

6. Other Applications of the Guidelines

6.1 Large buildings

Responsibility for many actions essential for control of water quality in large buildings is outside the responsibility of the water supplier as significant contamination occurs because of factors within the built environment and specific requirements in the “engineered building” environment (including hospitals and health care facilities) are distinct to those in the domestic environment.

General water safety is assured by maintenance protocols, regular cleaning, temperature management and maintenance of a disinfectant residual. For these reasons authorities responsible for building safety should provide advice and require specific water management safety plans.

Authorities responsible for building safety should ensure the development and implementation of WSPs. Such plans address not only drinking-water systems, but other water systems including cooling towers and evaporative condensers of air-conditioning devices.

6.1.1 Health risk assessment

The principal hazards that may accrue in the water supply systems of large buildings are ingress of faecal contamination (which may affect only the building or also the wider supply); proliferation and disposal of “regrowth” bacteria (especially legionella); and addition of chemical substances from piping, jointing and plumbing materials.

Devices such as cooling towers and hot or warm water systems if not appropriately maintained can provide suitable conditions for *Legionella* to survive and grow. In large buildings there is increased potential for regrowth of *Legionella* in long water distribution systems and maintenance of these systems need particular attention. In addition to supporting the growth of *Legionella* devices such as cooling towers and hot/warm water systems can disseminate contaminated water in aerosols (see 6.2).

Hospitals, other health care facilities, schools and hotels and some other large buildings are high-risk environments, both because of the complex nature of their water systems, and sensitivities of their occupants. Similar requirements to those outlined above for other engineered buildings apply, but heightened vigilance in control measure monitoring and verification are generally justified.

6.1.2 System assessment

Because such WSPs are limited to the building environment and since dose response is not easily described, adequate control measures are defined in terms of practices that have been shown to be effective.

In undertaking an assessment of the building’s distribution system, a range of specific issues must be taken into consideration. These factors relate to ingressor proliferation of contaminants and include:

- pressure of water within the system;
- intermittent supplies;
- temperature of water;
- backflow prevention; and
- system design to determine deadends and areas of stagnation.

6.1.3 Management

Pressure

The aim of a distribution system within a large building is to supply water at adequate pressure and flow. Pressure is influenced by the action of friction at the pipe wall, water demand, pipe length, gradient and diameter. For the purposes of maintaining microbial quality, it is important to minimise transit times and avoid low flows and pressures. Pressure at any point in the system should be maintained within a range whereby the maximum pressure avoids pipe bursts and the minimum ensures water is supplied at adequate flow rates for all expected demands. In a tall building, this may require pressure boosting at strategic locations in the network.

Backflow Prevention

Where piped water supplies are stored in tanks to augment intermittent supplies, or water is supplied to various equipment, the potential for backflow of water into the mains network exists. This may be driven by high pressures generated in equipment connected to mains water supplies, or by low pressures in the mains. A backflow event will be a sanitary problem if there is ‘cross-connection’ between the potable supply and a source of contamination. In situation where back-flow may occur, back-flow prevention devices should be fitted to the system.

System design

The design and management of piped water systems must take into account the impact of slow flows and dead-ends. Within the supply, the most significant points of risk will be areas where pipes pass through drains or other places where stagnant water pools may form. Water quality may also deteriorate on re-charging where surges may lead to dislodgement of biofilm, leading to aesthetic problems.

6.1.4 Monitoring

The primary emphasis of monitoring is as a verification of management processes. Monitoring depends primarily on monitoring of control measures, including:

- monitoring temperature, including monitoring of remote areas frequently (at least weekly);
- disinfectants and pH, when employed (weekly to monthly).

And in addition:

- monitoring microbial quality of water, particularly following system maintenance or repairs.

Monitoring of drinking-water quality is more frequent when the building is more new, or recently commissioned. When the building’s water system has not stabilized, monitoring should be more frequent until the water quality has stabilized.

6.1.5 Independent Surveillance

Independent surveillance is an essential element in ensuring continued water safety. In the case of water quality within large buildings this implies:

- specific attention to codes of good practices (e.g. at commissioning and in contacting construction and rehabilitation);
- suitable training for engineers and plumbers; and
- self-regulation by the plumbing community;
- effective certification of materials and devices in the market place; and inclusion of WSPs as an essential component of building safety provision.

6.1.6 Drinking-water Quality in Health Care Facilities

Health care facilities include hospitals, health and hospice centres, dental offices and dialysis units. Drinking-water should be suitable for human consumption and for all usual domestic purposes including personal hygiene. However, it may not be suitable for all uses or patients within health care facilities and further processing or treatment may be required.

Drinking-water can contain a range of microorganisms including *Pseudomonas aeruginosa*, *Legionella*, non-tuberculous Mycobacteria spp, *Acinetobacter* spp, *Aeromonas* spp, *Aspergillus* etc. There is no evidence that these microorganisms represent a health concern through consumption by the general population, including most patients in health care facilities. However, additional processing may be required to assure safety for consumption by the severely immunosuppressed such as those with neutrophil counts below 500/ μ L.

Non-faecal microorganisms in drinking-water also have the potential to cause infections if drinking-water is used to wash burn victims and wounds or to wash medical devices such as endoscopes and catheters. Water used for such purposes needs to be of a very high quality and requires additional processing such as microfiltration or sterilisation, depending on use.

Health facilities may include environments that support the proliferation and dissemination of *Legionella* (see 6.2). Hospitals are high-risk environment and, all potential nosocomial cases of pneumonia should be examined for *Legionella*, *Legionella* antibodies, and *Legionella* antigen. Transplant patients should be scrupulously protected from exposure to *Legionella* during treatment. In all cases of nosocomial pneumonia, every effort must be made to identify the source of infection and implement measures to cease further transmission.

Renal dialysis requires large volumes of water that exceed the chemical and microbiological quality requirements for drinking-water. Water used for dialysis requires special processing to minimise the presence of microorganisms, endotoxins, toxins and chemical contaminants. The vulnerability of renal dialysis patients was demonstrated in 1996 by the death of 50 renal dialysis patients after exposure to water contaminated by high levels of microcystin. Dialysis patients are also sensitive to chloramines and this needs to be considered when chloramination is used to disinfect drinking-water supplies particularly in areas where there are home dialysis patients.

All health care facilities should have specific water safety plans as part of their infection control program. These plans should address issues such as specific water quality and

treatment requirements, cleaning of specialised equipment and control of microbial growth in water systems and ancillary equipment.

6.1.7 Drinking-Water Quality in Schools

A long-term approach to improving hygiene in the community is working with children in schools. This enables the concepts of hygiene to become part of a general understanding of health and the influence of the environment. Schoolchildren can then introduce hygiene concepts to their parents. They learn from what they see around them, so that the school environment itself should meet the requirements of good hygiene, for example by providing toilets or latrines, water for hand-washing, generally clean surroundings, and hygienic facilities for the preparation and serving of school meals. Some schools are large buildings, guidance on large buildings is provided in 6.1.

One of the most important characteristics of effective health education is that it builds on concepts, ideas, and practices that people already have. Hygiene education programmes should be based on an understanding of the factors that influence behaviour at the community level. These might include:

- enabling factors such as money, materials, and time to carry out the behaviour;
- pressure from particular members of the family and community, e.g. elders, traditional healers, opinion leaders;
- beliefs and attitudes among community members with respect to the hygiene behaviour, and especially the perceived benefits and disadvantages of taking action, and the understanding of the relationship between health and hygiene.

An understanding of the factors that influence hygiene behaviours will help in identifying the resources (e.g. soap, storage containers), the key individuals in the home and community, and the important beliefs that should be taken into account. This will help to ensure that the content of the hygiene education is relevant to the community. Good advice should:

- result in improved health;
- be affordable;
- require a minimum of effort and time to put into practice;
- be realistic;
- be culturally acceptable;
- meet a felt need; and
- be easy to understand.

6.2 Legionella

Legionella bacteria are the cause of legionnaires' disease and legionellosis. They are ubiquitous in the environment and can proliferate at temperatures experienced at times in piped distribution systems. However exposure from water systems is preventable through the implementation of basic water quality management measures, including maintaining water temperature outside the range at which *Legionella* proliferates (25-50°C) and/or through the maintenance of disinfection residuals throughout the piped distribution system.

6.2.1 Health risk assessment

Legionella spp. can cause legionellosis, a range of pneumonic and non-pneumonic diseases. Risk from *Legionella* are associated with inhalation through aerosolisation of water, not through ingestion in drinking-water.

The risk of infection following exposure to *Legionella* is difficult to assess and remains a matter of some debate. Due to its prevalence in both natural and man-made environments, it must be considered that most people are frequently exposed, at least to low numbers. Generally, there is either no reaction to such exposure or asymptomatic production of antibodies. Drinking-water from natural sources and public supplies may carry low numbers of free *Legionella* organisms or amoebae containing *Legionella*.

Legionnaire's disease is a non-transmissible pneumonic form of legionellosis. Most cases of legionellosis are caused by *L. pneumophila*. General risk factors for the illness include; males 50 years of age or older; chronic lung disease; cigarette smoking, and excess consumption of alcohol. Further risk factors also include frequency of spa use and length of time spent in or around spas. Although the attack rate is often less than 1%, mortality rates among hospitalized cases range widely up to 50%.

Pontiac fever is a non-pneumonic, non-transmissible, non-fatal, influenza-like illness. The attack rate can be as high as 95% in the total exposed population. Patients with no underlying illness or condition recover in 2 - 5 days without treatment.

Risk of legionellosis from drinking-water is associated with proliferation of *Legionella* in hot and cold piped systems, when exposure is associated with aerosolisation arising from showers, toilets and other plumbing fixtures. The inference to be drawn from the many reported outbreaks and documented single cases is that inhalation of bacteria, or aspiration following ingestion, may lead to disease.

Most cases of disease associated with *Legionella* present in clusters. In both cluster and sporadic individual cases, exposure to *Legionella* has arising from proliferation in piped distribution systems, cooling towers, evaporative condensers of air-conditioning devices, piped hot and cold water maintained between 25°C and 50°C, (particularly in hospitals and hotels). Hot whirlpool, natural thermal baths and spa pools, nebulizers, and other means of producing warm aerosols are also potential sources of exposure to *Legionella*.

No unequivocal dividing line between those at risk and those not at risk has yet been established, however the risk of infection is high among transplant patients, patients receiving high-dose steroid treatment or intensive care, individuals being fed by nasogastric tube, and people with malignancies and end-stage renal disease. Special measures of protection and surveillance are essential for people in these categories. Increased susceptibility during outbreaks has also been observed among diabetic patients, the elderly, and people with reduced resistance to respiratory disease (e.g. smokers). Males of these groups appear to be more susceptible than females.

Individuals at high risk of legionellosis may exist in general population and where specific concern exists public health authorities may provide addition general guidance, or medical practitioners, specific guidance to patients in their care.

Hospitals are a potential high-risk environment with many at risk groups and, all potential nosocomial cases of pneumonia should be examined for *Legionella*, *Legionella* antibodies, and *Legionella* antigen. Transplant patients should be scrupulously protected from exposure to *Legionella* during treatment. In all cases of nosocomial pneumonia, every effort must be made to identify the source of infection and implement measures to cease further transmission.

6.2.2 System assessment

Most outbreaks of *Legionella* disease have been related to the engineered building environment. Concern for *Legionella* in drinking-water supply is not limited to hot/cold system, but also artificial spa pools and HVAC systems which use water received from piped distribution systems. Control of *Legionella* follows similar general principle to Water Safety Plans (WSPs) as applied to piped water supplies. However, typically most responsibility for actions essential for control is outside responsibility of the water supplier as most growth occurs because of factors within the built environment and specific requirements are distinct in the “engineered building” environments, including hospitals and health care facilities versus the domestic environment.

Since dose response is not easily described, adequate control measures are defined in terms of practices have been shown to be effective. This will normally include an assessment of temperature water in hot/cold systems, assessment of appropriate lagging of pipes and the monitoring of the building system, including remote areas for temperature. If temperatures cannot be maintained outside this range, a disinfection residual in the building drinking-water systems that provides appropriate levels of security, becomes an important control measure.

6.2.3 Management

Increased risk of proliferation of *Legionella* has been associated with drinking-water subjected to periods of stagnation and in systems operating at temperatures range 25°C to 50°C. Management of *Legionella* in a building’s piped distribution system requires the implementation of management practices, which may include:

- Setting of heaters to ensure hot water delivered to all taps is above 50°C. This implies that storages and pipes will be appropriately insulated to ensure delivery of water above this temperature;
- Disinfection where it is not possible to maintain water temperature outside the temperature range 25°C to 50°C.

High water temperature is the most efficient approach to both intermittent disinfection and continuous control in hot-water systems. In hot-water distribution systems, water temperatures should exceed 50°C in boilers, reservoirs, and circulating pipes, and not less than 50°C at outlets. However, maintaining operating temperatures of hot water systems above 50°C may result in increased energy requirements, and may present a scalding risk in young children, the elderly and other vulnerable groups.

In cold water distribution systems, temperature maintained at less than 25°C throughout the system provides effective control. However this may not be achievable in all systems, in particularly those in hot climates. Maintaining residual disinfection, e.g. > 0.5 mg/L free chlorine, appears to contribute to the control of *Legionella* in such circumstances.

To ensure compliance of a system, verification of control measures (e.g. control of temperature, biocide and pH residuals) is required.

The domestic environment is also likely to contribute a significant fraction of all *Legionella* infection. Control in household, requires:

- Plumbing codes/code of good practice which require minimization of pipe runs in hot and cold water systems outside temperature range 25°C to 50°C.
- Materials and devices should be certified as suitable for hot/cold water use. Certification authorities should take account of corrosion and microbial growth promotion potential in their testing regimes.
- Installation and maintenance of backflow devices and thermostatic mixing valves.
- Qualified plumbers to undertake necessary maintenance of plumbing systems to prevent cross-connection of hot and cold pipes, and pipes carrying potable and waste water.
- All new buildings both domestic and engineered should be inspected for compliance with design specifications on commissioning/completion, as part of normal building construction inspection.
- Clear and accurate layout of the engineered system needs to be available.

6.2.4 Monitoring

The primary emphasis of operational monitoring is confirm the efficiency of management processes. Monitoring depends primary on monitoring of control measure, including:

- monitoring temperature, including monitoring of remote areas frequently (at least weekly in large buildings);
- biocides and pH, when employed (weekly to monthly in large buildings).

Testing for *Legionella* bacteria serves as a form of verification and should be undertaken periodically, e.g. monthly to quarterly depending on the type of building environment. This testing should not replace the emphasis on control strategies. Monitoring is more frequent when the building is new, or recently commissioned. When the building is shown to be contaminated with *Legionella*, monitoring should be more frequent until the building complies with the Guidelines.

6.2.5 Independent Surveillance

Independent surveillance is undertaken to confirm water safety. In the case of legionella this implies:

- Endpoint testing, particularly at the extremities of the system where water quality is likely to be at its lowest
- Following up community outbreaks of legionellosis.

The testing for *Legionella* should be undertaken by competent laboratory using proven methodology.

For comprehensive information on *Legionella* in drinking-water, see *Legionella and Prevention of Legionellosis*

6.3 Emergencies and disasters

Drinking-water quality is one of the most important public health issues in most emergencies and disasters. As in stable situations, microbial contamination of drinking-water presents far greater health risks than does chemical contamination, except in certain circumstances such as a spill of a chemical to a surface water source. The main microbial risk associated with water quality in emergencies and disasters is from the ingestion of water that is microbially contaminated. In many emergency situations, this causes high rates of morbidity and mortality, principally through the transmission of diarrhoea, dysentery, enteric fevers, and infectious hepatitis. Epidemics of cholera and dysentery may develop rapidly from water-borne outbreaks, overwhelming health services and causing many deaths in a short period.

Contamination of water supplies may occur during collection, storage, and use in the home, as a result of lack of sanitation, or poor hygiene due to an insufficient quantity of water.

Other transmission routes for major water and sanitation-related diseases in emergencies and disasters include person-to-person contact, aerosols, and food intake. The importance of these other routes should be considered when applying the Guidelines, selecting and protecting water sources, and choosing options for water treatment.

A quantity of reasonably good quality water, sufficient for adequate hygiene is preferable to an insufficient quantity of very high quality water.

Different types of disaster affect water quality in different ways. When people are displaced by conflict and natural disaster, they may move to an area where unprotected water sources are contaminated. When population density is high and sanitation is inadequate, unprotected water sources in and around the temporary settlement are highly likely to become contaminated. If there is a significant prevalence of disease cases and carriers in a population of people with low immunity due to malnutrition or the burden of other diseases, then the risk of an outbreak of water-borne disease is very high. The quality of urban water supplies is particularly at risk following earthquakes, mudslides, and other structurally damaging disasters. Water treatment works may be damaged, causing untreated or partially treated water to be distributed, and sewers and water transmission pipes may be broken, causing contamination of drinking-water in the distribution system. Floods may contaminate wells, boreholes, and surface water sources with faecal matter washed from the ground surface or from overflowing latrines and sewers. During droughts, people may be forced to use unprotected water supplies when normal supplies dry up, and as more people and animals use fewer water sources, the risk of contamination is increased.

Emergency situations that are appropriately managed tend to stabilise after a matter of days or weeks. Many develop into long-term post-emergency situations that last for several years before a permanent solution is found. Water quality concerns may change over that time, and water quality parameters that pose long-term risks to health may become more important.

6.3.1 Practical considerations

Available sources of water are very limited in most emergency situations and providing a sufficient quantity of water for personal and domestic hygiene as well as for drinking and cooking is important. Guidelines and national water quality standards should therefore be applied flexibly, taking into consideration the risks and benefits to health in the short term

and long term. Attempts to apply guidelines and standards too strictly may result in insufficient water being available, resulting in an increased risk of disease transmission through lack of hygiene.

There are a number of considerations to make when providing drinking-water for a population affected by a disaster, including the following:

- *The quantity of water available and the reliability of supply* – this is likely to be the overriding concern in most emergency situations as it is usually easier to improve water quality than to increase its availability or to move the affected population closer to another water source.
- *The quality of the raw water* – it is preferable to choose a source of water that can be supplied with little or no treatment, provided it is available in sufficient quantity.
- *Sources of contamination and the possibility of protecting the water source* – this should always be a priority in emergencies, whether or not disinfection of the water supply is considered necessary.
- *The treatment processes required for rapidly providing a sufficient quantity of potable water* – as surface water sources are commonly used to provide water to large populations in emergencies, clarification of the raw water by flocculation and sedimentation or by filtration is commonly required before disinfection.
- *The treatment processes appropriate for post-emergency situations* – the affordability, simplicity, and reliability of water treatment processes in the longer term should be considered early on in the emergency response.
- *The need to chlorinate drinking-water supplies* – in emergencies, when hygiene conditions are poor and the risk of disease outbreaks is high, particularly in populations of people with low immunity, it is beneficial to chlorinate the water supplies even of small communities. The water supplies for all large population concentrations should be chlorinated to ensure a residual disinfection capacity in the water, reducing the likelihood of disease transmission through contamination of water in the home.
- *Consumer acceptability* – it is important to ensure that drinking-water provided in emergencies is acceptable to the consumers, or they may drink water from unprotected or untreated supplies.
- *Epidemiological considerations* – all of the above considerations should be made in the light of knowledge of the health status of the affected population and the factors that influence the transmission of water-related diseases.

6.3.2 Important quality criteria

The greatest water-borne risk to health in most emergencies is the transmission of faecal pathogens, due to inadequate sanitation, hygiene, and protection of water sources. Water-borne infectious diseases include diarrhoea, typhoid, cholera, dysentery and infectious hepatitis. However, some disasters, including those caused by, or involving, damage to chemical and nuclear industrial installations or volcanic activity, may create acute problems from chemical or radiological water pollution.

Whatever the source and type of contamination, decisions on acceptable water quality in emergencies involve balancing short- and long-term risks and benefits to health. At the same time, ensuring access to sufficient quantities of water is vital for health protection.

Many chemicals in drinking-water are of concern only after extended periods of exposure. Thus, it is advisable to supply water in an emergency even if it significantly exceeds the

Guidelines for some chemical parameters, provided water can be treated to kill pathogens and then supplied rapidly to the affected population, to reduce the risk of outbreaks of water-borne and water-washed disease. Where water sources are likely to be used for long periods, chemical and radiological contaminants of more long-term health importance should be given greater attention. In some situations, this may entail adding treatment processes, or seeking alternative sources.

In many emergency situations, water is collected from public water points, stored in containers, and then transferred to cooking and drinking vessels by the affected people. This system provides many opportunities for contamination of the water after it leaves the supply system. It is therefore very important that the people are aware of the risks to health from contamination of water from the point of collection to the moment of consumption, and have the means to reduce or eliminate these risks. When water sources are close to dwelling areas, they may easily be contaminated through indiscriminate defecation, which should be discouraged. Communication with the affected population is therefore extremely important for reducing health problems due to poor water quality.

6.3.3 Monitoring

Water quality should be monitored during emergencies. Monitoring may involve one or more of the following activities:

- regular monitoring through sanitary inspection and sampling and analysis of supplies for small communities;
- regular monitoring of water treatment processes;
- regular monitoring of water quality at all water collection points and in the home;
- occasional water quality assessment for the investigation of disease outbreaks or the evaluation of hygiene promotion activities.

Monitoring and reporting systems should be designed and managed to ensure that action is swiftly taken to correct changes in drinking-water quality that might affect health. Health information should also be monitored, to ensure that water quality may be rapidly investigated when there is a possibility that this might contribute to a health problem, and that treatment processes – particularly disinfection - may be modified to protect health when required.

Establishing and maintaining water quality in emergencies requires the rapid recruitment, training, and management of operations staff, and the establishment of systems for maintenance and repairs, consumable supplies, and monitoring.

6.3.4 Bacteriological guidelines

Conventional bacteriological water quality standards may be difficult to achieve in the immediate post-disaster period. The Guideline of zero *E. coli* per 100 ml of water should be the goal and should be achievable even in emergencies, provided that chemical disinfection is employed.

An indication of a certain level of a faecal indicator bacteria *alone* is not a reliable guide to biological water quality. Some faecal pathogens, including many viruses and protozoa may be more resistant to treatment, e.g. by chlorine than the indicator bacteria. More generally, if a sanitary survey suggests the likelihood of faecal contamination, then even a very low level

of contamination measured by bacteriological analysis may be considered to be a risk, especially during an outbreak of disease like cholera that may be waterborne.

Drinking-water should be disinfected in emergency situations with a residual disinfectant such as chlorine. Turbid water should be clarified to enable disinfection to be effective wherever possible. Minimum target concentrations for chlorine to point of delivery are 0.2 mg/l in normal circumstances and 0.5 mg/l in high-risk circumstances.

Where there is a concern about the quality of drinking-water in an emergency situation which cannot be addressed through normal procedures, then the appropriateness of individual (i.e. household) level treatment should be evaluated. For instance:

- water brought to a rolling-boil and cooled before consumption;
- the addition of one teaspoon of a commercial sodium- or calcium hypochlorite solution such as household bleach to a bucket of water (more chlorine solution for highly turbid water), mixed thoroughly and allowed to stand for about 30 minutes prior to consumption;
- small volumes of water can be shaken vigorously and exposed to sunlight for three to four hours using, for instance, a transparent container, such as a soft-drink bottle;
- application of commercial products including tablets or other dosing techniques to disinfect the water with or without clarification by flocculation or filtration; or
- use of end-use units and devices for field treatment of drinking-water.

Emergency decontamination processes may not always accomplish the level of disinfection recommended for optimal conditions, particularly with regard to resistant pathogens such as viruses and protozoan cysts or oocysts. However, implementation of emergency procedures may reduce numbers of pathogens to levels where the risk of water borne disease is largely controlled.

The parameters most commonly measured to assess microbial safety are: *E coli* (for which thermotolerant coliforms may provide a simpler surrogate); residual chlorine, turbidity and pH.

Residual chlorine

Taste does not give a reliable indication of chlorine concentration. Chlorine content should be tested in the field with a colour comparator, generally used in the range of 0.2–1 mg/l.

pH

It is necessary to know the pH of water because more alkaline water requires a longer contact time or a higher free residual chlorine level at the end of the contact time for adequate disinfection (0.4 to 0.5 mg/l at pH 6–8, rising to 0.6 mg/litre at pH 8–9 and may be ineffective above pH 9).

Turbidity

Turbidity adversely affects the efficiency of disinfection. Turbidity, or cloudiness, is also measured to determine what type and level of treatment is needed. It can be carried out with a simple turbidity tube that allows a direct reading in turbidity units, or NTU.

6.3.5 Sanitary surveys and catchment mapping

It is possible to assess the likelihood of faecal contamination of water sources by a sanitary survey. This is often more valuable than bacteriological testing alone, because a sanitary survey makes it possible to see what needs to be done to protect the water source and because faecal contamination may vary, so a water sample only represents the quality of the water at the time it was collected. This process can be combined with bacteriological, physical and chemical testing to enable field teams to assess contamination and—more importantly—provide the basis for monitoring water supplies in the post-disaster period.

Even when it is possible to carry out bacteriological quality testing, results are not instantly available. Thus, the immediate assessment of contamination risk should be based on gross indicators such as proximity to sources of faecal contamination (human or animal), colour and smell, the presence of dead fish or animals, the presence of foreign matter such as ash or debris, or the presence of a chemical or radiation hazard or wastewater discharge point upstream. Catchment mapping involving identifying sources and pathways of pollution can be an important tool for assessing the likelihood of contamination of a water source.

It is important to use a standard reporting format for sanitary surveys and catchment mapping, to ensure that information gathered by different staff is reliable and that information gathered on different water sources may be compared. For an example sanitary survey format, see, World Health Organization (1997b), and Davis & Lambert (2002). For more information on catchment mapping, see House & Reed (1997).

6.3.6 Chemical and radiological guidelines

Water from sources that are considered to have a significant risk of chemical or radiological contamination should be avoided, even as a temporary measure. In the long term, achieving the Guidelines should be the aim of emergency water supply programmes based on the progressive improvement of water quality. Procedures for identifying priority chemicals in drinking-water are outlined in WHO *Chemical Safety of Drinking Water: Assessing Priorities for Risk Management*.

6.3.7 Testing kits and laboratories

Portable testing kits allow the determination in the field of thermotolerant coliform count, free residual chlorine, pH, turbidity and filterability.

Where large numbers of water samples need testing or a broad range of parameters is of interest, laboratory analysis is usually most appropriate. If water supplier's laboratories or laboratories at environmental health offices and universities no longer function because of the disaster then a temporary laboratory may need to be set up. Where samples are transported to laboratories, handling is important. Poor handling may lead to meaningless or misleading results.

Workers should be trained in the correct procedures for collecting, labeling, packing, and transporting samples, and supplying supporting information from the sanitary survey to help interpret laboratory results. For standard methods of water sampling and testing, see World Health Organization (1997b; Bartram and Balance, 1996).

6.4 Safe drinking water for travellers

Diarrhea is the most common cause of ill health for travelers; up to 80% of all travelers are affected in high-risk areas. In localities where the quality of potable water and sanitation practices are questionable, the numbers of parasites, bacteria and viruses in water and food can be substantial and numerous infections occur. Cases occur even among people staying in resorts and middle and upper-level hotels. No vaccine is capable of conferring general protection against diarrhea caused by so many different pathogens. Besides causing embarrassment, inconvenience and misery for vulnerable people some infections may be fatal if not treated promptly and effectively. It is important that travelers are aware of possible risks and take appropriate steps to minimise these.

Contaminated food, water and drinks are the most common sources of infections. Careful selection of drinking-water sources and appropriate water treatment offer significant protection. Water can be treated or retreated in small quantities to significantly improve its quality and safety. The simplest and most important beneficial treatments for microbially-contaminated water are boiling, disinfection and filtration to inactivate or remove pathogenic microorganisms. Numerous simple treatment approaches and commercially available technologies are also available to treat drinking-water for single person use by a traveler or in the home. Preventive measures while living or travelling in areas with unsafe drinking-water, include:

- always avoid consumption or use of unsafe water (even when brushing teeth) if you are unsure about water quality. Avoid unpasteurized juices and ice made from untreated water;
- drink water that you have boiled, filtered and/or treated with chlorine or iodine and stored in clean containers; consume ice only if it is known to be of drinking-water quality;
- drink bottled water if it is known to be safe, carbonated bottled beverages (water and sodas) only from sealed, tamper-proof containers and pasteurized/canned juices and pasteurized milk; and
- drink coffee and tea made from boiled water and served and stored in clean containers. Avoid salads or other uncooked dishes that may have been washed or prepared with unsafe water.

6.4.1 Drinking-water disinfection techniques for small quantities

The greatest health risk from drinking-water for travelers is associated with microbial constituents of water. While boiling, filtration and disinfection are effective in reducing microbial risks, these treatments will generally not reduce most chemical constituents in drinking-water. However, most chemicals are only of health concern after long-term exposure.

Bringing water to a *rolling boil* is the most effective way to kill disease-causing pathogens, even at high altitudes. Let the hot water cool down on its own without adding ice. If the water is clear, no other treatment is needed if the water has been boiled.

If water is turbid (not clear, or with suspended solid matter), it should be clarified before disinfection; clarification includes filtration, settling and decanting. Clarification should be undertaken before boiling. Portable filtration devices that have been tested and rated to remove protozoa and some bacteria are also available; ceramic filters and some carbon block

filters are the most common types. The filter's pore size rating must be 1 micron (absolute) or less to ensure removal of *cryptosporidium* cysts (these very fine filters may require a pre-filter to remove larger particles to avoid clogging the final filter). A combination of technologies (filtration followed by chemical disinfection or boiling) is recommended as most filtering devices do not remove viruses.

Chemical disinfection is effective for killing bacterial and viruses and some protozoa (e.g. not *Cryptosporidium* cysts). The water should be clear before application of the disinfectant chemical. Some form of chlorine and iodine are the chemicals most widely used for disinfection. Often, after chlorination, a carbon (charcoal) filter is used to remove chlorine taste, and in the case of iodine treatment to remove excess iodine. Silver is not very effective for eliminating disease-causing microorganisms, since silver by itself is slow acting.

For people with weakened immune systems, extra precautions are recommended to reduce risk of infection from contaminated water. While drinking boiled water is safest, certified bottled or mineral water may also be acceptable. Iodine use as a water disinfectant is not recommended for pregnant women, those with a history of thyroid disease, and those with known hypersensitivity to iodine unless there is also an effective post treatment iodine removal system such as granular carbon in use.

In summary, for producing small amounts of water, boiling - especially if combined with clarification use of chlorine bleach or iodine are simple, inexpensive and effective ways of treating water to kill or inactivate pathogenic microorganisms that can cause waterborne disease. They should be used by both residents and travelers in areas where the safety of the local drinking-water is uncertain or unreliable. Bottled water and other drinks also have widespread application if it is certain that they are safe, e.g. that the bottled water has been produced under sanitary conditions from safe water. Simple and sometimes locally made ceramic and small sand filters can also provide some improvements in water quality by removing organisms that are retained by the filtering system which is dependent upon the pore size. More sophisticated and expensive devices are produced and marketed for a wide range of water treatment problems. Point of use devices can treat water that is used for drinking and cooking. All treatment systems are designed for a specific purpose, thus, it is important to select the specific type of device that is intended for the particular water quality problem that is encountered. It is also most desirable to use devices that have been tested by a qualified independent organization against the appropriate performance standard and demonstrated to meet all of the requirements of the standard. Operation and maintenance should be performed with any system according to the manufacturer directions to assure that the unit is performing as claimed and as the consumer expects.

The WHO Safe Drinking-water for Travelers and Emergencies brochure describe simple water treatment methods that travelers can use to produce safe drinking-water for short-term use.

6.5 Desalination systems

The principal purpose of desalination as a source of drinking-water is to enable sources of brackish or salty water, otherwise unacceptable for human consumption, to be used for this purpose.

Because of water scarcity driven by pressures arising from population growth, over-exploitation of water resources and pollution of other water sources, the use of desalination as a drinking-water source is increasing and is likely to continue to increase. Whilst most present capacity (around 60% of presently constructed capacity) is in the Eastern Mediterranean Region, desalination facilities exist all over the world and their use is likely to increase in all continents.

Most present applications of desalination are to estuarine, coastal and seawater. Desalination may also be applied to brackish inland waters (both surface water and groundwater); and may be used onboard vessels. Small-scale desalination units also exist for household and community use and present specific challenges to effective operation and maintenance.

Further guidance on desalination for safe drinking-water supply is available in [*title of document and publishing details - pending*].

In applying the Guidelines to desalinated water supply systems, account should be taken of certain major differences between these and systems abstracting water from fresh water sources. These differences include the factors described below. Once taken into account the general requirements of the Guidelines for securing microbial, chemical and radiological safety should apply.

6.5.1 Major issues

Brackish, coastal and seawater sources may contain hazards not encountered in freshwater systems. These include diverse harmful algal events associated with micro and macro algae and cyanobacteria; certain free-living bacteria (including *Vibrio* species such as *V. parahaemolyticus* and *V. cholerae*); and some chemicals such as boron and bromide which are more abundant in seawater.

Harmful algal events may be associated with exo- and endo-toxins that may not be destroyed by heating, that are inside algal cells or free in the water. They are usually non-volatile and where they are destroyed by chlorination this usually requires extremely long contact times. Although a number of toxins have been identified, it is possible that there are other unrecognized toxins. Minimizing of the potential for abstracting water containing toxic algae through location/siting and intake design plus effective monitoring and intake management is an important primary preventive measure

Other chemical issues such as control of “additives”, disinfection by-products (DBPs), pesticides, etc are similar to those encountered in freshwaters [cross-reference guidance on ‘materials and chemicals’ and other guideline values - pending], except that a larger variety and greater quantities may be used in desalination. Due to the presence of bromide, the distribution of disinfection by-products will likely be dominated by brominated organics.

Approaches to monitoring and assessing the quality of source waters developed for freshwater may be inapplicable to desalinated waters. In particular many faecal indicator bacteria die-off more rapidly in saline than freshwater; and the principal chemical contaminants of concern may be distinct.

The effectiveness of some of the processes employed in desalination in removing some substances of health concern remains inadequately understood. Examples of inefficiencies include imperfect membrane and/or membrane seal integrity (membrane treatment), bacterial growth through membranes/biofilm development on membranes (in membrane treatment systems); and carry over, especially of volatile substances (with vapour).

Because of the apparently high effectiveness of some of the processes used in removal of both microorganisms and chemical constituents (especially distillation and reverse osmosis), these processes may be employed as single stage treatments or combined only with application of a low level of residual disinfectant. The absence of multiple barriers places great stress on the continuously safe operation of that process and implies that even short-term decrease in effectiveness may present an increased risk to human health. This in turn implies the need for on-line monitoring linked to rapid management intervention. For further information, see WHO *Impact of Treatment on Microbial Water Quality and Occurrence of Pathogens in Surface Water and their relationship with Indicator Parameter*.

Water produced by desalination is “aggressive” towards materials used, for example, in water supply and domestic plumbing, pipes, etc. Special consideration should be given to the quality of such materials and normal procedures for certification of materials as suitable for potable water use may not be adequate for water, which has not been “stabilized”.

Because of the aggressivity of desalinated water and because desalinated water may be considered bland, flavourless and unacceptable, desalinated water is commonly treated by adding chemical constituents such as calcium carbonate with carbon dioxide. Once such treatment has been applied, desalinated waters should be no more aggressive than waters normally encountered in drinking-water supply. Chemicals used in such treatment should be subject to normal procedures for certification. For further information *Safety of Materials and Chemicals Used in the Production and Distribution of Drinking-water*.

Desalinated waters are commonly blended with small volumes of more mineral-rich waters, to improve their organoleptic quality and particularly to reduce their aggressivity to materials. Blending waters should be fully potable, as described here and elsewhere in the Guidelines. Where seawater is used for this purpose the major ions added are sodium and chloride. This does not contribute to improving hardness or ion balance and only small amounts (e.g. 1-3%) can be added without leading to organoleptic problems. Blending waters from coastal and estuarine areas may be more susceptible to contamination with petroleum hydrocarbons which could give rise to taste and odour problems. Some ground or surface waters, when used for blending after suitable treatment, may be employed for blending in higher proportions and may improve hardness and ion balance.

Desalinated water is a manufactured product. Concern has been expressed about the impact of extremes of major ion composition or ratios for human health. Evidence is too weak to describe the health risk associated with long-term consumption of such water although concerns regarding mineral content may be limited by the stabilization processes outlined above.

Desalinated water, by virtue of its manufacture, often contains lower than usual concentrations of other ions commonly found in water, some of which are essential elements. Water typically contributes a small proportion of these and most intake is through food. Exceptions include fluoride and declining dental health has been reported from populations consuming desalinated water with very low fluoride content.

Desalinated water may be more subject to ‘regrowth’ problems than other waters as a result of one or more of: higher initial temperature (from treatment process), higher temperature (application in hot climates) and/or the effect of aggressivity on materials (thereby releasing nutrients). The direct health significance of regrowth, with the exception of *Legionella* (see sections 6.2 and 7.x) is inadequately understood. In the absence of disinfectant residuals, nitrite formation by organisms in biofilms may prove problematic. Precaution implies that preventive management should be applied as part of good management practice.

6.6 Packaged drinking-water

Bottled water is widely available in both industrialized and developing countries. Consumers may have various reasons for purchasing packaged drinking-water, such as taste, convenience or fashion, but for many consumers, safety and potential health benefits are important considerations.

6.6.1 Safety of packaged drinking-water

Water is packaged for consumption in a range of vessels including cans, laminated boxes and plastic bags, and as ice prepared for consumption. However, it is most commonly prepared in glass or plastic bottles. Bottled water also comes in various sizes from single servings to large carboys holding up to 80 litres.

In applying the Guidelines to bottled waters, certain factors may be more readily controlled than in piped distribution systems and stricter standards may, therefore, be preferred in order to reduce overall population exposure. Similarly, when flexibility exists regarding the source of the water, stricter standards for certain naturally occurring substances of health concern, such as arsenic, may be more readily achieved than in piped distribution systems.

However, some substances may prove more difficult to manage in bottled than tap water. Some hazards may be associated with the nature of the product e.g. glass chips and metal fragments. Other problems arise because bottled water is stored for longer periods and at higher temperatures than water distributed in piped distribution systems. Control of materials used in containers and closures for bottled waters is, therefore, of special concern. In addition, some microorganisms, which are normally of little or no public health significance, may grow to higher levels in bottled waters. This growth appears to occur less frequently in gasified water and in water bottled in glass containers compared to still water and water bottled in plastic containers. The public health significance of this microbial growth remains uncertain, especially for vulnerable individuals, such as bottle-fed infants and immunocompromised individuals. In regard to bottle-fed infants, as bottled water is not sterile, it should be disinfected - for example by boiling prior to its use in the preparation of infant formula. For further information, see WHO *Heterotrophic plate counts*.

6.6.2 Potential health benefits of bottled drinking-water

There is a belief by some consumers that *natural mineral waters* have medicinal properties or offer other health benefits. Such waters are typically of high mineral content, sometimes significantly higher than concentrations normally accepted in drinking-water. Such waters often have a long tradition of use and are often accepted on the basis that they are considered foods rather than drinking-water *per se*. Although certain mineral waters may be useful in providing essential micro-nutrients, such as calcium, the Guidelines do not make recommendations regarding minimum concentrations of essential compounds, because of the uncertainties surrounding mineral nutrition from drinking-water.

Packaged waters with very low mineral content, such as distilled or demineralised waters are also consumed. Rainwater, which is similarly low in minerals, is consumed by some populations without apparent adverse health effects. There is insufficient scientific information on the benefits or hazards of regularly consuming these types of bottled waters.

6.6.3 International standards for bottled drinking-water

The Guidelines provide a basis for derivation of standards for all packaged waters.

The Codex Alimentarius Commission (CAC) has developed a *Standard for Natural Mineral Waters* and an associated code of practice. The CAC *Standard* describes the product and its labeling, compositional and quality factors, including limits for certain chemicals, hygiene, packaging and labeling. The *Code of Practice for Collecting, Processing and Marketing of Natural Mineral Waters* provides guidance to the industry on a range of good manufacturing practices matters.

The CAC is developing a draft of a *Codex Standard for Bottled/Packaged Waters* to cover packaged drinking-water other than *natural mineral waters*. Both standards refer directly to the Guidelines.

Under the existing Codex Standard and Code of Practice, *natural mineral waters* must conform to strict requirements including collection and bottling without further treatment from a natural source, such as a spring or well. In comparison, the draft *Codex Standard for Bottled/Packaged Waters* has been proposed to include waters from other sources, in addition to springs and wells, and treatment to improve their safety and quality. The distinctions between these standards are especially relevant in regions where *natural mineral waters* have a long cultural history.

Further information on the Codex Alimentarius Commission and its Codex Committee on Natural Mineral Waters, and the *Codex Standard for Natural Mineral Waters* and its companion *Code of Practice*, readers are referred to the Codex Alimentarius website <http://www.fao.org/WAICENT/FAOINFO/ECONOMIC/ESN/codex/>.

6.7 Food production

The quality of water defined by the Guidelines is such that it is suitable for all normal uses in the food industry. Some food production processes have special requirements of water quality in order to secure the desired characteristics of the product and the Guidelines do not necessarily guarantee that such special requirements are met.

Deterioration in drinking-water quality may have severe impacts in food production facilities and potentially upon public health. The consequences of a failure to use water of potable quality will be dependant on the use of the water and the subsequent processing of potentially contaminated materials. Variations in water quality that may be tolerated occasionally in the drinking-water supply may be considered unacceptable for some uses in the food industry. These variations may result in severe financial impact on food production, for example through product recalls.

The diverse uses of water in food production have different water quality requirements. Uses include: irrigation and livestock watering; those in which water may be incorporated in or adhere to a product (e.g. as an ingredient, or where used in washing of foods); and those in which contact between the water and foodstuff should be minimal (as in heating and cooling and cleaning water). Some food production processes may have special requirements to achieve desired characteristics which may not be of health significance.

To reduce microbiological contamination, the food industry may use specific treatments (e.g. heat) capable of removing a range of pathogenic organisms of public health concern. The effect of these treatments should be taken into account when assessing the impacts of deterioration in drinking-water quality on a food production facility.

Information on drinking water supply quality deterioration should be promptly communicated to vulnerable food production facilities.

6.8 Water safety on Aircraft and in Airports

6.8.1 Health risk assessment

The importance of water as a potential vehicle for infectious disease transmission on aircraft has been documented. In general terms, the greatest microbial risks are associated with ingestion of water that is contaminated with human and animal excreta. Waterborne diseases that are still being transmitted in many parts of the world including cholera and other enteric infections. Many airlines operate through countries in which these diseases are either endemic or occur from time to time, and in which the standard of sanitation may be low. Aircraft often cannot carry sufficient water to last throughout the complete flight and must therefore replenish supplies from sources in many different countries. If the source is contaminated, it is clear that, unless adequate precautions are taken, disease can be spread through the medium of aircraft water. A problem may be created if water cannot be uplifted because of its unsuitability. It is thus imperative that every airport should comply with Article 14.2 of the International Health Regulations and be provided with potable drinking water from a source approved by the health administration.

A potable water source is not a safeguard if the water is subsequently contaminated during transfer, storage or distribution in aircraft. Airports usually have special arrangements for managing the water after it has entered the airport. Water is usually delivered to aircraft by water servicing vehicles or water bowsers. Transfer of water from the vehicles to the aircraft can create risks and offer distinct possibilities for microbial or chemical contamination to arise e.g. from water hoses. Water supplied to air traveller and crew should meet the standards in the *WHO Guidelines for Drinking -water quality*.

6.8.2 Water safety plan

The traditional approach to assuring the safety of water on aircraft relied on sampling the end product. Although sampling can verify that the water is safe it is not suitable for early warning or control purposes. The detection of contaminants in both source water and water delivered to passengers and crew is often slow, complex and costly. A holistic approach to water safety on ships is essential. This can be achieved by the adoption of a HACCP -type water safety plan to cover both design (materials and construction) and operation. The plan can be used in the development of risk management strategies. Such strategies, if properly implemented, will ensure the safety of drinking water on aircraft, through the elimination, or reduction to a minimum concentration, constituents of water hazardous to health

The objective of a water safety plan is to systematically assess risks throughout a drinking water supply chain, from airport source to aircraft, and identify ways that these risks can be managed and methods to ensure that barriers and control measures work effectively. A risk management plan assesses the integrity of the entire water supply system and is able to incorporate strategies to deal with day to day management of water quality as well as upsets and failures.

A water safety plan (WSP) should consist of the following:

- Health risk assessment along the water supply chain from airport to aircraft
- System risk assessment to determine whether the water supply chain as a whole can deliver water of a quality that meets the above targets i.e. controls hazards
- Setting of control measures, management and monitoring of control measures and corrective action.

6.8.3 System risk assessment

In undertaking an assessment of the water distribution system, a range of specific issues must be taken into consideration, including:

- quality of source water;
- filtration systems and other treatment systems on aircraft;
- design and construction of water servicing vehicles;
- water loading techniques;
- design and construction of storage tanks and pipes;
- backflow prevention;

Airport water supply

The piped water supply delivered to airports should be obtained from water supply systems that comply with the WHO GDWQ.

Drinking water for aircraft should be obtained from the airport mains supply. If appropriate facilities exist, it can be conveyed direct from the supply point to the aircraft; if not, it can be transported in a water-servicing vehicle.

The mains supply point from which aircraft water is obtained should be above ground level and under cover to protect it from contamination. If possible, each airline should have a separate supply point and be responsible for maintaining its cleanliness. If however, the supply point is shared by several airlines or servicing agents, then the airport authority should

be responsible for control and maintenance. The supply point must be exclusively used for aircraft drinking water and should be situated at least 30 meters away from the supply point for toilet servicing vehicles. The hydrant hose should have a self sealing non -return valve coupling. The diameter of the supply hose should be different from that of the hose supplying water to toilet servicing vehicles.

Water servicing vehicles

Water servicing vehicles must be so designed and maintained that water in transit between the filling point and the aircraft water storage system cannot come into contact with any external matter or be affected by handling.

Tanks should be constructed of smooth, strong, corrosion resistant material, and be so designed that they will not retain sediment when full drainage is required. All corners should be rounded. Covers should be provided which, on removal, will permit full access to the interior for cleaning and maintenance. A tap should be fitted to the main tank to permit the taking of samples. Inlet and outlet valves should be self sealing, non return, and of the quick release type. They should be provided with caps for fitting when the vehicles are not in operation.

Transfer of water from water servicing vehicle to aircraft

The hoses should be made of non-toxic, impervious and durable material. When the hoses are not in use, all nozzles should be protected from contamination, either by a cover or by immersing them in a container of hyperchlorinated water. Before supplies are delivered to the aircraft the hose should be flushed out by pumping a small quantity of water through it.

Storage

On aircraft water is stored in tanks. These should be constructed of welded steel or reinforced fibreglass. The tanks should be designed to drain completely. If the aircraft has only one tank, or if several tanks are located together, there will be a single fill/ overflow point; if, on the other hand, the tanks are located in different parts of the aircraft each will have its own fill point. In all cases, fill points must be separated from the toilet servicing panels to avoid cross contamination. All components of the water system must be corrosion resistant and suitable for use with hyperchlorinated water.

Drinking water points should be sited outside toilet compartments. The water should be cooled by passing through automatic coolers. A dispenser and receptacle for disposable cups should be installed near the water point.

Cross connections

The distribution lines should not be cross-connected with the piping or storage tanks of any non-potable water system.

6.8.4 Management

Transfer from airport to aircraft

During transfer from the airport main supply to the aircraft or from a water supply vehicle to the aircraft water must be provided with sanitary safeguards throughout the water distribution system, including connections to the aircraft system, and through the aircraft system at each outlet to prevent contamination or pollution of the water during aircraft operation. Staff employed in water supply must not be engaged in activities related to aircraft toilet servicing.

Water servicing vehicles

All water servicing vehicles must be cleansed and disinfected frequently and regularly. One procedure is to fill the vehicle tanks once a week with a 50mg/l solution of residual chlorine, which should remain for a minimum period of 30 minutes. The vehicle should then be emptied through the delivery hose- not the drain plug. Afterward, the drain plug should be removed, and the tank flushed out with potable water through the valve coupling.

Once a month the interior of the water vehicle tank should be scoured to remove any deposits. This can be done either by using a stiff bristled brush soaked repeatedly in a strong hypochlorite solution or, when convenient, by steam jet, flushing out the tank with clean water, and then repeating the treatment with hypochlorite described above. Instructions for the cleansing and disinfecting of water vehicle tanks should be affixed to the vehicle for the benefit of operators. The dates of cleansing treatments should be recorded.

Storage tanks and pipes

On some aircraft, filters are fitted for the prime purpose of neutralising the chlorine content. It is important that these filters are serviced regularly otherwise they could disintegrate and contaminate the water. Also, once the chlorine content has been removed, the water has no protection against bacteria introduced downstream from the filter. Such filter should therefore be fitted at each water outlet.

Treatment of aircraft water

Even if potable water is supplied to the airport it is still necessary to introduce extra precautions to prevent possible contamination during the transfer of water to the aircraft and in the aircraft water system itself. Thus, prior to being loaded on aircraft, all water should be treated to ensure that the level of residual chlorine is maintained at 0.3mg/l. The treatment of the water vehicle tanks can be carried out manually or mechanically. When water is conveyed direct to aircraft from the mains supply point, dosing may be carried out automatically by using portable or fixed chlorinating units at the supply point. It is important to check that the water has been treated. A simple method of determining the approximate amount of residual chlorine should be available to ground engineers, cabin crew and catering officers, all of whom should be given the responsibility of testing at appropriate times. The ground engineer should ensure that the water is tested for the presence of residual chlorine before it is supplied to the aircraft. The cabin crew should test the water on board the aircraft before any passenger has had the opportunity of drinking it. All aircraft should carry a supply of chlorine testing and test neutralising tablets

Cleaning and disinfection of tanks

If the water supplied to the aircraft is potable and contains residual chlorine at the correct levels, the aircraft water tanks and system need not be disinfected so frequently. Where airlines do not request or ensure treatment of water, then disinfection must be much more frequent i.e. at least every 4 weeks. At the allotted time for disinfecting, the aircraft tank should be filled with water containing residual chlorine at a level 50mg/l, which should be left in the system for a minimum of 30 mins. Alternatively, a 200mg/l solution may be left in for a period of 3-55 minutes. The tanks should be drained; flushed out completely with potable water to make sure that the hyperchlorinated solution is completely removed, and then refilled with treated water

Repair and maintenance

Water safety is assured by repair and maintenance protocols, including the ability to contain potential contamination by valving and most importantly, the cleanliness of personnel, their working practices and the materials employed.

6.8.5 Operational monitoring

The aircraft operator is responsible for operational monitoring. The primary emphasis of monitoring is as a verification of management processes. Monitoring depends primarily on monitoring of control measures, including:

- quality of source water;
- hydrants and hoses for cleanliness and repair;
- disinfectant residuals and pH;
- backflow preventers;
- filters;
- monitoring microbial quality of water, particularly after maintenance or repairs.

Verification

Sampling by airlines should be carried out not less than 4 times a year for each airport supplying water. If samples are unsatisfactory, the airline or airport personnel should investigate and take steps to rectify any defects in treatment and also arrange for disinfection of the aircraft system.

6.8.6 Airport Health surveillance

Independent surveillance is an essential element in ensuring water safety on aircraft. This implies:

- Periodic audit and direct assessment;
- Review and approval of Water Safety Plans;
- Specific attention to the aircraft industry's codes of practice, the WHO *Guide to Hygiene and Sanitation in Aviation* and airport health or airline regulations;
- Respond, investigate and provide advice on receipt of report on significant incidents.

Surveillance or continuous and vigilant assessment of drinking water supplies is necessary to ensure that each component of the system (source, treatment, storage and distribution) operates without risk of failure.

6.8.7 Supporting Programmes

- Suitable training for crew dealing with water transfer and treatment;
- Effective certification on materials used on aircraft for storage tanks and pipes.

6.9 Water safety on ships**6.9.1 Health risk assessment**

The importance of drinking water supply as a vehicle for infectious disease transmission on ships has been clearly documented. In general terms, the greatest microbial risks are associated with ingestion of water that is contaminated with human and animal excreta. Waterborne transmission of the enterotoxigenic *E.coli*, Norwalk like virus (NLV), *Vibrio* spp, *Salmonella typhi*, *Salmonella* spp (non typhi), *Shigella* spp, *Cryptosporidium* Sp,

Giardia lamblia and *Legionella* sp on ships has been confirmed by epidemiological evidence. In some outbreaks no known agent was identified.

Chemical poisoning on a ship could also occur if crew or passengers are exposed to small doses of harmful chemicals over long periods of time. Of particular concern are contaminants that have cumulative toxic properties, such as heavy metals, e.g. from copper pipes or construction materials, and substances that are carcinogenic.

The WHO *Guide to Ship Sanitation* covers the unique factors that can be encountered during water treatment, transfer, production, storage or distribution in ships. The *Guide* includes specific features on the organization of the supply and the regulatory framework.

The organization of water supply from shore facilities to ships differs considerably from water transfer on land. Even though a port authority may receive potable water from a municipal or private supply, it usually has special arrangements for managing the water after it has entered the port. Water is delivered to ships by hoses on the dockside or transferred to the ship by water boats or barges. Transfer of water from shore to ships can create risks and offer distinct possibilities for microbial or chemical contamination to arise e.g. from water hoses.

In contrast to a shore facility, plumbing aboard ships consists of numerous piping systems, carrying potable water, seawater, sewage and fuel, fitted into a relatively confined space. On some ships, piping systems are normally extensive and complex and this could make them difficult to inspect, repair and maintain. A number of waterborne outbreaks on ships were caused by contamination of potable water after it had been loaded onto the ship, for example, by sewage or bilge when the water storage systems were not adequately designed and constructed. During distribution it may be difficult to prevent water quality deterioration due to stagnant water and dead ends. Water distribution on ships also may provide greater opportunities for contamination to occur than onshore because ship movement increases the possibility of surge and back-siphonage.

6.9.2 System risk assessment

In undertaking an assessment of the ship's distribution system, a range of specific issues should be taken into consideration, including:

- Quality of source water;
- Water loading equipment and techniques;
- Prevention of contamination in storage
- Prevention on contamination in the distribution system;
- Backflow prevention;
- Cross connections;
- Repair and maintenance;
- Residual disinfection;

6.9.3 Management

Quality of source water

The port authority has responsibility for providing safe potable water available for loading onto vessels. The ship's master will not have direct control of pollution of water supplied at

port. If water is suspected from coming from an unsafe source the ship's master should not uplift contaminated water.

Water loading equipment and techniques

During transfer from shore to ship and on board, water must be provided with sanitary safeguards through the shore distribution system, including connections to the ship system, to prevent contaminated water entering the ship. For example, hoses should be cleaned and disinfected before water is loaded onto ship, cross connection during loading between potable and non potable water should be avoided.

Prevention of contamination in storage

Potable water should be stored in one or more tanks that are so constructed located and protected as to be safe against any contamination from outside the tank. If possible, tanks should be constructed to limit build up of sedimentation. Non potable water pipes should not run through potable water tanks. If black or grey water pipes have connections above potable water tanks they should be appropriately welded.

Prevention of contamination in distribution

Potable water lines should also be protected and located so that they will not be submerged in bilge water or pass through tanks storing non-potable liquids. System design should minimize deadends and areas of stagnation;

The distribution systems on ships are especially vulnerable to contamination when the pressure falls. Local loss of pressure could result in back-siphonage of contaminated water, unless appropriate backflow prevention devices are introduced into the water system at sensitive points.

The distribution lines should not be cross-connected with the piping or storage tanks of any non-potable water system unless appropriate safety devices are used to prevent the flow of non-potable water to potable water

Repair and maintenance

Water safety is assured by repair and maintenance protocols, including the ability to contain potential contamination by valving and most importantly, the cleanliness of personnel, their working practices and the materials employed.

Residual disinfectants

Current practice on many ships is to use disinfectant residuals to control the growth of microorganisms in the distribution system.

6.9.4 Operational monitoring

The Ship's Master is responsible for operational monitoring. The primary emphasis of monitoring is as a verification of management processes. Monitoring depends primarily on monitoring of control measures, including:

- Quality of source water;
- Hydrants and hoses for cleanliness and repair;
- Disinfectant residuals and pH;
- Backflow preventers(weekly to monthly);

- Monitoring microbial and chemical quality of water, particularly after maintenance or repairs.

6.9.5 Port Health surveillance

Independent surveillance is an essential element in ensuring water safety on ships. This implies:

- Periodic assessment;
- Review of Ship's Water Safety Plans; it is important that these plans document roles and responsibilities.
- Specific attention to the shipping industry's codes of practice, the WHO *Guide to Ship Sanitation* and port health or shipping regulations;
- Respond, investigate and provide advice on receipt of report on significant incidents.

6.9.6 Supporting Programmes

- Suitable training for crew dealing with water transfer and treatment;
- Effective certification of materials used on ships for storage tanks and pipes.