99% removal credit for bacteria and parasites.

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