- Cross connection of different water qualities (e.g. drinking water and water of other quality)

❷ Possible private resource of the building and treatments applied to raw water before it enters the building water system

Several other sources than public drinking water networks may be called by water networks inside buildings (e.g. rain water or well water). In many developing countries, where the water supply system is intermittent, under ground and overhead reservoirs are integral components of the water distribution systems in the building. The integrity of such storage reservoirs is of critical importance as otherwise they may become a source of contamination of the drinking water inside buildings, in particular of faecal contamination.

If the water from the private source is not for human consumption, at each point of delivery adequate safeguards must be installed to prevent this water to be "misused" as drinking water (e.g. warning signs).

The potential risk of non public resource or water storage within the building is that contaminated drinking water is provided to the building's installation system. It becomes the key point for a risk analysis. Therefore it is essential that the associated network is well known. In particular, the following elements should be investigated and understood:
- Where exactly is the water resource? How is it protected from external pollution?
- What is the route followed by the water? What are the possibilities of contamination along this route (e.g. material in contact with water)?
- Is there any system to store this water? How is this storage accessible? What are the materials of this storage system, in particular those in contact with water? How is this storage protected from external pollution?
- What kind of treatment (e.g. disinfection)?

It is recommended to have a separate Water Safety Plan for the private water resource and possible water treatment installations.

❸ Water piping and cross-connections to non-drinking water systems

Water piping systems vary in lengths, complexities, materials and designs. The structure of a piping system can be understood by examining existing plans and by an on-site investigation. Plans should always be checked against the reality, since they are not always updated when upgrades or repairing operations are performed on the network. However, it is not always easy to know exactly the routes followed by the pipes throughout a building, due to the fact that these pipes are voluntarily concealed, or may be embedded in walls or ceilings. During on-site visits, it is primarily essential to try to identify:

- accidental cross-connections with non-drinking water;
- points of delivering to non-drinking water systems (e.g. technical systems, watering and spraying systems) and associated equipments (e.g. backflow preventers, anti-siphonage systems, valves, notices) or differences of pressure;
- dead-leg and blind ends;
- materials of pipes and other components;
- leaks
- thermal insulation of the piping system;
- ease of maintenance / disinfection.

With respect to the piping system potential hazards include:

- If water of different quality or for different use is transported in a building possible cross-connections of the piping systems pose additional risk on water usage. The different water quality may be not recognizable for users. During maintenance and rebuilding work connections between formerly separated piping systems may be easily installed. It is therefore important to check and document whether installations with different water qualities are strictly apart from each other and clearly marked. At points where connections between different piping systems are unavoidable, existing controls and precautions to prevent mixing or backflush of water need to be investigated. Technical guides exist that detail how to ensure this division by technical means.
- It is vital to identify points where the ambient temperature is not adequate and poses a risk that a microbial growth appears. For example, cold water pipes may be insulated in the same sheath as hot water pipes, with the consequence that cold water is warmed. The same effect may be observed in narrow shafts where hot and cold water tubes may be installed with insufficient distance.
- Unsuitable materials (e.g. lead pipes) may be used that cause a deterioration of the drinking water or may cause the failure of the material by corrosion. The corrosion of metallic materials is influenced by the water composition and the combination of different materials.

1. Author: Based on the abstract of The Journal of the Japanese Association for Infectious Diseases, Vol. 70, No. 2, 1996 by T. Kuroki et al. with some modification by Masaki Itoh
2. Year in which case study was recorded: 1996
3. Agent:
4. Problem/incident: Cryptosporidiosis outbreak
5. Building type: Multipurpose building
6. System type: Water supply with receiving tank
7. Country: Japan
8. Intervention (type):
9. 3 keywords: *cryptosporidium*, receiving tank, inappropriate design
10. Number of words: 420

From 30 August to 10 September 1994, there was an outbreak of Cryptosporidiosis among the people who visit or work in a multipurpose building in Hitatsuka, Kanagawa Prefecture, Japan. The multipurpose building was constructed in 1970 with six stories above the ground and one below. There were ten restaurants or pubs, a dance studio, a clothing store, a post office and accommodation for employees in the building. The epidemiological surveys by a questionnaire revealed that 461 out of 736 persons investigated complained of cholera-like of flu-like illness. From the study of water supply system in the building, it was found that there were two lines of water supply system; one was directly connected to public water supply to serve drinking water to first floor, independent from other floors and the other line supplied drinking water from second to six floors through receiving tank, which stored drinking water from public water supply, installed in the basement. Besides the receiving tank for drinking water, night soil tank, wastewater tank and artesian spring water tank were also installed in the basement. These tanks were made by concrete adjacent to each other and separated by concrete wall with holes upper part of the walls to connect each tanks. (This kind of tank design is not allowed in new regulations for buildings.) Although the objective of the holes was not clear, the holes might have functioned to discharge excess of drinking water in the receiving tank to night soil tank or wastewater tank. Water level of the wastewater tanks was kept down below the holes by pumping out wastewater to the public drain.

From the epidemiological survey, there were patients related except first floor (clothing store and post office) of the building and polluted drinking water was strongly suspected of this infection. According to the declaration of the owner of the building, the wastewater pump was broken at the time of outbreak. From the biological assay, several species of pathogenic bacteria were isolated both from stool and water samples, but they were not supposed to be linked to the outbreak. Oocysts of *Cryptosporidium parvum* were identified in 12 (48%) of the 25 stool samples. The oocysts were also found in tap water and other water samples from the receiving tank, the elevated tank and the other tanks. Therefore it is clear that the cause of this outbreak was polluted drinking water by *Cryptosporidium* oocysts and accidental malfunction of the drainage system was estimated to be the cause of contamination of drinking water in receiving tank.

❹ Installations for the preparation of hot water

The production of hot water is part of elements of comfort of numerous buildings. The energy used to produce this hot water may be various (e.g. electrical, petroleum product, solar, geo-thermal, primary fluids). Hot water production may be instantaneous, or based on its storage in hot water tanks. In large systems production of hot water can be centralised (it is then installed in a boiler room) or provided by multiple units.

All heating devices have to be kept maintained. Responsibility has to be identified.

All hot water boilers are potentially subject to scaling and/or corrosion risks. Size and capacity should be appropriate for the demand (not too small and not too large).

Large heating systems pose specific hazards due to:
- the frequent recourse to high volume tanks, within which stagnation and stratification can occur;
- lack of availability and stability of heating energy (e.g. variability of the temperature of primary fluids due to their use for other applications, variability of the availability of solar energy): this may result in instability of the temperature inside the hot water tank, and the correlative development of potentially hazardous micro-organisms (e.g. Legionella);
- leaks of fluids (e.g. heat-transporters or corrosion preventing additives) into drinking water, resulting in the introduction of toxic products inside hot water;
- other ways of exposing stored water to external pollution (e.g. installations close to highly polluted environments);
- inadequate management of the temperature of hot water inside tanks (e.g. low target temperature, non representative check-point to command the energy demand) resulting in large volumes of water let for hours at temperature ranges that may enhance the development of micro-organisms;
- corrosion and scaling due to faulty design, resulting in the accumulation of sediments and micro-organisms at the bottom of the tank;
- the presence of water treatment installations (e.g. anti-scaling), which can pose specific maintenance / installation risks.

Hazardous situations associated with small systems include:
- Inadequate management of temperature (e.g. manipulation of thermostats)
- Maintenance requirements are often neglected (e.g leading to accumulation of scale).

Methemoglobinemia attributable to nitrite contamination of potable water through boiler fluid additives – New Jersey 1992 and 1996

Two outbreaks of methemoglobinemia were reported in 1992 and 1996. In the first outbreak, acute onset of illness was reported in 49 children from one school. Onset occurred within 45 minutes after lunch. Initial symptoms were blueness of lips and fingers followed by nausea, abdominal pain, vomiting and dizziness. Fourteen children were hospitalised and treated

with supplemental oxygen and methylene blue. All children recovered in 36 hours. In the second incident 6 workers reported acute onset of blueness of the skin. Two of the workers were treated with supplemental oxygen and methylene blue. All recovered within 24 hours.
An investigation of the first incident found that the children had consumed soup diluted with a mixture of hot and cold tapwater. The soup contained 459 mg/L of nitrite while the hot water contained 4-10 mg/L nitrite. The hot water boiler had been returned to service that morning after earlier servicing using a commercial conditioning fluid containing nitrite and sodium metaborate. Investigations found that a backflow check valve preventing flow of water from the boiler to the drinking water system was stuck in the open position. In addition taps for the boiler treatment solution and the hot water coil were in the same area but unlabelled. The water system was flushed and the school discontinued heating of water through boiler coils.
An investigation of the second incident also found that a faulty backflow prevention valve had allowed boiler conditioning fluid to contaminate hot water used to prepare coffee.
Although the potential for this type of contamination from boilers was recognised with a regulatory requirement for backflow prevention valves there were no requirements for routine inspection, maintenance and replacement of valves. Maintenance of backflow prevention devices used to prevent contamination of drinking water is essential.

Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report 46 (9), 202-204.

❺ Hot water piping systems

Recognition of the hot water piping system should aim not only at mapping it, but also at describing its way of functioning, including expected flow rates under drawing conditions and non drawing conditions.

Depending on the type of preparation of hot water, the hot water piping system may be installed at the scale of the entire building, or only at the scale of a floor or a flat.

Large hot water piping system may pose problems due to:

- complex design, favouring the presence of dead legs and blind ends and non-circulating parts;
- for looped systems, insufficient equilibrium of permanent flow amongst all the loops, or insufficient total flow rate to feed all parts of the piping system;
- faulty insulation of the piping system;
- breakdown of balanced hydraulics due to hot water use patterns
- temperature loss
- operation of temperature reduction measures (mixing valves or switching of circulation pumps)
- corrosion
- leaks
- scaling
- materials of pipes and other components (e.g. material not suitable for hot water)

❻ Equipments installed at the points of use

Description of points of use encompasses the identification of all equipment using water, of their purpose and expected conditions of use, and of their actual use (or absence of use).

Equipment without hand contact (e.g. by light barriers) normally incorporate magnetic valves. These valves have been shown to be isolated sources of Legionella and *P. aeruginosa* and must be regarded as critical points to be evaluated during hazard analysis.

Points of use devices are various in type, size and flow rates. They encompass sinks, taps, baths and showers, but also WC, medical devices, sprinkling systems, drinking water fountains, decorative fountains, etc. They may present specific risks, such as:

- deficient mixing valves (esp. thermostatic valves which have mixing chambers) may facilitate the introduction of hot water into cold water pipes or the contrary, thus resulting into acceleration of microbial growth.
- aerosol formation (from e.g. showers, decorative fountains), thus represent sources of exposure to respiratory diseases (e.g. legionellosis).
- Back-contamination at point of entry of environmental micro-organisms (e.g. *Pseudomonas.)*,

❼ (and 1 and 2) Possible water treatment system (PoE or PoU)

Treatment may be subject to national or regional regulation; not all types of treatment may be allowed. Points of use are sometimes equipped with treatment systems (PoU treatments) such as carbon filters, softeners or physical applications. These treatments may present risks due to inappropriate adjustment, inadequate operation or lack of maintenance.

Treatment systems may also be installed at the Point of Entry for the whole system, or upstream from the production of hot water (PoE treatments). Treatment may be used to avoid corrosion or scaling problems, to provide additional disinfection, treatment of private resources or unsafe water or any other reason.

The sole installation of a water treatment system does not pose in itself a risk for the quality of drinking water. However, some risks may arise from:
- the inadequacies of the treatment with the water to be treated and with acceptable characteristics of drinking water
- a fault of installation and adjustment of the treatment systems: many treatment systems need to be installed only by professionals (e.g. softening systems should not be adjusted so that they produce a water with an hydrotimetric value of 0 mmol/l)
- lack of maintenance, favouring the accumulation of dirt, thus making of the treatment system an "incubator" of micro-organisms like Legionella and *P. aeruginosa*

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